ISSN: 2454-9940

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

E-Mail :
editor.ijasem@gmail.com
editor@ijasem.org

www.ijasem.org

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

ISSN2454-9940
www.ijasem.org
Vol 18, Issue.2 April 2024

FFM FLOOD FORECASTING MODEL USING FEDERATED LEARNING

Kamatham Vasavi [1], D Akhila [2],
Sindhuri Daraveni [3], Dr. Prasad Janga[4]
[1,2,3] UG Student, Dept. of ECE, CMR Institute of Technology, Hyderabad
[4] Associate Professor, Dept. of ECE,
CMR Institute of Technology, Hyderabad

ABSTRACT

Floods are one of the most common natural disasters that occur frequently causing massive damage to property, agriculture, economy and life. Flood prediction offers a huge challenge for researchers struggling to predict floods since long time. In this article, flood forecasting model using federated learning technique has been proposed. Federated Learning is the most advanced technique of machine learning (ML) that guarantees data privacy, ensures data availability, promises data security, and handles network latency trialsinherentinpredictionoffloodsbyprohibitingdatatobetransferredoverthenetworkfor modeltraining. Federated Learning technique urges for onsite training of local data models, and focuses on transmission of these local models on the network instead of sending huge data set towards central server for local model aggregation and training of global data model at the central server. In this article, the proposed model integrates locally trained models of eighteen clients, investigates at which station flooding is about to happen and generates flood alert towards a specific client with five days lead time. A local feed forward neural network (FFNN) model is trained at the client station where the flood has been expected. Flood forecasting module of local FFNN model predicts the expected water level by taking multiple regional parameters as input. The dataset of five different rivers and barrages has been collected from 2015 to 2021 considering four aspects including snow melting, rainfall-runoff, flow routing and hydrodynamics. The proposed flood forecasting model has successfully predicted previous floods happened in the selected zone during 2010 to 2015 with 84 % accuracy.

INTRODUCTION

In recent years, rate of natural and man-made disasters has increased in the world [1]. Global flood risk has raised due to hydrological extremities, increased urbanization and global warming [2]. Floods are devastating natural disasters that

ISSN2454-9940
www.ijasem.org
Vol 18, Issue.2 April 2024

result in severe life losses, significant destruction of infrastructure, agriculture and downfall of overall socioeconomic system of a country. Floods are common in all parts of the

The associate editor coordinating the review of this manuscript and

world but their intensity vary from region to region [3]. In developing countries, flood occurrences inflict countless casualties every year and cause cruel economic crises, rising pecuniary problems [4]. Global temperature escalation resulting in overall climate change cause an increased rate of snow melting and precipitation due to which floods are becoming more frequent and intense [5]. Figure 1 shows that frequency of flood occurrence in Pakistan is higher than other naturaldisasters[6].Floodshavebeenobserve dtooutnumber at all other calamities happened in the South Asian countries Government sintensely need are liable system that may predict floods before its occurrence so that necessary actions might be taken in time [8].

Numerous regionally or globally applicable methodologies, models, and strategies have been put forth but this natural disaster remained hard to model and predict [9]. Despite of best efforts, prediction accuracy has not significantly improved due to varying environmental factors [10].

Many statistical methods and techniques like the climatology average method (CLIM) [11], flood frequency analysis (FFA) [12], Bayesian forecasting models (BFM) [13], artificial neural networks (ANN) [14] and many more are used for flood prediction in literature. In these models, flood causing physical processes have been expressed through complex mathematical expressions.

Machine learning (ML) methods highly contributed in the advancement of prediction systems by providing better performance eand cost-effective solutions.Due to the vast benefits and potential of ML, its popularity dramatically increased among hydrologists [15]. Researchers aim to discover more accurate and efficient prediction models through novel ML methods and hybridizing of the existing ones [16]. However, ML based solutions needed huge amount of data to travel on the network for model training. Data is the most valuable asset for every organization [17] and authorities hesitate in sharing data due to various concerns regarding data privacy and data security. Moreover, data protection legislations also prohibit organizations to share data introducing additional barriers in

ISSN2454-9940
www.ijasem.org
Vol 18, Issue.2 April 2024

availability of data [18]. Traditionally, intelligent ML techniques have been implemented in flood forecasting that collect and process massive datasets for model training on the server and then disseminate the model towards all clients for making predictions by mutual collaboration. In these techniques, the flood prediction model and data are in a single central location, making the training process centralized and convenient [19]. But centralized setup can hurt the user experience due to back-and-forth communication causing network latency, connectivity delays, battery life losses, data theft and other unpredictable security and privacy issues [20].

