

# Project Proposal

## Lego Learning

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Course: ICS 635  
Assignment: Course Project  
Date: April 9, 2010



# Introduction to Lego Mindstorms

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## The brain (Brick)

CPU:	Pentium II
RAM:	32 MB
Hard disk space:	115 MB



## The sensors

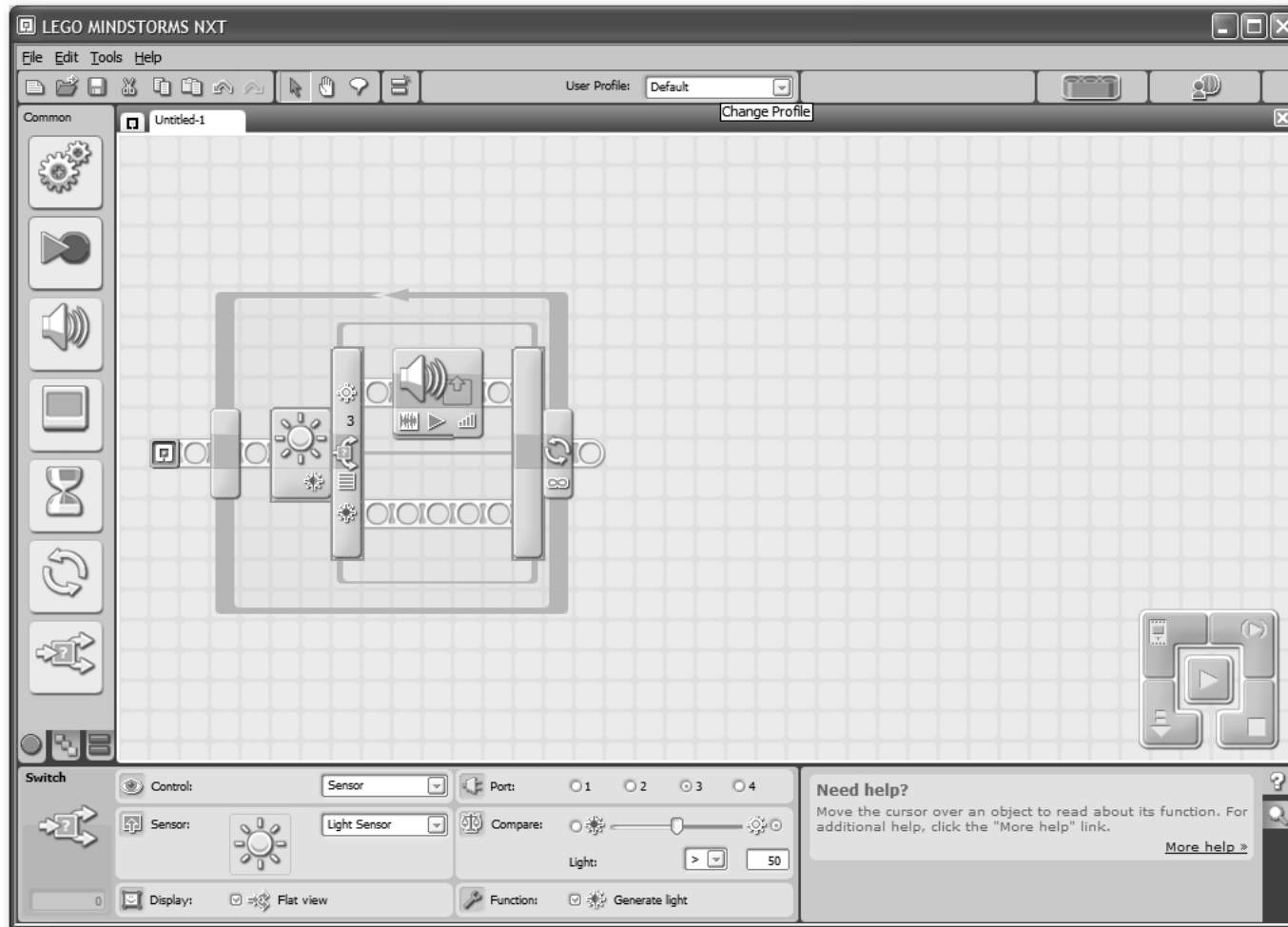
Touch:	0 or 1
Ultrasonic:	0 ~ 170 (cm)
Light / Color:	0 ~ 100 / RGB 0 ~ 255
Sound:	0 ~ 100
Rotation:	0 ~ 360 (degrees)



