DEVELOPMENT OF A MOBILE ROBOT WITH HUMAN-ROBOT INTERACTION (HRI) FEATURES

Submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Hons.)

by

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DECLARATION

I hereby, declared this report entitled "Development of A Mobile Robot with Human-Robot Interaction (HRI) Features" is the result of my own research except as cited in reference.

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirements for the degree of Bachelor of Manufacturing Engineering. The members of the supervisory committee are as follow:

…………………………………

(Dr. Syamimi Binti Shamsuddin)

ABSTRAK

Interaksi manusia-robot adalah kajian mengenai interaksi antara manusia dan robot yang bertujuan untuk membolehkan interaksi yang berjaya. Objektif kajian ini adalah untuk merekabentuk robot bergerak mudah alih dengan ciri interaksi manusia-robot (HRI) dan untuk membangunkan robot untuk mesra pengguna apabila berinteraksi dengan pesakit dan pelawat di wad hospital. Ciri-ciri HRI robot ini termasuk paparan kristal cecair (LCD) sebagai medium interaktif dan sistem output suara. CATIA P3 V5R20 digunakan untuk merekabentuk robot selepas mempertimbangkan reka bentuk mengenai kos dan kekuatan. Arduino Mega 2560 Rev3 digunakan sebagai pengawal dan diprogramkan menggunakan Arduino IDE. Editor Next digunakan untuk memprogram Graphical User Interface (GUI) pada paparan LCD. Robot menggunakan sensor inframerah garisan untuk menavigasi dari titik permulaan ke katil pesakit. Ia menggunakan sensor ultrasonik untuk mengesan halangan dalam laluannya. Modul text-to-speech Emic 2 digunakan untuk memprogramkan ucapan robot yang telah ditentukan sebelumnya. Robot itu melalui ujian fungsi dimana setiap perkakasan diuji 10 kali untuk menentukan kebolehpercayaannya. Selepas robot melepasi ujian, ia digunakan dalam percubaan kebolehgunaan di Pusat Kesihatan UTeM dengan 2 responden. Kedua-dua responden memberikan maklum balas yang positif mengenai kegunaan robot dalam persekitaran wad terutamanya untuk mengelakkan kebosanan. Tetapi perkakasan terutamanya LCD boleh ditambah baik untuk mempunyai saiz fon yang lebih besar sehingga pesakit senior dan warga tua boleh membaca perkataan di LCD. Kesimpulannya robot itu menunjukkan potensi besar dalam melayani pesakit di masa hadapan.

ABSTRACT

Human-robot interaction is the study on the interaction between a human and a robot aiming to enable a successful interaction. The objectives of this study are to design an assistive mobile robot with a human-robot interaction (HRI) features and to develop the robot to be user friendly when interacting with patients and visitors in the hospital ward system. The HRI features of the robot includes a liquid crystal display (LCD) as the interactive medium and a voice output system. CATIA P3 V5R20 is used to design the robot after a design consideration on the robot's cost and strength. Arduino Mega 2560 Rev3 is used as a controller and programmed using Arduino IDE. Nextion Editor is utilised to program the Graphical User Interface (GUI) on the LCD display. The robot uses line following sensor to navigate from starting point to the patient's bed. It uses an ultrasonic sensor to detect obstacle in its path. A text-to-speech module Emic 2 is used to program the pre-determined speech of the robot. The robot went through a functionality test where each of the hardware was tested 10 times to determine its reliability. After the robot passed the test, it was used in a usability experiment at Pusat Kesihatan UTeM with 2 respondents. Both respondents gave positive feedback about the robot's presense in ward environment especially to avoid boredness. However, the hardware especially the LCD can be improved to have a bigger font size for elderly patients to read the words on the LCD better. In conclusion the robot shows a great potential in serving hospital patient in the future.

