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Neural Network Based User Interface for Accident Forecast in Manufacturing Industries

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ABSTRACT

Safety in manufacturing industries nowadays can be seen to be gaining grounds of which its importance can neither be underestimated nor overemphasized. As a matter of facts, many industries have embraced an appraisal in their safety department by selecting specific safety interventions on which budget is to be made for the year. A critical look at selected safety interventions like personal protective equipment, motivation for workers, accident investigation, awareness creation, training, and guarding, shows that a judgmental approach to their selection in other to allocate funds for their execution often results into over allocation or under allocation of funds without reducing the number of accidents.

This paper has been able to design a user-friendly interface to simulate cost expended over certain safety interventions and the corresponding number of accidents recorded for a period of sixteen years using artificial neural network. The model was then used to predict number of accidents given the budget on the interventions for further years. The user friendly interface was developed which can be used by manufacturing industries to simulate budgets on commonly employed safety interventions and expected number of accidents based on a successfully trained neural network algorithm with a regression value of 0.99952.

Keywords *– Artificial Neural Network (ANN), Safety Intervention, Graphical User Interface (GUI),*

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I. INTRODUCTION

It can be rightly said that safety is one of the key factors in ensuring an efficient production. Over the years, appreciable numbers of families have been denied their means of livelihood due to their bread-winner's involvement in one industrial accident or the other, this probably as a result of the under-estimation of safety measures. Among this is the case of a young worker who sustained a serious eye injury while operating a grinder without using eye protection (WCB, 2008). The National Safety Council in 2004 tried to estimate the cost of work place injury to be $142.2 billion. (NSC 2005)In fact, many capable hands in manufacturing industries have gone to the great beyond at the early stage of their lives, at periods when their knowledge and intellect are needed most. Also on the part of industries, considerable amount have been spent on claims made by the personalities involved in one injury or the other. In other to address this issue, manufacturing industries now employ various safety interventions.

A safety intervention is defined very simply as an attempt to change how things are done in order to improve safety. Within the workplace it could be any new program, practice, or initiative intended to improve safety (e.g., engineering intervention, training program, administrative procedure). The effectiveness of various safety interventions employed can be investigated using a computer program called Artificial Neural Network.
Artificial Neural Network (ANN) or simply called Neural Network (NN) have being attributed several names (probably viewing it from its mode of operation) which includes; Parallel Distributed Processing Systems(PDPs), Neuro-Computing systems, a neuromorphic system, connection models etc. (Bose et. al 1996) " This is a technology that is intended for modelling the organizational principles of the central nervous system, with the hope that biologically inspired computing capabilities of the ANN will allow the cognitive and sensory task more easily and more satisfactorily than with the conventional serial processor." (Bose et. al, 1996) This technology has found its application in the world of aerospace, business, automobile, banking, credit card activities checking, defence, electronics, entertainment, insurance, manufacturing industries, medicine, oil and gas, robotics, speech recognition, securities, telecommunication, transportation etc.

This project is a continuation of previous works by Adebiyi et al. (2009) which focused on setting a sustainable manufacturing safety programme. Several approaches developed for optimal safety intervention prediction using MATLAB involves running of several lines of codes requiring the knowledge of the software such that industries with similar set of cost allocation cannot independently make a prediction of likely number of accidents, incidents or near-miss hence, the need for a user-friendly interface for this analysis.

1.1 SAFETY AND SAFETY INTERVENTIONS

Safety can be an expensive aspect of industrial operations unless efforts are made to enhance and optimize health and safety programs to reduce the long-term cost associated with health and safety related incidents and damage. The objective of a health and safety program is to minimize or prevent loss to humans, the environment, property and profits due to incidents. These programs are implemented by applying human resource time to preventive intervention activities that are expected to prevent or minimize loss. One step towards achieving this objective would be to quantify and analyze intervention activity and incidents for an existing health and safety program. A safety and health program could be described as a dynamic set of intervention activities implemented at a worksite to prevent incidents or reduce their likelihood of occurrence or their consequence severity.

