REAL-TIME PHYSICAL HUMAN MACHINE INTERACTION FOR ROBOTIC ARM

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Specially Dedicated to :

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ABSTRACT

Real-Time Physical Human Machine Interaction For Robotic Arm are project that develop some or the other technology that makes the maximum use of robot to help people do their work in an efficient way. A haptics technology was applied to this project to present the real-time operation which senses the arm movements that contact between robotic arm and human as the input. This project developed because of the hard to handle the robot arm movement that usually used the computer as interact device. The main objective of this project is to design and implement a prototype of robotic arm, to develop real time physical human for the robot arm, and to observe the movement of the robot arm is according to the input. This project is focus on robot arm that development of real time physical human by using the flex-sensors fixed with human arm using Arduino programming. The flex-sensors as the input of robotic arm movement for this project. Arduino programming is used as the interaction device between human arm and robotic arm.

ABSTRAK

Real-Time Physical Human Machine Interaction For Robotic Arm adalah projek yang terdiri daripada beberapa teknologi yang menggunakan robot secara meluas untuk membantu orang ramai melakukan kerja mereka dengan cara yang cekap. Teknologi haptics digunakan dalam projek ini dalam membentangkan operasi masa nyata yang mengesan pergerakan lengan yang berhubung antara lengan robot dan manusia sebagai masukan. Projek ini dibangunkan kerana kesukaran untuk mengendalikan pergerakan lengan robot dalam industri yang biasanya menggunakan komputer sebagai alat interaksi. Objektif utama projek ini adalah untuk bentuk dan melaksanakan prototaip lengan robot, untuk membangunkan masa fizikal nyata manusia pada lengan robot industri, dan untuk memerhatikan keseragaman pergerakan lengan robot itu mengikut input. Projek ini memberi tumpuan kepada lengan robot yang dihasilkan berlandaskan masa fizikal nyata manusia dengan menggunakan flex-sensor yang terletak tetap pada lengan manusia dan pengaturcara Arduino . Flex-sensor digunakan sebagai masukan bagi pergerakan lengan robot dalam projek ini. Pengaturcara Arduino digunakan sebagai peranti yang berinteraksi antara lengan manusia dan lengan robot.

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LIST OF ABBREVIATIONS

DOF	- Degree Of Freedom
DC	- Direct Current
CNC	- Computer Numerically Controlled
RF	- Radio Frequency
ADC	- Analog to Digital Converter
ALU	- Arithmetic Logic Unit
AC	- Alternative Current
LED	- Light Emitting Diode

CHAPTER I

INTRODUCTION

1.1 Project Overview

Real time is a level of computer responsiveness that a user senses as sufficiently immediate or that enables the computer to keep up with some external process. Real-time is an adjective pertaining to computers or processes that operate in real time. Real time describes a human rather than a machine sense of time. Commonly, real-time operating system are system that respond to input immediately and display objects moving across the screen at the same speed that they would actually move. This robotic arm is an autonomous robot which allowing a direct mapping from a human movement to robot. In this paper, the mechanism of a real time physical human machine is presented. This system was designed with combination of robotic arm and real time physical human machine. This system is several type of electromechanical devices used in haptics application. Haptics application is apply to this project with senses the body's movements that contact between robotic arm and human arm as the input to make it be real time. The human arm fixed with flex-sensors as sensation of robotic arm movement. Arduino programming use as the interaction device between human arm and robotic arm. Robot arm was base on the study of two Degree Of Freedom (DOF) human behaviour. The result denotes that flex sensors as input has a high potential to control humanoid robot arm to perform the real time physical human. Figure 1.1 show example of the human movement with the robotic arm.

Figure 1.1 : Human movement with robotic arm [3]

With the growth of interest towards humanoid robots, several robotic arm more or less humanoid have been developed, the goals of each project were different, and the results are not easily comparable to the purpose of declaring one project better than another. In general, research on a real time robotic arm is very useful for maintenance work in hazardous environments. One of the main concerns is the control robot arm movement with real time physical human. Most of the robot arm requires many degree of freedom to be various movement. However, the control system of the humanoid robot becomes more complicated if more degree of freedom are additionally used for robot arm design.

1.2 Problem Statement

The problem statement of this study can be expressed as follows:

Most in the robotic field, the movement of robotic arm is hard to handle. This is caused of the coding configured by the computer that as interact device for the movement of most robotic arm. If the movement of the robot can be control by the human interface, so that the robot arm can be easier in handling.

With the growth of interest toward robots, the goals of each project were different and the results are not easily comparable to the purpose of declaring better than another.

The control system of the humanoid robot becomes more complicated if more actuators are additionally used for robot arm design.

This project is to design a real time physical human interface to control the robotic arm movement by using the haptics application.

1.3 Objective of Research

The followings are the objectives of this research.

i. To design and implement a prototype of robotic arm.
ii. To develop real time physical human for the arm robot.
iii. To observe the movement of the robot arm is according to the input.

