MANIPULATION OF KUKA YOUBOT WITH HAND-MOTION USING WEBCAM AND MARKER DETECTION

MOHAMAD FADHLI IQBAL BIN ROSLI

BACHELOR OF MECHATRONICS ENGINEERING WITH HONOURS
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2019

MANIPULATION OF KUKA YOUBOT WITH HAND-MOTION USING WEBCAM AND MARKER DETECTION

MOHAMAD FADHLI IQBAL BIN ROSLI

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 “MANIPULATION OF KUKA YOUBOT WITH HAND-MOTION USING WEBCAM AND MARKER DETECTION 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 "Manipulation of Kuka Youbot with hand-motion using webcam and marker detection" 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

I dedicated my hard work to my beloved family

ACKNOWLEDGEMENTS

I would like to appreciate my university, University of Technical Melaka (UTeM) for providing an opportunity and such a good environment for me to undertake my Final Year Report (FYP) in fulfillment of the requirement for Bachelor of Mechatronic Engineering. I had acknowledged many useful assist and guideline from many different persons during the whole performance of my FYP. Firstly, I would like to express my sincere gratitude to my supervisor, Dr. Nik Syahrim Bin Nik Anwar for guiding me for my FYP. Besides, I would also to show my gratitude to all my classmates, especially those who have directly or indirectly provided me with useful information for my FYP.

Furthermore, I must share my special tanks of gratitude to my beloved parents for providing me the opportunity to study at university and giving me finance and mentally support throughout my study life and the whole period of my FYP. This accomplishment would not have been done or completed without them. I also want to show my thankfulness to all the lecturers, technician and staffs from Faculty of Electrical Engineering, UTeM for willing to assist me with all your good companionship.

Finally, I would like to express my indebtedness to my entire friend for willing to share and help me to complete my FYP with their knowledge and experiences. I perceive my FYP as a big milestone in career development. I will make great effort to use gained skills and knowledge, and I will continue to work on their improvement in order to attain desired career objectives.

ABSTRACT

This thesis presents a marker-based system for a robot manipulator for a Kuka Youbot platform. This project is designed to provide a smart, effective and easy to convey teleoperation interface. The user control aim is acquired by the motion capture in real time, processed and send it to the Kuka youbot manipulator. The system builds upon existing approach taken from other platform and the open source Robot Operating System and extends its capabilities to the Kuka youbot, resulting in a system that can detect motion of a marker in its environment and navigate the manipulator with a simple user interface. Aruco marker been use as the marker for this system as it can give the pose estimation of the squared marker. The hand pose is used as a model to specify the pose of a real-time robot's end-effector. The left arm is employed to provide a high-level user command such as "Manipulator Up/Down" and "Manipulator left/right". The desired result of the system will be demonstrated in a real-time teleoperation experiment using Kuka Youbot manipulator. Some possible application of the proposed system are in robot-assisted manufacturing, rehabilitation and tele-presence.

ABSTRAK

Tesis ini membentangkan tentang system berasakan penanda bagi robot manipulator untuk platform Kuka youbot. Projek ini direka bagi menyediakan keberkesanan, kepintaran dan kemudahan bagi penyampaian antara muka operasi. Matlamat pengguna diperolehi oleh tangkapan gerakan dalam masa nyata, ia di proses dan dihantar ke Kuka youbot manipulator. Sistem ini dibina atas pendekatan sedia ada yang diambil dari platform lain dan Sistem Operasi Robot sumber terbuka dan meneruskan kemampuannya ke Kuka youbot, mengakibatkan sistem yang dapat megesan gerakan penanda dalam kawalan persekitaran dan menavigasi manipulator dengan antara muka pengguna yang mudah. Penanda Aruco digunakan sebagai penanda bagi system ini kerana ia boleh memberi anggaran kedudukan posisi kuasa dua. Gerakan tangan digunakan sebagai model untuk menentukan gerakan pose dari effector akhir robot jarak jauh. Dua gerakan tangan mudah sambal memegang penanda ditetapkan untuk system penjejakan. Hasil yang diinginkan dari sistem akan menunjukkan dalam percubaan teleoperasi dalam masa nyata menggunakan manipulator Kuka youbot. Sesetengah kemungkinan pengunaan dalam sistem yang dicadangkan adalah dalam pembuatan, pemulihan dan penyediaan bantuan robot.

TABLE OF CONTENTS

PAGE

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

ROS	:	Robot Operating System
DOF	:	Degree Of Freedom
HRI	:	Human-Robot Interaction
FPS	:	Frame per-second
ROS	:	Robot Operating System
3D	:	Three Dimensional

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Over the last few decades, robots have developed from basic instruction pick and place into autonomous devices that able to perform a lot of tasks based on computer programming. These robots's expected not only just to perform tasks, but also to find alternative ways of doing the same task and integrate human perception with robotic consistency, control, and precision while working inside a common environment. In this kind of situation in which robots and human are sharing the same environment and participate with each other, the robotic system needs to know the human behavior to predict future actions and support decision making [1].

Human intelligence is vital for decision making and control in robot teleoperation, especially when robots are built for a dynamic environment, where object are unfamiliar and changing shape. Nowadays, a lot of mechanical devices been used for human-robot interfaces such as a joystick, computer mouse, keyboard and robot replica to complete the teleoperation task[2]. However, these mechanical devices require unnatural hand-arm movements to utilize the full extent of the human motion.

Rather use the electronics or mechanical device such as pre-programmed codes and joystick. There is a natural way to communicate with a robot in a difficult environment. Which by tracking a human hand-arm motion. To tracking the hand-arm motion, a vision system is required in order to track the movement of joints over an image sequence. The vision-based technique is non-contacting and less controlling of hand-arm motion, and thus they often use physical markers that are placed on parts of the body of the human[2]. Numerous applications that exist based on the marker-based tracking of human motion.

