A data fusion framework with novel hybrid algorithm for multi-agent Decision Support System for Forest Fire

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A B S T R A C T

In this study Forest Fire Decision Support System (FOFDESS) which is a multi-agent Decision Support System for Forest Fire has been presented. Depending on the existing meteorological state and environmental observations, FOFDESS does the fire danger rating by predicting the forest fire and it can also approximate fire spread speed and quickly detect a started fire. Some data fusion algorithms such as Artificial Neural Network (ANN), Naive Bayes Classifier (NBC), Fuzzy Switching (FS) and image processing have been used for these operations in FOFDESS. These algorithms have been brought together by a designed data fusion framework and a novel hybrid algorithm called NABNEF (Naive Bayes Aided Neural-Fuzzy Algorithm) has been improved for fire danger rating in FOFDESS. In this state, FOFDESS is an integrated system which includes the dimensions of prediction, detection and management. As a result of the experiments, it was found out that FOFDESS helped determining the most accurate strategy for fire fighting by producing effective results.

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1. Introduction

In the globalizing world, forest fires are the leading natural disasters which concern all the countries in respect of their effects and results. The fires are significant threats which cause the combustion of millions of hectares of forest area worldwide every year, significant amount of fire fighting costs, reactional value and even life—property losses. The most effective way of reducing the damages caused by forest fires is quick fire detection and response together with all the protective measures. Therefore, today various studies have been made in order to improve early fire prediction and detection systems even together with the ones which helps to develop response strategies during the fire (Alonso-Betanzos et al., 2003; Bernabeu, Vergara, Bosh, & Igual, 2004; Satoh, Weiguo, & Yang, 2004). Each of these developed system is successfully in use on their dimensions (prediction, detection or management). But, the greatest disadvantage of these systems is their independent development from each other. This situation has given a birth to a need for development of Decision Support Systems which include prediction, detection and management dimensions together. Furthermore, forest fire prediction and detection operations are dependent to many factors such as meteorological measurements (temperature, humidity, rainfall, etc.), ambient measurements and coefficient calculations. In order to reach effective results in the mentioned procedures, all the factors must be considered and brought together.

Data fusion which brings many sensors together and receives the related data from the connected databases is a more sensitive and accurate technique in comparison with one sensor usage (Elmas & Sönmez, 2008; Hall, 1992; Llinas & Waltz, 1999). In recent years data fusion techniques have been successfully used in complex systems which require many calculations and parameters in military, medicine, industry, etc., fields to obtain high degree decision fusion (Ataeia et al., 2005; Jouseau & Dorizzi, 1999; Yuan, Dong, & Wang, 2009). In this study a Decision Support System for Forest Fire (FOFDESS) has been developed by means of data fusion techniques. FOFDESS includes prediction, detection and management dimensions for forest fires. Each of these dimensions is a part of Decision Support System and brought together within the data fusion framework. Every dimension has its own sensors and high degree decision fusion has been carried out by gathering data received from multi-sensors with algorithms. During data fusion process, Artificial Neural Network and Naive Bayes Classifier algorithms which produce successful results and are widely used for pattern recognition, estimation and classification procedures have been used. In the study, the activity of FOFDESS during a controlled fire started in forest area has been tested. The test run has been performed in Antalya which is the most sensitive region of Turkey with respect to forest fires. The results have showed that FOFDESS have effective and powerful inferences in every step of the fire.
2. Decision Support Systems and FOFDESS

Decision Support Systems constitute a class of computer-based information systems including knowledge-based systems that support decision-making activities. Building computer-based expert systems requires eliciting, analyzing, structuring, validating and interpreting the information when researchers deal with a particular problem. In recent years, many applications have been emerged relative to agent-based Decision Support Systems. New approaches of researching intelligent Decision Support System (DSS) appear following the rapid progress of agent systems and network technology. The main point of using Decision Support Systems (DSS) is to provide a user with the possibility to consult with an automated system while making decisions. The DSS, as a rule, includes a set of procedures, starting from data determination and processing, and finishing by generation and evaluation of alternatives. Thus, a typical DSS can be logically divided and represented by three main calculation modules or levels: the first one, responsible for data fusion and pre-processing, the second, dedicated to necessary calculations (modeling, data mining, etc.) and the third, which executes simulation and manages human–computer interaction.

3. Data fusion framework of FOFDESS

Many models can be used for the data fusion process representation. A functional data fusion model can show the functions, databases and connections. But an architectural model is suitable for displaying software/hardware configuration, data flow and external/internal interfaces. Mathematical models should be used in order to indentify the algorithms and the logical processes. By the reason that variously characterized data is formed in a data fusion
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