1.4 Scope of Work

The followings are the scopes of this project.

i. Design the prototype of robotic arm using Autocad. The robotic arm design in two DOF.
ii. Development of real time physical human for the industrial robotic arm by using the flex-sensors fixed with human arm and Arduino programming.
iii. Validation of the robotic arm movement according to the human movement with flex sensor.

1.5 Contribution of the Work

There are significant outstanding issues related to the identification and control of real time system that need to be investigated. From the research as discussed previously for the problem statements and the importance, several contributions can be made in the vicinity of identification, control strategy and application. These are also reflected in several journal and conference papers arising

from this research study. The main research contributions of this study are as follows:

i. A design of prototype for robotic arm.
ii. A robotic arm with the real time physical human controller by apply the haptics application.
iii. A observation of the validation reaction for the arm robot with the input of flex sensor.

1.6 Structure of the Report

Chapter 2 present the literature review on robot arm for it system, technology, and research and development. The discussion is based on human interface for the robot arm and the real time reaction. The review is discussed in detail on chapter 3.

The methodology to build robot arm for real time by apply for the haptics application is present in Chapter3. This chapter deal with the modelling and control strategies of robotic arm. Firstly, the hardware that used is identify to build this project. Then, the type of programming is identify to make the coding as the software for this project.

Chapter 4 presents the result and discussion of this project on how the robotic arm function that use Arduino programming as the coding. In this chapter also show the detail of this project.

Conclusion and future research present in Chapter 5 that show the advantages and the weakness of this project that can be develop in the future to make this arm robot more multipurpose.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter discuss and analysis about various kind of robotic arm in the related field of robot, mainly focus to the real time robotic arm. Which use the human interface as the input. Besides that, theory of real time robotic arm also will be discussed in his chapter. This analysis is used to determine an exact design and understanding the requirement for the development of this project.

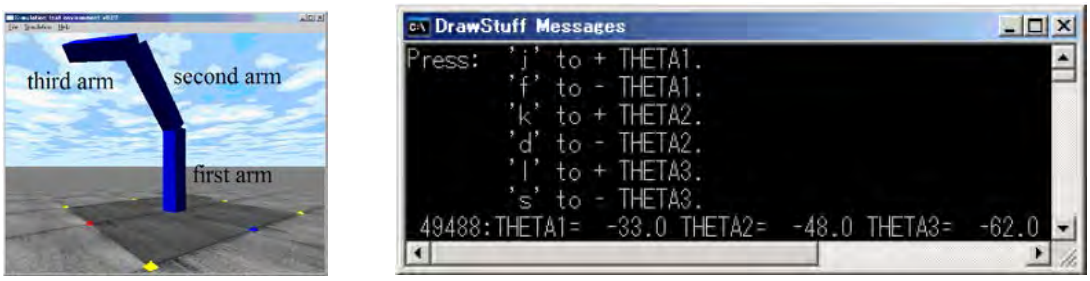
2.2 Robot arm system

Nowadays robots accompany people in everyday life and take over their daily routine procedures. Robotics is a special engineering science which deals with designing, modelling, controlling and robots' utilization. Robots were also recognized not only as simple action performer but as a machine that have diverse and variety of purposes and usages [1]. A robotic manipulator is a device capable of moving in different directions (base, shoulders, elbow, yaw, pitch, roll directions) elative to base and controlled by Haptics, Its base is actuated by a D.C motor mounted beneath it. The

degrees of freedom (DOF) is a joint on the arm, a place where it can bend or rotate or translate.

One of the more important function of arms was jointed robot manipulator that allow robots to interact with their environment. Many have onboard controllers or translators to simplify communication, though they may be controlled directly or in any number of ways. Due to this fact, standalone arms are often classified as full robots [2]. The robot used in this project is 4 Axis Robotic Arm designed for small mobile robots. It can grip objects with the size up to 60mm with the force up to 250gms. Arm has reach of 23cm. It can lift the payload up to 400gms. First two axis of the arm are made up of NRS-995 dual bearing heavy duty metal gear motors and remaining 2 axis and gripper uses NRS-585 dual bearing plastic gear servo motors. Axis 2 and 3 enables gripper to maintain its angle constant with the surface while moving up and down. Robotic arm can do Left-Right, Up-Down while keeping gripper parallel to surface, Twist motions and Gripping action. 5Amps supply current are required for proper operation of this robot arm. The robotic arm has following specifications.

In order to obtain behaviour of each angle of robot arm, simulation software based on ODE library was developed [4]. The program made can be interactively controlled by using keyboard button as well as provided sequence of robot arm angle data. Simulation of the robot arm using the ODE library is shown in Figure 2.1.



