Thesis Overview

Dynamic Data Driven Application for Forest Fire Spread Prediction

Mónica Denham*

Computer Architecture and Operating Systems Department, Universitat Autònoma de Barcelona, Spain.
PhD Thesis in High Performance Computing.
Advisor: Ana Cortes**
mdenham@unrn.edu.ar* ana.cortes@uab.es**

July 2009

This work describes a two stages prediction method for wildland fire growth prediction. Proposed method takes advantege of genetic algorithms in order to develope a high performance and scalable application.

Usually, a prediction is made using a forest fire simulator which receives several inputs (fire environment description) and it returns the state of the fire for a later instant of time. Having initial fire line and environmental characteristics, simulator uses some fire propagation model in order to simulate fire behavior (Figure 1 (a)).

Taking into account this classical prediction method, we can see that it has the advantage of performing just one simulation (what means low processor time requirements). But this advantage is in a sense the main weak point of the method: final prediction quality depends on the suitability of the unique simulation (that means, using a unique input parameters set).

The accuracy of the input parameters are really open to debate due to having its actual values is not easy, some times it is impossible. Consequently, we develope a method where a search of better parameter values is performed in order to reduce input data uncertainty. This

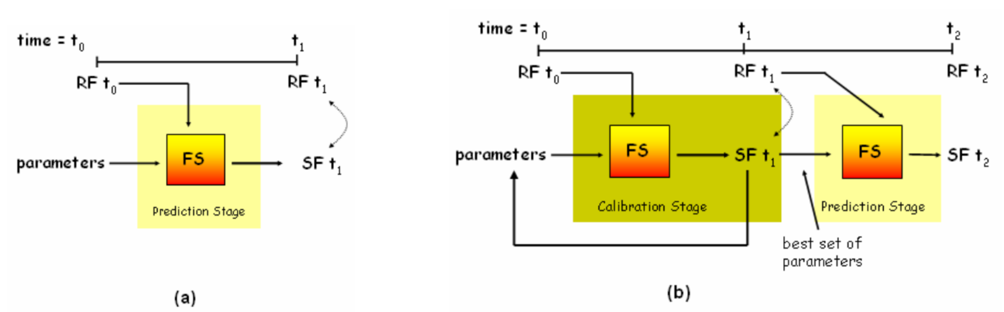

Figure 1: (a) Classical Prediction Method. (b) Two Stages Prediction Method. RF and SF mean Real Fire line and Simulated Fire line respectively.

method consists of two stages: a new stage was added before the prediction step. This new stage is called Calibration Stage, and it allows us to find a set of input parameter values that achieve a good simulation from instant t_i to instant t_{i+1}. Then, we can use this good set of input parameters to predict fire behavior during the next instant of time t_{i+2} (Figure 1 (b)).

The amount of different combinations of input parameter values leaves us a very big search space. In order to avoid that this Calibration Stage becomes a bottle neck, we had developed a parallel Dynamic Data Driven Genetic Algorithm [2]. Strategies adopted through this application result in an eficient search solution.

Our Dynamic Data Driven Genetic Algorithm dynamically incorporates new data (from storage device or on line captured) promising more accuracy data analysis, more accurate predictions, more precise controls and more reliable outcomes. Taking into account that two stages method needs the information of the real fire spread from instant t_i to t_{i+1}, useful information will be obtained from the analysis of this real fire progress. This information will be used for steering searching process through genetic algorithm, in order to improve the values of the parameters.

When slope or wind are strong enough (both or one of them), they influence fire growth in a determinant way. Thus, knowing wind and slope decisive influences and knowing the real fire shape (by the analysis of real fire at instant t_{i+1} disposed in Calibration Stage), we can combine this information in order to incorporate additional data that will be useful in order to improve fire spread simulations. This information will be used as feedback information in order to improve simulation accuracy.

Our system calculates wind characteristics taking into account fire growth history and slope characteristics (terrain slope and aspect). Once wind main characteristics are calculated they will be used through two methods for dynamically steering our genetic algorithm: Computational and Analytical Methods. In particular, Analytical Method was developed in order to validate Computational Method operation.

Computational Method uses different forest fires information (including fire environment) in order to discover wind main features. Forest fire main characteristics are stored through a data base. Then, all real forest fire characteristics are used in order to find the most similar fire into the data base. When most similar fire is founded, wind direction and velocity are injected during genetic algorithm operation. Analytical Method is based on an exhaustive study of Rothermel model and *fireLib* simulator [1] [3]. This method is based on some calculus performed by the simulator in order to obtain fire direction and velocity, by the combination of wind, slope and environmental factors.

Experimental results were analyzed and best application characteristics were studied. We could see that two stages prediction method improves prediction results. Performing a pre-search of input parameters values achieve an important error reduction due to the use of suitable input parameters values. Steering methods reduce simulation errors, achieving more precise simulations during calibration stage, and consequently, more precise predictions. These methods reduce total execution time, on account of the acceleration of searching convergence.

Mónica Denham
mdenham@unrn.edu.ar

References

[1] Bevins C., "FireLib User Manual and Technical Reference". http://www.re.org/downloads/fireLib/1.0.4/relib.pdf. Acceded on January 2006.

[2] Darema, F. "Dynamic Data Driven Applications Systems: A New Paradigm for Application Simulations and Measurements." ICCS 2004, LNCS 3038, Springer Berlin / Heidelberg, pp. 662-669.

[3] Rothermel R., "A mathematical model for predicting re spread in wildland fuels". USDA FS, Ogden TU, Res. Pap. INT-115, 1972.