Petersen (1998) evaluated the strengths and weaknesses of safety management practices and emphasizes on overall teamwork as a key to safety excellence. The author, however, signifies a safety audit or a perception survey to be a better measure of the safety and health programs than incidents. These recommendations by Petersen (1998) help in suggesting that; improving the program effectiveness can be accomplished with good communication approaches; however they do not quantify improvement in their effectiveness in relation to the changes

According to Cohen, and Cleveland (1978) they lay out differences between successful and unsuccessful safety programs. Their studies chalked out the unique practices observed by successful safety programs. Though these observations help in the design stage of a safety program, the question of how much effort to apply over time to an intervention activity to obtain a minimum incident rate is not answered by these studies. Behavioural modification studies and single intervention studies shed light on the quantity and quality of the intervention program but fail to observe the main and interactive effects on the response from several intervention factors.

The role of safety and health programme come into necessitation as a result of industrial and manufacturing accidents that occurs in the work site. Therefore the effect of accidents manufacturing must be duly considered.

Series of programmes have been organized and formulated in order to achieve safe manufacturing. These set of programmes are referred to as safety interventions. Adebiyi et al. (2009) classified these safety interventions into six vis-à-vis personal protective equipment, workers motivation, accident investigation, awareness creation, training and guarding. Haight et al. (2001) also attempted to classify safety interventions into four vis-à-vis Factor A (awareness, motivation, incentive intervention), Factor B (safety and skill and craft training and development intervention), Factor C (new tools and equipment design method intervention) and Factor D (Equipment activities e.g. inspection and preventive maintenance).

1.1. ACCIDENTS

Accidents are unintended and unforeseen events, usually resulting in personal injury or property damage. More often than not, industrial accidents and unsafe working conditions can result in temporary or permanent injury, illness, or even death. They also take a toll in reduced efficiency and loss of productivity. Some of the causes of accidents includes defective and poorly maintained machineries, poorly trained operators etc. The concept of accident is often confused with incident of which they are clearly different. While accident can be defined as occurrence in personal injury, damage, loss of life and property etc., incident can be defined as an occurrence that has the potential to result in personal injury, loss of life and property etc.

1.3 NEURAL NETWORK

Various forecasting models exists ranging from the moving average (MA) model, the single exponential smoothing (SES) to Holt Winter Additive Algorithm (HWA). These are commonly used for time series data. Accidents on the other hand is not a time series data of which its accurate prediction can best be done using ANN. Artificial Neural Network (ANN) which is an aspect of soft computing can be seen to be a parallel physical system that can acquire, store and utilize experiential knowledge. It is a physical paradigm that mimics the human brain in two ways;

1. Knowledge is acquired by the network through a learning process.
2. Interneuron connection strengths known as synaptic weights are used to store the knowledge.

The learning process of a neural network can be in two ways:
(a) Supervised learning which incorporates an external teacher, so that each output unit is told what its desired response to input signals ought to be.
(b) Unsupervised learning uses no external teacher and is based upon only local information. It is also referred to as self-organization, in the sense that it self-organizes data presented to the network and detects their emergent collective properties
The table below also gives the similarities between the artificial neuron and the biological neuron.

Table 1: Similarities between artificial and biological neuron

Biological neuron	Artificial neuron
Soma	Node
Dendrite	Input
Axon	Output
Synapse	Weight

As artificial Neural Network has many advantages so also it has disadvantages vis-à-vis:

Advantages of ANN
1. Ability to learn from experience.
2. Ability to recognize patterns in data.
3. Generalization.
4. Classification ability.
5. System design without prior knowledge.

Disadvantages of ANN
1. A neural network is a black box; it does not explain its decision.
2. With use of adaptive networks it is impossible to fully predict actions.
3. Computation might be time consuming.
4. Do not give precise results, which make them unsuited for certain tasks.

1.4. GRAPHICAL USER INTERFACE

A Graphical User Interface (GUI) also called a user-friendly interface is a platform which enables users of a particular computer program navigate through various commands and tasks by clicking or checking few boxes without a knowledge of the syntax of the program. In developing a good GUI, some conventional guidelines must be put in mind which though will not be discussed in details here are consistency, highlighting changes, labelling relevant icons with correct labels, less eye fatigue etc. The GUI used in this research was designed using the Matlab Graphical User Interface Development Environment (GUIDE).

