HUMAN-ROBOT INTERACTION (HRI) FOR REHABILITATION PATIENTS WITH AN ANIMAL ROBOT USING IMAGE PROCESSING

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

by

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Date : 19 June 2017

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Robotics and Automation) (Hons). The member of the supervisory committee is as follow:

…….....

(Dr. Syamimi Binti Shamsuddin)

ABSTRAK

Laporan ini membentangkan kajian interaksi robot-manusia (HRI) menggunakan robot haiwan terapeutik untuk pemulihan pesakit yang mengalami kemurungan. Penyelidikan ini melibatkan robot haiwan terapeutik PARO dan dua pesakit dari Pusat Rehabilitasi PERKESO Tun Abdul Razak Melaka. Objektif kajian ini adalah untuk mengenal pasti protokol HRI menggunakan robot haiwan terapeutik PARO untuk pesakit yang mengalami kemurungan dan untuk menganalisa interaksi antara pesakit dan robot haiwan PARO menggunakan algoritma pemprosesan imej OpenCV. Eksperimen ini telah dijalankan dengan dua pesakit dalam dua sesi yang berbeza. Sesi pertama adalah sesi temubual dan memperkenalkan robot kepada pesakit dan interaksi kedua adalah interaksi antara pesakit dan robot PARO. Tempoh interaksi adalah sepuluh minit tanpa PARO dan sepuluh minit interaksi dengan PARO. Sesi kedua telah dijalankan beberapa hari selepas sesi pertama. Tiga kaedah penilaian telah digunakan untuk menganalisa data yang diperoleh daripada eksperimen iaitu kajian HRI, pemprosesan imej dan alat-alat psikologi (yang telah dilakukan oleh ahli psikologi). Dengan menggunakan pemprosesan imej untuk mengesan jumlah senyuman pesakit, peningkatan pada senyuman kedua-dua pesakit semasa interaksi dengan robot PARO dapat dilihat. Keputusan menunjukkan bahawa kedua-dua pesakit gembira dan kadar kemurungan mereka berkurang semasa interaksi mereka dengan PARO.

ABSTRACT

This report presents the study of human robot-interaction (HRI) using therapeutic animal robot for the rehabilitation of patients with depression. The research involved therapeutic animal robot PARO and two patients from Tun Abdul Razak PERKESO Rehabilitation Centre Melaka. The objectives are to identify the HRI protocol using therapeutic animal robot PARO for patients with depression and to analyze the interaction between patient and animal robot PARO using OpenCV image processing algorithm. Experiments were conducted with two patients in two different sessions. The first session was to interview and introduce the robot to the patient and the second interaction was to continue the interaction between the patient and PARO robot. The duration of the interaction was compared between ten minutes without PARO and ten minutes interaction with PARO. The second session was carried out few days after the first session. Three evaluation methods were used to analyze the data collected from the experiments which are HRI survey, image processing and psychological tools (carried out by the psychologist). By using image processing to detect the number of smile of the patient, it can be seen that the number of smiles of both patients increased during the interaction with PARO robot. Results show that both patients were happy and their depression had reduced during their interaction with PARO.

DEDICATION

This project is dedicated to
my beloved father, Hj Santa bin Amir Husin
my appreciated mother, Hjh Jumdariah binti Ali Baradun
my siblings
my housemates
for giving me moral support, financial support, cooperation, encouragement and also understanding
Thank You so Much

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In the name of ALLAH, the most gracious, the most merciful, with the highest praise to Allah that I manage to complete my final year project without any difficulty.

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LIST OF ABBREVIATION

HRI	-	Human-robot Interaction
AAT	-	Animal Assisted Therapy
MATLAB	-	Matrix Laboratory
SAR	-	Search and Rescue
STEM	-	Science, technology, engineering and math
RET	-	Robot-enhance Therapy
MDD	-	Major Depressive Disorder
SAD	-	Seasonal affective disorder
ECT	-	Electroconvulsive Therapy
CBT	-	Cognitive Behavior Therapy
IPT	-	Interpersonal Therapy
MBCT	-	Mindfulness-based Cognitive Therapy
RAT	-	Robot Assisted Therapy
RAM	-	Random Access Memory
PSM	-	Projek Sarjana Muda

CHAPTER 1
INTRODUCTION

1.1 Research Background

Human-robot interaction (HRI) is the interdisciplinary study of interaction dynamics between humans and robots. Researchers and practitioners specializing in HRI come from a variety of fields, including computer science, engineering, humanities, and social. HRI has continued to be a topic of education and popular culture interest. In fact, existence of real-world robots have come long after movies, plays, and novels developed them as notions and start to make inquiries on how peoples and robots would cooperate, and what their particular parts in public area would be. Figure 1.1 shows the interaction between robot and human.

