A Portable Stochastic Forest Fire Modeling Tool

Flávio Sousa

LASEF

INSTITUTO SUPERIOR TÉCNICO

October 20, 2011

Motivation and Scope

Why do forest fire simulations?

- Forest fire has a heavy toll on natural and economic resources
- Poses a danger to human lives
- 1500 km^2 per year of Portuguese land burned (60 % affects residential area)
- Fire is a complex and destructive phenomena

Motivation and Scope

Why do forest fire simulations?

- Forest fire has a heavy toll on natural and economic resources
- Poses a danger to human lives
- 1500 km^2 per year of Portuguese land burned (60 % affects residential area)
- Fire is a complex and destructive phenomena

A forecast enables tactical decision by the fire fighting crew

Motivation and Scope

Forest Fire Simulators

- Fire Front Behavior
- Forecast for the next hours
- Manage fire fighting efforts

Motivation and Scope

Forest Fire Simulators

- Fire Front Behavior
- Forecast for the next hours
- Manage fire fighting efforts

Better informed decision

Forest Fire Simulators

Current Picture

- Continuous development since the 70's
- Many software applications by government forest research centers
- Valuable tool in fire fighting and prevention

Forest Fire Simulators

Data

- Fire Front Position
- Fuel Maps
- Wind Data
- Topography

Forest Fire Simulators

Data

- Fire Front Position
- Fuel Maps
- Wind Data
- Topography

Math Models

- Surface Fire
- Canopy Fire
- Spotting

Forest Fire Simulators

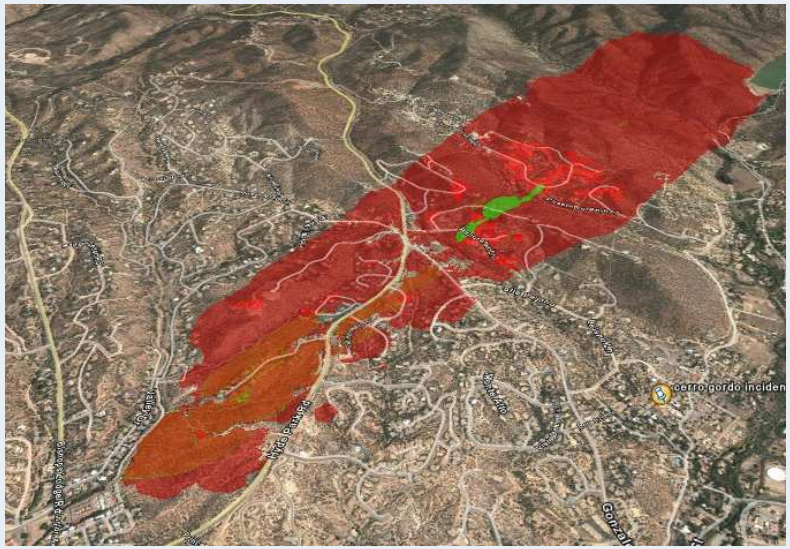
Data

- Fire Front Position
- Fuel Maps
- Wind Data
- Topography

Math Models

- Surface Fire
- Canopy Fire
- Spotting

Fire Front



Parametric Uncertainty

Problem: Uncertainty of Input Data

Parametric Uncertainty

Problem: Uncertainty of Input Data

"(...) poorly defined winds and unknown precision of fuel maps."

- Farsite Manual

Parametric Uncertainty

Problem: Uncertainty of Input Data

"(...) poorly defined winds and unknown precision of fuel maps."

- Farsite Manual

Solution:

Stochastic Uncertainty Quantification methods

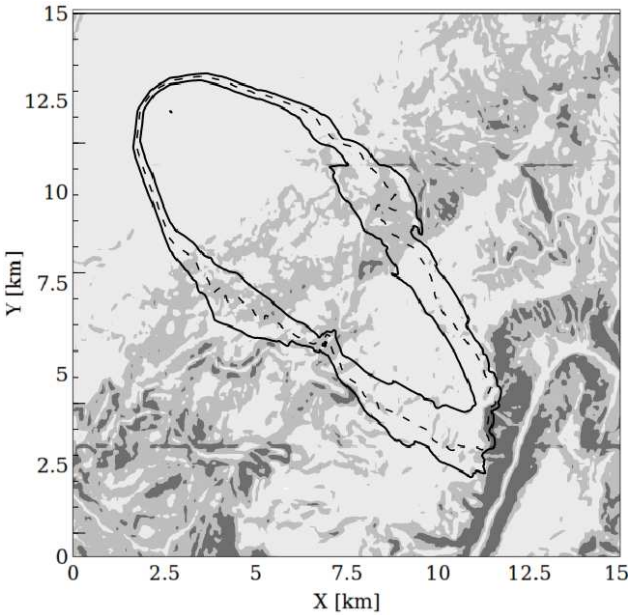
Stochastic Uncertainty Quantification

Quick Overview:

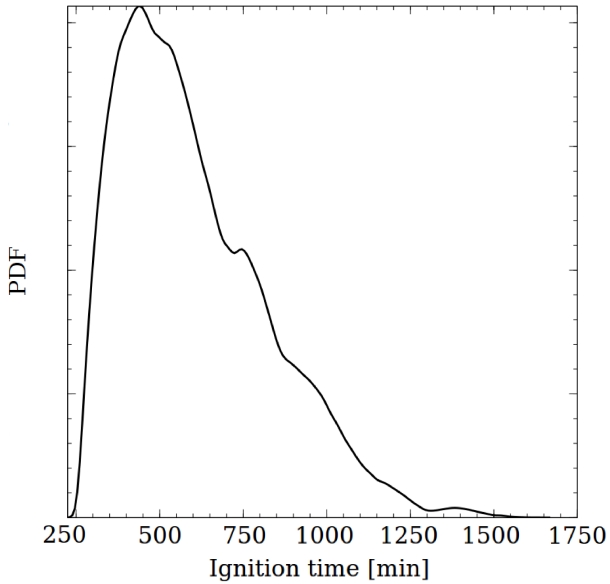
- Input variables described by PDF (e.g: mean and SD of Gaussian)
- Issue several deterministic fire front simulations
- Several methods:
  - Monte Carlo "Brute Force"
  - Spectral Projection: "Selective Sampling"
- Post Processing: "probabilistic" prediction

