



Associação Fraunhofer Portugal Research

Research of Practical Utility lies at the heart of all activities developed by Fraunhofer Portugal.

Founded in 2008 – as a result of the long-term Portuguese-German collaboration in Science and Technology – Associação Fraunhofer Portugal Research focuses on companies as customers and partners to promote innovative product development by delivering applied research results in an international context.

Adopting the well-tested – and undisputedly successful – model operated in Germany by Fraunhofer-Gesellschaft, Fraunhofer Portugal supports economic development and social well-being by contributing to the population's quality of life.

Currently, Associação Fraunhofer Portugal Research (Fraunhofer Portugal) owns and operates the Fraunhofer Portugal Research Center for Assistive Information and Communication Solutions (Fraunhofer Portugal AICOS) – a partnership between Fraunhofer-Gesellschaft and the University of Porto – focusing on Ambient Assisted Living (AAL) and Information and Communication Technologies for Development (ICT4D).

Acknowledged by the Portuguese Government as an 'Entity of Public Interest', Associação Fraunhofer Portugal Research was named after Joseph von Fraunhofer (1787–1826), the illustrious Munich researcher, inventor and entrepreneur.

A investigação de utilidade prática está no centro de todas as atividades desenvolvidas pela Fraunhofer Portugal.

Fundada em 2008 – e resultando de uma colaboração de longo prazo em Ciência e Tecnologia entre Portugal e a Alemanha – a Associação Fraunhofer Portugal Research mantém um enfoque nas empresas como parceiros, promovendo e desenvolvendo atividades de investigação aplicada num contexto internacional.

Adotando o bem-sucedido modelo de negócio operado na Alemanha pela Fraunhofer-Gesellschaft, a Fraunhofer Portugal apoia o desenvolvimento económico e promove o bem-estar social, ao contribuir para a melhoria da qualidade de vida das populações.

Neste momento, a Associação Fraunhofer Portugal Research (Fraunhofer Portugal) detém e opera o Fraunhofer Portugal Research Center for Assistive Information and Communication Solutions (Fraunhofer Portugal AICOS) – uma parceria entre a Fraunhofer-Gesellschaft e a Universidade do Porto – dedicada às áreas de "Ambient Assisted Living" (AAL) e de Tecnologias de Informação e Comunicação para o Desenvolvimento (ICT4D).

Reconhecida pelo Estado Português como Pessoa Coletiva de Utilidade Pública, a Associação tem o nome do famoso cientista, inventor e empreendedor Joseph von Fraunhofer (1787–1826), originário de Munique, Alemanha.

The cover features a modern, abstract design with a grey gradient at the top, a dark teal band, and a large teal area with a diagonal gradient. A white horizontal line is positioned above the title.

ANNUAL REPORT 2016

Fraunhofer Portugal: Leveraging the IoT for Societal Changes

2016 provided Fraunhofer Portugal AICOS (FhP-AICOS) the opportunity to evolve from the work carried out in the past towards a set of new goals targeted by a large new project and related to two key opportunities linked to the deployment of the IoT: Understanding context and delivering personalized, context sensitive support to human users.

This project, named Deus ex Machina, envisaged the creation of two new research lines whose technological and scientific foundations came from the previous competence centres. The EITCC – Eyes of the Internet of Things Competence Centre and the C3 – Companion Competence Centre are now the core of the upgraded strategic research agenda of FhP-AICOS, which founds its roots in the competences nurtured in its scientific team. Deus ex Machina was formally approved in January 2016 with a global investment of approx. 3M€, being the investment and incentive divided by FhP-AICOS and six research centres associated to the three universities of the north region of Portugal: University of Porto, University of Minho and University of Trás-os-Montes e Alto Douro. Together with our partners we strive to develop technology that will prepare us to provide leading edge innovations for our industrial customers.

This is most important, as regarding the industry contract research business, the outcome of 2016 was not as positive as it was expected due to a series of reasons that are mostly related with the delays of the PT2020 programme.

Being PT2020 an important political and economic instrument to leverage the socioeconomic growth of Portugal, these administrative delays have a direct impact on the normal development of the country as a series of public and private investments are being postponed for a long time. In some specific cases, these delays reached more than seven months after the deadline to announce the results of the call. Within this context, it is very hard to estimate and plan the expected outcomes of an organization due to the extensive time periods that result in impacts in more than one economic year.

This also impacted the performance of Fraunhofer Portugal: our performance indicator (Rho) was affected and resulted in a value below our plan, which could have been achieved highly likely in a scenario where we could have started the projects for our customers as planned. Most likely in 2017 the indicator will rise again to values above the 60% due to the accumulation of the expected revenue that will be accounted in 2017. This value would be in line with the expected performance and balanced with the results that characterized the performance of the organization during the last two years. At the end of 2016, the total Business Volume was circa 3,1M€, representing a decrease of 5% compared with the previous year.



Nevertheless, the evolution of industry revenues and EU revenues was positive in 2016 and, in the case of the first one FhP-AICOS achieved a growth rate of 42%. Most of the increase in the industry projects Backlog was due to PT2020 project proposals that were submitted in mid 2015 and beginning 2016, which were approved for funding, leading to six new industry projects contracted along the year and representing five new industry clients. Besides these contracts supported by PT2020 funding, FhP-AICOS was also able to contract two direct industry contracts with foreign clients. Also during 2016, the organization has been negotiating with a large company the participation in a PT2020 individual R&D project. Another project that the organization was able to start in 2016 concerns with the Sustainable Villages for Development – SV4D, a concept that FhP-AICOS is developing with Association of Communications and Telecommunications of the Community of Portuguese Speaking Countries – ARCTEL-CPLP for about two years and that finally is being contracted for implementation in the North region of Mozambique, more precisely in the Zambezia district. This region has an area of 103 478 km² and a population of approx. four million people. In terms of the network communications technology that is being used in this last project, there is the involvement of Fraunhofer FIT who is supplying the WiBACK technology to build the low cost communications infrastructure associated to the project.

In terms of EU projects, in 2016, FhP-AICOS started the implementation of two projects proposals that were submitted to the AAL Joint Programme (AAL JP) in 2015: CordonGris and Active@Home. These projects contributed to the growth of 20% of the EU revenues in 2016.

During the year, FhP-AICOS team was very active in project proposals submission, circa 4,4M€, and at the end of 2016 the total Backlog of proposal being evaluated is on the level of 2,5M€. The current expectations in terms of the achievement of R&D contracts coming from these proposals is very positive and with a likelihood to have contracts for the future years on a significant dimension. Actually, one of the positive aspects related to the project proposals submitted for funding in the PT2020 framework programme in 2015 and 2016 was the high success rates achieved. Having in consideration the different calls and different types of project proposals that FhP-AICOS submitted as coordinator, as partner in consortiums coordinated by industry clients, or in individual projects submitted by companies (in which the organization was subcontracted), the approval rates were above 50%, which revealed itself as a very positive sign of the quality of the proposals submitted for funding in national programmes. This result contrasts with the low success rates that were associated to the previous framework programme, QREN.

Along the year, FhP-AICOS had also the opportunity to celebrate different awards that made our team proud and motivated. One of the most positive results was the 2nd place in the Microsoft Indoor Position contest, won by Precise Indoor Location technological framework that was being developed in the past three years. This achievement brought once again the attention of important potential industry clients to FhP-AICOS and the future perspectives for licensing seem promising. Two other awards were obtained during 2016. One honourable mention to a technology related with low cost device to detect diabetic retinopathy in early stages of development and a best poster award to a scientific publication presented in the EU Falls Festival.

One of the most important scientific outcome achieved by the organization in 2016 was the fact that FhP-AICOS first patent was granted this year! The title of the patent is 'Mobile Device and Infrastructure System' and it addresses the innovation that is covered by the Ultra-Low Frequency Magnetic Communication (ULF-MC) technology that was invented by the Director of FhP-AICOS, Professor Dirk Elias.

In 2016 we also received the visits of important guests, namely the President of Fraunhofer-Gesellschaft, Professor Reimund Neugebauer, the Portuguese Minister of Science, Technology and Higher Education, Professor Manuel Heitor, and the Portuguese Minister of Economy, Professor Manuel Caldeira Cabral. Within the visit of Professor Neugebauer, FhP-AICOS had the opportunity to present some of its latest scientific and technological results which created an excellent impression to the visiting delegation.

Last but not least, 2016 ended up by being marked as a year for future changes. These future changes are associated to the announced leave of Professor Dirk Elias, the Director of FhP-AICOS that was mentoring the development of the organization since the first days of its formation. The success story of Fraunhofer Portugal of the last eight years is marked by the leadership and inspiring creations of Professor Dirk Elias, the person that planned and guided the organization development together with a brilliant team of people that were able to create visionary technologies and produce scientific results of excellence recognized by our peers. This change will mark the start of a new era for the development of Fraunhofer Portugal, being the challenge to the future FhP-AICOS' Director keep up with the excellency and the scientific and technological outcomes of the organization.

Dirk Elias and Pedro Almeida

Fraunhofer Portugal: Beneficiando do IoT para Promover as Mudanças Sociais

Graças ao esforço realizado no passado, o ano de 2016 permitiu que o Fraunhofer Portugal AICOS (FhP-AICOS) evoluísse para um conjunto de novos objetivos, orientados por um projeto inovador de grande dimensão relacionado com duas oportunidades fundamentais ligadas à implementação do IoT: Compreender o contexto e oferecer suporte personalizado e adaptado a utilizadores humanos.

Este projeto, designado Deus ex Machina, visa a criação de duas novas linhas de investigação, cujas bases tecnológicas e científicas derivam dos anteriores centros de competências. Atualmente, o EITCC – Eyes of the Internet of Things Competence Centre e C3 – Companion Competence Centre constituem a base da atual agenda de investigação estratégica do FhP-AICOS, que fundamenta as suas raízes nas competências da sua equipa científica. O projeto Deus ex Machina foi formalmente aprovado em janeiro de 2016, com um investimento global estimado em 3M€, sendo o investimento e incentivo dividido por seis centros de investigação, associados às três universidades da região Norte de Portugal: Universidade do Porto, Universidade do Minho e Universidade de Trás-os-Montes e Alto Douro. Em conjunto com nossos parceiros, esforçamo-nos por desenvolver tecnologia que nos prepare para fornecer inovações de ponta para os nossos clientes da indústria.

Esta situação é de extrema importância, dado que relativamente ao negócio de investigação de contratos com a indústria, o resultado de 2016 não foi tão positivo quanto esperado, por motivos de diferente natureza, mas essencialmente fruto de atrasos administrativos do programa PT2020.

Tendo em conta que o PT2020 apresenta-se como um instrumento político e económico relevante para promover o crescimento socioeconómico de Portugal, esses atrasos administrativos têm um impacto direto no desenvolvimento normal do país, uma vez que diversos investimentos de entidades públicas e privadas têm sido adiados por longos períodos. Em alguns casos específicos, verificam-se atrasos superiores a sete meses após a data de divulgação dos resultados das propostas. Neste contexto, torna-se muito difícil estimar e planejar os resultados esperados de uma organização, face a estes longos períodos de tempo que têm impactos em mais do que um ano fiscal.

Esta situação influenciou igualmente o desempenho da Fraunhofer Portugal, afetando o nosso indicador de desempenho (Rho), reduzindo-o face ao plano definido, o qual poderia muito provavelmente ter sido alcançado, num cenário em que iniciávamos projetos para os nossos clientes, tal como tínhamos planeado. É provável que em 2017 este indicador volte a subir para valores acima dos 60% devido à acumulação da receita esperada a ser contabilizada em 2017. Este resultado encontra-se em conformidade com o desempenho alcançado e equilibrado com os resultados, que caracterizaram o desempenho da organização nos últimos dois anos. No final de 2016, o volume total de negócios situou-se nos 3,1M€, o que representa um decréscimo de 5% face ao ano anterior.

Todavia, a evolução das Receitas da Indústria e da UE mostram-se positivas em 2016, e, no caso da primeira, o FhP-AICOS atingiu uma taxa de crescimento de 42%. A maioria do crescimento dos projetos da indústria em carteira deve-se aos projetos do PT2020, que foram submetidos entre meados de 2015 e início de 2016 e que foram aprovados para financiamento, conduzindo a seis novos projetos da indústria, contratados ao longo do ano e representando cinco novos clientes na área da indústria. Além destes contratos apoiados pelo financiamento do PT2020, o FhP-AICOS também fechou mais dois contratos diretos da indústria de clientes estrangeiros. Igualmente durante o ano de 2016, a nossa organização participou ativamente na negociação de um projeto individual PT2020 com uma empresa de grande dimensão. Um outro projeto que a organização vai começar a desenvolver é o SV4D – Sustainable Villages for Development, conceito que o FhP-AICOS está a desenvolver com a Associação de Reguladores de Comunicações e Telecomunicações da Comunidade dos Países de Língua Portuguesa – ARCTEL-CPLP há cerca de dois anos e que está finalmente a ser contratado para implementação na região Norte de Moçambique, mais precisamente na região da Zambézia. Esta região tem uma área de 103 478 km² e uma população de aproximadamente quatro milhões de pessoas. Em termos da tecnologia de comunicações de rede, que está a ser utilizada neste último projeto, existe um envolvimento da Fraunhofer FIT no fornecimento da tecnologia WiBACK para construir a infraestrutura de comunicações de baixo custo associada ao projeto.

Em termos de projetos da UE, em 2016, o FhP-AICOS elaborou duas propostas, que foram submetidos ao AAL Joint Programme em 2015: o CordonGris e o Active@Home. Estes projetos contribuíram para o crescimento de 20% das receitas da UE em 2016.

Durante o ano, a equipa FhP-AICOS manteve-se bastante ativa na apresentação de propostas, aproximadamente 4,4M € e, no final de 2016, o Backlog total das propostas foi estimado em 2,5M€. As expectativas atuais em termos de realização de contratos de R&D, provenientes destas propostas, apresentam resultados bastante positivos e com probabilidade de se assinarem contratos de grande dimensão nos próximos anos. Na realidade, um dos aspetos positivos relacionados com as propostas apresentadas para financiamento no programa PT2020 em 2015 e 2016 baseia-se nas elevadas taxas de sucesso alcançadas. Tendo em conta os diferentes concursos e os diferentes tipos de propostas apresentadas pelo FhP-AICOS como coordenador, em parcerias coordenadas por clientes da indústria ou em projetos individuais apresentados pelas empresas (em que a organização foi subcontratada), as taxas de aprovação ultrapassam os 50%, o que revelou ser um sinal muito positivo da qualidade das propostas submetidas para financiamento nos programas nacionais. Este resultado contrasta com as baixas taxas de sucesso associadas ao anterior programa QREN.

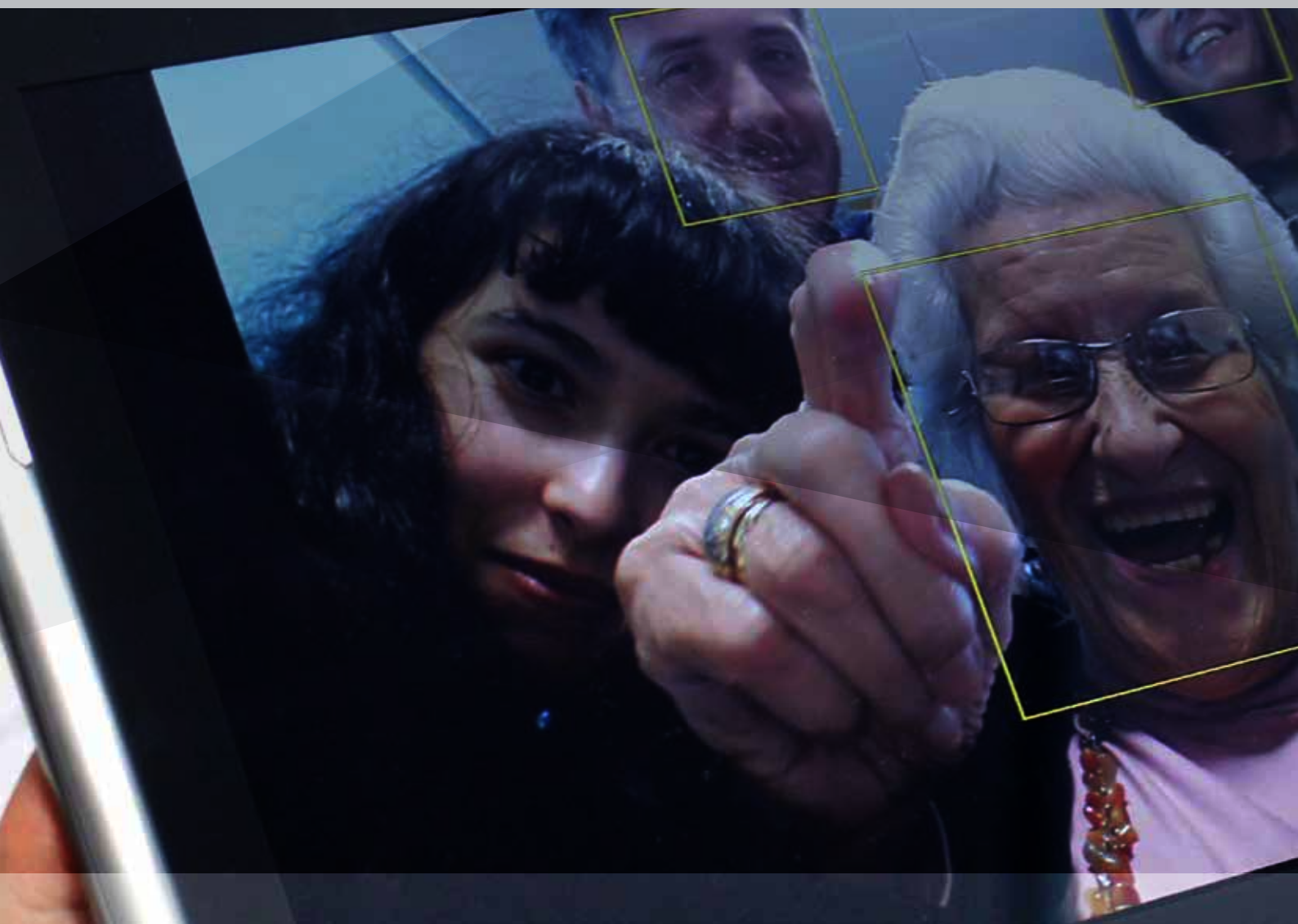
Ao longo do ano, o FhP-AICOS teve a oportunidade de conquistar diferentes prémios que foram motivo de orgulho e motivação da nossa equipa. Um dos resultados mais positivos alcançados foi um 2º lugar no concurso Microsoft Indoor Position, conquistado pelo sistema tecnológico Precise Indoor Location, que está a ser desenvolvido nos últimos três anos. Esse prémio chamou a atenção de importantes e potenciais clientes da indústria e gerou perspectivas promissoras de licenciamento para o FhP-AICOS. Ganhámos ainda dois outros prémios durante 2016: uma menção honrosa a uma tecnologia relacionada com dispositivo de baixo custo para detetar retinopatia diabética em estágios iniciais de desenvolvimento e um prémio de melhor cartaz, para uma publicação científica apresentada no EU Falls Festival.

Um dos resultados científicos de maior importância alcançado pela organização em 2016 baseia-se no fato de que a primeira patente FhP-AICOS ter sido concedida este ano! O título da patente é "Mobile Device and Infrastructure System" e visa a inovação coberta pela tecnologia Ultra-Low Frequency Magnetic Communication (ULF-MC), a qual foi criada pelo Diretor do FhP-AICOS, o Professor Doutor Dirk Elias.

Em 2016, recebemos visitas de convidados importantes, nomeadamente do Presidente da Fraunhofer Gesellschaft, o Professor Doutor Reimund Neugebauer, do Ministro da Ciência, Tecnologia e Ensino Superior de Portugal, o Professor Doutor Manuel Heitor, e do Ministro da Economia, o Professor Doutor Manuel Caldeira Cabral. Na visita do Professor Doutor Neugebauer, o FhP-AICOS teve a oportunidade de apresentar alguns dos seus resultados científicos e tecnológicos mais recentes, o que causou uma excelente impressão para a delegação visitante.

Por último, mas não menos importante, o ano de 2016 acabou por ser marcado como um ano de mudanças futuras, com a saída do Professor Doutor Dirk Elias, Diretor da FhP-AICOS, que orientou o desenvolvimento da organização desde os primeiros dias da sua criação. A história de sucesso da Fraunhofer Portugal nos últimos oito anos é marcada pela liderança e pelas criações inspiradoras do Professor Doutor Dirk Elias, responsável pelo planeamento e orientação do desenvolvimento da organização, em conjunto com uma brilhante equipa de pessoas, capazes de criar tecnologias visionárias e produzir resultados científicos com um elevado nível de excelência e reconhecidos pelos nossos pares. Esta mudança marcará o início de uma nova era para o desenvolvimento da Fraunhofer Portugal, sendo o desafio do futuro Diretor do FhP-AICOS acompanhar a excelência e os resultados científicos e tecnológicos da nossa organização.

Dirk Elias e Pedro Almeida





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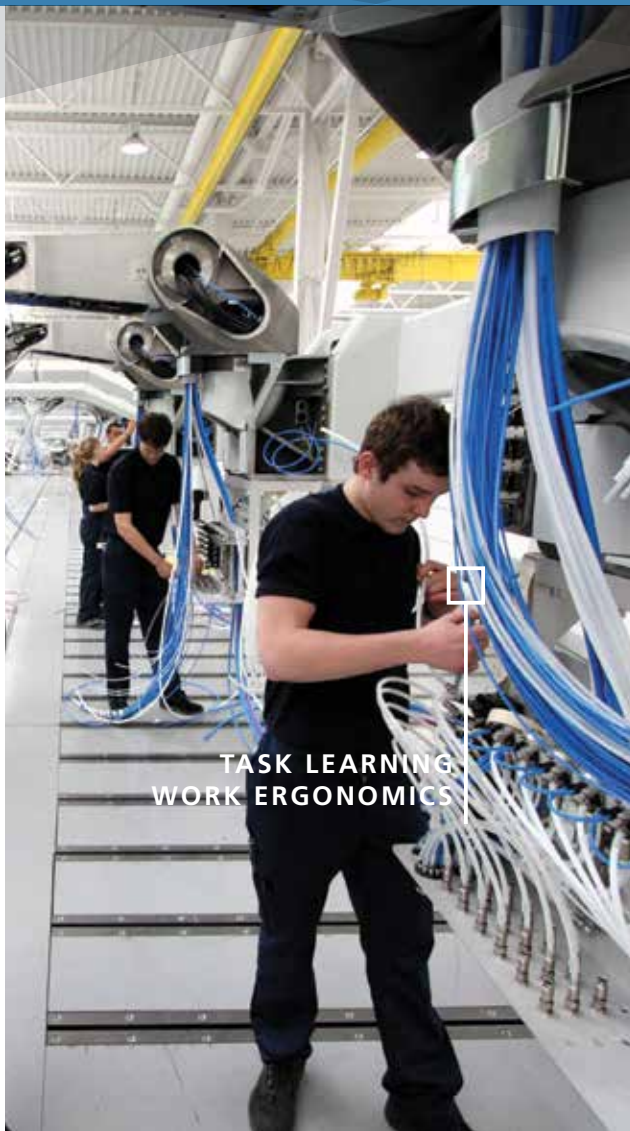
SERVICE

- 100 Location and Contacts

REPORT OF THE EXECUTIVE BOARD



ACTIVITY MONITORING
FALL DETECTION
SPORTS TRACKING



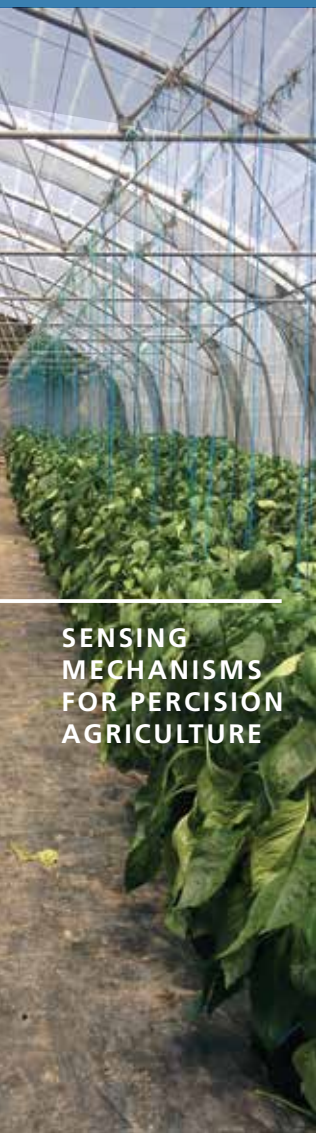
TASK LEARNING
WORK ERGONOMICS



GOVERNANCE & MANAGEMENT

OVERVIEW OF FRAUNHOFER PORTUGAL

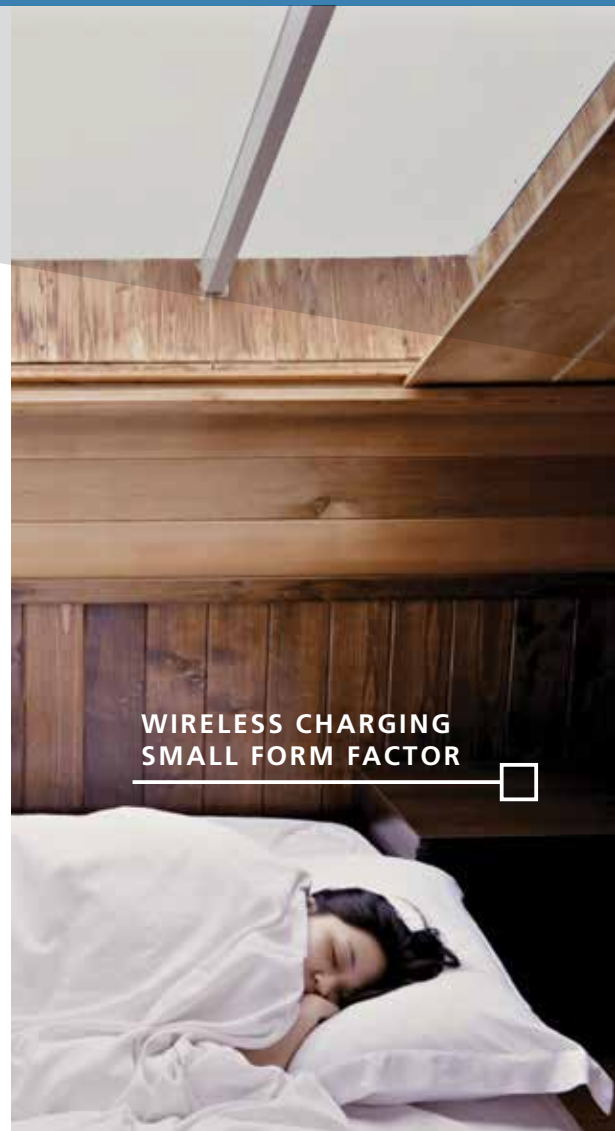
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SENSING
MECHANISMS
FOR PRECISION
AGRICULTURE



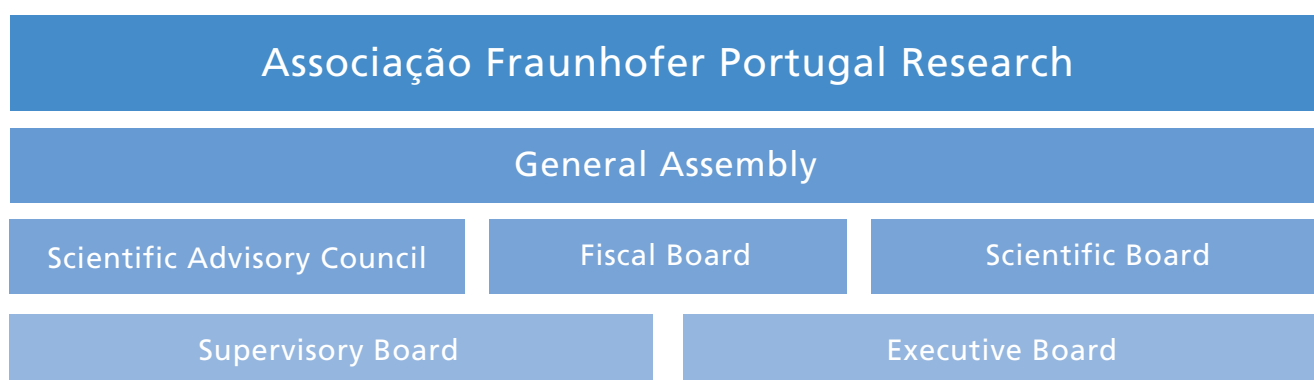
APPLIANCE CONTROL
USAGE MONITORING



WIRELESS CHARGING
SMALL FORM FACTOR

GOVERNANCE & MANAGEMENT

GOVERNANCE STRUCTURE



We seek to follow the best practices in every area of the Association's governance by reflecting such practices in our organization, principles and transparency.

