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Exploration of Climate Data and Temperature Forecasting using Machine Learning

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Exploration of Climate Data and Temperature Forecasting using Machine Learning

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Abstract: In this short communication, a concept has been presented to model geographical data to predict future temperature of Tabuk, region. Machine learning has been applied to the weather station data to develop a prediction model. The preliminary results are promising and encouraging and are envisaging to further this research towards the determination of unknown temperature rise in the region. This is important to mention here, that the problem has been formulated as a Regression problem, NOT as a classification problem. Hence, applying Convolutional neural networks is not possible, due to the non-existence of classes or converting the temperature values to classes does not make any sense. Hence, this is defined as a regression problem which achieved encouraging desirable results.

Keywords: machine learning; geographical data; temperature prediction

1. Introduction

Machine learning is widely used as a tool to predict or estimate unknown values or conditional attributes for an environment given the historical data. This technique has widely used in different technologies e.g. computer vision, robotics, signal processing, biomedical, aerospace and their associated frameworks [1,3,4,6,8,11,12]. Many researchers have used machine learning techniques to predict the future temperature values [2,5,7,9,10].

2. Data Collection and Data Patterns

Meteorological data uploaded here covers 31 years of meteorological information obtained from the Tabuk weather radar station (ID 40375), located at 28° 36′ N, 36° 63′E. The data includes Daily Maximum Temperature (Tmax), Minimum Temperature (Tmin), Temperature (mean), Rainfall (RF), Wind Speed (WS), Relative Humidity (RH), Pressure (Press), and Vapor (V), at the station level.

The data was plotted and is shown in the Figure 1. This can be observed in the data that it follows a sinusoidal wave pattern as shown in Figure 1. Moreover, the Fast fourier transformation (FFT) was applied on the data features and a very similar pattern can be seen as shown in Figure 2. To this end, a more subtle verification method was applied using Seaborn Python's builtin in utility Pair-plot as shown in the Figure 3. Having said that we prepared the data of these four feature sets available from the Tabouk weather station. The idea was to train the temperature values using different machine learning methods, e.g. Decision Trees (DT), K-Nearest neighbours (KNN), Support Vector Machines (SVMs) and other Deep Learning methods like Multi-Linear Perceptron (MLP) or Artificial Neural Network (ANN). The intent of this exercise is to realise that whether the features also vary w.r.t the temperature values and also whether their is a similar pattern which exists among the individual features, too.

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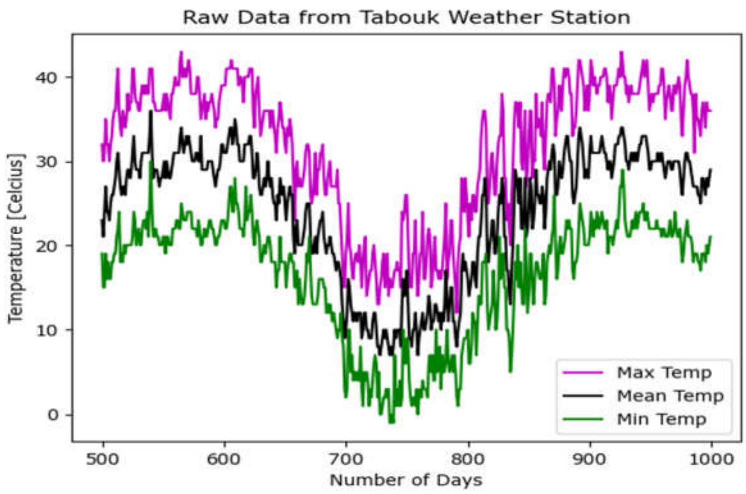

Figure 1. Five hundred days temperature data points. This can be seen that the data follows sinusoidal curve i.e. a sine wave pattern.

