"Floodie": Smart Flood Detection and Warning System

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***Abstract*— Floods are the most common natural disaster in the world. The main reason for flooding is the heavy rain. Sri Lanka also faces floods almost in every year. Floods cause great damage not only to human lives but also properties. Due to this, Sri Lankan government spends a lot of money to provide relief to those affected by the floods. The main reason for this situation is, the lack of a proper system for predicting rainfall and floods in Sri Lanka and informing the public about it. As a solution, this research proposes to create a proper weather forecasting and water level forecasting system and visualize the flooding areas in a google map. As well as this research propose a chatbot to give significant weather data to the public. It is complicated to predict the rainfall accurately with changing climatic conditions. For the predictions, Machine Learning are used normally. In this research Long Short-Term Memory (LSTM), Facebook prophet, gray model, Convolutional Neural Network and Arima model are used as forecasting models. In addition, create a device, which connected with IoT sensors, and it retrieves the real-time weather data and flood water levels. Then all real-time data which is taken from IoT devices are monitored in a web application. And in the web application, it visualizes the flooding areas in a google map. Then, after executing all predictions and validation which is implemented, highlight the spots which can be affected by flood disaster. And finally implement a chatbot to provide extensive knowledge about real-time weather data and forecasted data and others.**

Keywords*— Internet of things (IoT), Arima Model, Facebook Prophet, Gray Model, Convolutional Neural Network

I. INTRODUCTION

The advancement of technology and resources in today's world is expanding by the day. Science and technology can be used to forecast the weather in a particular location. Because of the complexity of the physical processes involved and the variability of rainfall in place and time, weather forecasting has been a tough issue in hydrology [5]. Flooding can result in a variety of losses, including loss of life or injury, property loss, settlement damage, irrigation system damage, and road damage. Machine Learning Algorithms have been frequent and successful in water-related studies in recent years [6].

Monsoon rains have a major impact on Sri Lanka. But till now, Sri Lanka has not accurate rainfall prediction and warning system. Therefore, people have to face so many problems during high rainfall. As a solution to this, this research is to create an IoT based Rainfall prediction system. Since Internet of Things is the most upcoming technology in the world, we hope to use IoT devices. There is not a IoT based rainfall prediction system in Sri Lanka. As we have experienced in heavy rainfall and floods, we should have the need of such a smart prediction system especially in a densely populated area like Colombo.

This project's is to determine flood risk, monitor flood levels, and forecast flood occurrence. The project collects data on rainfall, temperature, humidity, and changes in river water levels using IoT devices and sensors. The discovered data is uploaded to a cloud system, which uses a web application to relay flood risk and forecast. Floods are challenging to anticipate because of their non-linear and dynamic character, thus we use Grey model to predict the flood.

Creating a flood map is very effective because users who are suffering from flood disasters can easily visualize flood map data. This map shows a 10km radius around Kaduwela town. The map shows flood areas, safe areas, and areas prone to flooding in the coming week. Those areas have each color represented. The forecasting part is that areas are prone to flooding in the coming week. Therefore, it needs forecasting data. The ARIMA model is used by me to create forecasting data. The ARIMA model is one of the most extensively used techniques for time series forecasting, and it offers complementary solutions.

When a tragedy strikes, people turn to social media, news websites, and local television stations for the latest information, but this information is frequently outdated or diluted. Many media outlets consistently fabricate news that is unrelated to current events. As a result, obtaining a short news update from a local individual is more valuable than getting information from a variety of sources. As a result, a chatbot powered by artificial intelligence may be one of the local agents. People can ask queries to this chatbot by putting their concerns into a textbox. Users will be able to quickly learn about any possible dangers in their neighborhood. So that the user may get right to the subject instead of reading irrelevant news or waiting for a social media update.

