

INTELLIGENT SPYCAM WITH ROBOTIC ARM (ISRA)

HAZRUL FAZRIZAL BIN HILMAN

This report is submitted in partial fulfillment of the requirement for the award of Bachelor
of Electronic Engineering (Industrial Electronics) With Honours

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia, Melaka

April 2010



UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : INTELLIGENT SPYCAM WITH ROBOTIC (ISRA)
.....

Sesi Pengajian :

0	9	/	1	0
---	---	---	---	---

Saya: HAZRUL FAZRIZAL B HILMAN

.....
(HURUF BESAR)

mengaku membenarkan Laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (\checkmark) :

SULIT*

*(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)

TERHAD**

** (Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

TIDAK TERHAD

Disahkan oleh:

(TANDATANGAN PENULIS)

(COP DAN TANDATANGAN PENYELIA)

Alamat: D/A Che Mahmood,
Kg Banggol Judah, 18500
Machang, Kelantan.

Tarikh:

Tarikh:

“I hereby declare that this report is the result of my own work and research
except for quotes and cited in the references.”

Signature :.....
Author : HAZRUL FAZRIZAL BIN HILMAN
Date : 48 APRIL 2010

“I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of the scope and quality for award of Bachelor of Electronic Engineering (Industrial Electronic).”

Signature :.....
Supervisor’s Name : MISS ZARINA BT MOHD HOH
Date : 48 APRIL 2010

Dedicated to my family, especially Che Mahmood B Che Lah (father), and Puan Mek Jah Bt Yusof (mother). Also to my Projek Sarjana Muda supervisor, Miss Zarina Bt Mohd Noh. Not to forget, to all my friends.

ACKNOWLEDGEMENT

First and foremost, I would like to express sincere gratitude and appreciation to all people who have been involved either directly or indirectly and made it possible for me to complete my PSM I and PSM II.

I am very indebted to my PSM supervisor, , Miss Zarina Bt Mohd Noh for her guidance, support and especially her flexibility that she has given to me in order to complete my project and research and for time to time will be a meaningful memory and lesson for me for the future and my journey in this life.

Sincere appreciation also to UTeM staff especially the FKEKK Technicians for their help and also to UTeM Librarians that helped me so much in finding books and references related to my project and research.

Last but not least to others especially my family and friends who have given me moral support in order to go through all the hard work and also for my mom and dad blessing upon me.

Therefore, I end this acknowledgement with THANK YOU VERY MUCH in their reminiscence.

ABSTRACT

Design for intelligent SpyCam with Robotic arm (ISRA) is a project that to developed a intelligent system that can remotely control all the system by using the radio frequency (RF) signal. In this project there is much that should consider, especially in the arm design. In this project, the basic concept of a ISRA it is using transmitter and receiver to communicate between each system. The distance between receiver and transmitter to sent the data is depend on the frequency of the RF. The distance of the remote control is about 50m to 100 m, so it can be control in the wide area. By using the wireless camera it can easily to monitor the area needed by the user. The advantage of this project is, there is to reduce of the human power in the hazardous place or in the dangerous area. It also can be use as a spy camera to view the human activity through the computer.

ABSTRAK

Reka bentuk untuk “*intelligent SpyCam with Robotic arm (ISRA)*” merupakan satu projek yang boleh digunakan untuk mengawal semua system yang dengan menggunakan frekuensi isyarat radio (RF) pada jarak jauh. Dalam projek ini terdapat banyak yang perlu dipertimbangkan agar ianya menjadi satu sistem yang sempurna, terutama sekali dalam reka bentuk lengan “*arm*”. Dalam projek ini, konsep asas *ISRA* adalah dengan menggunakan isyarat pemancar dan penerima untuk menghantar atau menerima setiap isyarat antara setiap system yang digunakan. Jarak antara penerima dan pemancar bagi menghantar atau menerima data bergantung frekuensi RF yang digunakan. Jarak kawalan jauh untuk mengendalikan system didalam projek ini adalah 50m sehingga 100 m. Dengan menggunakan kamera tanpa wayar ia secara langsung mudah untuk memantau kawasan yang diperlukan oleh pengguna. Kelebihan projek ini ialah, ia dapat mengurangkan penggunaan tenaga manusia dalam mengendalikan tempat atau kawasan yang berbahaya. Ia juga boleh menggunakan sebagai sebuah kamera pengintip untuk melihat aktiviti manusia melalui komputer.