DEDICATION

Only

My respected father Zulmi Bin Wan

My appreciated mother Lila Binti P. Mohd Meeran

My siblings Zainab, Zulaika and Zulaini

For giving me moral support, advice, cooperation and encouragement and understandings

Thank You So Much and Love You All Forever

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LIST OF ABBREVIATIONS

HRI   -   Human-Robot Interaction

DOF   -   Degree of Freedom

LCD   -   Liquid Crystal Display

PLC   -   Programmable Logic Circuit

IR   -   Infrared

I/O   -   Input/Output

GUI   -   Graphical User Interface

IoT   -   Internet of Things

PWM   -   Pulse with modulation

LIST OF SYMBOLS

mm   -   Millimetre

cm   -   Centimetre

m   -   Metre

CHAPTER 1

INTRODUCTION

1.1 Background

Hospital, an institution that provides treatment with specialized medical and nursing staff and equipment. They consist of departments or traditionally called wards divided according to cases. In each ward, the nurses will focused on the care of the patients in any way needed so they may recover to their peak health and quality of life. A statistic from the Malaysian Department of Statistic in the year of 2014 shown that the ratio of nurse to population is 1:331, which means that 1 nurse to 331 people. In 2015 the statistic shown that the ratio of nurse to population is 1:312. Even though the ratio is getting better, but for 1 nurse to care and handle for 312 patients is a burden. In accordance with the increase of the Malaysian population in 2016, which is about 31.6 million, to 32 million in 2017, the quantity of nurses to population will either influx up or down depending on the factor whether the production of nurses can keep up with the population growth rate of 1.3%. The similar aging population is also a concern in other countries like in the United States as mentioned by Murray (2002) that there will be a lack of registered nurses by 2020.

As stated by LaCroix (2013), the advancement of medicine will not only bring positive value, but also a negative one, as people are living longer making the age-related disease increased. With the influx of the number of population, the burden placed on the nurses will increase and the quality of the work and service given to the patient will drop as they are overwhelmed by the quantity. The scope of work of the nurses is mainly assisting with daily activities of the patients, including assisting in patient mobility and hygiene management. To cope with patients with various different attitudes and emotion plus with doing a tedious job of repeatable time consuming simple routine task will be quite a task.

Technology is used to help solving the predicament by introducing robots to provide assistance. Robot is a machine, capable of carrying a multifaceted series of actions automatically. It is divided into two main categories which is Industrial Robots and Non-Industrial Robots. In this study, it will discuss on the introduction of service robot in health care setting

1.2 History of Robot

In the Webster's Seventh New Collegiate Dictionary (1966), the word robot originally came from the Czechoslovakian word that means work. Also, robot is a manipulator which can be reprogrammable designed to move material through variable programmed motions (Robot Institute of America, 1979).

Figure 1.1: Model of 'The da Vinci robot' with internal mechanism (Endourol, 2006)

Renaissance Italy, around 1495, Leonardo da Vinci have drafted a humanoid robot. In the journal by Taddei (2008), there are a detailed drawing of a mechanical knight or better known as Leonardo's robot when Da Vinci's notebooks is rediscovered. Though the design was not confirmed if it was ever produced.

In the early 20th century, digital computer or referred as 'Electronic Brain' by the researches is invented. Nilsson (1984) stated that Shakey, an autonomous robot which is capable of steering through a maze was commonly cited. Shakey is a mobile robot invented

by Stanford, that has the ability to perceive and model its environment, it can also complete simple task finding route and rearrange simple objects.

1.2.1 Introduction to social robot
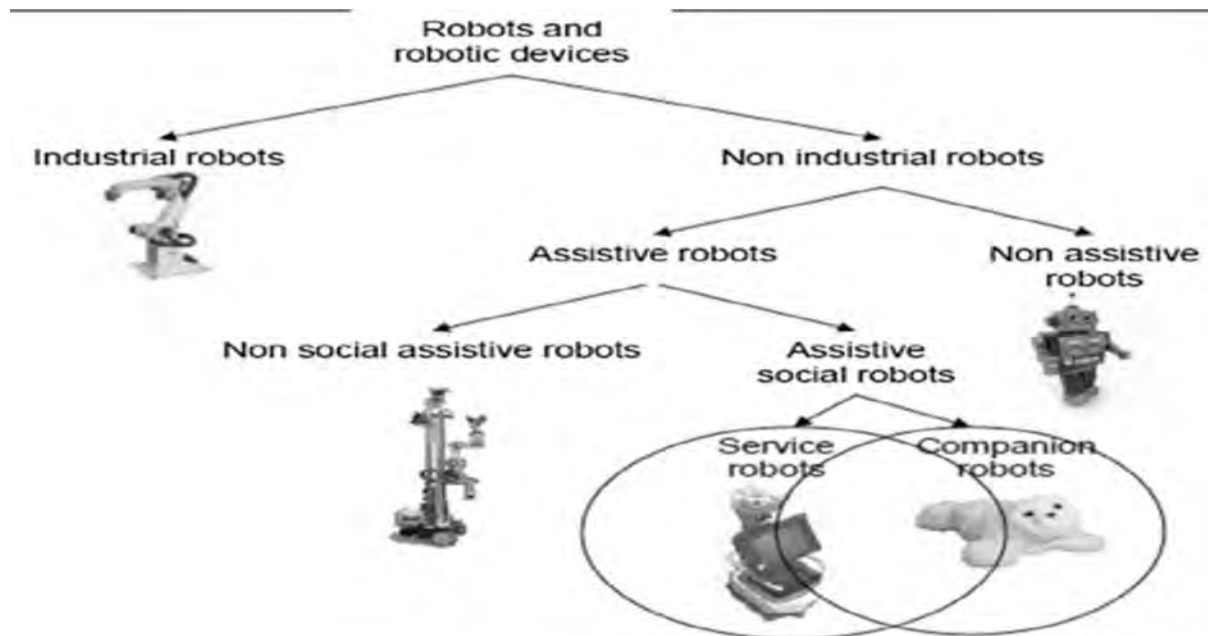
Figure 1.2: A general configuration of robots (Heerink, 2010)

