UNIVERSITI TEKNIKAL MALAYSIA MELAKA

MODELING COMPLEX AND DYNAMIC REAL LIFE SCENARIO

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Robotics and Automation) (Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Robotics and Automation) (Hons.). The member of the supervisory is as follow:

……

(Dr. Omid Reza Esmaeili Motlagh)

ABSTRAK

Model pengiraan lembut semakin menggantikan model matematik konvensional. Dalam penyelidikan ini, pengiraan lembut menemukan hubungan menyebeb yang ada dalam satu sistem tertutup. Kekuatan hubungan antara factor A dan factor B boleh diterjemah dalam bentuk berat dalam jaringan neural buatan. Model pengiraan lembut menjadi perhatian kerana terdapatnya kesulitan untuk meyelesaikan masalah yang kompleks dan dinamik. Kesulitan untuk menyelesaikan masalah ini adalah pengiraan yang sukar dan memakan masa. Selain itu, ianya juga susah untuk mendapatkan nasihat pakar yang tidak berat sebelah. Dengan melakukan pengiraan matematik, ianya adalah lebih baik untuk jaringan neural buatan seperti “fuzzy cognitive map” (FCM) untuk meniru sistem tersebut dengan realistik. FCM membetulkan semua berat hubungan dalam sistem dengan pembelajaran yang berdikari. Satu algoritme yang berdasarkan perceptron telah diaplikasikan dalam proses pembelajaran FCM. MATLAB adalah perisisan yang digunalan untuk membina model FCM. Bandingan masa pengiraan dan kejituan keputusan telah dilakukan. Semakin banyak data input, semakin serupa FCM berkelakuan seperti sistem yang benar. Satu kes pengajian telah dipilih untuk mengesahkan model FCM yang dibina. Penyelidikan pada masa hadapan boleh menyelidik lebih pada algoritme yang digunakan pada model FCM bagi mendapatkan masa pengiraan yang lebih cepat dan kejituan yang lebih tinggi.

ABSTRACT

Soft computing model is replacing conventional mathematical models. In this research, soft computation discovers the causal relationship exists among the factors within a closed system. The strength of relationship between factor A and factor B could be expressed in form of weights in artificial neural network. Soft computing models come into sight because there are challenges to solve complex and dynamic problems. The troubles to solve these problems are mainly involving bulky computation and time consuming. Besides, it is difficult to seek unbiased expert's advice. Instead of performing mathematical calculations, artificial neural network model such as fuzzy cognitive map (FCM) could realistically mimic the system. FCM tuned the weights of all relationship within a system independently through learning. An algorithm based on perceptron is applied in FCM learning process. MATLAB is the software used to build the FCM model. The comparison of computation time and the accuracy of the output results are done. The more input data, the more FCM behaves similarly to the real system. A case study is chosen to validate the FCM model. Future research could explore more on the algorithm used on FCM model to achieve shorter computation time along with higher accuracy.

DEDICATION

To my beloved parents

ACKNOWLEDGEMENT

I would like to thank to my project supervisor Dr. Omid Motlagh who assisted and guided my in order to accomplish this project. The title of the project was “Modeling Complex and Dynamic Real Life Scenario”. This investigation is proposed with the hope to reduce bulky computations in solving real life problems. In conjunction to this, I would like to offer my sincere gratitude to Dr. Omid Motlagh from the bottom of my heart for all the support, encouragement, and inspirations manage to obtain all the way through of this project. The excellent working relationship between my supervisor and me has provided me with bountiful knowledge and experience for the future. The help rendered to me is priceless, be in from the smallest of its kind to the largest. Last but not least, it is thankful to all my family members, course mates, friends, and other parties who had helped me direct or indirect in all the way until completion of my project.

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List Abbreviations, Symbols and Nomenclatures

ANN	-	Artificial Neural Network
FCM	-	Fuzzy Cognitive Map
GA	-	Genetic Algorithm
SA	-	Simulated Annealing

CHAPTER 1

INTRODUCTION

A causal system has nodes that affecting each other with a certain degree of weights. Mathematical modeling of causal system is always complex and bulky. Therefore, soft computation using neural and fuzzy application is replacing mathematical models to discover causal relationships which exist among parameters within a system. The weights representing the strength of the relationship between the nodes or parameters could be expressed in the gray scales of their actual values rather than binary values in neural networks. Hence, the weights could be tuned by using artificial intelligence systems such as fuzzy cognitive map (FCM) to realistically mimic causal relationships among the nodes representing all system variables.

1.1 Background

Hard computation involves a lot of mathematical calculations where it requires specific parameters in order to find the ultimate answers. This means that hard computation needs significant resources regardless of algorithm used for computation. Soft computation, on the other hand, provides a more flexible approach in finding the

answer patterns with a certain tolerance of uncertainty and imprecision rather than the specific answers.

