



Faculty of Manufacturing Engineering

**HUMAN-ROBOT INTERACTION WITH ANIMAL ROBOT
PARO FOR PATIENTS WITH DEPRESSION**

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Master of Science in Manufacturing Engineering

2019

**HUMAN-ROBOT INTERACTION WITH ANIMAL ROBOT PARO FOR
PATIENTS WITH DEPRESSION**

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**A thesis submitted
in fulfilment of the requirements for the degree of Master of Science
in Manufacturing Engineering**

Faculty of Manufacturing Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2019

DECLARATION

I declare that this thesis entitled “Human-Robot Interaction with Animal Robot PARO for Patients with Depression” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :.....

Name :.....

Date :.....

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Manufacturing Engineering.

Signature :.....

Supervisor Name :.....

Date :.....

DEDICATION

To my beloved mother

ABSTRACT

Researchers in the field of human-robot interaction (HRI) have developed many types of robots to interact with humans. Mental healthcare with the aid of robots is one of the branches in HRI studies. Presently, animal-assisted therapy (AAT) has been commonly used to give positive mental impact to patients in term of psychological, physiological and social. However, the use of animals exposes patients to zoonotic infection, bites and scratches. HRI studies have covered the role of animal robots for people affected with mental illness. World Health Organization (WHO) has classified depression as a common illness worldwide, with an estimated 350 million people affected. Depression is a serious mental illness. If left untreated, it could even lead to suicide. Animal robot PARO is classified as a Class II medical device by U.S. Food and Drug Administration (FDA). PARO has potential as an assistive device to treat depression. Previously, PARO is successful to help patients with dementia and Alzheimer. The aim of this study is to introduce PARO as a short-term companion to help patients manage depression during rehabilitation period at a multidisciplinary centre. PARO was used as an assistive device in the therapy for rehabilitation patients with post-stroke depression. This group was chosen because they have the highest rate of depression (30-35%) compared to other types of disabilities. Though animal robot therapy is on the rise, but in Malaysia, the awareness is still low. Thus, the first objective of this study is to investigate the perception of Malaysians towards PARO. Survey method was used to 112 public respondents and 12 rehabilitation patients. Survey results show that 91-96% of respondent were able to accept animal robot PARO during their first encounter with the robot. An interaction protocol for human-robot interaction was designed to enable PARO to be used as an assisted device. The interaction protocol was model based on literature review, discussion with experts and the study result on the robot perception. To evaluate the effect of human-robot interaction, an experiment was conducted at SOCSO Tun Razak Rehabilitation Centre (TRRC), Melaka using the experimental method. Patients were assessed using psychological tools in term of depression, anxiety and sleep quality. From the results, the depression reduced by 35%, where the severity level improved to normal level of depression. The third objective of this study is to develop HRI assessment tool using OpenCV-Python for smile detection. This is to further investigate the outcome of HRI between patients and PARO. By using Haar cascade classifier method, the pre-processing program was able to clean the dataset and improve the accuracy to 8-12%. Both psychological and HRI tools show congruency ($P < 0.001$) on the experimental results involving one patient for a pilot experiment and six patients for primary experiment. After interacting with PARO for three sessions within one month, the patients show positive results. Most of the patients show an increase in the number of smiles by 42% and recovery from depression and anxiety. This study proves that HRI using an animal robot can help patients by reducing their stress level through a facilitated therapy session.

ABSTRAK

Penyelidik di dalam bidang interaksi robot dan manusia (HRI) telah membangunkan pelbagai jenis robot untuk berinteraksi dengan manusia. Penjagaan kesihatan mental dengan bantuan robot adalah salah satu cabang dalam bidang HRI. Ketika ini, terapi menggunakan bantuan haiwan (AAT) kerap digunakan dan memberi impak yang positif di dalam konteks psikologi, fisiologi dan sosial. Walau bagaimanapun, penggunaan haiwan mendatangkan risiko seperti jangkitan, gigitan dan cakaran. Kajian HRI telah merangkumi peranan robot-haiwan untuk mereka yang menghadapi penyakit mental. World Health Organization (WHO) telah klasifikasikan kemurungan sebagai penyakit umum yang biasa dihidapi diseluruh dunia, dan dianggarkan sebanyak 350 juta orang telah terkesan daripadanya. Kemurungan adalah penyakit mental yang serius. Jika dibiarkan tanpa rawatan, penyakit mental ini boleh membawa kepada pemikiran seseorang itu untuk membunuh diri. Robot-haiwan PARO telah diklasifikasikan sebagai kelas dua alat perubatan oleh U.S. Food and Drug Administration (FDA). Sebelum ini, PARO telah berjaya menolong pesakit demensia dan Alzheimer. Kumpulan pesakit ini dipilih kerana kadar kemurungan mereka berada di tahap tertinggi (30-35%) berbanding penyakit lain. Objektif pertama kajian ini adalah untuk mengkaji persepsi rakyat Malaysia terhadap PARO. Majoriti daripada responden kajian adalah sebanyak 112 orang awam dan 12 pesakit rehabilitasi. Keputusan kajian menunjukkan 91-96% dari responden dapat menerima PARO sebagai robot. Tujuan kajian ini dijalankan adalah untuk memperkenalkan PARO sebagai teman jangka pendek untuk membantu pesakit mengurus kemurungan mereka. Objektif kedua kajian ini menggunakan kaedah eksperimen. Pesakit dinilai dari segi kemurungan, kebimbangan dan masalah tidur. Keputusan kajian mendapati 35% tahap kemurungan berkurang. Protokol interaksi untuk HRI telah berjaya dicipta untuk menggunakan PARO sebagai alat bantuan terapi. Protokol interaksi ini dicipta berdasarkan kajian semula penyelidikan, perbincangan dengan pakar dan hasil kajian persepsi terhadap robot. Untuk mengkaji keberkesanan PARO, eksperimen ini dijalankan di SOCSO Tun Razak Rehabilitation Centre (TRRC), Melaka. Untuk mengkaji keberkesanan HRI melalui penglibatan pesakit dan PARO, alat penilaian telah dibangunkan dengan menggunakan OpenCV-Python dengan mengenal pasti senyuman. Dengan menggunakan kaedah Haar cascade classifier, program ini dapat meningkatkan kecekapan dalam 8-12%. Kedua-dua alat psikologi dan alat HRI menunjukkan kesesuaian terhadap hasil eksperimen ($P < 0.001$) yang melibatkan satu pesakit untuk kajian perintis dan enam pesakit untuk kajian utama. Selepas berinteraksi bersama PARO selama tiga sesi di dalam jangka masa sebulan, pesakit menunjukkan kesan positif. Senyuman pesakit rehabilitasi meningkat 42% dan diikuti dengan pemulihan terhadap penyakit kemurungan dan kebimbangan. Kajian ini membuktikan penggunaan HRI yang melibatkan robot haiwan mampu menolong pesakit untuk mengurangkan tekanan yang dihadapi ketika menjalankan sesi terapi.

