QUANTIFICATION OF HUMAN DRIVING SKILL FOR HUMAN ADAPTIVE MECHATRONICS APPLICATIONS BY USING NEURAL NETWORK SYSTEM

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A project report submitted in partial fulfilment
of the requirements for the award of the degree of
Master of Engineering (Electrical - Mechatronics & Automatic Control)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

JANUARY 2014

To my beloved husband, mother, father and friends

ACKNOWLEDGEMENTS

In the name of Allah, the most gracious and the most merciful.

All praises to Allah for the strengths and His blessing in completing this thesis, Alhamdulillah. I would like to extend my deepest appreciation to my supervisor, Dr. Mohamad Hafis Izran Bin Ishak for his excellent guidance, patience, motivation, immense knowledge and providing me with an excellent atmosphere for doing these project. His guidance helped me in all the time while doing a research and writing this thesis. His support and guidance throughout the project is greatly appreciated. Definitely, without his guidance, I would not be able complete the thesis successfully. Besides my supervisor, my sincere thanks also go to Mr. Mustapha Muhammad, PhD student for helping me going through into deepest research about Neural Network System and leading me working on this project. Other than that, special thanks to my friends Mr. Ab Wafi Ab Aziz, Miss Yeow Seuk Fei, Mr. Auwalu Muhammad, and Mr. Mohd Fitri Allif Mohd Kasai for their supports, critics and ideas while completing this project. Last but not least, I would like to thank my husband, Mr. Mohamad Azwan Abu Bakar for his unconditional support, both emotionally and financially while doing this project. Also, thanks to my parents for always supporting me and encouraging me with their best wishes. Without them, I could not complete these thesis finished on a specific time.

ABSTRACT

Human Adaptive Mechatronic (HAM) is a two way relationship between human and machine. In HAM, not only human need to adapt the characteristics of machine but the machine also has to learn on human characteristic. HAM is an enhance system for Human Machine System (HMS) which consists only one way relationship between human and machine. As a part of mechatronics system, HAM has an ability to adapt with human skill improve the performance of machine. The example of application where HAM can be applied is driving a car. One of the important elements in HAM is the quantification of human skill. Thus, this project proposed a method to quantify the driving skill by using Artificial Neural Network (ANN) system. Feedforward neural network is used to create a multilayer neural network and five models of network were designed and tested using MATLAB Simulink software. Then, the best model from five models is chosen and compared with other method of quantification skill for verification. All simulation data are taken from M. Hafis Izran's in his PhD thesis experiment. Based on results, the critical stage in designing the networks is to set the number of neurons in the hidden layer that affects an accuracy of the outputs.

ABSTRAK

Manusia Adaptive Mekatronik (HAM) adalah hubungan dua hala antara manusia dan mesin. Dalam HAM, bukan sahaja manusia perlu untuk menyesuaikan diri dengan ciri-ciri mesin tetapi mesin juga perlu belajar pada ciri-ciri manusia. HAM adalah sistem meningkatkan Sistem Mesin Manusia (HMS) yang terdiri hubungan satu jalan di antara manusia dan mesin. Sebagai sebahagian daripada sistem mekatronik, HAM mempunyai keupayaan untuk menyesuaikan diri dengan kemahiran manusia meningkatkan prestasi mesin. Contoh aplikasi dimana HAM boleh digunakan adalah memandu kereta. Salah satu elemen penting dalam HAM adalah kuantifikasi kemahiran manusia. Oleh itu, projek ini mencadangkan satu kaedah untuk mengukur kemahiran memandu manusia dengan menggunakan system Rangkaian Neural Buatan (ANN). Rangkaian neural suap depan digunakan untuk mewujudkan satu rangkaian neural multilayer dan lima model rangkaian telah direka dan diuji dengan menggunakan perisian MATLAB Simulink. Kemudian, satu model terbaik dipilih daripada lima model dan dibandingkan dengan kaedah kuantifikasi yang lain untuk pengesahan. Semua data simulasi diambil daripada M. Hafis Izran dalam eksperimen tesis PhD beliau. Berdasarkan keputusan, peringkat kritikal dalam merekabentuk rangkaian adalah untuk menetapkan bilangan neuron pada lapisan tersembunyi yang boleh menjejaskan ketepatan output.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ANN	-	Artificial Neural Network
F	-	Fast
FLS	-	Fuzzy Logic System
HAM	-	Human Adaptive Mechatronic
HMS	-	Human Machine System
HS	-	High Skilled
L	-	Large
LS	-	Low Skilled
M	-	Medium
MD	-	Medium
MS	-	Medium Skilled
OOR	-	Out of Range
S	-	Small
SL	-	Slow
VF	-	Very Fast
VHS	-	Very Highly Skilled
VL	-	Very Large

