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RESEARCH ARTICLE

AN ARTIFICIAL NEURAL NETWORK APPROACH ON CATERING PREMISES INSPECTION IN PAHANG STATE

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ABSTRACT

Background: The hygiene level of the premise reflect the safety and quality of the food served in the food services kitchen and the poor sanitary condition can contribute to food poisoning outbreaks. Recently, many food poisoning cases reported from food services sector and most of the cases are from institutional food services. These premises sometimes are graded as clean or very clean which can be questioned, mostly at institutions such as schools. Objective; The aim of this research is to identify the level of significance among the contributing factors which influence the caterers' grading score in Pahang as the biggest state in Malaysian Peninsular using artificial neural network (ANN). **Methods:** In this research, the premises have been categorised into 3 categories namely Rest and Rescue Area (RnR) premises along the East Coast Highway, event caterers and institutional. A total of 268 premises were involved in this research with 66 (24.63%) RnR, 63 (23.51%) event caterers, and 139 (51.87%) institutional caterers. The instrument used in this research is based on the official risk based premise inspection form currently used by Ministry of Health Malaysia (MOH). The important items in the inspection form are process control, building and facilities, equipment and utensils, cleaning and maintenance, as well as food handler's requirements. These items consist a total of thirty-one (31) elements with respected weightage score based on risk to food safety. The collected data is analysed using two-layer neural network with tansig-linear configurations, with trainlm activation function. **Results:** Prior to data normalization, the dataset is partitioned according 70-30-30 sets. In this research, the final model is reliable where the relative error of the training set is 0.076. The five most significant factors influencing the premises grades are critical control points (CCP), transportation condition, risky other related activity, adequate toilets, as well as adequate and safe water supply.

Conclusion: As a conclusion, it is expected that the results will assist the related authorities to take appropriate actions prior to the important and compliance information, especially the significant aspects with respect to public health, permit, inspection and other related legal issues. It is suggested that the result can be improved by using other type of training functions such trainscg and trainbfg.

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INTRODUCTION

According to the law, all food prepared shall follow the requirement as stated in Food Acts and Regulations, Malaysian Food Act 1983, Food Regulations 1985 and Food Hygiene Regulations 2009. These Acts and Regulations are implemented by the Federal Ministry of Health Malaysia. The standards of foods are stated in the Food Regulations 1985 and for handling and hygiene of food is stated in Food Hygiene Regulations 2009 (Food Act 1983, n.d., Food Hygiene Regulations 2009, n.d.). Generally, the food must be free from any hazardous material including physical, microbiological and

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chemical substance. The preparation of food must be in hygienic condition; this requires good practices in order to have a safe food for human consumption. At the same time, the regulation also required all food handlers shall undergo food handlers training and being vaccinated. Generally the increasing number of people consuming meals away from home are forced by the modern society culture (Osimani and Clementi, 2016) and in Malaysia, eating out was a result of a transformation in food and culture observed among the Malaysian urban society which was no longer anchored at home (Noraziah Ali and Mohd Azlan Abdullah, 2012). The modern day, eating out has become part of modern life and the food services sectors or caterers became a bigger role in control the healthy diets (Lachat, Roberfroid, Huybregts, Van Camp, and Kolsteren, 2009) the complexity and a large number of meals serves by the food services sectors makes the preventive measure become a difficult task (Osimani and Clementi, 2016).

At the same time, eating outside home have been reported to be associated with many sporadic foods borne illnesses outbreaks which originated from catering / food services establishments. This contributors also stated as a determinant in order to protect the health of consumers especially when involving the vulnerable user groups such as childcare, schools, hospitals and nursing home (Garayoa, Abundancia, Díez-leturia, and Isabel, 2017; Laura R. *et al*., 2007). In Europe, the food business operators are required to implement and maintain on-going procedures based on Hazard Analysis and Critical Control Points (HACCP). In the food preparation, cross contamination, dirty work environments and poor personal hygiene are the factors identified as contributing factors to food borne illness in the catering establishments. Every institutional caterer has a central role to keep the wholesomeness and safety of the food in preventing food borne illness (Meleko, 2015).

