SMART ROBOTIC ARM IN MEDICINE ALLOCATION APPLICATION

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2019

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A report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Mechatronics Engineering with Honours

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2019

DECLARATION

I declare that this thesis entitled “SMART ROBOTIC ARM IN MEDICINE ALLOCATION APPLICATION” 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 checked this report entitled “SMART ROBOTIC ARM IN MEDICINE ALLOCATION APPLICATION” and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Mechatronics Engineering with Honours

Signature : ....

Supervisor Name : ....

Date : ....

DEDICATIONS

To my beloved mother and father

ACKNOWLEDGEMENTS

First and foremost, I wish to express my greatest appreciation and deepest gratitude to my supervisor, Professor Madya Dr. Chong Shin Horng for guiding and encouraging me throughout the entirely final year project. I would like to thank her for giving me valuable advice and suggestion on this report. Without her support and interest, this report would not have been the same as presented here. I am grateful for her patience and constructive comments that enriched this project. In particular, I would like to express my deep sense of thanks to my panels, Dr. Hairol Nizam bin Md Shah and Dr. Nurdiana bt Nordin for the comments and suggestions in that helping me in improving this project.

Next, my sincere gratitude is extended to all my fellow postgraduate students as well as my beloved friends and family for giving their generous efforts and assistances in enlightening me with their views and ideas. Their comments and suggestions are crucial for completing this project successfully. Last but not least, I place on record, my sense of gratitude to one and all who, directly or indirectly, have offered their helping hand during the entire period of final year project.

ABSTRACT

Medications are the most typical treatment intervention that used in healthcare to improve the health and well-being of patients. However, medication errors contain potential risk in affecting patient safety as well as treatment costs which then cause hazards for patients and their family. Hence, this project has proposed a Smart Robotic Arm in Medication Allocation Application in that to assits healthcare profession by reducing their tasks on medication dispensing. This project is developed by using TeraSoft 6 Degree of Freedom (DOF) Intelligent Technology Robot Arm System with code label based object recognition model. The inverse kinematic model is designed in Simulink Environment to control the position of Smart Robotic Arm for medication allocation. While, the code label based object recognition model is designed with Raspberry Pi Camera Module V2 and OpenCV ran in Raspberry Pi Model 2B for reading information of desired medication. The performance of the Smart Robotic Arm system is tested. The results have showed that the designed inverse kinematic model is capable in providing accurate solution after comparing with kinematic model that built in Peter Corke Robotics Toolbox. However, the designed robot controller has showed the limitation in optimizing the performance since the Smart Robotic Arm have experienced the steady-state error as well as vibration issue during positioning. Hence, the poor performance of robot controller has lead to the errorneous of Smart Robotic Arm in reaching the desired position in actual environment. Besides, the physical defecting in Smart Robotic Arm has also directed to the errorneous in reaching the desired position as well. Other than that, the code label based object recognition is built successfully and it has reached 100% accurate in detection and recognition of clear and blurred Quick Response (QR) code in 5cm between camera sensor and QR code image.