II. METHODOLOGY

2.1 ANN MODEL

In developing the neural network model, data of expenditures on some selected safety interventions and the corresponding number of accidents recorded for each year for a period of sixteen years were collected form a tobacco company. This data were compiled in an excel file and read into Matlab software. An ANN model performs efficiently when the data is pre-processed. This preprocessing also referred to as normalizing can be done through various algorithms but the 'mapminmax' algorithm was used here. It maps the row minimum and maximum values between a range of -1 and 1. This is often done in order to minimize the errors which usually occur in working with large data values. Network parameters like epoches were specified. The network was train using the Levenberg- Marquardt Back-propagation algorithm. The network was such that a two layer feed-forward network with 6 neurons in the first layer and 5 neurons in the second layer. The model was developed following the basic steps in ANN which includes:

a) Data collection and organization
b) Normalization of the input and output values
c) Defining the network structure (parameters)
d) Initializing the weight matrix and biases
e) Training the network with the train data
f) Testing the network
g) Saving the network.

2.2 User Interface Design

The user friendly interface was designed using the GUIDE toolbox in matlab. Several tools are located on the tool pallete. The tool ranges from the push button to the active x-control. Some of these were put to use in designing the interfaces. A property inspector inbuilt for every of the tools are changed to suit the desired outcome. The interface was then programmed such that the icons and action buttons perform the functions they are meant for through some underlying codes.

III. RESULTS AND DISCUSSION

Cost expended and the corresponding number of accidents for a period of 16 years were collected form a manufacturing industry as shown in table 3.1. The input for the artificial neural network being the cost was trained with their corresponding accidents being the target. A correlation coefficient of 0.99952 was obtained indicating that the number of accidents predicted and the actual is 99.952% related as shown below.

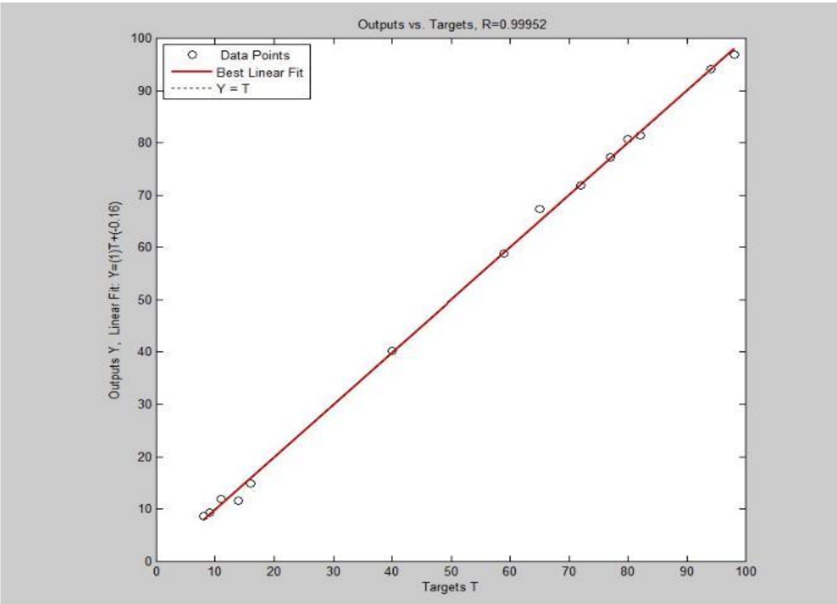


Figure 3.1: A Regression plot of the ANN Output with the Target

A GUI developed comprises of two interfaces of which the first interface consist of three pages. The third page is where the training of the model was performed as seen in fig.4.3. This model was then saved to be used in the second interface shown in fig. 4.3.

The forecasting is done on the second interface (fig.4.4) such that the user can put in his financial budget for the following year for the interventions listed and he can forecast the number of possible accidents for that year. On the interface the GUI was designed such that it flags an error message for multiple entries of cost for a single intervention and it also flags an error message for non-numerical inputs form the user.

IV. FIGURES AND TABLES

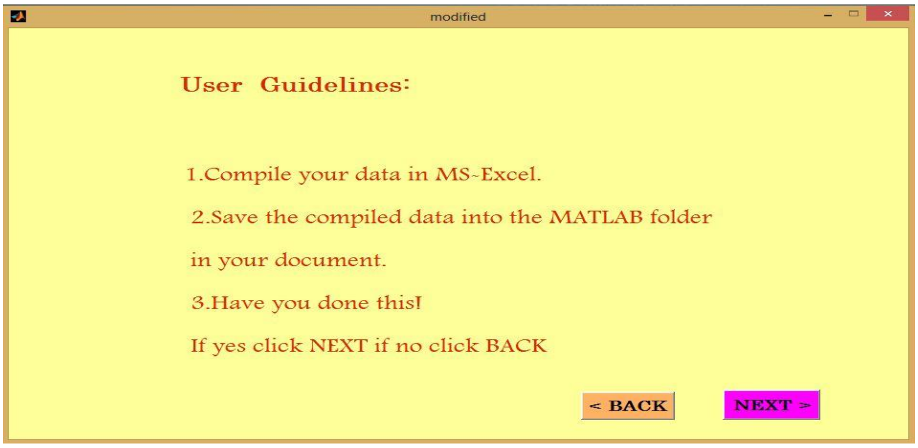


Figure 4.1: First Interface (Page 1)