Many preventive action has been taken by the responsibility agency in food borne illness prevention such food handler training and education, inspection and enforcements. Restaurants inspection is an important activity for ensuring food prepared are safe for public consumption (Medu *et al*., 2016). This paper consists of five sections. The first section is the introduction and background of this research. The second section is about the related literatures on food catering and food services followed by food premises inspection and food safety contributing factors in catering services. The third section is the methodology which include the instrument, research design and description of ANN, then followed by result and discussion in fourth section and conclusion in the final section.

Food Catering and Food Services

The terminology of 'food services system' and 'food catering system' was first applied to food production during the 1950s. The term of 'food services' was commonly use in the United State (USA) while 'food catering' was used in the United Kingdom (UK) (Smith and West, 2003). The term of catering system was described as "a particular method of organizing the production and services of foods" and further description of the catering can describe as "a system that have objective relating to the production and or services of food to specified groups of consumers".

While (Boyano, Espinosa, Rodriguez, Neto, and Wolf, 2017), describe catering services a as " The preparation, storage and, where appropriate, delivery of food and drinks for consumption by the consumer/client/patient at the place of preparation, at a satellite unit or at the premises/venue of the client". There also a definition by "the provision of food and beverages away from home" and involving both people and environment in the preparation and serving of food. This system is a complex system and can be divided into few sectors such as not-for-profit sector and profit sectors (Fusi, Guidetti, and Azapagic, 2016; Smith and West, 2003). The preparation of safe food is depending on the services providers through stringent guideline according to the requirement of safe food. These requirements are voluntarily adhered and regularly check by the competent authority such as Health Department and certain municipal authority. In Malaysia, these premises are subjected to minimum twice a year of inspection and is part of the routine department duty to ensure the compliance of the food caterer. In this research the caterers will be eluate using the establish form used by MOH for premise inspection and will find the most contributing factors toward safe food preparation in the catering sectors especially within three group of selected samples. Then the second evaluation will be done using the modified version of the form.

Food Premise Inspection

Food premises inspection is the onsite process of evaluation of the premises condition and operational status at the time of inspection, while combining with risk based will have a more meaningful result compared to traditional methods (Hoag, Porter, Uppala, and Dyjack, 2007). The risk based inspection will focus on the risk factors that may cause food borne diseases and this method will support the ultimate purpose of safeguarding the consumers (FAO/WHO, 2009). The frequency of the inspection is varying from country for example in Malaysia two routines annually, and follow-up if necessary (Jabatan Kesihatan Negeri Pahang, 2016), Canada (Saskatoon Health Region) one inspection annually and follow up if necessary (Medu *et al*., 2016) and in United State the frequency suggested by 2011 Food Code from one to four times per year based on risk-based priority (Hoag *et al*., 2007).

Food Safety Contributing Factors in Catering

Every institution which provides food for a large group of consumers has the responsibility to keep the safety and wholesomeness of food otherwise it may result outbreaks of food borne illness. Meleko (2015), reported that the most identified contributing factors of food borne illness in mass catering establishments were cross contamination, dirty work environment and poor personal hygiene practice by food handlers. This factor can be detailed as suggested by Legnani, Leoni, Berveglieri, Mirolo, and Alvaro, (2004) research among 27 HACCP certified food production centres shown that the most identified problem associated to the premises and equipment are inadequate of extraction fan, liquid soap, unsuitable cutlery and cutting board, hand operated waste bin, unsuitable containers and no thermometer for refrigerator. While common mistake during process of preparation were incorrect arrangement of refrigerator and lack of separation between cook and raw. Incorrect cleaning of work surface tool surface was detected. While in the processing steps, few important factors involve in food preparation such as time and temperature.

Temperature control which refer to heat treatment is one of the most important step in food preparation. These important factors

always found as a mishandling during the processing by the food handlers such as improper hot or cold holding temperature, improper heating, poor handling and unfit food handlers (Abdalgadir, 2017; Ko, 2013; Legnani *et al*., 2004; WHO Food Borne Disease Burden Epidemiology Reference Group, 2015).

