CNN based Flood Management System with IoT Sensors and Cloud Data

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Abstract: Water is one of the basic resource need for every human in the world. The improper management of water storage system can lead a human life to any extent. As a result of technology development, the proposed model is developed to manage the water storage systems like dam and lake through remotely placed sensor signals. The sensors which are placed in the storage places gives the strength and storage capacity of the dam and lakes. Similarly the sensors which are placed at the sender dam or lake are used to predict the incoming water level to the receiver lake. This improves the prediction rate of flood in the river paths and this prediction allows the incoming dam to send off some waters outside to allocate some space for incoming waters. The data which are generated by the connected dams are stored in a cloud space for analyzing the water flow management. The sensors connected in a lake or dam is connected with IoT platform to avoid wire connections. Hence this model avoids sudden floods during rainy conditions and it ensures the physical strength of the lake and dam by continuous monitoring process.

Introduction

Nowadays the IoT sensors are widely used for many applications due to its reliability. Lot of smart technologies and control equipment were developed with IoT sensors. The IoT applications are still undergrowth on many fields because of its simplicity in size and cost parameters. The installation and maintenance of IoT based applications doesn't costs huge than the human managements system. The precision and immediate response of the IoT system makes it to be even engaged with vehicle driving modules also. A simple architecture of IoT system is shown in the figure 1. It consists of a sensor with transmission module, wireless medium and a task controller. The projected architecture is a single ended communication of IoT transmission where the communication between the sensing element and the receiver never be interrupted by a third party sources. The transmission module is directly connected here with the sensors for carrying the signal to a remotely placed task controller. The task controller is a microcontroller chip connected with an IoT receiver module to interchange the collected information from the sensor devices. The response of the system will change here with respect to the signal received from the IoT channel.

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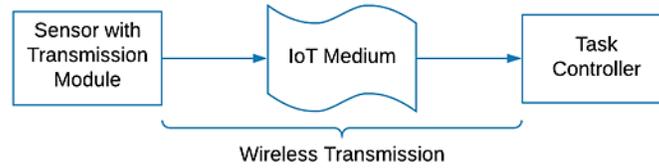
Figure 1. Architecture of single ended IoT transmission.

The sensor data which are collected from IoT sensors are transmitted immediately to the task controller to enable the necessary action. All such measures or obtained sensor data never be saved in most of the applications. Certain defensive and medical sensors are used to monitor the medium for certain hours to track the record of the measured data. In such applications an external storage is provided with the IoT modules for saving the data. Cloud data storage is a recent trend in internet data management to save any huge data for any time duration. The main advantage of the cloud data storage is accessibility. The measured values from the IoT devices are easily be traceable and readable from anywhere in the world. The architecture of cloud storage enabled IoT module is shown in figure 2, where the measured data are transmitted to the primary task controller. At the same time the measured data are forwarded to the cloud storage unit also. The secondary task controllers are can be in any 'n' numbers of controllers placed to do some of the specific tasks with direct connection to the cloud storage unit.
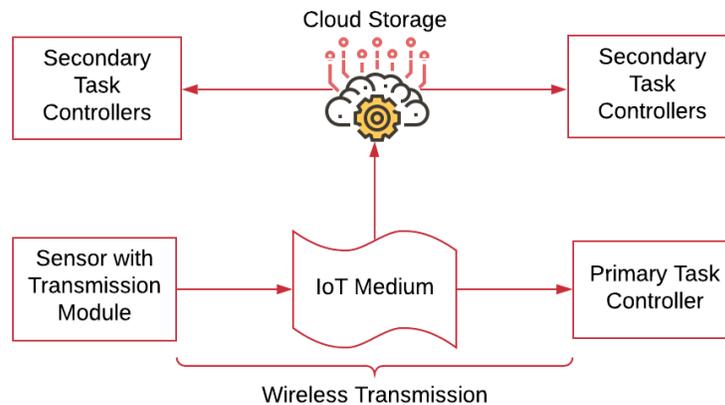
Figure 2. Architecture of cloud enabled IoT transmission.

The informations which are gathered by the cloud storage unit is widely applied for several manipulation tasks. A simple prediction and classification process of deep learning algorithms require large number of training sample to learn the module. The cloud storage data system enables such deep learning algorithms to train up them without need of collecting separate sample data. This improves the reliability on the training process.

