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Weather Monitoring System and Rainfall Prediction Using SVM Algorithm

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***Abstract*— The system proposed is an advanced solution for weather monitoring that uses IoT to make its real time data easily accessible over a very wide range. The system deals with monitoring weather and climate changes like temperature, humidity, wind speed, moisture, light intensity, UV radiation and even carbon monoxide levels in the air using multiple sensors. These sensors then sends the data to the cloud as cloud is used as a storage platform. The data uploaded to the web page can easily be accessible from anywhere in the world. The data stored in the cloud is then classified using Support Vector Machine algorithm to predict whether it is going to rain or not. The data is then represented graphically and displayed for the user. Due to the compact design and fewer moving parts this design requires less maintenance. The components in this project don't consume much power and can even be powered by solar panels. This project can be of great use to meteorological departments, weather stations, aviation and marine industries and even the agricultural industry.**

***Index Terms*— IoT, Support Vector Machine, Cloud platform, sensors.**

I. Introduction

Now a days, the innovations in technology mainly focus on controlling and monitoring of different devices over wirelessly over the internet such that the internet acts as a medium for communication between all the devices. Most of this technology is focused on efficient monitoring and controlling of different. An efficient environmental monitoring system is required to monitor and assess the weather conditions in case of exceeding the prescribed level of parameters (e.g., noise, CO and radiation levels) and for gathering data for research purposes(amount of rainfall, wind speed etc.). A system is considered as a smart system when the device equipped with sensors, microcontrollers and various software applications becomes a self-protecting and self-monitoring system. Event acknowledgment based and Spatial Process evaluation are the two categories to which applications are classified. Initially the sensor devices are deploy in environment to detect the parameters (e.g. Temperature, Humidity, Pressure, LDR, noise, CO and radiation levels etc.) while the data acquisition, computation and controlling action (e.g., the variations in the noise and CO levels with respect to the specified levels). Sensor devices are placed at diverse locations to collect the data to predict the behavior of a particular region of interest. The data are used for predicting the rainfall percentage in the particular area where the system is installed. The stored data are classified using the SVM algorithm which takes the values of weather parameters which are responsible for rainfall.

II. Related Work

In this high tech world many weather monitoring systems and forecasting systems are designed by considering different atmospheric parameters. Existing model [1] which uses wireless sensor networks to examine physical and atmospheric conditions. The atmospheric parameters such as temperature, humidity, pressure, light intensity in the atmosphere to make the environment interactive with the objects through wireless communication. In another system [6] they are interfacing the sensors (SHT25, BMP180 and wind Sensors) with the microcontroller ATMEGA-328 within the arduino uno board. The Arduino Uno is an open source easy to use microcontroller board with a variety of user friendly features. It is first programmed through the USB cable and Arduino IDE on a computer system. The software programming of the microcontroller is done in C or C++ in Arduino IDE. After uploading the sketch (arduino program) to the microcontroller the device starts collecting the data from the sensors connected to it. It sends the data serially to its Tx terminal. We can collect the data through USB cable but in our proposed system we are using Zigbee wireless link to receive the data. Once the Zigbee wireless link is configured, it can receive the data from other Zigbee modules connected to the hardware. Another system [7] used Support vector machine algorithm for classification and predicting the temperature forecast. Another existing system [3] consists of a microcontroller as a main processing unit for the entiresystem and all the sensor and devices can be connected with the microcontroller. The sensors can be operated by the microcontroller to reclaim the information from them and it processes the investigation with the sensor information and updates it to the internet through Wi-Fi module connected to it.

III. System Architecture

This system used Arduino Uno microcontroller as a main processing unit for the entire system and all the sensors and devices can be connected with the microcontroller. The sensors can be operated by the arduino to retrieve data from them and can be stored in the cloud and it can process the analysis with the sensor data and updates it to the internet through the Wi-Fi module connected to it. Updated data can be used for classification. Some threshold value for the weather parameter should be used for the classification by SVM algorithm. The values greater than the threshold value is the reason for the rainfall in that area. The rainfall percentage will be calculated and it will be represented graphically and send to the web browser which can be viewed by the user.

