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Predicting the Effects of Medical Waste in the Environment Using Artificial Neural Networks: A Case Study

Qeethara Al-Shayea[1] and Ghaleb El-Refea[2]

**[1] MIS Department, Al-Zaytoonah University of Jordan
Amman, Jordan**

**[2] Al Ain University of Science and Technology
Abu Dhabi, United Arab Emirates**

Abstract
Protection of the environment from medical waste hazards is becoming a serious problem. There is a big relation between medical waste and disease injury. The main idea of this study is predict the relation between medical wastes and diseases in Hashemite Kingdom of Jordan using Artificial Neural Networks (ANNs) model. There are six predictor parameters associated with solid and liquid wastes in the medical services sector which are affecting the diseases injury. This study deals with two types of diseases the first one is acute hepatitis and the other is typhoid. Generalized Regression Neural Network (GRNN) is used to predict the diseases injury. It is noticed a significant improvement in the prediction made by GRNN due to its generalization property. Results showed that all six parameters associated with solid and liquid medical wastes which have the largest regression value affect the acute hepatitis injuries and the typhoid injuries. It is also showed that the medical waste affected the typhoid injuries in large percentage so the regression is very large.
Keywords: *Regression, Artificial neural networks, General Regression Network, Prediction, Medical Wastes.*

1. Introduction

As in many other developing countries, the generation of regulated medical waste (RMW) in Jordan has increased significantly over the last few decades. Despite the serious impacts of RMW on humans and the environment, only minor attention has been directed to its proper handling and disposal [1].
The waste produced in the in the course of health care activities carries a higher potential for infection and injury than any other type of waste [2].
A. Puss, E. Giroult and P. Rushbrook [3] presented an overview of these environmental concerns from landfilling practices and their adverse environmental effects. In their paper, a number of remedial measures needed to minimize these environmental and socio-economic effects are suggested, with in total ten long term and eight short term measures for improving of the solid waste management system of Jordan.
Awad et. al. [4] presented research under the assumption that wastes generated from hospitals in Jordan and Irbid were hazardous.
Jahandideh et. al. [5] presented two predictor models including artificial neural networks and multiple linear regression were applied to predict the rate of medical waste generation totally and in different types of sharp, infectious and general.
Al-Habash and Al-Zu'bi [6] proposed an Idea about the medical waste management in the health sector and its impact on the environment in Jordan, the right and the safe management which include, segregate, classify, collect, processing of these waste may contribute to achieve the main goal which is to reduce the hazardous effect on the local community.

2. Artificial Neural Networks

An artificial neural network (ANN) is a computational model that attempts to account for the parallel nature of the human brain. An (ANN) is a network of highly interconnecting processing elements (neurons) operating in parallel. These elements are inspired by biological nervous systems. As in nature, the connections between elements largely determine the network function. A subgroup of processing element is called a layer in the network. The first layer is the input layer and the last layer is the output layer. Between the input and output layer, there may be additional layer(s) of units, called hidden layer(s). Fig. 1 represents the typical neural network. You can train a neural network to perform a particular function by adjusting the values of the connections (weights) between elements.

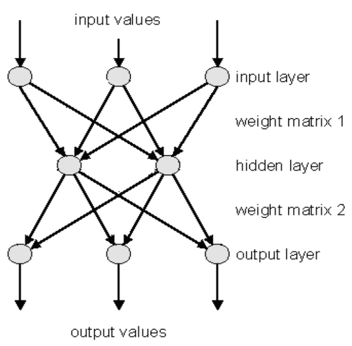

Fig. 1 A typical neural network.

For the researcher and the financial analyst, the main advantage of ANNs is that there is no need to specify the functional relation between variables. Since they are connectionist-learning machines, the knowledge is directly imbedded in a set of weights through the linking arcs among the processing nodes. In order to train a neural network properly one needs a large set of representative 'good quality' examples. In the case of bankruptcy problems, the researcher should be cautious when drawing conclusions from neural networks trained with only one or two hundred cases, as observed in most previous studies [7].

2.1 Generalized Regression Neural Network

The GRNN was applied to solve a variety of problems like prediction, control, plant process modeling or general mapping problems [8]. General regression neural network Specht [9], Nadaraya [10] and Watson [11], does not require an iterative training procedure as in back-propagation method.

The GRNN is used for estimation of continuous variables, as in standard regression techniques. It is related to the radial basis function network and is based on a standard statistical technique called kernel regression. By definition, the regression of a dependent variable y on an independent x estimates the most probable value for y, given x and a training set. The regression method will produce the estimated value of y, which minimizes the mean-squared error. GRNN is a method for estimating the joint probability density function (pdf) of x and y, given only a training set. Because the pdf is derived from the data with no preconceptions about its form, the system is perfectly general. Furthermore, it is consistent; that is, as the training set size becomes large, the estimation error approaches zero, with only mild restrictions on the function. In GRNN, instead of training the weights, one simply assigns to wij the target value directly from the training set associated with input training vector i and component j of its corresponding output vector [12]. GRNN architecture is given in Fig. 2.

