Flood Forecasting and River Monitoring Expert System in the Prahova River Basin

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Abstract: The development of an efficient flood forecasting and river monitoring system requires the use of an automated data acquisition system and the analysis of several hydrographic basin parameters that are monitored. Due to the strategic importance of river basin monitoring, in the last years, different modern techniques were applied, including some techniques based on artificial intelligence, such as ANFIS system, agent-based modeling and neural networks. In this paper is proposed a flood forecasting and river monitoring expert system prototype. Some experimental results obtained for the prototype expert system are presented.

Keywords: Expert System, Flood Forecasting, Hydrographic Basin, River Monitoring

1. INTRODUCTION

In the last years, several floods have been reported all over the world, and in particular, in European countries. The consequences of some floods were recently supported by different regions of Romania (Oprea *et al*, 2009).

Thus, it was necessary to develop effective software tools based on artificial intelligence techniques for flood prevention and real-time warning system.

Develop accurate forecasting models, by tracing the evolution of parameters in real time river water, increases the available time for local authorities to intervene effectively to reduce or eliminate the effects of catastrophic limit situations, such as flooding and massive drops in short time liquid precipitation or heavy snow, flood wave formation.

Training flow process and its integration on the slopes is a very complex process due to spatial and temporal variation of rainfall, infiltration and catchment characteristics. After training the net rain or leakage of surface water begins to flow on the slope, covering relatively short distances (50-80 m). Surface irregularities determine the flow concentration of the valley, which unite to form higher order river network (Popa, 2006).

Due to the formation way of the leak, very different from one basin to another, it haven not been developed so far an analytical solution to calculate the slopes and river bed from precipitation data.

Monitoring and analysis process in a drainage basin makes it possible to study in detail the reaction of the basin in case of large amounts of precipitation.

Expert system for monitoring and analysis of river basin developed in this paper is a knowledge-based system for monitoring, prediction and control of floods, including expert knowledge of hydrology and Engineer hydrology and solve problems related to the human expert.

To achieve an expert system, which has oversight of the hydrological drainage process and potential emergency situations prediction, information about the amount and intensity of rainfall, river flow in real time is needed. Direct access to information on the current state of the river system will reduce time to prevent floods and warning the population. Monitoring the current state of the river is effected by means of sensors and transducers located at different gauging stations on the river Prahova.

The system analyzes the current status of monitored parameters and, depending on the rules and heuristics known, estimated production of flood where the Prahova river basin indicates prevention and control measures to be taken from the human expert.

2. EXPERT SYSTEM ARCHITECTURE

Architecture shown in Figure 1 is a prototype expert system for monitoring and analysis of Prahova river basin which includes a knowledge base (CB), an inference engine (MI), a knowledge acquisition module (MAC), a method of generating explanations (MGE) and a user interface.

Information flow associated to processes in the system deployed is configured to facilitate exchange of information between various system tasks.

The user interface is connected to two components of expert system:

- Explanation generation module - enable-guided inference engine, highlighting steps up to the solution driven by memorizing the order in which rules were executed;

- Knowledge acquisition module - allows modification of rules by adding new elements or using existing ones.

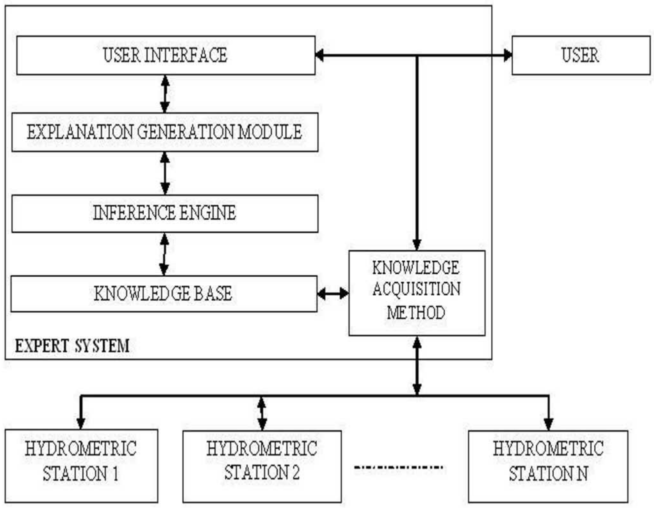

Fig. 1 The expert system architecture for monitoring and analysis of catchment

Raw data are acquired through knowledge acquisition module. They provide information on the following parameters: precipitation type, rainfall amount, rainfall intensity, rainfall fell on 10 days ago, the basin area, basin shape factor, the total time of flood, the flow rate of the basin, basin shape the degree of forestation, the main river slope, basin area, flood frequency and duration. Measurements made by the monitoring system are included under the facts and inference engine used during the reasoning.

3. DESIGN AND IMPLEMENTATION OF ONTOLOGY AREAS OF EXPERTISE AND KNOWLEDGE BASE

The objective of ontology development and implementation of the system was to represent a conceptual, shared and reusable (Oprea, 2002).

Ontology expert system seeks accurate explanation of the meaning of concepts so that the communication system to be as good as possible.

Purpose variables of the system are represented by estimate flood wave production (estimation_flood_wave), by determining the warning code (warning_code) and measures to warn the population.

Hydrological warning code is described in Table 1.

Table 1 Significance of hydrological codes

Hydrological codes	The significance of hydrological codes
Yellow code	Flood risk and water levels rise rapidly not causing significant damage, but require increased vigilance in cases of seasonal activities and / or exposed to floods. CAUTION exceeded quotas
Orange code	Flood risk generating major floods are likely to have significant impact on local life and safety of goods and people. EXCEEDING the quota Flood
Red code	Risk of major floods. Direct threat to the general safety of persons and goods. Exceeding the quota of danger

Knowledge base is implemented in VP-Expert and includes knowledge taken from human experts structured as rules. These rules allow the prediction of potential flood wave and measures to be taken in case of flood in a river basin by using the measured values of hydrometric stations.

Rule base is structured in several different sets of rules for determining what characterizes the parameters catchment studied.

Rules used for determining the flow are given below:

A SET OF RULES – FLOW RATE DETERMINATION

RULE 11
IF precipitation=small_under_40l_m2 AND flow_rate=between_0.1_0.3 AND basin_area=small OR basin_area=medium OR basin_area=large AND total_time_flood=abesent OR total_time_flood=medium OR total_time_flood=large AND river_level=between_CA_and_CI THEN flow=under_CA;

RULE 12
IF precipitation=medium_between_40_80l_m2 AND flow_rate=between _0.1_0.3 AND basin_area=small OR basin_area=medium OR basin_area=large AND total_time_flood=abesent OR total_time_flood=medium OR total_time_flood=large AND river_level=under_CA THEN flow=under_CA;

RULE 13
IF precipitation=medium_between_40_80l_m2 AND flow_rate=between_0.1_0.3 OR flow_rate=between _0.3_0.5 AND basin_area=small OR basin_area=medium OR basin_area=large AND total_time_flood=abesent OR total_time_flood=medium OR total_time_flood=large AND river_level=under_CA THEN flow=under_CA;

Symbolic values of measured quantities are fuzzy terms which are each associated with a range of values, as a

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