ABSTRAK

Ubat-ubatan adalah intervensi rawatan yang paling biasa yang digunakan dalam penjagaan kesihatan untuk memperbaiki kesihatan dan kesejahteraan pesakit. Walau bagaimanapun, kesilapan ubat mengandungi risiko untuk menjejaskan keselamatan pesakit serta kos rawatan yang menyebabkan kesusahan bagi pesakit dan keluarganya. Oleh itu, projek ini telah mencadangkan Lengan Robotik Pintar dalam Aplikas Pengambilan Ubat untuk membantu profesion penjagaan kesihatan dengan mengurangkan tugas mereka mengenai pengambilan ubat. Projek ini dibangunkan dengan menggunakan Sistem Lengan Robot Teknologi TeraSoft 6 Darjah Kebebasan (DOF) dengan model pengiktirafan objek berdasarkan label kod. Model kinematik songsang direka di Simulink untuk mengawal Sistem Lengan Robot dalam pengambilan ubat. Walaupun, model pengiktirafan objek berdasarkan label kod direka dengan Raspberry Pi Kamera Module V2 dan OpenCV beroperasi dalam Raspberry Pi Model 2B untuk membaca maklumat ubat yang dikehendaki. Prestasi sistem Lengan Robotik Pintar telah diuji. Hasilnya menunjukkan bahawa model kinematic inverse yang direka mampu memberikan penyelesaian yang tepat selepas membandingkan dengan model kinematik yang dibina di Peter Corke Peralatan Robotik. Walau bagaimanapun, sistem pengawal robotik yang direka menunjukkan kelemahan dalam mengoptimumkan prestasi kerana Lengan Robotik Pintar telah mengalami "*steady state erro*r" serta isu getaran semasa pergerakan. Justeru, kelemahan pretasi dalam sistem pengawal robotik telah menyebabkan Sistem Lengan Robot tidak dapat mencapai koordinat yang dikehendaki dalam persekitaran sebenar. Selain itu, kecacatan fizikal di Sistem Lengan Robot juga telah menyebabkan Sistem Lengan Robot tidak dapat dalam mencapai koordinat yang diinginkan juga. Selain itu, pengiktirafan objek berasaskan label kod dibina dan ia telah mencapai 100% tepat dalam pengesanan dan pengiktirafan kod "*Quick Response (QR)*" sama ada label kod yang jelas atau kabur dalam 5cm antara sensor kamera dan imej kod "*QR*".

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LIST OF SYMBOLS AND ABBREVIATIONS

DOF	-	Degree of Freedom
QR Code	-	Quick Response Code
N/A	-	Not Available

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CHAPTER 1

INTRODUCTION

1.1 Background

Medications are drugs that used in treatment to improve the health or treat disease. However, medication errors, a failure in treatment process will has potential risks to harm patient. Heavy duty of healthcare profession had increased their burden and hence it will make them unable to be distracted which may lead to medication errors to be occurred. In order to deal with this situation, a robotics system is needed to assist healthcare profession in that allowing them to pay attention to more important tasks.

1.2 Motivation

Medications are the most typical treatment intervention used in healthcare to improve the health and well-being of patients [1]. However, medication errors contain potential risk in affecting patient safety as well as treatment costs which then cause hazards for patients and their family. The National Coordinating Council for Medical Reporting and Prevention has defined medication error as any preventable event that may lead to inappropriate medication use or patient harm while the medication is in the control of the healthcare professional, patient or consumer [2]. In 2016 [3], a Johns Hopkins study has claimed that medical errors are the third leading cause of deaths in U.S which kills more than 250,000 people per year. Based on Patient Safety Unit of Health Ministry in 2014 to 2015 [4], they have received report of 3,526 medication errors and 248.307 near misses.

Typically, medication process has 5 stages which include prescribing, transcribing, dispensing, administering and monitoring [5]. Based on the studies in [6, 7], prescribing, the appropriate medication selection stage was the most common medication error which account more than 40% of medication errors. The studies also claimed that distraction is one of the main reasons for medication errors as about 75%

of medication errors have attributed to this reason. This is due to the healthcare profession have many duties in hospital or pharmacy and hence they are needed to complete the duties quickly in order to maintain hospital productivity. In the study of [8], percentage of errors was greater when only 1 pharmacist on duty compare to 2 pharmacists on duty which is 68% versus 29%. Hence, it is clearly showed that lack of adequate healthcare profession or pharmacist is one of the major reasons lead to medication errors.

However, robots nowadays are increasingly interacted and integrated into various working tasks to assists or replace humans due to their productivity, expert reliability and repeatability [9]. Besides, robot is capable to work around the clock without affecting the standard of quality and to perform rising range of 3D (dirty, dangerous and dull) tasks [10]. Moreover, the development of the artificial intelligence (AI) and machine learning in recent are believed will opening a door for robotic field to next revolution. As reasons, they have dealt with computer vision in that providing robots capability to see and identify the objects. So, this research has proposed a smart robotic arm with object recognition feature in medicine allocation application in that allowing the healthcare profession able to focus on more important tasks.