The Associative Structure of Fraunhofer Portugal clearly distributes functions, duties and responsibilities among its board members.

Management

Fraunhofer Portugal management is a shared responsibility of both the Supervisory Board (with broad assessment powers) and the Executive Board (responsible for daily management and current management actions).

SUPERVISORY BOARD

President

Georg Rosenfeld

Member of the Executive Board

Fraunhofer-Gesellschaft

Vice-President

João Paulo Oliveira

Board of Directors

The Navigator Company

Member

Paulo Simões

Board of Directors

Sonae SR, SGPS, SA

Member

Manfred Hauswirth

Board of Directors

Fraunhofer FOKUS

Member

Steffen Schudt-Pialat

Board of Directors

Volkswagen Autoeuropa



EXECUTIVE BOARD

Dirk Elias 1

President of the
Executive Board

With a professional career ranging from R&D activities to entrepreneurial experiences and management, Dirk Elias is a Dipl. Ing. in Electrotechnical Engineering by the Technical University of Munich and holds a PhD from the Technical University of Berlin.

Functional Assignments: General Administration, R&D Planning, Business Development, Facilities.

Pedro Almeida 2

Executive Board Member

With a professional career that started with R&D activities through to the full innovation cycle with the creation of a spin-off of a prestigious University in Portugal, Pedro Almeida holds a MSc in Electronics and Telecommunications Engineering by the University of Aveiro and holds a post-graduation in Advanced Management for Executives also from the same university.

Functional Assignments: Business Development, Planning & Control, Accountancy & Finances, Human Resources, Legal, Facilities.

Berthold Butscher 3

Executive Board Member

With a career highly oriented towards R&D, both in industry and in R&D institutions, Berthold Butscher holds a Dipl. Ing. in Electrotechnical and Computer Engineering from the University of Applied Sciences of Konstanz and from the Technical University of Berlin.

Functional Assignments: R&D Planning Support.

OVERVIEW OF FRAUNHOFER PORTUGAL

Vision

A Driving Force in Innovation

Fraunhofer Portugal proposes a radical change regarding technological innovation in collaboration with scientific institutions in Portugal and aims at creating scientific knowledge capable of generating added value for its clients and partners, exploring technology innovations oriented towards economic growth, social well-being and the improvement of the quality of life of its end-users.

Mission

Research of Practical Utility

Fraunhofer Portugal promotes applied research of direct utility to private and public institutions and of broad benefit to society, by managing and coordinating the cooperation of its research centres with:

- Other Research Institutions – such as universities and other relevant Portuguese or non-Portuguese research institutions, as well as Fraunhofer Institutes and other research centres integrated in the Fraunhofer-Gesellschaft knowledge network;
- Industry Partners – clearly perceived and understood as our main customer group, we are developing partnerships and cooperation agreements with private and public enterprises, as well as participating in business associations;
- Supporting Partners – Government Institutions and other Institutional partners.

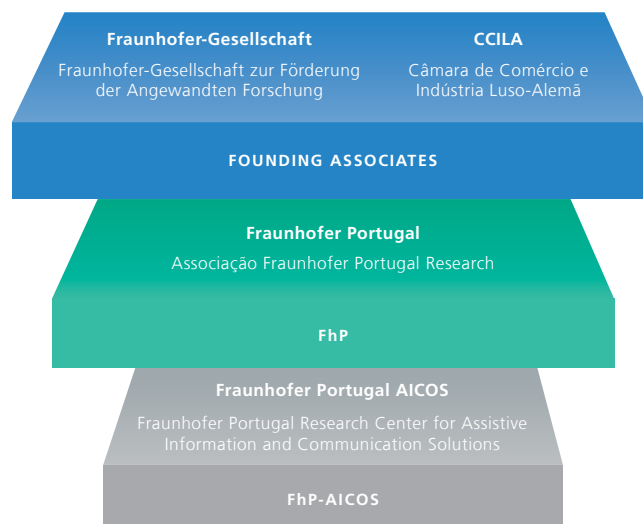
Funding Model

Fraunhofer-Gesellschaft and the Portuguese Foundation for Science and Technology (FCT) agreed on a tripartite funding model similar to the one used by Fraunhofer-Gesellschaft.

At Fraunhofer Portugal, our scientists and engineers work with a budget financed by external revenue (projects and licensing) and institutional funding provided by FCT and Fraunhofer-Gesellschaft.

The base line for this type of funding determines that it will be granted in progressively smaller amounts over the initial years, encouraging the implementation of an efficient business model mainly financed by external revenue.

External revenue should be guaranteed through research projects, development projects, contracts signed with third parties within Fraunhofer Portugal's fields of activity, intellectual property rights and licensing of the commercial optimization of products and services resulting from Fraunhofer Portugal's R&D results.



Fraunhofer-Gesellschaft

Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Founded in 1949, the research organization undertakes applied research that drives economic development and serves the wider benefit of society. Its services are solicited by customers and contractual partners in industry, the service sector and public administration.

At present, the Fraunhofer-Gesellschaft maintains 69 institutes and research units. The majority of the nearly 24,500 staff are qualified scientists and engineers, who work with an annual research budget of more than 2.1 billion euros. Of this sum, more than 1.9 billion euros is generated through contract research. More than 70% of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Almost 30% is contributed by the German federal and Länder governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

International collaborations with excellent research partners and innovative companies around the world ensure direct access to regions of the greatest importance to present and future scientific progress and economic development.

With its clearly defined mission of application-oriented research and its focus on key technologies of relevance to the future, the Fraunhofer-Gesellschaft plays a prominent role in the German and European innovation process. Applied research has a knock-on effect that extends beyond the direct benefits perceived by the customer: through their research and development work, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their

local region and throughout Germany and Europe. They do so by promoting innovation, strengthening the technological base, improving the acceptance of new technologies and helping to train the urgently needed future generation of scientists and engineers.

As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop the professional and personal skills that will allow them to take up positions of responsibility within their institute, at universities, in industry and in society. Students who choose to work on projects at the Fraunhofer Institutes have excellent prospects of starting and developing a career in industry by virtue of the practical training and experience they have acquired.

The Fraunhofer-Gesellschaft is a recognized non-profit organization that takes its name from Joseph von Fraunhofer (1787–1826), the illustrious Munich researcher, inventor and entrepreneur.

German-Portuguese Chamber for Industry and Commerce (CCILA)

With over 1.000 associates in Portugal and Germany, the objective of the Chamber is to enhance and promote the economic relationships between the two countries.

Associação Fraunhofer Portugal Research

Founded in 2008 – within the framework of a long-term Portuguese-German collaboration in Science and Technology – Associação Fraunhofer Portugal Research (Fraunhofer Portugal) promotes applied research that drives and encourages economic development and serves the wider well-being of society. The Association's services are sought out by customers and contractual partners in industry, the service sector and public administration.

Currently, Fraunhofer Portugal owns and operates the Fraunhofer Portugal Research Center for Assistive Information and Communication Solutions (Fraunhofer Portugal AICOS) – a partnership between Fraunhofer-Gesellschaft, Fraunhofer Portugal and the University of Porto – focusing on Ambient Assisted Living (AAL) and Information and Communication Technologies for Development (ICT4D).

Fraunhofer Portugal's development strategy accommodates the option to establish additional research units whenever a sustained demand for R&D services applied to a specific area of scientific knowledge is detected in the market.

Services

Fraunhofer Portugal's Research Services, rendered through the research institutions it operates, provides three different types of collaboration to industrial customers, also provided within public funded project participations:

- R&D Contract;
- R&D Consulting;
- Living Labs.

Fraunhofer Portugal is committed to building a reputation of excellence within different service dimensions such as knowledge, credibility, professionalism, creativity, flexibility, response time and cost.

Fraunhofer Portugal AICOS

Fraunhofer Portugal Research Center for Assistive Information and Communication Solutions

Incorporated as a partnership between Fraunhofer-Gesellschaft and the University of Porto and focusing its activity on Ambient Assisted Living (AAL) and Information and Communication Technologies for Development (ICT4D), Fraunhofer Portugal AICOS (FhP-AICOS) is the first research institution operated by Fraunhofer Portugal.

Extending the Reach of the Information and Knowledge Society

FhP-AICOS aims to enhance people's living standards by offering intuitive and useful technology solutions, capable of facilitating their access to the Information and Communication Technologies, and in this way assisting in the integration of an increasingly larger sector of the population in the Information and Knowledge Society.

Remarkable Technology, Easy to Use

FhP-AICOS' mission is to generate Remarkable Technology, Easy to Use. This means offering specialised competences centred on the improvement of end-user experience and usability of applications, generating applied research solutions capable of contributing to the market success of our client's products and services.

Collaboration plays an essential role in enabling the research centre to fulfil its mission. Therefore, FhP-AICOS strongly promotes and consolidates partnerships and cooperation with key players and decision makers in its strategic research areas, namely:



- *Association européenne pour la maladie de Parkinson* (Belgium): charitable organisation that brings together several national Parkinson organisations from Europe. Collectively, these organizations have more than 250.000 members in 36 countries and advocate for the rights and needs of more than 1.2 million people with Parkinson's and their families;
- *Centro de Excelência em Desmaterialização de Transações* (Portugal): leading entity that coordinates a network of knowledge and competences in the dematerialization of transactions in Portugal;
- *Centro de Investigação e Tecnologias Agroambientais e Biológicas* (Portugal): focused on the agro-food and forestry systems, it is composed of a multidisciplinary team with expertise ranging from fundamental sciences such as biology and chemistry to agronomists, forestry engineers and ecologists, with scientific experts in the fields of mathematics, physics, technological engineering and engineers, applied in the areas of: Eointegrity, Sustainable Agro-food Chains and Biosystems;
- *Centro de Reabilitação Profissional de Gaia* (Portugal): an association focused on the rehabilitation of people affected by accidents or diseases, which also assists young people with disabilities in their transition from school into an active life;
- *Charité – Universitätsmedizin Berlin* (Germany): with more than 300 years old, it is one of the largest university hospitals in Europe. At the university, approximately 3.700 doctors and scientists heal, do research and teach at the top international level. More than half of the German Nobel Prize winners in medicine and physiology come from the Charité, among them are Emil von Behring, Robert Koch and Paul Ehrlich;
- *Deutsche Sporthochschule Köln* (Germany): the only university in Germany dedicated exclusively to the field of sport and exercise science, which is studied in detail at 21 institutes, four affiliate institutes and nine academic centres;
- *Eidgenössische Technische Hochschule Zürich – Departement Gesundheitswissenschaften und Technologie* (Switzerland): one of the world's top 50 institutions, aims at creating a vibrant intellectual community where students and scholars join together in building the future, by committing to diversifying its student body and faculty, fostering global exchange, and promoting path-breaking research in all fields of knowledge;
- *Escola Superior de Tecnologia da Saúde de Coimbra* (Portugal): a centre of creation, transmission and dissemination of science, technology and culture, it holds as its mission the intervention and development at the levels of graduate and postgraduate education and research in health sciences and related areas, as well as the service to community and cooperation with national and international organizations in common interest activities and society in general;



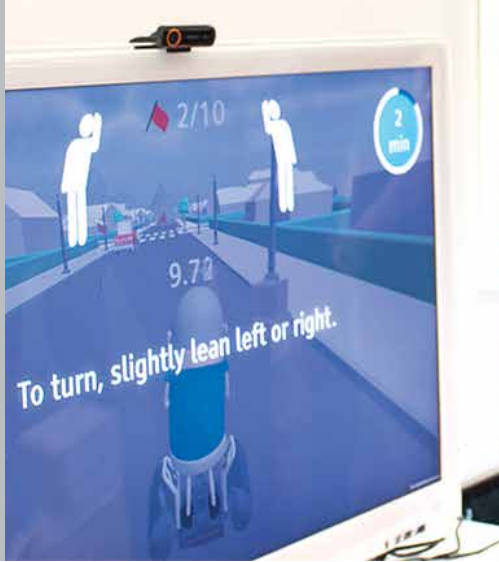
- *Eurecat – Centre Tecnològic de Catalunya* (Spain): the major Technology Centre of Catalonia, aiming its services at all business sectors with special focus on seven key strategic areas: Food, Energy and Resources, Industrial Systems, Design-based Industries, Industries related to sustainable mobility, Health Industries and cultural, experience-based Industries;
- *Faculdade de Economia da Universidade do Porto* (Portugal): with a long and prestigious history in the teaching of Economics and Management in Portugal, it is considered the best Portuguese University according to most international rankings;
- *Faculdade de Engenharia da Universidade do Porto* (Portugal): a top-level faculty that awards degrees in several engineering fields, such as, computer engineering, mechanical engineering, chemical engineering, etc.;
- *Faculdade de Medicina da Universidade do Porto* (Portugal): well renowned faculty that promotes teaching and provides scientific research of excellence and medical support activities to the community;
- *Fraunhofer FOKUS* (Germany): Fraunhofer Institute, based in Berlin, operates closely in related scientific fields, in this way pooling expertise in interdisciplinary collaborative projects as well as facilitating FhP-AICOS' seamless integration with Fraunhofer-Gesellschaft in different institutional aspects;
- *Fraunhofer IDMT* (Germany): Fraunhofer Institute focused on developing cutting-edge solutions in the digital media domain, consistently designed to meet user requirements and expectations;
- *Health Cluster Portugal* (Portugal): organization which focuses on the promotion and implementation of initiatives and activities leading to the creation of an innovative and technology-based national cluster;
- *Instituto de Biomecánica de Valencia* (Spain): is a technological centre that studies the behaviour of the human body and its interaction with products, environments and services, aiming to improve competitiveness among the business sector, by promoting people's well-being through the combination of knowledge in areas such as: Biomechanics, Ergonomics and Emotional Engineering, and its application to diverse sectors;
- *Instituto Nacional de Saúde Dr. Ricardo Jorge* (Portugal): public organization of the Ministry of Health, endowed with scientific, technical, administrative, financial and property of its own, that plays a triple role as State Laboratory in the Health Sector, National Reference Laboratory and National Health Observatory;
- *Instituto Português de Oncologia* (Portugal): the largest national institution dedicated to the research, diagnosis, treatment, prevention, study and teaching of areas within the domain of oncologic diseases;



- *Instituto Universitário de Lisboa* (Portugal): a public university that pursues teaching, research and community service activities, in areas such as, business, sociology, public policy, social sciences, technology and architecture;
- *Istituto Superiore Mario Boella sulle Tecnologie dell'Informazione e delle Telecomunicazioni* (Italy): is a research and innovation centre operating in the Information and Communication Technologies domain, playing an active role in devising innovative solutions on research areas such as: Advanced Computing, Mobile Solutions and Pervasive Technologies (Internet of Things);
- *KempenLIFE* (Netherlands): a cooperative established by and for older citizens living in the rural Kempen area, Netherlands. It aims to organise new services for comfort, welfare and care, making use of ICT and broadband internet, and collaborating with hospitals and care organisations in the field of eHealth to increase independent living and quality of life for its members;
- *Loughborough University* (United Kingdom): a UK top 15 University with an international reputation for excellence in teaching, research and sport, producing research that matters, with strong links with industry, commerce and the professions, in areas such as: Computer Science; Electronic, Electrical and Systems Engineering; Sport, Exercise and Health Sciences;
- *Nelson Mandela Metropolitan University* (South Africa): a dynamic African university offering professional and vocational training for leadership in generating cutting-edge knowledge for a sustainable future, specialised in the scientific fields of Health, Engineering, Business & Economics and Law;
- *Parque de Ciência e Tecnologia da Universidade do Porto* (Portugal): official Science and Technology Park of the University of Porto that fosters the creation of technology-based companies and the establishment of national and international private R&D centres, supporting an effective knowledge and technology transfer between academia and the market;
- *Santa Casa da Misericórdia de Lisboa* (Portugal): is the Portuguese largest private organization that pursues in a humanitarian way, objectives of social action, provision of health care, education and culture, and the promotion of the quality of life, particularly for the benefit of those in greater need of protection, with a special focus in the development of social work in the areas of: childhood, youth, family & community and elderly;
- *Seniornett Norge* (Norway): a non-governmental organization working for the inclusion of elderly people in the 'e'-world (PC, internet, social media, etc.), in cooperation with the Norwegian Government, Microsoft (Gates Foundation), several non-profit organizations and telecom companies. It has established 200 training centres all over Norway, where senior citizens can go for training, meet peers, ask questions and socialize;



- *Seoul National University* (Republic of Korea): one of the world's top 50 institutions, aims at creating a vibrant intellectual community where students and scholars join together in building the future, by committing to diversifying its student body and faculty, fostering global exchange and promoting path-breaking research in all fields of knowledge;
- *Tohoku University – Institute of Development, Aging and Cancer* (Japan): is a Usage/Research Centre for Aging Research affiliated with Japanese universities that promote aging sciences and aims to clarify basic mechanisms of aging, as well as to control age-related diseases, such as dementia and intractable cancers;
- *Universidade de Trás-os-Montes e Alto Douro* (Portugal): a recognized reference in the Portuguese university system, focuses on high quality Teaching, Research and Community Outreach, striving to be a Centre of Excellence for lifelong learning and for the creation, transmission and dissemination of culture, science and technology, in areas such as: Agricultural & Veterinary Sciences, Human & Social Sciences, Science & Technology and Sciences & Environment;
- *Universidade do Porto* (Portugal): our primary and distinguished university partner offering access to university know-how and infrastructures, as well as privileged contact with students interested in enrolling in advanced training at FhP-AICOS labs. We have closer cooperation with some of its faculties, namely the ones described above;
- *Universidade Eduardo Mondlane* (Mozambique): the oldest and largest university in Mozambique which focuses on producing and disseminating scientific knowledge, as well as promoting innovation through research, educating generations to face challenges to benefit society's development, namely in the scientific fields of Biology, Agronomy, Engineering, Human Sciences and Linguistics;
- *Università degli Studi di Torino* (Italy): one of the most ancient and prestigious Italian universities, aims at promoting culture and producing research, innovation, training and employment, by covering several fields of knowledge. Its Medical Diagnostic, Biosensor and Nanotechnologies research centres are amongst the best ones in Italy;
- *Universitat Politècnica de Catalunya* (Spain): a public institution dedicated to higher education and research, specialised in the fields of engineering, architecture and science;
- *Universität Siegen* (Germany): a modern, high-profile university with an international orientation guided by the central principle 'creating a humane future', by offering a variety of degree programmes in areas such as: Communications Technology, Computer Science Technology, Human-Computer Interaction, Information Systems, Microsystem Technology and Visual Computing;
- *University of Limerick* (Ireland): distinctive, pioneering and connected university that undertakes world-class research and delivers innovative teaching in the fields of Science and Engineering;



- *University of the Sunshine Coast (Australia):* is one of Australia's newest and fastest growing universities, offering more than 100 undergraduate and postgraduate study programmes in Business & Information Technology; Communication and Design; Education; Health; Humanities and Social Sciences; and Science and Engineering.

Strategic Research Agenda

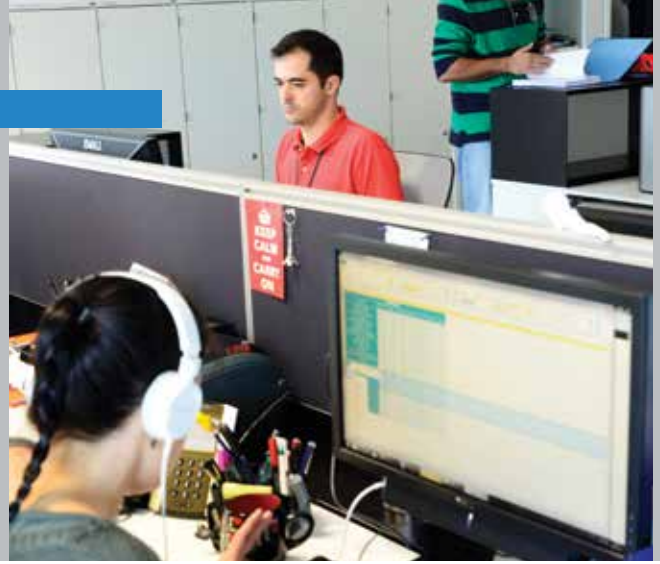
FhP-AICOS constitutes a new approach to Information and Communication Technologies through Fraunhofer-Gesellschaft and contributes to the creation and development of competences in activities of great relevance for the future, addressing two main business fields: Ambient Assisted Living (AAL) and the emerging field of Information and Communication Technologies for Development (ICT4D).

- AAL includes methods, concepts, (electronic) systems, devices and services that are providing unobtrusive support for daily life, based on the context and the situation of the assisted person. The technologies applied for AAL are user-centric, i.e. oriented towards the needs and capabilities of the actual user. They are also integrated into the immediate personal environment of the user. Consequently, the technology is adapted to the user rather than the other way around. In order to share relevant information between systems and services, technologies for AAL should ideally be based on modular and interoperable concepts.

FhP-AICOS intends to mainly address the needs of the ageing population, to reduce innovation barriers of forthcoming promising markets, but also to lower future social security and healthcare costs. This goal can be achieved through the use of intelligent products and the provision of remote services, including care services that extend the period during which senior citizens can live in their home environment. The services envisioned and developed by Fraunhofer will increase the individual's autonomy and assist them in carrying out their daily activities.

- ICT4D is a general term which refers to the application of Information and Communication Technologies (ICT) within the field of socioeconomic development or international development. ICT4D focuses on the direct application of information technology approaches to contribute to poverty reduction and to reduce the digital divide.

FhP-AICOS currently intends to focus its ICT4D activities on the African continent, with special emphasis on Mozambique and Angola. The primary target user group will be ICT users in rural and developing areas, and the objective is to provide solutions for mobile device services and applications which meet the local users' demands, contributing to a more positive user experience which, in many cases, may be their first contact with ICT.



Among the significant diversity of topics related to AAL and ICT4D, FhP-AICOS focuses on a reduced set of business sub-fields that our customers consider relevant and that are directly related to our core competences.

In the AAL business field, FhP-AICOS currently covers the following sub-fields:

- Fall and Activity Monitoring;
- Chronic Diseases and Well-Being Management;
- Assistive Environments.

With regards to the emerging ICT4D business field, one sub-field has currently been defined:

- ICT4D on Mobile Devices.

Additionally, FhP-AICOS supports the creation of scientific knowledge capital in three key areas that define the Center's core competences developed to date:

- Human-Computer Interaction (HCI): focusing on User & Social Experience, Mobile & Future Devices and Evaluation & Usability;
- Information Processing (IP): focusing on Content Retrieval, Context Awareness, and Multimodal Information Fusion;
- Autonomic Computing (AC): focusing on Remote Management, Control and Configuration.

MANAGEMENT REPORT 2016

Summary of Key Figures

	2016	2016 (Budget)
Total Budget	3.107.663 €	3.590.000 €
Staff Costs	2.095.344 €	2.310.000 €
Non Personnel Costs	635.364 €	730.000 €
Industry Revenues	641.486 €	860.000 €
Public Revenues & Others	802.900 €	1.040.000 €
Base Funding	1.663.277 €	1.690.000 €
FTE (Full Time Equivalent)	57,4	58,2



Economic and Political Background

- Positive economic environment with annual DGP growth of 1,2%.
- Commitment of the Portuguese Government to support scientific activities.
- Participation of Fraunhofer Portugal in the implementation of 'Centro e Interfaces Tecnológicos' and 'Laboratórios Colaborativos'.

According to the Economic Bulletin issued in December 2016 by Banco de Portugal, the Portuguese economy is expected to continue on the moderate recovery path of the most recent years during a projection horizon of 2016–2019. Current projections indicate that the annual GDP growth in 2016 shall be circa 1,2%, growing to 1,4% in 2017 and stabilizing in 2018 and 2019 with a GDP growth of 1,5%.

The export of goods and services continued to grow more than external demand during 2016 having the overall demand component the highest contribution to activity growth. The domestic demand increased along the year after parts of the taxes associated with the austerity imposed by the financial assistance programme had been relived. These features were consistent with a more sustained growth pattern and in tandem with the recovery of economic activity, as there was a gradual improvement of the labour market situation, which led to a decrease of the unemployment rate to 10,5%, the lowest level since the last quarter of 2009. In terms of the employed ICT specialists when compared with the total employment, Portugal continues with a rate on a dimension of 2,3% which is still below the average of the European Union (28 countries) of 3,5%.

Within the Portugal 2020 (PT2020) framework support programme, a special focus has been given to the promotion of investment through the opening of new calls and the implementation of measures to accelerate the investment. According to the last report of the Agência para o Desenvolvimento e Coesão, I.P.¹, published in September 2016, approximately half of the funding planned for PT2020 was already published in more than one thousand calls that opened until the end of the third quarter of 2016. Within this period, the total investment financed by PT2020 was 12,6B€, being approved 7,9B€ of funding, corresponding to an average funding of 68% over the eligible investment, 11,6B€. The domain related to the competitiveness and internationalization continued to register the highest value, 3B€, having increased 28% during the third quarter of 2016.

