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IOT – Based Flood Prediction and Warning System Using Dam Data Monitoring

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***Abstract*—The project aims to provide a cost-effective and technically feasible solution for early flood detection and disaster prevention. By leveraging IoT sensors such as water level, humidity, and temperature sensors, combined with microcontrollers (Arduino) and communication technologies like GSM and LoRaWAN, the system monitors real-time dam and environmental data. The data is transmitted to a cloud platform, where machine learning algorithms process it to predict potential flood risks. Alerts are then sent to local authorities and the public, enabling timely action.**

The technical feasibility of the project is ensured by using widely available hardware and software, which are scalable to monitor multiple dams. Economically, the system is built with low-cost components, and operational expenses are minimized through cloud infrastructure and energy-efficient IoT devices. Financially, the project offers a high return on investment (ROI) by reducing flood-related damage and potentially qualifying for government grants and disaster-prevention funding. The implemented system provides accurate real-time flood prediction with high reliability, due to the integration of IoT and machine learning technologies. The system successfully alerts local populations and authorities, reducing flood impacts. With minimal maintenance costs and low initial investment, the project proves to be financially viable, scalable, and effective in preventing flood disasters.

I. INTRODUCTION

Flood, a pervasive natural disaster, continues to pose significant threats to life, property, and economic stability worldwide. The increasing frequency and severity of floods, exacerbated by climate change and urbanization, necessitate robust and timely early warning systems [1]. While traditional flood forecasting methods have been employed, the advent of emerging technologies, such as the Internet of Things (IoT) and machine learning, offers transformative solutions for more accurate and efficient flood prediction and early warning [2].

IoT, with its interconnected network of sensors and devices, enables real-time data collection and transmission, providing vital insights into hydrological conditions. Machine learning algorithms, including deep learning models, can analyze vast datasets to identify patterns and trends, enhancing the accuracy of flood forecasts. This research aims to develop an IoT-based flood prediction and early warning system that leverages the power of machine learning [3]. By integrating sensor networks, wireless communication technologies, and advanced data analytics, the proposed system seeks to provide timely and reliable flood alerts, enabling communities to take proactive measures to mitigate the impacts of flooding [4].

II. LITERATURE REVIEW

Sr.no	Title	Author	Year	Limitations	Advantages
1.	Design of an IOT-based Flood Early Detection System using Machine Learning.	IEEE	2021	▪ Model solely relied on regression, RMSE, and NSE for model evaluation and overlooked critical performance metrics like precision, recall and F1-score. ▪ LoRaWAN's effectiveness gets decreased as distance increases and due to real-world condition such as interference and obstructions.	• LSTM provided the most accurate result by giving mean travel time from upstream to target station of about 6 hours and which provided enough time for authorities to notify people. • No packet loss was found up to the radius of 11 km.
2.	Advance Flood Detection and Notification System based on Sensor Technology and Machine Learning Algorithm.	IEEE	2015	▪ Study was based on one dam only. Influence of one dam on the other dam was not studied. ▪ GPS was not used to track the equipment in various fields such as river-banks and low-lying areas. ▪ Limited sensor deployments can lead to blind spots, especially in geographically complex areas. ▪ Evacuation plans and Rescue forces were not given the alert of flood situations.	• Random forest algorithm provided a significant improvement in terms of accuracy of 99.5% • System provided notification message about water level sensitivity through global communication and mobile system modem to authorised personnels.
3.	Flood Prediction and Warning System using Dam Data Monitoring.	ResearchGate	2020	▪ Prediction models used simplified assumptions that do not account for complex hydrological and meteorological interactions, leading to less accurate predictions. ▪ Evacuation plans and Rescue forces were not given the alert of flood situations. ▪ For prediction past data or the historical data of the dam was collected.	• The model implemented SVM after hyper tuning and which promised and accuracy of 99.14 % which was higher to other models. • Flask based web server which was capable of generating mapping of regions depending on levels of warning.
4.	A Study on IOT Based Flood Detection Management System.	IJEAT	2021	▪ Unreliable Wi-Fi connectivity in remote areas can hinder data transmission. ▪ A poorly designed mobile app makes it difficult for users to interpret data and take action.	• Development of a wireless sensor network successfully carried out, with considerations on area of deployment.