Figure 1.1: Interaction of NAO robot with human (Griffiths, 2014)

With a specific end goal to investigate the social and behavioral mechanisms of HRI, PARO (Figure 1.2) has been introduced to the world. PARO is a socially assistive robot resembling a baby seal and is widely used as a social companion for the elderly.

Nowadays, animal therapy is becoming more popular for its positive mental effects on patients with psychological problems such as dementia and autism (include suitable citation here). This therapy is also known as animal assisted therapy (AAT) or pet therapy. Barker and Dawson (1998) claimed that this treatment alludes to interaction with therapeutic goals between a person or group of individuals for whom the treatment is planned, and a prepared an animal encouraged by its handler. Animal that always been used in animal assisted therapy include cats, dogs or birds, for some reason other animals such as horses, rabbit and fish also can be used and it depending on personal client needs.

Figure 1.2: Therapeutic robot PARO (Shibata *et al*., 2014)

In this project, PARO the same therapy will be used for therapy but this time it focus on patients who are receiving treatment at a rehabilitation centre and this study covers the application of a therapeutic animal robot to give comfort and alleviate stress for patients receiving treatment at a rehabilitation centre.

1.1.1 What is a Robot?

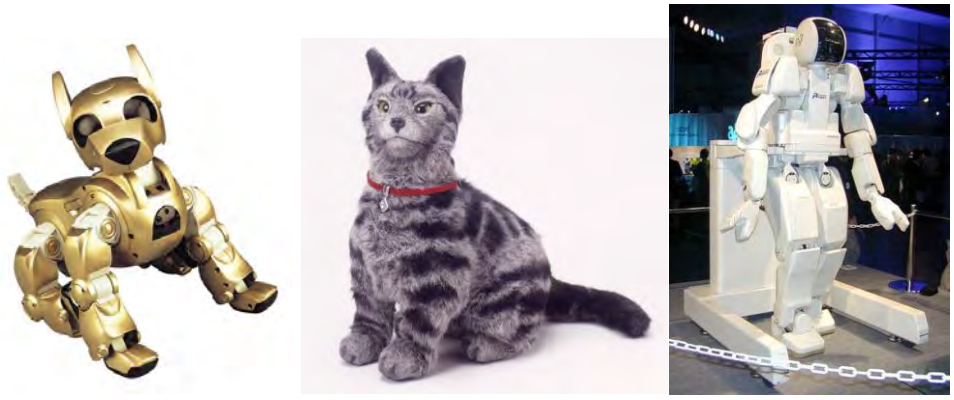
Robotic is a parts of modern technology in which it combine few types of engineering field. Robotics is a science-based technology, where it relates to the application robotic system and theory (Tsai, 1999).

According to Xie (2003), the term “robot” comes from the word Czech “robota” which means “labor doing compulsory manual works without receiving any remuneration” or “to make things manually”. Oxford dictionary defines that “Robot” as “a machine

resembling a human being and able to replicate certain human movements and functions automatically".

Flanagin, 2011 stated that robotics is differing territory of study with applications in various fields and parts of society. Properly designed robotic systems that take into account how they benefit human users make use of multiple methods of evaluation. Flanagin defined robotics as a mechanical framework controlled by installed or PC systems with reason for improving human task

Robot can come in many different forms such as humanoid, arm robot, animal and etc. as shown in Figure 1.3. A robot is developed replication of something that use robotic technology with the end goal of mirroring something else of accomplishing a task. Robot can be control by an outside control device or the control might be implement inside the robot.



(a) (b) (c)

Figure 1.3: Different forms of: (a) I-Cybie (Tiger Electronics); (b) NeCoRo (Omron); (c) Humanoid robot - P3 (Honda) (Fong *et al.,* 2002)

1.1.2 History of Human-robot Interaction (HRI)

In 1980s, robotics was perceived as on a very basic level interdisciplinary, with major commitments from mathematics, biology, computer science, control theory, electrical engineering, mechanical engineering, and physics. By the 1990s, robots were progressively required in mechanized assembling situations, in deep-sea and space investigation, in military operations, and in lethal waste administration. Predictions abounded that robots would get to be distinctly vital in home and office situations too. Toward the start of the twenty-first century, we are nearer to the day when different robot substances might be coordinated into individuals' day by day lives (Anna, 2016).

