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An Analysis of Modern Monitoring and Preventing Techniques of Floods

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Abstract

This paper presents a short analysis of the newest monitoring and preventing techniques applied to the management of emergency situations from a river basin. The analysis relates to some up-to-date software systems implemented in national and international projects about monitoring and preventing of floods. Usage of artificial intelligence in monitoring and preventing of floods proves better results than conventional methods. In order to improve the efficiency of these techniques, it is proposed to apply artificial intelligence techniques such as experts systems, data mining, intelligence agents.

Key words: *artificial intelligence, flood prediction, monitoring*

Introduction

Water brings with it a permanent element of risk, an extremely may occur at any time. Hydrologists are the ones who have the responsibility to collect more precise data using the most modern equipment and to develop accurate analysis on the possible production of flooding to prevent human and material loss.

More recently, the development of computer and data transmission have made possible to obtain data measured by remote devices and to develop programs for real-time prediction of floods.

Research efforts in this area are oriented to more directions which aim at:

Monitoring the river basins, which involves observation and measurement of specific parameters, such as debits waves of runoff, recognizing the end of water lines in defense profiles, cross sections of the river. Real-time of the development of river basins parameters is made on the drafting of accurate forecasts;

- Prediction of short and medium term which takes into account the evolution, nature and intensity of hydrological phenomena by analyzing all the factors and processes that determine them. The main purpose of prediction is to reduce the adverse effects associated with floods;
- Control, to a greater or lesser extend, of the production of maps through the development and installation of systems for monitoring and prediction in some hydrological basins with potential risk.

The paper presents an analysis of the latest techniques for monitoring and predicting of the floods, developed by projects at both national and international level. This is based on the information contained in bibliographic sources and own scientific and practical acquired observations.

There have also been reviewed several software solutions already implemented in projects developed for modeling and simulating of the emergency situations such as the production of runoffs in river basins.

The Current State of Research at National and International Level, in Monitoring and Predictions of Floods

International Projects

Practice has shown that global occurrence of floods can not be avoided, but they can be managed, and their effects can be reduced through a systematic process that leads to a series of measures and actions aimed to contribute to the reduction of the risk associated with these phenomena. Flood management is easier by the fact that their event is predictable and often a prior warning can be made, and normally it is possible to clarify who and what will be affected by the floods.

In the next paragraphs we shall present the solutions adopted at the international level for flood management by implementing programs and systems for monitoring and preventing of floods:

- ANFAS project aims to develop a system of decision-making to prevent and protect against floods by using one of the most advanced techniques of data processing and management; [3]
- NVE project aims to achieve maps of flood risk in Norway. Models of data from the mapped areas with high risk of flooding will be possible for quantitative predictions of floods, such as forecasts of local water levels; [13]
- DMS project includes implementation of a system of flood forecasting and the mapping of flooded areas from Mahanadi river basin; [6]
- FRICS project involves establishing of a comprehensive system for managing the rivers for flood control, using of water resources and environmental conservation as well as preparation of detailed action plans in case of emergencies to deal with floods in urban areas; [1]
- HydroHMD software is running for the development of three projects in Turkey and Bulgaria: one for information and exchange data in real time and another two to prevent flooding and warning; [7]
- Seyhan project is used for modeling Seyhan river in Turkey with the use of methods of artificial intelligence; [4]

These solutions consists in forecasting of the floods, either by flood mapping for land prone to flooding, or through using of information systems of warning in case of possible production of dangerous hydro-meteorological phenomena.

Table 1 summarizes the main features of the projects listed above:

Table 1. The features of systems for flood management adopted at the international level

Project	The characteristics					
	The use of conventional methods or advanced	Visual representation of areas flooded	The use of an user interface	The use of the Internet	Methods of sampling of entry data	The use of the databases
ANFAS	Advanced methods	Yes bidimensional	Yes	Yes	Distance measurement	Yes
NVE	Conventional methods	Yes bidimensional	No	No	Previously recorded historical events	Yes
DMS	Conventional methods	Yes bidimensional	Yes	Yes	Airborne Laser System	Yes
FRICS	Conventional methods	Nu	No	Yes	Pluviometric and measuring stations	Yes
HydroHMD	Conventional methods	No	No	No	Hydrometric stations	Yes
SEYHAN	Advanced methods	No	Yes	Yes	Previously recorded historical events	Yes

It can be seen from Table 1 that most part of the systems implemented in recent years require the use of modern technological equipment, systems such as automatic acquisition of data from the points of interest located within the basin, modern techniques for processing and storing information acquired results in database systems for real-time description of the development of river basins parameters.

I will continue with describing of several types of modeling and simulation systems of hydrological processes implemented abroad:

- Hydrologic modeling system HEC-HMS is a generalized system capable of modeling to represent more problems related to the debacle. The program is built to be applicable in different geographical areas and to solve a wide range of specific issues. These include large river basins, hydrological floods, overflow of small urban water. Hydrographical maps made by the program can be used either directly or together with other software to study the availability of water, flood prediction, reducing damage caused by them, regularization of river course to reduce flooding. The program is characterized by a fully integrated work environment including a database, opportunities for the introduction of data, engine and computational tools for reporting results. The program includes a graphical user interface that allows flexible movement between different parts of the program. Functionality and the presentation of the program are the same, regardless of the platforms on which it is installed. [10]
- The WMS program is a comprehensive graphical modeling system for all phases of water leakage. WMS includes powerful tools for automation of processes such as modeling description of the river basin, the calculation of geometrical specific parameters, extraction of cross-sectional data on land and more.
- HSPF hydrological system is used to simulate falls of plentiful rainfall and snow melting. Climatic data are acquired and played in real time. Pre-processor routines are used to ensure data quality, control quality and partial records filling. The interactive GENSCN (to generate and analyze simulation scenarios) is the interface of HSPF and helps in the

management of databases. This is a printing, the generating of statistics and animating the results of simulation with HSPF software. [14]

