Temperature Prediction using Fast Fourier Transform

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Abstract

This paper discusses the temperature computation and demonstrates an application of Fast Fourier Transformation (FFT) technique for temperature prediction. This temperature computation is based on the previous hourly temperature.

The temperature readings for the past month are collected using hardware designed using a temperature sensor. The dataset consists of 720 samples of the hourly temperature in Vellore.

The dataset is sent to a web server. The running python script applies an FFT algorithm and after processing the algorithm, the outcome is the prediction of the next hourly temperature.

INTRODUCTION

Weather temperature computation is a difficult task for researchers because it is a complex process. [7]. It encompasses knowledge from a variety of fields.

[5]. Weather generally refers to day-to-day temperature and precipitation activity, whereas climate is the term for the average atmospheric conditions over longer periods of time. Weather temperature computation is essential for today.

[1]. This weather temperature computation is useful in agriculture and production, energy industry planning, aviation industry planning, communication, and pollution dispersal, among other applications.

We don't know everything until tomorrow, so there's always hope for the future, even if it's unpredictable. [1]. Forecasting the aforementioned issues, according to some academics, is a very difficult task. They were forecasting the weather, the stock market, etc using some forecasting techniques.

[6]. This paper contributes to introducing a technique called FFT-Fast Fourier transform that calculates the weather temperature in the region of Vellore using a sample size of temperature collected over the past few months.

FAST FOURIER TRANSFORM

[2]. The official definition of the Fourier Transform states that it is a method that allows you to decompose functions depending on space or time into functions depending on frequency. [1]. Of course, because this is a rather technical concept, we'll 'decompose' it using a time series data example.

[4]. The Fast Fourier Transform is an algorithm that computes Discrete Fourier Transform and Inverse Discrete Fourier Transform. [6]. FFT can be used to forecast or model yearly rainfall and/or any natural time data because of its capacity to break down and reconstruct any natural time data series, as well as determine the presence of significant signals from observed long-term data series.

[6]. Other typical Fourier Transform uses include sound or music data, as well as signal processing. The Fourier Transform is beneficial to any domain that works with wave-like data.

DISCRETE FOURIER TRANSFORM

[3]. The discrete Fourier transform (DFT) is a complex-valued function of frequency that turns a finite sequence of equally-spaced samples of a function into a same-length sequence of equally-spaced samples of the discrete-time Fourier transform (DTFT).

[1]. Let $x_{0},\ldots,x_{N-1}$ be complex numbers. The DFT is defined as:

$$X_k = \sum_{n=0}^{N-1} x_n e^{-i2\pi kn/N} \qquad k = 0, \ldots, N-1,$$

Where $e^{i2pi/N}$ is a primitive Nth root of 1.

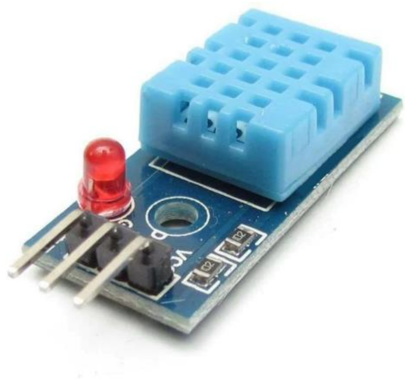
METHODOLOGY

Flow chart of the project:

To get the data to start the forecasting and also validate the predicted temperature, we built the hardware using a DHT11 module and ESP8266 module to measure the temperature and relay the information to the web server in Google Firebase.

We have collected the temperature measurement from the Arduino which is sent to the script running.

Pictures of the components:

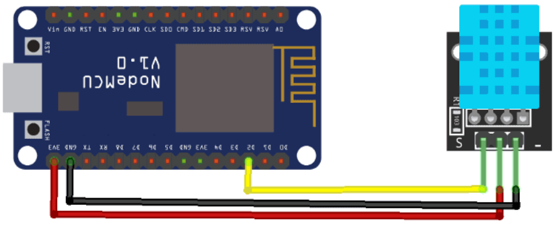


DHT11

The DHT11 is a basic digital temperature and humidity sensor. It measures the ambient air with a capacitive humidity sensor and a thermistor and outputs a digital signal on the data pin.
This sensor uses a Negative Temperature Coefficient Thermistor to measure temperature, which causes the resistance value to drop as the temperature rises.

