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# Real time Weather Forecast model for Disaster Management using Machine Learning Algorithms

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**Abstract**

In the present era of increasing technology, it is typical that people need detailed and easily available information about current weather and weather forecast. This app can be also used by the users who have no prior knowledge on calculating weather based on degree's in forms of logo which can be understand by anyone. The main motive is to provide an effective routine for the user by predicting the weather condition. Andhra Pradesh State Disaster Management Authority (APSDMA) wants to provide this service over a smartphone application. This application takes the data from the APSDMA. Weather Forecast uses an open weather API. This app can be also used by the users who have no prior knowledge about calculating weather based on degree's in forms of logo which can be understand by anyone. The main motive is to provide an effective routine for the user by predicting the weather condition. The scope of this app is that it tells us how many inches of rainfall we can expect in the next 5 days. Machine learning algorithms Artificial Neural Network (ANN) and Gaussian Process Regression (GPR) are used for prediction.

**Keywords:** Mobile application, Weather Forecast, Artificial Neural Network (ANN), Gaussian Process Regression (GPR), Geo location, Location Based Services

## 1. Introduction

Mobile devices such as smartphones or tablets are becoming common more and more and are widely used in banking, news reading and shopping, social networking and so on. This application helps the users to predict the weather condition on the particular day and it also the displays the weather condition in the form of logo and as well as in degree Celsius. This app is also useful for tourist to plan their vacation and locals to predict the weather essentially prepare for the day.

Even with the frequent calamities, there is an absence of an efficient disaster management system that will help the people before and during calamities. In recent years, natural calamities and disasters have increased day by day and people have suffered the consequences of them, one of the main reasons being the lack of information doesn't reach to the end users.

So there is a need for efficient information sharing before the calamity occurs and efficient rescue and relief operations to be done during and after the calamity. With the help of APSDMA and using Earth Network's weather forecast data, an application is developed which can help users by providing the real time data.
By the forecast they can make their plans and this app helps the user to carry the essential based their weather condition on their day. It also enhances ones living standards and enable the lives to live more comfortable.

**1.1. Motivation:**

The main motive is to provide an effective for the user by predicting the weather condition. In the recent years natural calamities and disasters have increased day by day and people have suffered the consequences of them, one of the main reasons being the lack information doesn't reach to the people. Deaths due to sudden weather is the topic covered in this report, there hasn't much done to save the life of deaths over the years but with the advancement in technology there is tremendous information which can be provided by Disaster management Centre, by using this data we can try to alert the general public.
The main motivation behind this application simply lies in the fact that how a calamity results in a huge life and property loss.
Lack of proper knowledge about the weather is responsible for at least 20% of the deaths caused by nature in most years in India such as sudden rainfall, damages to the crops. The main reason being:
(i) Predicting sudden changes in weather is very complicated since everything from trigger to strike happens in one second and it is even harder to locate its area of the change.
(ii) It is affected by the geography of the region. India is more prone to lightning, extreme temperature and even rainfall because of its geographical layout and changing weather
(iii) Lack of proper sharing of data with the people.
To address the lack of proper data sharing, we collaborated with APSDMA (Andhra Pradesh State Disaster Management Authority) to guide and assist the development of this application.
APSDMA is led by the Chief Minister of Andhra Pradesh. Along with the formation of APSDMA, the Government of Andhra Pradesh has also formed District Disaster Management Authorities (DDMA) in all districts with District Collector as Chairman of DDMA. A special wing namely SEOC (Special Emergency Operations Centre) is established within the APSDMA, it responds to severe emergencies and provides 24/7 round the clock surveillance on weather and takes appropriate measures when a calamity occurs. APSDMA has established a headquarters and started operations from Tadepalli, Guntur District.
APSDMA has also got cutting-edge technologies already implemented which helps in analysing and visualizing weather data, it has also tied-up with Earth Networks for Weather data.