1.3 Problem Statement

Trajectory planning is a vital issue that needed to be considering in robotic application and automation[11, 12]. As reason that, an ineffective trajectory planning will directly influence the accuracy of controlling robot arm in complete the tasks. Based on the studies, kinematics and dynamics are constraints that commonly to be considered during trajectory planning. However, only kinematics which deal with position control of manipulator arm will be focused on this research due to increasing of computational efforts when involve dynamics.

Object recognition knows as a computer vision technique that identifying objects in digital videos or images. Deep learning and machine learning algorithms are the familiar approaches in object recognition. Regard to previous research, a lot of object recognition techniques able to identify and classify the objects with high accurate results based on the neural network training, feature extraction or colour detection. However, the erroneous in recognition still can be occurred especially between two look-alike objects [13]. With text recognition, the look-alike objects can be differentiated based on their item's details on imprinted text. However, the accuracy of text recognition is easily affected by front type, character-character spacing, noise in image and tilting [14]. Hence, an object recognition technique that able to differentiate the look alike sound like (LASA) medication is needed in this research so that to prevent medication errors espiacially in dispensing stages.

1.4 Objectives

This project embarks on achieving the following objectives upon its completion:

i) To develop a kinematic model for positioning control of a smart robotic arm in medication allocation application.

ii) To develop smart robotic arm with an object recognition feature for identifying medicine.

iii) To validate the smart robotics arm performance in term of kinematics positioning as well as recognize medicine.

1.5 Scope

In accomplishing the intended objectives stated above, the scope below must be considered:

i) The smart robotic arm is developed by using TeraSoft 6 DOF Intelligent Technology Robot Arm System with Raspberry Pi 8MP Camera Module V2.

ii) The kinematic model for positioning control of smart robotic arm is focused in this research and hence only geometry issues such position and orientation will be considered. Besides, this model is built by using Matlab Simulink software in personal computer and used in controlling smart robotic arm through Micro-Box 2000/2000C, a controller.

iii) The object recognition with code label is focused in this research and it is developed by using OpenCv in Raspberry Pi 2 Model B, a microprocessor.

iv) The smart robotic arm is working at a lighting condition.

v) There only one code label is presented in camera each time.

1.6 Thesis Outline

This research project is documented and structured as follows. Chapter 2 discuss the literature reviews based on previous researches and findings. Chapter 3 provides methodology used in this project in that to achieve the objectives mentioned above. The analysis and discussion on results of this project are included in Chapter 4. Lastly, the conclusion of entire research as well as recommendation for future work are presented in Chapter 5. All the references and appendices related to this research are attached at the end of the thesis.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discuss the theoretical background that relate to the project. Besides that, the researches review on journals and conference papers according to research scope also has included in this chapter. Then, a short summary is provided at the end of this chapter to conclude the research gap as well as the finding on literature reviews.

2.2 Robotic Arm

Robotic arm is also known as robot manipulator which commonly programmable with human-like arm function[15]. The rigid members of robotic arm are named as links and they are connected by the moveable components called joints in that allowing either rotational or translational motion between adjacent links. Thus, it is seen that a kinematics chain is created from the links of robotic arm. At the end of the kinematics chain of robotic arm, an end effector, a device or an actuator that designed to accomplish desired task such welding, spinning and grasping is attached. In generally, robotics arm made of 5 and more joints and hence made it to precisely carry out human works [15, 16]. Besides, the robotic arm can be either autonomous or controller manually as well as fixed or mobile in design. Based on the mechanical structure, the robotic arm can be then classified into 6 main types which include cartesian robot, cylindrical robot, spherical robot, articulated robot, selective compliance articulated robot arm (SCARA robot) and parallel robot.

Cartesian robot as shown in Figure 2.1 is also known as linear or gantry robot. It is a robot with 3prismatic joints that coincide with cartesian coordinate axes.