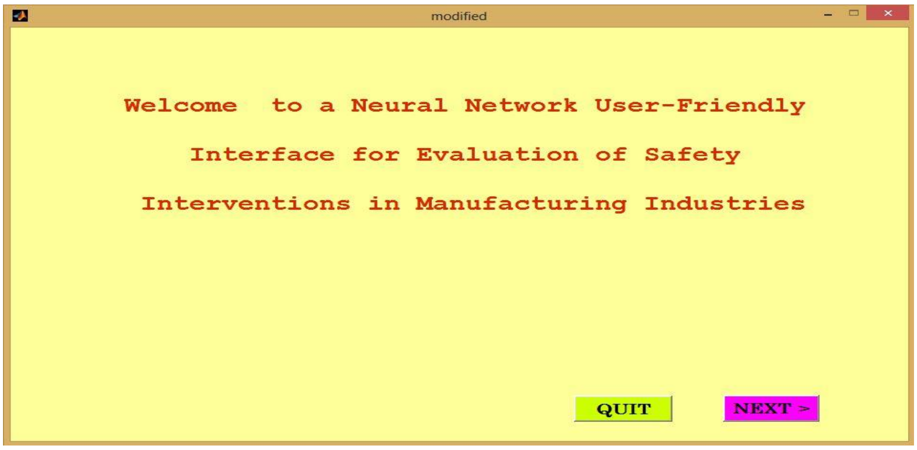
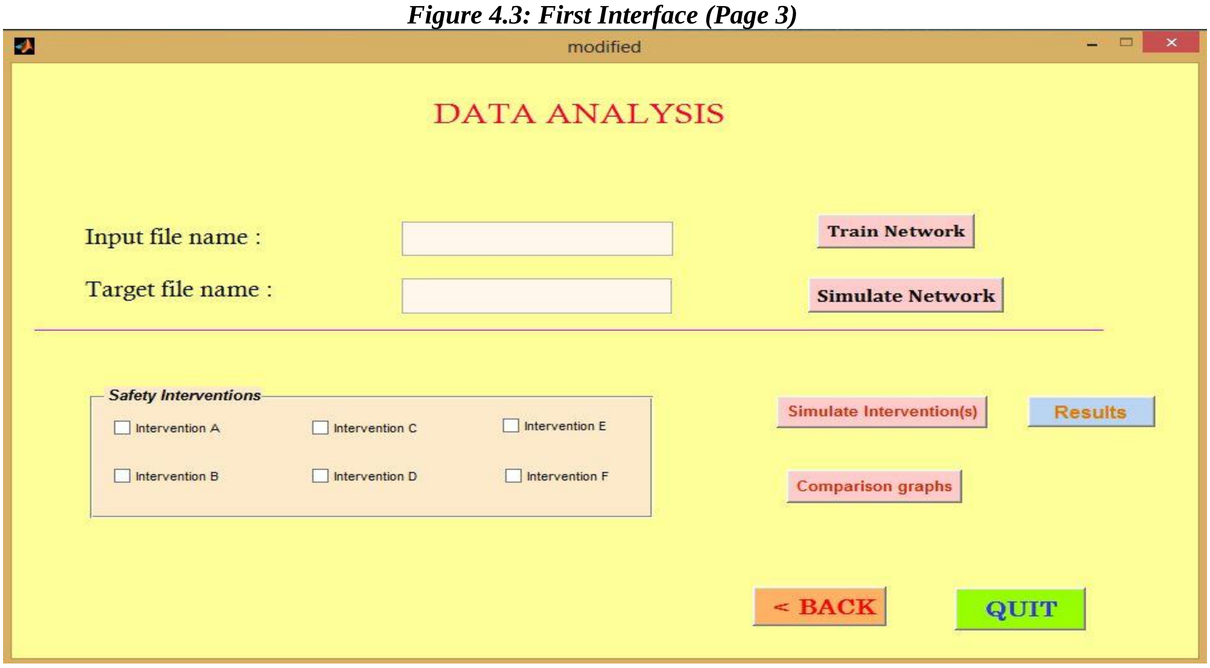