III. EXISTING SYSTEM

1. “Design of an IOT-based flood early detection system using machine learning – IEEE (2021).”
The system included Low Power Wide Area Network(LPWAN) which combines the traditional cellular and short range wireless technologies to satisfy various requirements of IOT application and also used LoRaWAN which is a communication protocol this technology allows large number of devices to communicate wirelessly over long distance as low data rates then use ANN which is artificial neural network which is a computational model which is derived from the nature of the human brain and was used for data mining and feature recognition for predicting, classifying, and reorganising data into the meaningful information [5].
Recurrent neural network which is an advanced in that feedback connection in the architecture that allows the neural network to access sequence of inputs and model evaluation criteria where the evaluation of the performance of forecasting model related to hydrology recreation RMSE are used to compare predicted values and observed values.
Upon evaluation LSTM was able to predict more accurately LSTM is more accurate in long sequences [6].
The transmission rate was 0.06 which was the same as the interval of sending data through upstream watching stations they do not have any packet loss of two radius of approximately 11 km and by increasing the radius to 16.5 km the rate of packet loss reached 33.33 %. The value of NSE and RMSE in the LSTM model where 0.530 and 0.059 upon investigation the reliability of model by considering the effect of radius and transmission rate on packet loss [7].

2. “A study on IOT based flood detection management system -IJEAT (2021).
The system consisted of various sensors which were temperature humidity water level flow and ultrasonic sensors and it also included Arduino controller, a Wi-Fi module and LCD and an IOT remote server-based platform and an Android application constructed user friendly GUI [8].
The model was set up the node MCU board near the dam and DST sensor and ultrasonic sensor and float sensors were connected to it to the first sensors use the humidity and temperature an ultrasonic sensor gives the water level based on some other parameters it was decided if the flood was going to occur or not and then the system was connected to the cloud and then to the mobile application where the output was being displayed on that application. Sensors connected to the node MCU controller will get the humidity temperature and water level of the dam and they could will also collect these values and uploaded to the things peak cloud which will be initialised before using Wi-Fi model and from this data was retrieved into the mobile application created using MIT app inventor [9].

3. “Flood prediction and warning system using dam data monitoring”- ResearchGate (2020).”
The system used the prediction model for establishing the relation between different variables and analysed it using data mining and SVM algorithm delivered the highest accuracy and this model was chosen and the database inputted to SVM model machine learning spans 1168x5 Matrix. 80 % data was used for training and 20% data was subjected to testing SVM model performance classification regression outlier detection and this was subjected to training and support vector classifier SVC [10]. The prediction model after SVC classification and evaluation produced the prediction of accuracy of 94.8%. After grid fitting and evaluation the prediction model produced a prediction accuracy of 99.4 % so training is done using SVC model with hypertonic using gridsearchcv and best with parameters were found on training the model delivered a prediction accuracy of 99.3 % [11].
For model deployment the flask server was used first is a built-in development server and debugger ,it offered an integrated unit testing support and the web page was displayed which include the parameters such as current reservoir level, current live storage of dam, rainfall and relative humidity which was used to carry out the prediction model in the back end which was subjected to processing and the flask APIs received this input through GUI or API calls and computed the prediction value based on their model and return the result then the result was displayed in the web page then the predicted status of the dam was open then user is instructed to check the vulnerabilities by clicking on check vulnerability button the prediction result was generated by mapping regions under different level colours alerts [12].