TABLES OF CONTENT

CHAPTER	TITLE	PAGE
	PROJECT TITLE	i
	STATUS DECLARATION FORM	ii
	DECLARATION	iii
	APPROVAL	iv
	DEDICATION	v
	ACKNOWLEDGEMENT	vi
	ABSTRACT	vii
	ABSTRAK	viii
	TABLE OF CONTENT	ix
	LIST OF TABLES	xii
	LIST OF FIGURES	xiii
	LIST OF ABBREVIATIONS	xvi
	LIST OF APPENDICES	xvii
I	INTRODUCTION	1
	1.1 Introduction	1
	1.2 Objective of this project	3
	1.3 Scope of project	3
	1.4 Problem Statement	4
II	LITERATURE REVIEW	5
	2.1 Background	5
	2.2 Arm	6
	2.2.1 Degrees of Freedom (DOF)	7
	2.2.2 Denavit-Hartenberg (DH) Convention and the Robot Arm Free Body Diagram (FBD)	7
	2.2.3 Robot Workspace	9
	2.2.4 Stand-Alone or Built-On Manipulators	12
	2.2.5 Grippers	12
	2.2.6 Shoulder Joint and Upper Arm	13
	2.2.7 Elbow and Forearm	13
	2.3 The Clapper	16

2.4	Servo Motors	20
2.5	Remote Controller	22
2.5.1	The R/C Controller's Interface	22
2.6	Applications	26
2.7	Common robot designs	27
2.7.1	Cartesian	27
2.7.2	Cylindrical	28
2.7.3	Spherical	28
2.7.4	Articulated	29
2.7.5	SCARA (Selective Compliance Articulated Robot Arm)	30
III	METHODOLOGY	31
3.1	Introduction	31
3.2	Flow and Gantt chart of methodology	32
3.3	Hardware design and development	34
3.3.1	Arm circuit	34
3.4	Electrical implementation	35
3.4.1	Voltage regulator	35
3.5	Servo motor control	36
3.6	Forward kinematics	37
3.7	Calculation of load torque	39
3.8	Camera attachment	40
3.9	The transmitter and receiver circuit for the remote control	40
IV	RESULT AND DISCUSSION	43
4.1	Introduction	43
4.2	Project result	44
4.3	Radio frequency (transmitter circuit)	44
4.3.1	Transmitter Design	45
4.3.2	Antenna	47
4.3.3	Signal analysis	48
4.4	Radio Frequency (receiver circuit)	51
4.4.1	AM Detection	53

4.4.2	Data Processing	55
4.5	Arm robot circuit	57
4.6	Location of Camera	58
4.7	Voltage regulator (5V)	59
4.8	Hardware analysis	60
4.8.1	Gripper	61
4.8.2	Waist	62
4.9	Software analysis	63
4.9.1	Simulation test	63
V	DISCUSSION AND CONCLUSION	66
5.1	Introduction	66
5.2	Discussion	67
5.3	Conclusion	68
5.4	Recommendation and project advantage	69
	REFERENCES	70