At the political level, the policies being adopted by the Minister of Science, Technology and Higher Education, Professor Manuel Heitor, denote a stronger commitment of the Portuguese Government to the support and financing of scientific activities and, naturally, the scientific institutions that host these activities. The political agenda during the last year was mainly focused on the promotion of the scientific knowledge, the stimulation of the scientific employment and fixation of highly qualified human resources and the engagement of private and public entities in innovation communities, which is clearly aligned with Fraunhofer Portugal's mission and has contributed to a growth of our engagement in partnerships with industry and other scientific organizations. A new approach of political concertation was also implemented, being regular the presence of the Minister of Science, Technology and Higher Education jointly with

¹ National agency responsible for the financial management of the PT2020 programme.



the Minister of Economy in events where the future strategy and financing of the scientific sector was being discussed, which denotes a positive relation between science and economy, benefiting therefore activities related with scientific knowledge and technology transfer.

One important change that occurred in the first quarter of 2016 was the appointment of the new Board of Directors of FCT – Fundação para a Ciência e Tecnologia. After an audition that involved the scientific and higher education communities, and involved also the creation of a Reflexion Group, the following names were appointed: Paulo Ferrão as President, Miguel Castanho as Vice-President and Isabel Ribeiro and Ana Sanchez as Board Members. Paulo Ferrão had been the director of the MIT-Portugal programme since 2006 and naturally is well acquainted with the international partnerships and the importance that they have in the development of the national scientific system.

By the end of 2016 a survey was published to identify and characterize the Network of National Technological Infrastructures, within the framework of the mapping process of the existing network. This process consisted in identifying and describing the existing entities that are part of the national scientific system that qualify as 'Centros e Interfaces Tecnológicos' or 'Infraestruturas de Acolhimento e Valorização de Atividades de C&T'², as well as characterizing the priority financing needs associated with the new and existing technological infrastructures. Fraunhofer Portugal qualifies for the first category, 'Centros e Interfaces Tecnológicos', and this survey was completed in order to have a formal recognition of this statute. The indications received during this process were that part of the future financing programmes will only be available to organizations that participated in this survey.

Another initiative that started to be discussed by the end of 2016 was the creation of 'Laboratórios Colaborativos' which intend to reverse the trend of the last years, where there was a decline of public and private investment in Research and Development (R&D) activities, and to stimulate the cooperation of companies with scientific institutions and higher education through autonomous collaborative strategies to develop research agendas and mobilizing programmes, duly agreed with the industry stockholders. Within the scope of this initiative, the name of Fraunhofer Portugal was included in the 'Plano Nacional de Coesão', published on November 24th 2016, as one of the main promoters for the creation of a Collaborative Laboratory in Precision Agriculture, which aims to support the development of skills in precision agriculture in different territorial contexts, through the support of research activities, in close coordination with industry partners.

Business Evolution

- Increase of the total Backlog Volume for period 2016–2018.
- Success in PT2020 project proposals above 50%.
- Decrease in total Business Volume due to administrative delays in PT2020.

During the year of 2016 the Business Evolution of Fraunhofer Portugal was generally positive, although a set of different external events lead to a situation where the organization was unable to maintain its growth path.

² *Types of scientific organization that are developing activities related with technology and knowledge transfer.*



Most of the successes attained along the year were directly related to positive outcomes achieved with the first rounds of submission of PT2020 project proposals, which started in July 2015, that lead to a positive impact on Fraunhofer Portugal's operation and contributed to a significant increase of the total project's Backlog volume for the period 2016–2018.

Looking at the results of 2016, the business evolution of the organization reflects a deviation from the plan due to the impact of several external factors, the main reason being associated with this effect the transition from the QREN framework programme to PT2020.

While until the second semester of 2015 Fraunhofer Portugal still had a significant number of scientific projects being financed by the QREN programme, which had an important contribution to the results at year end, the gap between contracted projects and projects to be contracted at the beginning of 2016 raised to unprecedented levels due to the transition of the framework support programmes, which increased significantly the challenge to continue the growth path along the year of 2016. At the beginning of 2016, the initial enthusiasm that motivated and encouraged Fraunhofer Portugal's team to achieve better results than last year, 2015, was partially based on the configuration of the calendared PT2020 programme calls, which unfortunately suffered several delays and seriously conditioned the availability to meet the challenging goals.

Nevertheless, positive facts could also be observed during the year, namely the increase of 42% of Industry revenues, which evidences that Fraunhofer Portugal enhanced its capacity to transfer technology to Industry clients and that the scientific results produced by the research team remain appealing to the socioeconomic ecosystem.

Business Development

During 2016, Fraunhofer Portugal's operational results have been consolidating after a period of uncertainty due to the transition of the QREN programme to the PT2020 programme, the initial perspectives being that the results at year end would be encouraging due to the high volume of proposals that were prepared and submitted along the year.

One important factor that became evident in 2016 was that the success rates in PT2020 project proposals were raised to a level above 50%. This result is enthusiastic as it reveals a positive scenario for future expectations of PT2020 proposals. Also relevant is that this result indicates that there is an increased investment of Portuguese SMEs in R&D and innovation, and simultaneously it indicates a growing interest from national industry clients on the results of applied research projects developed by FhP-AICOS.

The first positive news associated with Industry contracts were received during the first quarter of 2016 with the approval of two individual projects, submitted by Portuguese companies to PT2020 funding, where FhP-AICOS was subcontracted to implement part of the expected results of the projects. In these cases, the success rate of approval of proposals was 100% as Fraunhofer Portugal participation was only associated with these two proposals. Notwithstanding, it's important to mention that at national level the competition for this type of funding was intensive and the overall approval rates were on a much smaller dimension. Other positive aspect is that both projects are coordinated by new industry clients that were identified through New Business Development activities, which contributed to enlarge the base of Industry clients and to reduce the dependence of the organization of a limited number of existing clients.



Also in terms of Industry projects, the results of the PT2020 call that ended in March 2016, and whose results were announced in the beginning of August, brought positive news. From 6 project proposals submitted, FhP-AICOS received notifications of approval for funding of 4 proposals.

Regarding the SV4D – Sustainable Villages for Development project, during the first quarter of 2016 FhP-AICOS received two commitment letters, one from Guinea-Bissau and other from Mozambique. While in the first case, Guinea-Bissau, the political instability had impact in the expected development of the project (during the last one and a half year the Executive Board of the local regulator changed three times), in the second case, Mozambique, the outcome was positive.

No less important was the contribution of the existing clients of industry projects to the overall achievement of Industry revenues in 2016. The project ShopView2Market was practically concluded by the end of the year and the public demonstration of the results was performed in the beginning of 2017 with a significant success. Within the PT2020 framework support programme, this was the first PT2020 individual project that publicly presented its results, this achievement being important to promote the leadership position of Fraunhofer Portugal in terms of its capacity to support national industry in the accomplishment of challenging ICT projects.

Regarding National projects, the Deus ex Machina project was formally contracted in the first quarter of 2016 and the project implementation started during the same period. In terms of the contribution to the business volume for 2016, this project represented 100% of the amounts accounted as National Revenue in the year.

Within the same line of revenues, a project proposal was submitted in April 2016 for the development of a technology and scientific knowledge transfer initiative: Collective Transfer FhP. This proposal aimed to strengthen the initiatives capacity of FhP-AICOS to licence its technologies and to promote a stronger relation with industry clients, and other institutional organizations, that have potential to use technologies and know-how developed in the two business areas that FhP-AICOS actively develops: AAL – Ambient Assisted Living and ICT4D – Information and Communication Technologies for Development. In terms of activities, this project comprises a large set of dissemination actions in Europe and Sub-Saharan Africa and the involvement of some members of the R&D team in the development of pilot projects with specific application for a set of selected technologies of FhP-AICOS. The proposed activities for this project include:

- Initiatives related to interaction and scientific knowledge transfer, with a view to economic recovery including network activities, national and international promotion, with the completion of the contest 'Fraunhofer Challenge' and a new initiative called 'Fraunhofer Collective Transfer Day';
- Dissemination actions and dissemination of new knowledge and technology generated within the R&D activities of the FhP-AICOS, located in Porto, for the national and international business community, involving sectoral actions of experimentation and construction projects pilot demonstrators in the areas of 'Information and Communication Technologies for Development' (ICT4D) and also in the area of assistive technology to Assisted Living for Intelligent Environments, the 'Ambient Assisted Living' (AAL).



Still in this line of National Revenues, another delay that had impact in the estimations initially envisaged for 2016 was related to the Mobilizer projects call. By the time the Budget for 2016 was being prepared, in October 2015, the existing calendar of PT2020 calls indicated that the call for Mobilizer projects would open in the last quarter of 2015. Not only the call did not open during that time period, but it was also delayed to the second semester of 2016, which in practical terms reduced to zero the possibility to account revenues from these projects.

All combined, the effect of these delays had impact in the results of national projects in 2016, resulting in a lower Business Volume that was initially envisaged and expected at year end. As these external factors have a direct impact in all the scientific system in Portugal, such delays constitute real challenges for the management of scientific organizations that usually define their plans and human resources capacities aligned with expectations provided by both the calendar of calls and the formal dates indicated in the calls to announce the results of the proposals.

To provide a clear picture of the impact of these delays, by being able to account these results, Fraunhofer Portugal's overall business development would keep its growth track in line with the Business Volumes that were achieved in the last years, but due to these external reasons that are out of our control, this positive scenario did not occur in 2016.

Regarding future National projects, during the second semester of 2016 FhP-AICOS was actively engaged in negotiations with three different clusters at national level: National Portuguese ICT Cluster – TICE.PT, Health Cluster Portugal – HCP and the Textile Cluster. These negotiations were associated with the preparation and submission of three Mobilizer project proposals, one with each cluster, in the beginning

of October related to ICT, electronics, health and intelligent textiles for sport activities. Besides these proposals, another Mobilizer project proposal was prepared with the University of Trás-os-Montes e Alto Douro related to SmartFarming.

In terms of the evolution of European projects, in the beginning of 2016 Fraunhofer Portugal finalized the negotiations with Fundação para a Ciência e a Tecnologia (FCT) associated with two project proposal of the Active and Assisted Living Joint Programme (AAL JP) that were approved in 2015: Active@Home and CordonGris.

During 2016, FhP-AICOS was actively engaged in seven different European projects, but unfortunately one of them, the Clockwork project, continued to face significant delays due to problems in the consortium, which are still conditioning the full operational development of the project. Just a few months after the situation with the Italian partners had been solved, FhP-AICOS received the formal communication of a Portuguese partner, stating their decision to leave the consortium. As the activities performed by this partner had no possible replacement within the other entities of the consortium, FhP-AICOS, as coordinator of the project, identified other potential partners and an invitation was addressed to another company to participate in the project. The invitation was welcomed and the formal process was started to rearrange the consortium. Unfortunately, just after two months, the new company faced an internal reorganization and informed FhP-AICOS of its intention to leave the consortium, causing once again constraints in the execution of the project. Due to these administrative issues, the scientific development within this project was practically inexistent which led a small amount of revenues being accounted in 2016.



Also during the first semester of 2016, FhP-AICOS submitted two additional project proposals to the AAL JP, UnforgeTable and Fit4Seniors, FhP-AICOS being, in the first case, the coordinator of the project. Unfortunately, the final results were not exactly as expected due to the unfortunate situation that both proposals submitted were not approved for funding. One of the proposals, Fit4Seniors, was above the threshold defined for funding, but it was not granted due to the unavailability of budget in the local EU funding bodies for partners involved in the project.

Still at the operational level of European projects, FhP-AICOS faced difficulties in the implementation of the ACP Street Libraries project, as two of the African partners were unable to demonstrate the expenses they claimed in their activity reports. This situation caused some difficulties to attain the expected project indicators due to underfinancing of those partners, a factor that also caused constraints at the operational level as this funding would be required to maintain the planned activities of the project. Nevertheless, a set of workarounds, were put in practice to control the execution of the project until the beginning of 2017, date when the project operation was formally finished.

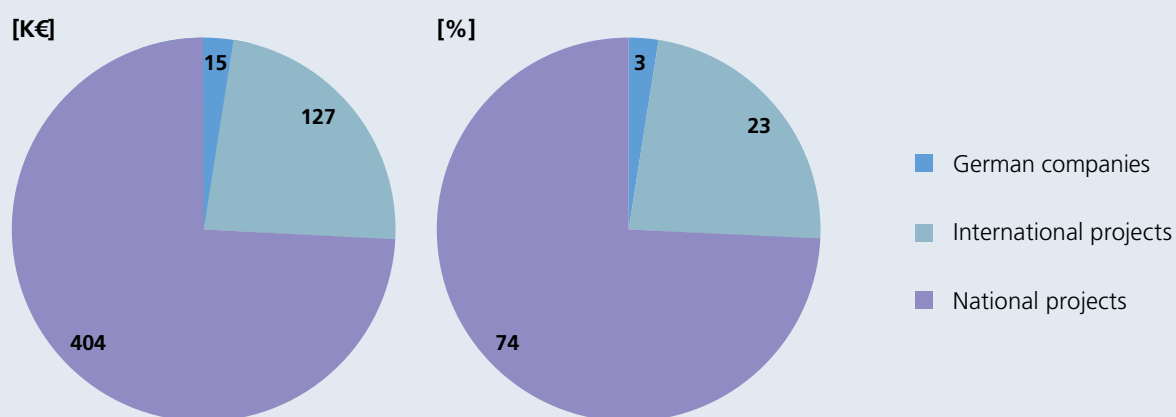
As a final balance, and contradicting with the not so positive evolution in both national and EU revenues, the evolution of revenues with Industry clients in 2016 contributed for positive outlooks and for the enthusiasm and motivation of FhP-AICOS' team, as this result is directly aligned with the primary goal of FhP-AICOS: transfer technology to industry clients. A significant part of this success is related to the strategy adopted by the New Business Development which

identified several clients at a national and international level and captivated their interest in developing activities with FhP-AICOS. In total, in 2016 the organization was able to start collaborating with seven new Industry clients, reflecting the interest of private companies in investing in the technologies and competences that exist in FhP-AICOS.

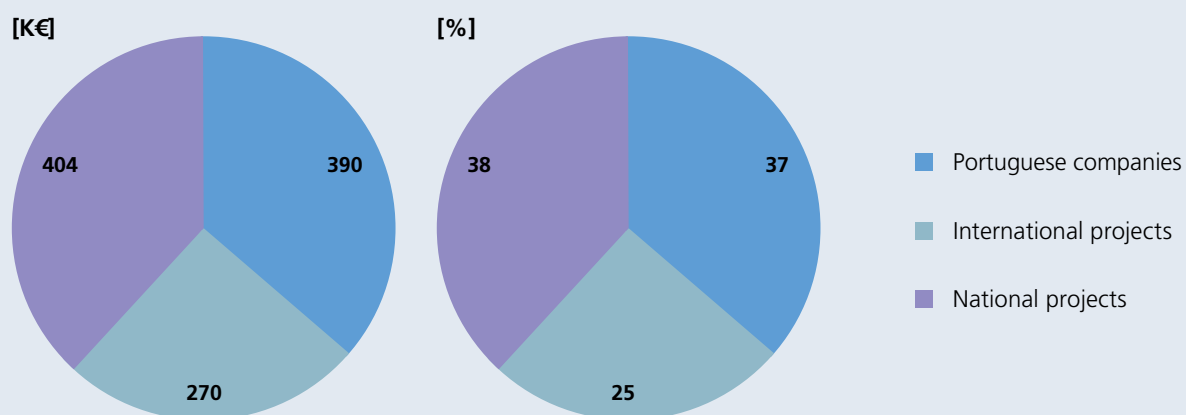
Another important KPI of FhP-AICOS activity is related to the involvement of German and Portuguese partners, either as contractors or partners, in the scientific projects of the organization. During the period of 2010–2016 we were able to generate 3,3M€ of revenues in projects that involve German partners and 4,8M€ of revenues in projects that involve Portuguese partners, which reveals our continuous and strong commitment to work together with German and Portuguese institutions and, in this way, to contribute towards strengthening the economic relationship between Portugal and Germany.

In 2016, we generated revenues of 127K€ with German institutions in international projects, 404K€ in national projects that include the participation of three Fraunhofer Institutes – Fraunhofer FOKUS, Fraunhofer IDMT and Fraunhofer IZFP – and 15K€ in projects for German Companies. In terms of revenues that involve Portuguese partners, in 2016 we generated 390K€ of revenues in projects that involve Portuguese companies, 404K€ of revenues in national R&D projects and 270K€ of revenues in international R&D projects that involve other Portuguese organizations.

Revenues Involving German Partners 2016



Revenues Involving Portuguese Partners 2016





Scientific Results & Corporate Development

- First patent awarded with 'Mobile Device and Infrastructure System'.
- Creation of mobile-based solution to pre-diagnose Diabetic Retinopathy.
- Professor Dirk Elias ceases functions as FhP-AICOS' Director and President of the Executive Board.

During 2016 FhP-AICOS attained a series of important scientific results that reveal an increase in the scientific developments of the organization and a higher interest of Industry clients in testing and evaluating the results of the scientific projects developed at FhP-AICOS.

One of the most important scientific outcomes that FhP-AICOS is proud to report is the fact that its first patent was granted this year, under the title 'Mobile Device and Infrastructure System'. The innovation that is covered by the patent is based on the Ultra-Low Frequency Magnetic Communication (ULF-MC) technology that was invented by Professor Dirk Elias.

This technology was the first step towards the current infrastructure of free indoor localization technological framework developed by Fraunhofer Portugal, within the Precise Indoor Location (PIL) project. With ULF-MC it is possible to create magnetic beacons that communicate via low frequency modulated magnetic fields with magnetic sensors, like Hall-Sensors, that can be found in practically any smartphone today. Using ULF-MC, small data packets can be sent to the phone when it is entering a modulated magnetic field which can contain important information, e.g., location ID to identify a room or a fixed position within a building. The key advantage of this technology when compared to

Radio Frequency (RF) beacons, like Bluetooth based beacons, is the easy to control dimension of the magnetic field. Thus it is possible to determine very precisely the position of the phone and it can even be used for mobile payment stations, or access control systems. The request of a patent was initially submitted in Germany in November of 2010 and internationally in November of 2011. In 2013, the request was translated to English and the patent was submitted in Europe and in the United States of America, having been granted in 2016. The attribution of the first patent to FhP-AICOS related to this technological framework, which started to be built five years ago, represented also a high stimulus for the scientific team in terms of the internal capacity to file patents. During that period four patent requests related to PIL were submitted. Having this first patent granted contributed with an important value for the organization, not only due to the economic value that might be associated with it in the future, but also due to the encouragement that effectively the scientific approach being used is unique and follows the requirements to be considered an invention patentable.

During all this period, of 2011–2016, FhP-AICOS continued to invest in the development of the indoor location technology mainly supported by funding of national scientific projects. A significant part of the existing scientific and technological knowledge related with indoor location started to be developed in the previous Fall Competence Center, which lasted between 2013–2015. With the approval of the project Deux ex Machina in 2016, this scientific topic continued to be developed and today it represents one of the most promising technologies being developed by FhP-AICOS. After the first participation in the Microsoft Indoor Location Competition, which was held on Seattle, United States, in April 2015, the scientific team worked intensively during the last year to improve the algorithms and associated indoor location technologies, envisaging the recognition by international



peers of the scientific quality of the results being achieved. In the 2016's edition of the same contest, which was held in Vienna, Austria, the results were extremely encouraging! In this global competition, FhP-AICOS' indoor location technological solution finished the competition as one of the most accurate solutions, having received the second place award. Naturally this excellent result attracted the attention of potential industry clients and during 2016 a set of contacts were established with different organizations, e.g., Microsoft, El Corte Inglés, SONAE, some of them having expressed an increased interest in trying our PIL technology in real environments for specific market applications.

Another technology that shows promising results concerns with the creation of a mobile application to detect diabetic retinopathy in early stages of development. Diabetic retinopathy is a complication of diabetes that affects the eyes. In the initial stages, it is generally asymptomatic. However, diabetic retinopathy is the leading cause of new blindness in persons aged 25–74 years in the United States. On early stages of retinopathy, the damage is limited to tiny bulges (microaneurysms) in the blood vessel walls of the retina, but visual loss due to diabetes can occur if the proper treatment for retinopathy is not provided in early stages. To protect the vision, one has to take prevention seriously by carefully controlling the blood sugar level and performing regular eye exams.

Based on this challenge, a mobile-based solution was created to provide an effective pre-diagnosis of diabetic retinopathy. On the latest generation of smartphones, which exhibits significant improvements in terms of image acquisition, portable adapters were mounted in the smartphone with built-in cameras to provide optical magnification required to reach the interior surface of the fundus of the eye (including

retina). After the image is acquired, an automated image processing algorithm is used to detect microaneurysms on early stages of diabetic retinopathy. When comparing FhP-AICOS approach with commercial solutions that address this same problem, important advantages can be identified. The commercial devices cost dozens of thousands of euros and have limitations in terms of portability of the associated equipment, while in the case of the approach created by FhP-AICOS the cost of the equipment its reduced to a couple of thousand euros and the portability is ensured due to the usage of a smartphone that replaces the usual computers that have to process the images acquired.

Due to the innovative approach adopted by FhP-AICOS scientific team, plus the economic added value and benefit to society, this project received an honourable mention as one of the best national technologies in a national event organized by Exame Informática, the most relevant ICT magazine in Portugal.

Regarding the Falls and Activity Monitoring activities, in 2016 FhP-AICOS scientific results were also distinguished within the E-NO FALLS Thematic Network. The main goal of this thematic network is to integrate and bring together knowledge, experiences and best practices acquired at the european and international level in the area of fall prevention, intervention and safety. It also aims at coordinating on-going activities and creating the necessary conditions and consensus on action plans, standards and specifications to ensure the widest future replication and co-deployment of innovative solutions (with special emphasis on Information and Communications Technology – ICT based ones).

EU Falls Festival 2016



BEST POSTER AWARD

Under the theme 'Implementation of Innovation into Policy and Practice', the European Union organized in 2016 the EU Falls Festival that brings together leading academics, researchers, health care practitioners, clinicians, industry representatives and key stakeholders from across the globe to celebrate best practice research and innovation in the multidisciplinary study and implementation of falls prevention in older people, which took place on February 23rd and 24th, in Bologna (Italy).

Within this event the E-NO Falls Thematic Network presented a scientific publication that identified the best practices and drew a roadmap for the market development containing the key challenges, steps and phases to go through, while implementing a business process of ICT-based fall prevention and effective intervention solutions for elderly people. This publication was distinguished with the 'Best Poster Award' during the event, FhP-AICOS being one of the entities that contributed to achieve this appreciated merit.

In 2016 FhP-AICOS started the implementation of a new European project funded by the AAL JP in the scientific area of Falls and Activity Monitoring: Active@Home. This project intends to be a holistic approach to increase the physical activity of elderly population, while motivating them through captivating and challenging multi-player exergames, video games played through physical exercise. The user will be able to choose the type of exercise that suits him/her best: from sequences of games composed together to create workouts, dance exercises based on traditional dances from different European countries or Tai Chi training. With this, social capabilities will be promoted to foster community engagement and enhance cultural and cognitive aspects.

Still in the context of Falls and Activity Monitoring, according to the European Agency for Safety and Health at Work, 600 million work days are lost every year in Europe due to musculoskeletal diseases. Physiotherapy is an effective treatment prescription in these various scenarios and the compliance with the correct repetition of the exercises proposed is crucial to the success of this kind of interventions. However, due to time and cost limitations, the number of sessions is usually low when compared to the potential of recovery of the patient. In order to tackle this societal challenge, a Portuguese SME and FhP-AICOS successfully proposed a project for PT2020 funding that aims to develop a complement to the physiotherapy sessions performed at the clinics. This project is named Physio@Home and it proposes a technology based on smartphones or tablets and wearables containing electromyography (EMG) and inertial sensors to track the execution of the movements and give feedback to the user at home. These devices will display intuitive games that will guide the user through the execution of the exercises and provide a visual feedback, increasing the ability to get a better performance. The gamification of rehabilitation exercises and their deployment in ubiquitous devices, such as smartphones or tablets, in combination with wearables for movement monitoring, will enable a more engaging complement to physiotherapy sessions and will ensure the correct execution of the exercises at home.



The scientific field of Internet of Things – IoT is one of the topics that FhP-AICOS started to address with more emphasis during 2016. Within this context the organization started in 2015 the development of a new concept for a device that could be present in different activities of the day-to-day and be a 'companion' in the sense that it would provide useful information and functionalities to the user. The name of the technology being referred in this section is the Pandlets, which are a development ecosystem that relies on a novel architecture of embedded electronics for wireless devices, which can be used to build new solutions for Wearables and IoT. To exemplify the usage of this technology, in 2016 FhP-AICOS published a white paper, 'A day with Pandlets', to explain how far Pandlets' applications can go. Some examples of usage were provided, e.g., jogging in the morning and monitoring all the movements, detecting falls, controlling home appliances, reading sensors in hydroponic farms, among others.

Still within this context, Internet of Things, a project named IoTiP – Internet of Things in Package is being developed by a Portuguese company and FhP-AICOS. The goal of this project is to embed sensing, processing, energy management and radio communications in a System-in-Package (SiP). This SiP, based on the emerging Wafer-Level Fan-Out (WLFO) technology, sets a new standard in miniaturization. It will provide a physical interface to enable a modular architecture that allows the adding of new features to cover a huge variety of applications. Moreover, IoTiP's ecosystem will provide a hardware abstraction layer that will allow developers to seamlessly interact with the SiP and its features. FhP-AICOS' expertise and competences, combined with the knowledge and experience of the company, have a strong potential to bring new disruptive solutions to be offered in the IoT market and to contribute to simplifying and speeding-up the development of new IoT solutions.

Within the scientific area of Chronic Diseases and Wellbeing management, in 2016 a new project was initiated: CordonGris. This project is associated with the AAL JP and intends to tackle elderly malnutrition in Europe. The aim is to develop an open and extensible ecosystem that involves the core entities of the food supply chains, in order to assist elderly people in improving the quality of their diets and managing their budget for shopping. CordonGris will be demonstrated in the three participating countries and it is expected to involve over 300 seniors throughout its two-year duration.

Last but not least, a final mention to the DeM project which continued to involve a large part of the senior scientific team of FhP-AICOS and that has been fostering a closer scientific relation with relevant research centers of the North region of Portugal.