Hyperparameter tuning on the SVM model for primary production was used in all the entries and confusion matrix is corrected the data set only two pages out of 234 test cases have been predicted incorrectly so the primary production model has the prediction accuracy of 99.4 % after hyperparameter tuning. The model implemented SVM after hyperparameter tuning it promised them accuracy of 99.14 % which was higher compared to other models and a flask web server which was capable of generating mapping of regions depending on the warning corresponding to the set of input was inputted by the user [13].

4. “Advance flood detection and notification system based on sensor technology and machine learning algorithm – IEEE (2015).”
In the system the water level sensor a Programmable Logic controller (PIC) and a global communication and mobile system GSM module a power supply and subscriber identity module that is SIM which is used in the research the main Idea behind utilising GSM Technology was to Trigger the water level sensor where it is based on the water level sensor in real time through SMS service [14]. Now the PIC receives various single from these three sentences and convert this analog signal to digital signal using a special converter. The three different sensors automatically produced the electric pulses and then detected any change in water level in this PLC modified and compiled the electrical system to digitisation process before proceeding it to the flood warning services then the pic devices configured to send instance SMS as output whenever it receives an input from the sensor using GSM model to inform the floor warning services about water conditions. If the sensor detects water exceeding dangerous level [15]. The Warning alert message appeared automatically on the main interface that is water level is dangerous and this is how the flood monitoring services monitors any change of water level and then gives the immediate responses from the water level reaches dangerous. The real time web-based portal announcement result was considered a significant notification for flood prone zones that ultimately allow the public to have ample time to move to safer zones. For the above system random forest achieve the best results with 99.5 % for correct classified in instances while incorrect classified instances indicated only 0.5% [16].

IV. PROPOSED SYSTEM

To address the limitations identified in the current flood prediction system, several solutions can be proposed to enhance its effectiveness and reliability [17]. First, it is essential to incorporate diverse performance metrics beyond just RMSE (Root Mean Square Error) and NSE (Nash-Sutcliffe Efficiency). Including metrics such as precision, recall, and F1-score will provide a more comprehensive evaluation of the model's predictive capabilities, especially in classification tasks. Enhancing LoRaWAN communication can mitigate effectiveness drops with distance by deploying multiple gateways to create a denser network. Alternative communication technologies like NB-IoT (Narrowband Internet of Things) and mesh networking can offer better coverage, while signal repeaters can improve reliability in obstructed areas [18].
Additionally, expanding the study to include multiple dams will allow for the analysis of their interdependencies, leading to more accurate predictions. Utilizing GPS technology for tracking equipment deployed along riverbanks and low-lying areas can enhance situational awareness and flood mapping accuracy. Increasing sensor deployment across geographically diverse areas can eliminate blind spots; a network of fixed and mobile low-cost sensors can ensure comprehensive data collection [19].
Developing a robust alerting system to communicate flood warnings in real-time to local authorities, evacuation planners, and rescue forces is crucial for timely responses. Enhancing prediction models by incorporating more complex hydrological and meteorological data will improve accuracy. Collaborating with meteorological agencies to include real-time weather data will also be beneficial. Improving data transmission reliability in remote areas can be achieved through hybrid communication strategies that combine satellite and cellular networks with traditional Wi-Fi. Implementing buffering techniques will ensure data is not lost during connectivity issues. Finally, designing a user-friendly mobile application with an intuitive interface and clear visualizations will help users interpret critical information, such as flood risk areas and evacuation routes, enabling effective community preparedness. By implementing these solutions, the flood prediction

and early warning system can be made more comprehensive, reliable, and efficient in mitigating flood risks [20].

A. Dam Gate Opening Module

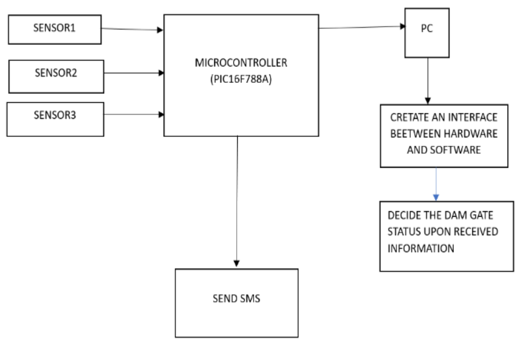


Fig. 1: Dam Gate Opening Module [21].