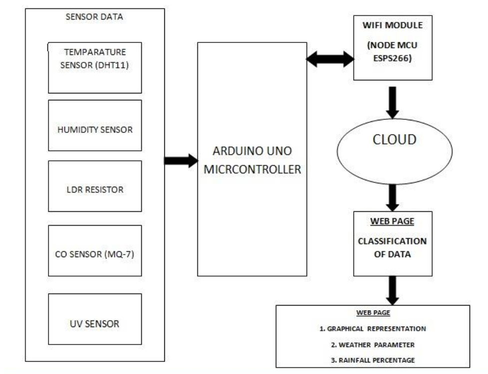

Fig. 1. Block diagram

IV. Proposed System

This system proposes an advanced answer for the weather monitoring system using IoT to make its real time data easily accessible over a very wide range. Predicting rainfall is one of the tougher task but using appropriate parameters and classifying them can help in predicting rainfall. Water vapor is a gas and invisible. The amount of water vapor in the air can be expressed as relative humidity (RH) which is the ratio of water vapor pressure (E) and saturation water vapor pressure (Es). Saturation vapor pressure is the partial pressure of vapor when evaporation and condensation rates are equal, represented by RH=100%. When RH > 100% net condensation occurs, but water has its own ideas. In a mixture of pure dry air and water vapor, water will not condense until around 400% RH. Reasons for this are a bit difficult but it has to do with very little droplets being more likely to evaporate as their bend is very large (Kelvin effect, saturation vapor pressure is higher over curved surfaces than flat ones). Fortunately for us, our atmosphere is not clean air but has small particulates suspended in it (aerosols). Some of these aerosols are classed as cloud condensation nuclei (CCN) and enable droplet formation at lower relative humidity. These work by forming a solute in water raising the power essential to fracture bonds and vanish the water (Raoult's law). The combined interactions of these are described by Köhler theory and describe droplet growth in terms of drop size, solute and super saturation (RH-100%). In a nutshell, there is a critical drop size below which drop size decreases for decreasing super saturation and above which drop size increases for decreasing super saturation. The critical super saturation is the super saturation needed to attain the critical drop size, and is generally small (e.g. 0.3% super saturation). Droplets under the critical size are 'haze drops' and these create up the haze you see on extremely humid days. Drops that reach the critical extent can keep on growing to turn into cloud drops. The condensed water is carried in the air but is no longer water vapour and is not part of relative humidity (but does contribute to the parcel density). It rains when water vapour is in the presence of CCN, driven to a super saturation causing growth to the critical drop size (on the order of µm) and continuing to grow to cloud drops and further to the much bigger drop sizes that make up drizzle (100-300 µm)and rain drops(mm), a process that takes around 40 minutes. Drops will grow until the updraft can no longer support their mass and then they fall from the cloud as rain. RH is the proportion of fading rate to condensation rate (growth rate of cloud to shrinking of cloud). Simply we can say that low RH means shrinking cloud (evaporation) and no cloud means no rain.

The process of converting cloud to rain is known as auto-conversion, and it is still a mysterious process. However, there are various studies that provide empirical relationships,

$$P_{AUTO} = \max(k_1 * (q_c - q_{c,threshold}), 0) \quad (1)$$

$$q_c = 0.622e/(p-e) \quad (2)$$

P_{AUTO} – Auto-conversion rate (kgs^{-1})
q_c – Cloud water (mixing ratio)
$q_{c,threshold}$ – Threshold value (0.0005 kg kg^{-1})
k_1 – Conversion rate (0.001 s^{-1})
p – Pressure
e – Vapour pressure

With the help of auto conversion value, temperature, dew point and the height parcels need to attain to freely convect (LFC). If there is forcing for packages to get that high and volatility above, then rain is a good bet. Classifying the data using SVM algorithm makes it easier to predict the rainfall. The system deals with monitoring weather and climate changes like Temperature, Humidity, Wind speed, Carbon monoxide level in the air, Light intensity, UV radiations, Soil moisture and after analysing and classifying the parameters, rainfall percentage is predicted.

A. Ardiuno Uno

It is an open-source physical computing stage based on a easy micro-controller board, and a development environment for writing software for the board. Arduino can be used to develop interactive objects, taking inputs from a variety of switches and or sensors, controlling a variety of lights, motors, and other physical outputs.