MATERIALS AND METHOD

Instrument

The inspection form used in this research are the standard risk based food premise inspection by Ministry of Health Malaysia (MOH). This form used by MOH in obtain the compliance of the caterers to the Malaysia standards and regulations which contain a total of thirty (31) elements under the thirteen (13) main section as listed below (main component and weightage/score) and in Table 1.

A. Process Control (25)
B. Building (7)
C. Food Handlers (13)
D. Equipment and Utensils, Food Preparation Area (9)
E. Water Supply (5)
F. Drainage and Plumbing (3)
G. Sanitation Facilities (6)
H. Waste Management (2)
I. Pest Control (3)
J. Premise Cleaning and Maintenance (2)
K. Transportation and Delivery (1)
L. Others Operation (1)
M. Others Process (Related to Public Health Risk) (10)

Research Flow

Figure 1 shows the research flowchart. This research was conducted between Mac 2017 until October 2017. A stratified random sampling procedure was used for selecting the participants in this research and a total of 268 caterers was selected from three type of caterers namely institutional, event caterers and RnR Caterers in Pahang State. The proportion of the sample are 66 (24.63%) RnR, 63 (23.51%) event caterers 139 and (51.87%). The each selected caterers were inspected using standardize risk-based inspection form used by MOH. Collected data were analysed using Neural Network SPSS, IBM SPSS Statistics for Windows, Version 22.

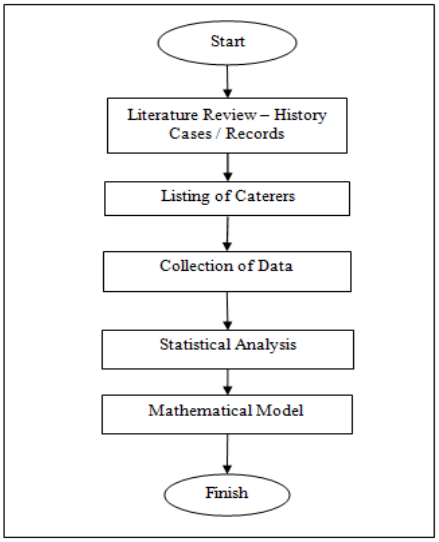

Figure 1. Research Flowchart

Artificial Neural Network

Artificial neural networks (ANNs) or connectionist systems are computing systems inspired by the biological mechanisms that constitute human brains, which automatically and continuously learn their nature or environment for better understanding and decision making.

In this research, we adapted two-layer neural network, with tansig trasfer function in the first layer and purelin transfer function at the second layer. Trainscg is the training function used in this research, with MSE equals to 0.0 as the criterion function. The data are partitioned into three different sets which are training (70%), validation (30%) and testing (30%) sets. A nonlinear model that contains more than one predictor variable neural network is developed in this research. The following model is a neural network model with 32 predictor variables,

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8, \beta_9, \beta_{10}, \beta_{11}, \beta_{12}, \beta_{13}, \beta_{14}, \beta_{15}, \beta_{16}, \beta_{17}, \beta_{18}, \beta_{19}, \beta_{20}, \beta_{21}, \beta_{22}, \beta_{23}, \beta_{24}, \beta_{25}, \beta_{26}, \beta_{27}, \beta_{28}, \beta_{29}, \beta_{30}, \beta_{31}$and β_{32}.

$$Y = purelin\left(LW^{2,1}\tan sig\left(\begin{bmatrix}(IW_1)^{1,1}*\beta_1+(IW_2)^{1,2}*\beta_2+(IW_3)^{1,3}*\beta_3+(IW_4)^{1,4}\\ *\beta_4+(IW_5)^{1,5}*\beta_5+(IW_6)^{1,6}*\beta_6+(IW_7)^{1,7}*\beta_7+\\ (IW_8)^{1,8}*\beta_8+(IW_9)^{1,9}*\beta_9+(IW_{10})^{1,10}*\beta_{10}+\\ (IW_{11})^{1,11}*\beta_{11}+(IW_{12})^{1,12}*\beta_{12}+(IW_{13})^{1,13}*\beta_{13}+\\ (IW_{14})^{1,14}*\beta_{14}+(IW_{15})^{1,15}*\beta_{15}+(IW_{16})^{1,16}*\beta_{16}+\\ (IW_{17})^{1,17}*\beta_{17}+(IW_{18})^{1,18}*\beta_{18}+(IW_{19})^{1,19}*\beta_{19}+\\ (IW_{20})^{1,20}*\beta_{20}+(IW_{21})^{1,21}*\beta_{21}+(IW_{22})^{1,22}*\beta_{22}+\\ (IW_{23})^{1,23}*\beta_{23}+(IW_{24})^{1,24}*\beta_{24}+(IW_{25})^{1,25}*\beta_{25}+\\ (IW_{26})^{1,26}*\beta_{26}+(IW_{27})^{1,27}*\beta_{27}+(IW_{28})^{1,28}*\beta_{28}+\\ (IW_{29})^{1,29}*\beta_{29}+(IW_{30})^{1,30}*\beta_{30}+(IW_{31})^{1,31}*\beta_{31}+\\ (IW_{32})^{1,32}*\beta_{31}\varepsilon^1\end{bmatrix}\right)+\varepsilon^2\right) \quad (1)$$