II. BACKGROUND AND LITERATURE SURVEY

According to the survey, India is the world's most agriculturally diverse country. Agriculture is reliant on rain. For forecasts, Machine Learning and Deep Learning like Artificial Neural Networks (ANN), Decision Tree Algorithms, Regression Models, and team processes of data handling models are extensively utilized in India. CMAK Zeelan Basha employed Auto-Encoder, Perceptron and Multilayer techniques. The three layers which are Hidden Layer, Input Layer and Output Layer make up an autoencoder [1].Rain gauges are an extremely helpful instrument and sensor for determining rainfall. A rain gauge is a sophisticated and improved device for measuring rainfall. WSN offers high-quality rainfall monitoring at a cheap cost, both in terms of people and money. Using a WSN-enabled architecture to broadcast a rainfall monitoring system using GPRS (General Pocket Radio Service) across a cellular network to collect real-time data is one of the good approaches for monitoring rainfall [2].Using the support of the vector machine algorithm, Xunlai Chen, Guangjun He, and Yuanzhao explained why short-term rainfall was so beneficial. In terms of short-term rainfall prediction, it beats other machine learning techniques [3].

In Sri Lanka, the Artificial Neural Network technique works well for forecasting monsoon rainfall. The climatic indicators ENSO, EQUINOO, and OLTC were used as predictor variables to anticipate monthly and seasonal rainfall. In certain aspects, the actual monthly rainfall and the forecasted rainfall from Artificial Neural Network models were different. A relatively simple ANN design was utilized, and the ANN was trained using a back propagation strategy, which may not have delivered the best result. Minor weights that may not have offered the best design were eliminated from Artificial Neural Network architectures instead of acquiring them for various months.[4]

IoT plays a special role in identifying special disasters and educating the public about disasters. Iot also paves the way for the Smart City concept. Iot hardware and software is unique in itself. Iot is the best solution for cloud-based solutions and is easy to operate based on our experience[7].This structure is a solar-powered pre-flood warning system. Flood risk detection uses a water level sensor. The data obtained by the sensors is transmitted by the GPRS convention. The focus of the observations will be on data collection, research and setting up of a flood alert service in the affected areas. A web application and a mobile application are created to display the water level, and provide continuous activity and forecast information to users of this service[8].The system collects sensitive data from a Raspberry pi controller and uses wifi to quickly send the received data to a specific location[8]. A notification service can quickly monitor flooding and provide real-time data to users quickly[8] .Data is sent to a specific control center, which analyzes the flooding and communicates to the user via a chatbot[9].Here the flood application in web application and mobile application is compared with the magnitude of the threat and the display values. The risk level in this section is not assessed in advance and is primarily aimed at variable water levels[10].It uses a series of machine learning algorithms to make predictions about probability and flooding. This paper shows the machine learning model[11]. ANN is based on a machine learning algorithm. It is important to predict, classify, and reorganize the data into meaningful information[9]. LSTM is an important algorithm for short-term flood forecasting. The purpose here is to stop the immediate damage caused by a flood. Short-term flood forecasting is challenging[12]. False color maps are useful for quick reaction since they indicate flooded regions but do not provide flood depth information. Flood depth maps are required by users in order to offer a quantitative assessment of floods [13].

Several classification processes for forecast data are used in the approach for identifying, assessing, and mapping flood-affected regions [14].The suggested flood monitoring system, which is based on a flood prediction system, is capable of automatically producing data on flood rise and flood forecasting [15]. This model exhibited 90 percent accuracy while using real-time data to assess the flooded area's susceptibility map. As a consequence, this map may be used to estimate the flooded areas' susceptibility. At a modest cost, the approach may be deployed rapidly and easily to sites with little map data [16]. With such 1D-2D models, the precision and resolution of the 2D surface model is a challenge. Indeed, the resolution of the input data, i.e., topographic data resolution, has a considerable influence on the 2D model's validity. The resolution of the 2D model must therefore be suitable for an accurate depiction of the city [17].

