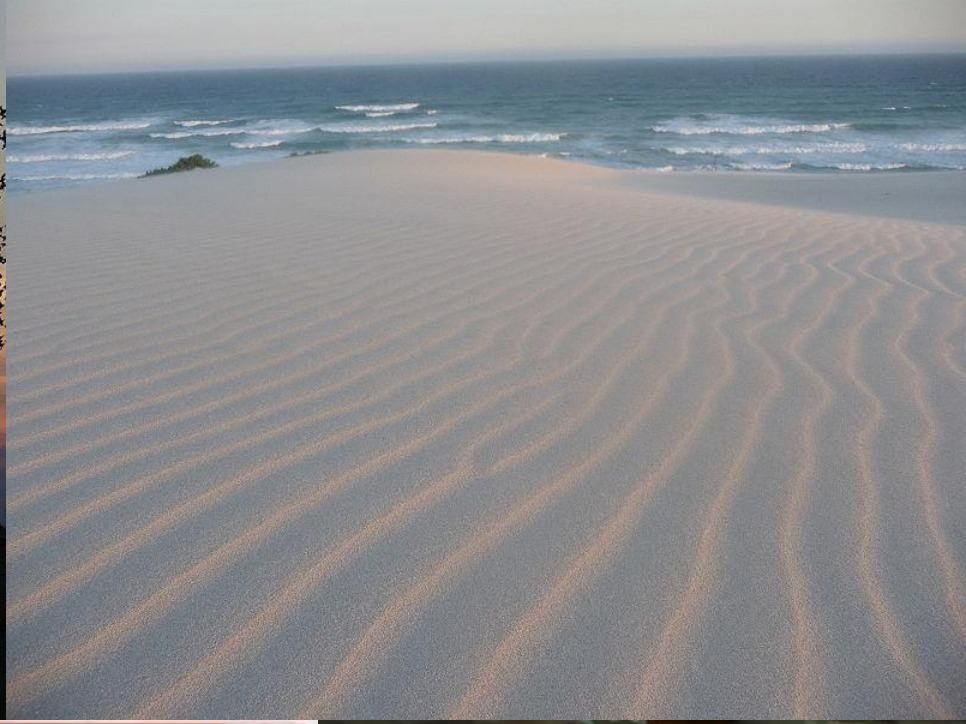


Emergent Behavior Robot

Bradley University

Senior Capstone Project

By: Andrew Elliott & Nick Hanauer

Advisor: Joel Schipper

April 29, 2010

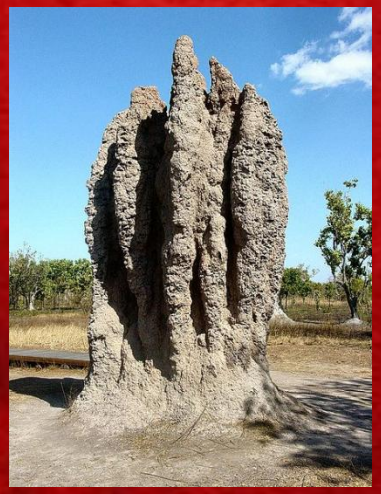
Overview

- Introduction
- Block Diagram
- Chassis
- Hardware
- Software Development
- Project Status
- Demonstration Video
- Future Work

Introduction

$2 + 2 = 5$

- Emergence
  - The result is greater than the sum of its parts
- Where does emergent behavior appear?
  - Weather phenomena
  - Geographical patterns
  - Animal behaviors
    - Swarming
    - Colonies