The Fraunhofer Portugal Challenge completed its 7th edition, reinforcing our high profile position within the Portuguese Academic Institutions. In this edition we were able to attract the interest of post graduate students who responded to our challenge with outstanding scientific research work. Evidencing this statement are the numerous visits to the Challenge's website (circa 2.200) and the numerous applications submitted from 6 universities country-wide, encompassing several heterogeneous courses, but in line with the scientific activities of FhP-AICOS. As an example, the 6 finalists came from courses as varied as Computer Science, Computer Engineering, Electrical Engineering, Mechanical Engineering, Technological Physics and Telematics Engineering. In total we received 14 applications, 9 in the PhD category and 5 in the MSc category.



An interface for 3D medical image manipulation in the MSc category and a robotic platform able to develop complex tasks in the marine environment in the PhD category, were the winners of the 7th edition of the Fraunhofer Portugal Challenge.

In terms of the results achieved in the scientific domain, the following table provides a summary of FhP-AICOS' activities with an important impact:

Scientific Activities

Papers	18
Master Theses	13
Patents Granted	1

The most prominent result of our scientific activities was the achievement of the first internationally granted patent with the title 'Mobile Device and Infrastructure System'. This patent is based on the invention of the Ultra-Low Frequency Magnetic Communication (ULF-MC) technology that was devised by Professor Dirk Elias.

In terms of the corporate development, during August 2016 Fraunhofer Portugal was honoured to receive for the first time the visit of the president of Fraunhofer-Gesellschaft, Professor Reimund Neugebauer. This visit was also accompanied by the Portuguese Minister of Science, Technology and Higher Education, Professor Manuel Heitor, a German delegation with four members of Fraunhofer Gesellschaft: Georg Rosenfeld – Executive Vice President Technology Marketing and Business Models, Frank Treppe – Director of Corporate Strategy and International Affairs, Raoul Klingner – Director of Research and Marion Früchtl – Scientific Advisor of the President; and the Chancellor of the Technical University of Chemnitz, Germany, Eberhard Alles.

The event was hosted in Fraunhofer Portugal headquarters in Porto, which recently received the 2016 Green GOOD DESIGN™ Award in the field of sustainable architecture.

In October 2016, the President of the Executive Board of Fraunhofer Portugal, and Director of FhP-AICOS, Professor Dirk Elias, announced that he would leave the organization by the end of January 2017.

Business Performance

- Total Business Volume of 3,11M€.
- Total Project Revenues of 1,44M€.
- Global performance of the organization of 53%.

In 2016, FhP-AICOS registered a descending trajectory both in the Business Volume and performance of its activity. As explained in the previous sections, the main reason behind the facts that had a direct impact in 2016 results is the delay in the administrative processes related to PT2020 project proposals, being this an external factor that unfortunately had a visible impact in the performance of the organization.

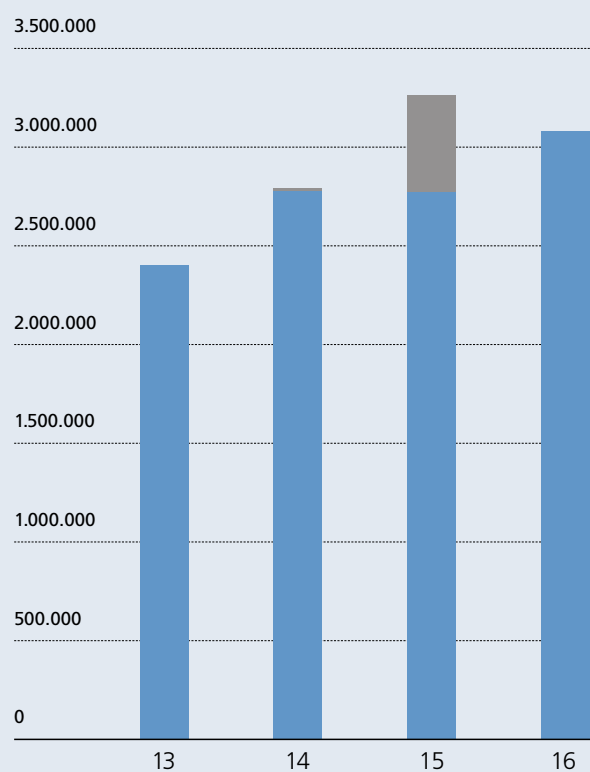
As the time frame associated with these delays was impossible to be foreseen, the planned expenses of the organization were slightly adjusted, but most of the investments were still executed as planned, which combined led to the decrease of the performance of the organization due to the impossibility to account the expected revenues related with these investments.

By the end of the year, the total Business Volume was circa 3,1M€, representing a decrease of 5% compared with the previous year. The main contribution for the decrease in the total Business Volume was due to the inexistence of CAPEX investments related to new infrastructures.

The total project revenues surpassed 1,44M€ representing a decrease of 13% when compared with the previous year. National project revenues decreased 53%, industry projects revenues increased 42% and EU project revenues increased 20%.

As a result of the combination of the above mentioned external factors, FhP-AICOS global KPI that measures the volume of revenues over the total operational costs has decreased. The total operational costs increased 6%, which in combination with the decrease of external revenues resulted in a global performance (total external revenues / total operational costs) of 53%.

Total Business Volume (cash basis) 2013–2016 [€]



	2013	2014	2015	2016
Major Infrastructure Capital Expenditure	0.00 €	10.000 €	474.668 €	-862 €
Contract Research (Total Expenses and Research Capital Expenditure)	2.386.466 €	2.781.572 €	2.792.212 €	3.108.540 €

Contract Research

- Staff costs on similar levels of the previous year.
- Non-staff costs consistent with activity growth.
- Increase in CAPEX related to investment on projects.

Personnel expenses for contract research increased 3% and represented 77% of our total operational cost in the financial year of 2016. This is in line with the same levels of activity of last year and allowed us to be prepared to the next round of PT2020 projects, which started during last quarter of 2016, and for the ones that will start until the end of the second quarter of 2017.

Non-personnel costs increased by 19%, in line with the 2014 and 2015 actual costs.

Capital expenditure with R&D contract research rose by 67% when compared with 2015. This evolution is a direct consequence of FhP-AICOS' current project investment profile.

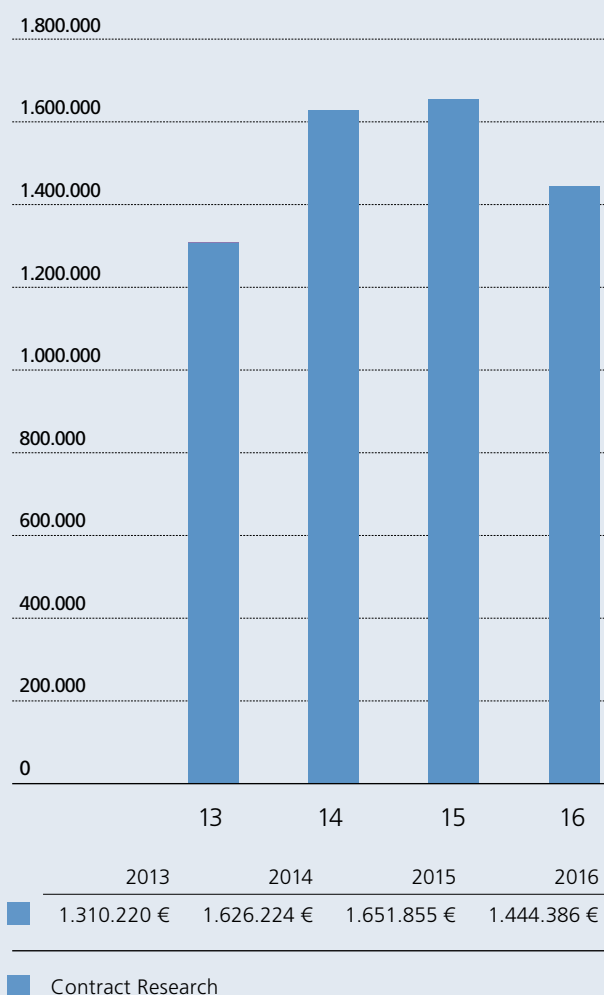
FhP-AICOS decreased its revenues by 13% vs. 2015. Since 2011, our compound annual growth rate³ is 22,85%, which are very good results considering the economic adjustment period experienced in Portugal since 2011.

Our Industrial Revenue increased 42% vs. 2015. This is a result of the start of PT2020 projects. In terms of geographical distribution, 38% is obtained from international clients. When compared with our Operational Revenues, Industry Revenues now account for 46%.

Revenue from national projects decreased 53% when compared to the last year.

Revenue from EU-funded research projects increased their share of 28% in our Operational Revenues. Since 2013, EU revenue has grown 59%.

**Contract Research Revenue Evolution
2013–2016 [€]**



³ Compound annual growth rate (CAGR) is a geometric average growth rate over a period of several years.



Employees

- Peak of 86 collaborators in March.
- Increase of FTE in 2,7%.
- Young and talented team with an age average of 31 years old.

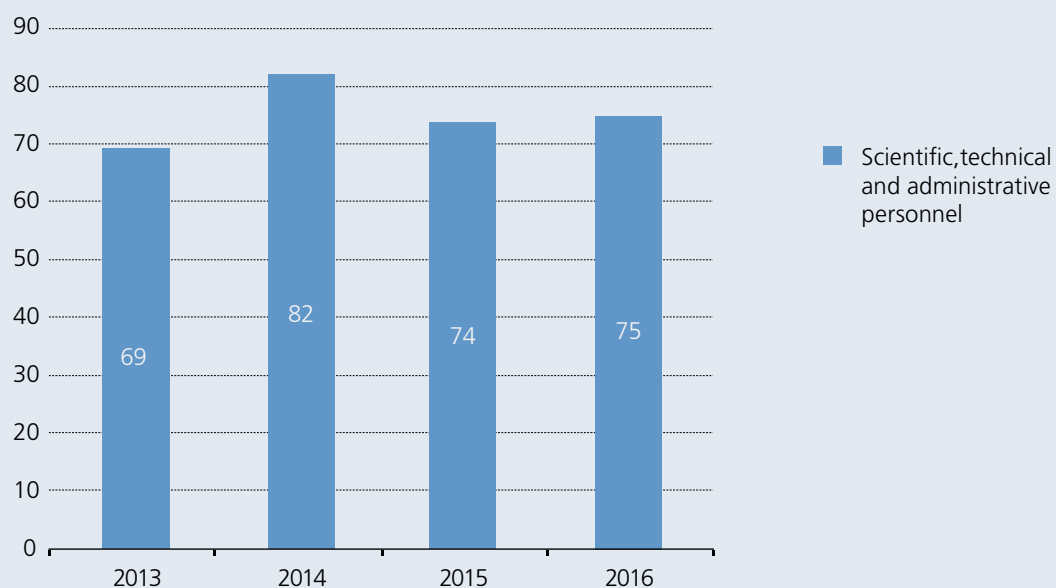
Fraunhofer Portugal's success and Human Resources policy is based on the respect for human values, merit, pro-activity, observance of the law and on knowing how to reach the goals we propose, in order to build a motivated team united towards innovation.

During 2016, we were able to increase our regular staff Full Time Equivalent (FTE) in 2,7% and this is proof that Fraunhofer Portugal is able to captivate and retain talents (57% vs. 56% in 2015).

As in previous years, Fraunhofer Portugal had a peak of collaborators during the months in which the thesis students were welcomed, reflected in March of 2016 with a headcount of 86.

During 2016, Fraunhofer Portugal was able to maintain the team on the average of 80 collaborators and closed the year with a total headcount of 75 collaborators.

Headcount Evolution 2013–2016





All in all we operate a young talented team with an age average of 31 year. Furthermore, we run a highly qualified team, as 96% of our staff members have a university degree, 65% are MSc and 9% have a PhD degree.

Also, during 2016, 36 collaborators joined Fraunhofer Portugal, 16 under work contract and 17 grant holders, it is noteworthy that from the 16 celebrated employment contracts 10 are the result of grants that we have attributed. In the same period some collaborators left Fraunhofer Portugal, 40% less than in 2015, the main reason behind this change being new work contracts offered by the industry sector. This is a result of the training and technical skills acquired at FhP-AICOS and, once again, proves that we are accomplishing our mission to increase the innovation pace of the Portuguese Economy by contributing to the qualification of highly skilled individuals that are of interest to the industry.

Regarding Human Resources activity, and following our vision to motivate the team and promote merit and pro-activity of all collaborators, in the second semester of 2016 we proudly announced the winners of the Entry Level Excellence Award, dedicated to two young researchers that achieved outstanding results: Lourenço Castro and Vânia Guimarães.

Outlook and Strategic Development

Contrasting with the results of 2016, the outlook for 2017 seems quite promising in terms of the increase in the total Business Volume. This positive outlook is based on the expectation that seven project proposals submitted in 2016 will be contracted in the next fiscal year and will contribute to a significant increase of the contracted volume of R&D projects.

One of the proposals mentioned above is the project Collective Transfer FhP. After a significant delay in the evaluation process it is expected that this process will be concluded in the next couple of months and that finally the project will be contracted. As part of the investments that were executed in 2016, the revenues associated with those investments will be accounted in 2017, therefore creating a positive influence in the results of the next year.

Four other proposals are related with the Mobilizer project proposals that were submitted in October 2016 for national funding. These projects are still being evaluated, but the current perspectives indicate a high likelihood that the four projects will be approved, which would have a positive impact in terms of the balance of the future contracts of FhP-AICOS.

Two other proposals refer to Industry projects, where the organization is subcontracted to participate in individual R&D projects funded by PT2020. One of these proposal refers to the project that was submitted by a large company for funding in the PT2020 programme under the contractual regime, which is available for large scale investments above 10M€.

The other project proposal concerns the development of an image acquisition module for a Portuguese company. This company has a clinical record management software that is used in several clinics all over Portugal and they became interested in integrating FhP-AICOS technology related with image acquisition that would allow them to enrich the functionalities of the existing software.

Actually part of these optimistic perspectives refer to revenues that would have been associated with 2016 results in normal conditions, i.e., in case the delays of the PT2020 programme had not affected the normal development of FhP-AICOS. This recovery will allow the organization to return to its planned growth path and continue the success story of the implementation of the Fraunhofer in Portugal.

Besides the project proposals submitted in 2016 that can generate results in 2017, there is still a significant additional number of calls and opportunities to be explored along the year. Recent history and success stories have shown that the maturity of the scientific knowledge and the technologies developed by the organization are receiving more attention from industry clients that are interested in exploring their economic value. At a national level FhP-AICOS has consolidated its position as one of the top institutions of the scientific and technological system and the excellent results of projects are the best publicity that any organization can have. There is an increasing number of entities that look for our organization and that are interested in developing projects with FhP-AICOS, which serves as motivation and as challenge simultaneously to satisfy the expectation of current and future clients.

Furthermore, the current policies and investments in the area of science and applied research are also encouraging in terms of the new opportunities that might arise during the next years. Recently a new strategic programme was approved by the Portuguese government, the 'Programa Interface', which aims to stimulate the cooperation between the different stakeholders of the scientific sector, namely universities, research centres, industry and other public and private entities, to leverage knowledge and technology transfer from the scientific organizations to the real economy.

The next year will also be marked by the appointment of a new Director for FhP-AICOS. The recruitment process is still ongoing and a decision is expected to be reached until the end of the first quarter of 2017. This transition will most certainly bring new perspectives for Fraunhofer Portugal and changes are likely to occur, therefore the Strategic Development of the organization will be conditioned by the perspectives and the vision of the new leadership that will come in the near future. Being FhP-AICOS in a stable condition and during a growth cycle, this change has the potential to bring new opportunities for the organization by the incorporating of new ideas and new approaches to incorporate scientific knowledge in applied technologies.

Having in mind all the successes achieved in the last eight years, a significant part of it being associated with the creativity, commitment and hard work of all collaborators of Fraunhofer Portugal, in general the future perspectives are positive and the whole team is engaged in continuing to bring to life new technologies that can support society's needs and improve its quality of life!

Perspetivas e Desenvolvimento Estratégico

Comparativamente com os resultados de 2016, as perspetivas para 2017 apresentam-se bastante promissoras em termos de aumento do volume de negócios total. Esta situação deve-se ao facto de no próximo ano fiscal existir uma elevada probabilidade de contratação de sete propostas, apresentadas em 2016, e que irão contribuir para um aumento significativo do volume de projetos de R&D.

Uma das propostas mencionadas baseia-se no projeto Collective Transfer FhP que, mesmo apresentando um significativo atraso na avaliação, conta-se que fique concluído nos próximos meses e que, finalmente, seja adjudicado. Por conseguinte, e dado que parte dos investimentos deste projeto foram efetuados em 2016, as receitas associadas serão contabilizadas em 2017, gerando assim um impacto positivo nos resultados do próximo ano.

No âmbito de outras propostas, quatro estão relacionadas com os projetos Mobilizadores, apresentadas em outubro de 2016 para financiamento nacional. Esses projetos encontram-se ainda em avaliação, mas as perspetivas atuais apontam para uma elevada probabilidade de serem aprovados, o que irá criar um impacto positivo em termos de balanço dos futuros contratos do FhP-AICOS.

Duas das outras propostas referem-se a projetos individuais de R&D de indústria, financiados pelo PT2020, nos quais a FhP-AICOS é subcontratada. A primeira refere-se ao projeto que foi apresentado para financiamento do programa PT2020, ao abrigo do regime contratual, que está disponível para investimentos em grande escala, superiores a 10M€.

A outra proposta diz respeito ao desenvolvimento de um módulo de aquisição de imagem para uma empresa portuguesa. Esta empresa possui um software de gestão de registos clínicos, que é utilizado em várias clínicas, distribuídas pelo país, que mostraram interesse em integrar a tecnologia FhP-AICOS relacionada com a aquisição de imagens, o que lhes permitiria enriquecer as funcionalidades do software existente.

Na verdade, parte dessas perspetivas otimistas referem-se a receitas que estariam associadas, em condições normais, aos resultados de 2016, isto é, caso os atrasos do programa PT2020 não tivessem afetado o desenvolvimento normal do FhP-AICOS. Esta recuperação irá proporcionar o regresso ao crescimento planeado da organização e à continuidade da história de sucesso da implementação da Fraunhofer em Portugal.

Além das propostas apresentadas em 2016 que podem gerar resultados em 2017, existe ainda um número adicional significativo de concursos e oportunidades a serem exploradas ao longo do ano. Acontecimentos recentes, bem como as histórias de sucesso do passado, têm mostrado que a maturidade do conhecimento científico e as tecnologias desenvolvidas pela organização têm vindo a receber mais atenção dos clientes na área da indústria, interessados em explorar o seu valor económico. A nível nacional, o FhP-AICOS consolidou a sua posição como uma das principais instituições do sistema científico e tecnológico, sendo os excelentes resultados dos projetos a melhor publicidade de qualquer organização. Tem-se verificado a existência de um número crescente de entidades que procuram a nossa organização e que se mostram interessadas em desenvolver projetos com o FhP-AICOS, o que constitui simultaneamente motivação e desafio, para satisfazer as expectativas dos atuais e futuros clientes.

Além disso, as atuais políticas e investimentos na área da ciência e da investigação aplicada apresentam-se bastante encorajadoras no que respeita às novas oportunidades dos próximos anos. Recentemente um novo programa estratégico foi aprovado pelo governo português, o Programa Interface, que visa incentivar a cooperação entre as diversas partes do setor científico, nomeadamente universidades, centros de investigação, indústria e outras entidades públicas e privadas, com o objetivo de impulsionar a transmissão de conhecimentos e tecnologias das organizações científicas para a economia real.

O próximo ano será também marcado pela nomeação de um novo Diretor da FhP-AICOS. O processo de recrutamento está a decorrer e espera-se que a decisão esteja concluída até o final do primeiro trimestre de 2017. Esta transição certamente trará novas perspectivas para a Fraunhofer Portugal e é provável que ocorram mudanças, condicionando o desenvolvimento estratégico da organização pelas perspectivas e pela visão da nova liderança, num futuro próximo. Dado que o FhP-AICOS se encontra numa condição estável e num ciclo de crescimento, esta mudança apresenta um forte potencial de novas oportunidades para a organização, através de novas ideias e novas abordagens, de modo a incorporar o conhecimento científico em tecnologias aplicadas.

Tendo em conta todos os êxitos alcançados nos últimos oito anos, associados na maioria dos casos à criatividade, empenho e trabalho árduo de todos os colaboradores da Fraunhofer Portugal, as perspectivas de futuro em geral mostram-se positivas e toda a equipa está empenhada e motivada para continuar a trazer novas tecnologias que possam apoiar as necessidades da sociedade e, consequentemente, melhorar a qualidade de vida!

REVIEW OF FRAUNHOFER PORTUGAL RESEARCH



STRATEGIC RESEARCH AGENDA

PROJECTS AND RESULTS 2016



STRATEGIC RESEARCH AGENDA

AS FRAUNHOFER PORTUGAL CURRENTLY ONLY OPERATES ONE RESEARCH CENTER (FRAUNHOFER PORTUGAL AICOS), ITS STRATEGIC RESEARCH AGENDA IS DICTATED BY FRAUNHOFER PORTUGAL AICOS' INTERESTS AND ACTIVITIES.

Business Fields

Fraunhofer Portugal AICOS (FhP-AICOS) addresses two main business fields: Ambient Assisted Living (AAL) and the emerging field of Information and Communication Technologies for Development (ICT4D).

Ambient Assisted Living

Ambient Assisted Living (AAL) includes methods, concepts, (electronic) systems, devices and services that are providing unobtrusive support for daily life, based on the context and the situation of the assisted person. The technologies applied for AAL are user-centric, i.e. oriented towards the needs and capabilities of the actual user. They are also integrated into the immediate personal environment of the user. As a consequence, the technology is adapting to the user rather than the other way around. In order to share relevant information between systems and services, technologies for AAL should ideally be based on modular and interoperable concepts.

A main driver for the development of AAL technologies is the increasing number of ageing population and the inversion of the demographic pyramid that is occurring in developed countries. AAL technologies can be instrumental in tackling the massively increasing cost of healthcare and social security. Another driver is the rising number of single person households together with rising expectations towards the quality of life. AAL technologies also cater towards the increasing demand of safe and comfortable living environments, as well as the increasing demand for communication and stronger social interaction with others.

FhP-AICOS intends to mainly address the needs of the ageing population, not only to reduce innovation barriers of forthcoming promising markets, but also to lower future social security costs. This can be achieved through the use of intelligent products and the provision of remote services, including care services that allow the time senior citizens can live in their home environment to be extended, while guaranteeing adequate comfort, safety and quality of life. These services will increase their autonomy and assist them in carrying out day-to-day activities.

The research and development of Ambient Assisted Living solutions by FhP-AICOS aims at a primary target user group – the Ageing and Elderly – with the purpose of:

- Extending the time people are able to live in their preferred environment by increasing their autonomy, self-confidence and mobility;
- Maintaining health and functional capability of elderly individuals;
- Promoting a better and healthier lifestyle for individuals at risk;
- Enhancing security and safety, to prevent social isolation and to help maintain the multifunctional network around the individual;

- Supporting caretakers, families and care giving organizations;
- Increasing the efficiency and productivity of resources used in ageing societies.

Information and Communication Technologies for Development

Information and Communication Technologies for Development (ICT4D) is a general term used to refer to the application of Information and Communication Technologies (ICT) within the field of socioeconomic development or international development. ICT4D focuses on directly applying information technology approaches to reduce the digital divide and therefore contribute to poverty reduction in developing countries.

FhP-AICOS intends to focus its ICT4D activities on the African continent, specifically on Mozambique and Angola. The primary target user group will be ICT users in rural and developing areas and the objective is to provide solutions for mobile device services and applications matching the local users' demands and contributing to a more positive user experience which, in many cases, may be their first contact with ICT.

One of the most dominant differences between ICT usage in industrial and developing countries is the type of devices and technologies used when interacting with ICT. In industrial countries, interaction with ICT is made primarily via PCs, while in developing countries the mobile phone has taken over the role of primary device of access and interaction with ICT.

Mobile devices, like smart(er)-phones and Mobile Internet Devices will continue to play a dominant role in developing countries in terms of growing widespread usage. In developed countries, the same tendency occurs, although the current use of PCs potentially slows down this trend when compared to developing countries.

Business SubFields

Due to the large amount of topics related to both fields, and our comparably small R&D team, we have chosen to focus on fewer subfields that our customers consider relevant and which, over the first period of operation, we were capable of creating, taking into account our core competences which clearly differentiate us from our competitors.

In the AAL business field we currently cover the following subfields:



Fall and Activity Monitoring

For frail and elderly individuals, falling can have serious consequences including injury, psychological damage, limitations on mobility and reduced quality of life. Technology addresses this issue following two different perspectives: providing a better emergency response after a fall has occurred and allowing for detection and prevention of falls, through continuous monitoring of senior adult activity. Despite the market potential, current technological solutions are cumbersome and are not inclusive, focusing only on formal caregivers, they present cost obstacles and are, in general, hard to handle and maintain. FhP-AICOS' approach to fall prevention, detection and activity monitoring focuses on the development of solutions for smartphones which have several clear advantages: cost effectiveness, user friendliness and inherently manageable.

Chronic Diseases and Well-Being Management

Along with an ageing population comes the higher incidence of different chronic diseases. In high-income countries, chronic diseases are the greatest cause of early death and disability and also a major source of costs for social security systems. FhP-AICOS partners with relevant entities (companies, health care providers, public entities, etc.) in an attempt to help society improve the services for chronic disease management, by creating valid prototypes and contributing to the standardization effort through several different existing solutions, or solutions which are yet to come.

Assistive Environments

As the world's population is ageing, there is a growing need to support independent living conditions for elderly individuals. Assistive environments incorporate the latest pervasive and ubiquitous technologies and provide a viable alternative to traditional assistive living solutions. One of the aims is to enhance the user comfort. Comfort can be an essential or fundamental benefit for people with disabilities or elderly individuals. Environments equipped with these solutions are able to compensate some disabilities of the senior users by simplifying daily routines and reducing the elderly individual's dependency on other people by taking advantage of the functionality of the environment by themselves, reinforcing their independence and personal freedom and allowing them to remain in their usual surroundings for longer time. FhP-AICOS' approach is to simulate assistive environments as closely as possible, by taking advantage of its Living Lab and to create applications that enable the consolidation of this vision.

With regard to the emerging ICT4D business field, one subfield has currently been defined:

ICT4D on Mobile Devices

The above mentioned subfield consists of mobile ICT solutions jointly developed with African partners for user groups in rural and developing areas in order to enhance the living standards of those groups. In the beginning, the solutions will target four application areas which were identified as the most market relevant in the next years: agricultural production chains (mAgriculture), micro-enterprises (ICT for Very Small Enterprises), mobile health (mHealth) and mobile Government (mGovernment).