Conversational agents, often known as chatbots, respond to users' natural language. Responses can be elicited using one of two approaches. Traditional approaches employ pre-defined rules. The use of neural network frameworks is a relatively new technology. This form of generative model is trained using a large conversation corpus. Chatbots then learn to reply to user input in grammatically accurate and meaningful ways [18]. The purpose of this project is to look at the existing situation of likely flood zones, derive additional contextual information, and talk about potential threats. [19] For data cleaning and pre-processing, multivariate imputation by chained equations is utilized, and it is a versatile and easy approach for dealing with missing values. [20] Following processing. In the last decade of the twentieth century, floods directly injured 1.4 billion people and killed 100,000 people, more than any other natural disaster. And flooding is the world's most common natural disaster, affecting people on all continents and in both developed and poor countries. Floods are expected to damage the global economy $100 billion each year on average. These statistics are expected to climb as the population and economic value of material assets in flood-prone areas grows, and other changes in baseline circumstances, such as climate, drainage basin characteristics, river alterations, and so on, are expected to exacerbate this trend [21]. The Artificial Neural Network Model developed in this article was able to anticipate floods by analyzing patterns of data from rainfall and water level. The following are the steps in the recommended strategy: 1. Create three artificial neural network models with feed-back back propagation. 2. Create pattern training and testing preparations; 3. Conduct learning-supervision training and backward feedback; and 4. Test the model output [22].

III. METHODOLOGY

A. Weather detection and forecasting

For the weather forecasting, Long Short-Term Memory (LSTM) and Facebook Prophet algorithms have been used. By testing the algorithms, Prophet has been used for the final forecasting. Because Prophet is very accurate and fast as well as it is fully automatic as a time forecasting model. Prophet always takes a data frame with two columns: ds and y. The ds (datestamp) column should have a Pandas-friendly format, such as YYYY-MM-DD for dates and y column, which represents the measurement we want to forecast, must be numeric. The four parameters Temperature, Humidity, Pressure and Rainfall is predicted for weekly, monthly, and yearly dataframes.

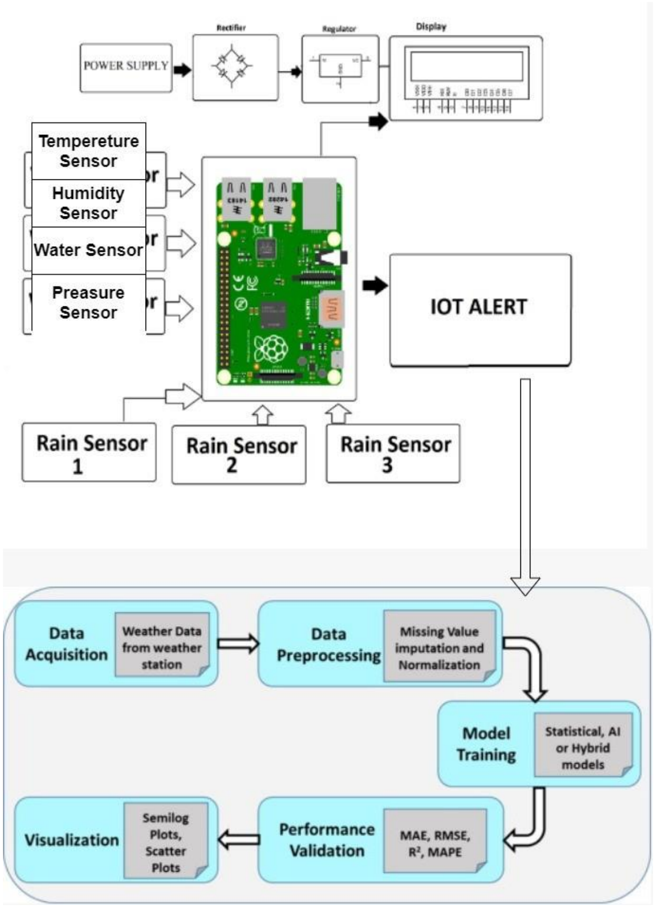

Fig 1: Weather forecasting component diagram

To measure the real-time data, there are some sensors and modules have been used with raspberry pi 4 board. Temperature and Humidity are taken from DHT22 module. Barometric pressure is taken from BMP280 barometric pressure sensor. To measure rainfall, it took more effort to measure rainfall. Raindrop sensor, PCF8531 ADC IC, servo motor and the water level sensor are used to measure rainfall. After getting the real-time data it will push to the designed web application as real-time weather data. The real-time weather data (temperature, humidity, barometric pressure and rainfall) are updated in every 5 seconds.

