MULTI-LAYER PERCEPTRON NEURAL NETWORK MODEL FOR PREDICTING GROUND-LEVEL OZONE CONCENTRATION IN MALAYSIA

By

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INTRODUCTION

- O_3 is a secondary pollutant and not emitted directly to the air.
- O_3 is a molecule made of three oxygen atoms (Vallero, 2014)
- The key precursors for the formation of ozone in the troposphere are from chemical reaction between volatile organic compounds (VOCs) and oxides of nitrogen (NOx) with the presence of sunlight. The major sources for VOCs and NOx emission are from motor vehicle emission and industries emission (DoE, 2014).
- Meteorology condition also have major impact on the formation of O_3 concentration especially on hot and sunny days (Vallero, 2014).

- The number of unhealthy days is increasing every year, the annual average O_3 concentration is slightly increased every year from 2000-2014 and sometime the daily maximum 1-hour O_3 concentration exceeded the Malaysian Ambient Air Quality Guidelines at several air monitoring stations (DoE, 2014). O_3 is a second important air pollutant that influenced the air pollution index.
- The effect of high ozone concentration especially on human health can cause health respiratory such as damage the lung function (Vallero, 2014) and on vegetation can be harmful to the plant yield (Fuhrer et al., 1997).
- The development of effective prediction models of O_3 concentration is important.

OBJECTIVES

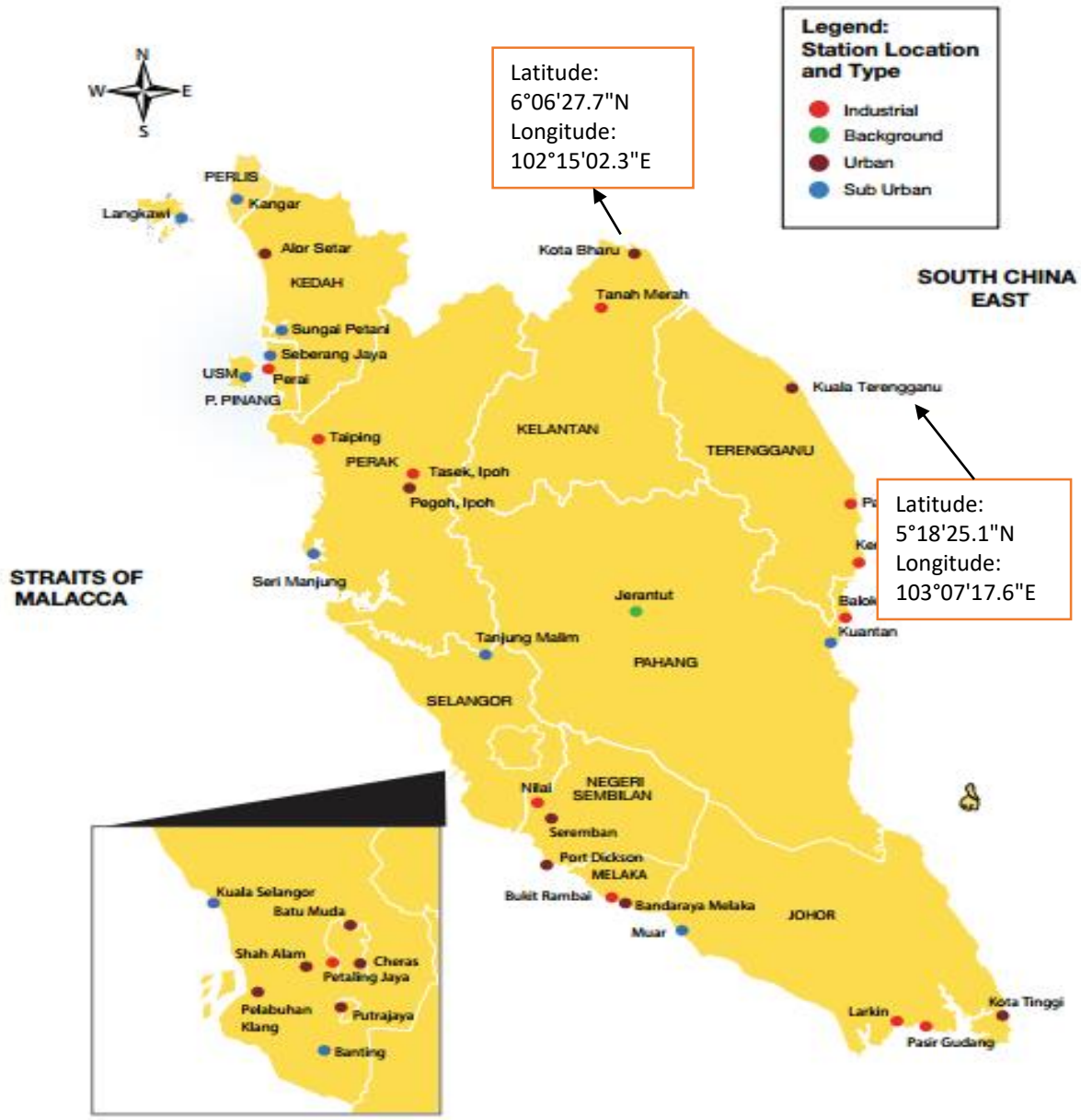
1) To predict ground-level O_3 concentration using multi-layer perceptron neural network model