**1.2. Objectives:**

1. The Primary objective of this application is to issue early notifications to people using the application.
2. Providing the ability to users to view the information about the weather such as humidity rate, temperature, rainfall rate, thunderstorm chances for the next five days which include updating the conditions for every three hours.
3. The app is designed to work even without entering any personal details i.e., new users need not signup, to start using the application, you can simply install the app and start using it.
4. Making sure that application works as intended even when the user is not using the application i.e., the application must work in the background sending location of the user to a remote server every 15 min and get appropriate responses and notify the user when he again opens back the app.
5. All we intended to do is providing the useful information to the people about the weather conditions so that they may plan and make activities such as sowing the seeds, safe stay of the farmers during heavy rainfall. This not only helps the farmers but is also beneficial to the common people by providing 5 day forecast of weather using machine learning algorithms Artificial Neural Network (ANN) and Gaussian Process Regression (GPR).

**1.3. Advantages**

1. Easy to use the application with minimum to no learning requirement, with intuitive user experience
2. Providing user, the ability to view the exact weather conditions with different constrains for even more information.

3. User no need to be on a specific carrier in-order for this app to work, this application is built to work seamlessly with any carrier & user will receive the information whenever he opens the app displaying the current time, date and day with the constrains of temperature, humidity, rainfall rate, thunderstorm chances including the constrain updating for every three hours of the day.
4. The user need not check the app continuously for alerts, this app runs in the background even when the app is not in use by taking the current information and details, the only requirement is that device needs to have network connectivity.
5. User is kept completely anonymous, there will be no need to fill any forms and register, to use the service. Users can simply download the app and start using the app with no strings attached.
6. Easy to use and provides accurate information which is helpful to all the people.
7. Provides assistance for not only for educate one but also for the people for who has no prior knowledge
8. Helps the user to predict the weather condition by providing 24/7 weather assistance.
9. Help tourists to can plan their travel smoothly.
10. Provides assistance to the fisherman to predict the weather condition have to go for fishing or not.

**2. Literature Review**

Literature provides statistical forecast models for linear data and Artificial intelligence based forecast models for non linear data. Even though these models have good accuracy but accuracy decreases for time series based real world data. Weather forecasting using DHT11 sensor is described in [1]. Climate observing has critical influence on mankind. Gathering of the various data of fleeting elements of the climate variations is extremely noteworthy. Authors of [2] proposed an application called MyMapVolunteers that detects the latitude and longitude of the volunteers. One of the problems associated with this application is the delay, which need to be very less for disaster management applications. This application avails the GPS functionality built into a smartphone to locate the volunteers' position, the latitude and longitude coordinates are then sent to a web server. The web server then receives the volunteers' locations data and stores them in a database and then when the location of a volunteer is to be shown, it is retrieved from the database and marked on the map using Google maps API. Web of Demotics (WoD) architecture is described in [3]. Àndroid app is proposed in [4]. AI based learning models for weather forecast is described in [5]. use cases for weather forecast is described in [6]. Openstreetmap app is described in [7] to alert people in Bangladesh. mobile app to check weather conditions is described in [8]. Work reported in Vajrapaat application is an application for the weather forecasting which is carried out by using a carrier support, for instance Vajrapaat application currently relies on BSNL for communication of alerts, it is mentioned that it works with other carriers, at the time of launch of this application, till now since the launch of this application there is no update on that matter. This is a very serious problem, for instance if a user is on some other carrier that is not interoperable with BSNL, then the user gets left out from the communication of alerts even though they have the app installed leaving the user endangered. Depending on carrier support for communication will affect the users, as they will be forced to change their carriers simply if they want to get alerts. And another problem associated with this application is that it can only work within the state of Andhra Pradesh.

Solution for the above problems lies in developing an application that doesn't use any carriers but utilizes the potential of the internet to deliver alerts and since we use the internet, there is no restriction on the location where the application can be used.

