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IOT BASED WEATHER MONITORING SYSTEM

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Abstract

Weather forecasts are the process of predicting the conditions of the atmosphere at a particular location and time. For various industries such as agriculture, transportation and energy, accurate weather forecasts are essential to make informed decisions and minimize possible damage caused by weather-related events. Our projects are designed and developed to provide accurate forecasts. The objective of this model is to integrate several sensors. The proposed system combines a small-scale multi-sensor scheme (temperature, humidity, pressure and gas) with an open-source edge computing framework. The main objective of the project is to develop a weather forecast system using time series analysis and ARIMA algorithms. The system will use this algorithm to identify patterns in historical weather data and predict future weather conditions. The system uses historical weather data to forecast future weather conditions such as temperature, humidity, pressure and rainfall. Our project includes data collection, data preprocessing, modeling training and evaluation. The collected weather data will be processed in advance to eliminate deviations and missing values. The ARIMA algorithm is strained with preprocessed data and the performance of the system is evaluated using a metric such as the mean square error and root mean square error (RMSE). The final output of the systemic weather forecast for a particular location, date and time. We will be able to provide a reliable low-cost alternative to each sector we use. The proposed platform provides and visualizes information to user devices in a world-wide scenario in a complete-to-end manner.

Keywords: *Multi Sensor-Based, ARIMA, RMSE, Time Series Analysis.*

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1. Introduction

The Internet of Things is a place where all current articles interact with the Internet using the method of linking data exchange. The Internet of Things can be monitored remotely through the current association. IoT is a good and exceptionally wise development that reduces human efforts and provides basic permission to actual devices. Sensors and other ordinary things work with the Internet and the limits of extraordinary data search, guaranteeing that they will change how we work, live and play. The impact of the Internet of Things on the Internet of Things and the economy is fundamental as specific assessments show, the number of IoT devices will reach $100 billion by 2025 and the total wage will exceed $11 trillion. It combines almost everything you can think of from phones to construction maintenance and fly engines.

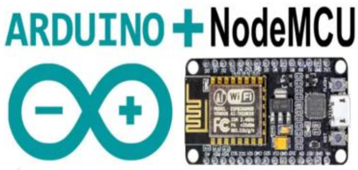
Weather forecasting is the use of science and technology to predict atmospheric conditions at a given place and time. Weather forecasting was carried out manually using changes in barometric pressure, current weather conditions, the conditions of the sky or cloud cover. Weather forecasting is now based on computer models that take into account many atmospheric factors. Thus, weather-related location data can also be used for real-time traffic updates. The paper is aimed at implementing a system that functions mainly as a source of weather data and real-time data, and is integrated with web applications and devices that are integrated with Arduino, different sensors and GSM modules that are integrated in the website. Data are continuous quantitative data that are analysed to show perfect correlation for accurate prediction using machine learning algorithms.

2. Designing of System and Proposed Methodology

The main device required is Arduino, which is structured in a physical-programmable circuit board format, and has a software that executes IDE on computers to write and burn code physical devices. The computer code interacts with the board and follows instructions. We are implementing a new system to continuously monitor environmental parameters for weather forecasting. The system consists of a microcontroller with temperature, humidity, gas and air pressure sensors. The temperature and humidity levels of the environment are detected by the temperature sensor and humidity sensor. The gas sensor monitors the gas level and the air pressure sensor monitors the air pressure. These data are updated in IOT. If these sensors detect values that exceed the threshold value, then the microcontroller updates the weather conditions of the IOT website's rainfall condition.

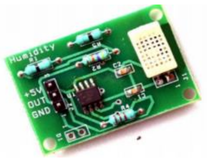
Hardware Description

The ESP32 is a series of low-cost and low-power chipset microcontrollers with integrated Wi-Fi, and its advantages include integrated RF components such as power amplifiers, low-noise receiver amplifiers, antenna switches, filters and RF baluns. This makes it very easy to design hardware around ESP32, since you need every few external components.

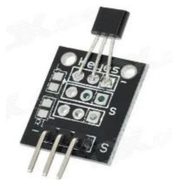


Monitoring the emission of gases is very important. From home appliances such as air conditioners to electric fireplaces and safety systems, it is very important for the industry to monitor gases. Gas sensors react spontaneously to the gas present to keep the system up-to-date about any changes. The MQ-8 gas sensor is highly sensitive to hydrogen gas and has anti-interference with gas. The envelope MQ-8 has six pins, four of which are used to take signals and the other two to provide thermal current. The MQ-8 gas module is mounted on a PCB board with a 5V DC operating voltage. The output values of the sensor can be obtained in both analog and digital form.

A humidity sensor senses and measures humidity and air temperature. Humidity can be measured using the electronic hygrometers. Resistance -type humidity sensor detects changes in the sensor element resistance values when changing humidity.