(a) Simulation Model (b) Output screen of each angle

Figure 2.1 : Simulation of robot arm using ODE library [4]

For a robot arm, the major problem is caused by the lack of a degree of freedom in the shoulder compared to a human arm [5]. Since most humanoid robots have two DOFs in the shoulder, they are not able to perform every human-arm posture. The cause is the lacked degree of freedom in the robot shoulder compared to a human shoulder. Thus, there is a need to evaluate the postural similarity between a human arm and a robot arm and then adjust the robot arm posture as similar to that of the human as possible. From the perspective of joint angle to evaluate the similarity metric, the joint angles in human and robot arms should be acquired. However, since the rotation sequence of the joint angles in a human shoulder is a puzzle to kinesiologists, it is infeasible to obtain the three Euler joint angles in the human shoulder without recognizing the rotation sequence from human demonstration data.

There are literally thousands of different applications currently performed by industrial robots. With more than one million multifunctional robots in use worldwide, they have become a standard in automation (Gramazio 2008). The reason for their widespread use lies in their versatility is they have not been optimized for one single task, but can perform a multiplicity of functions. Unlike other computer numerically controlled (CNC) machines, which are task-specific that robots can execute both subtractive and additive routines. Among other operations, they can load, unload, place, cut, bend, stack, spray, weld, and mill [6].

In today's society, robots are used in various areas especially in those where high precision is required [7]. Some of the examples where robotic arms found their appliance are in vehicle construction where efficiency and reliability are required, in chemical industry where environment is not suitable for human, in medicine where robotic arm precision is used in operations etc [9]. Robots have improved life standards and we are upgrading their performances in order to make our lives easier and more comfortable.

Since the advent of the robots, they are widely applied in many areas of industry all over the world. With the advancement of the robot, many new research theories and

technologies are developed on it [8]. This project is built a 3-D model for a kind of Panasonic 6-DOF welding robot in SolidWorks, and imported it into ADAMS to simulate the motion further with the simulation results of expected processing trajectory planning for the six links by using MATLAB.

2.3 Technology of robotic arm.

In order to control the robotic arm in the real industrial plant, many technologies have been done to obtain the good result. One of the technology have applied to design and implement a robotic arm and control it is by using haptics technology [1]. Recognizing hand motion that is controlled by haptics technology for virtual environment & human-machine systems capable of haptic interaction using wireless. Haptic is used in engineering systems to create virtual environment as a tactile feedback technology which takes advantage of sense of touch by applying motions, vibrations or forces to the user. This robot arm is able to pick any light weight item and operated by using the haptics glove, which fits over the user's entire hand like an exoskeleton has potentiometers on finger, wrist & picks up change in resistance with hand movement. The haptics glove make the robot arm moved up and down when the human who wear it and move wrist up and down respectively and so on. Hand motions converted into electrical signal from device work as tranducers, whitch is the sensor on the haptic and it replicated using a robotic arm is the basic idea of this paper. The project is divided into two modules namely, Haptics glove (Transmitter) & Robot side (Receiver). The primary goals by providing haptic cues is to facilitate the learning of complex human motion skills that are helpful to induce desired movements. There are several limitations on links in telemedicine must have 0% fault rates for extended periods of time, Robots are not as suitable for making complicated decisions, and Auxiliary controls are required to move the workspace of the device to a new location.

Object sorting system using robotic arm has been develop to present a smart approach for a real time inspection and selection of objects in continuous flow [2]. By

using Image processing procedure senses the objects in an image captured in real-time by a webcam and then identifies color and information out of it. This information is processed by image processing for pick-and-place mechanism. The sorting process is based on a 2 phase operative methodology defined as a self-learning step where the apparatus learns to identify objects and an operative selection process where objects are detected, classified using a decisional algorithm and selected in real time. It aims in classifying the colored objects by colour, size, which are coming on the conveyor by picking and placing the objects in its respective pre-programmed place. Thereby eliminating the monotonous work done by human, achieving accuracy and speed in the work.

Real Time Human Motion Imitation of Anthropomorphic Dual Arm Robot Based on Cartesian Impedance Control research is carried out by Ren C. Luo, Bo-Han Shih, Tsung-Wei Lin [3]. The robot is controlled by human demonstration in real time using Kinect sensor, which is can imitate the human arm motion by human demonstration in real time. The smooth robot arm movement trajectories are generated by an on-line trajectory generator used to limit the change of robot arm speed with velocity and acceleration constraints. Motion capture device was present in this project by use the Kinect sensor developed by the Microsoft. Kinect sensor composed of a RGB camera and a depth sensor is widely used in motion capture system recently because of its relative low price. The basic technique of the depth sensor is to project a structured infrared light continuously and calculate depth from the reflection of the light at different positions. By processing the depth image, user's skeleton joints can be captured and provided in real time. The main processes for this proposed of human motion imitation system are shown in Figure 2.2. First, the motion capture system provides the tracking targets for the robot to follow. Second, by means of the trajectory generator, we can avoid the change of tracking targets too fast and get robot arm moving trajectory much smoother. Finally, Cartesian impedance control was used to track the command trajectories and apply the concept of virtual spring to generate repulsive force to prevent self collision and also restrict the joint boundary to prevent the damage of the robot. By