Web-based hydroinformatics application for real-time water level presentation and short-term prediction

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Goal and scope

A prediction of a high water situation is one of the most essential hydrological tasks for river basin management and is mainly performed by means of traditional conceptual and deterministic models using the predicted precipitation. Modern urbanization tends to cause a fast response time in river basin between a heavy precipitation and consequent runoff processes. Therefore, it is even more essential nowadays to enable citizens a rapid and flexible access to information on the prevention or restoration measures in case of flood, on the basis of the cutting edge advances of Information and Communication Technology (ICT). The paper contains a description of a real-time web-based service for water level observation, processing, presentation and a short term prediction of a river water level in the area of interest. The Artificial Neural Networks (ANN) and Auto-Regressive eXogenous (ARX) input models are implemented for cost-effective water level prediction for a short horizon. On the whole, the web services should form a part of a publicly accessible web-based flood crisis management system.

Study area and data

The area of interest is the Oder River on the eastern border of Germany. The sixth biggest confluence to the Baltic Sea, the Oder is a trans-boundary river. The water level observations to be used for a real-time presentation and prediction for the city of Frankfurt/Oder and several other gauging stations are allocated real-time on a sampling interval of 15 min from a public data server in the Internet, provided by a relevant authority and saved into a local database. Water level data from some of the gauging stations considered are also available for the hydrological year of 1997, including a flood of 1000 years of return period and are used for off-line setup of the prediction models.

Methods

The water level presentator, as well as the prediction models are implemented using Java Servlet technology, which provides web developers a simple, consistent mechanism for extending the functionality of their web server. The presentation of the collected and predicted water level data is implemented in Scalable Vector Graphics (SVG), an XML language for describing two-dimensional vector graphics.

The Artificial Neural Networks (ANN) and linear statistical model, namely Auto-Regressive eXogenous (ARX) input models are applied for water level prediction. The ANN actually is a set of computational units, which eventually aimed to emulate the learning behavior of a human brain. Upon optimizing certain weight or connection strength between the artificial neurons, the ANN can *learn* the input/output relations on the basis of the existing observations. ARX is a linear time series

model, which uses the direct dependence of the previous measurements in auto-regressive form and exogenous forcing variables.

Obtained results

A real-time dynamic and interactive service for water level presentation has been developed with functionalities for data collection, saving into a local database, processing the user's requests and presenting it in a tabular and graphical view (www.ist-osiris.org/ffoder). Upon the user's request on time interval and time slice for presentation, the Java Servlet generates simultaneously a HTML page with JavaScript embedded, which produces a tabular and SVG view of the observed water level. The water level observation can be requested from 1 hour up to 1 year for presentation.

Carefully elaborated off-line study on water level prediction by the ANN and ARX models resulted in a satisfactory performance. The above models predict water level at the city of Frankfurt/Oder and several other locations on the basis of easily available information, which are upstream hydrological conditions. Hence, the above prediction models are implemented as an on-line water level predictor and integrated into a real-time water level presentator, from which the inputs are allocated. The water level presentator gives a user also a possibility to compare the predicted and observed values in the past for different prediction horizon and period. The water level prediction is made for 15 min to 12 hours of time span. Since, the implementation was not aimed the prediction models to be trained or setup on-line, the neural networks and ARX models have to be setup from time to time, whenever new extreme values are observed.

Conclusions

There is a need for a rapidly accessible on-line system to help citizens, as well as the decision makers to plan emergency and restoration measures during high water situations. A web-based service for a real-time water level presentation was developed as a part of a flood disaster management system in framework of the EC funded project OSIRIS (www.ist-osiris.org). The system should enable the average citizen with an Internet access to monitor the flooding events likely to occur in their area of interest and take the means of prevention measures suggested by the relevant authorities. A cost-effective and rapid-responding on-line tool by the ANN and ARX models have been implemented for water level prediction for a short horizon and integrated into the above web-based service. The predictions are based on the upstream hydrological conditions only. The data from further upstream is needed to enable prediction for longer time span. The on-line water level predictor can be used as an alternative or complement to conventional modelling approaches.

Keywords: web-based service for flood crisis management, on-line neural networks, water level prediction

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