**3. Proposed System**

A method and system that combines data obtained from the various meteorological departments and disaster management with geospatial information to achieve an improved and informative and interactive weather alert system using a user-friendly application. Figure 1 presents block diagram of the proposed system. This includes the following steps:

1. Determine the Latitude and Longitude from the user location
2. Retrieve the meteorological parameters from the APSDMA database
3. Use Machine learning algorithms GPR and ANN to predict next 5 days weather.
4. Display the data on user mobile

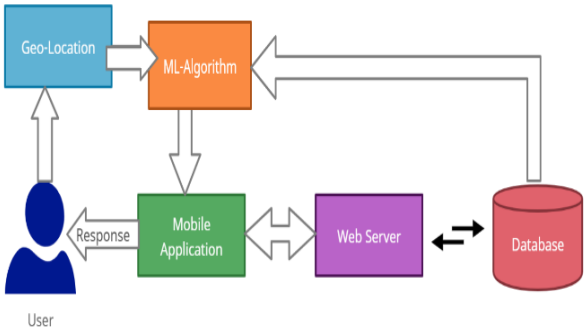


Figure 1: The Block Diagram[10]

The proposed system is expected to deliver the weather information. This application is built using MVVM architecture as shown in figure 2 which is advised by google for android applications, using this architecture introducing new features without affecting the existing features becomes very easy.

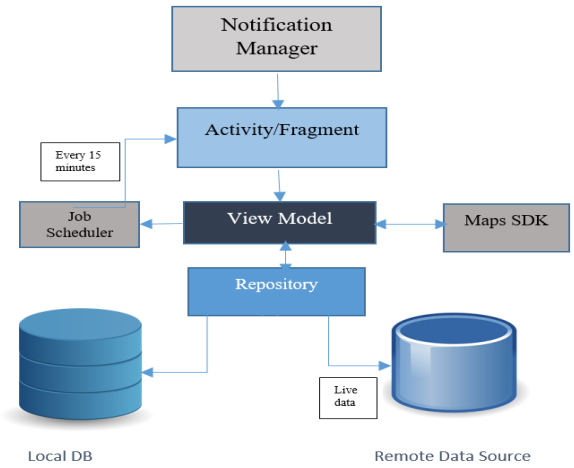


Figure 2: Architecture [10]

**3.1. Methodology of proposed system:**

Figure 3 presents Flow diagram of the proposed system. The app takes the GPS location to find the location of the user and with the data about the weather which include current time, date and day with the constraints of temperature, humidity, rainfall rate, thunderstorm chances, which are very crucial factors for determining the accuracy of prediction.

APSDMA has got a vast array of radars and various data sources scattered throughout the country which provides weather data to APSDMA, one such provider is Earth Networks which delivers data. Current systems deployed at APSDMA use BSNL as a carrier, subscribers typically extract simple storm information from APSDMA to provide users with the weather information. APSDMA provides the Attributes data information at periodic intervals.

There is a problem associated with BSNL as a carrier and that affects its subscriber's i.e., whether you are in that disaster area or not, if your BSNL connection belongs to that area (for ex: if you moved from that area to some other area at that time, even then you will be getting information because since you were in that area a while ago)

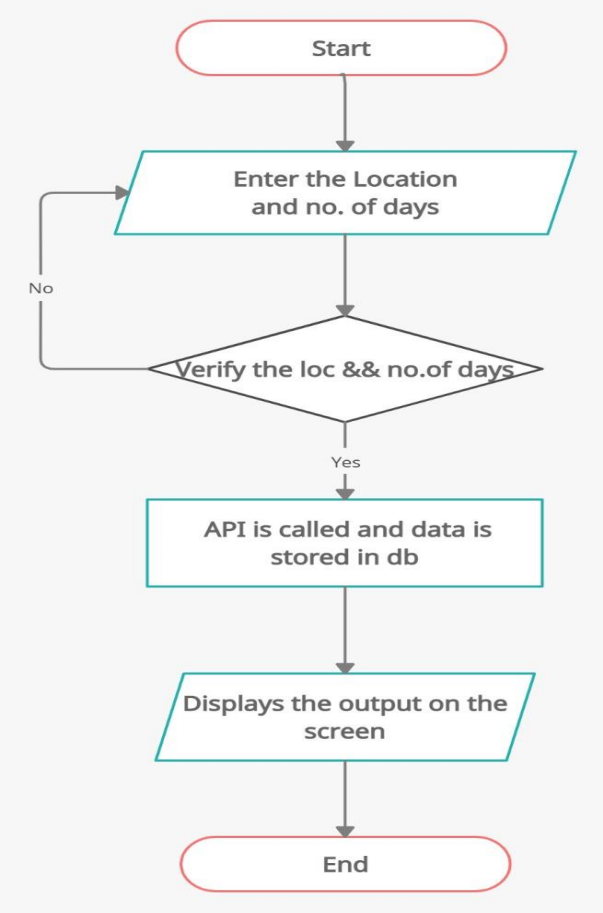


Figure 3: Flow diagram.