B. Wi-Fi Module

Node MCU is an open source IoT stage. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Express if system, and hardware which is based on the ESP-12 module.

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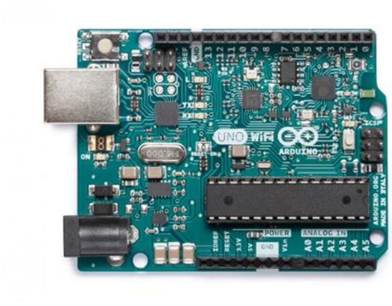


Fig. 2. Arduino

Fig. 3. Wi-Fi module

A. Cloud Platform

IoT cloud platform is designed to store and process Internet of Things (IoT) data. This platform is built to take massive volumes of data generated by devices, sensors, applications, websites and initiate actions for real time responses.

B. Support Vector Machine (SVM)

Support Vector Machine is machine learning algorithm that can be employed for both classification and regression purposes. SVMs are based on the idea of finding a hyper plane that best divides a dataset into two classes. SVMs accuracy level is high as compared to other machine learning algorithms. They are more efficient because it uses a subset of training points. We are using SVM algorithm to classify the weather parameters to predict the rainfall percentage. The basic idea of SVM is applied to binary classification. Most of the previous approaches are the method that decomposes a multiclass problem into multiple independent binary classification tasks. In practice, these methods usually bring about the inseparable cases which will reduce the accuracy of classifications. After obtaining the input data and applying the preprocessing method, the classification or prediction system can be used. The core of the forecasting system is based on support vector machine (SVM). Each instance in the training phase contains one "target value" and several "attributes". The objective of SVM is to generate a sculpt (based on the training data) which predicts the aim values of the test data given only the test data attributes.

The SVM [8] require the solution of the following optimization problem:

$$\min_{w,b,\xi} \frac{1}{2} w^T w + C \sum_{i=1}^{l} \xi_i$$

$$\text{subject to} \quad y_i(w^T \phi(x_i) + b) \geq 1 - \xi_i, \quad \xi_i \geq 0.$$

Here training vectors I x are mapped into a higher (maybe infinite) dimensional space by the function ϕ. SVM finds Linear sorting out hyper plane with the maximal margin in this high dimensional space. C > 0 is the penalty parameter of the error term. The kernel functions of the supervised classifier which have been used are:

A. Linear kernel

$$K(x_i, x_j) = x_i^T x_j$$

B. Radial basis function (RBF) kernel

$$K(x_i, x_j) = \exp(-\gamma \| x_i - x_j \|^2, \gamma > 0$$

C. Polynomial kernel

$$K(x_i, x_j) = (\gamma x_i^T x_j + r)^d, \gamma > 0$$

γ, r and d are kernel parameters.

As training matrix, it has been chosen the information related to temperature and relative humidity to predict rain. Each row of the matrix is a vector with previous information of the target value (the value it is wanted to predict). If the window size is ‘n’, there will be ‘n’ temperature values and other ‘n’ relative humidity values in that row of the matrix. The target value corresponding to that row is set into the vector of target values that is another input parameter of the training system.

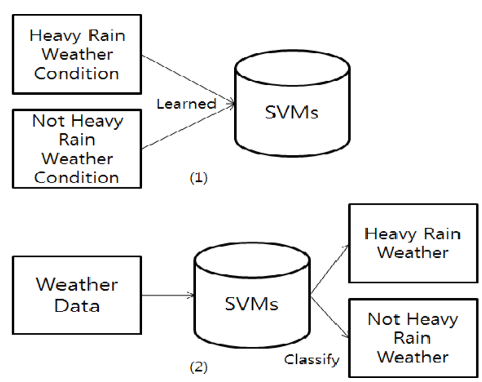


Fig. 4. Block diagram of SVM algorithm

C. Cloud Platform

1) Temperature and humidity sensor

The DHT11 is a fundamental, ultra-low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to calculate the neighboring air, and spits out a digital signal on the data pin (no analog input pins needed).