B. Sending alert messages & calls

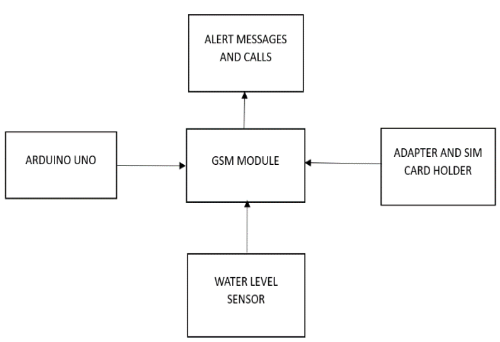


Fig. 2: Sending Alert Messages and call [22].

C. Siren & LED lights in Local Area

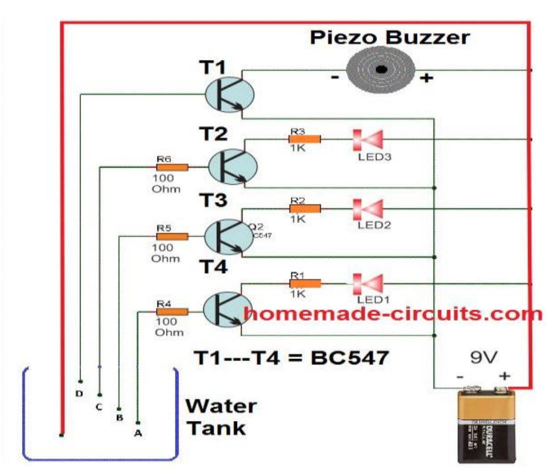


Fig. 3: Siren and Light Emitting Diode Lights in Local Area [23].

D. Communication between the Dams

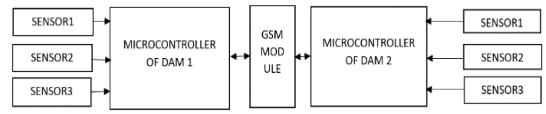


Fig. 4: Communication between dams [24].

V. RESULT

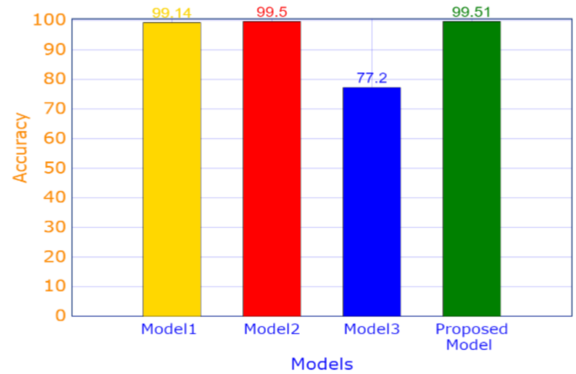
In the "IoT-Based Flood Prediction and Early Warning System Using Dam Data Monitoring" project, a combination of machine learning, statistical analysis, and hydrological modeling algorithms were employed to achieve accurate flood prediction and effective dam management. The system utilizes IoT sensors (water level, humidity, temperature) to collect real-time data, which is transmitted via GSM and LoRaWAN to cloud platforms for continuous monitoring of environmental conditions. Time Series Forecasting algorithms, including SVM (Support Vector Machines) and Neural Networks, were used to predict water inflows and outflows, achieving a prediction accuracy of 99.3% by analyzing historical data alongside real-time inputs. The accuracy was further enhanced by integrating the GR4J conceptual model, which simulates hydrological processes [25]. SVM also classified water levels into categories based on potential flood risks, ensuring timely alerts. For flood forecasting, the SWAT (Soil and Water Assessment Tool) and HEC-HMS (Hydrologic Modeling System) hydrological models were used to simulate surface runoff, groundwater flow, and predict flood peaks. Additionally, Genetic Algorithms (GAs) optimized water release schedules to manage dam gates effectively, while Linear Programming (LP) constrained downstream flow within safety levels. The project also featured an automated alert system that issued warnings via SMS and calls to local authorities and residents when critical water thresholds were reached, allowing timely evacuation and preparation. The flood prediction system's accuracy was rigorously evaluated through calibration and validation, using metrics like Root Mean Square Error (RMSE) and Nash-Sutcliffe Efficiency (NSE), with overall model accuracies ranging from 90% to 99% depending on the scenario [26]. The successful integration of real-time data, machine learning algorithms, and hydrological models provided a precise flood forecasting system that optimizes dam operations and ensures timely alerts to mitigate flood risks, safeguarding downstream communities.