As its name, service robot its main task is to help human by reducing their workload. The service robot is under the assistive social robots classification, where it is one of the branches from the assistive robot as shown in Figure 1.2. Assistive robot when it is introduced to a sensor or screen where it can interact with human will become an assistive social robot. The interaction of a robot and human through the usage of sensor and the screen is called Human-Robot Interaction features.

Social robots apply a social model by people to ease the interaction with them. As the technology becomes more advanced the way human interact with electronic gadgets and appliances have also changed. According to Lee et al (2010), with the fast growth of related technologies and the rise in request for human resources in public settings, it is estimated that robot will act a role in various social part.

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1.2.2 Human-robot interaction (HRI)

Human-robot interaction or known as HRI is the study of the interaction of human and robot that aims to enable a successful interaction between them. There are many studies being done on HRI have been a popular topic with the advance in technology. What is once considered impossible was being done as the expectation of this once defined as worker. Robots is now expected to play a role in society to help ease and interact with human in daily basis.

1.3 Motivation

The purpose of this project is about the design, fabrication and programming of a simple robot with human-robot interaction (HRI) capabilities in healthcare settings.

The main motivation of the study and fabricating of the robot is by the need to expose Malaysian to robot application in healthcare. To date, the exposure of robot in Malaysia is low as stated by (Argenan, 2017) that there is a paucity studies on developing HRI robots for health care applicants in this country. The demand of automation in industry or manufacturing or even in social settings has increased, along with the current trend of automation and data exchange in manufacturing technologies or better known as Industry 4.0. Industry 4.0 is one of examples called industrial revolutions, caused by mechanization, use of electrical energy and electronics and the needs of the people knowledgeable (Benešová & Tupa, 2017). As the increase of demand in using automation and robots, Malaysia must not be left behind, especially since Malaysia in not a research and development (R&D) nation making the exposure and the studies and research low. R&D took too much asset or allowances, but showed little improvement over time and the country cannot afford the expenditure over time because of various reasons and problem.

With the exposure of robots in the service field, such as healthcare settings, the society can be introduced to the new technology and know the benefit of a robot more clearly. Of course, a robot cannot replace a human with a 'warmth' in their care, but they can reduce the burden of the nurse by taking care of the miscellaneous task so the nurse can do a more thorough care to their patient.

1.4 Problem Statement

The research is conducted after identifying 4 main problems that occur in hospital wards.

i) Time needed for a nurse to attend to patients.

