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Coupled Modelling of Forest Fires and Floods in Multi-risk Scenarios under SCIER System

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Floods and fires represent one of most devastating natural phenomena in the territory of Europe. Moreover, the combination of natural hazards is recorded in many European countries such as flood followed by land slide, fire followed by flood causing large devastation in complex environment of human lives, health, property and nature. The protection against such combination of natural events requires involvement of sophisticated approaches and advanced technology.

The SCIER research project belongs to the 6\textsuperscript{th} Framework Programme of the European Commission, and aims to contribute in coping with environmental risks for prediction of occurrence and impact of these natural hazards with ultimate goal in protection of human health, property and environment. SCIER focuses on design, development and demonstration of an integrated system of sensors, networking and computing infrastructure, aimed for detecting, monitoring, predicting and assisting in crisis management of flood and fire natural hazards or accidents in the wildland-urban interface (W-UI), that is the areas where forests and rural lands interface with homes, other buildings and infrastructures.

SCIER system integrates networks of sensors, which monitorise environmental factors triggering and holding forest fires and floods, communication technologies, computation and processing systems, prediction models for forest fires and floods, GRID architecture for the computing of several possible futures and a GIS platform onto which the main application is installed. Small towns, settlements, housing areas and industrial installations are the targeted protection units around and within which a number of sensors are installed, such as temperature, air humidity and cameras, and which readings are collected and pre-processed by data sinks and sent to an alert-unit which is in charge to launch the information processes and communicate results to the end-users. Four study areas have been set-up in Czech Republic, France, Greece and Spain and a set of field and lab experimentations took place in 2007 and 2008 in Portugal and Greece to test and prove the concepts and the systems proposed in the project.

The purpose of the Sensing Subsystem in SCIER is the monitoring of the environmental parameters (e.g. temperature, humidity, wind-speed, etc.) that are relevant to the assessment of a hazardous situation. The measurements are done by sensor nodes, deployed in the W-UI, and are provided with wireless communication capabilities. They are organized in a wireless sensor network (WSN), which is linked to the communication infrastructure servicing the homes in the W-UI. Emphasis is given to sensor localisation, energy efficiency, incident driven sensor management, dynamic deployment of sensor networks and self-configured sensor network communications, and data collection and pre-processing of the sensor readings.
The SCIER sensing components deployed in the W-UI zones are the following:

- In-field sensor nodes, bearing two or three sensors, and responsible for measuring and transmitting raw parameter value
- In-field sensor nodes that act as cluster heads. They are similar to the sensor nodes except that they are more powerful and can bear additional, more complex sensors
- Out-of-field vision sensors based on an optical camera. They are capable of both reporting raw measurements corresponding to the various parts of the scene they focus on, and of notifying on high-risk levels of the measurements
- The data sinks, that relay the information to and from the sensor nodes towards the SCIER Computing System or the alerting control unit.

The network is made of nodes and a gateway. The nodes and the gateway use WiseMAC as the communication protocol. The Gateway is interconnected to the system that receives the data via a serial interface on which the HCI protocol.

The **Local Alerting Control Unit** (LACU) controls a network of variable type sensors, receives input from them, and executes fusion algorithms on the received data. LACUs are positioned all over the area prone to environmental risks, such as forest fires or floods. LACUs by themselves form a network with two distinct hierarchy/domain levels depending on the authority responsible for deployment and maintenance: LACUs belonging to the public infrastructure (public LACUs), and private LACUs, bought and installed by property owners.

**Figure 1.** Block diagram of a sensor node

**Figure 2.** LACU internal software architecture
Each node hosts an application (applicative software), which is the “main” of the software running on the node micro-controller. The complexity of this application is of course limited by memory space and time-related requirements.

Three modes of operations or “states” are designed for the LACUs:

1) NORMAL state: The LACU operates under normal conditions. No indication of an emergency situation has been detected.
2) NOTIFIED state: The LACU has already received a notification for a possible emergency situation (input source for this notification may be either the CS or a neighbouring LACU).
3) ALERTED state: An emergency situation has been acknowledged, either from the LACU itself or the CS.

This paper presents mainly the aspect, methods and results on coupling forest fire and flood models under the SCIER system in real multi-risk scenarios, and the use of the input of network of sensors. The basic approach followed is based on common understanding of soil characteristics and their change under circumstances of fire.

The use of CN curves together with land recovery curves constitutes the fundamental methodology used to couple forest fire and flood models. The hydrological response of the W-UI catchment to heavy rainfall differs depending on the different soil conditions, which are represented by CN curve numbers. Several if/then scenarios are presented and discussed in the paper showing the impact of burned area on the way floods are forming and routing in a particular river catchment. Sensitive areas are then detected by coupling fire/flood modelling, out of which particular restoration measures are proposed.

Figure 3. Process of coupling forest fire effect in the soil and hydrological models through the CN curve numbers

This multi-risk approach has already been followed in ORCHESTRA project [Caballero, 2007] in a similar area, also in Catalonia and also tested in MEDIGRID project in Extremadura region, in Spain [Bovolo, 2007] In ORCHESTRA pilot study case, the main
goal was to improve the inter-operability among the involved information and simulation systems through the implementation of OA services. This experience has helped in the development of the pilot study presented here, although in SCIER the focus has been given to the integration of sensed data for the monitoring of fire and floods conditions and the simulation of possible futures in a GRID infrastructure.

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REFERENCES AND BIBLIOGRAPHY