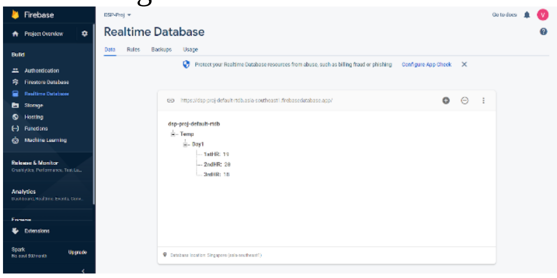
ESP8266 microcontroller

It is a low-cost WiFi module and uses a Tensilica L106 32-bit RISC processor.



Circuit Diagram

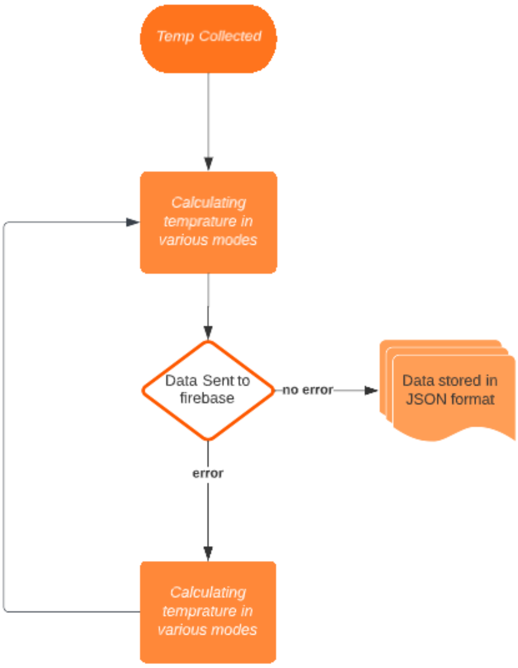
We also have created the firebase server for the Json File input from ESP8266 and we have designed the python script to test the FFT algorithm.



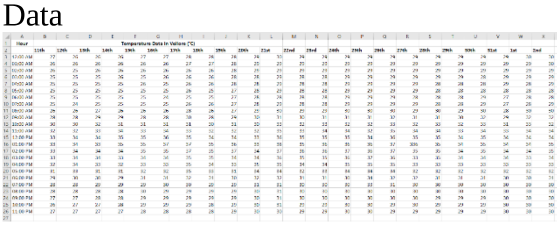
Example of the Database

The script is written and tested with taking help with [1].

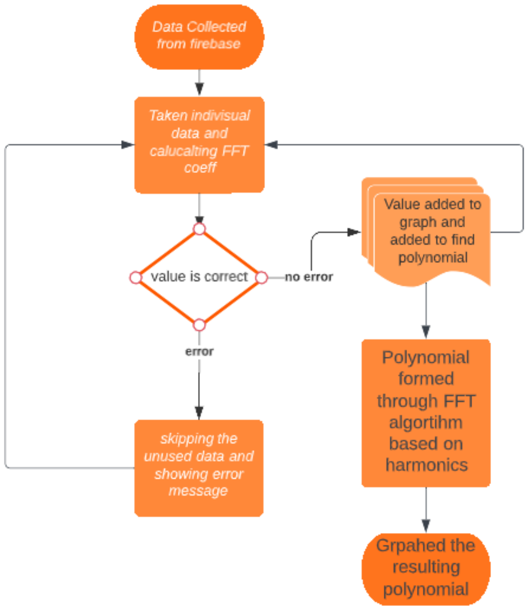
Code to the Node MCU board:



Data

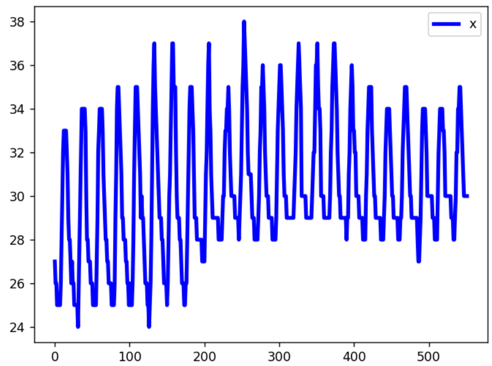


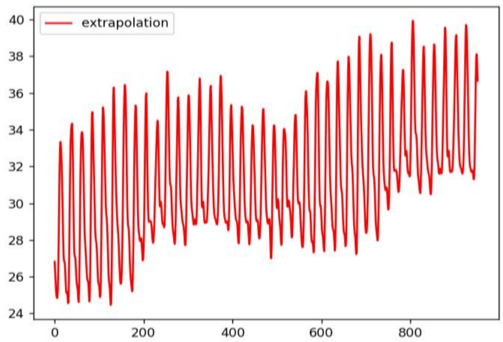
FFT script code:



RESULTS AND DISCUSSION

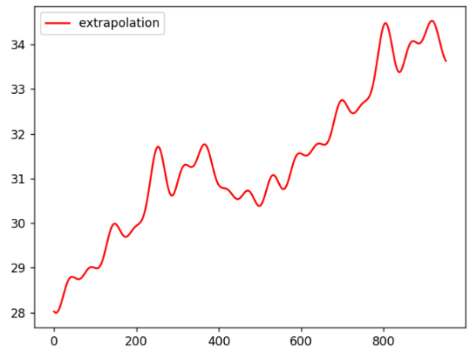
Input to the FFT algorithm





Predicted outcome by the algorithm

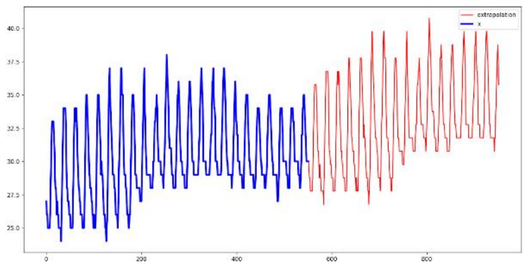
We can also vary the harmonics in the FFT which changes the number of sinusoidal components in the final equation. This then also shows the trends in the graphs



This with Harmonics = 10 and this can see the average temperature and trend increasing over time as we reach summer and with a big enough data set it will become more and more precise

In these graphs we notice that the FFT can replicate and predict the curve of any graph after interpolation but it isn't very accurate as the sharpness of the peak is dependent on the harmonics and in general can’t be used for pseudo random processes to predict.

Final Graph with input and output



Harmonics=500; prediction no. = 400

CONCLUSION

Temperature is a very sensitive data set to collect and predict as it not just varies on the time of the day but multiple hidden and important variables like humidity, location, and air currents.

Our prediction algorithm was meant to understand the basics of interpolation and understanding the relationship and dependencies of temperature and time of day. The trends we see through our graphs like peaks during midday and the peaks slowly rising and average temperature rising just goes to show that even with just knowing the temperature the prediction follows rational logic.

The variables our algorithm depends on in terms of accuracy are the number of harmonics, number of predicted outcomes and the size of the dataset fed to it.

We learnt how the Fourier Transform works and how to use it to predict temperature in time series in this post. This is an application where we utilized Fourier Transform to determine hourly temperature data.

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J. Christopher Clement is with the school of Electronics Engineering as an Associate Professor. He has been teaching the courses in Electronics and Communication Engineering for the past 16 years. He has received a seed grant project to carry out research on smart communications for smart grid using cognitive radio technologies. He has published his research articles in various journals of publishers including IEEE, Springer and Elsevier. His research interest includes signal processing, machine learning, wireless communication and cognitive radio communications.

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