Application of Fuzzy Logic to the Management of Flash-Flood Gates

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Disaster prevention schemes to protect public infrastructures are usually developed in consideration of the natural environment, such as social importance of the region, by setting a target safety thresholds development has been promoted as a target degree of safety set predetermined. In this regards, ponds and retarding basins are developed to attenuate flood waves by temporarily holding and store flash-flood water from the catchment area. Despite their social benefits to reduce urban inundation and increase the community recreational area, flood retarding basin can pose a potential threat to the downstream community if the flood water exceeds the design consideration. In recognition of stringent requirements for efficient flood controls of complex systems it is fundamental to develop accurate tool to extent to which knowledge of expert and advanced mathematical modelling can be easily integrated. The present study introduces the development of a fuzzy controller decision support system to sustain river authorities in flood control, prevention and risk mitigation. The most critical and common objective of flood control remains the operation of floodway gates to store the overflow during high flow periods and redirect the stored water to the river back during low flow periods. Such operation heavily relies on the forecast accuracy of the rainfall, the real time prediction of river streamflow, the forecast of the water levels in the protection structures (e.g., dam, or pound) and furthermore on the intuition of the experienced engineers at the local river office. The past flood records and practices demonstrated that engineers with different prior flood experience could be expected to behave differently during a flood event, inducing a high risk of conflicting consequences between river flooding and disastrous break of the pounds.

In order to overcome some of the existing complexity and uncertainties involved in the management and flood control process, a fuzzy controller decision support system (FFC-DSS) was implemented. The present FFC-DSS includes five sub-systems modules, namely (1) a database manager, (2) a rainfall forecast model using fuzzy pattern matching, (3) a storage model to forecast the river stream-flow, (4) a fuzzy database and information retrieval model for forecasting the water level in each pound, and (5) fuzzy control expert system for the operation of the emergency floodway gates. The developed FFC-DSS is a user-friendly operating system enhanced by dynamic computer graphic presentation of the forecasted hydrologic parameters and consequent risk damages (e.g., flood plain). The application of the FFC-DSS for flood management and control of the Tsuboi River basin, western Japan, was found a highly efficient tool to increase the operation accuracy and assess the susceptibility of the existing protection system to different flood scenarios.