# Introduction to Lego Mindstorms

NXT-G toolkit

LabVIEW: A data flow / visual programming language



# Java Setup

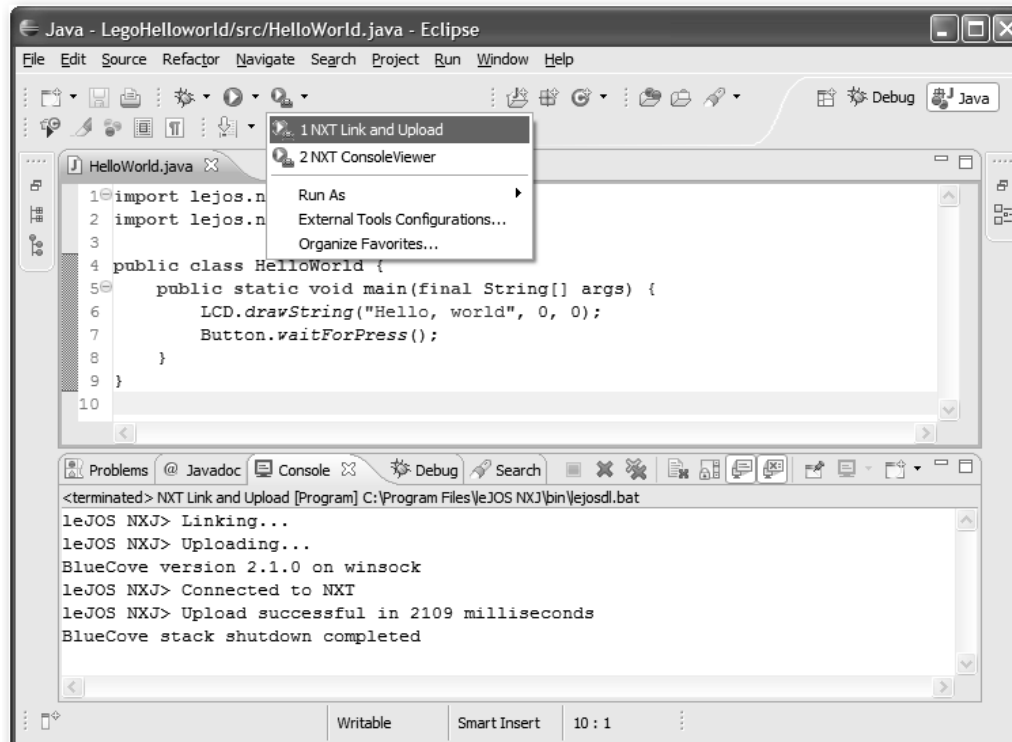
## Firmware setup

Replaced NXT-G operating system with leJOS, a Java-based firmware.

Robot now carries limited versions of JRE and JVM.

## Embedded programming environment

Configured Eclipse to compile and upload .nxt executable.