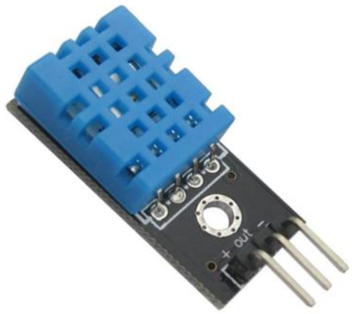


Fig. 4. Temperature and humidity sensor

2) *LDR light-dependent resistor*
Light intensity is measured using an LDR. An LDR is a section that has a (variable) resistance that changes with the light concentration that falls upon it. This allow them to be used in light sensing circuits. A light dependent resistor (LDR) is a light-controlled changeable resistor. The resistance of this decreases with increasing incident light intensity; in other words, it exhibits photoconductivity.

Fig. 5. LDR

3) *Co Sensor*
Carbon Monoxide (CO) sensor, suitable for sending CO concentrations in the air. The MQ-7 can sense CO-gas concentration anywhere from 20 to 2000ppm.This sensor has an elevated sensitivity and fast response time. The sensor's output is an analog resistance.

Fig. 6. Co Sensor

4) *Anemometer*
An anemometer is a device used for measuring the speed of wind, and is also a common weather station instrument. This device will help in measuring the wind speed which will be used for predicting rainfall.

Fig. 5. Anemometer

5) *UV sensor*
UV Sensors measure the power of intensity of incident ultraviolet (UV) radiation. UV sensors are used for determining disclosure to ultraviolet radiation in laboratory or environmental settings.

Fig. 6. UV sensor

V. GRAPHICAL REPRESENTATION

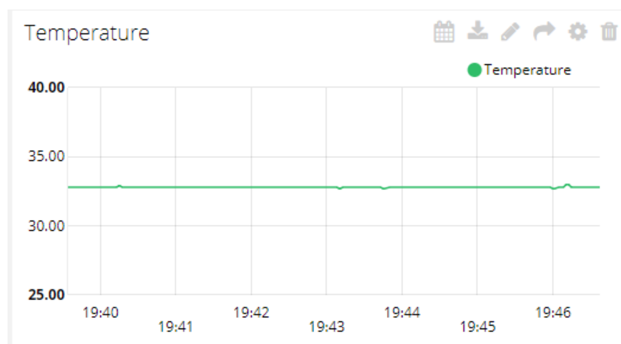


Fig. 7. Temperature

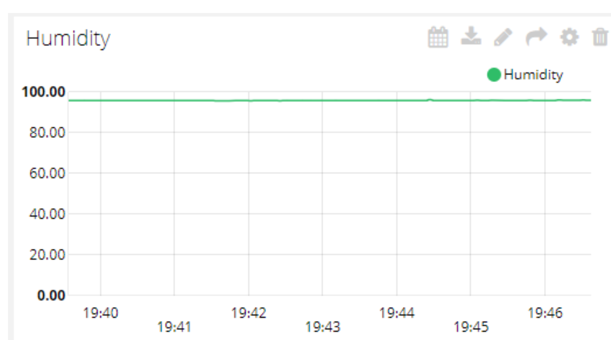


Fig. 8. Humidity

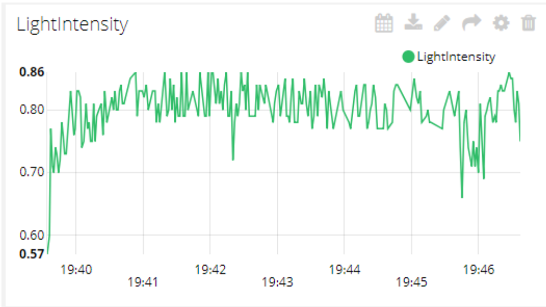
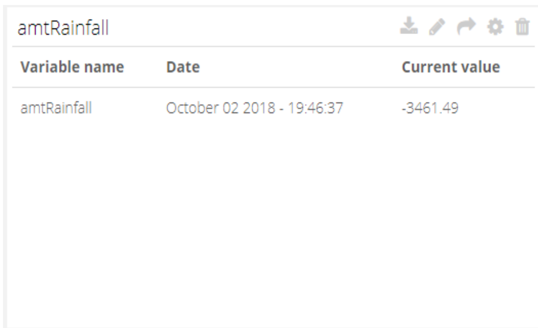