Core Competences

FhP-AICOS' core competences are strongly related to the demands of our customers in the above described business fields. Some competences have been specifically created based on the request of a specific customer, but the vast majority is related to our prediction of a future demand from the side of our customers. In order to gain competences, we are using internal projects that will ideally lead to existing results and competences when a customer requires them. In this case, we can successfully transfer an internal project into an external industry project. In other cases, we are able to convince customers with results from internal projects that do not yet completely match the requirements of our competence to achieve the desired result on time and with high quality. Thus, the selection process for internal projects is very important, as any competence that we create and which is not used afterwards within a reasonable time needs to be considered as holding academic value only and as an investment without return.

To date, FhP-AICOS has developed the following core competences:

Human-Computer Interaction (HCI)

At FhP-AICOS, designing products and services that are adapted to our specific target audiences and which meet their needs is a main goal to be addressed. The HCI team is responsible for performing user research, designing solutions according to its results and iterating them through evaluations with both experts and final users. As such, the group is expected to ensure the significance and usability of any solution developed at the institute. The research performed within the HCI core competence is focused on the following subfields:

- User & Social Experience, associated with research on users' characteristics as well as their environments and context. It provides the knowledge required to create meaningful solutions that meet users' demands;
- Mobile & Future Devices, a research field that includes the discovery of new technologies with the goal of enhancing users' interaction with current and novel systems;
- Evaluation & Usability, focuses on evaluating the extent to which developed solutions fit users' expectations. It includes systematic evaluation tests with both HCI professionals and end-users.

Information Processing (IP)

This core competence has originated from the demands imposed by our business fields and provides us with the capability to generate algorithms to solve the problems that arise in our projects. Advances in Information and Communication Technology have triggered an exponential growth in the amount of data available. IP scientific area is related to the methods developed to cope with these vast amounts of information ranging from simple sensor events, over natural language to complex multimedia content. The IP core competence has been divided, according to our main activities, into three main subfields:

- Content Retrieval, a research field concerned with the search of information within multiple contexts. It is mainly related to the development of algorithms to extract and process the data retrieved from the different sources available;
- Context Awareness, focuses on the development of ubiquitous solutions that use unconventional sensor data and combine it with environmental context information, such as the users' location or even meteorological and other geographical information;
- Multimodal Information Fusion, concerned with the combination of the information retrieved by different sources. It is mainly applied in FhP-AICOS to fuse the information retrieved by different sensors in order to replace external sensors by software for smartphones.

Autonomic Computing (AC)

FhP-AICOS aims to create solutions adapted to people's needs and competences. However, the variety of communication technologies, Operating Systems and networked devices creates complexity in the daily life of non-technical people. The AC core competence addresses the aforementioned complexity by proposing solutions capable of adapting to time changing conditions while hiding the intrinsic complexity from the non-technical people. Moreover, due to the specific requirements of FhP-AICOS business fields, there was the need to focus on one specific AC subfield:

- Remote Management, Control and Configuration, a research field consisting of reusing and extending remote management protocols and service discovery standards as well as implementing modular and adaptive software architectures. It is mainly applied at FhP-AICOS to cope with the lack of interoperability between devices and applications and the reduced remote management capabilities in AAL and ICT4D.



As a consequence of the work we carried out in the business subfield 'Fall and Activity Monitoring' related to the very interesting achievements regarding the related competences in 'Multimodal Information Fusion', we decided to increase our activities in order to prepare for the predicted market demand through the creation of a Fall Competence Center (FCC). The FCC concentrates our efforts and extends the scope to go beyond the current focus on fall detection and fall risk prediction to the two additional application fields of falls in extreme sports and incident detection for security and safety personnel. Likewise, we extended our activities in the emerging business field ICT4D through the creation of the ICT4D Competence Center (ICT4DCC), which concentrates all the competences required to develop and assess solutions for mobile devices in the application fields of mAgriculture, mHealth, mGovernment and ICT for Very Small Enterprises (business solutions for the growing micro-enterprises in developing countries). It also allows us to form an international team with guests from Africa and Europe that have the potential to create a joint melting pot for the related activities of Fraunhofer in Germany.

PROJECTS AND RESULTS 2016

EXTERNAL PROJECTS

In accordance with the Fraunhofer Business Model, two thirds of Fraunhofer Portugal's income should be generated by external projects which can have one of two formats: Industry Contract Research, i.e. projects having industry partners as clients, or Government Contract Research, i.e. projects resulting from the participation in national and EU publicly funded programmes. This section describes the external projects that are being developed at Fraunhofer Portugal AICOS (FhP-AICOS).

ACP Street Libraries – Culture for All

Description: The main objective of the ACP Street Library project is to contribute to the development of culture in ACP (African, Caribbean and Pacific Group of States) countries mainly by promoting the creation of new Street Libraries and the modernization of existing ones. The partners involved in the project also plan to develop a set of activities related to the ACP Cultural sector promotion and consolidation mainly by encouraging the preservation of local cultures that are currently only transmitted in oral format.

There are four specific objectives associated to the project implementation, namely:

- Increase the number of ACP Street Libraries;
- Increase the number of books available for oral reading in ACP Street Libraries;
- Improve existing databases of ACP countries local culture;
- Improve ACP countries discussion and cooperation platforms.

The key stakeholders of the project will be actual and future cultural entrepreneur's, who will benefit from the project or to promote and disseminate their artistic work; NGOs (Non-Governmental Organizations) and private and public institutions, who will benefit from the project by building the necessary capacity to create new Street Libraries and cultural projects; universities and research centres, who will benefit from the project results by promoting technology transfer to the local students, local partners and international ACP members; and finally, the local population, children and young people of ACP countries, who will have access to more cultural resources and who will be able to preserve their local legends and histories for the future generations. All the actions developed in the project will comply with user centred design methodologies, being the end-users always directly involved in all the project activities.

Partners: FhP-AICOS (coordinator); ASRAD – Appui Solidaire pour le Renforcement de L'aide au Developpement; Microsoft Portugal MLDC – Microsoft Language Development Center; VPWA – Volunteer Partnerships for West Africa; YCWL – Youth Crime Watch of Liberia.

Outcome: This project aims at the creation of a set of actions, services and features supported on mobile technologies, that will allow actual and future cultural entrepreneurs, NGOs and private and public institutions, to leverage Street Libraries in ACP Countries, developing this cultural action at regional, national and international levels as well as maximize its impact on local populations, especially in children and young people.

Active@Home – Social ExerGaming, Dancing and Tai Chi for Wellbeing and Fall Prevention 1

Description: This project aims at developing a holistic solution, focusing on physical, cognitive and social aspects, to promote physical activity at home and foster fall prevention (and provide fall risk prediction), based on typical exergames, dance and Tai Chi.



The solution should feature a home entertainment system (frontend) designed for large screens (TVs) and support motion capturing through inertial sensors (either as individual devices or the ones integrated in the smartphones/smartwatches). A hardware abstraction layer should be implemented so that the solution can be scalable and not be tight to a specific set of sensors. The project also includes the development of a specially designed sensor featuring an IMU that can be attached to specific parts of the body to allow proper and accurate tracking of all body movements.

On the other hand, the solution should be supported by a backend that should not only be able to manage user profiles and store all game session data for further analysis, but also be able to manage models of new dances or Tai Chi movements, so that the frontend can validate the user movements against them, adding a new level of scalability to the solution.

The advent of social networks should not be neglected and the system should allow users to share results and therefore instigate healthy competition. Furthermore, group dancing (either locally or online) is a must-have, as it will nourish social interaction and integration and eventually reinforce adherence to the programme.

The socio-cultural component is also quite important, revolving around the traditional dances of each country. Older adults are keen on traditions and customs, and presenting them the possibility of learning and being challenged to perform new traditional dances adds a new motivational factor while stimulating the cognitive function. Also, the possibility of organizing community events, dance groups and competitions using this system will strengthen bonds with the community and contribute to a support network that will further help people living in their homes.

Partners: Dividat GmbH (coordinator); Comfort Keepers Portugal; ETH Zürich – Eidgenössische Technische Hochschule Zürich | Departement Gesundheitswissenschaften und Technologie; MIRALab SARL; Unie KBO – Unie van Katholieke Bonden van Ouderen.

Outcome: FhP-AICOS will have the chance to follow the success of the 'Dance! Don't Fall' solution, as well as improve current ExerGames platform, namely in what it takes to providing support to new frontend technology based on HDMI dongles, which greatly simplifies system setup, designing new or improving DSP algorithms for motion tracking / movement recognition and expanding/improving the sensor hardware abstraction layer. There may be also the opportunity to develop a wearable sensor featuring a 9-DOF IMU, based on the FhP-AICOS Pandlets technology.

Clockwork – Smart System for the Management and Control of Shift Workers' Circadian Rhythms

Description: The main goal of the Clockwork project is to create a healthy and comfortable work environment by supporting middle-aged to older adults in the improvement of their circadian rhythms. Particularly, the solution will target shift workers, such as healthcare professionals, who are greatly affected by chronodisruption, which can thus lead to health issues, long absences or early retirement.

This objective will be achieved through the enhancement of external synchronizers that will help older adult workers maintain a healthy and robust day and night rhythm by introducing some imperceptible modification in their environment.

To do this, three main tools will be used: an activity monitoring device, a feedback and support application framework and an innovative environmental circadian empowering system module, which includes the design of a lighting device, a wireless sensor network and actuators to regulate the environment. The feedback and support application framework is not only the platform that communicates with the user, but it is also responsible for managing the information gathered by the sensors and controlling the different devices to adjust the environmental conditions to the person's needs.

Partners: FhP-AICOS (coordinator); Ab.Acus Srl; BCB – Informática y Control SL; Grado Zero Espace Srl; KOHS PIMEX – Kviecien Occupational Health Solutions; RK Tech Ltd.

Outcome: User activity monitoring and smart home environment to control users' circadian rhythm.

CordonGris – Making Sense of Data to Promote Effortless Healthy Eating Habits and Autonomy for Older Adults 2

Description: One major cause of older adults' frailty in many countries is malnutrition. A study from January 2015 reported that 1 in every 6 seniors reaching the emergency room are malnourished (Pereira, Bulik, Weaver, Holland, & Platts-Mills, 2015) and those at risk of malnutrition are estimated to be as much as 2/3. Malnutrition can have serious consequences on one's health and independence. Being unable to follow a healthy diet will most likely lead older adults into a vicious cycle: functional decline leads to malnutrition and malnutrition leads to further decline.

The project will create a system to gather and manage all the data that is relevant for the recommendation of a healthy diet, coming from different sources: sensors for activity monitoring, user reported data, country-specific food databases, retailers' information, producers' information and service providers'

information. By making sense of all the data, the central intelligent system can generate recommendations that range from meals to physical activity or other healthy behaviours and prompt people to adopt a healthier lifestyle against malnutrition. With its intelligent treatment of the data, along with the recommendations, the project will provide the conditions for the 'flat-rate food' concept to become a reality.

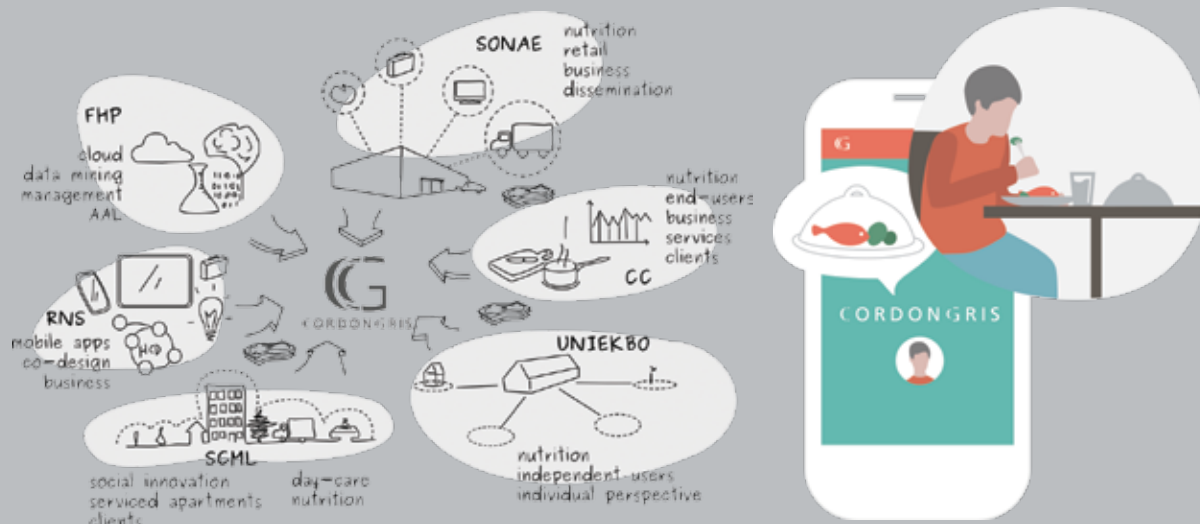
The project is born out of previous knowledge from the different partners and it is designed to build on a strong contribution from field implementations in the three countries participating in it: Portugal (R&D + food supplier + end-user), United Kingdom (food supplier + end-user) and the Netherlands (independent end-user).

Because food can take various forms, our idea is also to acknowledge and work with these different ways of consuming food, e.g. retailers, food producers, pre-prepared food or the well-known concept of meals-on-wheels.

Partners: FhP-AICOS (coordinator); Can Cook CIC; Red Ninja Ltd; Santa Casa da Misericórdia de Lisboa; Sonae Modelo Continente, S.A.; Unie KBO – Unie van Katholieke Bonden van Ouderen.

Outcome: To develop a convenient system that leverages the potential of the Internet of Things to guarantee longer living at home by tackling malnutrition. We will do this by:

- Helping older adults manage their groceries shopping;
- Leveraging the power of local communities to assist each other in food related aspects;
- Providing intelligent and healthy food and meal recommendations to older adults based on health characteristics, lifestyle, culture, resources, availability, local production and season;



- Creating a comprehensive system that brings together the needs of consumers, retailers and food producers;
- Proving the concept of ‘flat-rate food’ on field trials.

DeM – Deus ex Machina: Symbiotic Technology for Societal Efficiency Gains

Description: When thought of at a distance, many of today’s societal challenges stem from waste, inadequate use of resources, lack of integrated solutions and effort replication. All of these are leading not only to citizens being unable to maintain their living standards, but most importantly, to what some academics call defuturing.

Facing this challenge, societies demand more from less for more, seemingly unsolvable, but which appears to be the point in ancient Greek drama, when such an impenetrable problem is suddenly disentangled by a new element coming onto the play: the ‘Deus ex Machina’.

Societies are striving for these new elements towards efficiency gains mediated by a symbiotic relationship of humans with technology. We need elements such as these, which are able to deal with complex problems and, at the same time, be transparent to the users, as ‘companions’ who assist in difficult, unknown or just prosaic tasks.

We have devised a clear project to begin tackling these challenges. It consists of two research lines, being one built on top of the other. The first one will research and create building blocks – from tangible to intangible elements –, while the second will put these building blocks at the service of pressing societal needs in European and African countries.

The first research line (EITCC – Eyes of the Internet of Things Competence Centre) will concentrate on the aspects

to understand the environment, the user, his/her context and actions, and is serving as a technological base to all target domains in the other research line (C3 – Companion Competence Centre). Using the tools emerging from the EITCC, C3, the second research line, will study relevant societal challenges within scientific domains in relation to humans in order to design ‘companions’, which are non-intrusive, assistive tools for everyday life.

Partners: FhP-AICOS (coordinator); 2C2T – Centro de Ciência e Tecnologia Têxtil; Centro ALGORITMI; CIDESD – Centro de Investigação em Desporto, Saúde e Desenvolvimento Humano; CINTESIS – Centro de Investigação em Tecnologias e Serviços de Saúde; CITAB – Centro de Investigação e Tecnologias Agroambientais e Biológicas; CPUP – Centro de Psicologia da Universidade do Porto.

Outcome: Four work packages build the EITCC:

- Sensing and acting: bringing novel sensing mechanisms and actuation by accessing existing devices and developing new Internet of Things (IoT) sensing sources;
- Local information fusion: research on data aggregation algorithms to create refined and contextual information obtained in multiple local sensing devices;
- Remote information fusion and big data analytics in the cloud: implement information fusion from multiple distributed sensors, historical and contextual data to provide higher level abstraction data to C3;
- Networks for ICT4D: development of solutions for ad-hoc broadband networks for remote locations in developing countries.

C3 will study relevant societal challenges within six domains:

- Mind and behaviour: researching human interaction with computers, with a particular focus on human dignity, ethics, perception, cognition, communication and cultural aspects;
- Health: researching solutions for patient empowerment, reducing burden in public health care and streamlining the path to full digitally supported electronic health;
- Nutrition: understanding what people eat, why they eat it, and how healthier and more sustainable behaviours could be encouraged towards gains in health and reduction of food waste;
- Agriculture: considering applications suitable to developed and developing regions towards sustainability and efficiency gains by introducing precision agriculture;
- Activity monitoring: understanding users, their activities, context and behaviour, and providing tailored recommendations and tools that will be useful for tackling the challenges of coping with ageing and health conditions, preventing diseases by keeping an active and healthy lifestyle, improving the performance of sports athletes and increasing public safety and security;
- Community tools and social inclusion: developing inclusive tools, which make use of crowdsourcing and data mining concepts, focused on citizen empowerment, participatory monitoring, urban service delivery and social equity.

E-No Falls – European Network for Fall Prevention, Intervention and Security

Description: The main goal of the E-NO FALLS Thematic Network is to integrate and bring together knowledge, experiences and best practices acquired at the European and international level in the area of fall prevention, intervention and safety. E-NO Falls network aims at coordinating on-going activities and creating the necessary conditions and consensus on action plans, standards and specifications to ensure the widest future replication and co-deployment of innovative solutions (with special emphasis on Information and Communications Technology – ICT based ones).

Partners: UPC – Universitat Politècnica de Catalunya (coordinator); Ana Aslan International Foundation; CETEMMSA – Fundació Privada Cetemmsa; Charité – Universitätsmedizin Berlin; COOSS Marche ONLUS – Cooperativa Sociale Coss Marche Onlus Societa Cooperativa Per Azioni; Emergency Response Ltd; Fondazione Santa Lucia; FORTH-ICS – Foundation for Research and Technology Hellas | Institute of Computer Science; Fundació TicSalut – Tecnologia, Innovació i Salut; MCRoberts BV; NEN – Nederlands Normalisatie Instituut; NUI Galway – National University Ireland Galway; Nordforce Technology AB; Senionnett Norge; Siveco Group, S.A.; Smart Homes – Nationaal Kenniscentrum voor Domotica & Slim Wonen; UL – University of Limerick.

Outcome: The E-NO FALLS thematic network is a forum for all stakeholders within the value chain (such as industry, user organizations, formal and informal care providers, public authorities, investors, housing and insurance companies and service providers across Europe) to share knowledge, expertise, resources, best practice experiences and to build consensus to highlight the remaining obstacles to be overcome and to eventually provide guidance for ICT-enabled solutions and their roll-out.



FallSensing – Technological Solution for Fall Risk Screening and Falls Prevention 3

Description: Falls are one of the most common health problems in the elderly population, representing more than 50% of the hospitalizations due to lesions in this age group. Falls are also considered one of the main causes for loss of independence and institutionalization.

Falls have a multifactorial origin, however most of the fall risk factors are amendable by implementing falls prevention programmes based on improving strength and balance and modifying behaviours. Even though, fall risk screenings and the implementation of such falls prevention programmes are rarely part of the elder's routine.

In this project the creation of the FallSensing system is proposed. This system will enable the evaluation of multiple fall risk factors and the implementation of fall prevention exercise plans, while providing biofeedback during the execution of the exercises. The data collected during fall risk evaluations or performance of falls prevention exercises are stored in a medical record platform, so that the healthcare professionals and caregivers may follow the evolution of the user and define personalized exercise plans. These personalized exercise plans may also be automatically recommended by the system promoting a continuous adaptation of the intervention plans to the evolution of the user.

FallSensing system is intended to create a new technological solution to enable screening and monitoring of the risk of falling and the implementation of falls prevention programmes in the elderly population. The system will be simple, adapted to different use cases, transportable and with low operation costs, so that everyone in risk of falling may have the possibility to reduce this risk and prevent falls.

Partners: Sensing Future Technologies, Lda (coordinator); ESTeSC – Escola Superior de Tecnologia da Saúde de Coimbra.

Outcome: The main outcome will be a fall risk screening and falls prevention solution based on technology.

The technology will be deployed and validated by ESTeSC physiotherapists in different settings: clinics, nursing homes, municipalities and local health facilities.

ARS Centro, the network Ageing@Coimbra and Municipality of Nordeste from Azores endorsed the project.

For FhP-AICOS it's an opportunity to transfer the knowledge and solutions created in the FCC to the market.

INNOVASmartInnovation – RD&I Partners

Description: The core business of the Portuguese company 'InCorporate (Linkintense)' is the development of software tools for management support, such as Innovation Management Systems and Business Process Management Systems. RD&I Partners is a project of 'InCorporate' to improve and extend their 'Innovation & RDI Management System' which integrates their current product portfolio and is already in use by some R&D institutions.

Within the Innovation Management Support Tools, 'InCorporate' has developed a module to manage the workflow of ideas generation, validation and implementation (project management) and a first version of the module for innovation partners' integration.

This new project will be dedicated to the development of an integrated and improved innovation management system capable of supporting the following processes: idea generation and implementation; innovation strategic partners' integration; knowledge management and technological surveillance; open innovation/ crowdsourcing.

Partner: Linkintense, S.A. | InCorporate (coordinator).

Outcome: Integrated and optimized innovation management software solution.

IoTiP – Internet of Things in Package: Wafer Level Modular Architecture for Internet of Things 4

Description: Over the last few years we have seen the integration of sensor technology, processing power and radio connectivity in the objects that surround us in our daily life, corresponding to the emerging Internet of Things (IoT). Despite the increasing number of smart devices there are still some challenges that have a negative impact in the sustainability and dissemination of the IoT. One of the most concerning challenges is the time and costs associated with hardware development. Having this in mind, IoTiP addresses these problems by presenting a development platform that will contribute for the spread of the IoT concept. IoTiP's platform combines hardware, firmware and software components to build a development ecosystem for the IoT. This will contribute to the simplification and speeding-up of the development of new IoT solutions, thus contributing for a more advanced technology addressing new markets and requirements.

Furthermore, IoTiP will also address technical related issues, such as miniaturization, reduction of energy consumption, integration with other systems or the access to higher levels of information.

The proposed ecosystem is built on the top of a new System-in-Package (SiP) that embeds sensing, processing, energy management and radio communications. This chip will also provide a physical interface to enable a modular architecture for adding new features that can be of practical use in a huge variety of applications. Moreover, IoTiP's ecosystem will provide a hardware abstraction layer that will allow developers to seamlessly interact with the SiP and its features in order to reduce even further the development cycle. In the scope of the project it is also proposed the development of a web platform to provide the specifications, documentation and examples to develop solutions based on IoTiP's ecosystem.

Not only is the project goal to offer a development platform that stimulates the creation of new IoT solutions, but also to enable former low-tech industries, such as footwear or textile industries, to embed technology in their solutions yielding a differentiated product.

Partner: Nanium, S.A. (coordinator).

Outcome: Development ecosystem for the Internet of Things that includes:

- A novel miniaturized and modular SiP architecture;
- An abstraction layer featuring seamless access to hardware core functions and optimized algorithms for information extraction;
- A web portal to present the ecosystem, features, documentation and examples;
- An example application developed based on IoTiP's ecosystem to demonstrate its potential and main advantages.



MASPARK – Characterizing Freezing of Gait in Parkinson’s Disease

Description: Among the symptoms that mostly impact quality of life for people affected by Parkinson Disease (PD) are the problems associated with walking: rate loss, slowing down, shuffling and freezing. Freezing is strongly related to the cognitive disorders that many of these patients show. Freezing responds poorly and irregularly to drug therapy and deep brain stimulation. To improve this, rhythmic sensory stimuli at frequencies related to the speed and cadence of the march are successfully being used. In a previous project, REMPARK, an automatic mobility support system (SAM) for PD was developed, consisting of a wearable inertial sensor for real-time detection of abnormal gait, wirelessly connected to a mobile phone which, in turn, acts as a gateway and processes the data from the sensory stimulation devices.

In the MASPARK project we are using this system to study freezing: there is a group of 25–30 patients meeting inclusion criteria. The experiment is performed at the day-care centre and at patients’ homes.

The following parameters are measured:

- The number of freezing episodes and how long they stay frozen at baseline, on and off, for one week;
- The same parameters while applying sensory stimuli: acoustic, for one week, after one month;
- Assessment of quality of life before and after wearing the SAM, with and without automatic application of the sensory cues.

Partners: Centro Médico Teknon (coordinator); UPC – Universitat Politècnica de Catalunya.

Outcome: Improve the Auditory Cueing System with music. Help evaluate the system’s impact on quality of life through Technology Acceptance Models.

MobileDRS – Mobile Diabetic Retinopathy Screening

Description: Diabetic Retinopathy Screening is a project with the Portuguese company First Solutions – Sistemas de Informação, S.A. with the goal of developing and validating a mobile solution for the risk assessment of diabetic retinopathy by image processing. The project will be focused on the screening of preliminary diabetic retinopathy. The mobile solution must be integrated with an information system for management of Population Screening Programmes, which allows the implementation of the functional circuit from the examination invitation to treatment and follow-up (SiiMA Rastreios: <http://www.first-global.com/pt-pt/Solucoes/SiiMA-Rastreios/RRD>).

Partner: First Solutions – Sistemas de Informação, S.A. (coordinator).

Outcome: Mobile-based Risk Assessment of Diabetic Retinopathy by Image Processing (MSc Thesis EyeFundusScope), integrated with retinopathy screening solution of FIRST’s SiiMA Rastreios.



My-AHA – My Active and Healthy Ageing 5

Description: The project proposes a holistic view of interrelated frailties: cognitive decline, physical frailty, depression and anxiety, social isolation and poor sleep quality, which are a major burden to older adults and social and health care systems. Early detection and intervention are crucial in sustaining Active and Healthy Ageing (AHA) and slowing or reversing further decline.

The main aim of My-AHA is to reduce frailty risk by improving physical activity and cognitive function, psychological state, social resources, nutrition, sleep and overall well-being. It will empower older citizens to better manage their own health, resulting in healthcare cost savings. My-AHA will use state-of-the-art analytical concepts to provide new ways of health monitoring and disease prevention through individualized profiling and personalized recommendations, feedback and support.

An Information and Communication Technologies based (ICT-based) platform will detect defined risks in the frailty domains early and accurately via non-stigmatising embedded sensors and data readily available in the daily living environment of older adults. When risk is detected, My-AHA will provide targeted ICT-based interventions with a scientific evidence base of efficacy, including vetted offerings from established providers of medical and AHA support. These interventions will follow an integrated approach to motivate users to participate in exercise, cognitively stimulating games and social networking to achieve long-term behavioural change, sustained by continued end user engagement with My-AHA.