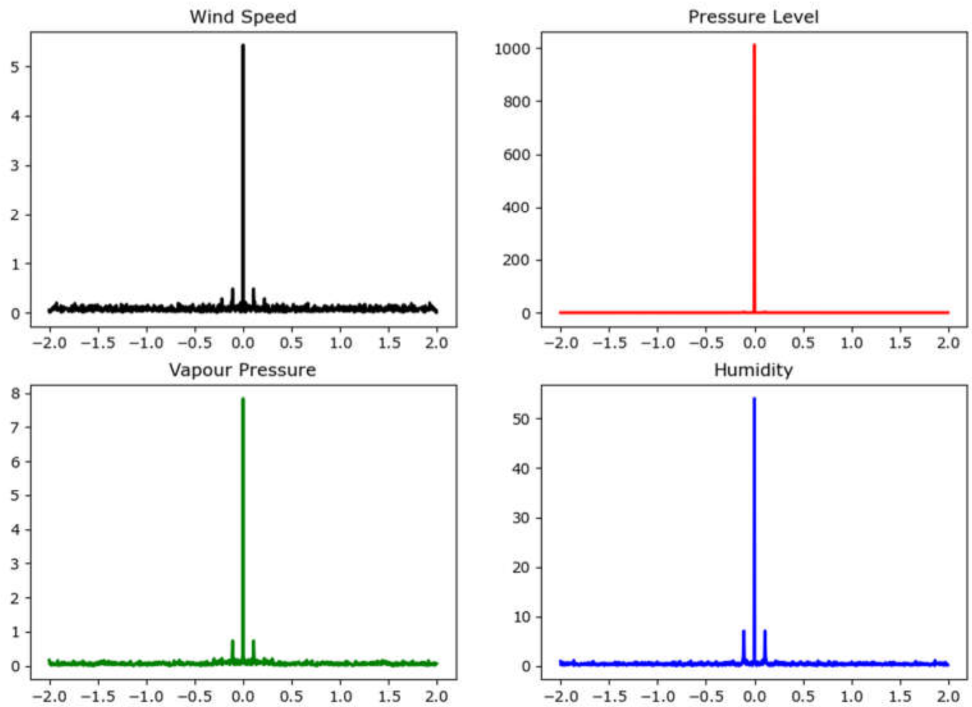

Figure 2. Fast Fourier transformation (FFT) was applied to individual features of the data.

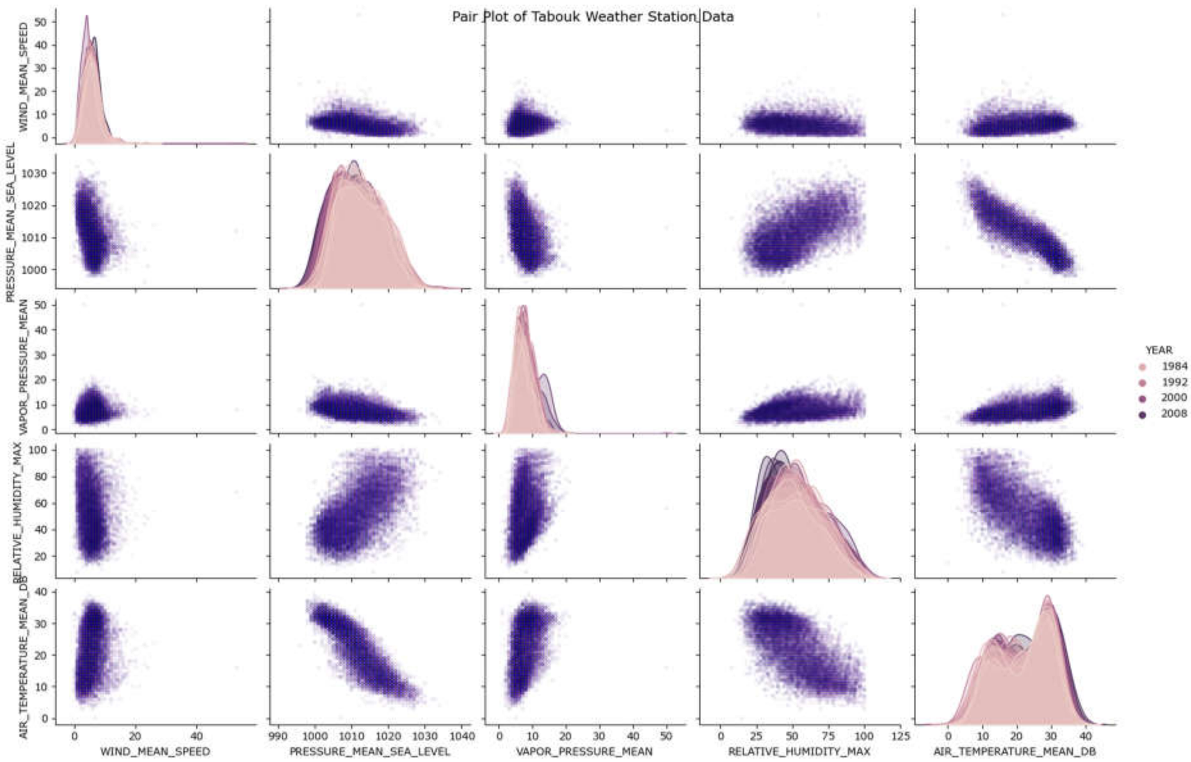

Figure 3. Pair plot of the major features of the temperature data set. The relative kernel density estimation (KDE) was used to find the inter-relation between the features.

In order to verify all these hypothesis we developed different machine learning models, explained in more details in the results section.