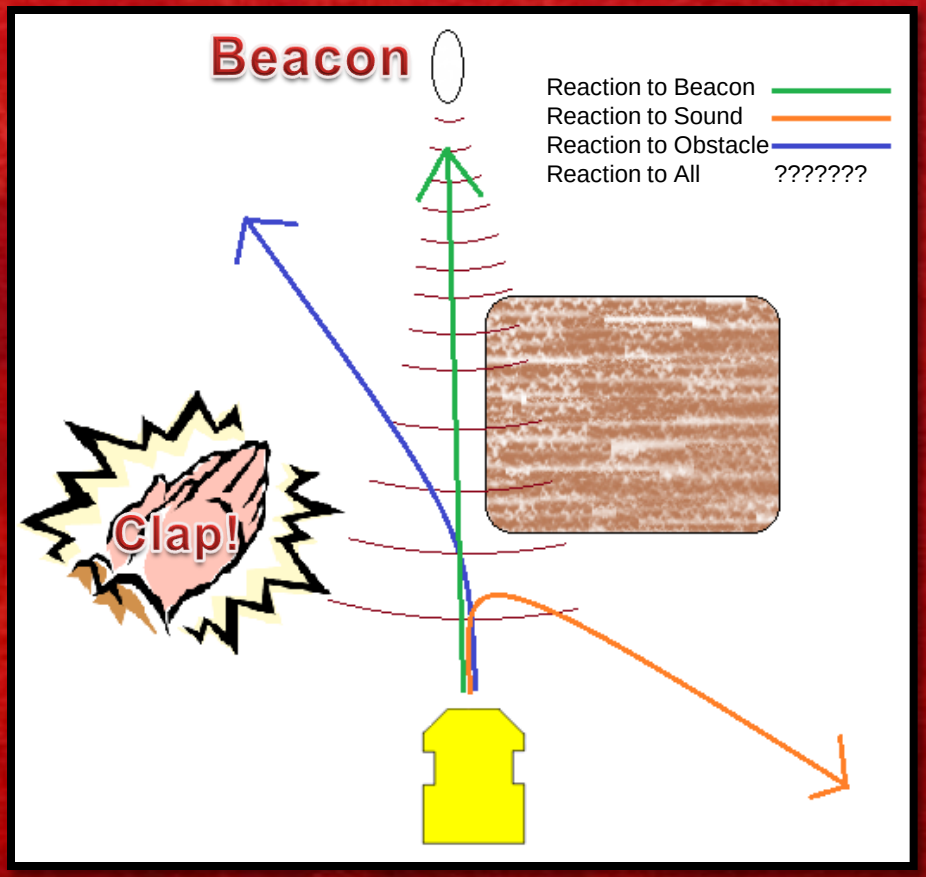


Goal

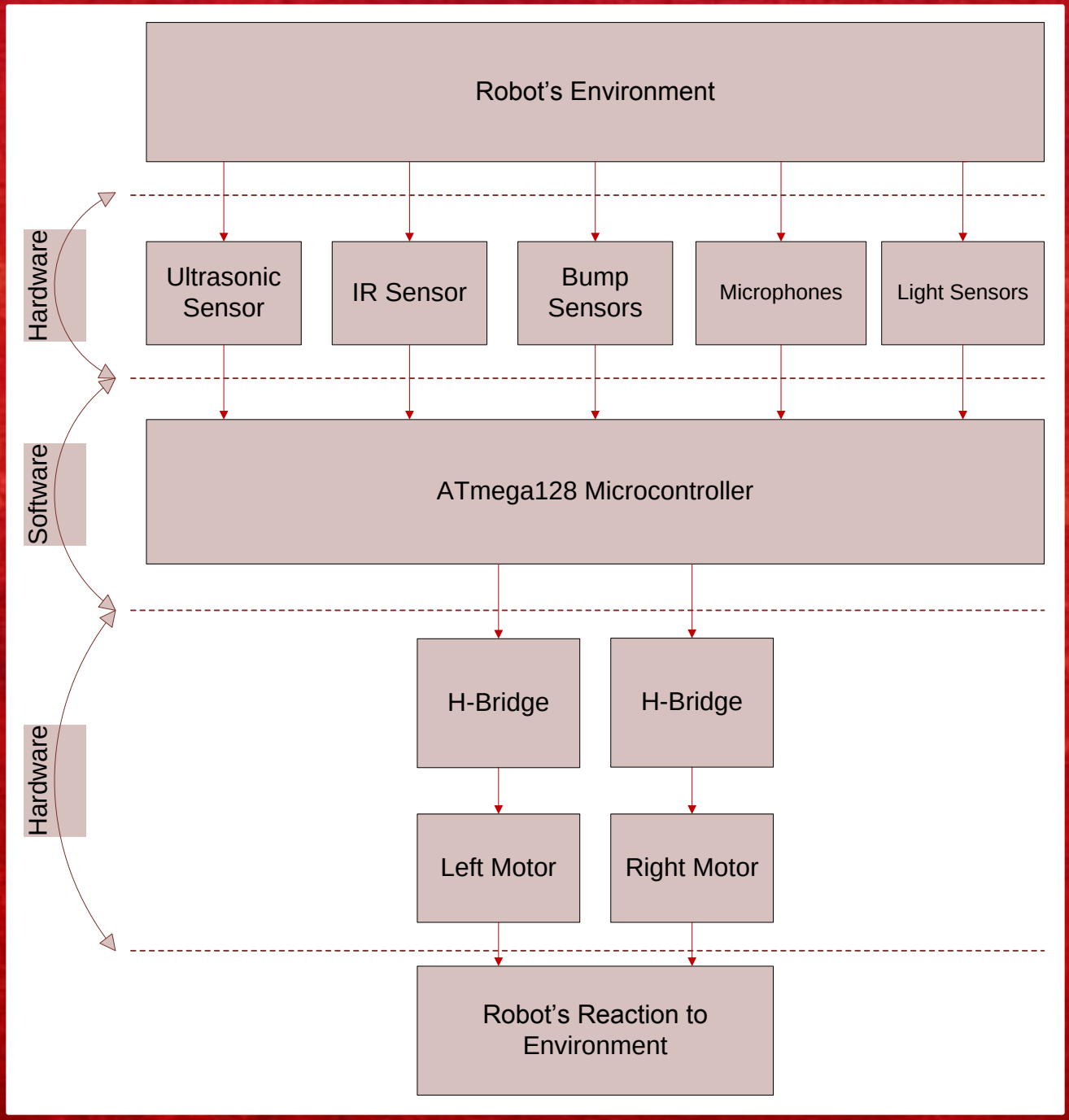
- Explore the use of emergence in robotics
  - Adapt to their dynamic environment
- Create a robot that:
  - Avoids obstacles
  - Flees from loud sounds
  - Influenced by shade of floor tiles
  - Seeks and travels to beacon
  - **Displays emergent behavior**

Objective

- What are we using it for?

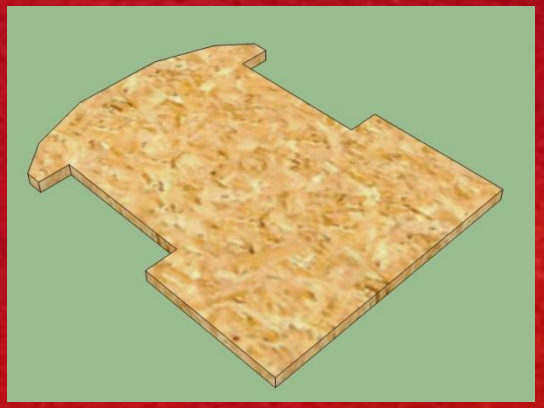


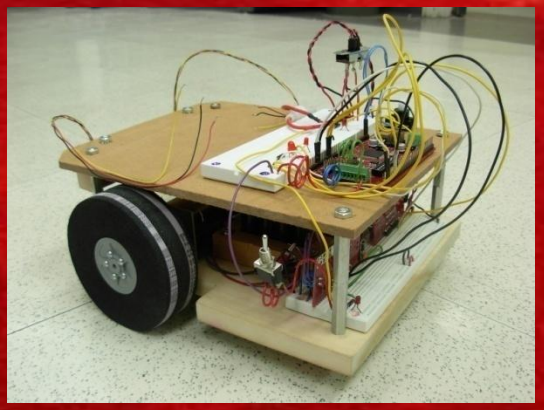
High-Level System Overview



Robot Chassis

- Designed in GoogleSketchup
- Cut from wood
- Fabricated and attached brackets
  - Motors
  - Sensors
  - Batteries
- Ceramic drawer pull as rear caster
- Second level added
- Hardware temporarily mounted

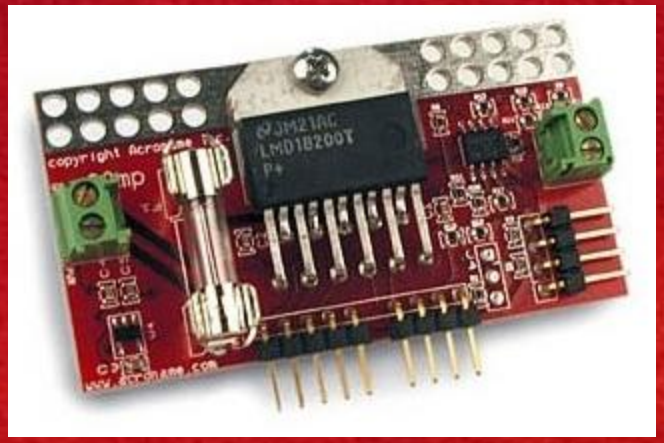




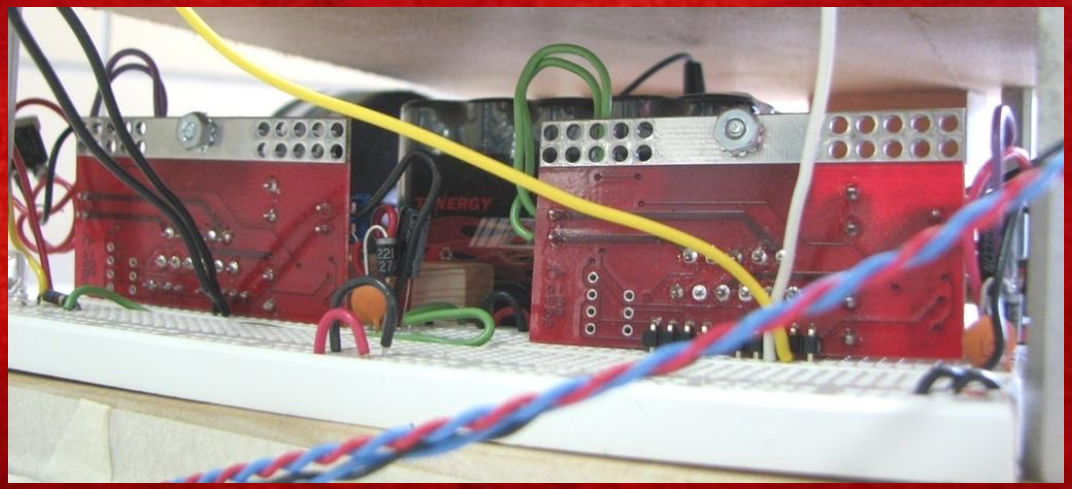
Hardware

- Motor
  - Specifications @ 24 volts
    - No load speed is 360 RPMs
    - Nominal current is 0.3 A
    - Stall Current is 2.8 A
  - Weighs 0.46 lbs