2) To identify the most important precursor that influenced the O_3 concentration

Scope of study

- This study will focus on prediction of ground level ozone with the ozone's precursors (NO, NO_2, CO, SO_2) and meteorological parameters (AT, RH, WS) for the period of 2009-2012.
- The selected sites are Kuala Terengganu and Kota Bharu which represent for urban areas.
- The model was established by using MATLAB R2014a.

AIR MONITORING STATIONS

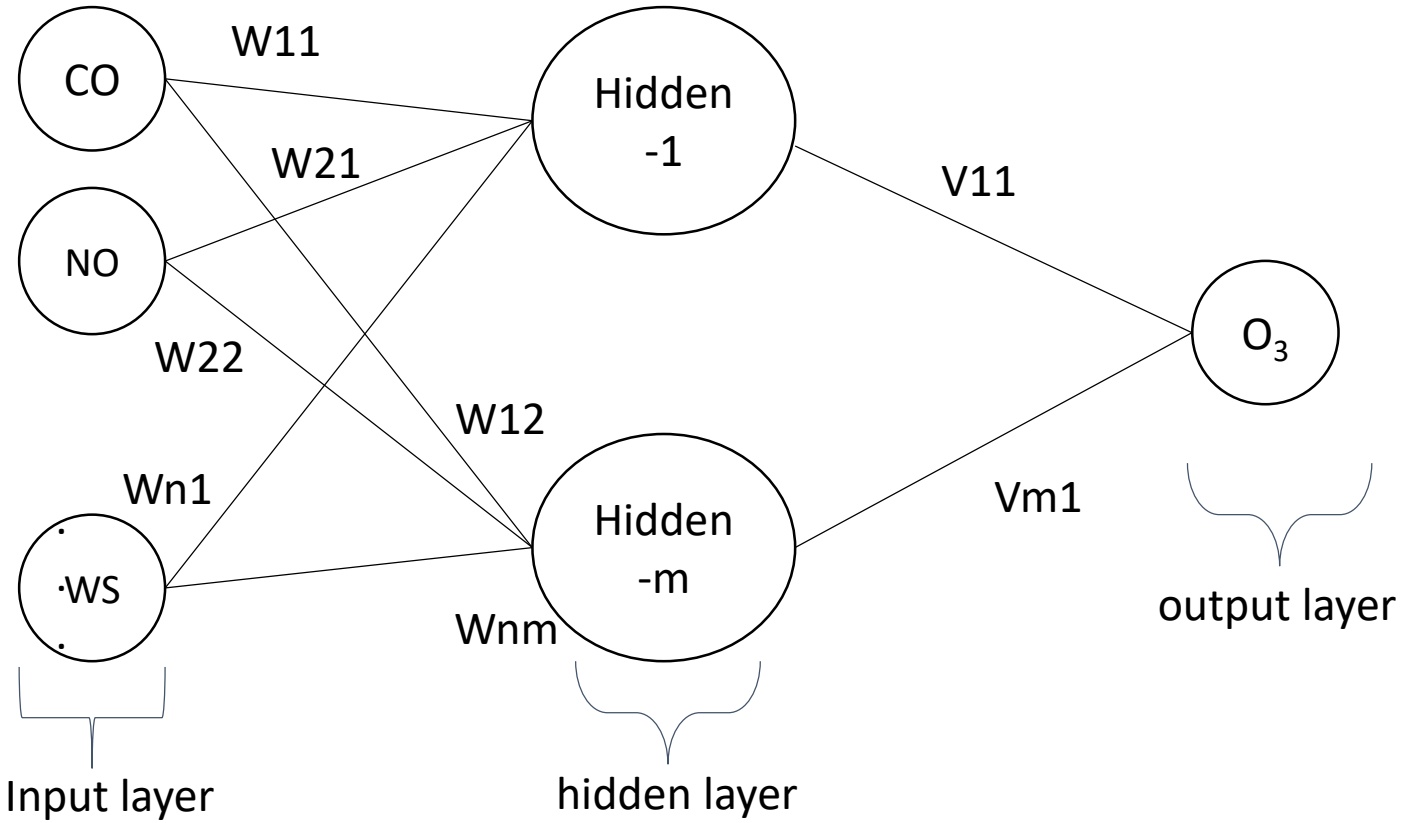


RESEARCH METHODOLOGY

Applied training LM algorithm

Sigmoid transfer function

Linear transfer function



V-output weight

W-hidden weight

Figure 1: MLP-ANN structure

PERFORMANCE INDICATORS

Performance indicators	Formula	
Root Mean Square Error (RMSE)	$RMSE = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(P_i - O_i)^2}$	Close to 0, model is appropriate
Coefficient of Determination (R^2)	$R^2 = \left(\frac{\sum_{i=1}^{n}(P_i - \bar{P})(O_i - \bar{O})}{n.S_{pred.}S_{obs}}\right)^2$	Close to 1, model is appropriate

RESULT

Table 1: Summary of descriptive statistic

	Descriptive statistic	O_3 (ppm)	CO (ppm)	SO_2 (ppm)	NO (ppm)	NO_2 (ppm)	T (^{0}C)	RH (%)	WS (Km/h)
Kota Bharu	Mean	0.017	0.47	0.0014	0.0035	0.006	28.8	71	9.1
	Median	0.016	0.42	0.0010	0.002	0.005	29.2	70	6.9
	SD	0.010	0.28	0.0007	0.004	0.004	3.1	13	7.4
	Max	0.069	3.56	0.009	0.07	0.055	37.5	100	54
Kuala Terengganu	Mean	0.02	0.39	0.001	0.002	0.004	29.2	71	7.1
	Median	0.01	0.33	0.001	0.001	0.004	29.5	67	7.0
	SD	0.011	0.27	0.0006	0.003	0.002	3.3	17	3.1
	Max	0.07	1.9	0.008	0.051	0.024	39.8	100	20.1

Table 2: Performance indexes for MLP-ANN model

Stations		RMSE	R^2
Kota Bharu	Training	0.006626	0.64
	Validation	0.006812	0.62
	Testing	0.006716	0.64
Kuala Terengganu	Training	0.006473	0.64
	Validation	0.006716	0.61
	Testing	0.006812	0.62