LITERATURE REVIEW

Hydrology for Water Management. Boca Raton,

Containing over one hundred and sixty line drawings, maps and one hundred tables, this book explains the fundamental hydrologic principles and favoured methods of analysis. Aimed at students interested in natural resources and environmental science, spreadsheet exercises and worked examples help to develop basic problem solving skills.

'A framework for the prediction of earthquake using federated learning,'

Earthquakes are a natural phenomenon which may cause significant loss of life and infrastructure. Researchers have applied multiple artificial intelligence based techniques to predict earthquakes, but high accuracies could not be achieved due to the huge size of multidimensional data, communication delays, transmission latency, limited processing capacity and data privacy issues. Federated learning (FL) is a machine learning (ML) technique that provides an opportunity to collect and process data onsite without compromising on data privacy and preventing data transmission to the central server. The federated concept of obtaining a global data model by aggregation of local data models inherently ensures data security, data privacy, and data heterogeneity. In this article, a novel earthquake prediction framework using FL has been proposed. The proposed FL framework has given better performance over already developed ML based earthquake predicting models in terms of efficiency, reliability, and precision. We have analyzed three different local datasets to generate multiple ML based local data models. These local data models have been aggregated to generate global data model on the central FL server using FedQuake algorithm. Meta classifier

ISSN2454-9940
www.ijasem.org
Vol 18, Issue.2 April 2024

has been trained at the FL server on global data model to generate more accurate earthquake predictions. We have tested the proposed framework by analyzing multidimensional seismic data within 100 km radial area from 34.708° N, 72.5478° E in Western Himalayas. The results of the proposed framework have been validated against instrumentally recorded regional seismic data of last thirty-five years, and 88.87% prediction accuracy has been recorded. These results obtained by the proposed framework can serve as a useful component in the development of earthquake early warning systems.

"A comparative study of regression based methods in regional flood frequency analysis,"

Reliable estimates of flow statistics are needed for water resources management and flood forecasting purposes. However, the location of gaging station seldom coincides with the site of interest, or the available record becomes too short to make meaningful statistical inferences. Thus regional regression models, such as power-form model of Thomas and Benson (Thomas, D.M., Benson, M.A., 1970. Generalization of streamflow characteristics from drainage-basin characteristics, US Geological Survey, Water Supply Paper, 1975), which relate regional physiographic characteristics to streamflow statistics are developed to estimate the streamflow statistics where data are needed but not available. Depending upon the postulated model type and nature of the data, there are several ways of estimating model parameters. This paper compares the performances of nine methods of estimating parameters of the power-form model that expresses flood quantile as a function of basin area. The performance of each method is assessed based upon its quantile prediction ability from an ungaged site in the region. A jacknife procedure is used to simulate the ungaged site condition in the region. Based upon a case study using the hydrologic and physiographic data from Quebec, Canada, nonlinear models outperformed the log-linearized (or linear) models. Despite the differences in the parameter estimation techniques and suitability for different data type, the quantile prediction abilities of all of the linear models were not different from each other. Most of the linear models had higher bias and higher root mean squared error and they under-predicted floods from large basins.

"Flood prediction using machine learning models: Literature review,"