LIST OF TABLES

NO	TITLE	PAGE
3.1	1: D-H table of arm parameter	38

LIST OF FIGURES

NO	TITLE	PAGE
1.1	A family tree shows development of robots	2
2.1	4 DOF Robot Arm, three are out of plane	7
2.2.	3 DOF Robot Arm, with a translation joint	8
2.3	5 DOF Robot Arms	8
2.4	Assume that all joints rotate a maximum of 180 degrees	9
2.5	Now rotating that by the base joints another 180 degrees to get 3D	10
2.6	example of robot workspace	11
2.7	The gear transfer system used to actuate the shoulder of the revolute arm	13
2.8	Shoulder shaft detail. <i>A.</i> Completed shaft; <i>B.</i> Exploded view	14
2.9	A close-up view of the elbow joint	14
2.10	The completed arm with gripper attached	15
2.11	The clapper gripper <i>A.</i> , assembly detail <i>B</i> top view	16
2.12	Construction detail of the basic two-pincher gripper	17
2.13	Hardware assembly detail of the pivot bar and fingers of the two-pincher gripper. <i>A.</i> Assembled sliding joint; <i>B.</i> Exploded view	17
2.14	The finished two-pincher gripper, with fingertip pads and actuating cables	18
2.15	A commercially available plastic two-pincher robot arm and claw toy	18
2.16	A two-pincher gripper based on a homemade work drive system. <i>A.</i> Assembled gripper <i>B.</i> Worm shaft assembly detail	19
2.17	Adding a second rail to the fingers and allowing the points to freely pivot causes the fingertips to remain parallel to one another	19
2.18	Actuation detail of a basic two-pincher gripper using a motor	20

2.19	The typical radio-controlled (R/C) servo motor	21
2.20	The internals of an R/C servo. The servo consists of a motor, a gear train, a potentiometer, and a control circuit	21
2.21	pin out diagram for the Holtek HT-12E	23
2.22	Holtek HT-12E and HT-12D	24
2.23	Transmitter and Receiver	25
2.24	Example for the robot application	26
2.25	Example for Cartesian robot	27
2.26	Example for cylindrical robot	28
2.27	Example for Spherical robot	28
2.28	Example for articulated robot	29
2.29	Example for SCARA robot	30
3.1	Flow Chart of PSM1	32
3.2	project Gantt chart	33
3.3	Arm circuit	34
3.4	Voltage regulator circuit	35
3.5	Servo motor control	36
3.6	Forward kinematics for cylindrical coordinate robot	37
3.7	Camera attachment to the arm robot	40
3.8	Transmitter circuit	41
3.9	Receiver circuit	42
4.1	Transmitter block diagram	44
4.2	Circuit testing on project board	45
4.3	Transmitter circuit On PCB	46
4.4	Antenna	47
4.5	Analysis of data output from the transmitter	49
4.6	Analysis of RF output from the transmitter (before transmitted the signal)	49

4.7	Analysis of RF output from the transmitter (after transmitted the signal)	50
4.8	Receiver block diagram	51
4.9	The Receiver on the PCB design	52
4.10	complete Receiver circuit	53
4.11	AM Envelope detector	54
4.12	AM Coherent detector	54
4.13	Integrated & Dump Filter	56
4.14	The arm	57
4.15	The camera	58
4.16	5V supply voltage circuit	60
4.17	Gripper	61
4.18	Waist of robot	62
4.19	Simulation of servo turning in +ve 90° position	64
4.20	Simulation of servo turning in 0° position	64
4.21	Simulation of servo turning in -ve 90° position	65

LIST OF ABBREVIATIONS

DH	-	Denavit-Hartenberg
DOF	-	Degree Of Freedom
FBD	-	Free Body Diagram
FEC	-	Forward Error Correction
ISRA	-	Intelligent SpyCam With Robotic Arm
PCB	-	Printed Circuit Board
PIC	-	Peripheral Interface Controller
PWM	-	Pulse Width Modulation
RF	-	Radio Frequency
R/C	-	Remote Control
SCARA	-	Selective Compliant Articulated Robot Arm

LIST OF APPENDICES

NO	TITLE	PAGE
A	Programming language	71
B	PIC16F873X Data Sheet	74
C	RF-TX315 & RF-TX433	89
D	RF-RX315 & RF-RX433	97

CHAPTER 1

INTRODUCTION

1.1 Background

At the dawn of the 20th century, an explosion of new scientific theories and inventions led to the creation of a literature that sought to explore their implications and a variety of possible futures. In the science fiction magazines of the 1920s and 1930s, the alien “bug-eyed monsters” were often accompanied by hulking robots. These robots were often relentless in their attempts to carry out some sort of evil plan. Robots also appeared in other media. Indeed, the word robot is first found in the 1921 play Rossum’s Universal Robots by the Czech playwright Karel Capek. Here and in Fritz Lang’s 1927 movie Metropolis, the robot took on a social dimension, symbolizing the threat of automation to human livelihoods and suggesting the relentless metronome-like pace of the industrial world. While many writers caused people to fear robots, Isaac Asimov inspired a generation of engineers to build them [1].

