Air Quality Prediction Using Artificial Neural Networks

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Introduction

- Predicting air quality is a complex task due to the dynamic nature, volatility, and high variability in time and space of pollutants and particulates
- Air quality index (AQI) is an indicator created to report air quality, measuring how clean or unhealthy the air is and what associated health effects might be a concern, especially for risk groups.
- Air quality is being monitored for about two decades. This has allowed a better understanding of the changes in air pollution in response to particular activities and government regulations

Objective

- To train an ANN (Artificial Neural Network) model for prediction of AQI of a place.
- Defining the required harware configuration for the same in the industry.

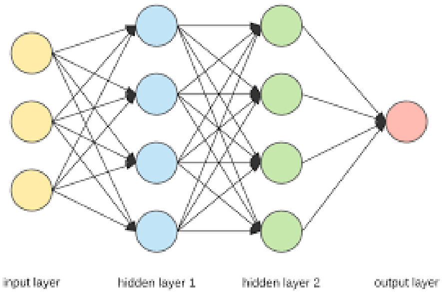

Figure 2: Artificial Neural Network

www.ieee/deepsurveysignlanguage.com

Experimental setup

Dataset: **MISCA**(Self Made)

- Dataset contains the data of **8** Features which are Average Temperature, Max Temprature, Min Temprature, Atmospheric Pressure, Humidity, Wind Speed, Wind Direction and Average wind speed.
- **Input Layer** have **128 units** ,**3 Hidden Layer** with **256** units each and **Output Layer** layer having **1 units**.
- The **3 Densely connected layers** performing computation and push the output forward with activation function set as 'ReLU' for all the layers..
- Output layer contains **1 neuron**, and is wrapped with 'linear' activstion function.

Model Function

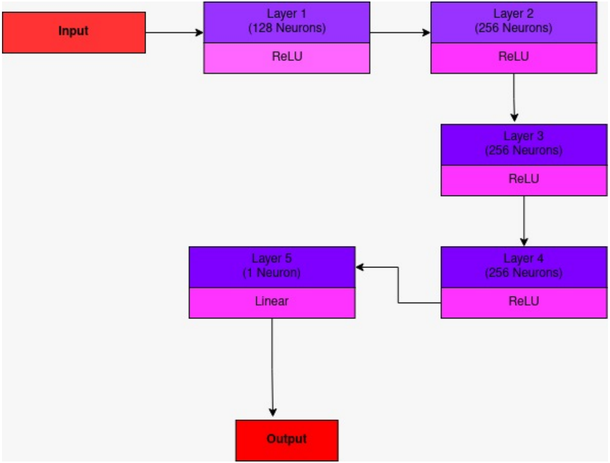

Figure 3: Technical Flowchart

Experimental Setup

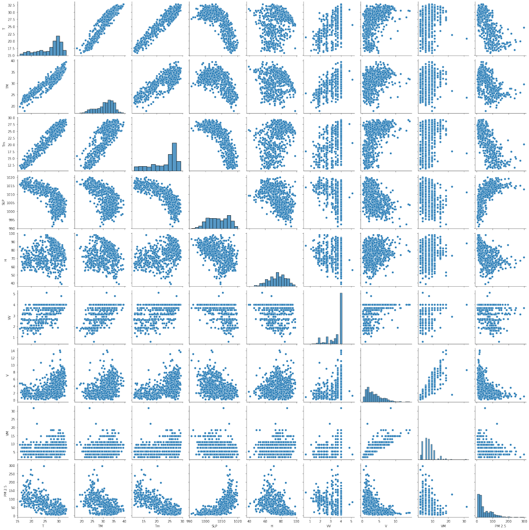

Figure 4: Pairplot of features

Experimental Setup

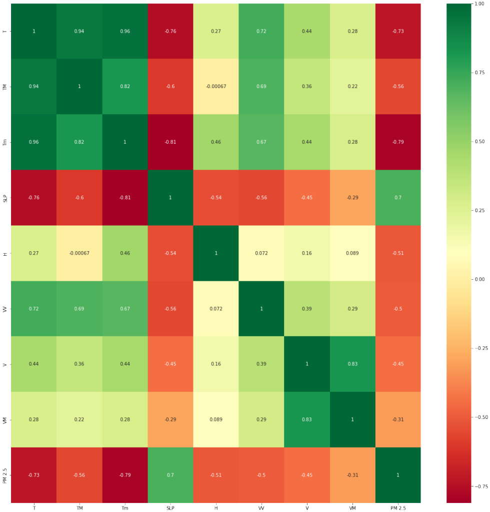

Figure 5: Coorelation Heatmap

Source :https://towardsdatascience.com/colah/lstm/github.com

Experimental Setup

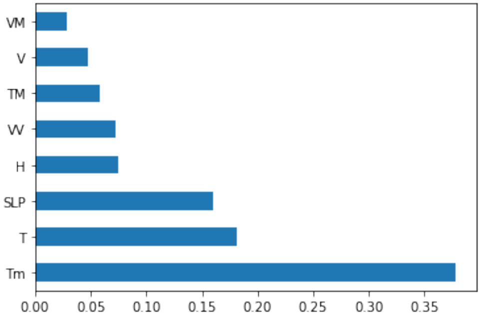

Figure 6: Graph of feature importances

Experimental result

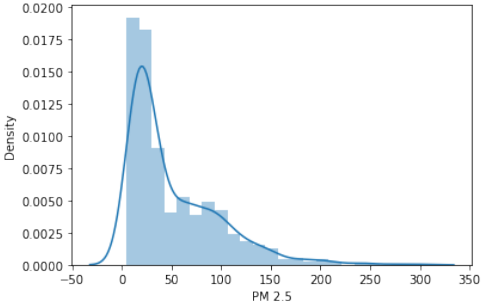

Figure 7: Distribution of Output Feature (PM2.5)