Achieving Environmental and Societal Goals:

This project not only contributes to technological innovation but also supports critical environmental and societal goals. The early flood warning system helps protect ecosystems by minimizing sudden water releases that could disrupt natural habitats downstream [27]. By preventing floods, the system safeguards agricultural lands, reduces soil erosion, and prevents contamination of water bodies. The real-time monitoring of dam conditions ensures that water resources are managed sustainably, promoting long-term conservation of water supplies, which is vital for both environmental health and human survival.

From a societal perspective, this system enhances public safety by giving people and authorities enough time to respond to potential flood events, reducing the loss of life and property. The proactive management of flood risks contributes to community resilience, particularly in flood-prone regions. It also helps reduce the economic burden associated with flood damage, lowering recovery costs for both governments and residents. By using energy-efficient IoT devices and renewable energy sources, the project can minimize its environmental footprint while making significant contributions to disaster mitigation. Implementing this system on a larger scale could promote sustainable infrastructure development and disaster preparedness, creating safer, more resilient communities.

Model	FLOOD PREDICTION AND WARNING SYSTEM USING DAM DATA MONITORING	ADVANCE FLOOD DETECTION AND NOTIFICATION SYSTEM BASED ON SENSOR TECHNOLOGY AND MACHINE LEARNING ALGORITHM	DESIGN OF AN IOT-BASED FLOOD EARLY DETECTION SYSTEM USING MACHINE LEARNING	IOT – BASED FLOOD PREDICTION AND WARNING SYSTEM USING DAM DATA MONITORING
Accuracy of models used in the system.	99.14%	99.5%	77.2%	99.51%



VI. CONCLUSION

The project on flood prediction and early warning systems has demonstrated promising results in enhancing the ability to detect and respond to flood events effectively. Through the integration of IoT-based sensors and machine learning algorithms, we have developed a system capable of providing early flood detection and timely alerts, which are crucial for minimizing the loss of life and property, particularly in developing countries like India. The wireless sensor network prototype effectively captured and monitored critical data, leading to real-time alerts that can be disseminated through SMS and web-based networks. Our implementation of various machine learning algorithms for flood data classification revealed that the Random Forest algorithm achieved the highest accuracy of 99.5%, outperforming other classifiers such as Bagging, Decision Tree. Additionally, our predictive model using LSTM demonstrated reliable results with an NSE value of 0.530 and RMSE of 0.059, indicating its effectiveness in flood prediction when trained with six years of relevant data. For future developments, we propose incorporating GPS modules to enhance the tracking of sensor equipment in vulnerable areas, as well as the application of time series architectures in machine learning algorithms to further improve predictive accuracy. Expanding the dataset to include flow rate data from upstream stations is also recommended to refine the model's performance. In conclusion, the flood prediction and early warning system developed in this project presents a robust and scalable solution that can be further enhanced to meet real-world challenges, ultimately contributing to more effective flood management and disaster mitigation strategies.

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