Similarly as computers started as scholarly and research-related computational devices however got to be distinctly individual electronic frill for the overall population, robots now can possibly serve not just as cutting edge workhorses in logical attempts additionally more personalized appliances and assistants for ordinary people. In any case, while the study of human-computer interaction has a moderately long history, it is just as of late that adequate advances have been made in automated discernment, activity, thinking, and programming to permit researchers to start genuine thought of the intellectual and social issues of human-robot interaction (Anna, 2016).

A leap forward in independent robot innovation happened in the middle 1980s with work in conduct base on mechanical technology. A moment critical achievement for robotic as it applies to HRI is the rise of hybrid architecture; these designs all the while permit refined receptive practices that give central robot capacities alongside the abnormal state psychological thinking required for unpredictable and persevering collaborations with people. Robot practices at first centered on mobility, yet later commitments look to create exact anthro209 pomorphic practices, adequate practices of family unit robots, and alluring practices for robots that take after, pass, or approach Humans (Goodrich and Schultz, 2007).

Each robot application seems to have some type of association (Figure 1.4), even those that may be considered "fully autonomous". For a tele-operated robot, the sort of cooperation is self-evident. For a completely autonomous robot, the association may

comprise of abnormal state supervision and course of the robot, with the human giving objectives and the robot keeping up information about the world, the assignment and its limitations. Also, the collaborations might be through perception of nature and understood correspondences by, for instance, the robot reacting to what its human companion is doing. Taking an extremely wide and general perspective of HRI, one should seriously think about that it incorporates creating calculations, programming, testing, refining, handling, and keeping up the robots (Goodrich and Schultz, 2007).

Figure 1.4: Representative types of robots. In clockwise order beginning in the upper left: Robota; SonyAIBO; A sophisticated unmanned underwater vehicle; Shakey; Kismet; Raven; iRobot_ PackBot (Goodrich and Schultz, 2007)

For this situation, communication comprises basically in finding and diagnosing issues, taking care of these issues, and afterward reconstructing (or rewiring) the robot. The contrast between this sort of "programmingbased" interaction and advanced HRI is that the field right now underscores proficient and dynamic collaborations instead of simply rare interactions.

Notwithstanding, a few researchers are tending to programming based of interaction by investigating productive programming ideal models to support robot development (Horswill, 2000).

1.1.3 What is Human-robot Interaction (HRI)?

Human-robot interaction (HRI) is fields of study committed to design, understand, and examines the framework of robotics for use by humans (Bani Hashim, 2016).

Interaction, means that a communication between human and robot. It may happen in many forms, but the forms are usually changed if the human and the robot are in close proximity to each other or not. Hence, there are two types of communication between human and robot, Figure 1.5 shows spatial classification of HRI.

a) Remote interaction – The human and the robot are not arranged and are isolated spatially or even transiently.

b) Proximate interaction – The people and the robots are assembled.