Experimental result

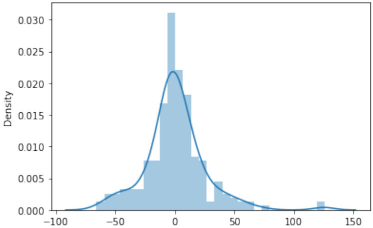

Figure 8: Distribution of Error

```
In [35]: from sklearn import metrics
         print('MAE:', metrics.mean_absolute_error(y_test, prediction))
         print('MSE:', metrics.mean_squared_error(y_test, prediction))
         print('RMSE:', np.sqrt(metrics.mean_squared_error(y_test, prediction)))

MAE: 17.256978376003808
MSE: 652.3202964224939
RMSE: 25.540561787527185
```

Figure 9: Model Evalution Results

Experimental result

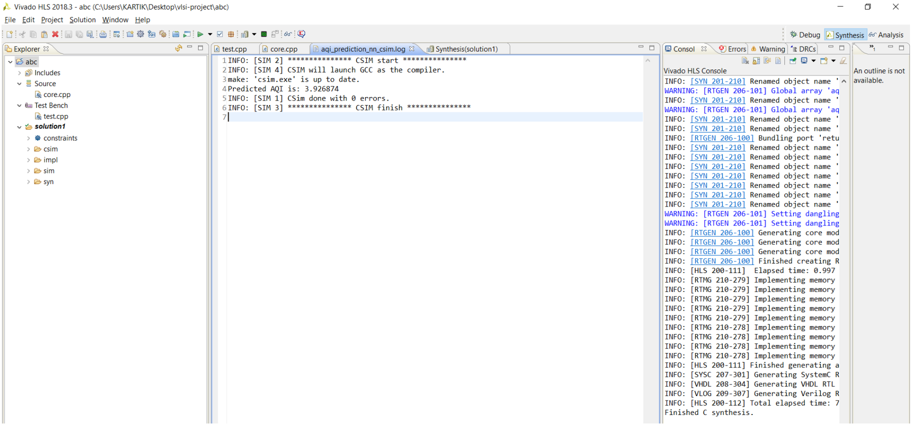

Figure 10: Output in Vivado HLS

Perfromance Estimates

- Timings

Clock	Target	Estimated	Uncertainty
ap_clk	10.00	7.796	1.25

Table 1

- Latency

Latency		Interval		Type
min	max	min	max	
2160157	2160157	2160157	2160157	none

Table 2

Utilisation Estimates

Name	BRAM_18K	DSP48E	FF	LUT
DSP	-	-	-	-
Expression	-	-	0	546
FIFO	-	-	-	-
Instance	4	15	1709	3638
Memory	1285	-	0	0
Multiplexer	-	-	-	590
Register	-	-	558	-
Total	1289	15	2267	4774
Available	40	40	16000	8000
Utilization (%)	3222	37	14	59

Table 3

Interface

RTL Ports	Dir	Bits	Protocol	Source Object	C Type
s_axi_CRTL_BUS_AWVALID	in	1	s_axi	CRTL_BUS	scalar
s_axi_CRTL_BUS_AWREADY	out	1	s_axi	CRTL_BUS	scalar
s_axi_CRTL_BUS_AWADDR	in	5	s_axi	CRTL_BUS	scalar
s_axi_CRTL_BUS_WVALID	in	1	s_axi	CRTL_BUS	scalar
s_axi_CRTL_BUS_WREADY	out	1	s_axi	CRTL_BUS	scalar
s_axi_CRTL_BUS_WDATA	in	32	s_axi	CRTL_BUS	scalar
s_axi_CRTL_BUS_WSTRB	in	4	s_axi	CRTL_BUS	scalar
s_axi_CRTL_BUS_ARVALID	in	1	s_axi	CRTL_BUS	scalar
s_axi_CRTL_BUS_ARREADY	out	1	s_axi	CRTL_BUS	scalar
s_axi_CRTL_BUS_ARADDR	in	5	s_axi	CRTL_BUS	scalar
s_axi_CRTL_BUS_RVALID	out	1	s_axi	CRTL_BUS	scalar
s_axi_CRTL_BUS_RREADY	in	1	s_axi	CRTL_BUS	scalar
s_axi_CRTL_BUS_RDATA	out	32	s_axi	CRTL_BUS	scalar
s_axi_CRTL_BUS_RRESP	out	2	s_axi	CRTL_BUS	scalar
s_axi_CRTL_BUS_BVALID	out	1	s_axi	CRTL_BUS	scalar
s_axi_CRTL_BUS_BREADY	in	1	s_axi	CRTL_BUS	scalar
s_axi_CRTL_BUS_BRESP	out	2	s_axi	CRTL_BUS	scalar
ap_clk	in	1	ap_ctrl_hs	aqi_prediction_nn	return value
ap_rst_n	in	1	ap_ctrl_hs	aqi_prediction_nn	return value
interrupt	out	1	ap_ctrl_hs	aqi_prediction_nn	return value
X_Addr_A	out	32	bram	X	array
X_EN_A	out	1	bram	X	array
X_WEN_A	out	4	bram	X	array
X_Din_A	out	32	bram	X	array
X_Dout_A	in	32	bram	X	array
X_Clk_A	out	1	bram	X	array
X_Rst_A	out	1	bram	X	array

Table 4

Experimental conclusion

Following are the conclusions drawn from the experiments:

1) From making of the dataset to training and testing in real time , the model have performed reasonably well.

2) We have also defined for the necessary hardware configurations, its utilisation and the interface it provides.

Thank You