GRNN is based on the following formula [13]:

$$E[y \mid x] = \frac{\int_{-\infty}^{\infty} y.f(x,y).dy}{\int_{-\infty}^{\infty} f(x,y).dy} \quad (1)$$

where y is the output of the estimator, x is the estimator input vector, $E[y|x]$ is the expected output value, given the input vector x and $f(x,y)$ is the joint probability density function (pdf) of x and y.

The function value is estimated optimally as follows:

$$y_j = \frac{\sum_{i=1}^{n} h_i.w_{ij}}{\sum_{i-1}^{n} h_i} \quad (2)$$

Where w_{ij}= the target output corresponding to input training vector x_i,

$h_i = e^{\frac{-D_i^2}{2.spread^2}}$, the output of the hidden layer neuron,

$D_i^2 = (x-u_i)^T(x-u_i)$, the squared distance between the input vector x and the training vector u, x= the input vector,

u_i=training vector i, the center of neuron i, spread=a constant controlling the size of the receptive region.

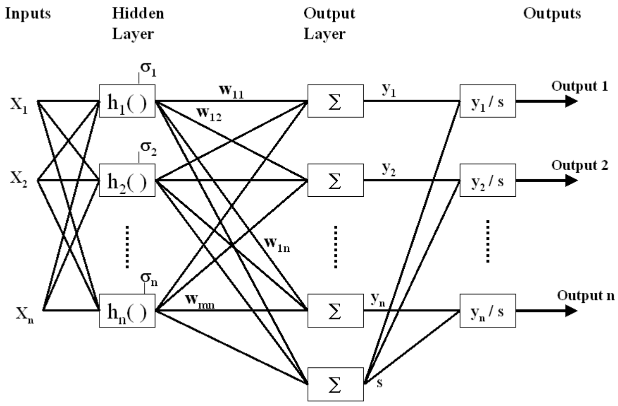

Fig. 2 Generalized Regression Neural Network (GRNN) Architecture.

3. Experimental Results

3.1 Data

This study was conducted at Hashemite Kingdom of Jordan which is split the database to north, central and south regions. The environment data is obtained from the department of statistics-GIS during 2002-2009. This dataset contains six parameters which represent the quantity of solid and liquid wastes in medical services sector are the outputs of the network. The input is number of cases to two diseases. The first is acute hepatitis and the other is typhoid and para typhoid. Table 1 presents the wastes in medical service sector which are considered as predictor variables used in the study.

Table 1: Predictor variable of datasets used in the study

Environmental data		
S. No.	***Predictor Variable Name***	***Measurement***
1	Body human waste	number
2	Waste water	liter
3	Waste of chemical and medicine	liter
4	Fluids resulting from dialysis unit	liter
5	Lab tests residues	liter
6	Medical waste	number

3.2 Results Analysis

A generalized regression neural network (GRNN) with a radial basis layer and a special linear layer and linear output neurons was created using the neural network toolbox from Matlab 7.10 as shown in Fig. 3.

Generalized regression neural networks are a kind of radial basis network that is often used for function approximation. The use of a probabilistic neural network is especially advantageous due to its ability to converge to the underlying function of the data with only few training samples available. GRNN is adopted to discover the association between medical wastes and diseases.
The first layer has as many neurons as there are input/ target vectors. Each neuron's weighted input is the distance between the input vector and its weight vector. Each neuron's net input is the product of its weighted input with its bias. Each neuron's output is its net input passed through radial basis transfer function. Radial basis transfer function is a neural transfer function which calculates a layer's output from its net input. If a neuron's weight vector is equal to the input vector (transposed), its weighted input will be 0, its net input will be 0, and its output will be 1. The second layer also has as many neurons as input/target vectors.
A spread slightly lower than the distance between input values, in order, to get a function that fits individual data points fairly closely is used. A smaller spread would fit data better but be less smooth.

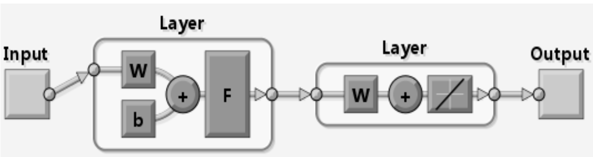

Fig. 3 A generalized regression neural network (GRNN).