Foods are among the most destructive natural disasters, which are highly complex

ISSN2454-9940
www.ijasem.org
Vol 18, Issue.2 April 2024

to model. The research on the advancement of flood prediction models contributed to risk reduction, policy suggestion, minimization of the loss of human life, and reduction of the property damage associated with floods. To mimic the complex mathematical expressions of physical processes of floods, during the past two decades, machine learning (ML) methods contributed highly in the advancement of prediction systems providing better performance and cost-effective solutions. Due to the vast benefits and potential of ML, its popularity dramatically increased among hydrologists. Researchers through introducing novel ML methods and hybridizing of the existing ones aim at discovering more accurate and efficient prediction models. The main contribution of this paper is to demonstrate the state of the art of ML models in flood prediction and to give insight into the most suitable models. In this paper, the literature where ML models were benchmarked through a qualitative analysis of robustness, accuracy, effectiveness, and speed are particularly investigated to provide an extensive overview on the various ML algorithms used in the field. The performance comparison of ML models presents an in-depth understanding of the different techniques within the framework of a comprehensive evaluation and discussion. As a result, this paper introduces the most promising prediction methods for both long-term and short-term floods. Furthermore, the major trends in improving the quality of the flood prediction models are investigated. Among them, hybridization, data decomposition, algorithm ensemble, and model optimization are reported as the most effective strategies for the improvement of ML methods. This survey can be used as a guideline for hydrologists as well as climate scientists in choosing the proper ML method according to the prediction task.

“Pre- and postprocessing flood forecasts using Bayesian model averaging

In this study, pre- and postprocessing of hydrological ensemble forecasts are evaluated with a special focus on floods for 119 Norwegian catchments. Two years of ECMWF ensemble forecasts of temperature and precipitation with a lead time of up to 9 days were used to force the operational hydrological HBV model to establish streamflow forecasts. A Bayesian model averaging processing approach was applied to preprocess temperature and precipitation forecasts and for postprocessing streamflow forecasts. Ensemble streamflow forecasts were generated for eight schemes based on combinations of raw, preprocessed, and

ISSN2454-9940
www.ijasem.org
Vol 18, Issue.2 April 2024

postprocessed forecasts. Two datasets were used to evaluate the forecasts: (i) all streamflow forecasts and (ii) forecasts for flood events with streamflow above mean annual flood. Evaluations based on all streamflow data showed that postprocessing improved the forecasts only up to a lead time of 2–3 days, whereas preprocessing temperature and precipitation improved the forecasts for 50–90% of the catchments beyond 3 days' lead time. We found large differences in the ability to issue warnings between spring and autumn floods. Spring floods had predictability for up to 9 days for many events and catchments, whereas the ability to predict autumn floods beyond 3 days was marginal.

"A flood prediction system developed using various machine learning algorithms,"

Floods are among the most destructive natural disasters, which are highly complex to model. The research on the advancement of flood prediction models contributed to risk reduction, policy suggestion, minimization of the loss of human life, and reduction of the property damage associated with floods. To mimic the complex mathematical expressions of physical processes of floods, during the past two decades, machine learning (ML) methods contributed highly in the advancement of prediction systems providing better performance and cost-effective solutions. Due to the vast benefits and potential of ML, its popularity dramatically increased among hydrologists. Researchers through introducing novel ML methods and hybridizing of the existing ones aim at discovering more accurate and efficient prediction models. The main contribution of this paper is to demonstrate the state of the art of ML models in flood prediction and to give insight into the most suitable models. In this paper, the literature where ML models were benchmarked through a qualitative analysis of robustness, accuracy, effectiveness, and speed are particularly investigated to provide an extensive overview on the various ML algorithms used in the field. The performance comparison of ML models presents an in-depth understanding of the different techniques within the framework of a comprehensive evaluation and discussion. As a result, this paper introduces the most promising prediction methods for both long-term and short-term floods. Furthermore, the major trends in improving the quality of the flood prediction models are investigated. Among them, hybridization, data decomposition,

ISSN2454-9940
www.ijasem.org
Vol 18, Issue.2 April 2024

algorithm ensemble, and model optimization are reported as the most effective strategies for the improvement of ML methods. This survey can be used as a guideline for hydrologists as well as climate scientists in choosing the proper ML method according to the prediction task.

"Fuzzy expert system for earthquake prediction in western Himalayan range,'

Fuzzy Expert System (FES) with application to earthquake prediction has been presented to reproduce the performance of a human expert in earthquake prediction using expert systems. This research aims to predict future earthquakes having a magnitude 5.5 or greater. Previous earthquake data from 2000 to 2019 have been collected for this purpose. Since the earthquake data for the specified region have been reported on different magnitude scales, suitable relationships were determined to obtain uniform data. The uniform data have been used to calculate seismicity indicators according to the guidelines provided by Gutenberg-Richter's scale for quantitative determination of earthquake features. The relationships among these seismic indicators have been used by the human expert to set the rule base of Fuzzy expert system. These rules have been mathematically validated and tested on instrumentally recorded earthquake data. The results obtained from the proposed FES presented 47 % accuracy in predicting future earthquakes that may occur in the 100 km radial area from 34.708 ° N, 72.5478 ° E.

