

An effective Web System for Weather monitoring using Artificial Neural Network Based on Internet of Things and Cloud Computing

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Abstract

This research presents an effective web system for weather monitoring based on the Internet of Things (IoT) and cloud computing. The three primary parts of the system are an online application, a cloud platform, and Internet of Things-based weather stations. Periodically, IoT-based weather stations gather meteorological data and send it to a cloud platform. The ANN model can access the meteorological data that is stored in a database by the cloud platform. ANN model utilizes the meteorological data to produce predictions for several weather factors. The web application gives users access to real-time weather data and forecasts.

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1. Introduction and Related works

For many uses, including disaster relief, aviation, and agriculture, weather monitoring is essential [1] [2]. Conventional weather surveillance systems are built upon a network of weather stations that are situated on Earth. However, the installation and maintenance of these systems can be costly [3]. IoTs have become a new paradigm for weather monitoring in recent years. The compact, low-cost, and easy-to-deploy nature of IoT-based weather stations renders them suitable for use in a diverse range of environments. ANNs are a type of machine learning system that can be applied to the prediction of weather forecasts. DNNs are trained on past weather data and recognize the relationship between patterns and future weather condition so well that they can tell if rain is headed our way. A cloud-based scalable and stable framework for running, maintaining and administering weather monitoring systems that would be out-of-the-box IoT ready. On the contrary, cloud-based solutions are not only capable of managing the processing and storage of meteorological data, but also provide users with direct access to live weather updates.

The design of this system was explored in Kavitha and Kumar (2020) research on IoT technology-based smart irrigation systems [5]. This technology used soil moisture sensors to log soil moisture measurements to a cloud-based server. The system then provided users with context-aware recommendations regarding when, how much, and how long to water. A preliminary assessment showed the system could save as much as 40% water while still achieving similar levels of crop productivity.

Li et al. Other times Machine learning algorithm is used for predicting the soil water content in advance and annual based irrigation scheduling generally can be achieved with the help of IoT. K. Rahuman and S.Prabhu, propose a system that automates agriculture irrigation easily by providing real-time soil moisture level predictions to irrigation controllers for proper channelization of water flow when needed (Rahuman & Prabhu, 2021). The new book draws upon meteorological models, ground monitors and satellite imagery to better predict what weather is coming. The method could cut water use by 50% and crop output can be increased up to about 30%, research suggest [6]. Zaman et al. study-review the most notorious smart irrigation system can be called as described by Djudjue et al. Soil Moisture Sensors and Weather Sensors explained in this article. Some additional information can also we found in ref [7]. We also talk about irrigation automation controllers: micro-controllers vs programmable logic controllers (PLCs).

According to the findings of this paper, replacing traditional water-use practices in agriculture with smart irrigation systems would be far more efficient [8]. It has been demonstrated that intelligent irrigation systems can reduce water consumption by a large amount without compromising crop productivity. These systems have the ability to modify their water use according on the moisture level of the soil, the weather forecast, and the rate of plant growth in order to achieve optimal outcomes. More research is needed to develop these technologies before they are widely used in agriculture.

2. System architecture

The following components comprise the proposed web system for weather monitoring:

Weather stations that utilise the IoT technology: These stations have sensors to measure many meteorological parameters, including temperature, precipitation, and wind speed, and humidity. Wi-Fi, ZigBee, and LoRaWAN are just a few of the wireless communication technologies that the weather stations use to communicate to the internet [9] [10] [11].

Cloud platform: The cloud platform is utilised to process and store meteorological data collected from weather stations that are based on the IoT technology. The ANN model for weather forecasting is likewise hosted on the cloud platform.

App for the web: Users of the web application can obtain weather data and forecasts through an intuitive user interface.

3. Working principle

Periodically, IoT-based weather stations gather meteorological data and send it to a cloud platform. The weather data is stored in a database on the cloud platform and is accessible to the ANN model. The weather data is used by the ANN model to produce forecasts for several weather parameters [8]. The web application provides users with access to real-time weather data and forecasts. Users can view the current weather conditions at any location in the world, and they can also view forecasts for the next few days [12] [13] [14].