You receive details of weather a while back this is not real-time data and it is of not much use, this problem can't be solved by only depending on a carrier location data, we need to use GPS data of the smartphone and by this way we can deliver pinpoint alerts which is not previously possible.

So, relying on a carrier for notifying the user is not a viable option since there are multiple carrier's and they lack interoperability, so we can use internet as a communication medium instead of relying on carriers since internet is interoperable.

Using the internet this app can deliver mass information to people who are in regions. In order to make proper use of the internet and keep the information synchronized the application runs in the background, once every 15 minutes, checking whether the user has moved into a different area, if that is the case the details get updated this happens every three hours of the day with the next five days forecast.

### 3.2 Pre-Processing Using Min-Max Normalization

Data collected from different sensors may have incomplete, noisy and in-consistent data. Preprocessing helps for data smoothing and normalization. Min-Max normalization as given in Eq (1) is used.

$\frac{value-min}{max-min}$ (1) [13]

Where value is the attribute value, min is the lowest value of the attribute and max is the maximum value of the attribute

### 3.3. Gaussian Process Regression:

Gaussian Process Regression (GPR) as given in Eq(2) is a Bayesian approach used in regression and is independent of the parameters.

$P(w|y) = \frac{p(y|X,w)P(w)}{P(y|x)}$ (2) [14]

1. Read the dataset
2. x=df.iloc[:,:2]
3. yd = df.iloc[:,2]
4. find x.shape
5. Set x_train and yd_train , x_test, yd_test
6. Call GaussianProcessRegressor().fit(x_train, yd_train)
7. reg.predict x_test and yd_test
8. Save the model for validation
9. Load the model from the file and validate on real time data and print appropriate alert message

### 3.4 Artificial Neural Networks:

**ANN using Feed Forward propagation** is constructed using a set of weights given by Extended Kalman Filter (EKF)[11]. Reason for using EKF instead of Stochastic Gradient Descent (SGD) is that, EKF can determine weights in a sequential fashion and maintains approximate error covariance. It is being adopted by many navigation systems as stated in [12]. Relu Activation function is used in the hidden layers and Softmax is used in the classification layer.

1. Read the file
2. Perform pre-processing using Min-Max normalization
3. Use EKF as given in Eq(3) to estimate the weights of the neural network
   y= z - h(x′) (5) [3]
   where z is the input value, x1 is the predicted value, y is the error, h is the mapping function.
4. Set training, testing and validation datasets
5. Load ANN model and set iterations =100 with Relu activation at convolution layer and Softmax at classification layer
6. Use cross entropy loss function to evaluate the model
7. Save the model for validation
8. Load the model from the file and validate on real time data and print appropriate alert message

### 3.5 Technologies used:

Native Android Framework is used to build the native mobile app, for the android system. Geo Location API (android) that facilitates getting user location using the GPS sensor on the mobile phone, this location is used to check the weather information. Nodejs Web Server is used to get the user location and since the user location changes frequently, we can't perform and store the result and refer it later, every operation needs to be instantaneous as we are dealing with real-time data, so the app sends the user location to the server every 15 minutes running in the background and server performs some geospatial queries on the user location. This process takes place even when the app is closed and not in use. The reason for choosing Mongo DB Database is that the data we handle in this application is entirely Geospatial involving latitude and longitude data, and it also provides various queries related to Geospatial Operations previously which is not possible using traditional Relational databases. This data store holds the locations, in order to speed up query processing time, Geospatial indexes are used. The data persists in the data store only for 45 minutes and later it is deleted automatically, this is achieved using a “Time to Live” index. Java programming language is used for Android development [9].