Causal problem is defined as the current events that resulted from the consequences from the previous events. The traditional way of solving causal problems are always involving complex and bulky computations in order to find solutions. Although hard computation provide a more accurate answer for some causal problems, the time factor and inability to deal with noisy and uncertain data has always contributed to inefficiency of those systems. Hard computation also requires the huge collection of data and the advice of the experts in related field. Sometimes, it is difficult to get the expert in the field to solve the problems. There is a lack of intelligent system that could model the causal system. This justifies the utilization of soft computing models such as Fuzzy Cognitive Map (FCM). This project is aimed to model such system with real data from the real life scenario. In this study, the intelligent system is hoped to be able to solve the problems in causal system with much lesser computation time consumption and to give an ideal solution.

1.2 Problem Statement

The current problem in the causal systems is lack of coherent model to ease the bulky computations. Besides, it is quite expert depending to solve a problem. When the system is depending on experts to solve a problem, it is said to be not intelligent enough. Experts' definition of a problem may generate different views as different expert has different biased. It is time consuming when involving bulky computations and evaluating the impact of the experts' advice, thus this could not provide real time solutions to the problem.

1.3 Objectives

These are the objectives to be achieved during this project:

1. To develop a soft computing algorithm for modeling causal system
2. To validate the system on real-life example cases

1.4 Scope

Soft computing techniques the focus goes to FCM due to it is generated automatically based on models of artificial intelligence, a type of machine learning, without expert interference. So it is expert-independent. Besides, it could accept almost any algorithm to be applied into it and tune itself to optimization. FCM needs only some expert's define in the beginning of the learning such as determining which algorithm to be used and input data. The learning process, however, is totally automatic. FCM used to apply in the four bar linkage system is expected to reduce the computation time in just minutes.

By using the MATLAB software and real data, the soft computing model will be trained with the training rules to find out the best solution (being the weight of the graph edge connecting two graph nodes) with tolerance of 0.01. Depending on availability of an initial dataset, training rules could be either supervised or unsupervised. With the aim of reducing computation time in the causal problem, the scope is limited to supervised learning rules such as the perceptron and simulated annealing. This is also due to the desired output is available, making the rules to be prefered. The technique should optimize to find possible global solution, where the model must avoid the local minima,

limit cycles and chaotic situation. As example cases, a four bar linkage system will be used to validate the model generated.

1.5 Research Design

Throughout the research, the first thing to do is to define the problem, and then the number of concepts could be determined. After studying the related materials or the past knowledge to solve the problem, suitable algorithms could be tried out to formulate the soft computing training rule. The output values could be set into desired tolerance and iteration cycles. MATLAB will be used for the computation process. If the result is satisfied, the evaluation of the result will be carried out. If the result is not satisfied, another algorithm is needed to be try out.

1.6 Significance of Study

The significance of this study is to greatly reduce the amount of computation time to solve causal problems. The expert's bias could also be eliminated. Due to complex computation, weighty error might occur. Machine learning that applied artificial intelligence could learn by itself without much supervision, thus reducing the dependency on human to solve causal problems. The soft computing model could learn a system in a short time and provide almost instantaneous global solution without biased, which satisfy the need of industrial real time problem solving. The model could also generate realistic scenario and provide solution with better accuracy. With the advantages that the model possesses, the industry can apply this method in daily's

problem solving tasks to increase their productivity in terms of time and cost management.

1.7 Organization

This report consists of five chapters where the first chapter is the introduction of the project, followed by the chapter of literature review. Next, the methodology chapter will discuss about the methods that have been used in this project. There is data generated for each method, thus the chapter of results and discussion contains the analysis of the data. The report ends with the last chapter, which is the conclusion and recommendation.

1.8 Summary

The main concern in this study is to give real time solutions to a problem without biased and improved accuracy. By implementing the soft computing model using MATLAB, computation time is expected to be reduced. The next chapter will discuss more on the past knowledge and methods to solve causal problems.

CHAPTER 2

LITERATURE REVIEW

2.1 Artificial Neural Network

Artificial neural network (ANN) simulates the brain cell (neuron) functions. A brain cell consists of synapses and axon to transmit signals. When synapses detect signals that are strong enough, the neuron is activated and the signals will pass along the axon. Signals are sent to other synapses to possibly activate another neuron. Figure 2.1 shows the biological analogy of a neuron cell.

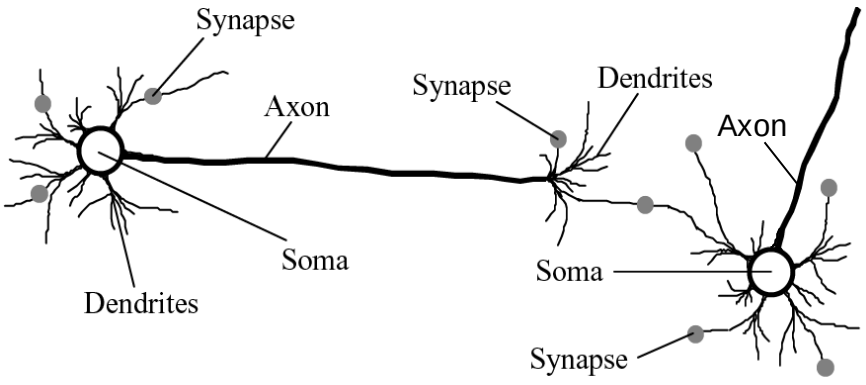

Figure 2.1 The structure of a biological neuron.

