An Abstract of Thesis

on

Design and Development of IoT Based Fuzzy Expert System for Flood Detection and Avoidance

by

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Every year, flood claims several lives in India and abroad. Floods are caused by several factors, including heavy precipitation, tsunamis, or failure of structures (i.e. dams, levels, retention ponds), that contained the water. A flood can be categorized in a periodic flood or in an aperiodic flood. Periodic floods occur on rivers while aperiodic floods happened due to heavy rain or waterlogging in raining seasons.

Flood control has been an important step in the flood management process. It is performed by many techniques including installation of rock berms, sandbags, maintaining normal slopes with vegetation and construction or expansion of drainage channels. In this row, after Katrina (2005), the research community has started seriously focusing on drainage structures. Though drainage structures of different shapes have been designed and installed by various researchers, but the problem is still not resolved. Hence, the researcher has proposed two grid structures, including hexagonal and octagonal based on the cellular automata (CA). In addition, a procedure to find out the best grid pattern for a drainage system to avoid flood or waterlogging has also been proposed. For the same, evaluation of different grid shapes of CA has been performed to find out the most suitable patterns for various cases. This evaluation is done on the basis of a number of exit paths available in grid patterns. The researcher has analyzed and compared three grid patterns including a square grid, hexagon grid, and octagon grid. Linear and bilinear elevations of flood plain have been considered for comparison. After this evaluation, a suitable grid pattern with the tanks at each corner of the drainage mechanism has been suggested. The validation of the proposed method to develop the drainage system has been performed using the Paired T-Test.

Though there have been many approaches for flood detection, but results are not satisfactory as the number of casualties due to flood is increasing year by year. Hence, there is a need to develop an appropriate technique for the detection of a flood. To cater to the need, the researcher has proposed techniques for flood detection based on the Internet of Things (IoT) and Artificial Intelligence. IoT, WSN, and MANET are key technologies generally used for the detection of a flood. Out of these three, IoT is an efficient technology able to communicate and analyze the problem. This technology involves many devices to sense. In the thesis, a new terminology has been proposed for the IoTs used to monitor real-time environment i.e. The monitoring of real-time environments using IoT is referred to as the Internet of Environmental Things (IoET).

Device design is a fundamental issue in implementing IoET. To overcome the issue, the researcher has selected the appropriate components. It is done on the basis of the Systematic Literature Review (SLR). The SLR has determined the types, numbers, and usefulness of components in order to build an effective flood detection device in the real-time environment. Components of devices in IoET have been selected according to their applicability extracted through SLR, and have been incorporated to design low-cost flood detection devices. The researcher has designed various flood detection devices by integrating suitable components. The devices designed during this research are tested for their accuracy. The researcher has also analyzed the properties of the components, including current requirements and power consumption. The cost of deployment of these devices has also been analyzed. Validation of the proposed transmitting device has been performed by using F-test.

Further, the deployment strategy of devices is also an issue in IoET as well as in Wireless Sensor Network (WSN) applications. The researcher has addressed the issues of deployment of devices for flood detection. Deployment strategies have been proposed to deploy sensing devices in flood plain of newly

developing cities as well as existing cities. These strategies determine the quantity and locations of devices in order to build an effective system. It decides many intrinsic properties of an IoET, such as the number of devices and cost, etc. Sensor nodes form Things of IoET network are responsible for providing sensed data to the application. For sensor node deployment, a Cell Elimination Algorithm (CEA) and Cellularly Deployment Algorithm (CDA) have proposed for existing and newly developing cities, respectively. Both techniques fill the research gap observed during the literature review. In addition, these can serve as guidelines for IoT designers, solution providers and system integrators of IoT applications. The validation of the proposed CEA and CDA has been performed using the T-Test and F-test in one way ANOVA.

The location of device installation will also affect the accuracy of sensed data. Hence, tanks of drainage structure and path of water flow have been assumed as appropriate locations for device deployment. The researcher has made an attempt to utilize sensory data in an expert system after receiving it from IoT. This expert system provides information about the risk of the flood before it happens. A risk assessment is performed based on a threshold that may vary from city to city because the level of peak rainfall for the different cities may differ. So, the threshold is assumed as a variable in designing of an expert system. While the simulation of an expert system, an evaluation of fuzzy rules and impacts of input rules on output has been done. Based on the evaluation, a Web-based expert system (Risk finder system) has been developed. Validation of the proposed method to develop an Expert System has been performed by finding a relationship between water level and rainfall using Multiple Linear Regression.