The development of the digital computer as well as sophisticated electronics and control systems during the 1940s gave engineers the practical means to start building real robots. Norbert Wiener, a mathematician whose interests ranged from computers to game theory to neurology, provided in cybernetics a badly needed theoretical framework for understanding communication, feedback, and control in machines including robots [1].

Building and programming a robot is a combination of mechanics, electronics, and problem solving. What you're about to learn while doing the activities and projects in This text will be relevant to "real world" applications that use robotic control, the only difference being the size and sophistication. The mechanical principles, example program listings, and circuits you will use are very similar to, and sometimes the same as industrial applications developed by engineers [2].

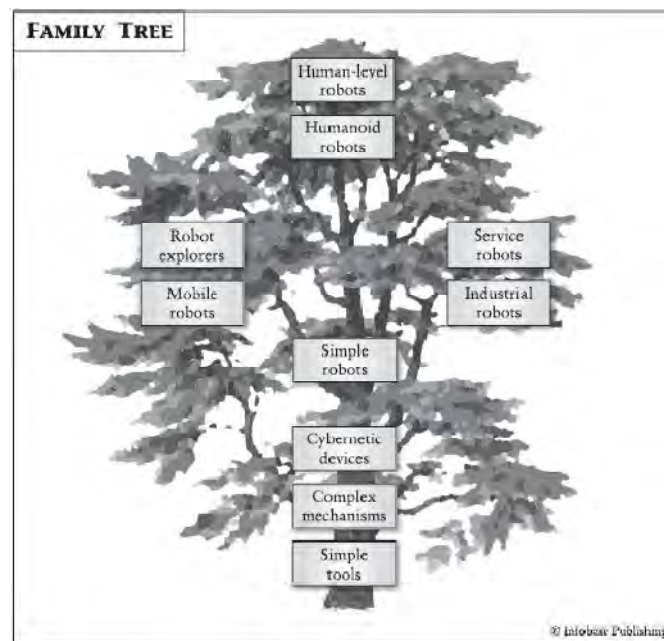


Figure 1.1: A family tree shows development of robots.

Figure 1.1 shown development of robot, from increasingly complex tools and machines. After they gained mobility, robots then branched into a variety of roles, with the potential of becoming humanlike in structure and behavior.

1.2 Objective of this project

1. To design and build a prototype system that can remotely control the system.
2. To find the suitable camera that can be used for this application.
3. To investigate the user interface that can easily be controlled by human.
4. To design small arm that can easily install to the project.
5. To investigate and research about the controlled unit using the PIC to control all the system.

1.3 Scope of project

Below are the scopes of hardware and software for this project:

Hardware and Software section

- a) For the user interface design, this system can be control by using the wireless or radio frequency (RF). So before choosing the best interface, the understanding both of the concept is very important.
- b) By choosing the best resolution and suitable camera is to make sure this project can function properly and at the same time can view higher resolution video to the user.
- c) The servo motor is a motor that is driven and controlled by an electrical pulse train generated by digital device. Each pulse drives the servo motor by a fraction of one Revolution, called the step angle.
- d) Skype software or other software that can be used to view the video on the computer.
- e) The C language is used to design the PIC program. The PIC is module provides a master Module controlled to control the robotic arm that install to this project.

1.4 Problem Statement

The main problem in this project is to design the system that can carry the camera and arm. At the same time, this system also can be control remotely by using the wireless or radio frequency (RF). The PIC is used to make sure all the system can function automatically. It also can be used as a spy in small area without being seen by enemy.