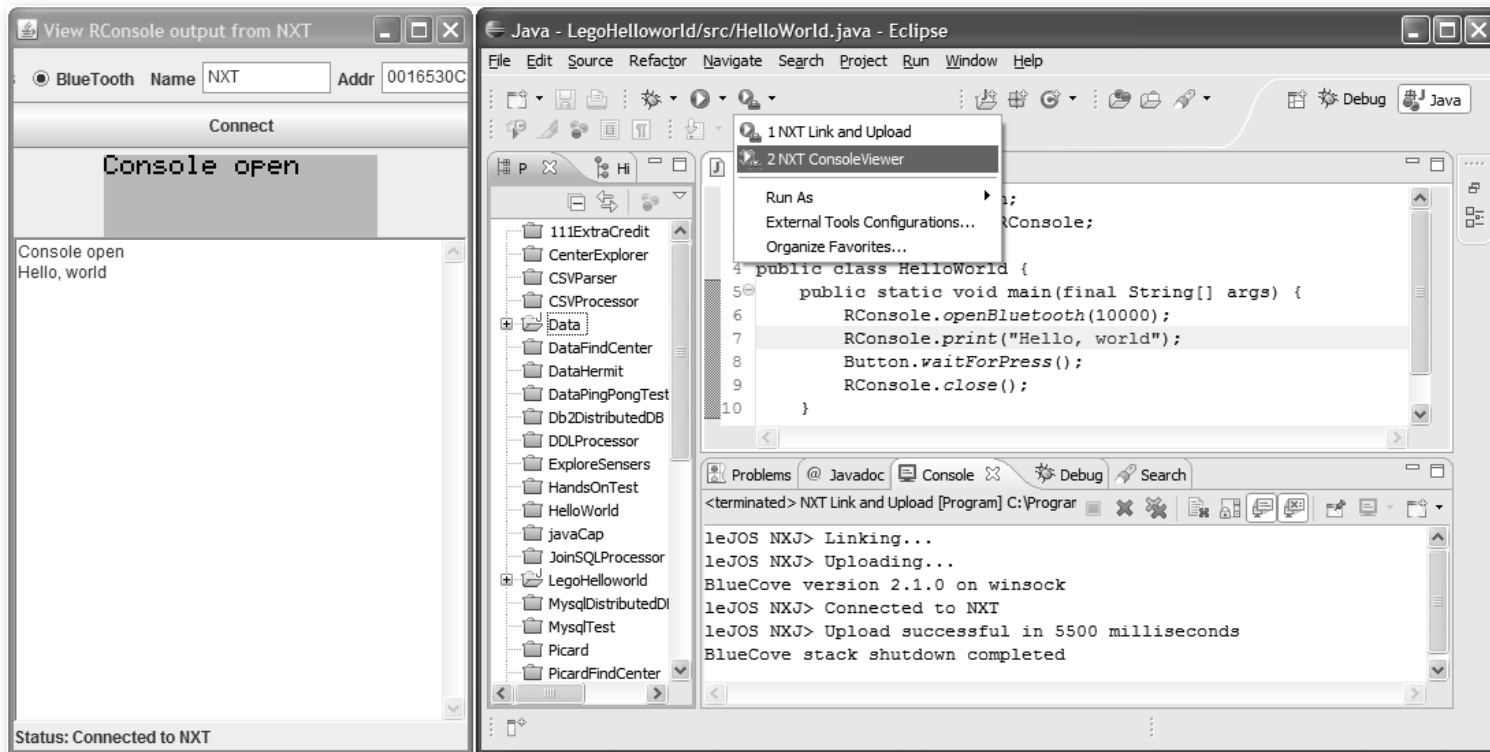


# Java Setup

Runtime diagnostics

Bluetooth or USB communication with PC.

Remote console provided with leJOS development kit.