Hardware

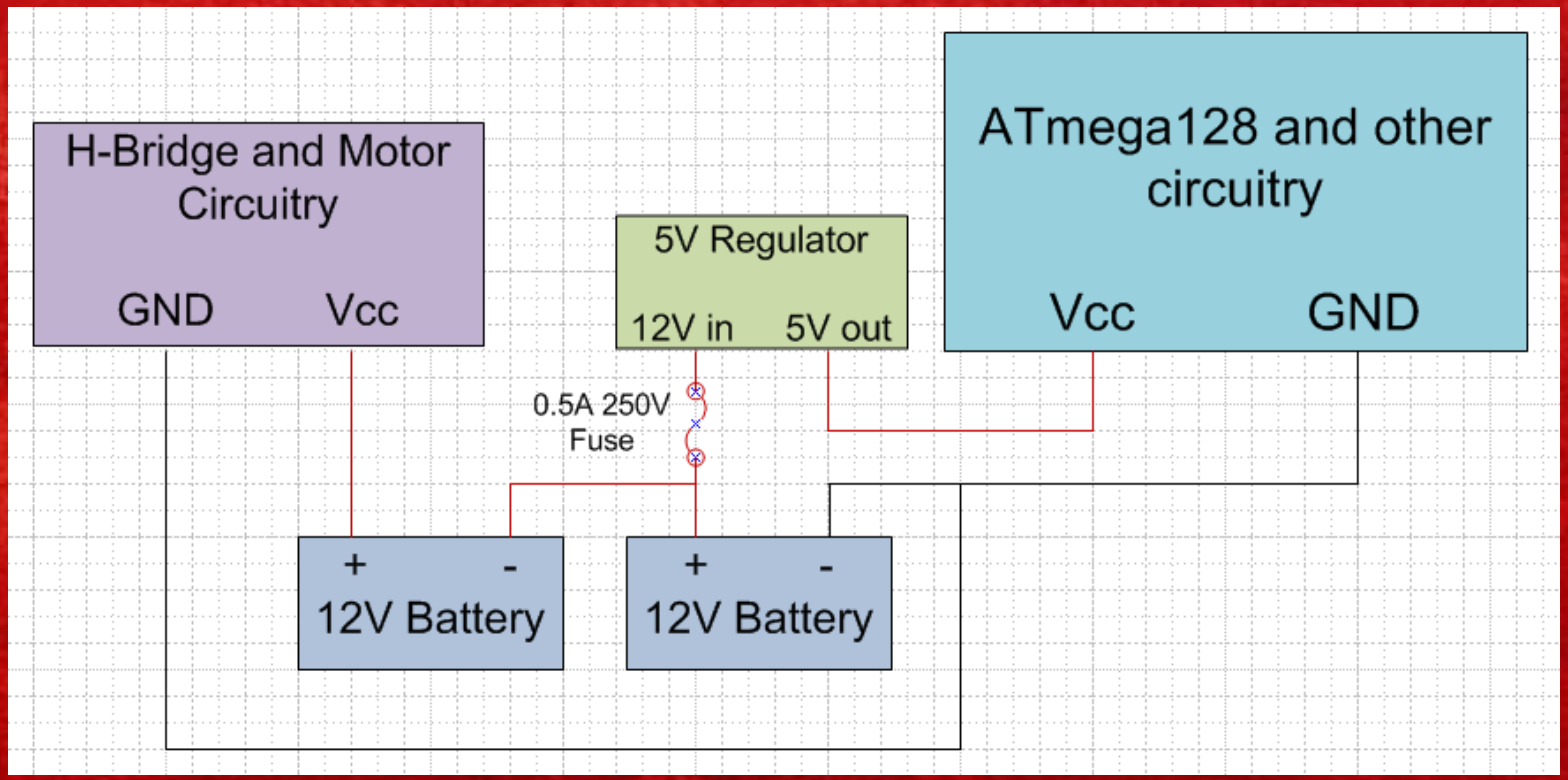


- H-Bridges
  - Control motor speed and direction
  - 3 amp continuous output -- 6 amp peak
  - Operate up to 55 volts
  - Motors only drew 0.6 amps at 24 volts



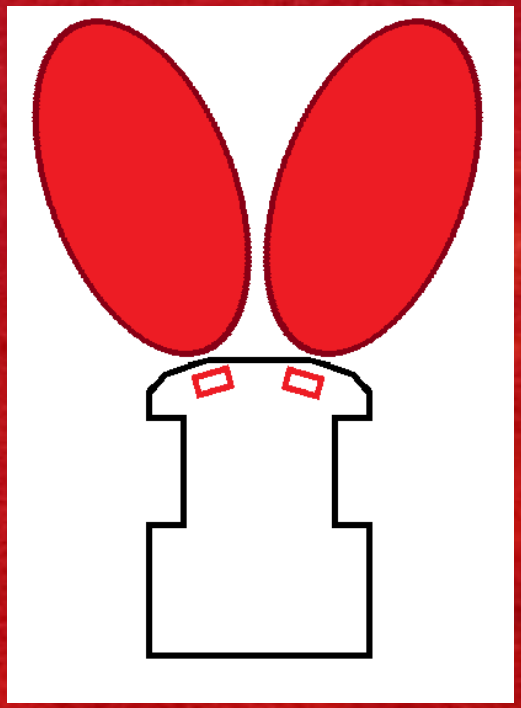
Hardware

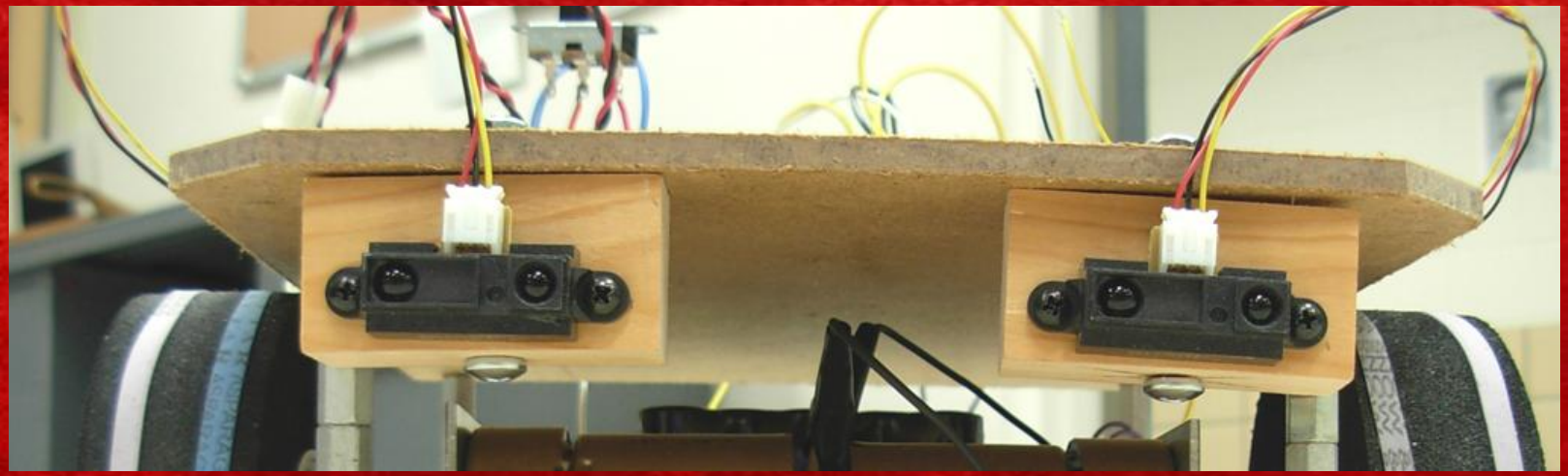
- Batteries
  - Two 12 volt Nickel Metal-Hydride batteries