ACKNOWLEDGEMENTS

First and foremost, I would like to take this opportunity to express my sincere acknowledgement to my supervisor Dr. Syamimi Binti Shamsuddin from the Faculty of Manufacturing Engineering Universiti Teknikal Malaysia Melaka (UTeM) for her essential supervision, support and encouragement towards the completion of this thesis.

I would also like to express my greatest gratitude to Dr. Fairul Azni Bin Jafar, co-supervisor of this project for his advice and suggestions in evaluation. Special thanks to UTeM short term grant funding for the financial support throughout this project.

Particularly, I would also like to express my deepest gratitude to SOCSO Tun Razak Rehabilitation Centre (TRRC), Melaka especially to Dr. Hafez Bin Hussain executive director of the SOCSO TRRC , Mr. Lim Thiam Hwee, rehabilitation psychologist and Dr. Fazita Binti Abdul Talib rehabilitation medical officer.

Special thanks to all my peers, my mother and siblings for their moral support in completing this degree. Lastly, thank you to everyone who had been to the crucial parts of realization of this project.

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LIST OF ABBREVIATIONS

AAA	-	Animal-Assisted Activities
AAT	-	Animal-Assisted Therapy
ANOVA	-	Analysis of Variance
AUC	-	Area Under the Curve
AVI	-	Audio Video Interleave
BBC	-	British Broadcasting Corporation
BDI	-	Beck Depression Inventory
BSD	-	Berkeley Software Distribution
CES-D	-	Center For Epidemiologic Studies-Depression Scale
CHMM	-	Characteristic Hidden Markov Model
CK	-	Cohn-Kanade
CPG	-	Clinical Practice Guideline
CSV	-	Comma-Separated Values
CT	-	Computed Tomography
EEG	-	Electroencephalogram
EKG	-	Electrocardiography
EMG	-	Electromyography
HAM-A	-	Hamilton Anxiety Rating Scale
HAM-D	-	Hamilton Depression Rating Scale
HD	-	High Definition

HOG	-	Histograms of Oriented Gradients
HRI	-	Human-Robot Interaction
HRSD	-	Hamilton Rating Scale for Depression
IDE	-	Integrated Development Environment
IEEE	-	Institute of Electrical, And Electronics Engineers
JAFEE	-	Japanese Female Facial Expression
K10	-	The Kessler
KR-20	-	Kuder-Richardson 20
LBP	-	Local Binary Pattern
LDA	-	Latent Dirichlet Allocation
LDA	-	Linear Discrimination Analysis
LDCRF	-	Latent-Dynamic Conditional Random Field
LPQ	-	Local Phase Quantization
MDD	-	Major Depressive Disorder
MDS	-	Minimum Dataset
MOH	-	Ministry of Health Malaysia
OT	-	Occupational Therapy
PANAS	-	Positive and Negative Affect Schedule
PHQ-9	-	Patient Health Questionnaire -9
PSD	-	Patients with Post-Stroke Depression
PT	-	Physical Therapy
RAM	-	Random Access Memory
RAT	-	Robot Assisted Therapy
RM	-	Ringgit Malaysia

ROCR	-	Receiver Operating Characteristic
SPSS	-	Statistical Package for The Social Sciences
ST	-	Speech Therapy
SVM	-	Support Vector Machine
TRRC	-	Tun Razak Rehabilitation Centre
WHO	-	World Health Organization
XML	-	Extensible Markup Language

LIST OF SYMBOLS

ρ	-	Rho value of 100
n	-	Sample size
σ^2	-	Variance
Σ	-	Sum up

LIST OF PUBLICATIONS

1. Zulkifli, W.Z., Shamsuddin, S., Jafar, F.A., Manaf, R.A., Alarood, A.A., and Hwee, L.T., 2018. Smile Detection Tool using OpenCV-Python to Measure Response in Human-Robot Interaction with Animal Robot PARO. *International Journal of Advanced Computer Science and Applications*, pp. 365-370.
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