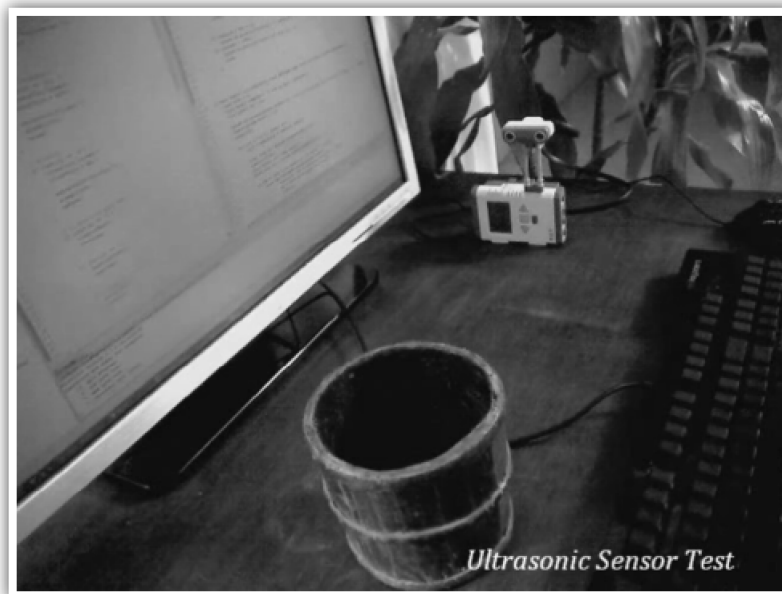
# Sensor Exploration

## Ultrasonic sensor test

Measures continuously for 1 second.

Reports min, max, average distances.

Executes until Escape button pressed.



```
View RConsole output from NXT
  USB  BlueTooth  Name  Unknown  Addr  0016530C53BB
  Connect
  samples: 4431
  average: 12.5984
  max: 12.9921259
  min: 12.5984251
Console open
[samples: 4363]
[average: 12.5984251968504]
[max: 12.992125984252]
[min: 12.5984251968504]
[samples: 4454]
[average: 12.5984251968504]
[max: 12.992125984252]
[min: 12.5984251968504]
[samples: 4449]
[average: 12.5984251968504]
[max: 12.992125984252]
[min: 12.5984251968504]
[samples: 4419]
[average: 3.54330708661417]
[max: 13.3858267716535]
[min: 2.75590551181102]
[samples: 4481]
[average: 2.36220472440945]
[max: 2.75590551181102]
[min: 2.36220472440945]
[samples: 4503]
[average: 2.36220472440945]
[max: 2.75590551181102]
[min: 2.36220472440945]
[samples: 4492]
[average: 2.36220472440945]
[max: 2.75590551181102]
[min: 2.36220472440945]
[samples: 4463]
[average: 3.54330708661417]
[max: 13.3858267716535]
[min: 2.36220472440945]
[samples: 4472]
[average: 12.5984251968504]
[max: 12.992125984252]
[min: 12.5984251968504]
[samples: 4471]
[average: 12.5984251968504]
[max: 12.992125984252]
[min: 12.5984251968504]
[samples: 4484]
[average: 12.5984251968504]
[max: 12.992125984252]
[min: 12.5984251968504]
[samples: 4431]
[average: 12.5984251968504]
[max: 12.992125984252]
[min: 12.5984251968504]
Console closed
Status: Connected to Unknown
```

# Sensor Exploration

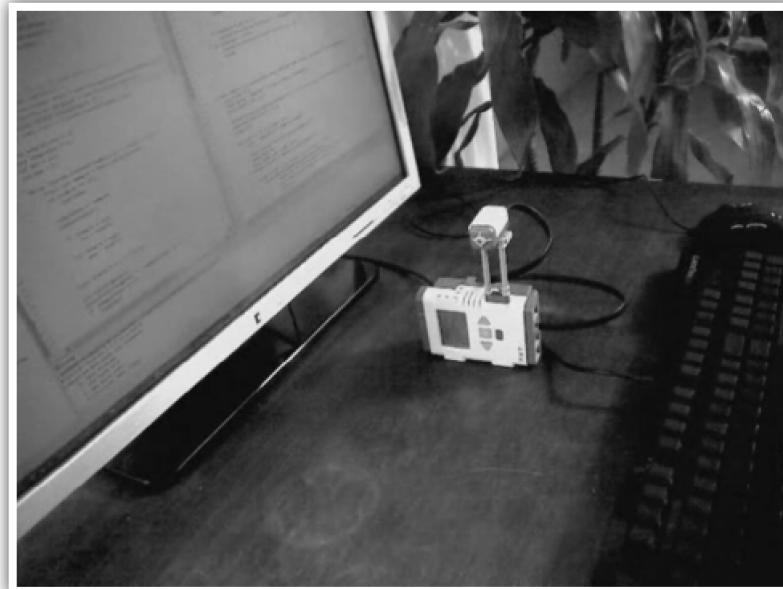
## Touch sensor test

Waits for button press.