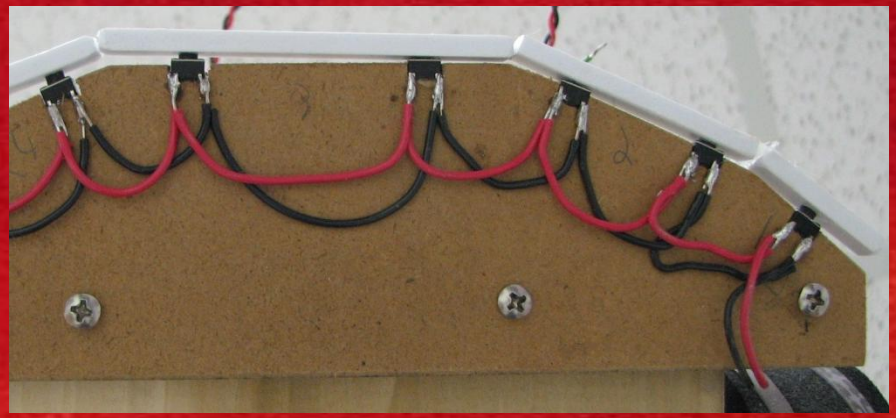
Hardware

- Infrared Sensors
  - Obstacle avoidance
  - Easy interfacing
  - Operating range 4" to 30"

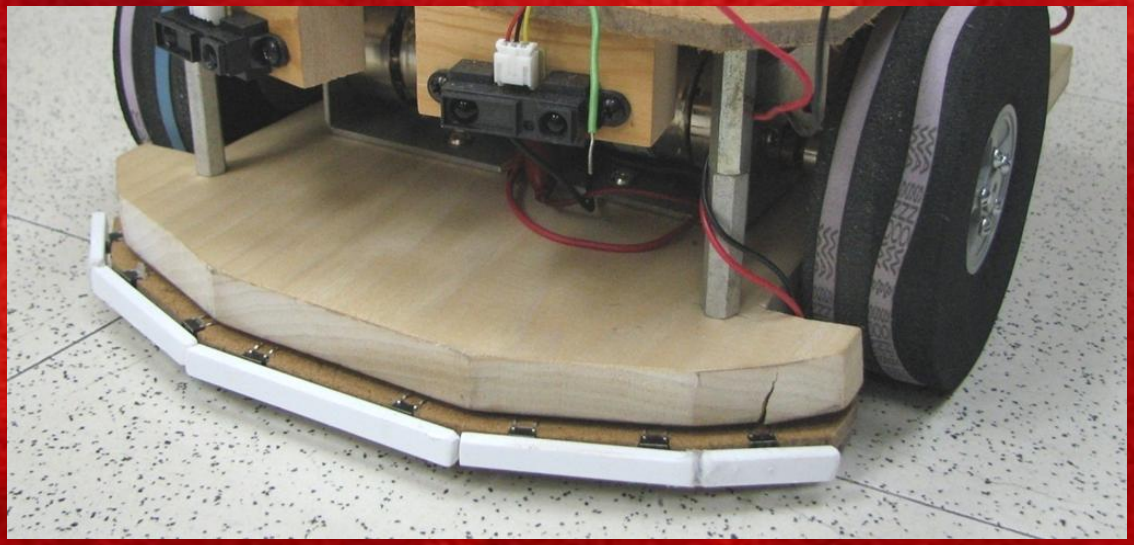




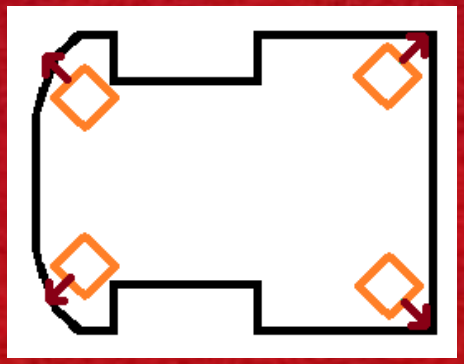
Hardware



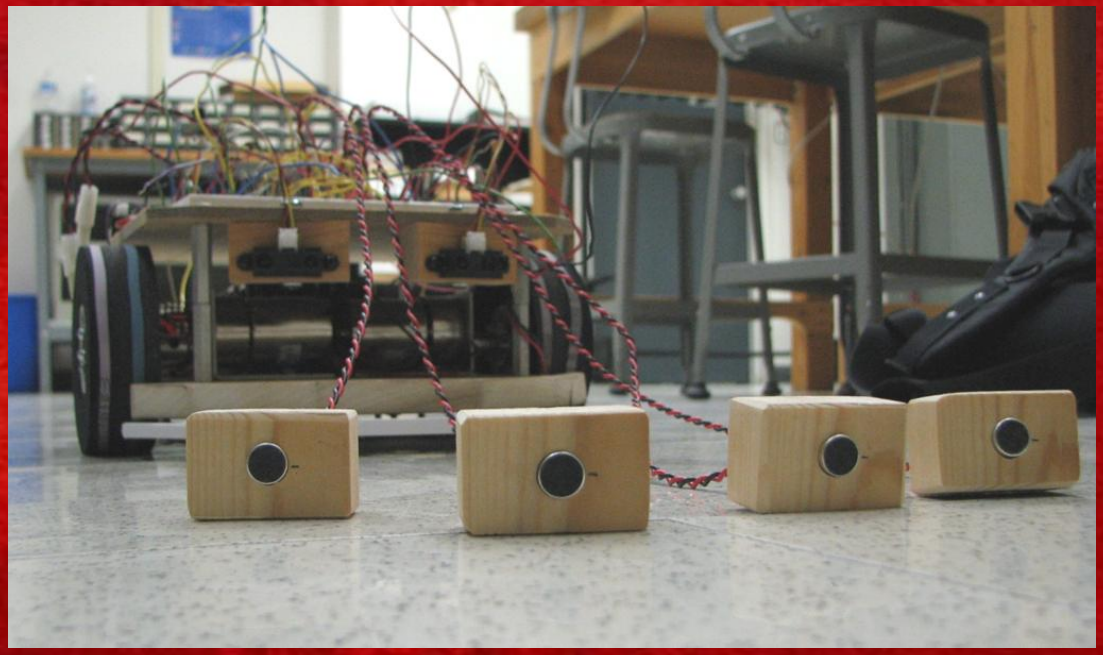
- Bump Sensors
  - Momentary switches
  - Detect obstacles missed by IR sensors
  - Array mounted on front of chassis