3. Results

The results are presented after building various machine learning models using different algorithmic techniques, e.g. DT, KNN, SVM and multi-layer perceptron (MLP) which treated the data as a regression problem. The results show that SVM as a regression technique (SVR) for this dataset did not perform well as can be seen in the Figure 4a. The error was chosen as negative mean squared error, hence it can be seen in Figure 4b that together with the stacking algorithm, all the rest of them were within the bounds of -2 to -2.4. Means, the stacking algorithm can be used to predict the future temperature values of Tabuk region.

A need for Climate and Geographical data specific novel machine learning algorithms and human machine interaction systems

These results pose a challenge that there is a need for the development of temperature values specific and their features specific machine learning algorithms. Although, one algorithm on this dataset performed better but what happens when the feature set increases. Classical machine learning algorithms assign weights in a linear way, there is a need for an algorithm which learns the weights and not just simply adds or subtracts them but assign some intelligent weighting system on the features. One of the theories in Psychological sciences has a potential to do this job of assigning weights with reorganizational capabilities, called as Perceptual control theory (PCT) [13–19]. There is an effort undergoing to develop machine learning systems similar to human control systems and we hope one day better machine learning systems based on perceptual models will be created which will be more accurate and light in memory.

Moreover, with the geographical and climate data being collectable from synthetic aperture radars (SAR) and satellites. There is definitely a need for designing better human machine learnable interfaces. These digital interfaces can help climate and geographical sciences researchers to manipulate and process their data more conveniently [20–29]. With the advent of virtual reality and

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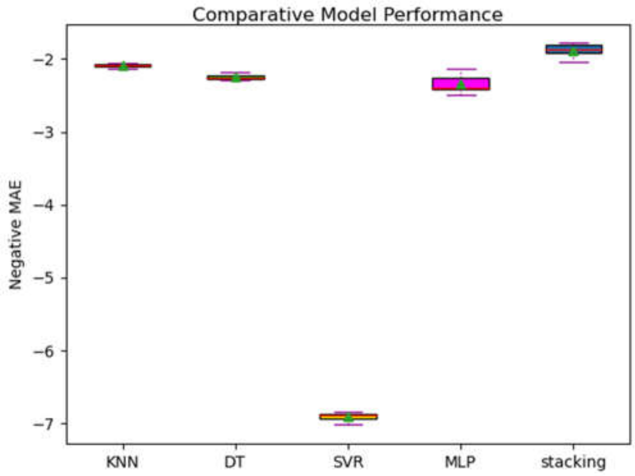
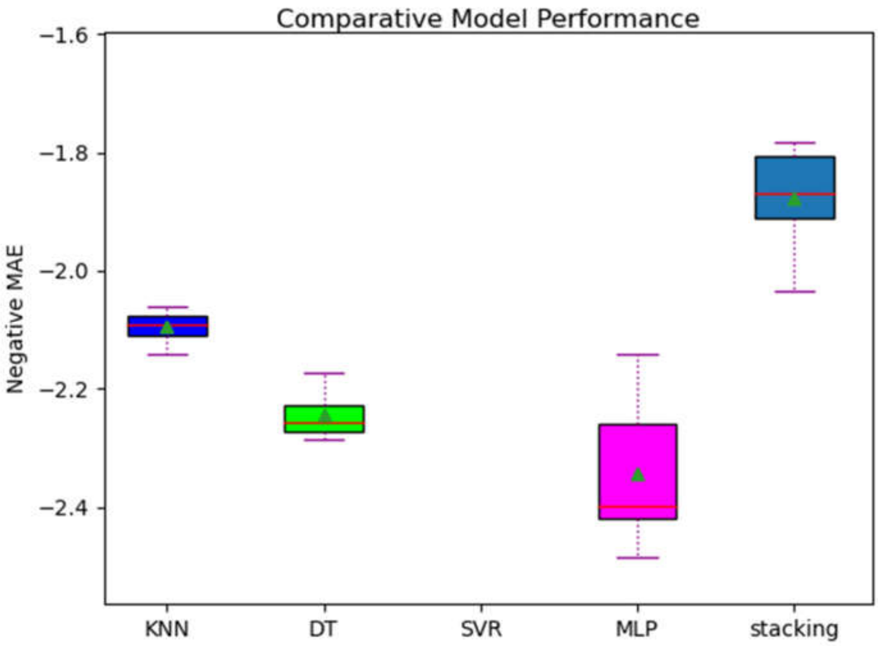
augmented reality this would be useful along with machine learning interfaces to facilitate climate sciences researchers.



(a)



(b)

Figure 4. The results of the dataset. (a) All machine learning algorithms were trained and tested on the real time data. The negative mean squared error was calculated for all the algorithms. (b) A more detailed analysis can be seen, after zooming on the significant boxplots without SVR.

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