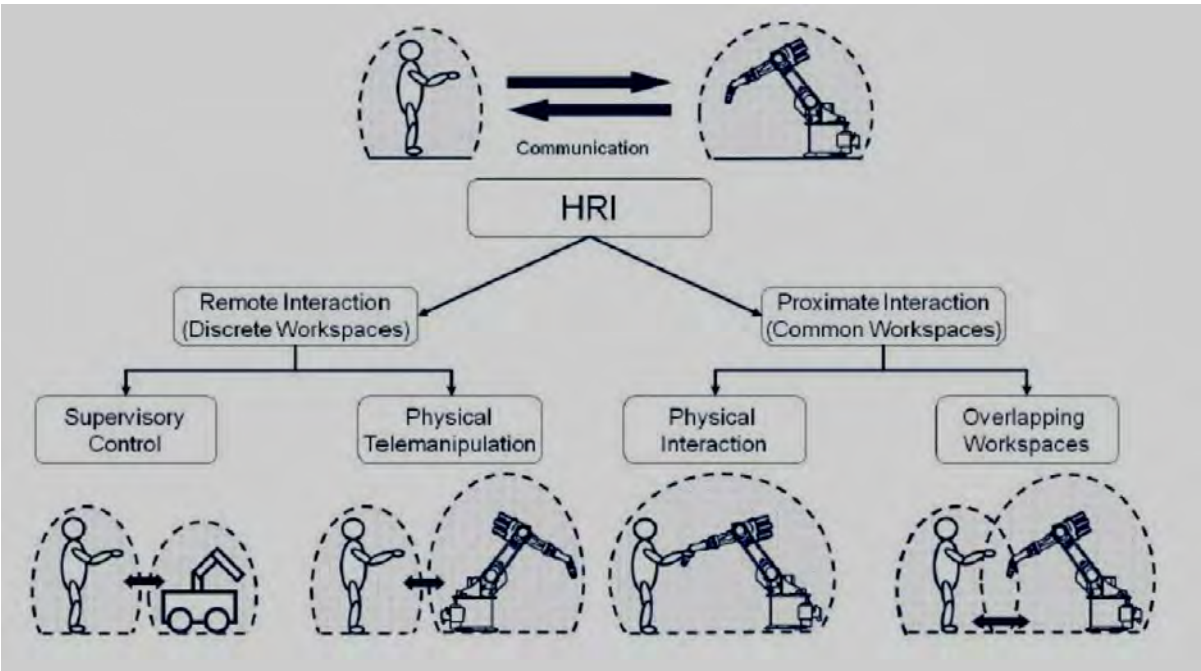


Figure 1.5: Spatial classification of HRI (Bani Hashim, 2016)

In this general class, it is valuable to separate between function that required social collaboration, versatility, or physical control. Remote cooperation with versatile robots is usually referred to a supervisory control or teleoperation, and remote connection with a physical controller is regularly referred as tele-control.

Proximate interaction with versatile robots may appear as a robot aide, and proximate association may incorporate a physical cooperation. Social communication incorporates social, emotive, and psychological parts of association. In social collaboration, the people and robots connect as associates or colleagues. Imperatively, social connections with robots give off an impression of being proximate as opposed to remote due the volume of work in social associations is unfathomable (Goodrich and Schultz, 2007).

It has been a theme for human-robot interaction in hypothesis and sci-fi even before the robot itself exist. Various parts of HRI are continuations of human correspondences subjects that are more seasoned than apply autonomy, since HRI depend on information of (at times regular) human correspondence. The HRI origin as a discrete trouble was reported by 20th –century author Isaac Asimov in 1941, in his novel I, Robot. He states the Three Laws of Robotics as (Feil-Seifer and Matari´, 2009):-

a) A robot may not injure a human being or, through inaction, allow a human being to come to harm.
b) A robot must obey any orders given to it by human beings, except where such orders would conflict with the First Law.
c) A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

The three laws of robotics resolve an idea for a safe interaction. More risk of a human being injured will be rises if human and the robot get closer and the relationship are more intricate. Advance societies manufacturing employing robot overcome the problem by not allowing human and robot share the same workspace at a time was achieved by increasing the scale of safe zone and cages (Máximo, 2012)

1.1.4 Types of Robot in Human-robot Interaction

There are several types of robot used in HRI with different application such as mobile robot, humanoid robot and animal robot. This robot either for military, service, hospitality, and etc.

Autonomous mobile robots are the realization of the technology of mobility and task's execution techniques. The technology of movement is the mechanisms that allow a mobile robot to move through a real-world environment that includes locomotion, sensing, localization, and motion planning (Bani Hashim, 2016)

Mobile robot is a robot that can move from one place to another without any assistance from human operator (Figure 1.6). Mobile robot have a special feature which it can move freely within a predefine workspace to achieve the desired goal unlike industrial robot that can only move in a specific workspace. This capability make mobile robot suitable for a large repertory of application structure or unstructured environments (Tzafestas, 2014).

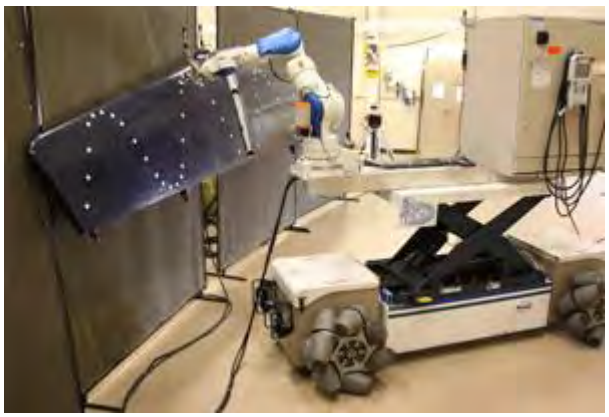


Figure1.6: Mobile robot working on aircraft wing (Brumson, 2012)

Siegwart *et al.* (2011) states that mobile robots need locomotion mechanisms that enables it to move unbounded throughout its environment.

The field of humanoids robotics, widely recognized as the current challenge for robotics research, is attracting the interest of many research groups worldwide. Important efforts have been devoted to the objective of developing humanoids and impressive results