Figure 2.1: Cartesian Robot [17]

Cylindrical robot as shown in Figure 2.2 is a robot which consist of at least one rotary joint at the base and one linear joint for links connection in that allowing it to work within a cylindrical workspace.

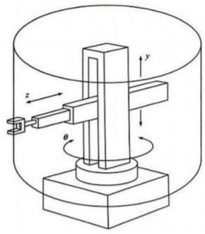

Figure 2.2: Cylinder Robot [17]

Spherical robot as shown in Figure 2.3 is also named as polar robot. It is a robot which generally included one linear joint with two rotary joints in that creating a polar coordinate system and workspace.

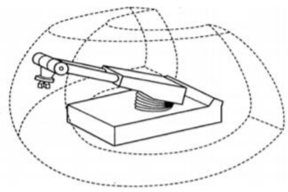

Figure 2.3: Spherical Robot [18]

Articulated robot as shown in Figure 2.4 is a robot that featured two rotary joints or more. In common, the links of arm are joined by rotary joints and arm is attached to the base with a twisting joint.

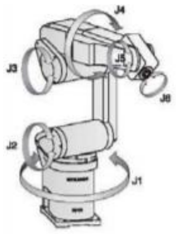

Figure 2.4: Articulated Robot [17]

SCARA robot as shown in Figure 2.5 is a robot that consist of two parallel rotary joints that provide it to move along the plane.

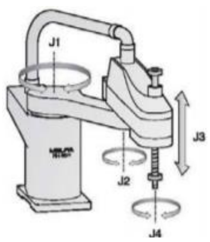

Figure 2.5: Selective Compliance Articulated Robot Arm, SCARA Robot [17]

Parallel robot as shown in Figure 2.6 is also named as delta robot, a spider like robot. It is built by connecting the jointed parallelogram end effectors to a fixed base.

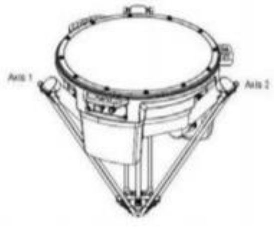

Figure 2.6: Parallel Robot [17]

2.3 Robotic Arm Trajectory Planning

Trajectory planning is one of most vital and fundamental topics in robotics field [12]. Trajectory planning consists in finding a temporal motion law over a specific geometric path based on goal that desired to be achieved by a robot. The kinematic and dynamic constraints are other inputs need to be considered during the trajectory planning. However, the robot dynamics are commonly ignored during the trajectory planning process to reducing computational efforts. While, the trajectory output will be the time function of the robot's moving path.

In general, the trajectory planning consists of two different sections which include joint space trajectory planning and cartesian space trajectory planning based on the elements that being controlled during the robotic motion control. For the joint space trajectory planning, each joint angle is controlled separately so that desired movement of manipulator in term of position and orientation is occurred through forward kinematics. On the other hand, the inverse kinematics provide the solution to cartesian space trajectory planning in determining the alteration of angle of joints based on the position and orientation of manipulator.

In [19], Zhao has studied the polynomial trajectory planning for 6 DOF robotics arm. The cubic polynomial interpolation and quantic polynomial interpolation methods for joint space trajectory planning are being compared in this paper. The motion planning of the manipulator from the starter point to the target point is realized by the cubic polynomial interpolation and the quantic polynomial interpolation method respectively. The angle, velocity, acceleration curve is also obtained in Matlab simulation. After comparing and analysing, the results show that the quantic polynomials method has more obvious effect on the trajectory planning of the 6-DOF robotic arm. The quantic method is proved that can make the robotic arm to run smoothly, reduce the occurrence of jitter and vibration, improve the stability of system, prolong the life of robotic arm.

L. Wu et al has proposed an iterative algorithm by applying the Levenberg-Marquardt (LM) in exacting inverse kinematics solution for a class of 7R 6-DOF robots with non-spherical wrist in [20]. By introducing a virtual wrist centre, an analytical solution is first presented and used as an estimation of exact solution as well as an initial data for further algorithms. From the product of exponentials (POE) formula obtained in analytical solution, the iterative algorithm is derived to solve the