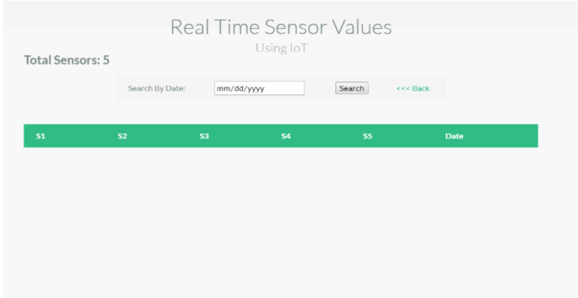
The LM35 series is a precision integrated circuit temperature device that produces a linear output voltage proportional to the centigrade temperature. The LM35 device is more advantageous than linear temperature sensors. The low output impedance, linear output and precise inherent calibration of the LM35 make interfaces with reading or control circuits particularly easy. Since the LM35 device draws only 60A. From the supply, the self-heating of the device is low as 0.1°C in still air. The LM35 device is rated to operate over a −55°C to 150°C temperature range.



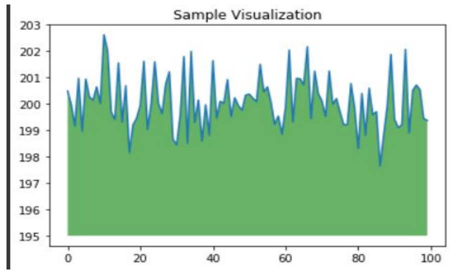
Digital flow sensor units are ideal for air flow systems. The sensor is robustly constructed and provides a digital pulse every time airflow through the pipe. The output can be easily connected to the measuring microcontroller and displayed on the LCD board.

Software Description

Espresso's ESP32EX provides a highly integrated Wi-Fi SoC solution that meets the needs of users in the Internet of Things industry for efficient power consumption, compact design and reliable performance. The ESP32EX has complete and self-contained Wi-Fi networking capabilities including antenna switches, radio baluns, power amplifiers, low-noise reception amplifiers, filters and power management modules. The compact design reduces the size of the PCB and requires a minimum of external circuitry.

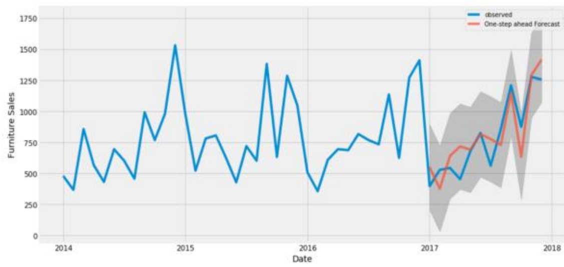


Google Colaboratory can use all of the power of popular Python libraries to analyze and visualize data. The code cell generates random data using NumPy and data visualization using matplotlib. With Colab, you can import image datasets, train image classifiers on them and evaluate models in a few lines of code. Colab laptops run code on Google's cloud servers, meaning you can use Google hardware, including GPUs and TPUs, regardless of your machine power. All you need is a browser.



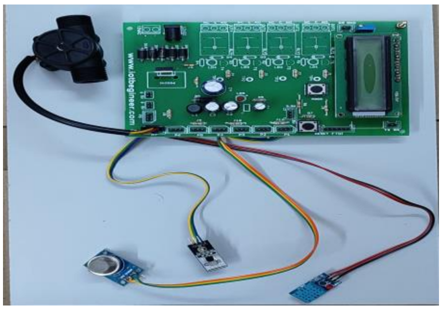
ML Algorithm

We use a machine learning algorithm called Time Series Forecasting using ARIMA (Auto Regressive Integrated Moving Average). It is a technique that uses historical and current data to predict future values for specific periods or points in the future. Analyzing the data, we have stored in the past can make informed decisions that can guide our business strategy and help us understand future trends.



The main advantage of extreme learning machines is that they require less training time than traditional learning machines. In addition to computational efficiency, ELM has shown that it is more advantageous in terms of efficiency and generalization performance.

Prototype



3. Time Series Forecasting (TSR)

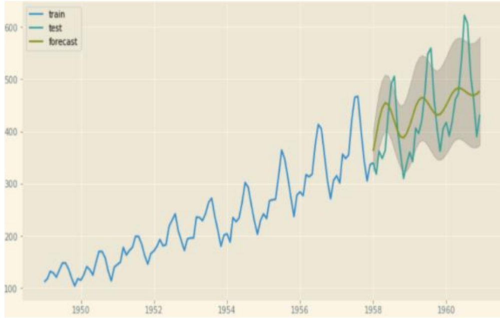
Time-series forecasting is a technology which uses historical and current data to predict future values over time or specific point in time. By analysing past data, we can make informed decisions that guide our business strategy and help us understand future trends. Machine learning techniques such as random forest, gradient-increasing regression and time delay neural networks can be used to extrapolate time series data, but are far from the only available or best choice. The most important property of time series algorithms is the ability to extrapolate patterns outside the field of training data, which is not possible by default for most machine learning technologies. This is where specialized time-series prediction techniques come in.