Waits for button release.

Reports duration.

Executes until Escape button pressed.



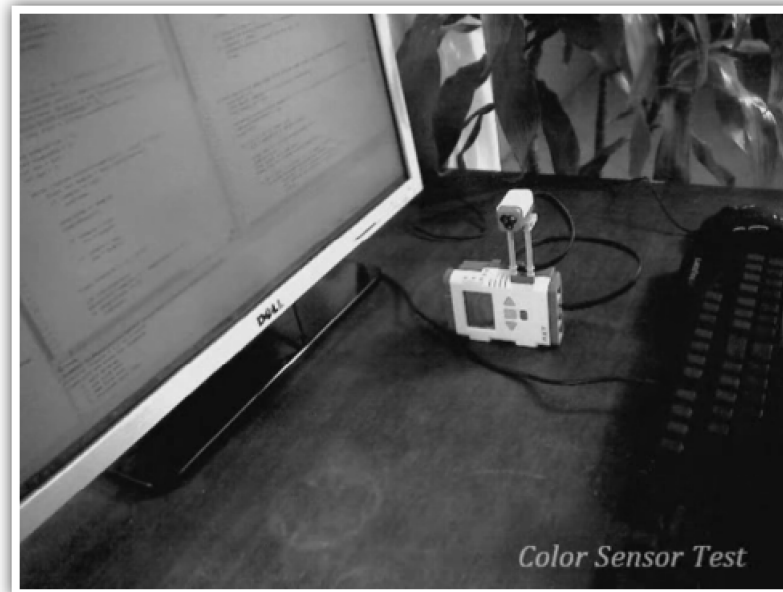
# Sensor Exploration

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## Light and Color sensor test

Preliminary tests failed using sensor.

Validated hardware using third-party executable.



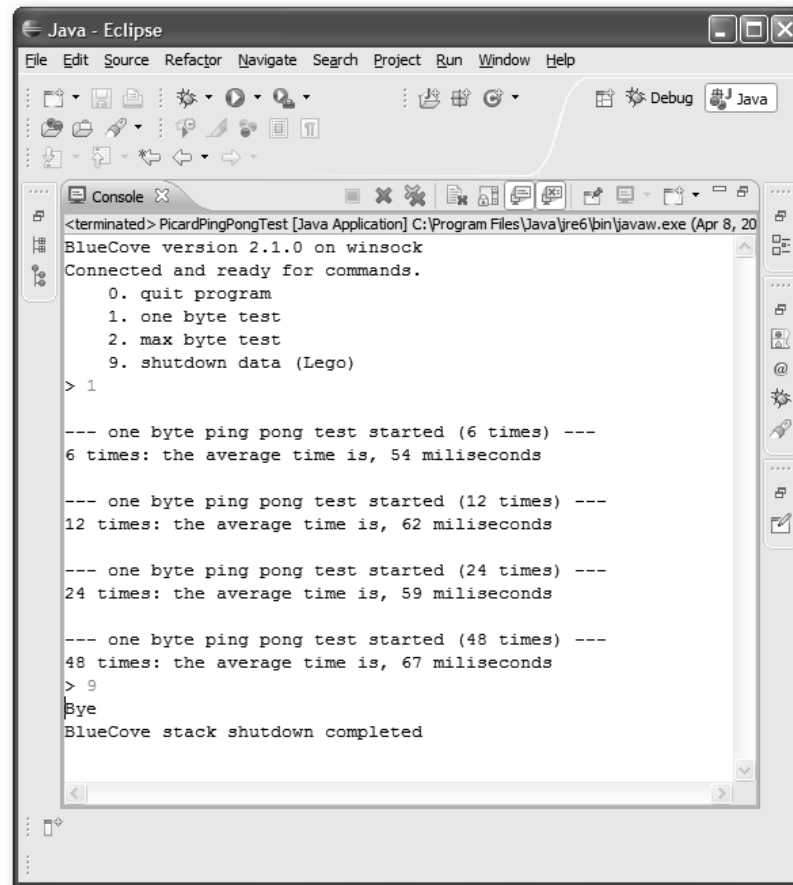


# Bluetooth Communication

Latency test

One-byte ping-pong test.