B. Flood detection and forecasting

The main controller here is a low-cost microprocessor called Raspberry pi. The system uses an ultrasonic sensor and a GPS sensor as sensors. Ultrasonic sensor detects rising and falling water levels, and GPS sensors track the location of the device[5]. Data from the ultrasonic sensor is uploaded to the Google Spreadsheet via the Raspberry pi device. The data are analyzed to identify patterns in the data and to study the difference in water level.

Fig 2: power bi analytics of the data

Grey Model (1,1) is one of the predicting strategies that has proven to be successful in prediction. Grey modeling (1,1) does not require any prior information and can be utilized when there is a limited amount of input data. According to the gray system theory, the first-order accumulation sequence (1-AGO) created[8]. The Grey model has the advantage in flood forecasting of being simple to apply in forecasting without presuming that anticipated storm occurrences have the same stochastic characteristics as the storm events themselves. The main advantage of the Grey model in rainfall-runoff modeling is that no past assumption about the processes involved are required[9]. In this case this project considering two major reasons about flood occurring. Rainfall changing chart and flood level changing chart are shown the major reasons for flood occurring.

The difference is shown that the simple grey prediction model can accurately estimate flood stage utilizing two observations of water level and rainfall level for the research scenarios, especially in places where hydrological data is scarce[10]. The data are analyzed to identify patterns and created the rainfall prediction chart and water level prediction chart (Fig. 3)

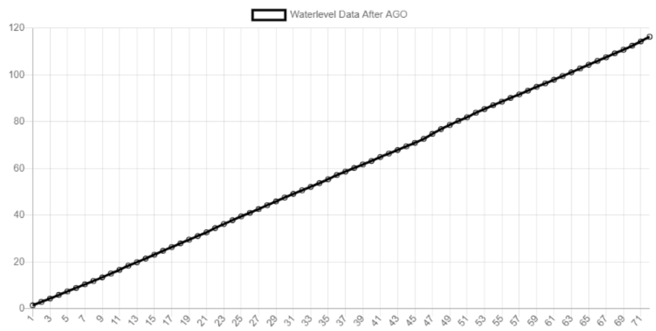

Fig 3: water level changing chart

The accuracy of this forecasting process is 0.23 and the precision grade table of GM (1.1) (Fig. 4) confirms that the accuracy is very good in the predictions made by the Gray Model.

Grade	*C*
Good	≤0.35
Acceptable	0.35<C≤0.50
Just	0.50<C≤0.65
Unacceptable	>0.65

Fig 4: precision grade of GM (1,1) model table

C. Chatbot

In this chatbot, the main functionality is to give an accurate and more reliable answer to the end-users' questions. Without any delay end, users can get the live pieces of information about the disasters. in this chatbot system, there are 5 main entities. They are UI, NLP, Algorithm, API, and training data

