

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

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**A report submitted
in partial fulfillment of the requirements for the degree of
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2019

DECLARATION

I declare that this thesis entitled “MANIPULATION OF KUKA YOUNGOT 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.

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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

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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 sambil 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 penggunaan dalam sistem yang dicadangkan adalah dalam pembuatan, pemulihan dan penyediaan bantuan robot.

TABLE OF CONTENTS

	PAGE
DECLARATION	
APPROVAL	
DEDICATIONS	
ACKNOWLEDGEMENTS	i
ABSTRACT	ii
ABSTRAK	iii
TABLE OF CONTENTS	iv
LIST OF TABLES	vii
LIST OF FIGURES	viii
LIST OF SYMBOLS AND ABBREVIATIONS	x
LIST OF APPENDICES	xi
CHAPTER 1 INTRODUCTION	1
1.1 Introduction	1
1.2 Motivation	2
1.3 Problem statement	4
1.4 Objective	6
1.5 Scope	6
1.6 Thesis Outline	7
CHAPTER 2 LITERATURE REVIEW	9
2.1 Introduction	9
2.2 Research from the previous project	9
2.2.1 Vision-Based System for Robot Manipulation	9
2.2.2 Articulated Robots using Marker-Based System	10
2.2.3 Markerless Vision-Based Hand Arm Tracking system	10
2.2.4 Vision-based System for Human Robot Interaction	11
2.2.5 Summary of Research on Marker-Based Manipulation	11
2.3 Robot Manipulator	12
2.3.1 Robot Operating System (ROS)	14
2.3.2 Robotic manipulator	15
2.3.3 Arm Navigation Stack	16
2.4 Human-Robot Interaction	17
2.4.1 Vision System	18
2.4.2 Camera	20
2.5 Marker-Based System	21
2.5.1 Hand Tracking Motion	22
2.5.2 Aruco Marker	23

2.6	Summary	27
CHAPTER 3 METHODOLOGY		28
3.1	Introduction	28
3.2	Project Overview	28
3.3	System Flowchart	30
3.4	System Block Diagram	32
3.5	Hardware Description	33
	3.5.1 Kuka Youbot	33
	3.5.2 Robotic Arm Manipulator	34
	3.5.3 Logitech Webcam Camera	36
3.6	Software Description	37
	3.6.1 Robot Operating System (ROS)	37
	3.6.2 Open Source Computer Vision (OpenCV)	37
3.7	Marker-Based Hand Motion Detection System	38
	3.7.1 Image Resize	39
	3.7.2 Image Segmentation	40
	3.7.3 Shape Removal and Filtering	40
	3.7.4 Image Pyramid Creation	40
	3.7.5 Marker Code Extraction	41
	3.7.6 Corner Upsampling	41
	3.7.7 Estimation of t_i	42
	3.7.8 Inverse Kinematics	42
3.8	Experiment Implementation	46
	3.8.1 Camera Calibration	46
	3.8.2 Tracking Aruco marker	47
	3.8.3 Kuka Youbot arm manipulator tracking Aruco marker position	48
	3.8.4 Forward Kinematic	49
	3.8.5 Evaluate the motion trajectory of Kuka youbot	50
	3.8.6 Data Collection	51
CHAPTER 4 RESULTS AND DISCUSSIONS		53
4.1	Introduction	53
4.2	Aruco Marker Detection	53
	4.2.1 Analysis Result (Distance vs Aruco Marker size)	55
	4.2.2 Motion Recognition	55
	4.2.2.1 Linear Path Motion	57
	4.2.2.2 Circular Path Motion	61
	4.2.3 Analysis Result (Performance Evaluation)	62
4.3	Kuka Arm Manipulator Path	63
	4.3.1 Trajectory Kuka Arm Manipulator for Linear Path	65
	4.3.2 Trajectory of Kuka Arm Manipulator for Circular Path	67
	4.3.3 Analysis Result (Accuracy Evaluation)	70
4.4	Performance Kuka Arm Manipulator	71
	4.4.1 Trajectory of Kuka Arm Manipulator for Linear Path	71
	4.4.2 Trajectory of Kuka Arm Manipulator for Circular Path	74
	4.4.3 Analysis Result (Performance Evaluation)	77
CHAPTER 5 CONCLUSION AND RECOMMENDATIONS		79
5.1	Conclusion	79
5.2	Future Recommendation	80

