Robotic Controlled Character Recognition
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Using a Lego’s Mindstorms™ RCX Robot

Background: RCX and leJOS

- The RCX is a programmable brick
  - Hitachi H8300 Processor, 16MHz, 32K RAM, 28K available for safe firmware use
  - It can be programmed by downloading a program written in one of several available programming languages from a PC to the brick’s RAM via a special infrared (IR) interface.
  - After downloading and starting a software control program, an RCX-enabled Mindstorms robot may function totally on its own, acting on both internal and external stimuli according to the programmed instructions.

leJOS is a tiny Java virtual machine

- Replaces the default Lego Mindstorms firmware
- leJOS itself requires 17k of available RAM, leaving only 15k for user programs
- An Eclipse plug-in allows Lego control applications to be written in the most popular Java development environment

Project Objective

- To write a program in Java that will allow an RCX robot to identify letters according to a 3x3 matrix, and have the robot print the found characters on its LCD.
- The letters will be cut from black paper and mounted on a white backdrop. Each letter will be subdivided into 9 parts forming a 3x3 matrix.
- The robot will use the navigational code to steer its way through the matrix using transverse motions.
- The RCX robot will determine if part of the letter is in a particular section of the matrix by turning bits on or off according to the light reflected back into its sensor.

The Recognizer Algorithm

- After pressing the ‘run’ button on the brick it navigates the matrix.
- The way the program uploads to the robot through the IR Port took forever.
- Then its processed through this compare method:
- Which is stored as an array of numbers called: “infoCollected” that looks like this:

```
[{'1', '0', '1'}, {'1', '1', '1'}, {'1', '0', '1'}]
```

Obstacles of the Project

- The first hurdle of this project was learning Java and the Eclipse v3.0.1 environment. The project also required the use of leJOS, and I had to learn the libraries and interfaces provided by leJOS that interact with the RCX.
- The robot had a slight drift when it attempted a straight line.
- Manipulating the cut-out letters so that each letter will have a unique identity when read.
- Working with very limited memory in the brick, limited Java functions, and the excessively long downloading times.

Abstract

Embedded systems represent over 90% of all microprocessors and exist in many devices used in daily activities (e.g., cell phones, automobiles, televisions). Such systems are typified by limited resources (e.g., small memory footprint), which make programming their behavior a challenge. Robotics control systems provide an excellent platform for investigating aspects of embedded systems design.

This project describes an investigation into a robotic control system that is a of recognizing written characters. The implementation of the project is based on a Lego Mindstorms robot that is controlled by software written in Java. The software for the robot was written in Eclipse, which is a popular Java development environment. The compiled bytecode is executed on a tiny virtual machine, which also must be downloaded onto the robot through an infrared connection.

The investigation extended the Ledeen-Teitelman algorithm, which partitions a character into a 3x3 matrix. For implementation on the robot, the algorithm was adapted to make a robot traverse the matrix while looking for differences read by a light sensor (i.e., a change in the sensor value indicates that a piece of a character exists in a specific cell of the matrix). During the traversal, whenever a dark value was read, a bit representing the cell location is stored. At the end of the traversal, the collected values of the light sensor represent a bit stream that can be mapped to a unique alphabet character. After traversal, the robot will display the character value on its LCD screen.