VLS	-	Very Low Skilled
VS	-	Very Small
VSL	-	Very Slow

LIST OF SYMBOLS

E	-	Actual error obtained by human subject
E_n	-	Normalized Error
E_s	-	Smallest possible error obtained by human subject
J	-	Skill index
T_n	-	Normalized Time
t	-	Time achieved by target
T_B	-	The best theoretical time calculated using maximum speed

CHAPTER 1

INTRODUCTION

1.1 The Relationship between Human and Machine

In this new era of technology, human needs a machine to help them in their daily lives. But most of the machine cannot operate independently without guided and controlled by the human. Therefore, human factor is the main consideration in order to design the motion control system (Harashima and Suzuki, 2006). Unfortunately, the main limitation of HMS is the adaptation of machine as respect to human reaction which the communication between human and machine is not in balance condition (Harashima and Suzuki, 2006). Most of existing machine only required human to understand and learn on machine characteristics which is refer to one way relationship (Harashima and Suzuki, 2006).

1.2 Problem Statement

Based on the data source from World Health Organization (WHO 2011), Malaysia has placed to the number of 20 in world's rank of road traffic accident. This ranking related with regards on the news provided by Utusan Online on 12th October 2011, 5:25 pm, it said that 70 percent of the accident happened in Malaysia has consumed by human error. Another 30 percent contributory factors consumed by road condition and vehicle a defect which covers for 20 percent and 10 percent respectively. From these data, it shows that human error is originates from the weaknesses of human itself such as common mistakes by the driver, injudicious action, or inexperience driver. Several common mistakes that normally happened like failing to observe correctly, sudden braking, swinging over, fail to give a signal and loss of control. Injudicious actions such as exceeding the limit of speed make an illegal turning direction, disobeying double line, and disobeying traffic lights normally provided by several human who did not follow the rules appropriately. Inexperience driver may affect the accident on the road because they are not familiar with road and vehicle conditions, reckless in driving, and careless with driving situation. These entire situations happened in different condition, but it is still in the same type of subject which is the weaknesses of human to make an error.

Based on statistics on accident’s report, Heinrich Domino which is pioneer in the accident causation theories assumed that 88 percent of accidents happened due to dangerous acts by human, 10 percent from unsafe conditions, and another 2 percent are connected with natural disasters (Seyyed Shahab Hosseinian and Torghabeh, 2012). Therefore, from this theory it shows that in any sudden condition, human cannot handle it directly regards to its environment.

Generally, human needs time and effort to operate the machine. It is in the same condition if human want to drive a car. Human should learn on how to operate the car and to manage the car in different environments. Therefore, human needs a guidance and training in order to increase their knowledge and understandings about driving a car. These entire situation shows that, only human has the ability to learn the characteristics of car, but the car does not play any role to improve the skill and performance of human. In other hand, it shows that human still react as a main controller and the machine still cannot identifies the changes of human features.

1.3 Objectives of Project

The objectives of this research in order to achieve the aims of project are:

i. To design an Artificial Neural Network (ANN) system for quantifying on human driving skill.
ii. To obtain the best ANN system of human driving skill.
iii. To verify the results with previous experiment that consists of different method of quantification.

1.4 Scope of Work

In HAM, there are a lot of issues to be discussed. Nevertheless, only a few scopes will be discussed on this thesis as follows:

i. Covers only the main element in HAM which is the quantification of human driving skills.
ii. Neural network system is used to quantify the driving skill.
iii. Simulation data is based on M.Hafis Izran's experimental results.
iv. Simulation, analysis, and validation of the system are completed by using MATLAB. The designed ANN system is verified through a comparison with other methods.
v. The designed ANN system is verified through a comparison with other methods.

1.5 Thesis Layout

This thesis is organized as follows:

Chapter 2 introduces the literature review about Human Machine System (HMS) and Human Adaptive Mechatronics (HAM) which are related with human and their driving skills. The main research that related with HAM is presented.

Chapter 3 defines the methodology that used in order to complete the thesis and its covers only for experimental works by using software applications. Detail explanations of each stage are discussed.

Chapter 4 describes the process to design the Artificial Neural Network (ANN) system for quantifying human driving skill in HAM. Following the system development, data collection method, and network validation method are presented.

Chapter 5 explains the results and discussion of each ANN model. Following the best model, model accuracy, advantages and limitation of the model are discussed.

Chapter 6 summarizes the thesis described in previous chapters. The conclusions and future works are presented.

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