The proposed platform will provide numerous incentives to engage diverse stakeholders, constituting a sustainable ecosystem with empowered end users and reliable standardised interfaces for solutions providers, which will be ready for larger scale deployment at project end. The ultimate aim is to deliver significant innovation in the area of AHA by cooperation with European health care organizations, Small or Medium-sized Enterprise (SMEs), Non-Governmental Organization (NGOs), etc.

Partners: Università degli Studi di Torino (coordinator); Deutsche Sporthochschule Köln; GESMED – Gestió Socio Sanitaria al Mediterrani, SL; IBV – Instituto de Biomecánica de Valencia; Institut für experimentelle Psychophysiologie GmbH; Istituto Superiore Mario Boella sulle Tecnologie dell'Informazione e delle Telecomunicazioni; IP Health Solutions BV; Johanniter Österreich Ausbildung und Forschung gemeinnützige GmbH; JIN CO Ltd; Kaasa solution GmbH; Loughborough University; Seoul National University; Tohoku University – National University Corporation; Universität Siegen; USC – University of the Sunshine Coast.

Outcome: Development of an innovative ICT-based platform to detect subtle changes in physical, cognitive and social domains that indicate an increased risk of subsequent vicious cycle of disability and diseases, including dementia, depression, frailty and falls. The ICT-platform will continuously monitor individuals' risk profile including their lifestyles with cognitive, physical and social capabilities. This information will be used to determine individuals' risk profiles and to provide personalized intervention strategies for sustainable use.

The ultimate purpose of My-AHA is to contribute to the slow-down of cognitive and physical decline and, possibly, delay the onset of associated end-stage diseases through empowering citizens to manage their own health by improved health literacy.



Physio@Home – My Rehabilitation Suite at Home 6

Description: Physiotherapy is an effective treatment prescription in various clinical scenarios, for example, to minimize musculo-skeletal pain, recover the range of motion after joint surgery, recover function and independence after stroke or other neurological damage, improve posture, among others. A high number of sessions and the compliance with the correct repetition of the exercises proposed, requiring focus and motivation, are crucial to the success of this kind of interventions.

However, the number of sessions is usually low as compared with the potential of recovery of the patient, because of time and cost limitations. It is frequently recommended to the patient to continue practicing some exercises at home, which is difficult to accomplish due to lack of motivation and feedback during the execution of the exercises.

The current project aims to develop a solution to extend physiotherapy programmes to people's homes as a complement to the sessions performed at the clinics. The solution proposed is based on smartphones or tablets and wearables containing electromyography (EMG) and inertial sensors that will be used to track the execution of the movements and give biofeedback to the user. The smartphone or tablet will display intuitive games that will guide the user through the execution of the exercises and provide biofeedback. The performance metrics collected about the exercises during the games will be stored and made available to the physiotherapist through a web portal.

The gamification of rehabilitation exercises and their deployment in ubiquitous and pervasive devices, such as smartphones or tablets in combination with wearables for movement monitoring, will enable a more engaging complement to physiotherapy sessions and ensure the correct execution of the exercises at home.

Partner: PLUX – Wireless Biosignals, S.A. (coordinator).

Outcome: A rehabilitation suite that can be taken home in order to improve the motivation and adherence to complementary sessions of physiotherapy at home by using exercise interactive video games (exergames) and wearables.

This project intends to improve the efficiency and cost-efficacy of physiotherapy and rehabilitation processes by allowing to complement the sessions at the clinics with the execution of some exercises at home.

The project will result in a new product for PLUX, extending their Physioplux system that is currently only used at clinical facilities to the user's home.



ShopView2Market – Automated Solution to Validate Shelf Layouts in Stores 7

Description: ShopView leverages computer-vision technology for retailers that want to gain a competitive edge in product placement auditing. The solution relies in a drivable platform equipped with a high speed flash synced with multiple digital cameras, aided by a light softener, a laptop and a couple of sensors to:

- Photograph shelves – controlling reflections and minimizing blur in high-resolution;
- Recognize the positioning of real products – via information and image processing algorithms;
- Evaluate product placement – validating against target planograms;
- Reporting errors to store manager in aisles covered by the Buggy's imaging system.

Other features include:

- Layout management of multiple stores;
- Map of aisles in floorplan;
- Panoramic full-length views;
- Label detection;
- European Article Number (EAN) decoding;
- Multiple-camera matching.

The former ShopView project has finished having its R&D objectives accomplished. Although it is capable of doing the job with a considerable degree of reliability, some challenges and limitations were identified through the execution of the project: automatic integration, usability, auditing features should be completed with correction features – to be able to act upon the information created by ShopView, e.g. for restocking, rearranging and optimizing shelf product placement.

FhP-AICOS proposed to address the identified issues in ShopView and complete the validation of the solution throughout a long-term pilot, with demonstrators all over the world: the ShopView2Market.

Partners: WeDo Consulting – Sistemas de Informação, S.A. (coordinator); Sonae Modelo Continente, S.A.

Outcome: ShopView2Market solution validated with high (7) Technology Readiness Level, with enough maturity for product roadmap and commercial use, which means:

- Demonstrations without critical failures in operational environment;
- Easy installation and configuration;
- Fully integration with retailer business model;
- Functionalities adapted to user expectations.



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SmartBEAT – Smart System for the Management of Heart Failure in Older Adults 8

Description: The increasing number of patients with Heart Failure is overloading the public healthcare systems. In Portugal there are 260.000 individuals with Heart Failure and in Europe this figure reaches 15.000.000. The prevalence of the disease in citizens with 70+ years is of over 10%. In Portugal, Europe and in the U.S., the costs associated with this pathology represent 1-2% of all costs related to healthcare and it is estimated that the recurrent hospitalizations, common in Heart Failure patients, correspond to, approximately, 70% of all HF costs. An example of the increasing impact of Heart Failure on health systems is the priority given in the U.S. to the development of strategies that reduce readmission of patients with Heart Failure.

The SmartBEAT project aims to address the needs of senior Heart Failure patients and their formal and informal caregivers by offering an integrated solution to leverage patient self-care through autonomous condition monitoring and real-time feedback to their caregivers. Using SmartBEAT, it is possible to improve disease outcomes and enhance the quality of life of senior Heart Failure patients. This objective will be achieved through the acquisition of user's physiological data using a Vital Signs System and a smartphone application integrated with a Monitoring Engine and a Caregivers Gateway for data analysis, management and reporting.

Partners: FhP-AICOS (coordinator); CHSJ – Centro Hospitalar São João; FMUP – Faculdade de Medicina da Universidade do Porto; KempenLIFE; LifeOnKey Inc; Remedus BVBA; Seniornett Norge; SGE – (Stichting Gezondheidscentra Eindhoven); Smart Homes – Nationaal Kenniscentrum voor Domotica & Slim Wonen; Verhaert – New Products & Services NV; Vigisense SA.

Outcome: SmartBEAT proposes to develop a system that allows for Heart Failure outpatients mobile monitoring and screening. The solution aims at early identification of hemodynamic imbalance inherent in an episode of acute decompensated Heart Failure. SmartBEAT is a simple, cheap and quick follow-up solution for Heart Failure older adults which allows to optimize the quality of care, reduce costs, reduce the number of readmissions and, ultimately, improve the prognosis and reduce mortality in this population.

TABPHONE – Senior Tabphone

Description: The aim of this project is to develop a tabphone to be used by elders, allowing them to monitor health parameters and physical activity. Additionally, it should also locate the users (indoor and/or outdoor) when wearing the planned developed smart bracelet. The tabphone should be resistant to falls, liquids and dust. Moreover it should be ergonomically adapted to the physical characteristics of the elderly population. The connection between the tablet/ Docking Station should occur without the need for physical connection, allowing, for example, for the battery to be charged with a wireless technology (e.g. induction). The tabphone will be integrated with sensors for measuring vital signs, such as heart rate and Electrocardiogram (ECG).

Another objective is the development of a bracelet as an accessory device of the tabphone that can be used by the elderly, when walking. Whenever the elderly is wearing the bracelet, the device must perform a set of measurements related to monitoring physical activity, locating the user indoor and/or outdoor and detecting user's falls. It should act as a modular element that can communicate with the tablet / Docking Station whenever in their reach. Alternatively, it must also possess the ability of working independently, transmitting the recorded measurements through mobile network with a GSM card.

Partner: HidePixel, Lda. | SiosLIFE (coordinator).

Outcome: Integration of FhP-AICOS fall detection and activity monitoring algorithms in the bracelet planned by the consortium.

WGW4IoT – Wireless Gateway for IoT 9

Description: The goal of this project is to develop a wireless gateway to control a wireless sensor network of up to 100 temperature reading sensors for industrial environments, following the concepts of the Internet of Things topic.

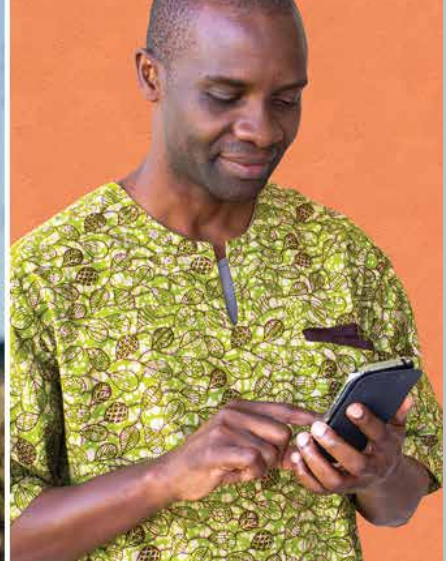
The gateway (GW) shall communicate with the sensors via one of several supported Radio Frequency (RF) protocols: Zigbee, Bluetooth, 6LoWPAN, LoRa, etc., as well as proprietary ones. The RF modules (manufactured by the client) will be attachable to the GW, which in turn shall recognize the type of RF protocol that is being used (there will be no simultaneous usage of more than one RF technology). The GW shall also store the readings sent by the sensors and allow access to the stored information via RS485 and Ethernet ports, using Modbus protocol or through an available RESTful API.

On the local intranet, a web portal served by the GW will allow the visualization of data, control and configuration of the GW and of the Wireless network.

Partner: Bresimar Automação, S.A. (coordinator).

Outcome:

- Innovative and scalable sensor gateway ready for industrial environments;
- Reutilization of some results of the EnAware project.



INTERNAL PROJECTS

In order to foster core competence building and to enhance our team's experience, we frequently assess ideas and launch internal project initiatives.

Comm4Dev – Communications for Development 9

Description: WiBACK and PostboxSync (the evolution of PostboxWeb) are joining forces to explore the lack of a GSM stable solution by creating the concept of the Comm4Dev – a reliable, stable, easy to use and self-configurable solution. Together with PostboxSync, they shall allow to greatly extend the covered and connected areas.

The Comm4Dev includes a communication system for voice (GSM) and data (IP/internet via Wi-Fi and/or 3G/Sat) with an easy setup, and auto and/or remote configuration, opening the possibility to remove the need to have technical persons on site. Therefore, Comm4Dev (the WiBACK component) must support clients with third party SIM cards and data transmission on the smartphones using PostboxSync.

Partners: Core Network Dynamics GmbH; Fraunhofer FOKUS.

Outcome: WiBACK offers true and very economic internet access in rural areas, while PostboxSync offers store-and-forward internet access for Android Phones suitable for many scenarios without additional infrastructure. The milestones include:

- Integrated demo for infrastructure and software integration under a common environment, to serve remote and uncovered areas where the platform may address the communication needs;

- PostboxSync Framework for Android with analytics and PostboxServer;
- Postbox Companion with a set of applications installed according to the context of use, which are able to run within PostboxSync environment for Android.

DEMalariaScope – Digital Analysis of Malaria Infected Blood Smears via Mobile Devices

(Associated with the DeM – Deus ex Machina)

Description: The main goal of the DEMalariaScope is to contribute to the EITCC and simultaneously improve the MalariaScope solution. For the EITCC, this project will create components for local image processing and information fusion, as well as explore new approaches for machine-learning and cloud computing. These outcomes will then be used to improve the MalariaScope solution and other C3 companions based on image processing (e.g. EyeFundusScope).

Specifically for MalariaScope, the aim is to increase the robustness of the optical magnification prototype and performance of the image processing modules in terms of classification and computational time. Moreover, the final MalariaScope solution will be considered as an output of the C3 in the area of health and wellbeing.

Partner: INSA – Instituto Nacional de Saúde Dr. Ricardo Jorge.

Outcome:

- Prototypes of sensors and actuators;
- Performance tests of sensors / actuators and algorithms;

- Prototype of information fusion of sensors of the same kind;
- Field tests with prototypes of local information fusion algorithms;
- Tests with prototypes of remote fusing algorithms and big data analytics in the cloud;
- Prototypes of machine learning algorithms for sensing and contextual data;
- Field tests with remote fusion algorithms and big data analytics in the cloud.

DEMBACCHUS – Boosting Agriculture with a Companion for Connecting Healthy Plants, Users and Sensors 10

(Associated with the DeM – Deus ex Machina)

Description: Boosting Agriculture with a Companion for Connecting Healthy Plants, Users and Sensors (BACCHUS) is a subproject of DEM – Symbiotic technology for societal efficiency gains.

Sustainable Precision Agriculture is a farming activity that associates viable technology to standard agriculture methodologies. Boosting productivity, reducing waste and improving agro-food quality requires intelligent, environmental and knowledge-based decision making systems, as precision tools that deliver quick solutions to act on over-fertilization, climate change and chemical-charged soils.

Image processing and computer vision techniques will have a major input from the soft computing area, namely advanced neural computing and machine learning, as a way to incorporate uncertainty in the associated support systems.

Algorithms of background analysis will be developed for early detection of stress conditions in crops, digesting the risk factors and producing individual advices on diseases and pests.

The different stakeholders need to be able to get the right information at the right time and place. Mobile technologies have the potential to play a major role in the improvement of these recommendation systems.

We envision the BACCHUS solution to be of interest for winemaking companies, towards connecting the producers, farmers and retailers through systems for managing the full supply chain using big data and cloud services from the EITCC.

A Farming Education module will provide the best practices and actuation methods to allow the farmer to be connected to a broader community, sharing experiences and making use of the common knowledge. The highly visual representation of information and easy interaction with the end-users will be crucial for a true companion in agriculture. The use of mobile technologies brings together this wider perspective of the agriculture within the economic, social and institutional environment, making the development of specialized tools a differentiator factor to foster the productivity and performance of individual farmers.

For cost-optimized farming with healthy crops and correct growth on time, meteorological data in combination with actual physical parameters of the current status of the crops, as the leaf moisture, must be evaluated and combined. Water stress evaluation, which is gaining renewed importance in climate changing scenarios, is one of the challenges that the north area of Portugal is facing. The information provided by non-destructive techniques, as hyperspectral imaging, will be fused with other types of sensors to evaluate water stress. Driven by the high value of the crop, precision viticulture will



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be focused on grape quality and yield maps, both of great importance during harvest to avoid mixing grapes of different potential wine qualities.

This project will also include prototype validation in real scenarios of hydroponics, green houses and open fields.

Partner: UTAD – Universidade de Trás-os-Montes e Alto Douro.

Outcome: BACCHUS will be a mobile companion for crop monitoring and farming education by using recommendation tools and will include the following features:

- Agriculture companions to control and predict the productivity;
- Real time monitoring to allow an efficient and timely actuation;
- Storage of historical information and learning from past experience will allow to detect behaviour patterns and to provide intelligent recommendations or alerts.

DEMCloudIoTRepo – Cloud Repository for Datasets Management and Data Visualization (Associated with the DeM – Deus ex Machina)

Description: In the context of the Deus ex Machina (DeM), the objective of this project is to develop tools and Application Programming Interface (APIs) for the management, visualization and storage of datasets in a centralized cloud infrastructure.

This research line has a strong focus on the development of algorithms to process Internet of Things (IoT) sensor data and therefore a solution to support the collection, storage, access and visualization of all data becomes a valuable asset. This solution aims to be the foundation that will support the development and validation of signal processing and machine learning algorithms which rely on samples associated with ground truth.

Besides supporting the development process, other outputs will be produced that can be reused by other projects:

- A data model that is able to represent data from very different sensors (inertial, temperature, imaging, etc.) may become the standard to represent data across all projects which will increase the compatibility and reusability of all algorithms;
- Communication protocols will be researched to find the most suitable to efficiently and securely communicate data of this nature;
- A flexible visualization tool will support the data analysis process both in development and production environments.

Partners: There are no partners in this project.

Outcome:

- Central Cloud based Repository for Datasets of sensor data to centrally store the sensor datasets from all projects;
- Services to store sensor data in the central repository;

- Services to read sensor data stored in the central repository;
- Security mechanisms to ensure authentication and access authorization to the services;
- Standard representation of sensor data to be used in all projects – maximize interoperability between components.

DEMComm4Dev – Comm4Dev

(Associated with the DeM – Deus ex Machina)

Description: Development of solutions for ad-hoc broadband networks for remote locations in developing countries.

Provisioning of broadband access to regions with lower population density and, consequently, with no (or with poor quality) broadband installations. The ever same problem for these areas is the cost per user which is too high to deploy a fibre infrastructure or conventional mobile broadband networks (4G). The ad-hoc planned networks are self-managing and are very energy efficient in order to make use of renewable sources to power them. They are also suitable to get deployed in rural areas in industrial countries with limited connectivity in agriculture scenarios.

This project aims to develop a software framework that exposes a Delay Tolerant Network (DTN) architecture based on Android smartphones, by enhancing the results obtained from PostboxWeb, and to develop lean integration strategies to connect existing mobile networks from commercial operators to interface with the low cost ad-hoc networks described.

Partners: Core Network Dynamics GmbH; Fraunhofer FOKUS.

Outcome:

- Prototypes for network infrastructure and software framework for disruptive scenarios;
- Report on field tests with prototypes of low-cost/low-power and reliable wireless technology in uncovered areas;
- Bluetooth Mesh integration to final prototypes of network infrastructure for disruptive scenarios.

DEMCommunity – Community Tools

(Associated with the DeM – Deus ex Machina)

Description: Community tools aim to integrate both formal and informal approaches to citizen engagement, focusing on the link between the use of new technologies, digital education and social inclusion, particularly for disadvantage and vulnerable groups, either in Europe or Sub-Saharan Africa. The goal of DEMCommunity is the development of inclusive tools, focused on citizen empowerment, participatory monitoring, urban service delivery and social equity.

This project will provide core competences that will support the activities under the scope of the C3 research line. The tasks considered in this project are directly related with the study and development of solutions that can be used by citizens either in European and African contexts, improving their lifestyles and taking advantage of Information and Communication Technologies (ICT) to improve daily activities. Among these tasks are considered the continuous evolution of some existing projects (e.g. IZIDoc and Ourmoz) and tasks related with the adaptation of some apps to be used in different contexts (e.g. PostboxWeb).



This project also intends to take advantage of our partnership with Eduardo Mondlane University (UEM) from Maputo, Mozambique. This partnership provides a real testing environment, extremely useful for field tests, providing information about the usability and feasibility of our products in real environments.

Partner: CIUEM – Centro de Informática da Universidade Eduardo Mondlane.

Outcome:

- Develop a platform to simplify administrative procedures between citizens and public services by mediating process management and improving efficiency of service delivery;
- Develop a crowdsourcing platform for easy information exchange among citizens, creating open and inclusive communication and data collection channels between the community, decision-makers and institutions or public services;
- Develop tools and methodologies that make platforms available and functional for every citizen, focusing on usability issues, reaching vulnerable or poorly represented citizens and bridging the digital divide.

DEMEyeFS – EyeFundusScope 11

(Associated with the DeM – Deus ex Machina)

Description: The main goal of DEMEyeFS is to allow a non-expert assessment of diabetic retinopathy with the aim of enhancing the proximity of screening programmes to the population, by:

- Helping collecting images of the retina with low-cost equipment that can be widely available, oppositely to the retinograph (gold standard but 30 times more expensive);
- Automatically detecting microaneurysms and other relevant structures with a smartphone-based solution to recommend forwarding relevant cases to a reading centre in a central hospital.

Partners: There are no partners in this project.

Outcome:

- Improvements in the construction of a prototype to improve the field-of-view and image quality even without drug-induced pupil dilation;
- Local and Remote Decision-Support System for Diabetic Retinopathy;
- Segmentation methods for real-time segmentation of mobile-acquired images.



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DEMInd – Mind and Behaviour 12

(Associated with the DeM – Deus ex Machina)

Description: Regardless of the application domain, human-computer interaction is central to the development of companions within project C3. Therefore, this project is designed to conduct research on fundamental principles of human-computer interaction which can support the developments to be made at service and application levels for the companions.

Examples of studies to fit under DEMInd are: ethics, attention, perception, memory, iconography, language or multitasking.

Partners: There are no partners in this project.

Outcome: Support to the development of C3 companions.

DEMLOC – Location Awareness Platform

(Associated with the DeM – Deus ex Machina)

Description: The location based services market is forecast to generate over €40.000 million by 2019. Given our interest in including location awareness in some of our current projects, and its potential for future companions, it is very appealing to focus our efforts in this field applied on a single robust platform. DEMLoc will shape a group of experts in finding and tracking people, animals or objects, aiming to minimize tasks replication in the localisation field internally, thus optimising efficiency and delivery times.

The idea is to create a software library that estimates the most accurate positioning information the available data can provide, which may, subsequently, be extended to appropriately match each companion's needs. Using this information, health care professionals can track patients,

equipment and supplies inside hospitals, retailers can use analytics to improve their stores management, regular people can find their way to safety during emergency situations and an endless stream of other benefits.

Data to be used by this platform can come from a myriad of sources which include inertial and positioning sensors and Wi-Fi, Bluetooth, GSM and GPS radios, either from a single device or a fusion of multiple sources. Even contextual information, like learning a user's schedule and habits, can be used to infer location.

Partners: There are no partners in this project.

Outcome:

- Software library that estimates the most accurate positioning information possible;
- Separate software libraries for each positioning module;
- Basic demonstration software for each developed module, helping companions to integrate the corresponding features.

DEMNutritionHF – DEM NutritionHF

(Associated with the DeM – Deus ex Machina)

Description: When professionals recommend a nutritional plan to their clients, they need to be aware of several factors which influence, or are influenced by, their recommendations. This project will use FhP-AICOS' experience on the development of nutritional recommendation systems and explore the use case of patients with Heart Failure.



A nutritional companion for adults with Heart Failure will be developed:

- Loads information from Portuguese nutritional database;
- Provides a nutritional plan added/created by a health professionals, taking into consideration the nutritional limitations of the disease;
- Verifies the nutritional plan compliance;
- Provides educational tips for the patients.

Partner: CINTESIS – Centro de Investigação em Tecnologias e Serviços de Saúde.

Outcome: Recommendation system for Heart Failure patients.

DEMSafety – Towards Increased Safety of Field Operatives and Improved Emergency Situation Management 13 (Associated with the DeM – Deus ex Machina)

Description: The main purpose of this project is to develop a companion for remote monitoring of the activities of field operatives in the context of operations management, for accurate and timely decision making during the management of critical field operations.

This project will output new advances in optimizing strategies for emergency situations by fusing the physiological data, geolocation and physical activity of field operatives, improving responses in firefighting and rescue scenarios.

Opportunistic wearable physiological sensors and inertial sensor processing, developed in the EITCC, will allow to recognize the condition (stress, heart rate, body temperature, etc.) and physical activity of the field operative, for example if he is walking, running or has felt. The exact location of the operatives may be also obtained using GPS outdoors, enabling the detection of isolated operatives.

Also, advances in real-time processing of streamed video will help to better understand the context of the operation, for example if the operative is moving in a crowded area, if there is smoke, fog or other environmental factor, as well as detecting events that may be relevant for operations management. The video streams should be provided by the wearables, optionally complemented by images from drones and vigilance street cameras, making it possible to understand the context of the operation.

All the information collected is gathered in the operations management centre where, using data analytics algorithms developed in the EITCC, meaningful information about the operation will be extracted and provided to the operations manager, along with recommended actions to support critical decision making.

Partner: CIDESD – Centro de Investigação em Desporto, Saúde e Desenvolvimento Humano.

Outcome: The outcome will be a complete ecosystem for remote management of field operatives and emergency situations, which will open new business opportunities with safety, security and insurance companies, firefighters and police associations. This activity should be developed in collaboration with the research centre in sports sciences, health sciences and human development – CIDESD – and with the relevant input and collaboration from the firefighters squad from the Portuguese municipality Tarouca.

DEMSmartCompanion – SmartCompanion 14

(Associated with the DeM – Deus ex Machina)

Description: Google Fit was a software framework allowing app developers and hardware makers to record, log and display health-related data with as little coding as possible. Google Fit is made up of three APIs: Sensors, Recording and History. These APIs are the Google-prescribed standards for getting data from physical sensors to apps and interfaces that want to use it. The official list of data types covers activity times and types, calories burned, pedalling rate, wheel speed, distance covered, heart rate, height, weight, power generated in a workout, steps taken and elevation.

Apple Health, worked in the same direction, by concentrating the data from all those fitness apps and wearable companion apps on the iPhone and attempting to put the data in one place. Apple's official list of default data types is more comprehensive. It covers gender, sleep patterns, blood type, workout duration and intensity, body temperature, heart rate, blood alcohol level, blood glucose, diet, cycling activity, walking activity and more, even how many times a person has fallen.

Since in Android most of the health data types provided by Apple health, like sleep patterns, blood type, heart rate and blood glucose, are not available, we think that Smart Companion could provide this API in order to concentrate in the launcher a set of default data types (e.g. medication, chronicle diseases, caregiver contact, gender, weight, height, age, walking activity, etc.). As so, third party applications or companions can access this data types and used them. Moreover, these applications could also insert data into this content provider.

Additionally, continuous improvements to SmartCompanion are planned, including usability testing and UI re-designs, development of an initial tutorial and set-up integrated with a contacts migration tool.

Partners: There are no partners in this project.

Outcome:

- Smart Companion User profile and data content provider;
- Provide Smart Companion data to third-party apps (e.g. medication that user is taking, or physical activity);
- Usability improvements and new tutorial with simplified contacts migration.