In this research, the general model is

$$TotalMark = purelin\left(LW^{2,1}\tan sig\left(\begin{bmatrix}(IW_1)^{1,1}*A1+(IW_2)^{1,2}*A2+(IW_3)^{1,3}*A3+(IW_4)^{1,4}\\ *B4+(IW_5)^{1,5}*B5+(IW_6)^{1,6}*B6+(IW_7)^{1,7}*B7+\\ (IW_8)^{1,8}*B8+(IW_9)^{1,9}*C9+(IW_{10})^{1,10}*C10+\\ (IW_{11})^{1,11}*C11+(IW_{12})^{1,12}*C12+(IW_{13})^{1,13}*D13+\\ (IW_{14})^{1,14}*D14+(IW_{15})^{1,15}*D15+(IW_{16})^{1,16}*D16+\\ (IW_{17})^{1,17}*E17+(IW_{18})^{1,18}*F18+(IW_{19})^{1,19}*F19+\\ (IW_{20})^{1,20}*F20+(IW_{21})^{1,21}*G21+(IW_{22})^{1,22}*G22+\\ (IW_{23})^{1,23}*G23+(IW_{24})^{1,24}*H24+(IW_{25})^{1,25}*H25+\\ (IW_{26})^{1,26}*E26+(IW_{27})^{1,27}*J27+(IW_{28})^{1,28}*J28+\\ (IW_{29})^{1,29}*K29+(IW_{30})^{1,30}*L30+(IW_{31})^{1,31}*M31+\\ (IW_{32})^{1,32}*WORKERS+\varepsilon^1\end{bmatrix}\right)+\varepsilon^2\right) \quad (2)$$

The final model will include only the significant predictors to describe Total Mark. Table 1 also represents the variables used in this research as well as the explanations of each variable, and Figure 2 illustrates the theoretical framework of this research in order to achieve the main objective.