Hardware

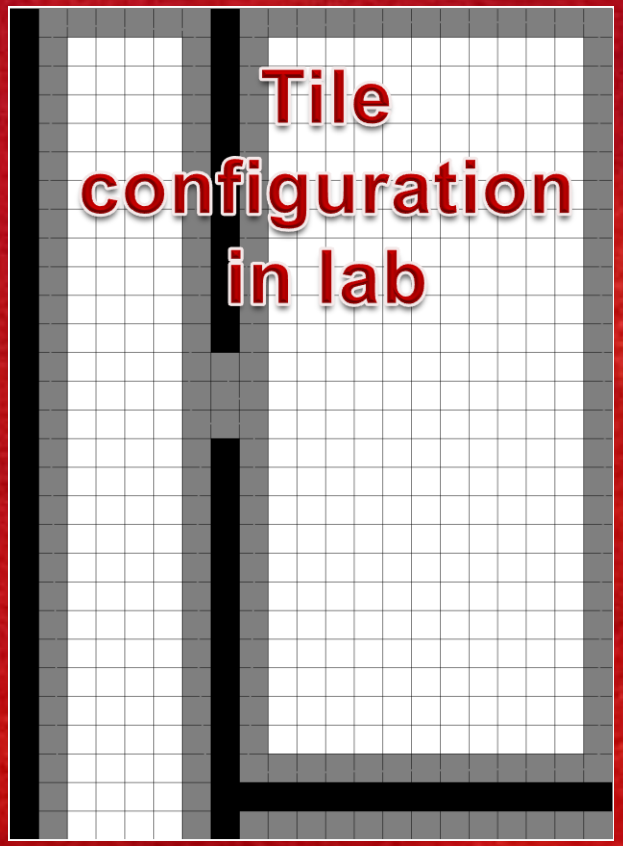


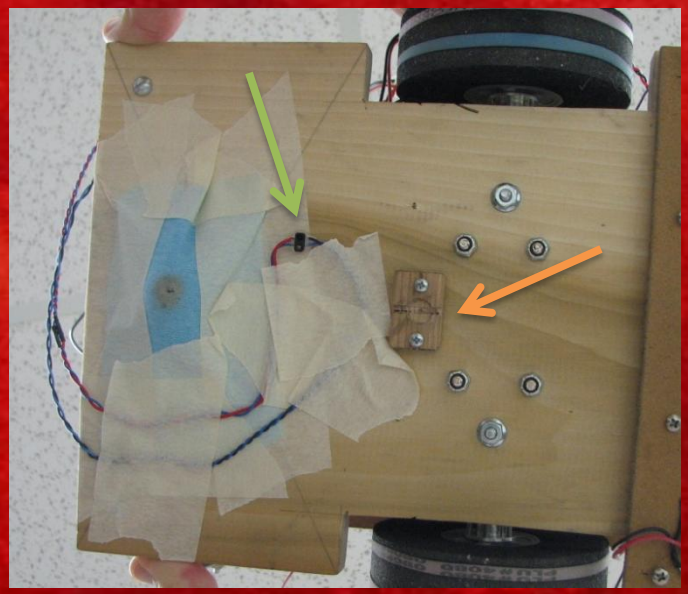
- Microphones
  - Multiple microphones used to detect source of loud sound

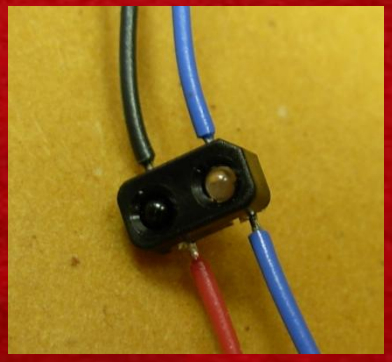


Hardware

- Reflective Light Sensors
  - Detect reflectivity of surfaces
  - Used to respond to floor tiles
  - Very small operating range

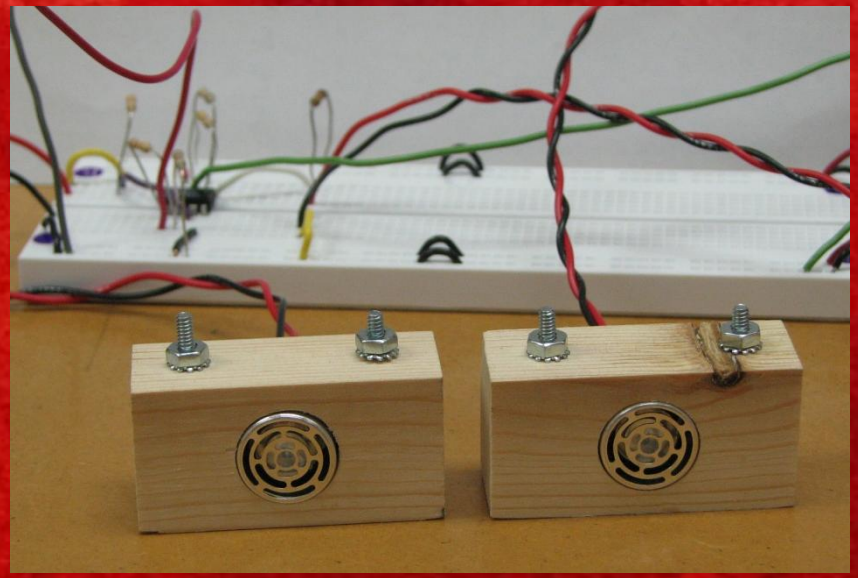


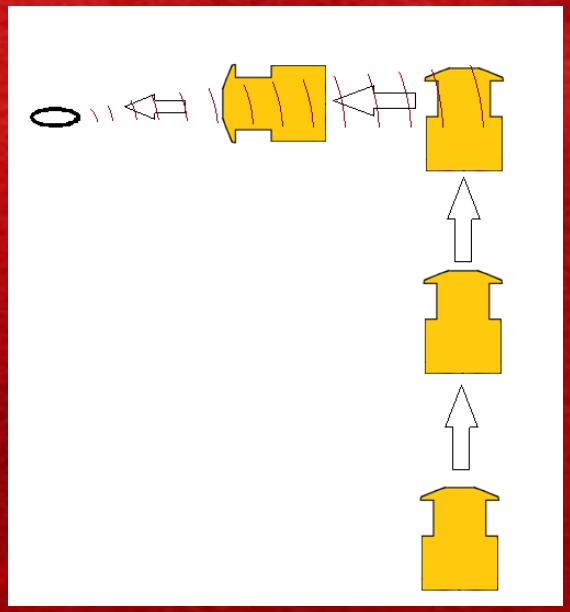




Hardware

- Ultrasonic Receiver/Transmitter
  - Transmitter sends a directional signal
  - Receivers pick up signal
    - Signal strength used to determine direction