CHAPTER II

LITERATURE REVIEW

2.1 Background

This chapter is intended to provide a review of the current literature relevant to the topic of this project, and provides justification for the course of research pursued according to the goals outlined in Chapter 1. This chapter is subdivided into three sections: on kinematic modeling of robotic systems, methodologies for synthesizing modular robotic manipulators, and random search methods. Each of these areas is critical for the process of automatically creating, modeling and evaluating reconfigurable robotic system.

2.2 Arm

The control of the arm is provided by the control box that came with the arm except that the connections from the control box go through the microcontroller which controls the outputs to a series of switches that turn on/off /switch direction of the arm's gear motors. The mode of operation is provided by a push-pull button and a push button. When the push-pull button is off and the push button is not pressed, the arm is in normal mode. When the push-pull button is on, the arm is in training mode and when the push button is pressed, the arm is in playback mode. The arm automatically reverts to normal mode after it has finished executing the trained motion.

The ability to manipulate objects is a trait that has enabled humans, as well as a few other creatures in the animal kingdom, to manipulate the environment. Without arms and hands, it wouldn't be able to use tools, and without tools it wouldn't be able to build houses, cars, robots. It makes sense, then, to provide arms and hands to the robot creations so it can manipulate objects and use tools. It also can duplicate human arms in a robot with just a couple of motors, some metal rods, and a few ball bearings. Add a gripper to the end of the robot arm that has been creating to complete arm-hand module. Of course, not all robot arms are modeled after the human appendage. Some look more like forklifts than arms, and a few use retractable push rods to move a hand or gripper toward or away from the robot [4].

2.2.1 Degrees of Freedom (DOF)

The degrees of freedom, or DOF, are a very important term to understand. Each degree of freedom is a joint on the arm, a place where it can bend or rotate or translate. It can typically identify the number of degrees of freedom by the number of actuators on the robot arm. Now this is very important. When building a robot arm there have a few degrees of freedom allowed for the application, because each degree requires a motor, often an encoder, and exponentially complicated algorithms and cost [11].

2.2.2 Denavit-Hartenberg (DH) Convention and the Robot Arm Free Body Diagram (FBD) [8].

The Denavit-Hartenberg (DH) Convention is the accepted method of drawing robot arms in FBD's. There are only two motions a joint could make: translate and rotate. There are only three axes this could happen on: x, y, and z (out of plane). Below I will show a few robot arms, and then draw a FBD next to it, to demonstrate the DOF relationships and symbols. The Figure 2.1, Figure 2.2 and Figure 2.3 show to us the Degree Of freedom (DOF) for the arm robot. Note that I did not count the DOF on the gripper (otherwise known as the end effectors). The gripper is often complex with multiple DOF, so for simplicity it is treated as separate in basic robot arm design.

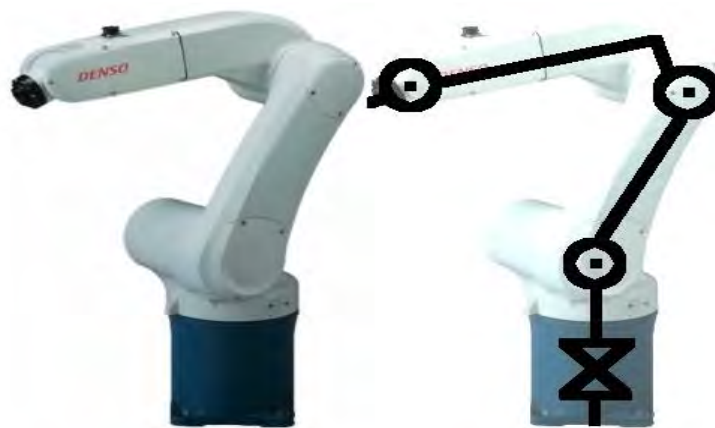


Figure 2.1: 4 DOF Robot Arm, three are out of plane [8].