Approximately 50 – 70 ms round trip.



```
<terminated> PicardPingPongTest [Java Application] C:\Program Files\Java\jre6\bin\javaw.exe (Apr 8, 20
BlueCove version 2.1.0 on winsock
Connected and ready for commands.
  0. quit program
  1. one byte test
  2. max byte test
  9. shutdown data (Lego)
> 1

--- one byte ping pong test started (6 times) ---
6 times: the average time is, 54 milliseconds

--- one byte ping pong test started (12 times) ---
12 times: the average time is, 62 milliseconds

--- one byte ping pong test started (24 times) ---
24 times: the average time is, 59 milliseconds

--- one byte ping pong test started (48 times) ---
48 times: the average time is, 67 milliseconds
> 9
Bye
BlueCove stack shutdown completed
```

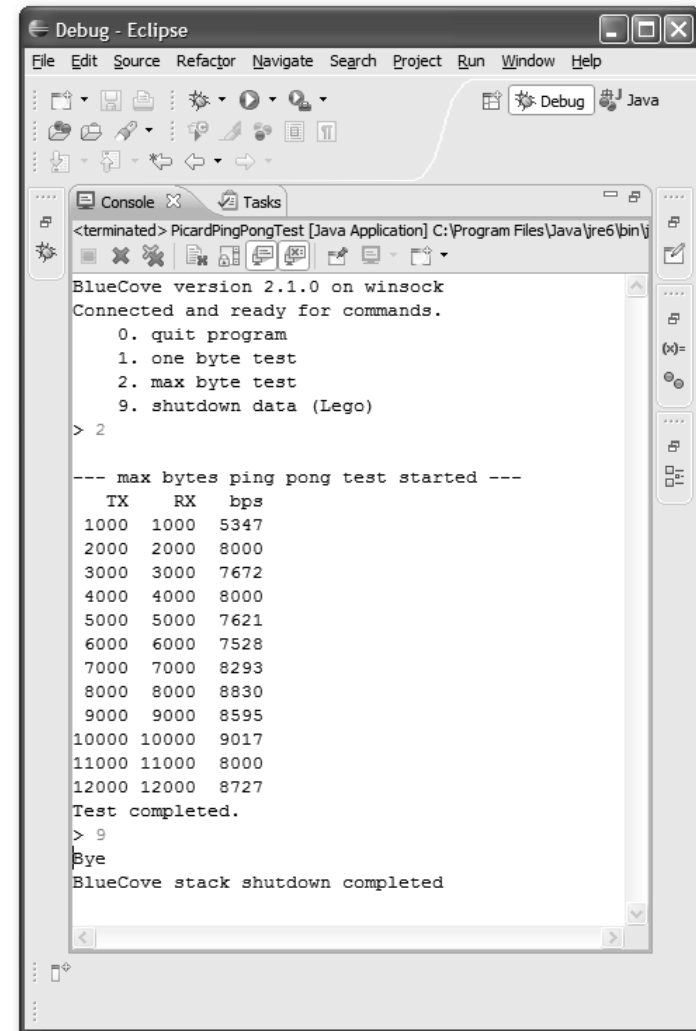
# Bluetooth Communication

## Bandwidth test

Experimentally discovered  
maximum buffer size for  
communication.

Approximately 16,000-byte  
limit.

Approximately 8,000 bytes  
per second.



```
Debug - Eclipse
File Edit Source Refactor Navigate Search Project Run Window Help
<terminated> PicardPingPongTest [Java Application] C:\Program Files\Java\jre6\bin\j
BlueCove version 2.1.0 on winsock
Connected and ready for commands.
0. quit program
1. one byte test
2. max byte test
9. shutdown data (Lego)
> 2

--- max bytes ping pong test started ---
  TX   RX   bps
1000 1000 5347
2000 2000 8000
3000 3000 7672
4000 4000 8000
5000 5000 7621
6000 6000 7528
7000 7000 8293
8000 8000 8830
9000 9000 8595
10000 10000 9017
11000 11000 8000
12000 12000 8727
Test completed.
> 9
Bye
BlueCove stack shutdown completed
```

# First Objective

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## Goal

Drive away from obstacles. In other words, look for center of room.