Figure 4.2: First Interface (Page 2)

Figure 4.3: First Interface (Page 3)



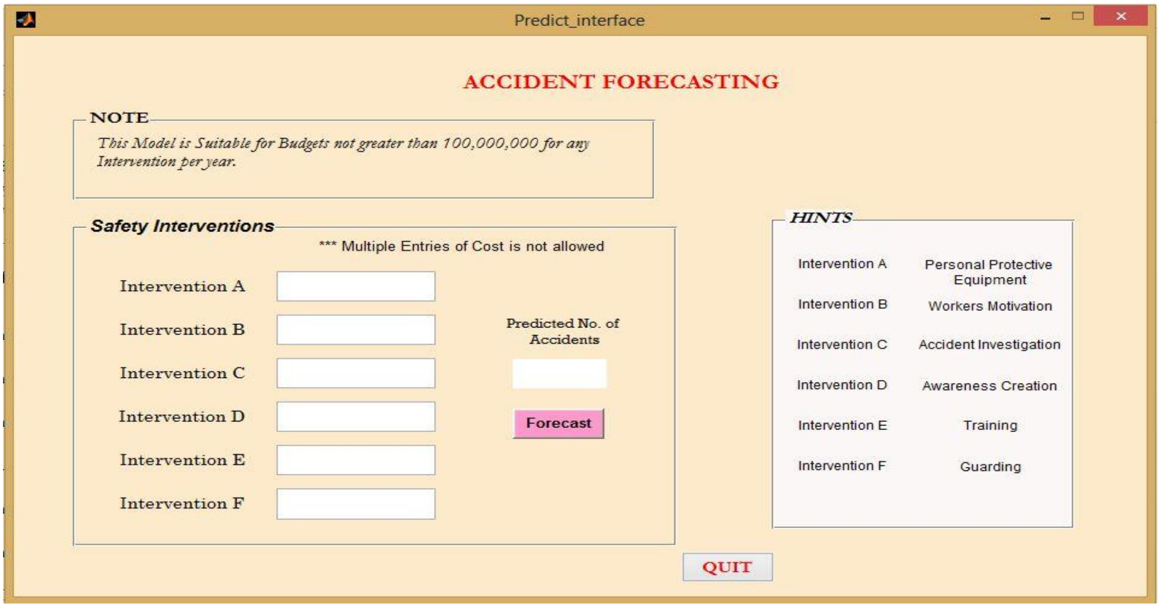


Figure 4.4: Second Interface

Table 2: Cost on Each Intervention and Accidents Recorded Per Year.

YEAR	A	B	C	D	E	F	ACCIDENTS
1993	1650960	2628400	10150000	4860000	360000	4088000	98
1994	2026800	1192000	861600	1800000	0	3440000	80
1995	2089440	952600	2696900	1290000	60000	3332000	77
1996	2193840	553600	5755700	440000	160000	3152000	72
1997	1734480	2309200	7703000	4180000	280000	3944000	94
1998	2465280	483800	13709000	1770000	420000	2684000	59
1999	2193840	553600	5755700	440000	160000	3152000	72
2000	1985000	1351600	361920	2140000	40000	3152000	82
2001	1734480	2309200	7703000	4180000	280000	3944000	94
2002	2340000	5000	10038000	750000	300000	2900000	65
2003	2862000	2000000	25332000	5000000	800000	2000000	40
2004	120000	2100000	25055000	0	100000	150000	14
2005	1958000	1561000	185000	5000000	600000	170000	16
2006	2550000	2522000	100015000	0	1500000	40000	8
2007	2000000	2406000	5085000	0	1200000	1320000	9
2008	848000	2040000	12088000	1000000	200000	70000	11

V. CONCLUSION

This work will go a long way in helping manufacturing industries in performing a cost benefit analysis, giving them an overview of the minimum amount they can spend on a safety intervention and the number of accident they are likely to record for that year. It will also enable them see which safety intervention is of paramount importance. The user-friendly interface is easy to navigate through and of which needs no personality with a prior knowledge of matlab will provide an independency and eliminate the stress of employing a matlab specialist for safety analysis.

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