Stochastic UQ: post processing and forecast

Mean position and error bar

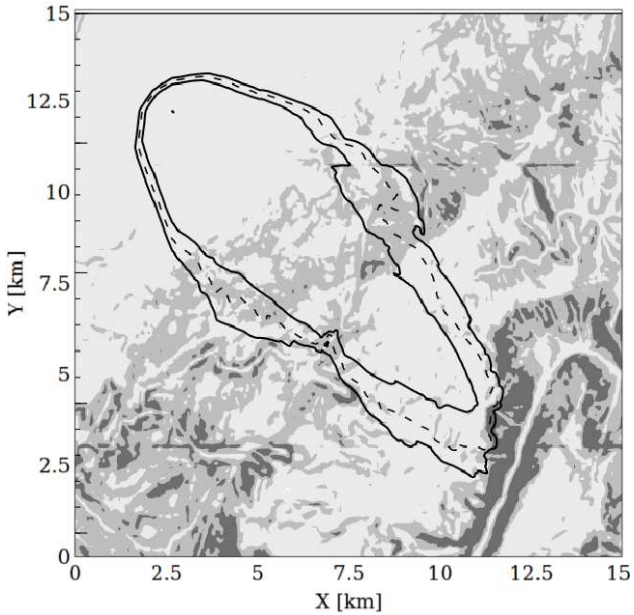


PDF of ignition time

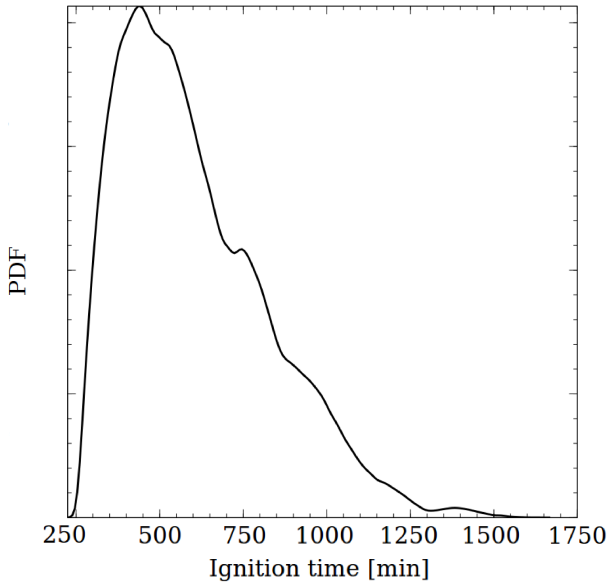


Stochastic UQ: post processing and forecast

Mean position and error bar



PDF of ignition time



Computation time becomes troublesome in faster than real time (FTRT) simulations

FTRT Fire Front Simulation

- Optimization and performance of the fire model
- Possible solution: Exploit code parallelism with GPUs
- Server based simulation – remote access

Idea Concept

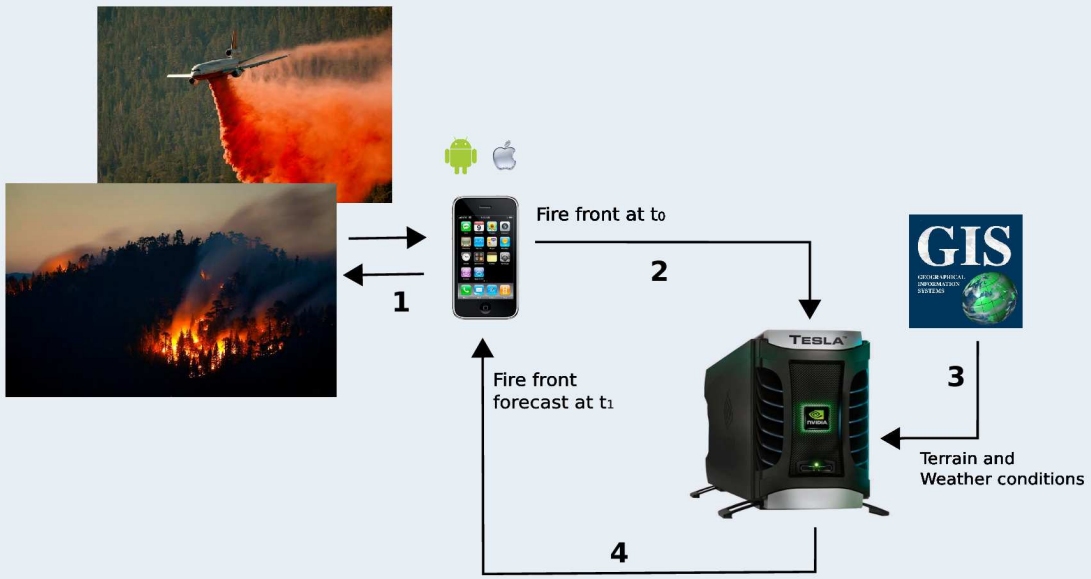
A forest fire numerical model with parametric UQ, accessed remotely by fire fighting crews

Window of opportunity:

- Smart-phone application based interface
- Price and availability of GPU platforms offering impressive SP
- Fire models are available in the public domain

