Chapter 16

Sensor and Computing Infrastructure for Environmental Risks: The SCIER System

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ABSTRACT

The SCIER platform is an integrated system of networked sensors and distributed computing facilities, aiming to detect and monitor a hazard, predict its evolution and assist the authorities in crisis management for hazards occurring at Wildlife Urban Interface (WUI) areas. The goal of SCIER is to make the vulnerable WUI zone safer for the citizens and protect their lives and property from environmental risks. To achieve its objective, SCIER integrates technologies such as: (1) wireless sensor networks for the detection and monitoring of disastrous natural hazards, (2) advanced sensor data fusion and management for accurately monitoring the dynamics of multiple interrelated risks, (3) environmental risk models for simulating and predicting the evolution of hazardous phenomena using Grid-computing. In this chapter we present the key software components of the SCIER system architecture, namely the sensor data fusion component and the predictive modeling and simulation component.

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INTRODUCTION

The tendency for the development of extensive WUI (Wildlife Urban Interface) areas is a relatively new phenomenon. This refers to all types of areas where forests, water bodies, and rural lands interface with homes, other buildings and infrastructures, including first and secondary home areas, industrial areas and tourist developments (Stewart, 2007). The related problems that it generated, especially with regards to increasing fire and flood risks, started becoming noticeable only in the 1990s. The rapid development of WUI areas is the result of pollution and overpopulation of city centers that grew in the 1970s. However, in many cases, the rapid development of such WUIs was unplanned, or poorly planned. Settlements were built without efficient road networks, and homes and other buildings were developed in or near areas that form the flood plain of water catchments. Often there is no provision for routes of escape in case of a disaster.

The Sensing and Computing Infrastructure for Environmental Risks (SCIER) system constitutes an integrated sensing and computing platform capable of delivering to the authorities and the citizens valuable real time information regarding natural hazards that may affect the WUI. SCIER aims at providing the functionality needed for detecting, monitoring and forecasting the hazard’s evolution. Sensors deployed in the region monitor environmental parameters (e.g., temperature, humidity, wind direction and speed) and feed the data to predictive models running in the computing infrastructure. The SCIER platform builds upon existing technical expertise and recent progress in the areas of sensors, communications, Grid computing, Geographical Information Systems (GIS), data fusion and predictive modeling. Indeed, the information produced by the SCIER platform can in many cases be a key factor in the effective fighting of the hazard’s consequences. SCIER predicts the evolution of the main phenomenon as well as the risks associated with any secondary phenomena it may trigger. Furthermore, for the people living in vulnerable WUI areas, it addresses their needs for security and reliable alerting services. Finally, SCIER provides Civil Protection Authorities with a tool for the effective management of crisis situations caused by natural hazards.

Related Work

In this section we briefly discuss prior research activities on natural hazard detection and monitoring. Most of them deal with fire detection and make use of temperature and humidity sensors, smoke detectors and infrared cameras. In (Chen, 2003) a fire-detection system is proposed based on multi-sensor technology and neural networks. The sensed contextual data includes environmental temperature, smoke density and CO density. In (Pehrsson, 2000) and (Pehrsson, 2003), the authors present a system that is based on various types of sensors and use neural networks. However such systems require the use of training data and most of them are evaluated indoors where the weather conditions are fully controllable and, surely, completely different in comparison with those observed in a WUI. A system for wildfire monitoring using a wireless sensor network (WSN) that collects temperature, relative humidity and barometric pressure is described in (Doolin, 2005). The authors in (Calle, 2006) and (Sivathanu, 1996) propose systems based on infrared (IR) technology for the detection of fires. Furthermore, (Kucuk, 2008) and (Kosucu, 2009) have proposed solutions in which sensors are deployed from an aircraft. In (Hefeeda, 2007) the authors propose a distributed k-coverage algorithm to balance the load across all deployed sensor nodes. However, these systems use either in-field or out-field sensors, thus rendering them vulnerable to false alarms. In addition, aerial or satellite images are frequently used for outdoor fire detection and monitoring. In (Mandel, 2007) the authors present a system architecture which attempts