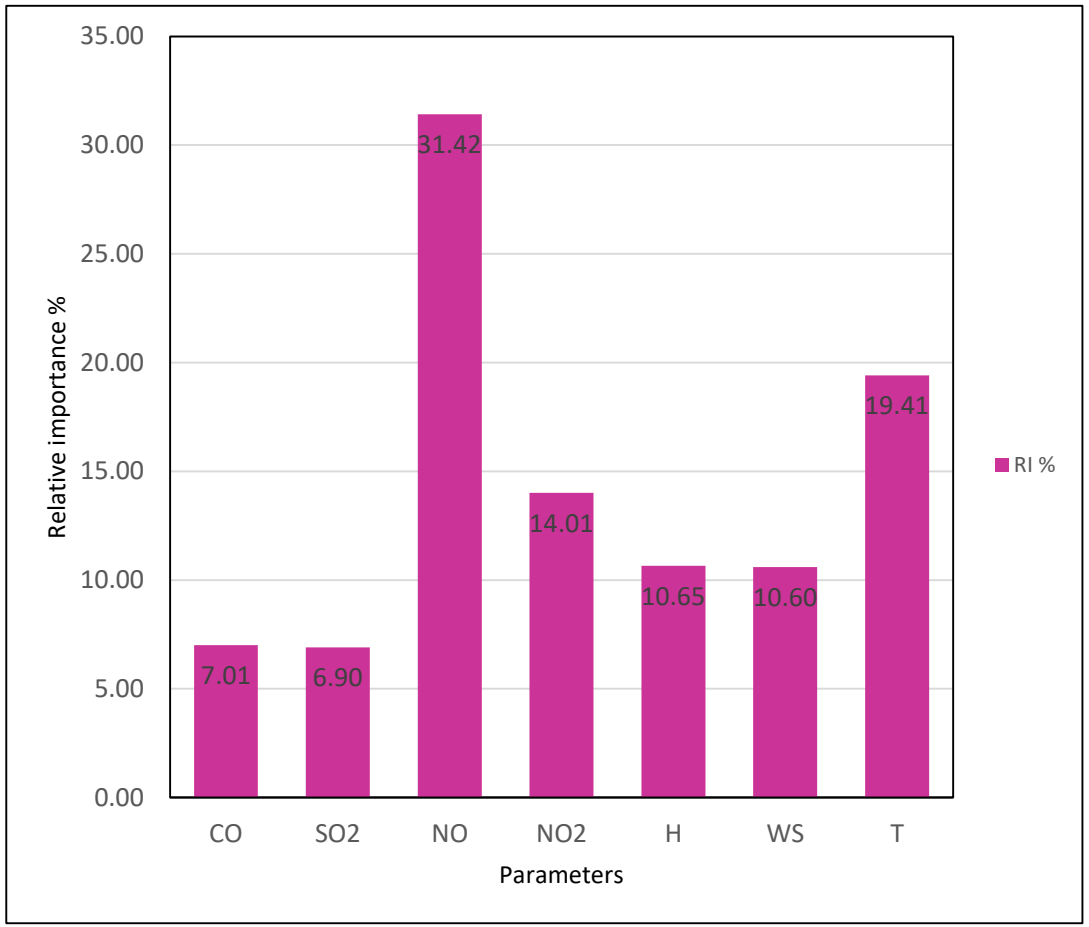


Figure 2: Relative importance for Kuala Terengganu

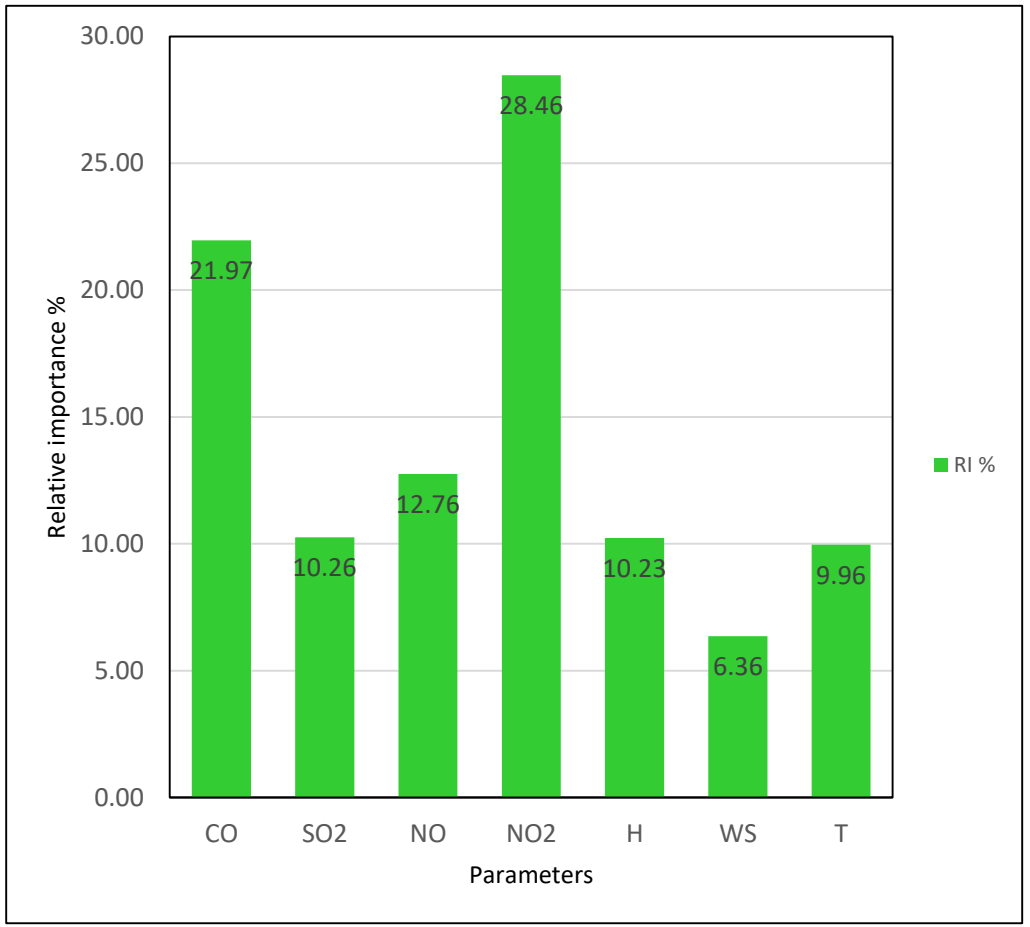


Figure 3: Relative importance for Kota Bharu

CONCLUSION

- This study revealed that the MLP-NNs with LM algorithm provide better approach for prediction of O_3 concentration at both area. The model gave lower error measure with the value of 0.006812 at Kota Bharu and 0.006716 at Kuala Terengganu. The model also gave high accuracy measure (0.62 and 0.61) at Kota Bharu and Kuala Terengganu respectively.

- The most important precursor that influence the ozone concentration at Kota Bharu is NO_2 concentration while NO concentration showed the highest relative importance at Kuala Terengganu.

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