DEMSmartMoves – Continuous Accelerometry Monitoring of Fall Risk and Real Falls

(Associated with the DeM – Deus ex Machina)

Description: The main goal of the DEMSmartMoves is to contribute to the DEM EITCC and C3 with the following Work Packages:

- EITCC Sensing and actuating – First and second prototypes of data processing algorithms. Development of fall detection and activity monitoring algorithms that are independent of in-body sensor location. Extraction of metrics such as the time, speed, amplitude, symmetry of movements, or the usual sequence / patterns of activities. Computation and validation of continuous metrics of physical activity, such as number of steps, activity/inactivity periods, variability of gait, among others and their combination in a physical risk of falling index. The level of association between this index and the falls occurrence frequency will be determined. The Falls Detection algorithm will be improved and validated against other studies using the FARSEEING Real Falls Database. The combination



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of metrics in a risk of falling index will be validated by association with the falls occurrence frequency;

- C3 Activity monitoring – Prototype of companion for daily living activities monitoring. Development of interfaces of the companion for continuous fall risk assessment and recommendations for falls prevention;
- EITCC Local information fusion – First prototype of inertial sensor fusion algorithms. Development of a tool for easily training a classifier suitable for arm gestures recognition and then deploying it in an Android. Since the arm has a great number of degrees of freedom and wrist movements and gestures are very diverse, the inertial sensor signals obtained from free daily living conditions in this position are expected to be very noisy. Therefore gesture recognition problems are not trivial and should be addressed using classifiers that are able to take into account both sequences of sub-gesture motions and model inter-gesture sequential dependencies, for example higher order Hidden Markov Models. In order to achieve high recognition accuracy, other levels of information, such as location and time of the day could also be added in a higher level classification layer. This module will then be used in activity monitoring companions, in particular for rehabilitation and physical activity monitoring and in nutrition companions, for reporting of food and beverages intake;
- C3 Activity monitoring – Prototype of companions for physical activity monitoring. Development of interfaces of the companion for recognition and characterization of movements for physical activity and rehabilitation.

Outcome: The main outcomes of this project are:

- Algorithms and interfaces for continuous fall risk monitoring;
- Algorithms for recognition and characterization of specific arm movements and gestures;
- Interfaces to apply these algorithms in the scope of rehabilitation and physiotherapy movements;
- In addition, the DeM deliverables referred will be produced.

DEMThings – Sensing Things

(Associated with the DeM – Deus ex Machina)

Description: Combining data from multiple sources is mandatory to understand how humans behave and how we relate with the 'things' that surround us on our everyday life. By extracting and combining information from the data collected by multiple sources it is possible to get more meaningful information.

Combined information can then be used to understand the context where a user is inserted, in order to enhance its experience and to provide a personalized and most helpful service to fulfil a specific task. Combining multiple sources of data can also be used to extract information related to trends (in agricultural environments for instance) and even to anticipate future behaviours.

In order to merge multiple sources of sensor data there are several challenges that need to be tackled, being time synchronization issues one of the most relevant. Additionally, the tools used to visualize combined data and extracted information need also to be adapted to ensure that it can be easily perceived.

Partners: There are no partners in this project.



The main purpose of this project is to develop the necessary mechanisms to synchronize and compress the data collected from multiple sources (e.g. several inertial sensors placed around the human body, such as smartphones, watches and Pandlets).

These developments aim to ensure that data acquisition and transmission process are the most accurate and efficient, by maintaining data integrity and reducing power consumption.

Moreover, this project aims to create an intuitive visualization tool based on a dashboard that can be configured to display different types of data or information and combine them.

Partner: Centro ALGORITMI.

Outcome: The developments under the scope of this project will directly contribute for EITCC's Sensing and acting, Local processing and fusion and Remote fusing and big data analytics in the cloud.

Moreover this project aims to:

- Explore data compression mechanisms to reduce the amount of data being transmitted through the network;
- Develop mechanisms to optimize Bluetooth Smart bandwidth.

Related to EITCC Information Fusion from complimentary sensors, EITCC Inertial Sensor Fusion and EITCC Information Fusion from sensors of the same kind tasks, this project aims to:

- Explore and implement synchronization mechanisms to allow data collection from multiple sources.

Related to EITCC Cloud visualization of the sensed and processed data, this project aims to:

- Develop a dashboard to represent time sequences that can be dynamically reconfigured based on data type.

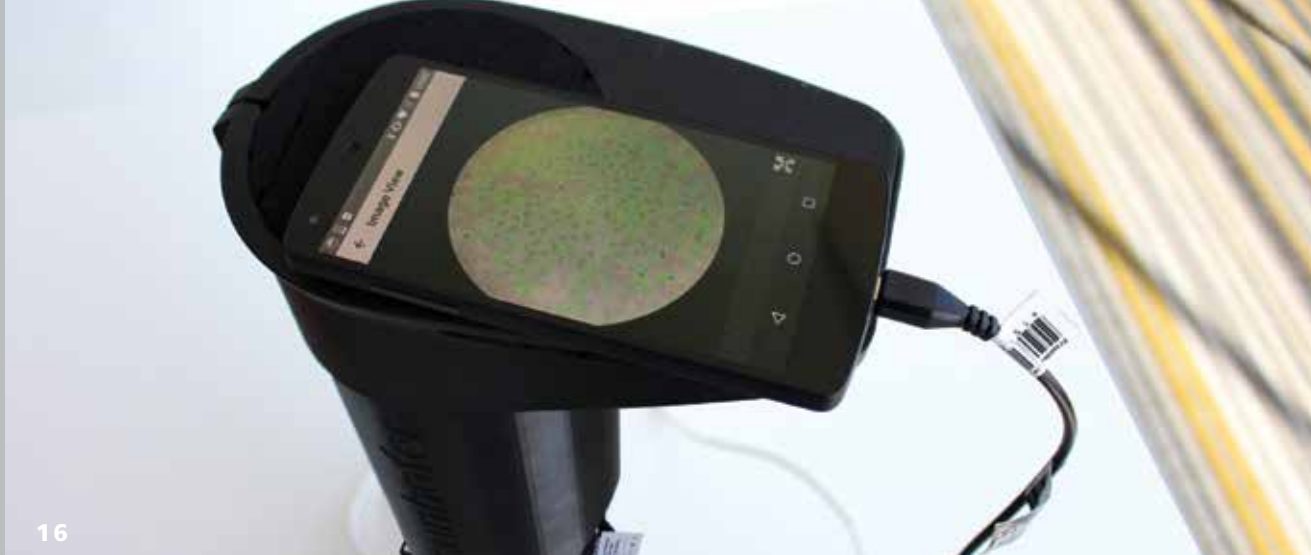
The results of this project should be independent blocks to ensure that they can be reused by other projects developed under the scope of DeM.

EyeFundusScope – Mobile-based Risk Assessment of Diabetic Retinopathy by Image Processing 15

Description: Diabetic Retinopathy is a Diabetes complication and the leading cause of avoidable blindness in adults. If detected early it can be treated by laser surgery, however its early detection is frequently missed since it progresses without symptoms until irreversible vision loss occurs. The continuous monitoring is therefore essential to protect the vision.

The EyeFundusScope concept comprises a smartphone, a low-cost ophthalmoscope mounted on the smartphone built-in camera, image processing algorithms for detection of microaneurysms (first sign) and decision-support to provide an indication of the presence of Diabetic Retinopathy. A solution based on this concept can be of great value in the context of large screening actions, in which a lower number of specialists needs to be involved, since it can be used by a general or non-specialist practitioner. In addition, it can be extended to other eye diseases and stand as a useful tool for eye health screening in developing countries.

Current work resulting from EyeFundusScope Master Thesis (MSc) already includes: a mobile app to capture images from the retina, optic disk tracking, vascular segmentation and microaneurysm detector, all running on a smartphone. However, we still need to improve the robustness of the detection methods and also to include a decision-support system.



This project aims at developing a smartphone-based image processing platform that will implement low computational-cost algorithms and yet highly efficient in the lower quality images of the smartphone camera. This platform will be structured in a flexible way so that it can be used to detect microaneurysms, but also other image features, aiming to be re-used in other FhP-AICOS projects.

In order to open the field-of-view and improve image quality, stitching algorithms similar to those used in ShopView can be implemented in the mobile framework (already tested in the MSc project). This is particularly important since drug-induced dilation of the pupil should be avoided in the screening scenario, for sake of simplicity and speed.

Partners: There are no partners in this project.

Outcome:

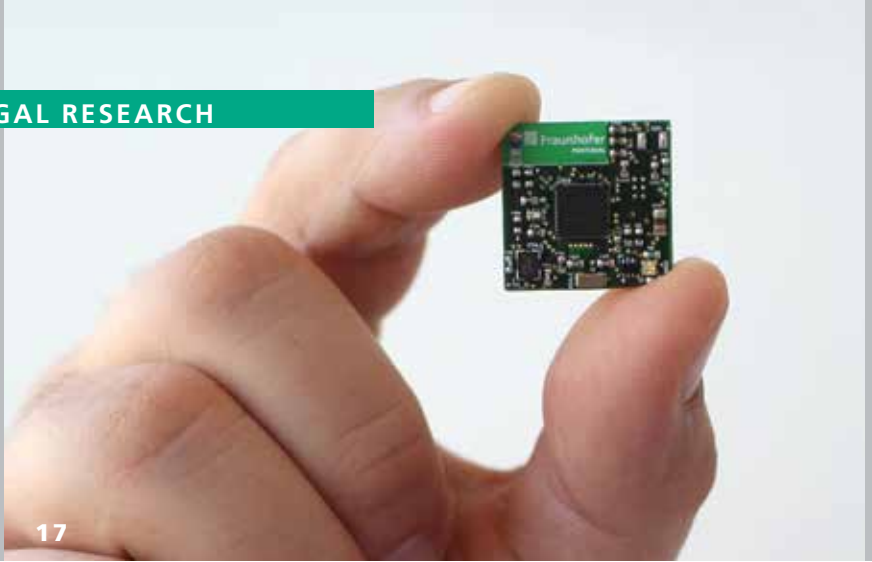
- Image processing Android platform adapted to use the processing power of current smartphones in the images acquired using the built-in camera;
- New prototype of a smartphone ophthalmoscope adapter using LED light;
- Fields of application:
 - Retinopathy screening solution and decision-support system;
 - Other eye diseases screening for developing countries;
 - Other Preventive Health projects using mHealth apps.

MalariaScope – Digital Analysis of Malaria Infected Blood Smears via Mobile Devices 16

Description: Malaria is a leading cause of death and disease in many developing countries, where young children and pregnant women are the most affected groups. In 2012, there were an estimated 207 million cases of Malaria, which caused approximately 627.000 Malaria deaths. Around 80% of Malaria cases occur in Africa, where the lack of access to Malaria diagnosis is largely due to a shortage of expertise, being the shortage of equipment the secondary factor. This lack of expertise for Malaria diagnosis frequently results on the increase of false positives, since prescription of medication is based only on symptoms. Thus, there is an urgent need of new tools that can facilitate the rapid and easy diagnosis of Malaria, especially in areas with limited access to quality healthcare services.

MalariaScope was a project included in FhP-AICOS' Information and Communications Technologies for Development Competence Center (ICT4DCC), in cooperation with the infectious diseases department of the National Health Institute Dr. Ricardo Jorge. This project aimed to create a mobile-based solution that can provide an effective pre-diagnosis of Malaria to be used in medically underserved areas. It uses the new generation of cellular phones in the system architecture, which exhibit significant improvements in terms of image acquisition and image processing and that are becoming widespread worldwide, even in developing countries. Moreover, this project aimed to create a magnification gadget that can be connected to the smartphone and provide the necessary magnification capability. Thus, the project was divided into three main components: the optical magnification component, the image processing and analysis component, and the smartphone application component.

Partner: INSA – Instituto Nacional de Saúde Dr. Ricardo Jorge.



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Outcome:

- **Optical Magnification:** The project aimed to develop a cheap alternative to the current microscopes, that can easily be adapted to a smartphone and to be used in the field. The developed optical magnification gadget guarantees the same magnification factor as a common microscope and uses the smartphone built-in camera to capture the images for further analysis. The process is to place the smartphone in the adapter along with the blood smear, and have the smartphone image sensor record a set of magnified images. This collection of acquired images is then processed and an analysis report of the blood smear is provided;
- **Image Processing and Analysis:** For the automatic detection of Malaria parasites, this project aimed to investigate computer-aided methods that can be used for the successful automatic analysis of Malaria-infected blood smears. The developed image processing and analysis module designed is able to: (1) Determine the parasite density of Plasmodium Falciparum species in the trophozoite life-cycle stage in thick blood smear images; (2) Identify and count the Plasmodium Falciparum species in the trophozoite life-cycle stage in the thin blood smear images;
- **Smartphone Application:** The MalariaScope solution was envisioned to be used by technical personnel without specialized knowledge in Malaria diagnosis. The user collects and prepares a blood sample of the patient, introducing it in a slot in the optical magnification prototype. Using the companion mobile application, installed in a smartphone that is coupled to the optical magnification prototype, the user can create new patients and add new samples (and the corresponding views) to a specific patient. The

user can then take pictures of the sample using the smartphone's camera, while using the stage XY axes controllers on the prototype to change the magnified views. The captured views can then be sent to analysis through the mobile app, which returns a report indicating the parasite density of each sample, so the correct procedures and medication can be administered.

nPandlets – Add-on Nodes for the Pandlets Ecosystem 17

Description: This project follows the road map established on the FhPSafetySensor project, during which the pandlets ecosystem was designed and the pandlet base dot, sensing dot and memory dot were produced, installed and used both in external and internal projects.

Based on this outputs several projects are now reusing the pandlets devices and ecosystem and this project will introduce new functionalities that will enhance the set of features in the pandlets ecosystem.

Partners: There are no partners in this project.

Outcome: The pandlets ecosystem will be enhanced with the following outcomes:

- A mesh network implementation based on Bluetooth smart;
- Additional sensing capabilities for precision agriculture;
- Improved embedded algorithms for location invariant activity monitoring;
- An Application Programming Interface (API) for controlling and collecting data from the new nodes.



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PIL – Precise Indoor Location 18

Description: Indoor location systems are an important enabling technology for applications such as indoor navigation, public safety and security management, ambient intelligence, as well as providing huge potential around advertisement and retail businesses.

Because of the lack of reliable GPS (Global Positioning System) signals inside buildings, the so-called pedestrian navigation systems (PNS) have emerged as a solution for the indoor positioning unsolved problem. These systems rely on dead reckoning algorithms based on fused data provided by an Inertial Measurement Unit (IMU).

Since smartphones embrace always-on and sensor fusion was already a topic studied at FhP-AICOS, under the scope of FCC, using these devices as IMUs seemed to be the obvious solution to achieve a highly accurate indoor location system at very low cost.

Dead reckoning based on the fused data provided by IMU on the smartphones can then be used to evaluate one's current position by using a previously determined position. Location-based sensor fusion will become a standard feature in next generation smartphones.

Since dead reckoning is subject to cumulative errors, navigational aids are needed in order to give accurate information on position. This aided information can be gathered from any system that can provide reference points with increased resolution.

In order to evaluate the accuracy of this location-based sensor fusion, FhP-AICOS' approach relies on the Ultra-Low Frequency Magnetic Communication (ULF-MC) system as

a navigational aid. ULF-MC is a communication technology developed at FhP-AICOS in 2012, that when combined with a last fix from a Global Navigation Satellite System (GNSS) will lead to absolute coordinates.

Partners: There are no partners in this project.

Outcome: This project will result in a service which maps navigational aids on a real-world indoor map model and project the path information, retrieved by the smartphone, over it.

SmartCompanionV3 – Smart Companion (Phase III)

Description: Smart Companion (SC) is an Android customization that was specially designed to address seniors' goals and needs. It aims to be a permanently available companion to support seniors in their daily activities, through a number of tools, from messaging to medication reminder applications. Smart Companion intends to create two ecosystems. On one side, a technological one where seniors can use multiple different gadgets like smartphones, tablets, tv's, bracelets, external sensors, weight scales, multimedia car systems, etc. And on the other side, Smart Companion wants also to support a social ecosystem where all the three levels of users can interact between each other:

- Primary User (Seniors);
- Secondary User (Informal Caregivers: children, family, friends);
- Tertiary User (Formal Caregivers: doctors, nurses, physicians).

Partners: There are no partners in this project.



Outcome:

- Smart Companion User profile and data content provider;
- New Smart Companion smartphone apps and integration of thesis and improvements;
- Integration of PIL for emergency scenarios;
- UI tablet improvements.

SmartMoves – Monitoring and Improving Physical and Cognitive Abilities

Description: Physical activity and specific body movements are increasingly being recommended as preventive or therapeutic prescriptions and also to improve well-being. Particularly, in the process of ageing, keeping the mobility, muscular strength, balance and cardiovascular resistance are essential protective measures against cardiovascular diseases, falls and associated consequences.

In a first stage the project is focused on monitoring specific movements performed in the context of rehabilitation or dance that require cognitive attention and a correct execution.

A tool to measure hip and knee angles during gait, lateral steps and knee bending was developed. The relative angles during movements are calculated using the inertial sensors and validated against goniometer measurements. Other metrics associated with rehabilitation movements are being studied and implemented.

A framework for evaluating dance movements is being developed taking into account similarities between the signals collected using inertial sensors and a previously generated template.

Partners: There are no partners in this project.

Outcome: One outcome of this project was a tool for accurate detection of angle variations in the hip and knee during the execution of three movements: hip lifting, lateral hip opening, knee flexing and extending. This tool will be extended to the evaluation of other specific movements and associated metrics in the context of rehabilitation.

Another outcome is the near real-time evaluation of dance movements and their classification in terms of correctness of execution and timing against a signal template.

SousChefV2 – Mobile Application for Older Adult Nutrition (Phase II) 19

Description: Nutrition and physical activity are at the basis of active ageing. SousChefV2 is following FhP-AICOS' previous developments in the field of nutrition. Field research and field trials have shown that older adults require information and guidance on nutrition-related decisions. Furthermore, monitoring of nutritional intake and physical activity are useful not only for users themselves, but also for professional caregivers.

The project will enhance the original SousChef project to do the following:

- Integrate FhP-AICOS' previous work on activity monitoring;
- Prepare the recommender system to be able to include: price, product season, weather, meal price, stock management, leftovers, food intake logging and generation of a shopping list;
- Develop a smartphone application that will be able to generate a meal plan, change meals according



to users' preferences, log intake and easily visualize activity along with nutrition related information.

The resulting application is expected later to be able to integrate other developments made at FhP-AICOS (e.g. Personal Finances, ANIEPIL). It is designed to act as a food companion for older adults, following the existing strategy at FhP-AICOS with other mobile applications.

Partners: There are no partners in this project.

Outcome: Development of central components to support FhP-AICOS' nutrition-related projects: data base, recommender system and mobile application.

UserNetwork2016 – The COLABORAR Initiative: The Network for Seniors, The Network of Seniors 20

Description: The user network COLABORAR is the largest co-design network of and for seniors in Europe. Born in 2011, it has steadily increased the number of registered volunteers and has been supporting a growing number of research projects. The efforts for dissemination at a European level have begun and, in 2016, we intend to settle at this level so that we can bring co-design, user research and user testing to an international level.

COLABORAR provides FhP-AICOS researchers the conditions for user research and usability testing, by arranging protocols with specific institutions and finding specific users as demanded by internal and external projects. It serves as a communication channel between FhP-AICOS researchers and real users, after which researchers are responsible for conducting their planned activities with users. COLABORAR also came to assume the role of training researchers and students on human-centred design techniques. As such, projects should take into account the services provided by COLABORAR.

For 2016 the main goals were:

- Cement COLABORAR's capacity to offer services to external clients;
- Assist researchers and New Business Development (NBD) Department in planning the involvement of COLABORAR in external projects;
- Increase contacts with Lisbon institutions to support the work on the AICOS' Lisbon office;
- Invest on dissemination actions to enlarge the group of followers of COLABORAR's activities;
- Enlarge the national and international group of individual and institutional collaborators;
- Optimize the Customer Relationship Management (CRM) application (namely, enable it to calculate and store costs in projects associated with using the services of COLABORAR);
- Offer training and support to researchers;
- Have a COLABORAR mobile app for remote user research.

Partners: There are no partners in this project.

Outcome: Currently, COLABORAR aggregates over 60 partner institutions, including senior universities, adult day-care centres, living centres and healthcare institutions. So far, it has supported over 2.000 user research and testing activities.

INCUBATING PROJECTS

The scientific and business activities of Fraunhofer Portugal AICOS are driven by the performance related funding model operated by Fraunhofer-Gesellschaft, which means that FhP-AICOS' research work is oriented toward concrete applications and results. In pursue of this objective we have submitted several proposals for projects to be developed in a near future.

CTFhP – Collective Transfer Fraunhofer Portugal

Description: Since the beginning of its implementation in 2008, the Associação Fraunhofer Portugal Research has developed a number of Scientific and Technological Knowledge Transfer initiatives in order to promote the results of their applied research projects and, simultaneously, promote the importance and the contribution of this research to the development of society in general.

This project presents a set of actions in the field of dissemination and diffusion of new knowledge and technologies generated in R&D and further actions in the field of effective demonstration of this knowledge, intending to make a remarkable contribution to overcome circumstantial difficulties and to be able also to demonstrate a model of good practice in technology transfer to the other entities of the Portuguese system of R&I. The project is focused on the following two types of activities:

- Initiatives related to interaction and scientific knowledge transfer, with a view to economic recovery including network activities, national and international promotion, with the completion of the idea contest 'Fraunhofer Portugal Challenge' and a new initiative called the 'Fraunhofer Collective Transfer Day';

- Dissemination actions and dissemination of new knowledge and technology generated within the R&D activities of the FhP-AICOS, located in Porto, for national and international business community, involving sectoral actions of experimentation and construction projects pilot demonstrators in the areas of information and communication technologies for development, 'Information and Communication Technologies for Development – ICT4D and also in the area of assistive technology to Assisted Living for Intelligent Environments, Ambient Assisted Living – AAL'.

Partners: There are no partners in this project.

Outcome:

- Knowledge Transfer Initiatives (Fraunhofer Portugal Challenge and Fraunhofer Collective Transfer Day);
- Dissemination of Pilot Projects related to ICT4D;
- Dissemination of Pilot Projects related to AAL.

HealthyAgeing – TICE.HealthyAgeing

Description: The TICE.HealthyAgeing project was submitted to the so-called *Projectos Mobilizadores* funding programme. The project is driven by two societal challenges 'promote healthy living' and 'active ageing', to avoid the increase in spending on chronic diseases treatments. On the other hand, the social care providers, by their proximity to elderly people, are important actors to help solve this problem. Thus, the cross-cutting theme of the project will be capacitation and training of the tertiary sector, also known as service sector (e.g. Private Institutions of Social Solidarity) to better promote health and quality of life, through Information and Communication Technologies (ICT).

The project aims to adopt a platform to address gaps in the health prevention ecosystem, providing gains across the value chain; organizations from the tertiary sector will gain access to a vast repository of interoperable solutions and will be able to subscribe them, with a lower investment cost. Developers (students, entrepreneurs, Small or Medium-sized Enterprise, etc.) gain access to a centralized market, reducing the marketing costs and needs assessment. The main objective for this project will be the inclusion and acceptance of technology by the tertiary sector in the areas of health prevention and to improve quality of life and welfare conditions.

The project intends to establish an ecosystem that aims to promote active aging through the development of applications and services suitable for both caregivers and elderly users.

Partners: Glintt – Healthcare Solutions, S.A. (coordinator); DigitalWind, Lda.; Exatronic – Engenharia e Electrónica, Lda.; IPN – Instituto Pedro Nunes – Associação Para a Inovação e Desenvolvimento em Ciência e Tecnologia; NOS; Sensing Future Technologies, Lda.; Talents & Treasures, Lda.; TICE.PT; Universidade de Aveiro; Universidade de Coimbra.

Outcome:

- Development of technologies and products for day care centres, informal caregivers and elderly people;
- Development and implementation of monitoring and prevention applications for patients with chronic diseases to be used by non-hospital systems;
- Definition and implementation of testbeds in Portugal;
- Awareness and training actions for informal and formal caregivers from care organizations.

MedTech2Market – MedTech-2-Market

Description: The MedTech-2-Market project was submitted to the so-called Projectos Mobilizadores funding program. The project aims to promote in Portugal an ecosystem dedicated to research, development, production, marketing and dissemination of technologies and solutions targeting the national and international health market. The project will have a special focus on socially impactful areas and economically emerging related to the use of information technology, communications and electronics.

The project extends from the production of knowledge to the widespread dissemination of the solutions developed, applicable both in the context of provision of formal health care, and in the day-to-day universe of users / patients.

The project crosses different knowledge areas, such as health sciences and engineering, as well as crosses high-tech sectors (e.g., Information and Communication Technologies, Nanotechnologies) with other traditional sayings (e.g., textile, plastics), whether productive or services.

From a medical / clinical perspective, the approach focuses on prevention, monitoring and treatment of diseases, especially chronic ones – with special focus on neurological disorders and cancer, as well as diabetes, nephrology and cardiovascular diseases – and rehabilitation at home.

Partners: ENERMETER – Sistemas de Medição Lda (coordinator); Associação CCG/ZGDV – Centro de Computação Gráfica; BeyonDevices S.A.; CeNTITVC – Centro de Nanotecnologia e Materiais Técnicos, Funcionais e Inteligentes; CITEVE – Centro Tecnológico das Indústrias Têxteis e do Vestuário de Portugal; Comfort Keepers Portugal – Conforto em Casa, Lda.; FEUP – Faculdade de Engenharia da Universidade do Porto; Increase Time S.A.; INESC TEC – Instituto de Engenharia de Sistemas e Computadores, Tecnologia e Ciência; INESC-ID – Instituto

de Engenharia de Sistemas e Computadores, Investigação e Desenvolvimento em Lisboa; INL – International Iberian Nanotechnology Laboratory; INOV INESC Inovação – Instituto de Novas Tecnologias; Inovamais – Serviços de Consultadoria em Inovação Tecnológica, Lda.; Intellicare – Intelligent Sensing in Healthcare, Lda.; Ipatimup – Instituto de Patologia e Imunologia Molecular da Universidade do Porto; IPN – Instituto Pedro Nunes - Associação Para a Inovação e Desenvolvimento em Ciência e Tecnologia; ISCTE – Instituto Superior de Ciências do Trabalho e da Empresa; ISEP – Instituto Superior de Engenharia do Porto; MindProber, Lda.; Neuroinova, Lda.; PLUX – Wireless Biosignals S.A.; PT Inovação – Portugal Telecom Inovação S.A.; UA – Universidade de Aveiro; UBI – Universidade da Beira Interior; UM – Universidade do Minho; UTAD – Universidade de Trás-os-Montes e Alto Douro.

Outcome:

- Development of medical technologies and products / eHealth services;
- Development and implementation of monitoring and patient management in hospital and non-hospital systems;
- Definition and implementation of testbeds in Portugal;
- Definition of systems / models for procurement and health technology assessment;
- Awareness and training actions on eHealth for users, health facilities and tourism providers.

SmartFarming – Smart Farming Mobilizer

Description: SmartFarming is a proposal submitted to the so-called *Projetos Mobilizadores* funding programme. The main goal of the *Projetos Mobilizadores* programme is to implement a research and innovation agenda to a specific field, by bringing together companies and R&D institutes. On one hand side, it is proven that innovation results can create new types of markets for a specific field. On the other hand side, is also true that these new markets require improved knowledge, technological development and research, creating a perfect environment for improved relationships between these players.