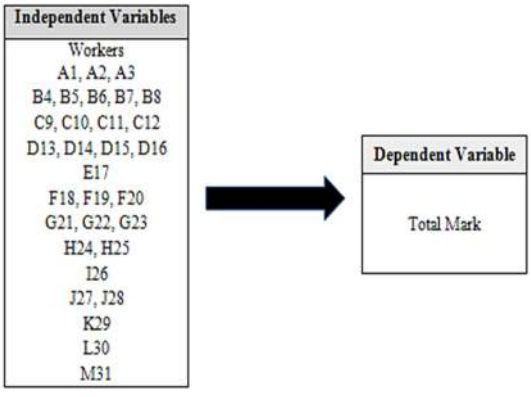

Figure 2. Theoretical Framework

Table 1. The Variables Used in This Research

No.	Variable(s)	Parameters	Notation	Type
1.	Dependent	Total Mark	The total score to determine the grade of the premise	Continuous
1.	Independent	Workers	Number of workers in the premise	Continuous
2.		A1	Critical control points	Continuous
3.		A2	Raw materials specification	Continuous
4.		A3	Control of cross contamination	Continuous
5.		B4	Away from source of contamination	Continuous
6.		B5	Suitable floor condition	Continuous
7.		B6	Suitable floor and wall	Continuous
8.		B7	Adequate lighting	Continuous
9.		B8	Adequate ventilation	Continuous
10.		C9	Food handlers health examination	Continuous
11.		C10	Food handlers practice	Continuous
12.		C11	Protective clothing	Continuous
13.		C12	Training and records	Continuous
14.		D13	Food Contact Surface	Continuous
15.		D14	Non-food contact surface	Continuous
16.		D15	Hygiene facilities and method	Continuous
17.		D16	Suitable storage and FIFO	Continuous
18.		E17	Adequate and safe water supply	Continuous
19.		F18	Effective waste water	Continuous
20.		F19	Plumbing - no cross and back flow	Continuous
21.		F20	Plumbing - well fitted	Continuous
22.		G21	Adequate toilets	Continuous
23.		G22	Adequate changing room	Continuous
24.		G23	Complete hand washing facility	Continuous
25.		H24	Adequate waste bin	Continuous
26.		H25	Maintenance of disposal area	Continuous
27.		I26	Effective pest control	Continuous
28.		J27	Cleaning and maintenance	Continuous
29.		J28	Separate storage cleaning chemical	Continuous
30.		K29	Transportaion condition	Continuous
31.		L30	Other documentation	Continuous
32.		M31	Risky other related activity	Continuous

Table 2. The Descriptive Statistics

Variables		Mean	Std. Deviation	N
Total Mark		88.14	7.047	268
District		4.42	2.888	268
Category		2.01	.695	268
Number of workers		5.80	4.248	268
A1-	Critical control points	14.72	2.033	268
A2-	Raw materials specification	4.63	1.316	268
A3-	Control of cross contamination	3.13	2.423	268
B4-	Away from source of contamination	.98	.148	268
B5-	Suitable floor condition	1.20	.981	268
B6-	Suitable floor and wall	1.52	.854	268
B7-	Adequate lighting	.96	.207	268
B8-	Adequate ventilation	.99	.121	268
C9-	Food handlers health examination	1.77	.641	268
C10-	Food handlers practice	3.60	1.206	268
C11-	Protective clothing	2.49	1.133	268
C12-	Training and records	3.25	1.561	268
D13-	Food Contact Surface	2.15	1.355	268
D14-	Non-food contact surface	.79	.410	268
D15-	Hygiene facilities and method	2.63	.988	268
D16-	Suitable storage and FIFO	1.49	.872	268
E17-	Adequate and safe water supply	4.93	.607	268
F18-	Effective waste water	.86	.349	268
F19-	Plumbing - no cross and back flow	.96	.199	268
F20-	Plumbing - well fitted	.91	.291	268
G21-	Adequate toilets	1.00	.061	268
G22-	Adequate changing room	2.00	.000	268
G23-	Complete hand washing facility	2.70	.905	268
H24-	Adequate waste bin	.76	.425	268
H25-	Maintenance of disposal area	.91	.291	268
I26-	Effective pest control	1.80	1.472	268
J27-	Cleaning and maintenance	.74	.440	268
J28-	Separate storage cleaning chemical	.96	.190	268
K29-	Transportaion condition	1.00	.061	268
L30-	Other documentation	.96	.207	268
M31-	Risky other related activity	9.93	.862	268

RESULTS AND DISCUSSION

Table 2 shows the descriptive statistics of the all variables used in this research. From the descriptive statistics, it can be concluded that the average of grade of premises in Pahang is A which is very clean. The numbers of workers have a wide range for all the premises categories which are constantly related to the size of premises. The average of worker for event caterers, institutional and RnR were 6.43, 6.08 4.03 respectively. The range of workers in all RnR premises are small due to the standards size of the premises. From Figure 3, it can be seen that the network performed very well where the network residuals scattered mostly on the 0 errors line. Figure 4 shows the network architecture used in this research which consist of five hidden nodes in the hidden layer. From Table 3, it is understandable that the most important variable contribute to total marks is critical control points which is total 100 percent influence. Table 4 shows the parameters estimates of neural network models. The results can be viewed clearly in Figure 5. In this form, the critical control points were referring to control of temperature during cooking (at 70^0C or more), holding or storage of high risk food (below 4^0C or more than 60^0C), maintaining freezer temperature, pH at 4.6 or below and rapid cooling technique. This is parallel to other country risk based inspection form Brazil, Los Angeles, New York City, and New South Wales (Da Cunha, Rosso, & Stedefeldt, 2016). However, the authors feel that the weightage of this point should be elaborated more instead of single 15 mark deducted such as cooking 5 mark, holding 5 mark and rapid cooling 5 mark respectively. The second and third important variables (transportation condition and risky other related activity) should be rearranged and prioritise with others such as food handlers practice, avoiding cross contamination and cleaning activity (Garayoa *et al*., 2017; Laura R. *et al*., 2007; Legnani *et al*., 2004).