Hence, a human-robot interaction using webcam and marker detection system for Kuka youbot manipulator will be designed and developed. The system used a marked-based system to detect human arm motion to complete the Kuka youbot manipulation task. For this purpose, the Kuka youbot manipulator and the vision system need to employ an algorithm for the system implementation.

1.2 Motivation

The main motivation for manipulation of Kuka youbot with hand-motion using webcam and marker detection is to provide a system that can assist a person with the limited ability of arm movement. Any part of body which is injured due to accidents and disability require rehabilitation process in order to get healthy and stronger. It's very important to improve and increase the muscle in any part of the body to makes the limb functional again. For those who have disability problem its very vital to get back to the normal condition before as their life will get better. Recovery may be a treatment to handle a person with physical disability to decrease the negative comes about the lasting illness to a least.

The help the person with a limited ability of arm movement is necessary for rehabilitation reasons. This aid is required not only to cover the human performances of the arm in motion and force but also to have a strictly stable dynamics environment [3]. An arm recovery is one of the rehabilitation element that needs to be focus on. A patient will perform the therapeutic exercise with the help by physiotherapist. The exercise will involve passive and active exercise.

The users of robot manipulator in the rehabilitation have increased in the past year. In term of cost and time duration of the therapy, robots give significant impact for the recovery process. Hence, this project will provide an ideal system to be the human assistance for arm rehabilitation. Several applications between human and robot interaction in different aspect have been list in table 1.1.

Table 1-1 Example application between human and robot interaction [4]

Application area	**Remote/Proximate**	**Role**	**Example**
Search and saving	- Remote	Human is supervisor or operator	Remotely operated search robots
	- Proximate	Human and robot are peers	Robot supports unstable structures
Assistive robotics	- Proximate	Human and robot are peers	Assistance for the blind, and the therapy for the elderly.

	- Proximate	Robot is a mentor	Social interaction for autistic children.
Military and laws	- Remote	Human is supervisor	Reconnaissance
	- Proximate	Human and robot are peers	Patrol support
Teaching	- Proximate	Robot is mentor	Robotic classroom assistant Robotic museum tour guide
Space	- Remote	Human is supervisor or operator	Remote science and exploration
	- Proximate	Human and robot are peers	Robotic astronaut assistant
Home and industry	- Proximate	Human and robot are peers	Robotic companion
	- Remote	Human is supervisor	Robot construction

1.3 Problem statement

The ability to control objects in our environment is an important human behavior. The use of a single multipurpose device such as robot, offer significant advantages over a variety of assistive devices and tools. However, for a person who had a limb disability, it will be difficult to control any kind of situation that their faces. Thus, a method is needed to enable to control the robot where only a few different commands are implemented such as “up”, “down”, “left” and “right”. This motion may look simple but it very difficult to execute for those who have a limb disability. Therefore, it is desired to have a human-robot collaboration system that is able to help human and overcome the problem. Hence, this assistive robot plays a significant role in physical therapy and recovery.

Recently, a depth camera such as the Logitech camera has shown its efficiency in tracking a 3D image in real time. The low cost of the hardware camera, as well as the setup for the tracking system, make it preferable used in the controllable environment. By processing the captured depth image, the possibility is high to identify depth-based edge extraction and ridge data which are used to track the marker. The camera-based system is always facing the problem with long processing time for high resolution images. The image is recognized by analyzing the location and orientation of the marker. However, run-time detection is always not accurate, which result in corrupting the activity of recognition accuracy. The main focus of this work is to propose a new method so that the recognition marker process can be more accurate.

Finally, to recognize human hand using vision is very challenging due to non-uniform shape and size of a human hand. The ultimate goal of hand tracking is to be able to detect and track hands from a different kind of user, using a single camera. The process is extremely challenging due to a fast motion, changing lighting condition, different size of a hand, and occlusion. Given these challenges, we start by solving a relatively less challenging problem interaction hand motion by detecting a fixed marker shape.

1.4 Objective

The objectives of this project are:

1. To develop a marker-based recognition system that allows a user to control the 5 DOF Kuka youbot manipulator using hand motion.
2. To evaluate the perfomance of the proposed system in term of trajectory accuracy and jerking level.

1.5 Scope

The main purpose of this project is to detect a motion of a human arm while holding an Aruco marker and to develop an algorithm for the Kuka youbot mobile manipulator. The design focusing on the machine vision system that allows human to interact with the Kuka youbot using marker based. There are two major part for the system:

- Tools: we examined the existing hardware and software
- Algorithms: concept employed by the software and how it produces a useful result

Several hardware and software are employed to design the machine vision system to achieve human-robot interaction based on marker-based. The scopes of this project are:

1. Aim of this project is to include the ranges of Aruco marker system with a marker detection technique.
2. Manipulate the Kuka youbot arm using an Aruco marker in controllable environment.
3. Calculate the inverse kinematic for the path Kuka youbot manipulator.
4. Focussing on the trajectory of the Kuka arm manipulator based on velocity, acceleration, time and jerk.

1.6 Thesis Outline

This thesis essentially comprises of five chapters. Chapter 1 will focus on the overall overview of the project such as objectives, scope, and problem statement. Chapter 2 will focus on literature review and also related researchers of the project that has been extracted from the journals from Science Direct, IEEE, books, articles and from the established website regarding of the project. Next, this chapter also consists of an overview and working principles that will be implemented for this project.

Chapter 3 describing the complete methodology that is used in project implementation. Methodology part discussed steps that involved for hardware and software part.