The proposed system is applied with cloud data storage for another application. In the proposed work the cloud data storage is not utilized for training the algorithms. It aims to predict the future values by certain mathematical operations. The data of certain weeks, days and hours are needed in the prediction calculation for estimating the water management process. Similar to the figure 2 architecture, the data of a particular dam or lake is manipulated by several secondary dam system to estimate their incoming water sources. The main motive of the proposed work is as follows-

- Continuous monitoring of sensor data at any critical situation.
- Delay less transmission of predicted data.
- Intelligent disaster management at flood conditions and
- Smooth operation of water flow system.

Related work

A Holt-Winter's prediction approach was proposed to predetermine the flood flow process [1]. A group of IoT devices were utilized here to measure lot of required parameters on water flow measurement and all those data were analyzed by high performance computing algorithm. The data collection includes weather report data, meteorological data along with national oceanic and atmospheric administration record. All such data were collected together to form a dataset to train the prediction model. Along with Holt-Winter's prediction approach, a singular value decomposition was employed to reduce the attributes and the location about the flood rating was analyzed with K-mean cluster algorithm. An IoT based big data analytics system [2] was applied to a health care monitoring process. Here the collected informations of the patients are made to form a big data in the cloud. An analytic process was employed to the big data architecture to extract the useful informations alone for predicting the patient's health.

A flood disaster prediction model [3] was developed by using IoT sensors and big data analytics tool. The tool was equipped with convolution deep neural network for training the model. The prediction system has a preprocessing step for removing the repeated data as well as for encrypting the missing data in the informations. The system was trained to predict the chances for disaster presence. The developed model was compared with ANN and DNN to prove its efficiency in prediction. The analytical results indicates that the accuracy of the proposed model performance than the other two classifiers. A secure internet of everything [4] was designed to safer the big data from the attack vulnerability. The general IoT systems are equipped with more number of sensors based on the application. The collected signals are transferred to some cloud environment to form a big data for manipulation and analytic purpose. In such cases there are chances for the big data to get hacked and manipulated by a third party hacker. In order to avoid such issues the secure internet of everything system was developed. The performance of the IoT system was compared with WSN and MANET for finding their cost efficiencies in data transmission [5]. The performance was analyzed by detecting the flood level through network sensors. The performance work says that IoT platform gives better accuracy than the traditional networks, in terms of speed also the IoT performs well. The accuracy of the system may get change with respect to the kind of algorithm employed in it. But speaking on cost wise estimation, the IoT is quite higher which is tolerable due to high accuracy. Because the drop rate and delay was comparatively higher in the WSN and MANET programs. So for the critical applications like flood and other health related application, the IoT stands well than the traditional ones.

To easy up the cloud computing process, an edge computing model was implemented [6]. The edge computing architecture was equipped with artificial intelligence techniques to make the computing process faster and efficient. The performance of the edge computing technique was analyzed with network simulator tool and the results indicates a better performance on edge computing in terms of delay. A disaster management system [7] was proposed to save elder people on critical conditions. The system was equipped with plenty of sensors to detect floods, heavy rain, and earthquake and so on. All the sensors are connected to the IoT platform for giving intimation to relatives and rescue team on emergency situation. The system works independently with an uninterrupted power supply to maintain the continuity. A network allocation system for faster data transmission has been developed with the help of fog network [8]. This improves the data transmission speed to certain extent and it consumes very lesser energy for the transmission. The fog network allows transmission of huge data with lesser time.

An information system for snowmelt flood was designed [9] on the basis of IoT and GPS systems. The geographical information system was employed here to collect the data from very far area through remote sensing medium. The IoT platform was employed here to transmit the measured values for cloud data management and manipulation. An artificial intelligence based secure system was dedicated for IoT systems in health care applications [10]. The system was developed by enabling a security key for data transmission. Hence the receiver section need a decryption algorithm for opening the security key to view the transmitted informations. This system provides random key for every data transmitted with respect to the time. A RF transmitter based flood and earthquake detection system was made to alert the rescue team [11]. The system was equipped with Think Speak IoT platform for sharing the observed sensor readings. A solar panel based energy supply system was also attached in the design to charge the battery source. Hence the system assures uninterrupted signal to the receiver side on critical conditions.

The data mining algorithms are comes up in recent years to segregate the useful informations from the big cloud data [12]. Generally the IoT platforms are connected with more number of sensors to predict various kind of natural disasters like earthquake, flood, and rain so on. While for predicting the rain, the earthquake data and flood data are need not to be considered for the calculation. Hence an artificial intelligence based data mining algorithm is

needed for segregating the useful information from the big data for analytic purpose. These data mining algorithms are fast and efficient than the human and other manipulation process. A river flood prediction system [13] was proposed by analyzing the sensor informations with machine learning algorithms. The work was verified with LSTM and random forest algorithm to estimate the prediction accuracy. While in the comparison random forest performs better than the LSTM model. The data collected from the sensors are splitted in to separate section for training and testing the model at the earliest. After that the algorithm is made to be freedom for regular analysis process.