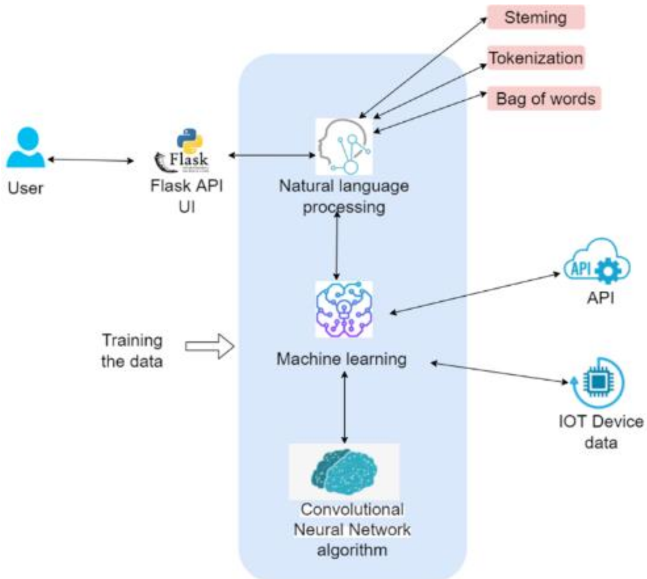

Fig 5: Chatbot individual diagram

The first process of the This pipeline is Tokenization. Tokenization is the process of breaking down large amounts of text into smaller bits. Tokenization divides the raw text into words and phrases, which are referred to as tokens. Next tokenized words are going through the steaming process. in this process these words will reduce a word to its word stem, which affixes to suffixes and prefixes or to the roots of words known as a lemma, is known as stemming. Finally, it will give an output as a Bag of words (Bow). The bow is a technique for extracting text characteristics for use in modelling, such as with machine learning techniques. After this NLP Pre-processing Pipeline, The Bag of words is directed to a Feedforward neural network. This Feedforward neural network consists of three layers. The bag of words which is an output of the NLP pre-processing pipeline, will go through this three-layer and go to a SoftMax. Then it will output the most accurate answer for the end user's question.

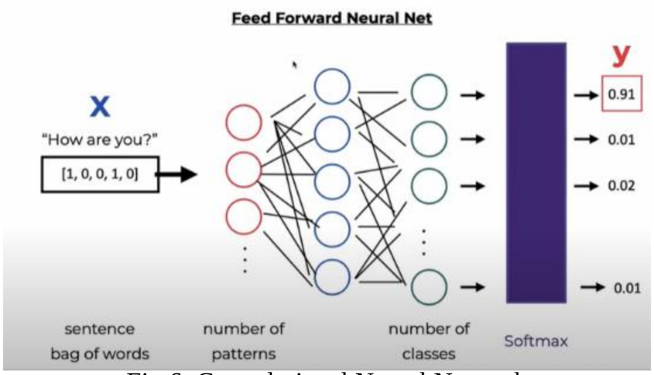

Fig 6: Convolutional Neural Network

D. Flooding area visualization

Using Time Series Forecasting to display a 7-day flood prediction on a map, the user may get a more reliable prediction. The proposed system acts as a flood victim's assistant by recommending the safest sites for floods. For this, an ARIMA model is proposed to develop time series forecasting for the system. The purpose of this approach is to use a map of Sri Lanka to show where flooding is expected to occur and how much of the region will be flooded if rain falls this week. In this tutorial, we will be building an interactive map that predicts floods in Sri Lanka based on the ARIMA model. Our map will have a user interface which lets users can see flood from different locations in Sri Lanka and view the number of floods that are predicted for that location. The IOT devices, which give rainfall forecasts in the research locations, deliver the predicted flood data. The application will be built with the Python, Flask, and Matplotlib libraries.

IV. RESULTS AND DISCUSSION

A. Weather detection and forecasting

For detecting real-time data, Raspberry pi 4 module, breadboard, BMP/BME280 Digital Barometric Pressure sensor, DHT22 sensor, Rainfall level sensors, Raindrop sensor, and PCF8531 ADC IC are used. After connecting Raspberry Pi module to the Wi-Fi using Headless Raspberry Pi method, real-time data push to the web application which detect from the sensors. The real-time weather parameters are Temperature, Humidity, Pressure and Rainfall.