TSR V/S Other Prediction Algorithm

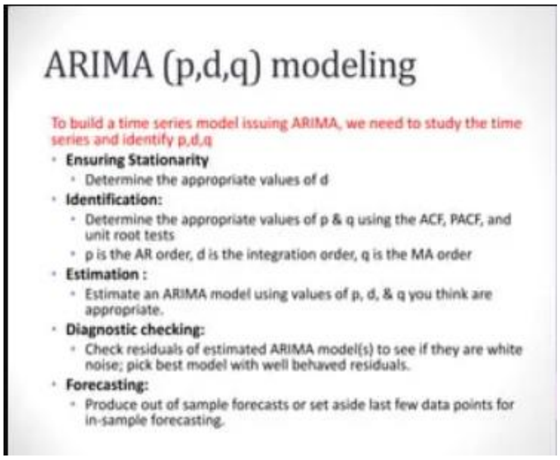
The choice of time series forecasts and other machine learning algorithms depends on the specific problem and data. The time series forecast model is usually successful in short-term predictions of a clear trending time series data. Other machine learning algorithms are more accurate for long-term predictions and more complex data patterns, but may require more data and computational resources.

Arima (Auto Regressive Integrated Moving Average)

Using ARIMA to map this set to identify any trends or pattern of data that can be used to predict future weather conditions. ARIMA models usually have three parameters: p, d, and q. The parameter p represents the order of the autoregressive component, which captures the dependency of the current value on the previous values of the time series. Parameter represents the difference order needed to keep the time series static, and parameter q represents the transition component order that captures the dependence of the current value of previous errors. d denotes the difference.

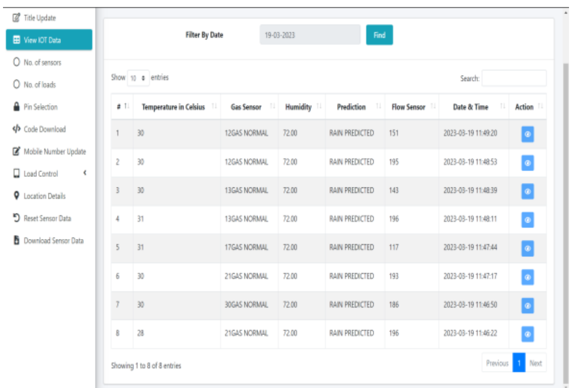


Once you have determined the optimal values of p, d, and q in your dataset, you can use the ARIMA model to predict future weather conditions. However, it should be noted that ARIMA is one of many weather forecasting methods and that accuracy depends on the quality, quantity and specific parameters used in models.



4. Output

Below attached image is the readings taken by the sensor and stored in a database in the cloud whenever the kit is switched on. These values are displayed on a website.



#	Temperature in Celsius	Gas Sensor	Humidity	Prediction	Flow Sensor	Date & Time	Action
1	30	12GAS NORMAL	72.00	RAIN PREDICTED	151	2023-03-19 11:49:20	
2	30	12GAS NORMAL	72.00	RAIN PREDICTED	195	2023-03-19 11:48:53	
3	30	13GAS NORMAL	72.00	RAIN PREDICTED	143	2023-03-19 11:48:39	
4	31	13GAS NORMAL	72.00	RAIN PREDICTED	196	2023-03-19 11:48:11	
5	31	17GAS NORMAL	72.00	RAIN PREDICTED	117	2023-03-19 11:47:44	
6	30	21GAS NORMAL	72.00	RAIN PREDICTED	193	2023-03-19 11:47:17	
7	30	30GAS NORMAL	72.00	RAIN PREDICTED	186	2023-03-19 11:46:50	
8	28	21GAS NORMAL	72.00	RAIN PREDICTED	196	2023-03-19 11:46:22	

The below csv file is obtained from the same website in the downloaded format. Under the prediction column, we received "RAIN PREDICTED". It appears due to the parameters like temperature and humidity exceeding the threshold value.

Temperature in Celsius	Gas Sensor	Humidity	Prediction	Flow Sens	Date
28	21GAS NORMAL	72	RAIN PREDICTED	196	2023-03-19 11:46
30	30GAS NORMAL	72	RAIN PREDICTED	186	2023-03-19 11:46
30	21GAS NORMAL	72	RAIN PREDICTED	193	2023-03-19 11:47
31	17GAS NORMAL	72	RAIN PREDICTED	117	2023-03-19 11:47
31	13GAS NORMAL	72	RAIN PREDICTED	196	2023-03-19 11:48
30	13GAS NORMAL	72	RAIN PREDICTED	143	2023-03-19 11:48
30	12GAS NORMAL	72	RAIN PREDICTED	195	2023-03-19 11:48
30	12GAS NORMAL	72	RAIN PREDICTED	151	2023-03-19 11:49

Once these values are downloaded in the form of a csv file, it is attached to the machine learning code in the Google Colaboratory and the prediction of temperature and humidity is obtained for the next 7 days.

```
Temperature forecast for the next 7 days:
69    28.563525
70    28.316679
71    29.073597
72    28.815539
73    29.445335
74    29.210993
75    29.715650
Humidity forecast for the next 7 days:
69    19.905754
70    19.768371
71    19.807924
72    19.796537
73    19.799815
74    19.798871
75    19.799143
```

5. Conclusion

As a result, we can predict the temperature, humidity and weather conditions for the next 7 days using the ARIMA model in Time Series Forecasting.

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