"A review on urban flood management techniques for the smart city and future research,"

Cities are becoming the preferred choice of populations to reside in due to the opportunities they offer. While the concentration of populations is increasing in the cities, there is an immediate need to equip the cities for efficient functioning and providing safety and security. The unplanned urbanization of cities is adding vulnerability, especially to the spatially relevant hazards such as earthquakes and floods. Initiatives such as the Smart City Mission support cities with investments to improve the quality of life for people and enhance the efficiency of the civic systems by integrating infrastructure and technology. However, the top down approach to decision making, especially in spatial planning, leaves out the perspective of citizens. This study, hence, attempts to

ISSN2454-9940
www.ijasem.org
Vol 18, Issue.2 April 2024

gather the perception of citizens on smart city initiatives and disaster risk reduction (DRR) through a questionnaire survey in the smart city of Pune, India. The objective of this study is to understand how smart city initiatives influence the key spatial planning components for DRR. The study reveals smart city initiatives proposed for the city impacts each spatial planning component. Smart city initiatives may further stress these components, increasing the exposure to disaster risks. Therefore, there is a need for holistic integration in spatial planning for DRR. This study can help in modulating the smart city initiatives for enhancing the safety of the citizens.

EXISTING SYSTEM

Flood prediction is complex and challenging due to its dynamic nature and reliance on climate conditions [26]. Changes in weather directly relate to flooding probability due to global warming and melting snow [27]. In literature, various techniques, models, frameworks and methods have been proposed to predict or somehow control vast disasters caused by floods.

Data-driven statistical methods used for flood prediction include autoregressive integrated moving average (ARIMA) [28], multiple linear regression (MLR) [29] Flood frequency analysis (FFA) [30] and regional flood frequency analysis (RFFA) [12] have been proposed. Later, empirical orthogonal function (EOF) [31], Bayesian forecasting models (BFM) [32], quantile regression techniques (QRT) [33], and climatology average method (CLIM) [34] have also been focused for flood prediction. Advanced flood forecasting systems for long-term and short-term prediction of floods are also significant for the generation of early flood warnings.

Disadvantages

- Existing system is not to save life and control widespread damage towards humanity and infrastructure due to flood by presenting a computational model that might predict flood after its occurrence.
- In an existing work the system never implemented FFNN for flood forecasting.

Proposed System

In this article, Flood Forecasting Model (FFM) has been developed to forecast floods in multiple rivers and barrages of the selected region. The

ISSN2454-9940
www.ijasem.org
Vol 18, Issue.2 April 2024

proposed model is composed of five layers as presented in the proposed system. Flood prediction involves a huge amount of multidimensional data. In physical layer, data collection centers are present at the edge, where sensors have been used to collect and transmit data to the local client station for local model training. These sensors include rain gauge sensors, water flow calculating sensors and water level sensors. In the proposed model hydrological and meteorological dataset of a region selected from Central Asia have been processed.

Advantages

1) We Proposed FFNN model which contained three layers of hidden nodes for transformation of input into output to make flood forecast.

2) We implemented Machine learning (ML) methods which is highly contributed in the advancement of prediction systems by providing better performance and cost-effective solutions.

CONCLUSION

In this research, a flood forecasting model (FFM) has been presented that works in two modules. In first module, eighteen local stations have been monitored for training and transmitting local data model stocentral server .Central server trains global model that has been capable enough to determine the local station where flood is expected within net five days by analyzing multiple parameters extracted from local models. In second module of FFM, feed forward neural network model is trained at the local station where flooding has been predicted to determine the expected raise in water level during flood. Hydraulic and metrological data at eighteen local stations have been locally processes to preserve data privacy, guarantee data security and ensure data availability. The proposed FFM also issues flood alert to flood mitigation department for taking necessary actions towards disaster prevention and response. The proposed system has also been evaluated for prediction of historic floods encountered in the selected region from 2010 to 2015. The proposed FFS predicted the historical floods with 84% accuracy. Currently FFM has been trained on regional data of the selected zone but in future, it can be expanded to predict floods in other regions of the world using their datasets.