Table 3. Independent Variable Importance

Variables	Importance	Normalized Importance
Number of workers	.013	10.4%
Critical control points	.127	100.0%
Raw materials specification	.054	42.4%
Control of cross contamination	.051	40.3%
Away from source of contamination	.008	6.2%
Suitable floor condition	.016	12.8%
Suitable floor and wall	.018	14.1%
Adequate lighting	.015	11.9%
Adequate ventilation	.016	12.4%
Food handlers health examination	.030	23.9%
Food handlers practice	.039	30.4%
Protective clothing	.028	21.7%
Training and records	.036	28.5%
Food Contact Surface	.026	20.7%
Non-food contact surface	.008	6.5%
Hygiene facilities and method	.029	22.9%
Suitable storage and FIFO	.026	20.3%
Adequate and safe water supply	.055	43.1%
Effective waste water	.010	7.6%
Plumbing - no cross and back flow	.017	13.4%
Plumbing - well fitted	.015	11.8%
Adequate toilets	.060	47.5%
Complete hand washing facility	.032	25.4%
Adequate waste bin	.009	6.7%
Maintenance of disposal area	.014	10.9%
Effective pest control	.031	24.2%
Cleaning and maintenance	.009	7.1%
Separate storage cleaning chemical	.014	11.3%
Transportaion condition	.091	71.4%
Other documentation	.014	10.9%
Risky other related activity	.089	70.4%

Table 4. Parameters Estimate

		Predicted				
		Hidden Layer 1				Output Layer
Predictor		H(1:1)	H(1:2)	H(1:3)	H(1:4)	Total Mark
Input Layer	(Bias)	-.627	-.217	-.633	.507	
	Workers	.271	-.004	-.124	.087	
	A1	-.551	-.012	.190	.503	
	A2	.028	-.209	-.480	.140	
	A3	-.299	-.497	-.056	.138	
	B4	-.010	.027	-.045	.047	
	B5	-.321	-.031	-.194	.093	
	B6	.072	-.252	-.041	-.013	
	B7	-.173	.026	-.195	.049	
	B8	-.184	.099	-.075	-.006	
	C9	.083	.127	.213	.297	
	C10	-.008	.085	.286	.335	
	C11	-.002	-.277	.053	.015	
	C12	-.123	-.199	-.490	.133	
	D13	-.627	.078	-.391	.170	
	D14	.300	-.032	-.149	.101	
	D15	-.194	-.126	-.373	.089	
	D16	.104	.039	-.131	.324	
	E17	-.054	-.209	-.255	.018	
	F18	-.118	-.122	-.020	-.058	
	F19	-.301	-.057	.437	-.057	
	F20	-.312	.160	.089	.112	
	G21	-.406	.204	.078	-.385	
	G23	.355	-.076	-.177	.218	
	H24	-.203	-.024	-.318	.012	
	H25	.004	.158	.492	.184	
	I26	-.143	-.326	-.498	.070	
	J27	.159	-.093	-.135	.053	
	J28	-.004	-.068	-.457	.001	
	K29	.450	-.143	.305	.080	
	L30	.007	.022	-.048	.085	
	M31	-.245	-.110	.265	.069	
Hidden Layer 1	(Bias)					-.721
	H(1:1)					-.364
	H(1:2)					-.819
	H(1:3)					-.025
	H(1:4)					1.112