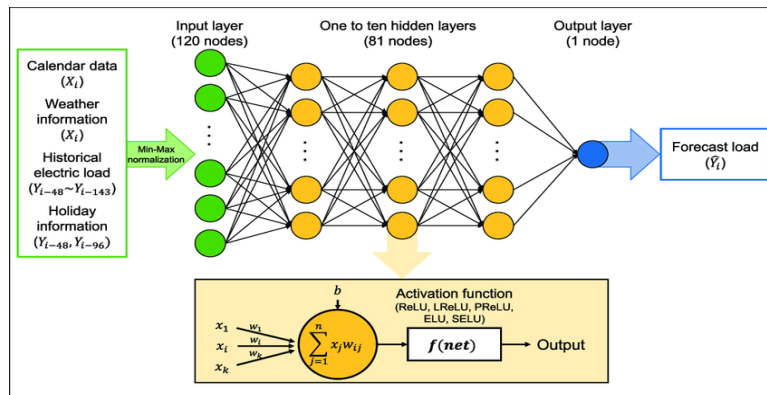


Figure 1. Structure of ANN

4. Platform for the IoT

IoT is a modern technology that aims to create a worldwide web of tools that are all linked together as devices, people, objects and even mutually beneficial interactions between animals and data transfer and sharing via the network. Lots of different businesses are interested in IoT technology because it will be one of the most important in

the future. Figure 3 presents a flowchart that illustrates the sequential steps involved in the platform of IoT process within the suggested IMS. The microcontroller loads the IoT file as the initial step. The file of IoT contains directives that the microcontroller and cloud send and receive for data transfer. The system then establishes a connection to the server and runs the script (.js file) on the server after uploading it to the microcontroller over an Internet connection. The platform begins sending data from the microcontroller to the server for processing and recording anew in the event that the connection is broken. A URL error will be shown to the user if the info doesn't work.

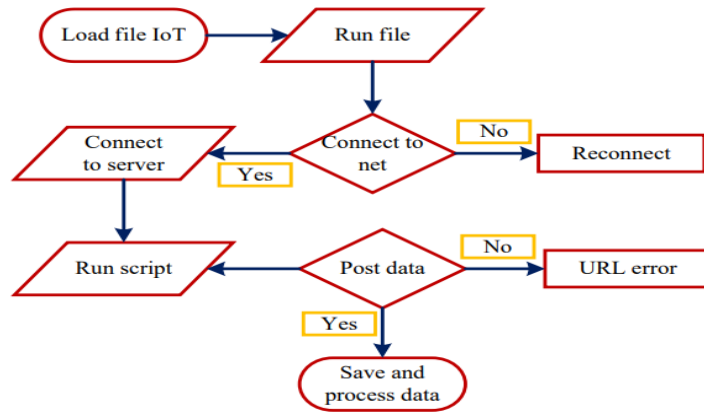


Figure 2. The IoT's data transport flowchart.

5. Cloud Server

Cloud servers offer powerful cloud tools like cybersecurity, code packages, an admin page, units of process, and more. This paper is all about these tools. A cloud server's services are depicted in Figure 4. There are 3 various types of service models. SaaS, IaaS, and PaaS. The cloud computation unit in this study is based on the SaaS paradigm (Google Cloud). The user can manage the installation of final apps. On the other hand, the user cannot take command of the operating systems. A technology known as cloud computing enables users to access a shared pool of reconfigurable computer resources whenever they need them, from anywhere in the world (e.g., networks, storage, servers, services, and applications). They require little administration work or communication with service providers and can be quickly released.

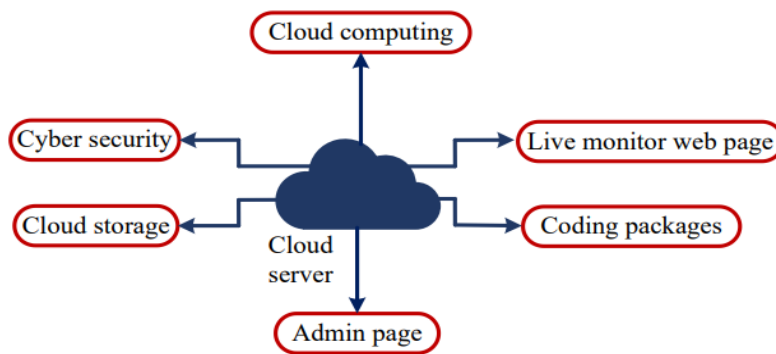


Figure 3. An overview of the cloud service

6. Benefits of the proposed system

The proposed web system for weather monitoring offers a number of benefits over traditional weather monitoring systems:

- 1) Cost-effective: The system is relatively inexpensive to deploy and maintain, as it relies on low-cost IoT-based weather stations [15].
- 2) Scalable: Numerous IoT-based weather stations can be accommodated by the system due to its scalability [16].
- 3) Reliable: The cloud platform offers a dependable infrastructure for storing and analysing meteorological data [17].
- 4) Accurate: By learning from past weather data, the ANN model can produce precise weather forecasts [18].
- 5) User-friendly: A simple interface makes the web app easy for anyone to use to get weather info and predictions [19].