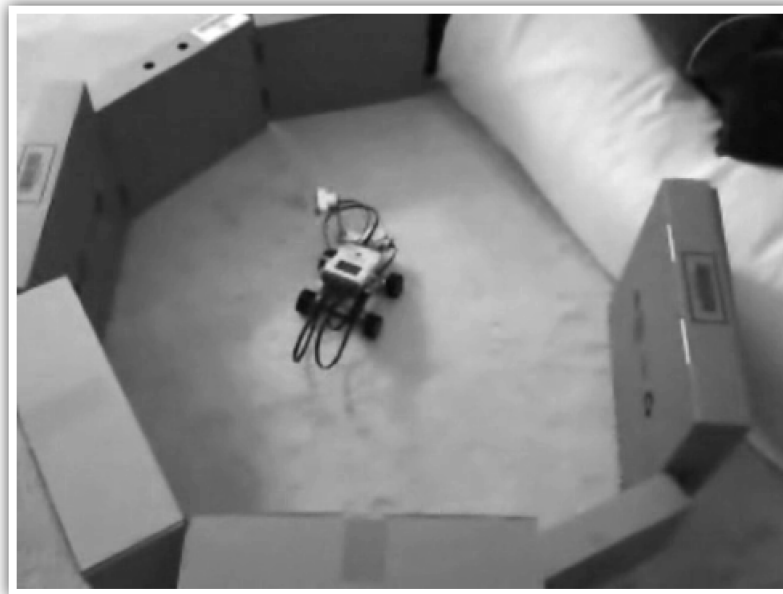
## Algorithm

Continuously read from sensor, evaluate data, and decide new direction.

Repeat this procedure until center is found within margin.

## Implementation

Simple state machine with command-response PC-robot protocol.



# Second Objective

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## Goal

Simultaneous movement, measurements, and communication.

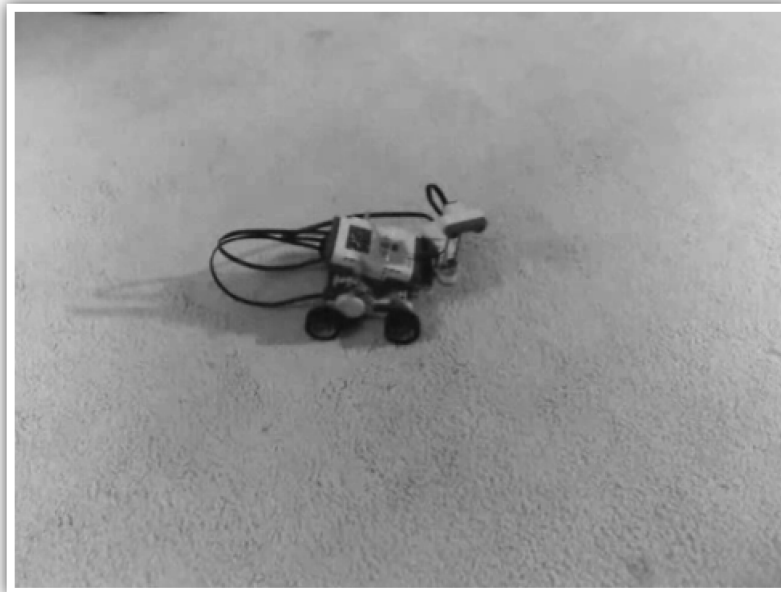
## Algorithm

Vector superposition of robot distances to sample points in scalar field.

## Implementation

Thread 1: Message pump.

Thread 2: Sensor recording, motor management, and decision making.



# Possible Projects

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## Map exploring

Currently under development.

## Projectile targeting

Building machine arm with two degrees of freedom.

Challenged by targeting consistency and verification methods.

Preliminary success using webcam as additional sensory input.