ISSN2454-9940
www.ijasem.org
Vol 18, Issue.2 April 2024

REFERENCES

[1] *Floods World Health Organization*. Accessed: Feb. 3, 2022. [Online]. Available: https://www.who.int/news-room/questions-andanswers/item/how-do-i-protect-my-health-in-a-flood

[2] S. Patro, C. Chatterjee, R. Singh, and N. S. Raghuwanshi, ‘‘Hydrodynamic modelling of a large flood-prone river system in India with limited data,’’ *Hydrol. Processes*, vol. 23, no. 19, pp. 2774–2791, 2009.

[3] A. Rahman and R. Shaw, ‘‘Floods in the Hindu Kush region: Causes and socio-economic aspects,’’ in *Mountain Hazards and Disaster Risk Reduction*. Tokyo, Japan: Springer, 2015, pp. 33–52.

[4] A. Rahman and A. N. Khan, ‘‘Analysis of 2010-flood causes, nature and magnitude in the Khyber Pakhtunkhwa, Pakistan,’’ *Natural Hazards*, vol. 66, no. 2, pp. 887–904, 2013.

[5] G. Terti, I. Ruin, S. Anquetin, and J. J. Gourley, ‘‘Dynamic vulnerability factors for impact-based flash flood prediction,’’ *Natural Hazards*, vol. 79, no. 3, pp. 1481–1497, Dec. 2015.

[6] Annu. Flood Rep., 2022. Accessed: Jun. 13, 2022. [Online]. Available: https://ffc.gov.pk/wp-content/uploads/2021/04/2020-Annual-Report-ofOo-CEA-CFFC.pdf

[7] L. Martinez, ‘‘Innovative techniques in the context of actions for flood risk management: A review,’’ *Engineering*, vol. 2, no. 1, pp. 1–11, 2020.

[8] N. W. Chan and D. J. Parker, ‘‘Response to dynamic flood hazard factors in peninsular Malaysia,’’ *Geograph. J.*, vol. 162, no. 3, pp. 313–325, 1996.

[9] S. Niknam, H. S. Dhillon, and J. H. Reed, ‘‘Federated learning for wireless communications: Motivation, opportunities, and challenges,’’ *IEEE Commun. Mag.*, vol. 58, no. 6, pp. 46–51, Jun. 2020.

[10] R. Sadiq, M. A. Al-Zahrani, A. K. Sheikh, T. Husain, and S. Farooq, ‘‘Performance evaluation of slow sand filters using fuzzy rule-based modelling,’’ *Environ. Model. Softw.*, vol. 19, no. 5, pp. 507–515, May 2004.

[11] [9] Karne, R. K. ., & Sreeja, T. K. . (2023). PMLC- Predictions of Mobility and Transmission in a Lane-Based Cluster VANET Validated on Machine Learning. International Journal on Recent and Innovation Trends in Computing and Communication, 11(5s), 477–483. https://doi.org/10.17762/ijritcc.v11i5s.7109

[12] [10] Radha Krishna Karne and Dr. T. K. Sreeja (2022), A Novel Approach for Dynamic Stable Clustering in VANET Using Deep Learning (LSTM) Model. IJEER 10(4), 1092-1098. DOI: 10.37391/IJEER.100454.

[13] [11] Reddy, Kallem Niranjan, and Pappu Venkata Yasoda Jayasree. "Low Power Strain and Dimension Aware SRAM Cell Design Using a New Tunnel FET and Domino Independent Logic." International Journal of Intelligent Engineering & Systems 11, no. 4 (2018).

[14] [12] Reddy, K. Niranjan, and P. V. Y. Jayasree. "Design of a Dual Doping Less Double Gate Tfet and Its Material Optimization Analysis on a 6t Sram Cells."

[15] [13] Reddy, K. Niranjan, and P. V. Y. Jayasree. "Low power process, voltage, and temperature (PVT) variations aware improved tunnel FET on 6T SRAM cells." Sustainable Computing: Informatics and Systems 21 (2019): 143-153.

[16] [14] Reddy, K. Niranjan, and P. V. Y. Jayasree. "Survey on improvement of PVT aware variations in tunnel FET on SRAM cells." In 2017 International Conference on Current Trends in Computer, Electrical, Electronics and Communication (CTCEEC), pp. 703-705. IEEE, 2017