### 3.6 Performance Evaluation Measures

Performance of the machine learning algorithms will be calculated using several measures as described in the following:

(i) Confusion matrix: It is used to find algorithm performance as shown in the table **1.**

Table 1 Confusion Matrix **[15]**

| | Predicted a=0 | Predicted b=1 |
|---|---|---|
| actual a=0 | TP | FP |
| actual b=1 | FN | TN |

(ii) Classification Accuracy Rate (CAR): Equation (4) [15] is used to calculate accuracy where TP means True Positives, FP means False Positives, FN means False Negatives and TN means True Negatives.

$$accuracy = (tp + tn) / (tp + tn + fp + fn) \quad (4)$$

iii) Precision: It is calculated using Equation (5) [15] that measures the relevancy of the result

$$\Pr ecision = tp / (tp + fp) \quad (5)$$

(iv) Recall: It is calculated using Equation (6) [15] to measure relevancy of the result generated.

$$\mathrm{Re}\, call = tp / (tp + fn) \quad (6)$$

(v) F-Measure is calculated to find balance of precision and recall as given in Equation (7) [15].

F1=2*(precision*recall)/(precision +recall ) (7)

Other measures that will be used are True positive rate (TPR) and False positive rate (FPR).

## 4. Results

The following figure 4 to figure 6 present the details of how the data gets displayed. But, for now only the temperature is displayed but the actual output is also attached to provide a detailed understanding of it.

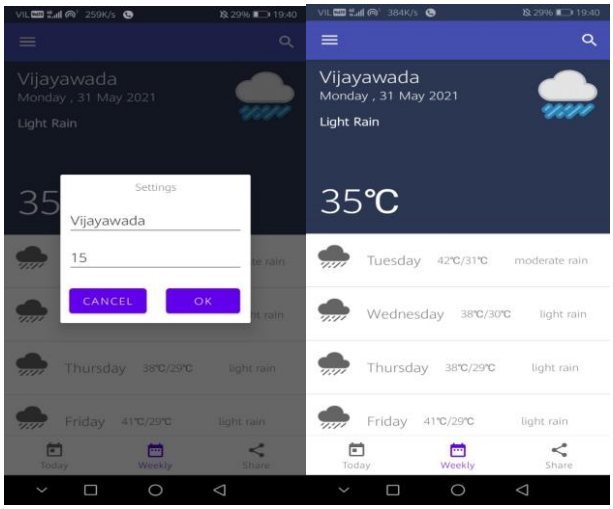


Figure 4: *(a)* Fetching the input city and the number of days<=15 (b) Forecast for N days

The following figure 5 displays constrains with the appropriate symbols. It shows the actual output that gets generated displaying constrains with the information updating every three hours.

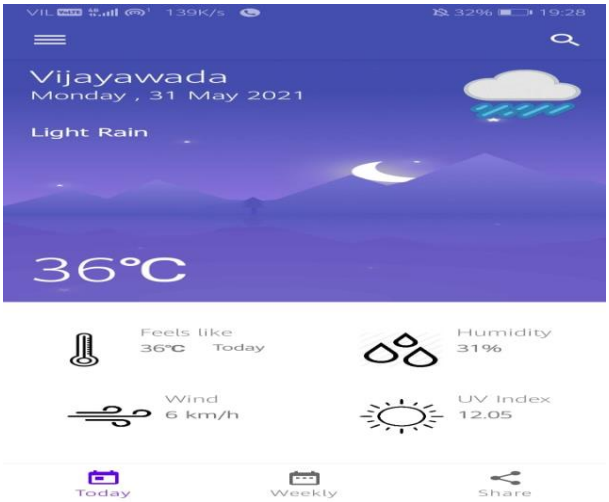


Figure 6: Display Output for a particular day

**5. Conclusion:**

Weather Forecasting and Disaster Management not only depends on the government agencies rescue and relief operations, but it also depends on the preparedness of people and proper awareness about it. Even though Short Message System (SMS) services are being used right now by the APSDMA for communicating to the BSNL users, an app is needed to communicate to smart phone users. The developed app will determine the user's Geo-location and accordingly will display the weather forecast. Real time metrological data is retrieved from APSDMA data server and is given to machine learning algorithms for prediction of weather for the next 5 days. Noise data is pre-processed using min max normalization so as to forecast accurately. Experimental results show that the app is user friendly and can scale to more number of meteorological parameters. Our future work is to evaluate the error graph of the proposed app

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