"I admit that I had read this report and in my opinion this report is sufficient in the manner of scope and quality, to be awarded with a Bachelor Degree of Electronic Engineering (Computer Engineering)".

Signature   :

Supervisor Name: MR. SANI IRWAN BIN MD SALIM

Date   :   5/5/06

ROBOTIC DEVELOPMENT USING LEJOS ENVIRONMENT

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"I admit that this report is done my own effort accept for summary and statement which I had already mention the source from"

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Specially dedicated to my beloved family, supervisor and friends

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ABSTRACT

In this project, one robot is developed using Lego Mindstorms. That robot will be programmed using Java. All of this method is called LeJOS (Lego Java Operating System). The program that written is downloaded or transferred to RCX (Robotics Command Explorer). This is the main part in Lego Mindstorms also known as Robot's Brain. The function for this robot is to collect a ball and put it to another designated place. This robot uses sensors to detect the ball and collect it. Sensors and motors are as a utilized main part in development of robot body. Firstly, the robot is constructed according to function which is to handle a tennis ball as its object. After finish the construction, the robot will be programmed using Java programming language included in LeJOS environment. Programming will include initializing sensors, motors, robot movement and ball detection. Basically, the main equipments or software used is Computer, Java Program, Lego Mindstorms, RCX, IR Tower and Tennis ball. The aim of this project is to show about how Java functions in robotics theory and underlying principles in robotics. So, to develop this project, technologies such as Lego Mindstorms, Java and LeJOS is used.

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INTRODUCTION

1.1 Backgrounds

Distance education is one of the advantages nowadays. Many universities and schools are looking for including this variety of education in their programs. Intended for a specific course in basic robotics and programming, Lego's robot Mindstorms system is an excellent solution for learning robotics. It is portable, easy to start with and relatively contemptible. Consequently, to make movement for that robot's, some robot program will write depends on it movement. Many kind of programming can be done and be relevant. Examples like Robolab (including in Mindstorms Robot Kit), C language and LeJOS. From three main programming tools, Robolab is a famous programming. It is very simple and easy to utilize. Programmer or user only needs to choose an instruction that including in Robolab software. School student also familiars with this software.

Nowadays, many programmers use C language, because they can write more instructions and robot movement. LeJOS (Lego Java Operating System) is new programming language. Therefore, many programmers are not familiar with this language. In this project, Java programming language will be used fully to program a robotics. This programming language is chosen because it has many advantages compare with other programming language. Java will be main task in this project and Lego Mindstorms will be using to apply a programming that was written.

The Lego Java Operating System (LeJOS) allows running Java code inside the RCX, letting program in a familiar language as opposed to using the default Lego interpreter. It includes an API that gives direct access to the inputs and outputs from Java, as well as subset of the standard Java API. So, knowing about Java will give a head start in creating programs for RCX. The fact that LeJOS is new firmware for the RCX, thus does not leverage the Lego firmware, will allow to make programs which are more advanced than what is possible using either Lego programming environment or NQC (Not Quite C).

The LeJOS system is a very small Java runtime environment, much smaller than most of the known Java implementations from Sun. The LeJOS contains some limitations compared to standard Java, the lack of the garbage collector being most prominent. The program will program in ways that bound the number of objects allocated.

1.2   Objectives

This project will develop on it objectives. The main objectives for this project are to use Java programming language to program a robotics and also design a movement for that robot depend it work. One robot will construct using Lego Mindstorms and use Java programming language to program it. Combination Java and Lego Mindstorms will call LeJOS.

The next objective is to development one robot that very useful for human using Lego Mindstorms for example to collects a ball. So, the program that wrote not only to make a simple movement, but the movement will be useful for human.

Others objective is to study about advantages and disadvantages using Java to programming Lego Mindstorms compare with others programming language. This is important objectives to introduce people which programming language is better in programming robotics.

1.3   Problem Statement

Now, people or student will choose to use famous software like Robolab to program their Robotics that construct using Lego Mindstorms. This is famous software that include with Lego Mindstorms Kits. Only a small count of people used Java Programming language to program their robotics actually for Lego Mindstorms Robotics.

Build education oriented robotic application using Java programming. People will choose to use either C/C++ programming language or Visual Basic in programming. But, they don't know that Java have more advantages compare with other programming language. That has only little advantages by using C/C++ and Visual Basic in programming.

1.4   Scope of Projects

Java programming language base on Lego Mindstorms (LeJOS) are utilizes in this project. One robot will develop using Lego Mindstorms that capability on handling and moving tennis ball size from one point to another point. Program was written depend on the robot movement. Debug will do if a problem occurred either program or robot design. All data or program will be transferred using IR Tower.