In ANN, inputs receive signals (x)and will be multiply with the weights (w). The weights are indications of the signal strength. The positive weights will exhibit the signals while the negative weights will inhibit the signals. The summation of all the weighted inputs (∑ xw)gives a value to compare with the threshold value (ɵ). If the sum is more than the threshold value, meaning that the signals are strong enough, the neuron will then undergo an activation function to produce output signals. Figure 2.2 below shows the single layered artificial neuron structure.

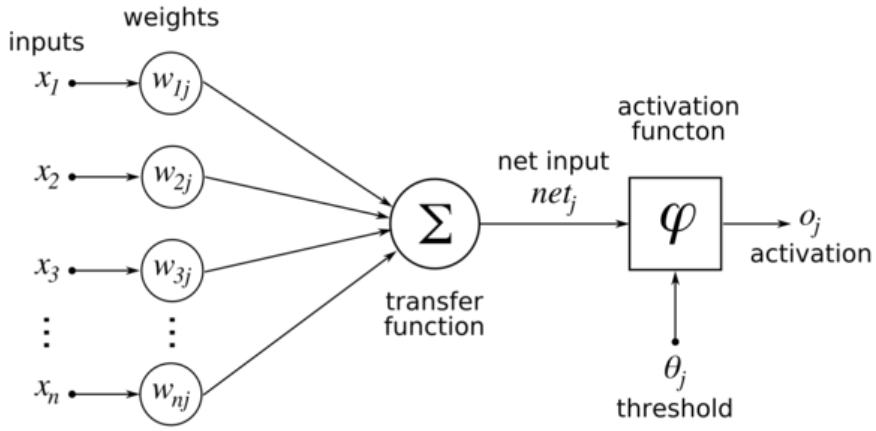

Figure 2.2 The artificial neuron structure.

There are different types of basic activation functions; the step function, the sign function, the sigmoid function and linear function. These functions are shown in Figure 2.3 as follows,

Given $X = \sum_{n=1}^{n} x_n w_n$, Y = output;

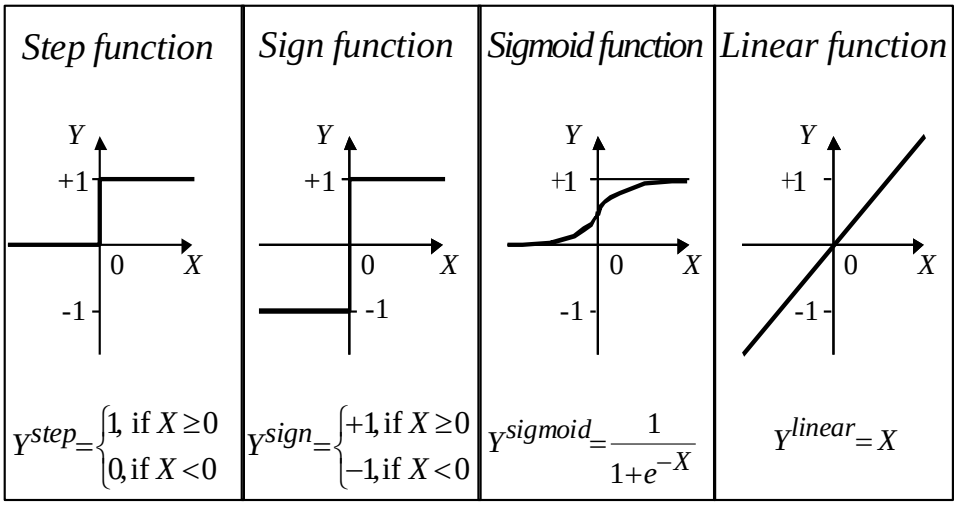

Figure 2.3 The types of activation function.

ANN has two types of neural network topologies, the feed forward neural network and the recurrent neural network. In feed forward neural network, the signals flow through layer by layer of processing units without feedback. On the other hand, recurrent neural network has feedback connections from a layer to the previous layer and the dynamic behavior is taken into account.

ANN could perform some tasks after going through learning rule also known as the training algorithm. The learning rule can be classified into three different categories which are, supervised learning, unsupervised learning and reinforcement learning. In supervised learning or associative learning, the network is trained by training set, where inputs and matching output patterns are provided. This training set will be provided either by an external teacher or the system that consist of the neural network. The weights are adjusted so that the output result is closer to the target result. In unsupervised learning or self-organization, the network is trained with respond to the input signals. The weights are adjusted based on the input and there is no target output available. The neural network will perform some clustering operation by its own and progress its representation of input stimuli. In reinforcement learning, it is more similar to a try and error learning and interaction with the environment. The reinforcement