Idea Concept

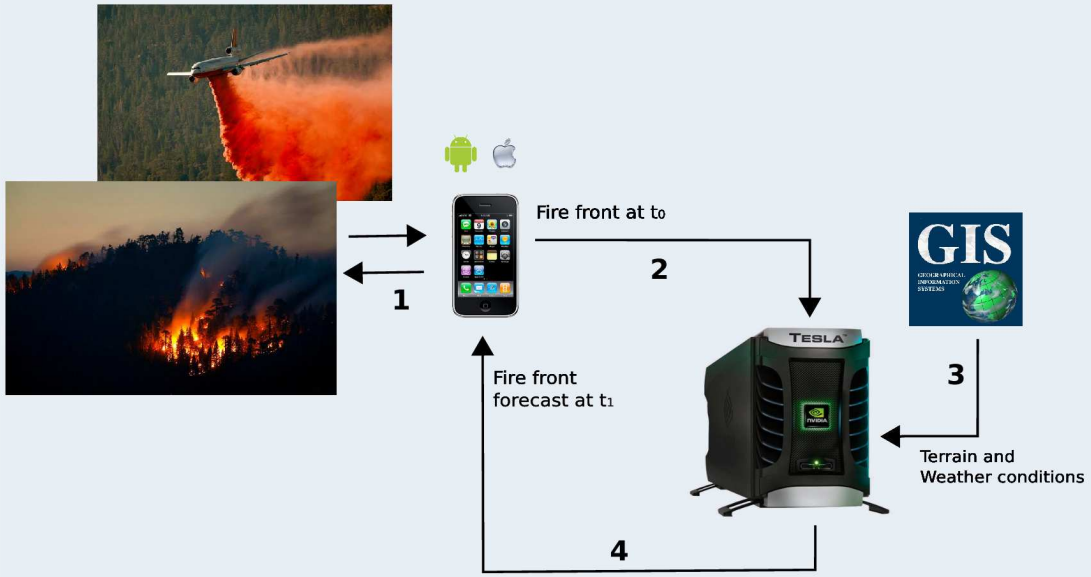
Remote Aplication Operation



Idea Concept

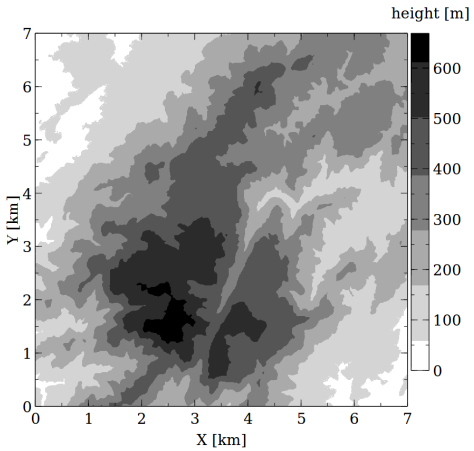
Local data

Remote Aplication Operation

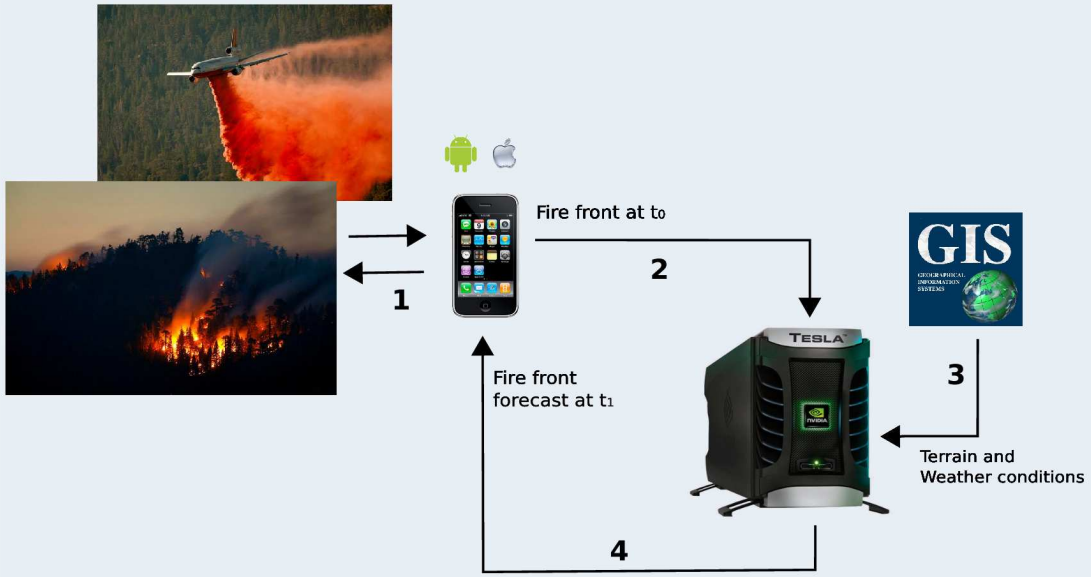


Idea Concept

Server data

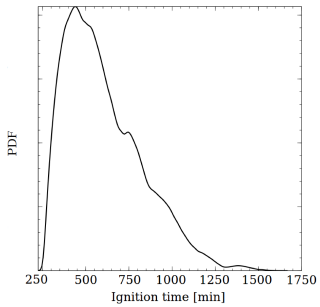


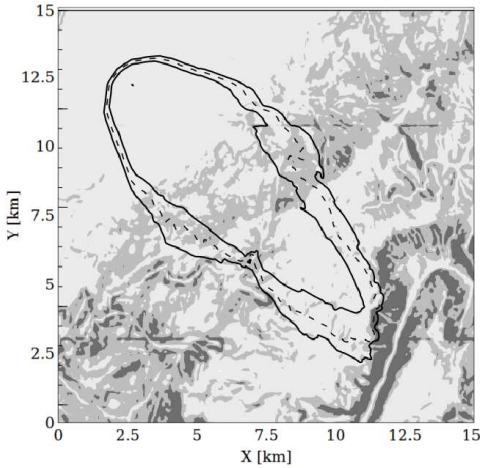
Remote Aplication Operation



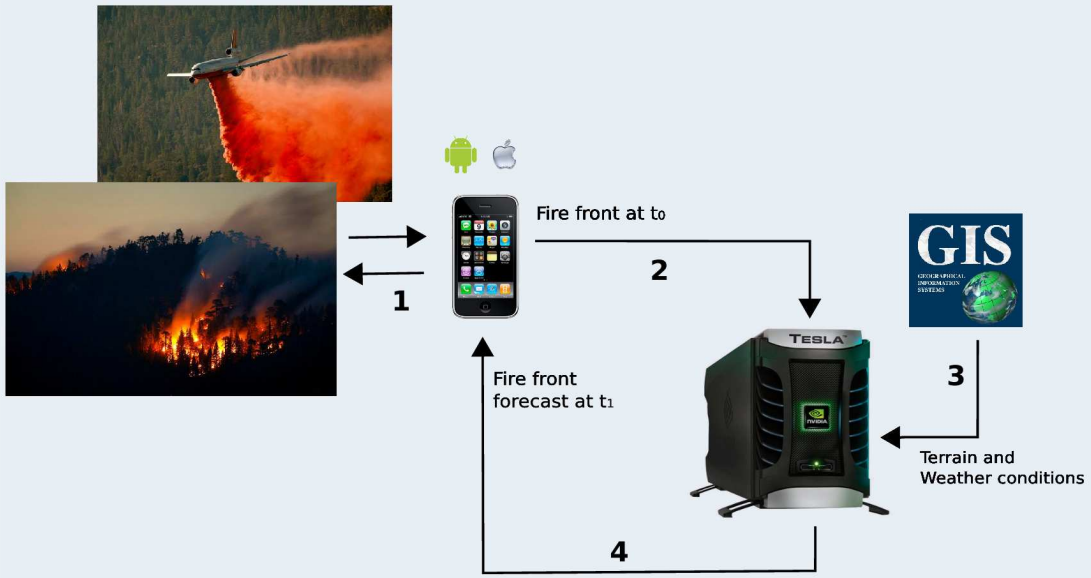
Idea Concept

Forecast





Remote Aplication Operation



Business Model

- Fire models are public domain (although stochastic fire modeling is a new concept and GPU porting is not trivial)
- Closed source distribution is not a suitable approach

Business Model

- Fire models are public domain (although stochastic fire modeling is a new concept and GPU porting is not trivial)
- Closed source distribution is not a suitable approach
- Service: computing time in state-of-the-art HPC servers to worldwide users
- Main clients: fire fighting departments, faculties, research departments, private users

Business Model

- Fire models are public domain (although stochastic fire modeling is a new concept and GPU porting is not trivial)
- Closed source distribution is not a suitable approach
- Service: computing time in state-of-the-art HPC servers to worldwide users
- Main clients: fire fighting departments, faculties, research departments, private users
- Server limitation addressed by a queue priority oriented fee: high priority users pay more to run first

Conclusions

- Predict fire behaviour
- Access worst case scenarios and ignition time probability
- Evaluate residential area risk
- Manage efforts and resources