CHAPTER II

LITERATURE REVIEW

2.1   Introduction

Before start this project, literature review about Lego Mindstorms and also about Java had been done. These two are the main parts in my project. Lego Java Operating System not is the new system in the world but it rarely use. Programmer always chooses to use either Robolab or C programming language to program the RCX. In Lego Mindstorms, it has many main important parts. All of these parts must enclose before can complete build and design one robot that has a specific movement.

2.1.1 LeJOS Operating System

LeJOS is a replacement firmware for the Lego Mindstorms RCX brick. It is a JVM (Java Virtual Machine) that fits within the 32kb on the RCX so it acts as the operating system. LeJOS provides an API that gives direct access to the input and outputs of the RCX. The API provided for LeJOS also gives many different methods to control the RCX unit with an easy implement. It allows controlling the light sensors, the motors, the touch sensors, and the IR tower communication.

LeJOS allows running Java code inside the RCX, letting program in a familiar language as opposed to using the default Lego interpreter. It includes an API that gives direct access to the inputs and outputs from Java itself, as well as a subset of standard Java API. Since this is not a fully-featured Java OS, an alternate compiler is provided for compiling and generating classes for the LeJOS that called JavaCard or Java 2 Micro Edition (J2ME). The Java programs and standard Java API are subset of standard Java so they can easily evolve to fully-featured OS in the future, given that RCX memory constraints allow that.

LeJOS was originally developed solely by Jose Solorzano, but is now maintained by Paul Andrews and Jurgen Stuber. Great effort has taken in making a Java environment for the RCX, given the inherent constraints of the RCX. So, knowing about Java will give a head start in creating programs for RCX. The fact that LeJOS is a new firmware for the RCX, and thus does not leverage the Lego firmware, will allow to make programs which are more advanced that is possible using either the Lego programming environment or NQC (Not Quite C).

LeJOS features a fully functional implementation of the Java language, including pre-emptive threads, multi-dimensional arrays, recursion, floating point operations, trigonometry functions and string constants, just to name a few features. The main LeJOS goal differs a bit from its predecessors, because its aim to be as complete and efficient as possible rather than very small.

2.1.2 LEGO

Lego comes from the combination of Danish "leg godt", which means to "play well". It is brand and a company which creates toys and different pieces and plastic bricks that one can use to construct different forms and shapes. Mindstorms is a product line by LEGO that allows to design and program real robots that move, act, and think on their own. With Mindstorms, anyone can create everything from a light-sensitive intruder alarm to a robotic rover that can follow a trail, move around obstacles, and even duck into dark corners.

2.1.2.1 LEGO Mindstorms Box

This box contains a lot different parts, including, motors, sensors, the RCX, and different LEGO parts. Some relevant and the most important parts for this application will be described. It also have different type of tire, gear any a lot of small Lego components.

2.1.3   The RCX Unit

The heart of this new system is the RCX (Robotic Control X) or other name called Robotic Command Explorer, an autonomous LEGO microcontroller-based brick that can be programmed using a PC. The RCX serves as the brain of LEGO MINDSTORMS inventions. It uses sensors to take input from its environment, processes data, and signals output motors to turn on and off. Users first build their robot using the RCX and LEGO pieces. Then, a program for their design is created using RCX Code, a simple, powerful programming language. Next, they download their program to the RCX using a special infrared transmitter. Their creation can now interact with the environment, fully autonomous from the computer. The RCX (The Robotics Command Explorer) unit, also called brick, is large yellow Lego brick about 6.5 x 10 x 4.5 cm. It contains a Hitachi H* microcontroller, 8 bits CPU at 16 MHz and an infrared port, four buttons and a LCD. This brick is fully programmable in many languages and can use different firmware, including LeJOS.

Figure 2.1 The RCX

(Source: *AVR Robot Controller 1.1* article, April 2004 issue of Servo Magazine)

The RCX can be controlled in two ways:

i)   Remote control (direct control from a personal computer)

ii) Autonomous control (first designs a program on the computer, then download it into the brick for execution without further need for the computer)