	vi
REFERENCES	81
APPENDICES	84

LIST OF TABLES

Table 1-1 Example application between human and robot interaction [4]	3
Table 2-1 Summary of Previous Project	11
Table 3-1 Specification Logitech C310 Webcam	36
Table 4-1 Table value of angle joint for Linear path	65
Table 4-2 Table value of angle joint for the circular path	68

LIST OF FIGURES

Figure 2-1 KUKA Youbot	13
Figure 2-2 Kuka Youbot's arm dimension [10]	14
Figure 2-3 Logitech Web-camera	20
Figure 2-4 Example Hand motion tracking for controlling the robot	22
Figure 2-5 Example 2D markers	23
Figure 2-6 Patterns of Aruco marker	24
Figure 2-7 Robot's position relation to the detected marker	26
Figure 2-8 Robot's total location using the marker detection	26
Figure 3-1 The overall flow chart for this project	30
Figure 3-2 System Flowchart	31
Figure 3-3 System Block Diagram	32
Figure 3-4 Kuka youbot platform with some sensors	34
Figure 3-5 Kuka Youbot Arm	34
Figure 3-6 Scope of movement of Kuka youbot Arm	35
Figure 3-7 Logitech C310 HD Webcam	36
Figure 3-8 Step of Aruco marker detection	38
Figure 3-9 Steps for identification and detection of markers	39
Figure 3-10 Kuka Youbot Arm Frame	43
Figure 3-11 Coordinate of Kuka Youbot Arm	44
Figure 3-12 2D Coordinate Frame of Kuka Youbot	44
Figure 3-13 Webcam Calibration using chessboard	46
Figure 3-14 Tracking Aruco marker position	47
Figure 3-15 Experiment Setup for this project	48

Figure 4-1 Aruco Marker been generate	53
Figure 4-2 Distance vs Aruco Marker Size graph	54
Figure 4-3 Detection at various orientation	55
Figure 4-4 System Reference Frame	56
Figure 4-5 Aruco maker detection for Linear path motion	57
Figure 4-6 Hand motion tracking for 50mm Aruco marker size	58
Figure 4-7 Hand motion tracking for 100mm Aruco marker size	59
Figure 4-8 Hand motion tracking for 150mm Aruco marker size	60
Figure 4-9 Aruco maker detection for circular path motion	61
Figure 4-10 Hand tracking for 100mm size for circular path motion	62
Figure 4-11 Kuka arm manipulator scope movement	64
Figure 4-12 Path of the manipulator using trigonometry	64
Figure 4-13: Kuka arm manipulator end effector for the linear path	66
Figure 4-14 Top view Kuka arm manipulator end effector for linear path	67
Figure 4-15: Kuka arm manipulator end effector for the circular path	68
Figure 4-16 Top view Kuka arm manipulator end effector for circular path	69
Figure 4-17 Angle Position for Kuka arm manipulator for linear path	72
Figure 4-18 Velocity for Kuka arm manipulator for linear path	72
Figure 4-19 Acceleration for Kuka arm manipulator for linear path	73
Figure 4-20 Jerk for Kuka arm Manipulator for linear path	74
Figure 4-21 Position Angle for Kuka arm manipulator for Circular path	74
Figure 4-22 Velocity for Kuka arm manipulator for circular path	75
Figure 4-23 Acceleration for Kuka arm manipulator for circular path	76
Figure 4-24 Jerk for Kuka arm Manipulator for circular path	76

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

Appendix A: Research Gantt Chart	84
Appendix B: Kuka arm manipulator coding	90

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 performance 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.