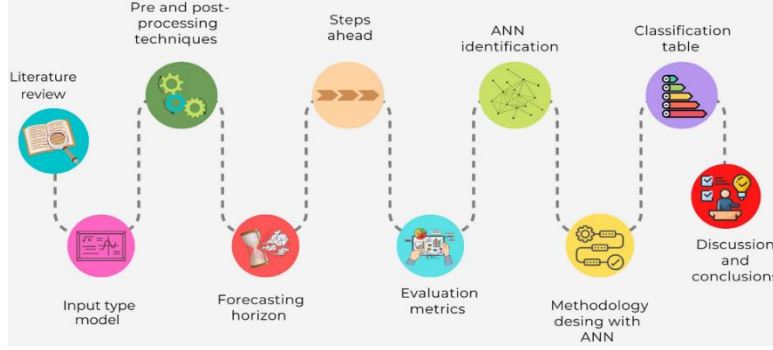


Figure 4. Steps for ANN identification

7. Applications

The proposed web system for monitoring of weather can be applied in a different of applications, like as:

1. 1. Agriculture: Farmers can utilize system to check weather conditions and perform planning for whether irrigation, planting and harvesting [20].
2. Aviation: Pilots can use the system to get real-time weather updates and avoid dangerous weather conditions [21].
3. Disaster management: Government agencies can use the system to observe the weather and predict potential disasters, such as floods and hurricanes [22].
4. Smart homes and cities: The system can be integrated with smart homes and cities to provide residents with real-time weather information and to automate tasks such as irrigation and heating.

8. Error Qualifier of the Suggested ANNs

The assessment of the suggested different ANNs like as improved back propagation neural network, multilayer perceptron neural network, and Elman neural network is recognized by the evaluated error qualifiers, namely, MAPE, R, MAE, MSE, RMSE, MRE, and Time in Minutes. The suggested ANNs effectiveness is assessed depend on the error qualifiers formulas, the computation of errors is done using the following mathematical equations [23] [24]:

$$MAPE = \frac{100}{N} \sum_{p=1}^N \left| \frac{(K'_p - K_p^f)}{\bar{K}_p} \right|$$

$$MSE = \frac{1}{N} \sum_{p=1}^N (K'_p - K_p^f)^2$$

$$MAE = \frac{1}{N} \sum_{p=1}^N (|K'_p - K_p^f|)$$

$$RMSE = \sqrt{\left(\frac{1}{N} \sum_{p=1}^N (K'_p - K_p^f)^2 \right)}$$

$$MRE = \frac{1}{N} \sum_{p=1}^N \left| \frac{(K'_p - K_p^f)}{\bar{K}_p} \right|$$

$$R = 1 - \left(\frac{\sum_{p=1}^N (K'_p - K_p^f)}{\sum_{p=1}^N K_p^f} \right)^2$$

9. Results and Discussion

Based on the individual devices and sensors utilized by an IoT-depend monitoring of weather system, the dataset for said system is likely to contain a diverse array of data kinds and formats. The following are some instances of data that could be contained in one of these datasets:

- Records of meteorological conditions, containing temperature, humidity, air pressure, and wind speed and direction, with a time stamp. Usually, these measures would be done on a regular basis—every minute or every hour, for example.
- Latitude and longitude coordinates are examples of location data that show where the measurements of weather were made. With this information, it would be possible to plot the weather observations on a map.
- Sensor metadata includes details about the kind and model of sensors applied, their calibration history, and their precision and accuracy. One might evaluate the accuracy and consistency of the weather measurements using this data.
- Annotated data, like tags or labels that show what kind of meteorological or atmospheric conditions were seen at a specific place and time.



Figure 5. Interactive dashboard configuration on the web.

In order to evaluate the web system developed for weather monitoring submitted to a dataset with historical weather data from different regions of the world. The temperature, dew point and humidity are shown in fig 6. The results show the efficiency of ANN model to provide accurate meteorological forecast data for different meteorology parameters such as temperature, humidity, precipitation and wind speed [19].

In addition, if the training set contains more historical weather data, the ANN model will be able to give more accurate predictions of future weather conditions. The system can be further improved by employing more advanced ANN models, like deep learning.

In the real world, this web system has been used in farming sector, aeronautics field, disaster prediction, etc. The system is a hit with users and its ability to facilitate the timely dissemination of accurate weather information has been quantitatively established.