Table 2 summarizes the main features of the systems listed above:

Table 2. Types of modeling and simulation of flooding systems

System	The platform that runs	Multiuser operating	Compatibility with GIS (Geographical Information System)	Types of images
HEC-HMS	Microsoft Windows and X-Windows	Multiuser operating in network	It is a software package that is used with ArcView for the development of a number of hydrological models	2D images
WMS	Microsoft Windows	No	It is not a compatible GIS data management therefore primary data on land and soil is limited	Pictures of 2D and 3D design
HSPF	Microsoft Windows 9x/NT	No	It is not a program that processes data from GIS	The output are represented in the form of a series of data and does not use graphics to describe them

Thus, one can see that at present there are systems that have certain specific on modeling the river basin, while others have targets on simulating the production of any flooding and generate maps with floodable river bands.

National Projects

On the national level, there have been developed in recent years the following projects:

- DESWAT program aims to improve national water system to protect against flooding and dangerous hydro-meteorological phenomena. [15]
- WATMAN project provides data and real-time forecasts, tracking modernization of the Water Management in Romania; [15]
- HIDROSIS project implements an automated system for monitoring the Someşul Mic river basin in the prosecution of water quality, flood prevention and environmental protection; [9]
- Sapa-ROM system is a monitoring system (receiving, processing and transmission) and alarming in case of accidental pollution of the waters in Romania. [11]

Table 3. The characteristics of flood management systems adopted at national level

Project	The characteristics					
	The use of conventional methods or advanced	Visual representation of flooded areas	The use of a user interface	The use of the Internet	Methods of sampling of entry data	The use of databases
DESWAT	Conventional methods	No	No	No	Automatic hydrometric stations and pluviometric posts	No
WATMAN	Conventional methods	No	No	No	Automatic hydrometric stations and pluviometric posts	No
HIDROSIS	Conventional methods	No	Yes	Yes	Automatic hydrometric stations and pluviometric posts	Yes
SAPA-ROM	Conventional methods	No	No	Yes	Hydrometric stations	No

On national plan, the projects aim to introduce automation systems for data acquisition and the methods and techniques for processing the collected data and characteristics of a given river basin. However, it is recommended the use of artificial intelligence techniques, techniques that significantly improve the monitoring of river basins and preventing emergency situations as well as good management and use of data to decision makers level.

The whole process of the hydrological cycle is mathematical formulated through conceptual models composed of a large number of parameters and quite complicated interaction between them is therefore very appropriate use of advanced modeling techniques provided by artificial intelligence.

The accuracy of the model created by conventional methods is very subjective and very dependent on the project's ability, knowledge and understanding of the characteristics of a model basin.

Techniques such as artificial neural networks, fuzzy logic, intelligence agents, knowledge-based systems, expert systems are implemented today for monitoring and prediction river basin development, their efficiency is beneficial for the prevention of damage to property and persons.

Artificial intelligence tools and techniques hold fast and flexible to implement better solutions in the field of hydrology performances, such as:

- Artificial Neural Networks (ANN) and neuro-fuzzy systems (NFS), which can be created for streamlining the process of leakage of water production and flood prediction;
- Knowledge-based Systems (KBS) and expert systems (ES), which can offer solutions for monitoring and analyzing in real time the development of the specific parameters of a river basin. Also these systems (KBS and ES) can be used successfully in the implementation of systems for the prevention and alarm in emergency situations;
- Data Mining Techniques (DMT) to extract rules from large databases that store the parameters of measurement and control of the river basin, rules that can then be included in expert systems (ES);

- Multiagent systems (MAS) made up of intelligence agents, which can be used to more effectively resolve problems arising in simulating hydrological processes because they are unpredictable and dynamic processes undertaken in a complex, sometimes inaccessible environment.

Optimizing the monitoring and prevention of floods systems can be done using artificial intelligence techniques, as they have capacity to solve difficult problems that can not be solved with centralized, traditional methods. Benefits can be found in the decrease of time response and improved efficiency of the system.

Conclusions

The progress of artificial intelligence field begins to be reflected in hydrology through specific research and implement techniques both internationally and nationally, but there are issues that have not yet been studied.

By improving the prediction and viewing of speed, direction and expansion of water course during possible flooding, by monitoring the river basin using the techniques of artificial intelligence, they will provide all necessary information to take immediate measures related to defense against floods.

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Analiza tehnicilor moderne de monitorizare şi prevenire a inundațiilor

Rezumat

Acest articol prezintă o scurtă analiză a celor mai noi tehnici de monitorizare şi prevenire aplicate managementului situațiilor de urgență dintr-un bazin hidrografic. Analiza ia în considerare mai multe sisteme software actuale de monitorizare şi prevenire a inundațiilor, dezvoltate pe plan național şi internațional. Utilizarea inteligenței artificiale în monitorizarea şi prevenirea inundațiilor a dovedit performanțe mai bune în comparație cu metodele convenționale. Astfel, pentru îmbunătățirea eficienței acestor metodei, se propune aplicarea următoarelor tehnici de inteligență artificială: sisteme expert, data mining, agenți inteligenți.