US Army Corps of Engineers®

Urban Flood Demonstration Program

An Urban Flash Flood Prediction System Using Computationally Intelligent Techniques

Figure 1. Floodwater on Alexander Road, Las Vegas, Nevada during a 1999 flash flood event (courtesy Clark County Regional Flood Control District)

Products A technical report describing the results of the research effort in FY10.

Benefits The rainfall intensity and hydrology of the Las Vegas area are important factors in flash flood forecasting. Flash flood forecasting requires both hydrological and meteorological information in near real-time. To obtain rapid response and reliable results, a new computation tool using modern computational intelligence methodology, such as artificial neural networks (ANNs) is proposed.

Issue In the arid and semi-arid regions of the world, water resources are limited and under increasing pressure due to expanding populations, increased per capita water use and irrigation. Floods are infrequent but extremely damaging, and the threat from floods to human populations and infrastructure is increasing due to urban development. Clearly, effective water management is essential and this requires appropriate decision support systems including modeling tools (Wheater 2008). Traditionally the prediction of urban runoff uses a simple watershed formulation and some watershed data such as soil moisture deficit or soil structure, which are rarely available, adversely impacting the accuracy of the prediction. The relationship between rainfall and storm runoff is not linear as used in this type of formulation. However, model-based flood forecasting attempts to predict the state

of hydrometric parameters such as water levels and river flows at a number of locations.

Historical events have shown that the greatest damage to human life and property occurs under the conditions of flash flooding in urban areas. The severity of a flooding event is controlled by a combination of river basin terrain, local thunderstorm movement, past soil moisture conditions and the degree of vegetative clearing. Urban flooding occurs where there has been development within stream floodplains. Urbanization increases the magnitude and frequency of floods by increasing impermeable surfaces, increasing the speed of drainage collection, reducing the carrying capacity of the land, and, occasionally, overwhelming sewer systems. In general, as land is converted from fields or woodlands to roads or parking lots its ability to absorb rainfall diminishes. Urbanization increases runoff by a factor of 2 to 6 times over what would occur on natural terrain. During periods of urban flooding, streets can become swift moving rivers, while basements can become death traps as they fill with water.

Description

In this preliminary study, the real-time flash flood prediction is examined by two sub-watersheds in Las Vegas Valley as demonstration examples. The first example uses USGS water discharge data to quantify the flash flood behavior in the Lower Las Vegas Wash. The magnitude and phase propagation of the flood wave from the upper to lower washes are trained and tested by time-lagged recurrent supervised ANNs. The second study area is the Flamingo/Tropicana sub-watershed. Real-time precipitation data from 14 Clark County Regional Flood Control District rain gauges represent the model input. An unsupervised ANNs approach is used to cluster or group the input streams. The runoff from the sub-watershed outlet represents the output function to quantify the relationship from the above grouping of flash flood rainfall information.

More detailed investigation, including adding water level as additional output, to extend the study area to other sub-watersheds as a valley-wide approach and to develop data assurance program to minimize uncertainty, will be proposed in follow-on phases of this research effort.

Sponsor

Urban Flood Damage Reduction and Channel Restoration Development and Demonstration Program for Arid and Semi-Arid Regions (UFDP)

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References

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