A process mining technique was framed to secure the transmitted IoT during the testing process [14]. The data misbehavior is observed by this kind of algorithms. Data manipulation and missing can be happened due to attacks as well as data loss. The process mining system monitors the data transmission to ensure the success rate of the receiving data. Therefore the chances for data attack is reduced in the cloud computing process. A recommendation work on data mining algorithms [15] was structured to find out the best suitable algorithm for analyzing the big data with respect to their applications. The work says that all the data mining algorithms wont suite for all the applications. A customized data mining algorithm has be made for each and every application so that a remarkable efficiency can be achieved for the whole system. The verification process must consider about the computational time, complexity and flexibility.

Proposed Method

The motive of the proposed work is to manage the flood during emergency and normal conditions. The architecture of the proposed method is shown in figure 3, where four dams are connected through a cloud environment for sharing the collected data. All the dams are connected here with group of sensors to monitor the incoming water flow, outgoing water flow, and status of the present dam level. The climatic changes in the dam area is also continuously monitored to determine the rain. In the figure 3, the water ways are marked with blue lines. Hence dam 3 has 2 incoming lines from dam 1 and 2 and 1 outgoing line to dam 4. The incoming and outgoing valves are connected here with an intelligent system to operate based on the values predicted by the cloud computing algorithm.

The outflow of the water from dam 1 and dam 2 is considered along with the distance for predicting the time and space required in dam 3 for occupying the water storage. If the water storage capacity of dam 3 is not enough, the algorithm takes the storage capacity of dam 4 for calculation process. Hence the dam 3 starts to open their valves of outgoing to send some water to the dam 4. If the dam 4 don't have the required space. It will open the valve and send the water to the sea. This method avoids sudden and heavy water flow in the river areas. It makes the process in uniform manner and avoid heavy flood scenario in the river areas. As the method is equipped with rain prediction system. It can make space for rain water also.
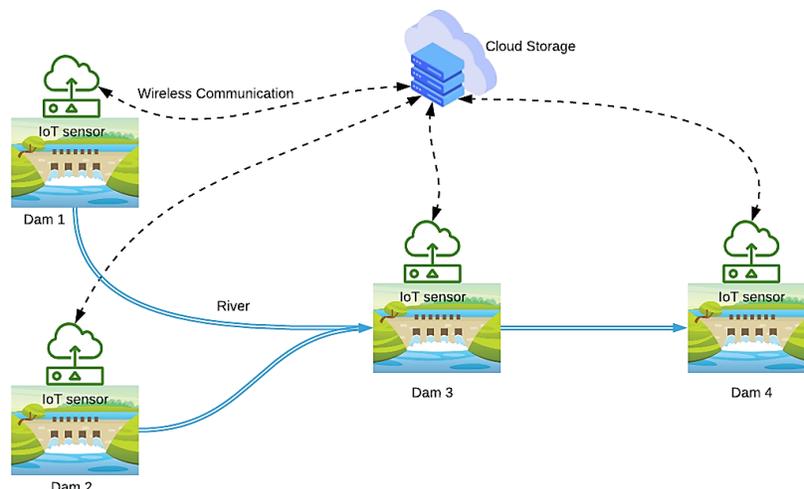

Figure 3. Architecture of the proposed model.

The description of the IoT and computing module is shown in the figure 4. The whole system can be broadly segregated into three modules namely sensor module, cloud storage, IoT and computing module. The IoT and computing module is a primary module in the proposed model design. It consists of microcontroller unit to act as a brain for doing multiple tasks in efficient manner. All the sensors, and cloud storage contents are connected to the microcontroller through a transceiver module. The sensor modules of the primary dam is directly connected to its microcontroller and indirectly connected with cloud storage to the nearby connected dam microcontrollers. To upload the sensor values to the cloud storage an IoT transceiver is employed in the proposed model.
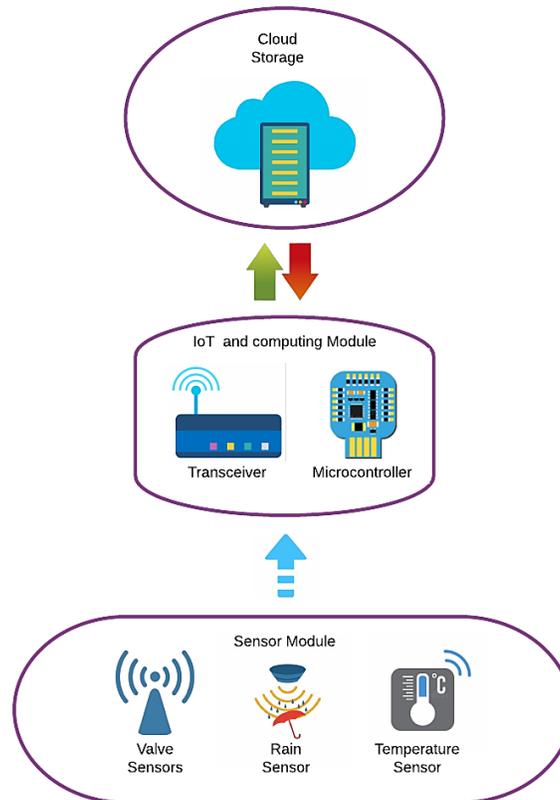
**Figure 4. Hardware setup of the proposed model.**