Fig. 9. Light intensity



amtRainfall

Variable name	Date	Current value
amtRainfall	October 02 2018 - 19:46:37	-3461.49

Fig. 10. Amount of rainfall

VI. Implementation

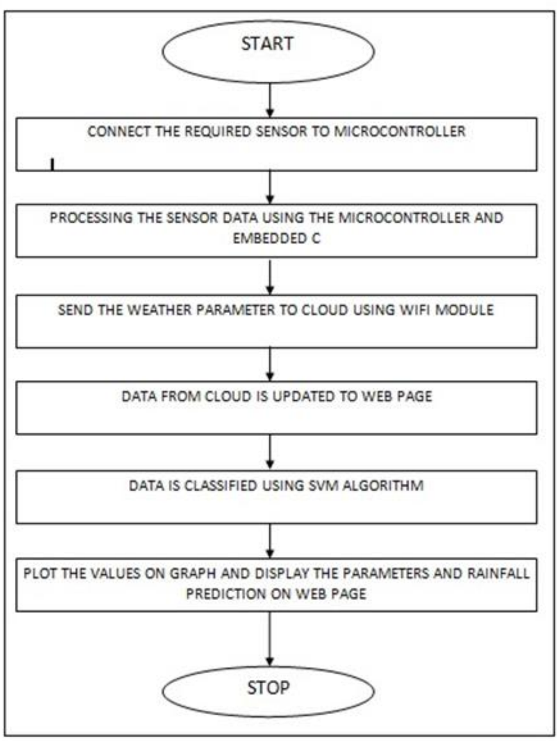


Fig. 11. Flowchart

In this implementation model we used Arduino UNO board with Wi-Fi module is as embedded device for sensing and storing the data in cloud. Arduino UNO board consist of analog input pins (A0-A5), digital output pins (D0-D13), inbuilt ADC and Wi-Fi module connects the embedded device to internet. Sensors are linked to Arduino UNO board for monitoring, ADC will convert the corresponding sensor reading to its digital value and from that value the equivalent environmental parameter will be evaluated. The implanted device is placed in exacting area for testing purpose. The sound sensor detects sound intensity levels in that area and Carbon Monoxide (CO) sensor MQ-9 will record the air quality in that region, if the threshold limit is crossed the resultant controlling action will be taken (like issuing message alarm or buzzer or LED blink).All the sensor devices are linked to internet through Wi-Fi part. After triumphant completion of sensing, the data will be processed and stored in database for prospect reference. After completing the analysis on data the threshold values will be set for controlling purpose. The Wi-Fi connection has to be established to transfer sensors data to end user and also drive it to the cloud storage for outlook usage. Since the data recorded from the sensors are analyzed and need to be classified for predicting the rainfall percentage. As rainfall depends on various weather parameters, therefore in order to check whether the calculated value of the parameter is greater than the threshold value to predict the rainfall.

VII. Beneficiary of the System

- Our proposed ‘Smart weather monitoring system’ unlike conventional weather monitoring instruments is very small and compact allowing it to be installed easily on rooftops.
- It is light and portable; this advantage allows us to easily carry it to remote location for installation. Due to its design it can be easily be carried by a weather balloon to measure atmospheric changes at high altitudes.
- The power requirements for our system (sensors and boards) is much less compared to the existing instruments in the market hence enabling us to use solar cells as power supply. This not only cuts down on cost but allows us to leave the monitoring system in remote, areas where power is not easily available, for long periods of time. Addition of solar panels also helps our design be eco-friendly.
- The sensors used in our product are much cheaper compared to the ones that are used in the existing weather monitoring systems making our design more cost effective.
- These sensors send the data to a web page and the sensor data is plotted as graphical statistics. The data uploaded to the web page can easily be accessible from anywhere in the world. The data gathered in these web pages can also be used for future references unlike the existing system where data has to be physically transferred.

VIII. Conclusion

To implement this system we need to deploy the sensor devices in the environment for collecting the data and analysis. By deploying sensor devices in the environment it will record real time data. It can act together with other objects through the network. Then the composed data and analysis results will be obtainable to the end user through the Wi-Fi. The elegant way to watch environment and a capable, low cost embedded system is presented with diverse models in this paper. This system retrieves the data from the sensor and sends it to cloud for storage. This data is useful for the users for time to time update about the current weather. This model is further expanded to predict the rainfall percentage of that current area.

These data are plotted graphically and displayed in the web page for the users.

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