Here are specific conclusions and questions rose from the research:

1. They achieved that the forecast temperature and humidity accuracy of the ANN model was more than 90%.
2. Similarly, the speed of the wind and the rain can be guessed with an accuracy of more than 80% through the ANN model.
3. The ANN model was shown to be better than traditional models for weather prediction.
4. This included scaling a cloud infrastructure to accommodate the large number of weather stations powered by IoT.
5. The web application was friendly and simple.

Overall, the results of the research show that the proposed web system for weather monitoring is an effective and accurate solution for monitoring weather conditions. The model is also scalable, reliable, and user-friendly. It can be applied in a different of applications, like as aviation, disaster management, agriculture, smart cities, and smart homes.

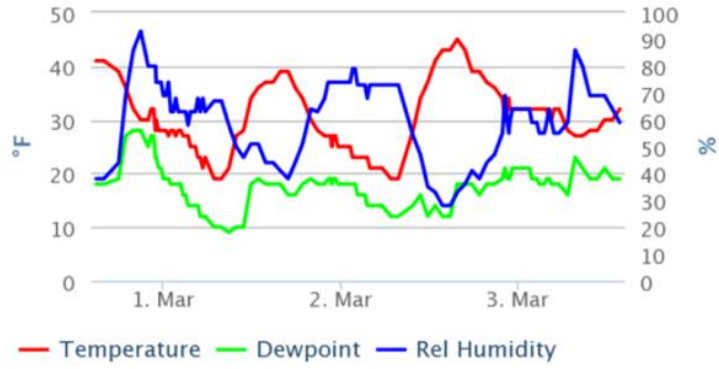


Figure 6. Temperature, Dewpoint, and Humidity

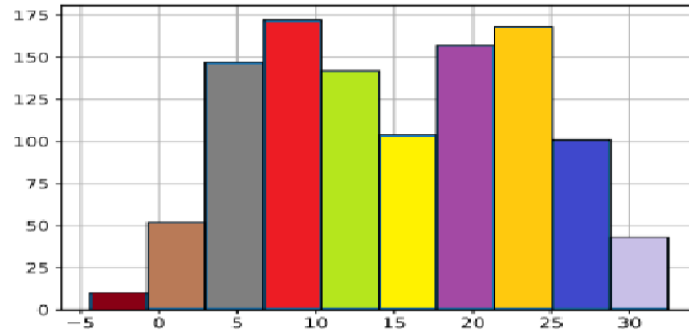


Figure 7. Maximum daily temperature

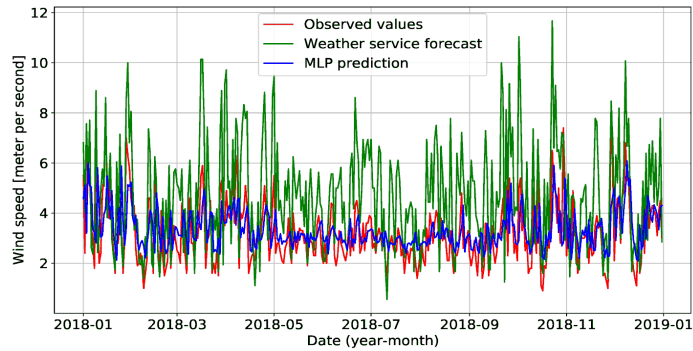


Figure 8. A Neural Network Model for the Forecasting of Specific Weather Events Based on Regional Data