SmartFarming addresses the specific problems of agri-food, animal production and forestry sectors. Smart Farming aims to adapt and implement Precise Agriculture techniques to some of the regions of Portugal's inland (North, Centre and Alentejo), contributing to economic development and the creation of qualified jobs. This project also intends to improve the transformation of those regions in more advanced territories, where innovation can transform current farms into sustainable and profitable agricultural areas.

SmartFarming comprises five specific developments, known as Products, Processes or Services:

- INFLAMA: New technologies for fire detection;
- inAgro: Integrated management system agricultural operations;
- InPec-ENERGY: Smart grids for livestock;
- WOODSTOCK: Quote management system for forest products;
- Wine-of-Things (WINoT): Autonomous monitor and control solutions for vineyards.

In the scope of SmartFarming, FhP-AICOS will be actively involved in the developments related to WOODSTOCK and WINoT, acting as coordinator in the last one.

WOODSTOCK aims to be a multi-user oriented tool for the different stakeholders of the forest activity, to share information, learn and advise, increase yields, predict outcomes, and improve business practices. The use of WOODSTOCK as a support tool to the day-by-day operations contributes strongly to a better and more efficient management of resources and responsibilities, knowledge dissemination and to promote transparency throughout the value chain.

WOODSTOCK delivers valuable information to help the several players in the forest product's value chain to better understand their products and make more informed decisions. Besides providing information on quotes and availability on the forest products, WOODSTOCK will also make available different services to the producers, such as a route optimizer, an automatic price calculator, methods for estimate area and yield, among others.

Additionally, by storing and processing historical data it should be possible to develop more precise forest policies, thus being a tool also for governmental agencies.

WOODSTOCK platform is built on top of a Geographic Information System, that besides being available online should be accessible through a smartphone, for consulting information, promoting products and register events.

WINoT is an integrated monitor and control system for vineyards.

It was designed to cover large areas with a low-cost wireless sensor network. The several nodes communicate between them and an internet gateway through a LoRaWAN infrastructure in order to cover large distances. Additionally, each node has a built-in Bluetooth Smart transceiver that allows for local configuration and to get sensor data from several Bluetooth nodes within the range of the main node.

The collected data is then forwarded and stored in a cloud based platform, built on top of a Geographic Information System, to help farmers in their daily activities and to control the irrigation system.

Partners: Esri Portugal – Sistemas de Informação Geográfica S.A. (coordinator); Agri-Ciência – Consultores de Engenharia, Lda.; Cerfundão – Embalamento e Comercialização de Cereja da Cova da Beira, Lda.; Equiporave Ibérica, Lda.; Hexastep S.A.; IPCB – Instituto Politécnico de Castelo Branco; ISEGI-UNL – NOVA IMS – Instituto Superior de Estatística e Gestão de Informação da Universidade Nova de Lisboa – Nova Information Management School; I-SKYEX, Lda.; IT – Instituto de Telecomunicações; Micro I/O – Serviços de Electrónica, Lda.; Quinta de Ventozelo – Sociedade Agrícola e Comercial S.A.; Symington – Vinhos S.A.; UE – Universidade de Évora; UTAD – Universidade de Trás-os-Montes e Alto Douro.

Outcome:

- A 'companion' like web platform and mobile application to help forest stakeholders;
- A low cost integrated solution to monitor and control vineyards;
- Contribute to our internal activities related to project DeM's vision in the scope of precision agriculture activities.

TexBoost – Less Commodities More Specialities Application

Description: TexBoost is a mobilizer project proposal (*'Projeto Mobilizador'*). The aim of this type of projects is to mobilize a complete industry sector to advance in its specific core business(es), through innovation. FhP-AICOS will participate in a specific subproject with a company like Damel and a research centre specialized in textiles (CITEVE), with whom we had contacts in past, to bring innovative concepts to a surfing suit.

The Portuguese company Damel – Confecção de Vestuário, Lda. will develop together with CITEVE (textile and clothing specialists) an innovative Surf Suit equipped with active warming among other non-technological features. This suit will be used in an extreme use case with an expert in Big Waves Surfing (Sebastian Steudtner), who wants to surf a big wave in Norway.

Damel wants to further advance their Surf Suit by including technology provided by Fraunhofer Portugal AICOS. A wearable or a set of wearables will be developed and incorporated in the Surf Suit. The wearables should contain a physical help button, location and communication capabilities. Performance features (velocity, number of waves) will be computed and displayed in the smartphone during or in the end of the surf session.

Partners: CITEVE – Centro Tecnológico das Indústrias Têxteis e do Vestuário de Portugal (coordinator); Damel – Confecção de Vestuário, Lda.

Outcome:

- Innovative Surf Suit including wearable sensors for increased security of the surfer and performance metrics computation;
- A new application for the Pandlets and the technology transference of SmartSurf project's results to the market.



ACADEMIC ACTIVITIES

Regarding academic activities, it is worth highlighting that the Director of FhP-AICOS is an invited Professor at the Faculty of Engineering of the University of Porto and FhP-AICOS is responsible for proposing a set of topics for MSc theses. The MSc students join FhP-AICOS team to work on applied research projects and also in their own thesis. The topics proposed for theses are aligned with the Strategic Research Agenda defined by the Scientific Board of FhP-AICOS.

3DArm – Inertial Sensor-based 3D Upper Limb Motion Tracking and Trajectories Reconstruction 21

Description: Continuous long-term capture of upper limb movement and trajectories can be used to assess performance in the workplace and rehabilitation at home. Wearable Inertial Measurement Units (IMUs) are an attractive solution for measuring orientation and movement of the arm because of their low cost, lightweight and small size. However, the accurate tracking of the upper limb motion can be quite challenging, due to the complexity of the upper limb bio-mechanical structure and movement.

This project aimed at creating a new wearable motion tracking system based on inertial sensors to estimate orientation and find the motion trajectories of the human upper limb. To that purpose, two IMUs were placed on the upper and lower arm, enabling the measurement of each arm segment orientation. Motion trajectories were estimated by combining sensor fusion and orientation tracking with bio-mechanical models of the upper limbs, which took into account the relationship between each arm segment and the human motion limitations. To avoid the burden of manually aligning the sensors to each other and with the mounted arm segment, a simple calibration process was developed.

Outcome: A new wearable motion tracking system for the upper limb motion and trajectories tracking was developed. Two IMUs are required to estimate the orientation of each arm segment and, considering the bio-mechanical properties of the upper limb movement, motion trajectories of the upper limb joints are reconstructed. To avoid the burden of manually aligning the sensors to each other and with the mounted arm segment, a simple calibration process was created. The algorithm developed enables the monitoring of complex arm movements with applications in rehabilitation and daily life monitoring.

ADaFE – Adaptive Data Collection Front-End

Description: The idea behind this project was to create a system to ease the process of data collection in mobile applications where the user input is necessary. This was achieved through the usage of an adaptive Object-Model architecture to create an adaptive Front-End interface automatically deployable to a mobile application.

The system administrator can specify, on a friendly web interface, a set of forms, their types, attributes, behaviours, restrictions and interdependencies as metadata. Later the system sends these rules as metadata to an Android device, running a framework responsible of translating the metadata into a visual Front-End interface which the end user can use to collect data. This mobile framework is simple to integrate on an existing application, in order to reduce the costs involved in future layout implementations or changes in already existing ones.

This system will allow the creation of modular interfaces, easily adaptable according to the usage scenarios (clinical data, population surveys, etc.) and its end user (medical staff, volunteers, etc.) needs enhancing their interaction experience while using the applications.

Outcome:

- Web Interface for the definition of the forms;
- Mobile framework for metadata interpretation;
- Proof of Concept mobile application using the framework.

BPOL – Battery Performance Optimisation Library

Description: As the smartphone manufacturers equip their devices with ever more powerful Central Processing Units (CPUs), along with the fact that the devices' screens get bigger and bigger, the battery performance starts to decrease and the need for an efficient resource management becomes more important than ever. Developers of mobile applications often forget how important the efficient use of the device's power is for the user experience and how even the most ingenious application can easily become unusable if it drains battery too fast.

The aim of this project is to develop an Android library that will assist apps in better management of the resources they use and thus help to provide an extended battery life.

Outcome: An Android library helping applications to provide a better battery performance by improving the way they manage their resources.

CervCancerScreening – Cervical Cancer Automated Screening Module 22

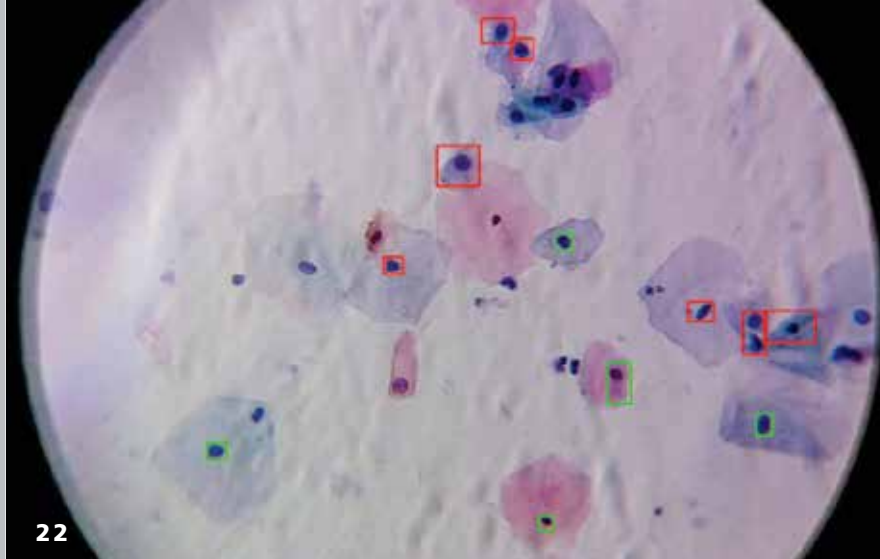
Description: Cervical Cancer is a largely preventable disease, but worldwide it is one of the leading causes of cancer death in women, with most deaths occurring in low to middle income countries. Screening tests such as the conventional pap smear or Liquid-Based Cytology (LBC) has been responsible for a 50% decrease in Cervical Cancer deaths.

The purpose of this project was to explore image processing techniques to count and then detect malignant cells with specific morphological alterations. The images were acquired with the MalariaScope prototype.

The developed image processing module should be able to detect the adequability of the cellular samples for testing and search malignant cells with specific morphological alterations.

Since the application of such Cervical Cancer screening programmes in low to middle income countries strongly depends on the financial means and specialized resources, this project aims to identify the suitability of usage of a low cost solution (the MalariaScope prototype) to observe LBC samples together with the development of an image processing module to help in such screening process.

Outcome: An image processing algorithm was developed to apply in LBC images. The algorithm developed was able to segment the cervical cells and identify the cells' nuclei. The segmented nuclei could later be analysed and classified as normal or abnormal, depending on their morphology, a first approach was studied in this project however further development is needed in this field.



ChagasEarlyDetection – Early Detection of Chagas Disease on Blood Stream

Description: Chagas disease, also known as American Trypanosomiasis, was discovered in 1909 by Carlos Chagas, and is caused by the protozoan *Trypanosoma cruzi* (hereafter called *T. cruzi*). Accordingly to the World Health Organization (WHO) report from March 2013, approximately 7 to 8 million people worldwide are currently infected with *T. cruzi* and are at risk for developing cardiac or gut pathology normally associated with chronic Chagas disease. *T. cruzi* is transmitted to humans by infected triatomine bugs (known as 'kissing bugs'), which take blood meals from the inhabitants, and then defecate, leaving *T. cruzi* into wounds or mucosal sites. Although Chagas disease was once confined to the Americas, primarily Latin America, migration from endemic countries has led to the appearance of Chagas disease in nonendemic regions as well. Transmission of *T. cruzi* is possible through blood transfusion (or blood share), tissue transplantation and also congenitally.

T. cruzi parasites may be detected in the bloodstream if the analysis is performed early, either by direct observation of blood or by various culture techniques, but unfortunately, the infection at this early stage often goes undetected because symptoms are nonspecific or absent. This microscopical detection might take about 30 minutes of careful looking by a specialist.

The main goal of this project is to explore image processing and analysis techniques for the recognition and counting of *T. cruzi* parasites in a thin blood smear, either in the trypomastigotes and amastigotes stage, saving this way a lot of time to specialized teams and allowing the detection of the disease by non specialized teams. The images will be acquired with a generic microscope using the 'Skylight' smartphone-to-microscope adapter (requiring a magnification of 400x3) and will be analysed looking for *T. cruzi* parasites. It is expected that this analysis can be performed either in a central server or in a mobile platform.

Outcome: Develop image processing and analysis techniques for the recognition, identification and counting of *T. cruzi* parasites. The developed image processing module should be able to count and correctly differentiate the *T. cruzi* in trypomastigote and amastigotes stages. It is expected that the analysis can be performed either in a central server as in a mobile platform.

CWSEFS – Cotton Wool Spots in Eye Fundus Scope

Description: Diabetic Retinopathy is a Diabetes complication and the leading cause of blindness in adults in the world. If detected early it can be treated by laser surgery, however its early detection is frequently missed since it progresses without symptoms until irreversible vision loss occurs. Poor glycemic control and hypertension may be manifested by changes at the retinal microvasculature, damaging the blood vessels of the light-sensitive tissue at the back of the eye (retina). These changes lead to a higher degree of vessel permeability, which in turn causes fluid leaks. These leakages, depending on the exact location where they occur can degrade visual acuity. The continuous monitoring is therefore essential to protect the vision, but Retinal Photography (Fundoscopy) is expensive and not easily available in developing countries and not even in some developed countries.

This project follows the successfully achieved results of the EyeFundusScope, focused on the first detectable signs of the pathology called microaneurysms, detected by image processing algorithms running in smartphone with a low-cost ophthalmoscope mounted to the built-in camera. Current work resulting from EyeFundusScope already includes: a mobile app to capture images from the retina, optic disk tracking, vascular segmentation and microaneurysm detector. However, the detection methods needs to be completed with more features and a decision-support system.

Exudates are often formed as a result of slightly more advanced stages and their detection is used for a robust evaluation of the patient condition. In particular, soft exudates, also called cotton wool spots, are relevant findings which are still part of nonproliferative (treatable) retinopathy. The main objective of this project is to find these cotton wool spots by texture-based feature extraction and to build a decision-support system for risk assessment of Diabetic Retinopathy. Currently, there is no similar solution to be used by non-specialist practitioner's end-users, for automatic annotation of retinopathy by smartphones.

This project aims at developing a smartphone-based low computational-cost algorithms and yet highly efficient in the lower quality images of the smartphone camera, improved by multi-image denoising techniques. In addition, the decision-support system can be extended to other eye diseases and stand as a useful tool for eye health screening in developing countries.

Outcome:

- Image recognition and automatic annotation of cotton wool spots on eye fundus in smartphone fundography;
- Decision-support systems for risk assessment of Diabetic Retinopathy based on microaneurysm and cotton wool spots;
- All image processing algorithms must be running in Android platform and adapted to efficiently use the processing power of current smartphones.

DPT – Digital Personal Trainer 23

Description: Monitoring physical exercise is becoming an increasingly relevant topic, with new fitness tracking devices and applications being released very often. While these options are highly popular among fitness communities, they are either very limited (i.e.: just counting steps or workout time) or require a lot of effort and dedication to log your activities (i.e.: manually inserting exercise type, repetitions and duration).

This project aims to fix these issues and create new possibilities, by developing software for smartphones or wearable devices that will automatically track physical activities, detecting specific workouts, repetitions and even correctness (e.g. posture, speed, frequency, extension, etc.), becoming a digital personal trainer.

To achieve this goal, the software will depend on sensor fusion and machine learning algorithms, which will go through a short learning period to correctly identify specific exercises.

The versatility of this concept makes it attractive for very diverse scenarios, ranging from rehabilitation activities for elderly people to high performance exercises for professional athletes.

Outcome: A functional Android application capable of learning and consistently detecting at least two different exercises.



EasyIoT – Easy Peripherals for the Internet of Things

Description: Wearables and Internet of Things are the new big words of the recent technological developments worldwide. In the past few years, the embedded systems manufacturers shifted their efforts into developing low power/cost Integrated Circuits (ICs) and Systems on Chip (SoCs) capable of providing always connected capabilities to the most varied devices, providing data and analytics for a multitude of tasks like health companions and motion trackers with the desired outcome of improving the general well-being or monitoring our day-to-day lives.

It is estimated that by 2020, approximately 26 billion objects will be connected together within the internet, directly or indirectly by using different protocols such as Bluetooth Smart for the low level devices ('things') and WiFi/GSM for the higher level ones (gateways).

Generally, these 'things' need a big effort into developing robust firmware for their controllers that can be exceptionally diverse, with each having their development environment. Half of this time is spent into developing higher level protocols of communication that will promote the trade of information between the 'thing' and the gateway. Most of the time, this trade is limited to what is implemented in the controller and adding new functionalities leads to updates in both the gateway and the 'thing'. This can be really expensive since, normally, higher level developers don't have the knowledge necessary to work at the lower level and vice-versa.

In order to allow a centralized development, it would be interesting that some kind of abstraction is added to this controller to allow a more transparent integration of new functionalities and even allow higher level developers to create a complete

application without being concerned with hardware details, and simply taking advantage of their interfaces like Inter-Integrated Circuit (I2C), Universal Asynchronous Receiver/Transmitter (UART) and General Purpose Input/Output (GPIO) to get information from sensors and alike.

FhP-AICOS is working on this area and already created a customizable sensing 'thing' named Pandlet that can be used in diverse contexts. It possesses several sensors and interfaces that make the connection of new ones easy and sends information to the gateways by using Bluetooth Smart.

Using this concept of abstraction, this project developed a set of Bluetooth Smart profiles and a companion Android API that allows the interaction of a gateway with the peripherals (I2C, UART, GPIO, Serial Peripheral Interface (SPI), Analog to Digital Converter (ADC)) of the Pandlet seamlessly. This allows the high level developer to see the peripherals as an extension of the gateway and not a separated device. The developed profiles are generic and their implementation in micro-controllers other than the Pandlet is straightforward.

Outcome:

- Set of Bluetooth Smart profiles that allow the seamless interaction with a micro-controller peripherals;
- Android API to support the developed profiles;
- Increased knowledge and experience using Bluetooth Smart and seamless Android integration of external devices.



KneeGraphy – Classification of Knee Arthropathy with Accelerometer-based Vibroarthrography

Description: Osteoarthritis is one of the most common diseases of the knee joint, especially among obese and elderly. However, the diagnosis relies on expensive and invasive methods as X-ray imaging or arthroscopy.

Vibroarthrography (VAG) has been proposed as a non-invasive tool for therapists to evaluate the pathological condition of the knee joint during physical therapy. It has been proposed to use accelerometers to determine if the vibrations of an osteoarthritic knee could be differentiated from a non-pathological knee under in-vivo conditions.

During a dynamic activity, the interaction between the moving articulating surfaces induces vibrations of the bones. In a healthy joint the articulating surfaces are smooth and the vibration is minimal, but as the cartilage degenerates, the articular surfaces become more rough and vibrations increase and may become audible in extreme cases.

The accelerometers record the change in acceleration resulting from both the movement of the joint as well as from the vibration of the bones and feature extraction methods should be implemented to extract meaningful information from the accelerometer signals to develop pattern recognition algorithms for the classification task.

The inertial sensors could alternatively be coupled to an elastic knee brace to be more practical for elderly use and long term monitoring. This system could be used in the future as a non-invasive assessment tool of the articular cartilage condition. Further research could focus on determining earlier stages of arthritis, before they become symptomatic.

Outcome: Development of an accelerometer-based system for knee data acquisition and differentiation between normal and pathological knee.

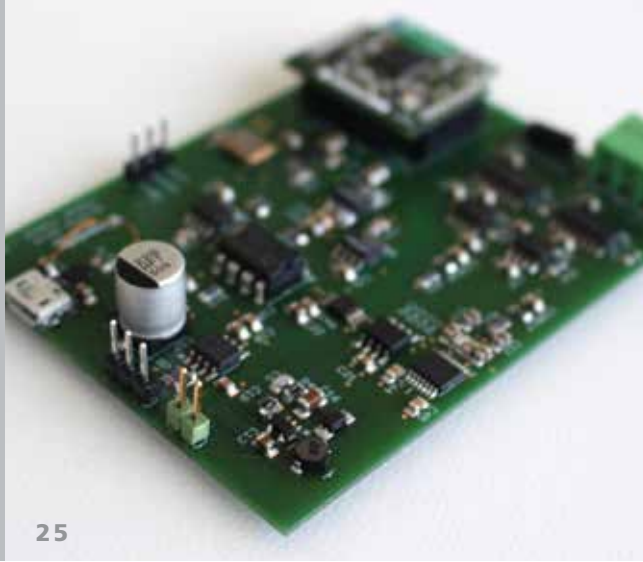
This thesis could drive the study of specific pathological conditions that affect gait and that benefit from physiotherapy. It could also be incorporated as a screening tool for people with arthritic knee joints.

LFDetection – Lymphatic Filariasis Detection 24

Description: Lymphatic filariasis (commonly known as elephantiasis) is a parasitic disease that occurs when filarial parasites are transmitted from mosquitoes to humans. When a mosquito with infective stage larvae bites a person, the parasites are deposited on the person's skin, entering the body. The larvae then migrates to the lymphatic vessels where it develops into adult worms in the human lymphatic system. Infection is usually acquired in childhood, but the painful and profoundly disfiguring visible manifestations of the disease occur later in life. Whereas acute episodes of the disease cause temporary disability, lymphatic filariasis leads to permanent disability.

Currently, more than 1.4 billion people in 73 countries are at risk. Approximately 65% of those infected live in the South-East Asia Region, 30% in the African Region, and the remainder in other tropical areas.

The main goal of this project is to explore image processing and analysis techniques for the recognition and counting of filarial worms in a giemsa stained blood smear. This implicates to detect and distinguish the worms of the remaining blood elements, as well as distinguish the two most common filarial worms (W.Bancrofti and B.Malayi). The images can be acquired



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with a generic microscope using the 'Skylight' smartphone-to-microscope adapter, but a simpler smartphone magnification gadget might serve the purpose. This detection might open the path to the revealing of other blood worms and inclusively for the diagnosis of other diseases like, for instance, Loa Loa.

Outcome: Develop image processing and analysis techniques for the recognition and identification of two kinds of filarial worms (W.Bancrofti and B.Malayi) in the blood stream. This analysis can be performed in a mobile platform.

MICH – Measuring Impedance in Congestive Heart Failure 25

Description: Measurement of thoracic impedance is becoming increasingly available in the clinical setting as a tool for assessing hemodynamics and volume status in patients with Heart Failure. The two major categories of impedance assessment are the band electrode method and the implanted device lead method. Base Thoracic impedance is a sensitive measurement, indicating fluid retention in Heart Failure patients as early as 12 days before symptom development or weight gain.

The main objective for this project was to develop a mobile system to monitor patients Base Thoracic impedance. The user is be able to verify the performed measurement in Smart Companion and the device could be integrated in the future in SmartBEAT project.

Outcome: A mobile system to monitor patients base Thoracic impedance integrated with Smart Companion and with SmartBEAT project.



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SHRAM – Smart Heart Rate and Activity Measurement 26

Description: Heart rate monitoring for fitness is important for exercisers to control their training load. Moreover, heart rate irregularities that may occur during the day as a consequence of a weak pulse or a hard blood vessel may be caused by heart disease or another problem.

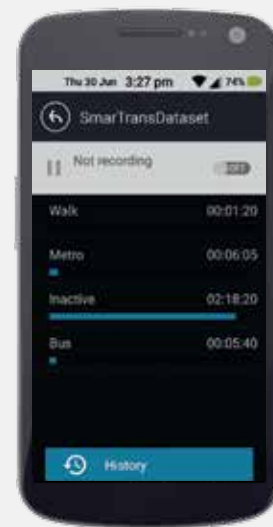
The goal of this project is to reuse electrocardiography (ECG) sensors for heart rate analysis in combination with activity monitoring, preferentially positioned at the wrist as a bracelet.

The objective is to improve activity monitoring related features with the heart rate and study the inter-combination between energy expenditure, speed, activity and heart rate and ultimate generate alerts for abnormal heart rates, as a consequence of stress situations, for example.

The system should allow a continuous monitoring of heart rate in combination with activity monitoring in a daily basis.

Outcome:

- Develop a fused algorithm that combines information from inertial sensors and heart rate monitors;
- Validate an heart rate monitoring system for continuous usage in combination with activity monitoring;
- Generate trigger alarms for abnormal heart rate values and relate this alarms with pop-up questionnaires to infer stress situations.



SmartMedBoxes – Monitoring of Medication Boxes Using Wireless Sensors

Description: Low medication adherence is huge problem amongst older adults and can cause serious problems to their health. Taking the wrong medications at wrong times can lead to the hospitalization of older adults. This problem is being addressed by a large community of researchers which led to a wide spectrum of solutions. These range from simple smart-phone applications that alert users to take the medication on time, to custom smart medication boxes which will alert the users via audio signals when it is time to take the medication. Both solutions represent a great burden for the users because when using smartphone applications they have to dismiss the alerts even when they remember to take the medication on time. When the medication is not at hand the alarms just ends up to be dismissed and the medication is not taken.

The goal of this project was to create a solution to minimize the problem described before by using a set of sensors that are applied to the medication boxes. These sensors are able to identify when the user has taken the medication and/or warn the user when the wrong medication was taken. The sensors would have an accelerometers or a gyroscopes to classify how the box is being manipulated by the users. The sensors are attached to the medication boxes and the movement detected on them is sent wirelessly to a smartphone which automatically dismisses the medication reminder.

Outcome:

- Study the best technology to use as sensor tags;
- Implement a mobile app capable of interacting with the wireless sensors;
- Test the mobile app with older adults.

SmarTrans – Smartphone Based Transportation Mode Detection 27

Description: The main objective is to create an independent platform for automatic detection of the transportation mode of a person, carrying a mobile device. Current existing approaches use mainly the Global Positioning System (GPS) signal to accomplish this task, but they fail when there is no signal available or they only allow general categories (e.g. still, walking, motorized).

The goal of this project is to be specific when detecting the transportation mode (walking, cycling, car, bus, metro, train, moto) using the inertial sensors as the main source of data. This can be done using the smartphone, or using an external device connected to it (e.g. a Pandle), which shall be carried by the person.

Moreover, the platform shall also include the possibility for a remote caregiver to receive information about the transportation mode in real time, as well as to check the daily activities, allowing for a full logging and understanding of the person's daily activity habits.

Outcome: A mobile platform for determine, in real time, the type of transportation mode.

Complement the Mover algorithms and subsequently, improve the Smart Companion activity monitoring capabilities.

SERVICE



A photograph of a modern building facade featuring large glass panels and dark, textured panels. The image is overlaid with a teal gradient and a white horizontal line. The text 'LOCATION AND CONTACTS' is centered on the line.

LOCATION AND CONTACTS

LOCATION AND CONTACTS



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