The microcontroller fetches the data from the cloud storage unit during the computation process for analyzing the incoming water flow from the connected dams. Therefore the computational algorithm analyzes the available space in the primary dam to occupy such water. If there is lag in space availability, the primary dam will make the valves open to send off some waters to the next connected dams. Similar to the same process all the connected dams will work and allocate space for the incoming waters.

Experimental Results

A four tank network system has been developed to verify the proposed work. All the tanks are connected with a relay operated valve control for allowing the water flow. An algorithm based on Convolution Neural Network (CNN) has been implemented in this work for classifying the space availability of the connected tanks to allow the water to flow in a regular mode. The accuracy of the connected system has been verified for 76 ranges of water flow and it is tabulated in the table 1 along with the sensitivity and specificity. The system is also engaged with Artificial Neural Network (ANN) and Support Vector Machine (SVM) for analyzing the performance of the proposed CNN algorithm. A comparison chart with respect to the tabulated value is represented in the figure 5.

Table 1. Performance evaluation among the classification algorithms.

Algorithms	Analysis metrics		
	Accuracy	Sensitivity	Specificity
CNN	85.53	92.11	78.95
ANN	82.89	86.84	78.94
SVM	80.26	89.47	71.05
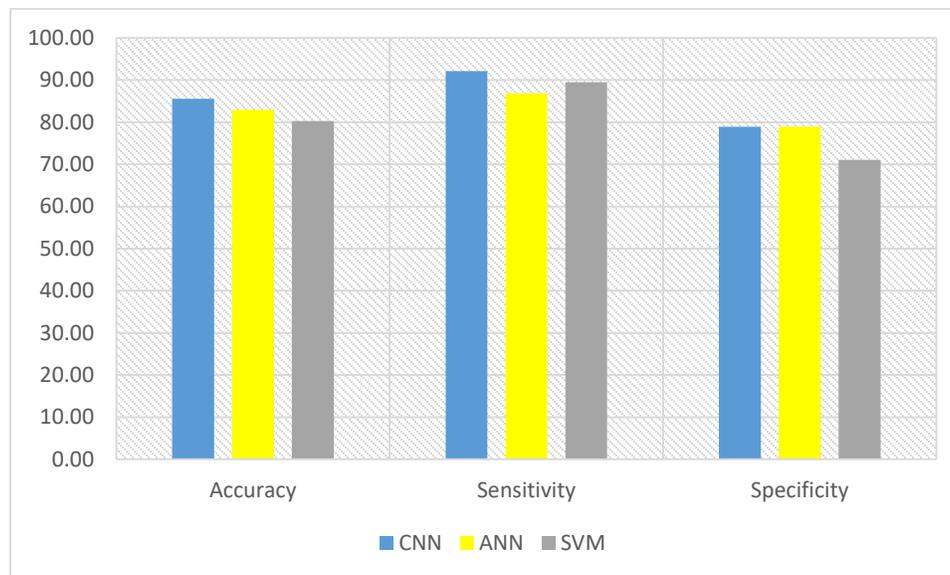
Figure 5. Performance comparison chart of the algorithms.

Conclusion

A deep learning based control system has been proposed in the work for analyzing the flood flow from the dam valves. The proposed work has been verified with a four tank system comprises of IoT sensors and cloud computing algorithms. The result indicates that the CNN algorithm based classification system on predicting the available space of the tank performs efficiently with higher accuracy among the other two algorithms. The system can be implemented to the real time dam with higher efficient sensor and transmission modules. The water flow rating of the proposed method has been verified with water flow sensor on every incoming and outgoing pipelines. It shows that the proposed system makes almost a regular water flow speed among the pipelines. Hence it ensures the proposed flood management process can works well in real time dams in efficient manner.

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