Software Priorities and Behaviors

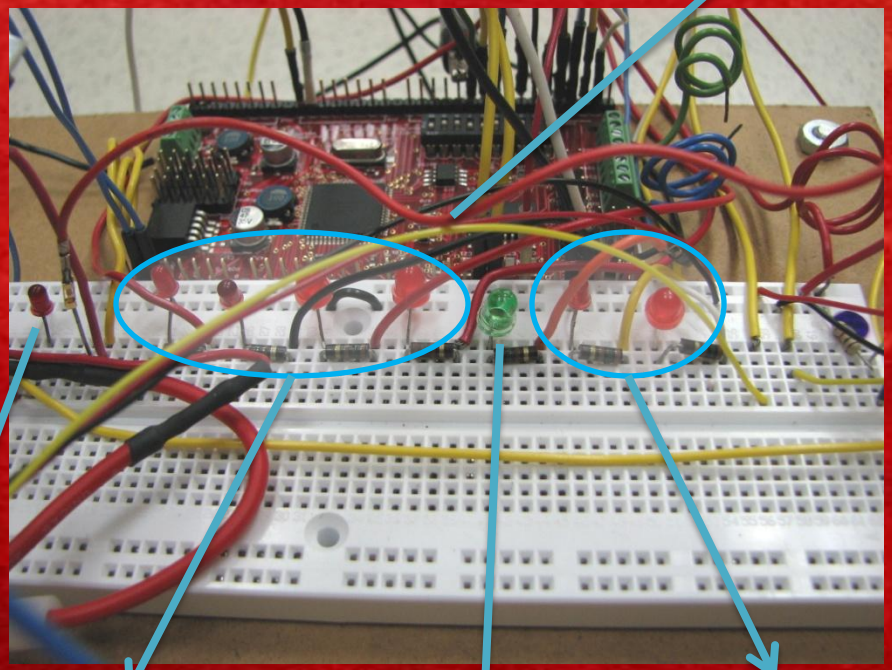
- Priorities (1 is the highest)

Task	Obstacle avoidance	Avoidance of loud sounds	Beacon found	Travel on dark tiles	Roam
Priority	1	2	4	5 (3 when evading sound)	6

- Behaviors (all include obstacle avoidance)
  - Roam
    - Search for beacon
  - Avoid Loud Sounds
    - Travel quickly away from source of sound
    - Find shelter (dark floor tile)
  - Beacon Found
    - Travel toward beacon

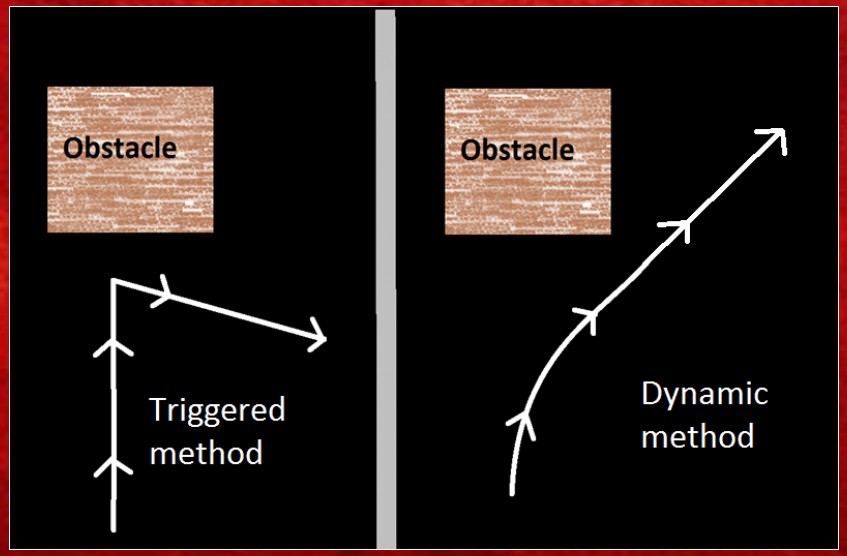
Software Development

- All software written in C
- Test applications for individual components
  - Infrared sensors
  - H-bridges
  - Microphones
  - Reflective light sensors
- Pre-programmed path
  - Test locomotion



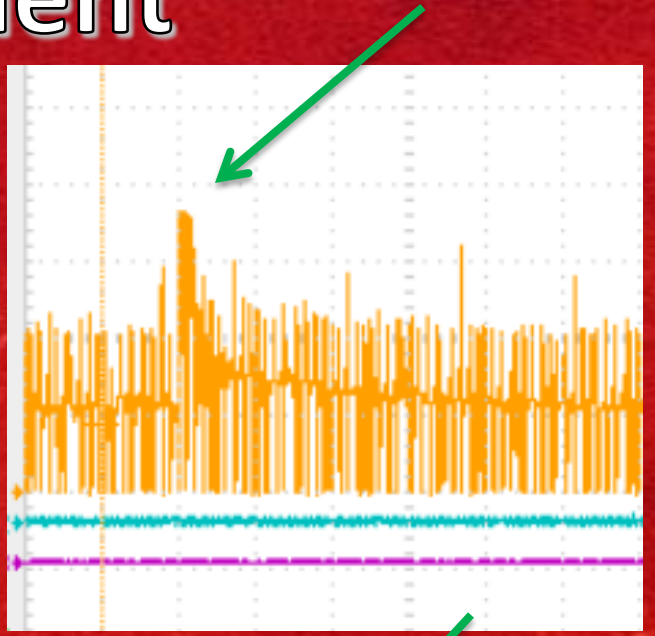
Software Development

- Obstacle avoidance
  - Triggered method
    - if(ir_volt >= threshold) {avoid_obstacle;}
  - Dynamic method
    - right_duty = duty_100 - ir_left*ir_conver_fac;



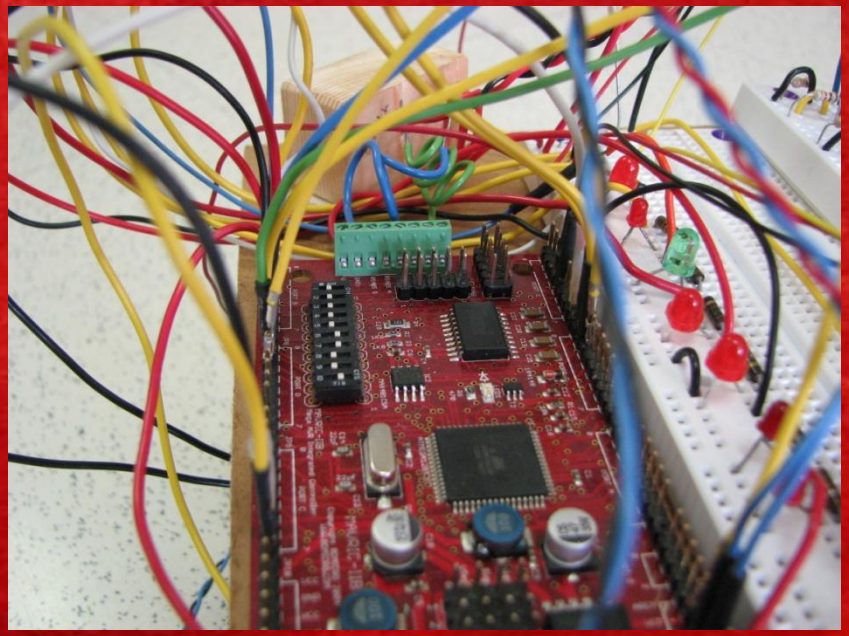
Software Development

- Added:
  - Bump sensors
  - A microphone
    - 5 volt regulator
  - All four microphones
  - Reflective light sensor