In the ward, the nurses are responsible to the well-being of the patient, be it their care nor their problem, the nurse will take care of it with the best of their ability. As the current technology develops, the age of human liveability also increased, making the influx of patients especially the elderly increase. The increase of patient will also increase the burden of the nurse where it will affect the quality and details of care to the patient. This is mentioned by UTeM researches (Argenan, 2017) who develop a simple robot with HRI features to solve the waiting problem of hospital patients and visitors to get attention from a nurse.

ii) Repetitive simple routine

As the number of patients increase as the year increased, the number of nurses cannot catch up with the intake of patients. With too many patients to handle and take care of, the nurse will not have enough time to take care of every patient thoroughly. A simple routine such as checking up on patients, giving medicine or even pouring some water to them is done by the nurse. From Ettelt (1998) the task which were those repetitive simple routine, took time and keep experienced hospital staff from doing their primary job: caring for patients.

iii) Patients in the ward get lonely and bored

As a patient, especially with a chronic disease and in critical condition, they are not allowed to roam around too much as they need a rest. Without nothing to do and no visitor, the patient can get their minds off with interacting with the robot by using the LCD display

iv) Patient's visitor/carers cannot leave patients alone

Sometimes, the visitor cannot leave the patient's alone for example if the patient's is in critical condition or in need of companion. So an interactive mobile robot will be useful to help by bringing a water bottle to the visitor.

1.5 Objectives

The objectives of this study are;

    i)   To design an assistive mobile robot with a human-robot interaction (HRI) features including an LCD display and voice output.

    ii)   To develop and program the robot to be user friendly for the interaction with patients and visitors and test the robot for application in the hospital ward system

1.6 Scope and Limitation

In this paper, the main focus will be the on usage or application of the assistive social robot. The robot will be used in the ward to lessen the burden of the nurse. The robot can help by bringing a water bottle or interact using LCD and voice output with the patient. It will be designed to have a user friendly look using Catia to ease the interaction between the robot and human. Human-robot interaction features like the LCD and the voice output system will be equipped on the robot. The LCD will be programmed to have the clinic's portal and a game to relieve the boredness of the patient. The robot will be controlled using an Arduino Mega controller that will be programmed using Arduino IDE. It will have an infrared sensor or line following sensor for navigation and an ultrasonic sensor for obstacle detection and avoidance.

For the design of the robot, it needs to have a user friendly look with a voice output for some minimal interaction between the patient and the robot, but the design and interaction must not be too human-like. As suggested by (Mori's Uncanny Valley, 1970) human will be more repulsive when the robot created is human-like especially when it look and act not perfectly like human being. As such, human characteristic can't be blindly applied as it can influence people negatively toward social robots (Eyssel *et al*, 2012).

Table 1.1: The Project element and scope covered

Project Element	Scope Covered
Software	Catia Version 5, Arduino IDE, Nextion Editor
Material	Plywood, Acrylic sheet
Controller	Arduino Mega 2560
Hardware	Infrared Sensor, Ultrasonic Sensor, Liquid Crystal Display (LCD) monitor, RF Module, Emic 2
Types of Robot	Mobile Robot
Test method	Survey
HRI Features	Interactive Touchscreen, Voice Output
Algorithm	Line-Following
Target Application	Patients in Pusat Kesihatan UTeM (Emergency Ward)

Table 1.2 shows the Gantt chart for the final year project 1.

Table 1.2: The Gantt chart for Final Year Project 1

Things \ Week		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Title Selection	Planned	▨	▨													
	Actual	▣														
Meeting with Supervisor	Planned	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
	Actual		▣	▣	▣	▣	▣	▣	▣	▣	▣	▣	▣	▣	▣	
Chapter 1: Introduction	Planned		▨	▨	▨											
	Actual			▣	▣	▣										
Chapter 2: Literature Review	Planned					▨	▨	▨	▨	▨						
	Actual						▣	▣	▣	▣	▣					
Chapter 3: Methodology	Planned										▨	▨	▨			
	Actual											▣	▣	▣		
Poster Presentation	Planned													▨		
	Actual													▣		
Submission of Final Report	Planned														▨	
	Actual														▣	

Table 1.3: The Gantt chart for Final Year Project 2

Things	Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Robot and Circuit Design	Planned	�	▪												
	Actual	▪	▪												
Fabrication	Planned		▪	▪	▪	▪									
	Actual		▪	▪	▪	▪	▪								
Troubleshoot	Planned				▪	▪	▪	▪	▪	▪	▪				
	Actual		▪	▪	▪			▪		▪	▪				
Meeting with Supervisor	Planned	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
	Actual	▪	▪		▪			▪			▪	▪	▪	▪	
Testing	Planned							▪	▪	▪	▪	▪	▪		
	Actual						▪	▪		▪	▪				
Analysis	Planned									▪	▪	▪	▪	▪	
	Actual												▪	▪	
Presentation	Planned													▪	
	Actual														