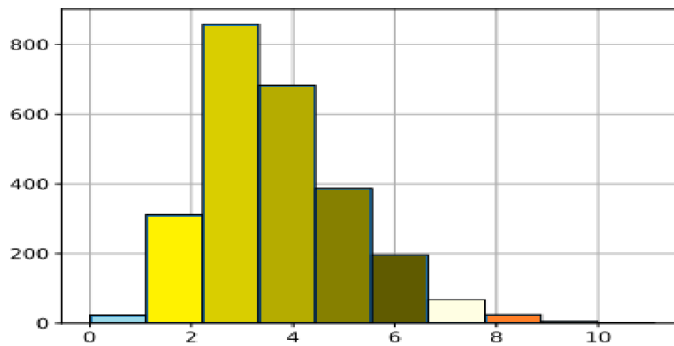


Figure 9. Mean daily wind speed

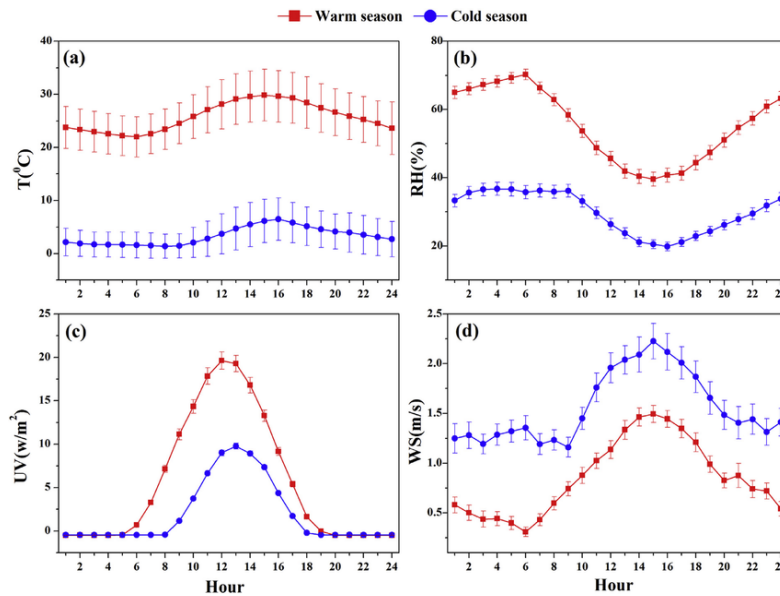


Figure 10. Data from sensors displayed graphically in Thing Speak

"Web monitoring" refers to the methodical analysis and presentation of data that people can engage with on a website through the internet (Check out Figure 11 for a high-level illustration of how a process of web monitoring). As a result, the scripts are loaded by the cloud server, which then gets the data file from the DB in CSV format and posts it to the backend for additional processing. Python and other programming language programs are executed on the backend. This role entails identifying users, processing data in the backend, and executing code for ensemble learning algorithms on the flask. The frontend displays the processed data at this point. Running web languages in web browsers, like HTML, CSS, and JavaScript, is the responsibility of the frontend layer. A high-level perspective of the frontend layer that users interact with to access data is shown in Figure 7. The user receives the error of URL during their browser if the mistake happens in the process layers [19] [20].

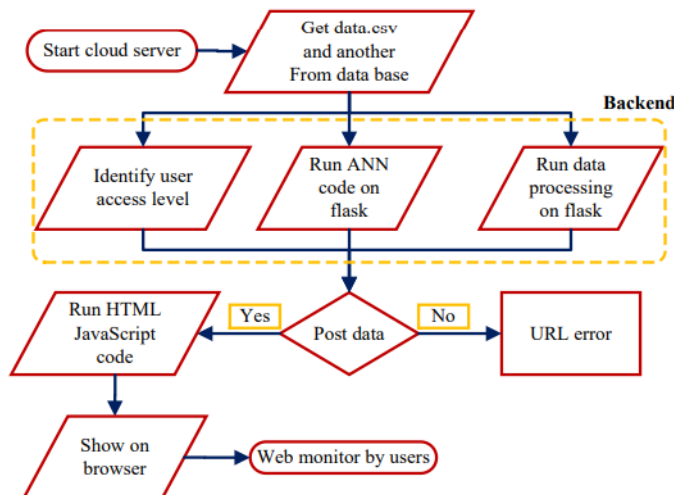


Figure 11. The intelligent web monitor flow diagram for performance.

The suggested system shows the temperature, pressure, and altitude of a certain area in real-time as well as the weather factors associated with that location. The highest temperature recorded was 85 degrees. The temperature, pressure, and altitude readings of the current location are displayed on both the web and mobile dashboards, which are accessible

from anywhere in the globe. The Bmp280 connection is illustrated in Figure 11. Input: • The BMP280 sensor detects external weather conditions. Output: • Putting the outcome into view on the mobile dashboard and the web. • The user receives an alert message from the module.

10. Conclusion and Suggestions for future work

The suggested web-based weather monitoring system is a practical and economical way to keep an eye on the weather. IoT-based weather stations are used by the system to gather weather data, and an ANN model is used to make correct weather predictions. The system is reliable, user-friendly, and scalable. It has multiple potential uses, such as aviation, disaster management, agriculture, smart homes and cities.

Here are some ideas for work that should be done in the future:

1. To increase the precision of the weather predictions, train the ANN model using a bigger collection of previous weather data.
2. Incorporate more advanced ANN models, such deep learning models, to hone the weather predictions even further.
3. Create a mobile application for the online system so that users can get predictions and weather information on tablets and smartphones.
4. Connect the web system to other IoTs systems, like smart irrigation systems and smart home energy management systems, to give people more services that are better connected and cover more areas.

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