Project Status

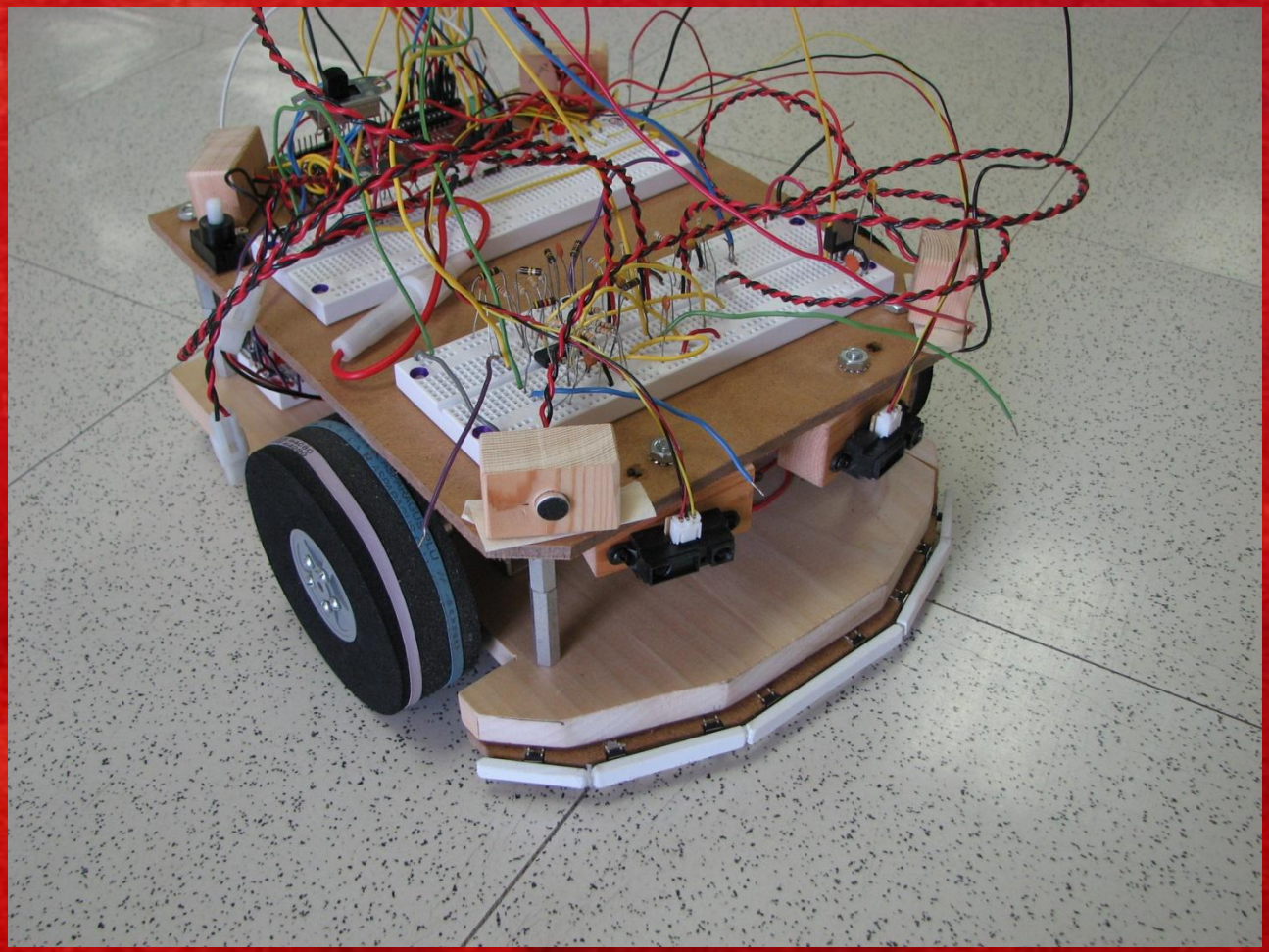
- Chassis built
- Components built and integrated
  - H-bridges
  - IR sensors
  - Bump sensors
  - Microphones
  - Reflective light sensors
- Behaviors implemented
  - Obstacle avoidance
  - Sound avoidance
  - Reaction to shade of floor tiles



Current Software Structure

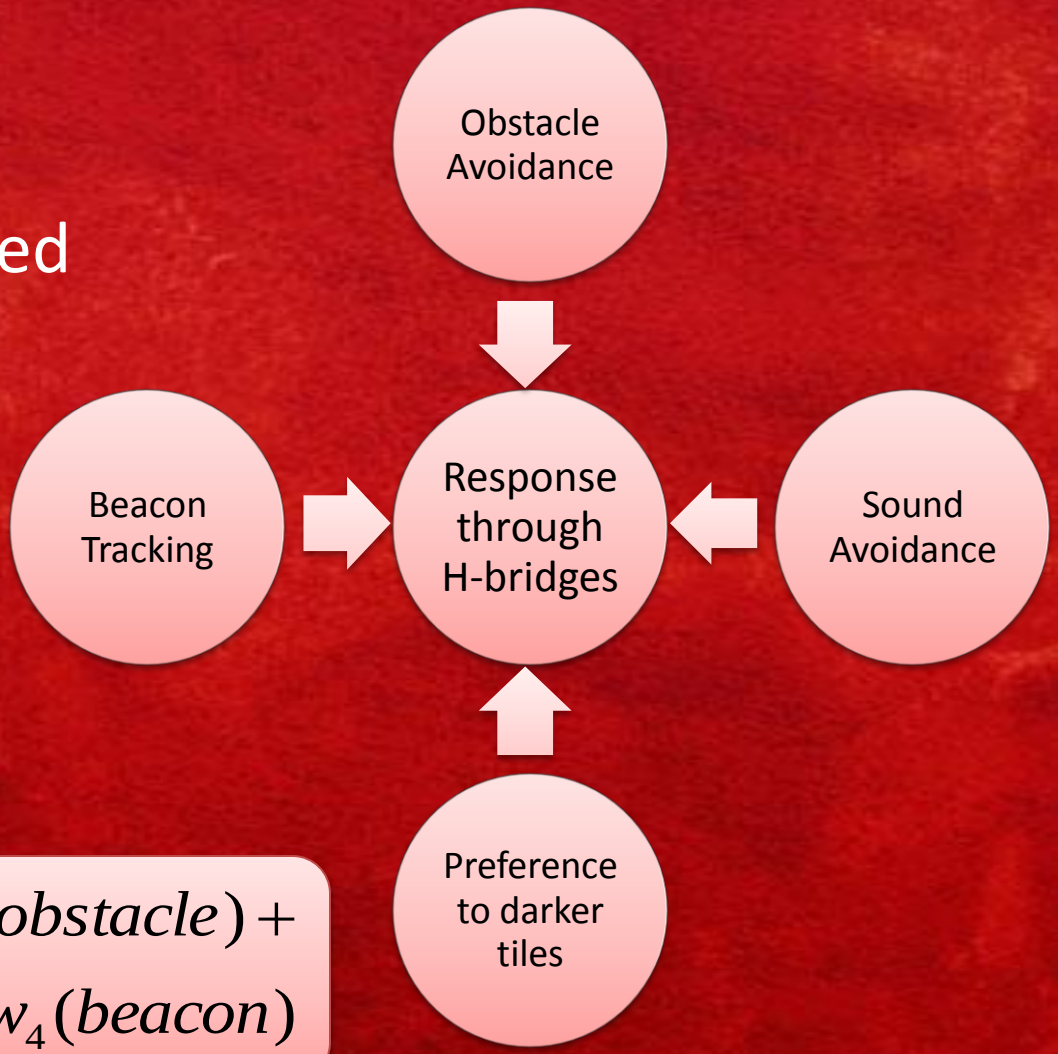
State	Situation
0	No triggered events
1	Object too close on left
2	Object too close on right
3	Object too close in front/Bump sensor triggered/Duty cycles too low
4	Microphone 0 triggered (front left)
5	Microphone 1 triggered (front right)
6	Microphone 2 triggered (rear left)
7	Microphone 3 triggered (rear right)