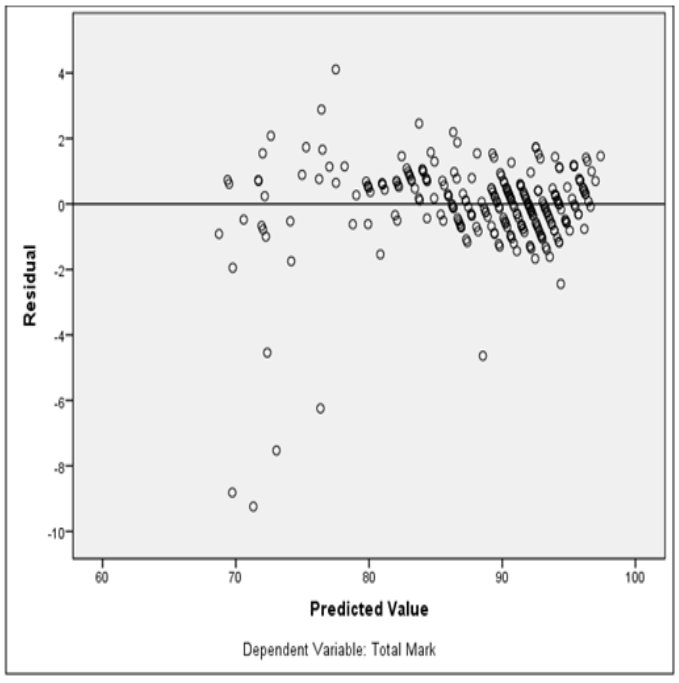

Figure 3: Network residual

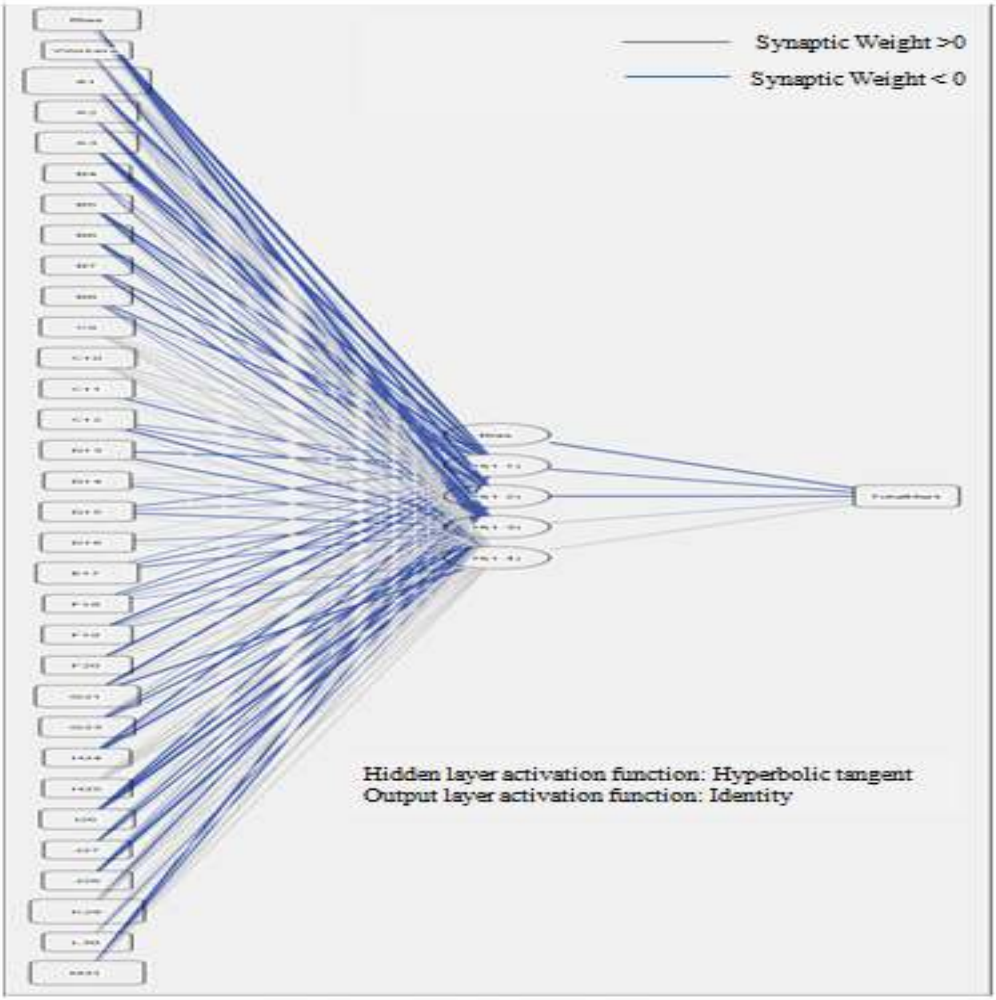

Figure 4: The architecture of neural network model in this research

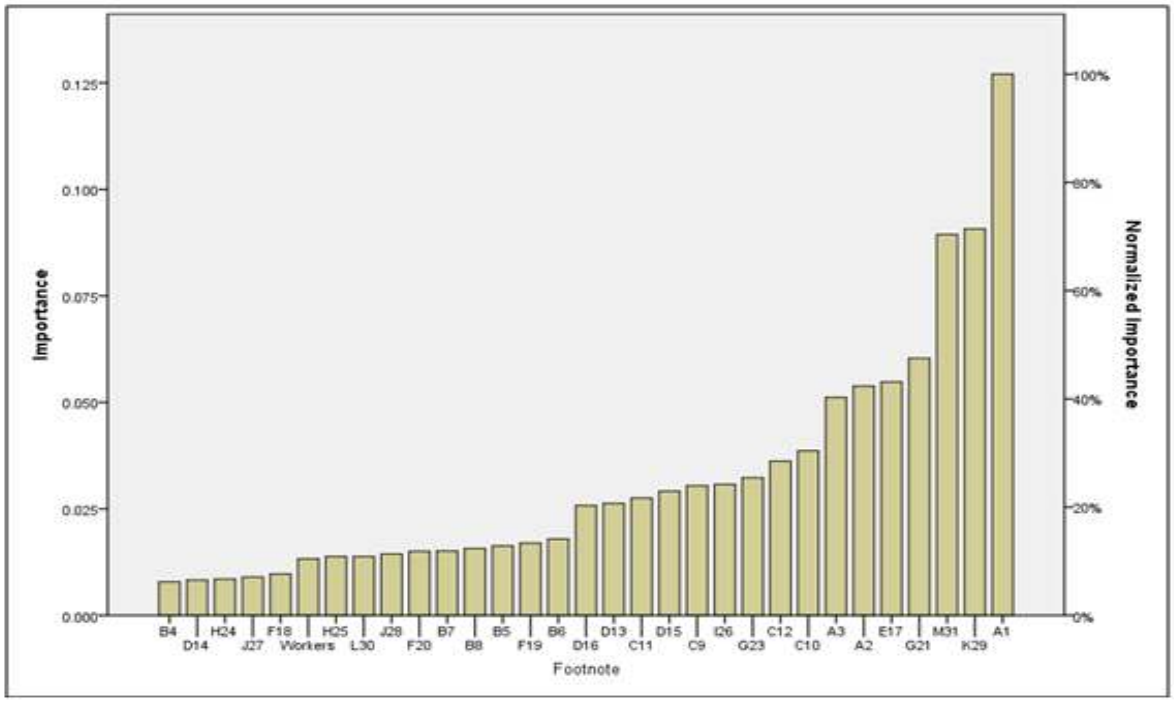

Figure 5: Variables importance levels

Conclusion

As a conclusion, the analysis result shown the five most significant factors influencing factors the premises grades are critical control points, transportation condition, risky other related activity, adequate toilets, as well as adequate and safe water supply which contribute to 100 percent, 71.4 percent, 70.4 percent, 407.5 percent and 43.1 percent respectively. This form need an improvement since the critical point of under the section A was highly or over weighted to be in one single element. This should be elaborated in more specific and tabulated under other section as well and designing a risk based inspection form should be focusing on evaluated risk from previous research. It is expected that the results will assist the related authorities to take appropriate actions prior to the important and compliance information, especially the significant aspects with respect to public health, permit, inspection and other related legal issues. It is suggested that the result can be improved by using other type of training functions such trainscg and trainbfg.

Acknowledgement

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