The RCX has three input ports for sensors (e.g. push button or light sensor) and three output ports (e.g. for motors or lights).
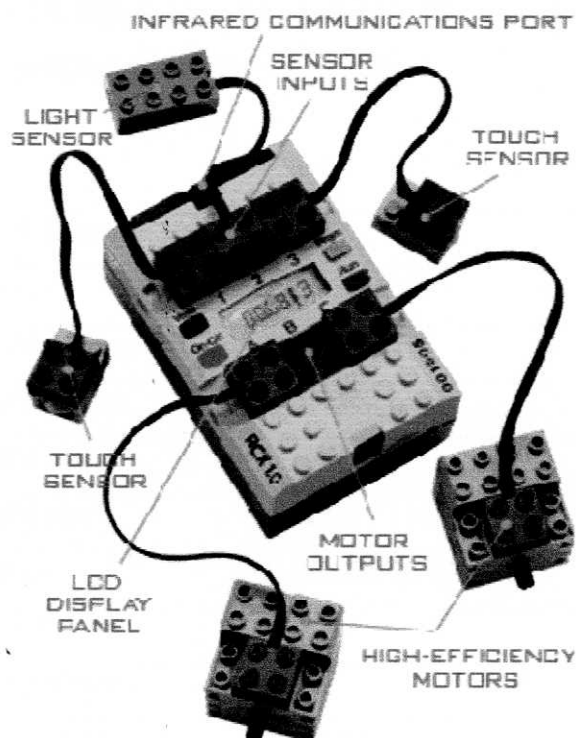
Figure 2.2 Inputs and Output for RCX

(Source: *AVR Robot Controller 1.1* article, April 2004 issue of Servo Magazine)

Communication is by infrared light. An IR-transceiver ('the tower') is connected to a serial port of the personal computer. A wireless link to the RCX itself allows it to move freely, especially as part of moving robot vehicles. At the core of the RCX is a Hitachi H8 microcontroller with 32K of external RAM. The microcontroller is used to control three motors, three sensors, and an infrared serial communications port. An on-chip, 16K ROM contains a driver that is run when the RCX is first powered up. The on-chip driver is extended by downloading 16K of firmware to the RCX. Both the driver and firmware accept and execute commands from the PC through the IR communications port. Additionally, user programs are downloaded to the RCX as byte code and are stored in a 6K region of memory. When instructed to do so, the firmware interprets and executes the byte code of these programs.

RCX Specs	
Series	H8/3297
Product name	H8/3292
Part Number	HD6433292
ROM size	16K
RAM size	512
Speed	16MHz @ 5V
8-bit Timers	2
16-bit Timers	1
A/D Conversion	8 8-bit
I/O pins	43
Input only pins	8
10mA outputs	10
Serial port	1

Table 2.3 RCX Specification

2.1.4 IR Tower

The USB infrared tower will be connected to the computer and is used for downloading the LeJOS firmware and programs to the RCX unit. It actually need to install a driver before can be used. The IR Tower driver is including with Robolab CD driver.
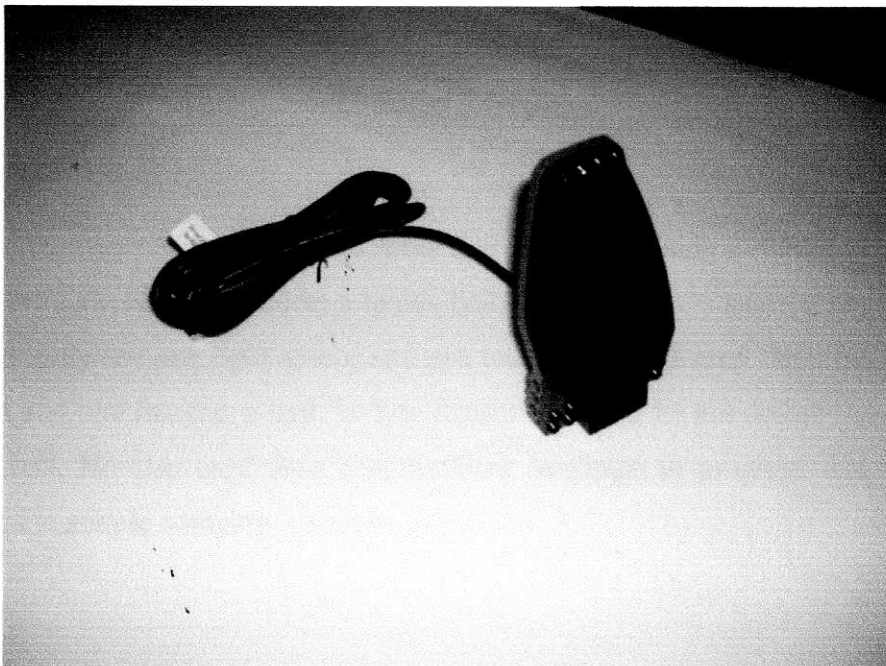

Figure 2.3 IR Tower