Fig 7: Real-time weather data

For the rainfall forecasting first used LSTM (Long Short-Term Memory) model. It's time series forecasting model. Although LSTM model is light weight it is not fast. Therefore, for the forecasting FB Prophet algorithm is used. It is faster and smoother than the LSTM model. The parameters, Temperature, Humidity, Pressure, and the Rainfall is forecasted for next seven days.

B. *Flood detection and forecasting*

Before commencing the investigation, the data gathering method was performed in its entirety. We were able to gather a great deal of data about specialists. When it came to gathering real-time data and putting the technology into practice, however, there were several practical challenges. The issues we discovered were a lack of data collection methods and technological understanding. Existing approaches are non-technological and relatively archaic and planned to construct an IoT and Machine Learning-based solution because of our discoveries.

To achieve this goal, the users in this study are marked by the risk of flooding. The project introduces a mobile extinction and web application that is easy for users to handle. This model allows the user to predict the flood level at the location and monitor the current flood level. The accuracy of this forecasting process is 0.23 and the precision grade table of GM (1.1) confirms that the accuracy is very good in the predictions made by the Gray Model.

C. *Chatbot*

In the research of flood detection and warning systems the model that has been trained with the convolutional neural network and feeds forward neural network algorithm is fine-tuned and configured to detect the user input text Probability or accuracy above 85% final output this makes sure that the system would be sure of the result that is being provided to flood victims

Users can get the real-time data such as temperature, rainfall, Humidity, and pressure that are gathered from IoT devices and get the forecasting that is gathered by the prediction of flooding date, and temperature. Users can simply ask a text question from the chatbot and the chatbot will give the most accurate answer to the end-user

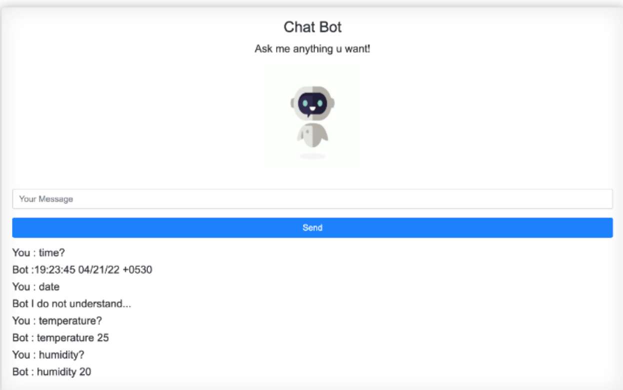

Fig 8: Chatbot real-time data revealing

D. *Flooding area visualization*

The model that has been trained with the Time series forecasting utilizing ARIMA model in the research of flood detection and warning systems. When making future judgments or doing analysis, time series forecasting is incredibly useful; we can accomplish it quickly with ARIMA. There are a variety of time series forecasting models to choose from, but ARIMA is the most user-friendly. The Map component's major goal is to provide end-users with live data from IoT devices as well as 7-day forecasting information from this map. The user can also get real-time flood information, such as where the water has submerged, where flooding is occurring, and where it is safe. The web application is used by flood victims on their mobile phones or computers. Because this last situation is so essential, the majority of users will use this application through mobile phone. We made this web application mobile responsive so that flood victims can use it when they are in the midst of a crisis. We don't have a flood detection system in Sri Lanka, nor do we have an online source for flood data or a flood map, therefore this system is a good way for victims to access the most reliable and accurate real-time data and information.

Fig 9: Flood risk areas

CONCLUTIONS

Sri Lanka does not have a proper early flood detection and warning system. It has only a manual old fashioned flood detection system. so people don't get real-time, accurate data in disaster situations. Since Sri Lanka faces floods almost every year, we should have needed such a smart prediction system, especially in densely populated areas like Colombo.

Smart Flood Detection and Warning System is a real-time IoT and machine learning-based early warning system that consists of a user-friendly chatbot and a Map visualization. This system is very useful to flood victims in populated areas. The main objective of this system is to reduce the flood damage and save the victim's lives.

This system can be marketed for government weather offices such as a meteorological department. We can market our web application among people all over the country through social media.

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