**ACSE-5 ASSIGNMENT 1 REPORT BY HEATHROW GROUP**

1. **Group members**

Tayfun Karaderi Yusuf Falola

2.0 **Overview**

This study is geared towards numerical prediction of temperature in January 2020, 2030 and 2050 for **Heathrow**, London. We ensured at least 50 data points were used for each parameter in this study. The **average temperature**, that is, the average value of minimum and maximum temperature, was considered. Variables considered to predict temperature include; year, CO2 emission, sunspot number, and population growth. Method of linear regression was adopted in this analysis. We created a single variable regression model for the temperature and year, then a multivariable regression model for temperature and year, CO2 emission, sunspot number and population growth. It was observed that the multivariable model overfitted the data and its temperature predictions blew up for long term predictions.

1. **Numerical method description**

Linear models were used to establish relationships between the attributes (years, CO2 emission, sunspot number, and population growth), and the response (temperature). The first model was a linear relationship between the attribute (years), and response (temperature). The L2 norm was considered. Differentiating the L2 norm partially with respect to each of the two model parameters and equating it to zero (minimising the L2 norm error), one can arrive at a matrix equation to find the optimal model parameters. The errors of the forecasted temperatures were estimated by calculating the standard error of the fitting, which is a reasonable estimate for short term predictions. The shortfall of this method is that the underlying model does not fit the data perfectly and the actual errors will grow over time. Fitting a quadratic model didn’t do any much better (e.g. it was observed that standard error for fitting quadratic polynomial was usually very similar to that of first order polynomial), hence the first order polynomial model was adopted to avoid vastly overfitting the data. The second model was a multivariable regression model, incorporating other variables influencing temperature; population growth (Mullan & Haqq-Misrah, 2018), sunspot number (Reddy & Reddy, 2015), atmospheric CO2 concentration (John, 2011). This model performed much different compared to the previous model, but predictions blew up for long term predictions. Each variable in the model was raised to the power of 0.1 to reduce the blow-up rate. Also, the standard error was not propagated as an estimate of prediction error since the model was clearly a vastly overfit (see Plot\_of\_Temperature\_Predictions.pdf). Overall, the single variable regression model seems to predict the distant future temperatures better.

1. **Code structure and execution**

The code has a main function and two other functions, one to read the temperature data and the other to read the data containing other parameters affecting temperature. The model parameters are determined in the main function. The temperature data were split into different months to determine model parameters for each month to be used in calculating the temperature prediction for the user specified year and month. The same procedure was repeated for the multivariable model also, however, this time temperature values for years 1948-1961 were excluded since we could not find the population of Heathrow before 1961.

The code makes use of the Jama library for handling linear algebra operations and for this purpose, our GitHub page should be cloned. The user should open the Temperature\_Forecast.vcxproj file. It is assumed the user has MSVC 2017 installed. Then folder directory should be included by right clicking on Temperature\_Forecast.vcxproj >> properties >> C/C++ >> General >> Additional Include Directories. Once the program is run, the user would be prompted to enter the year for which he/she wants the temperature to be predicted, then the month of prediction, (1 for January and 12 for December and so on). The temperature prediction for the two models used would show up for the specified month and year. This result would also be automatically saved in the prediction.txt file.

1. **References**

* Mullan, B & Haqq-misrah, J. 2018. Population Growth, Energy Use, and the Implications for the Search for Extraterrestrial Intelligence. Futures, pp. 1-14.
* John, R. 2011. Cumulative Carbon Emissions and Climate Change. The Oxford Institute for Energy Studies.
* Reddy, V & Reddy, P. 2016. Impact Due to Sunspot Activity on Climate Change: Some Salient Results. Int'l Journal of Earth Sciences and Engineering. 09(01).