Six GRNN with medical wastes as input and acute hepatitis as a target was been created. Then simulate the network with 8 samples. The spread value was chosen 0.1. The percent correctly predicted in the simulation sample for all medical wastes are shown in table 2.

Table 2

Predictor Variable Name (Medical wastes)	*Regression value*
Body human waste	R=0.65727
Waste water	R=0.41544
Waste of chemical and medicine	R=0.34625
Fluids resulting from dialysis unit	R=0.4763
Lab tests residues	R=0.62707
Medical waste	R=0.40936

Six GRNN with medical wastes as input and typhoid as a target was been created. Then simulate the network with 8 samples. The spread value was chosen 0.1. The percent correctly predicted in the simulation sample for all medical wastes are shown in table 3.

Table 3

Predictor Variable Name (Medical wastes)	*Regression value*
Body human waste	R=0.88687
Waste water	R=0.62446
Waste of chemical and medicine	R=0.69068
Fluids resulting from dialysis unit	R=0.73998
Lab tests residues	R=0.86629
Medical waste	R=0.93993

It is clear from the results, that all medical wastes are very influential factors in the pathogenesis of disease, viral hepatitis acute typhoid.
Fig. 4 shows the multiple regressions for the six affecting factors as input and acute hepatitis as target. The spread value was chosen 0.1. The percent correctly predicted in the simulation sample is approximately 53 percent.

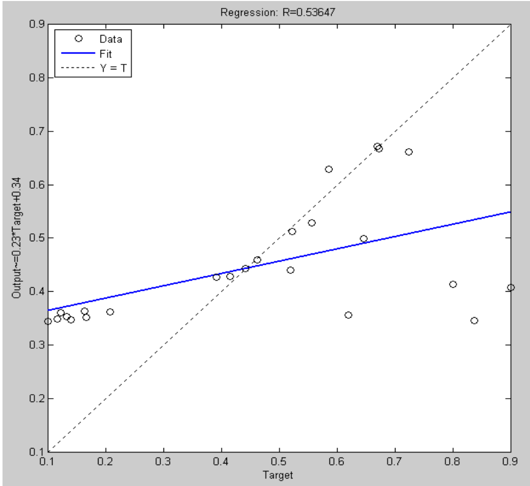

Fig. 4

Fig. 5 shows the multiple regressions for the six affecting factors as input and typhoid as target. The spread value was chosen 0.1. The percent correctly predicted in the simulation sample is approximately 97 percent.

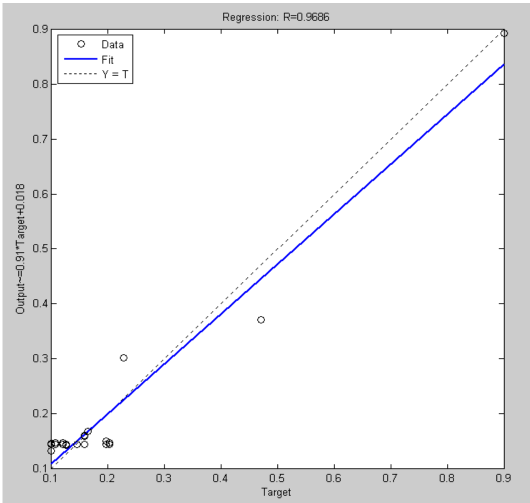

Fig. 5

4. Conclusions

In this paper the general regression neural network is used for the prediction of the diseases injury. The advantage of using the GRNN in the prediction is its generalization property. The results of this study provide evidence that the human body waste and lab tests residues are the most affecting in acute hepatitis. While the medical waste is the most affecting in typhoid injure.

The results also indicate that the variables examined in the study provided a significant contribution in predicting disease injure human.

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Qeethara Kadhim Abdulrahman Al-Shayea is Associate Professor in Department of Management Information Systems Faculty of Economics & Administrative Sciences Al-Zaytoonah University of Jordan. She has received Ph. D. in Computer Science, Computer Science Department, University of Technology, Iraq, 2005. She received her M.Sc. degree in Computer Science, Computer Science Department from University of Technology, Iraq, 2000. She has received her High Diploma degree in information Security from Computer Science Department, University of Technology, Iraq, 1997. She has received B. Sc. Degree in Computer Science Department from University of Technology, Iraq, 1992. She is interested in Artificial Intelligent, Business Intelligence, Image Processing, Computer Vision, Coding Theory and Information Security. She has already published many papers in international journals and conferences

Ghaleb A. El-Refae is a Professor. He is president of Al Ain University of Science and Technology in United Arab of Emirates. Ghaleb A. El-Refae, has a Ph. D. and M.A in Financial Economics form USA, M. Sc and B. Sc in Accounting. His research interest is in the application of IT and IS in Business and Economics. He has already published over 30 papers in international journals and conferences

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