Demonstration Video



Emergent Software Structure

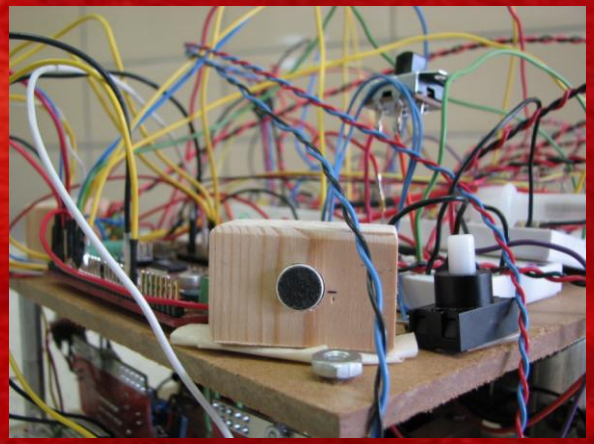
- One state
  - All situations handled at once
  - Response is simultaneous

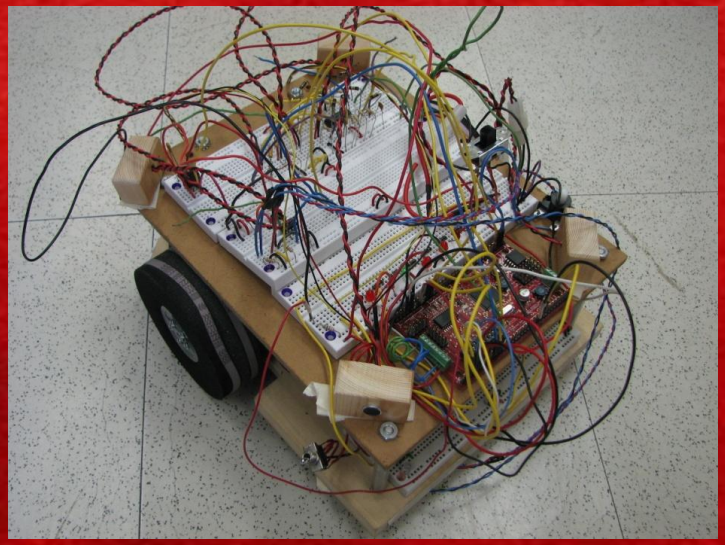


$$dutycycle = w_0(roam) + w_1(obstacle) + w_2(sound) + w_3(tile) + w_4(beacon)$$

Future Work

- Integrate ultrasonic sensors
- Implement beacon finding
- Determine exact source of sound
- Develop emergent behavior
- Clean up hardware






Thank you, Dr. Schipper & Mr. Schmidt
Questions?
Emergent Behavior Robot
Andrew Elliott & Nick Hanauer

Microprocessor Speed Needed

- Maveric-IIb has 16MHz clock
- Speed of sound = 13,397.244 in/sec
- Microphones 8in apart

$$\frac{13{,}397.244 in/s}{8in} = 1.675 KHz$$

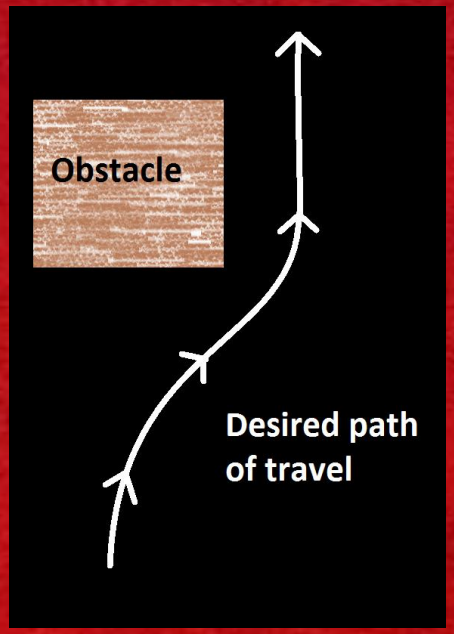
- Need frequency above 1.675KHz

Battery Life

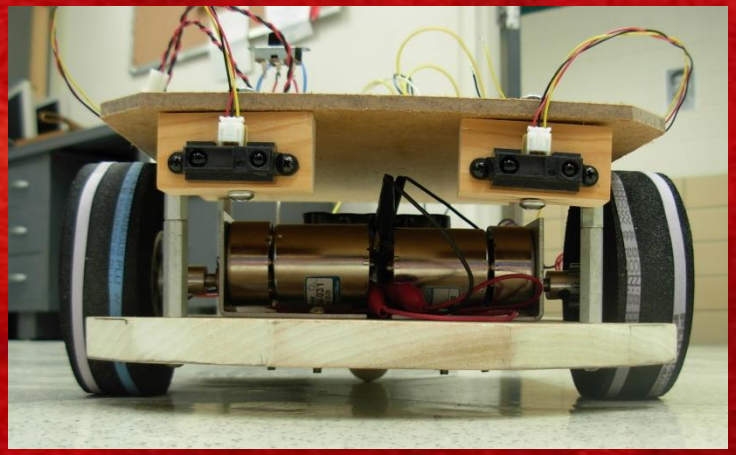
Component	Voltage	Amps
Electronics	5.116	.17
Motors	26.09	.596
Regulator Losses	7.634	.17
Battery Supply	12	2.3Amp Hours

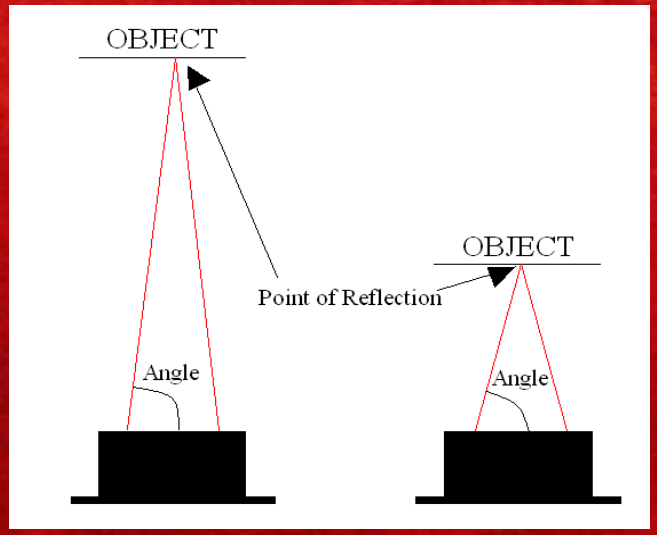
- Total Current draw = $.17 + \frac{.596}{2} + .17 = .654$
- Battery Life = $\frac{2.3 AmpHours}{.654 A} * .8 = 2.81 Hours$

Infrared Sensors



1. IR Sensor emits a pulse of light
2. Light travels to and reflects off an object
3. Light returns to IR sensor after a delay
4. Delay is used to determine objects distance from sensor

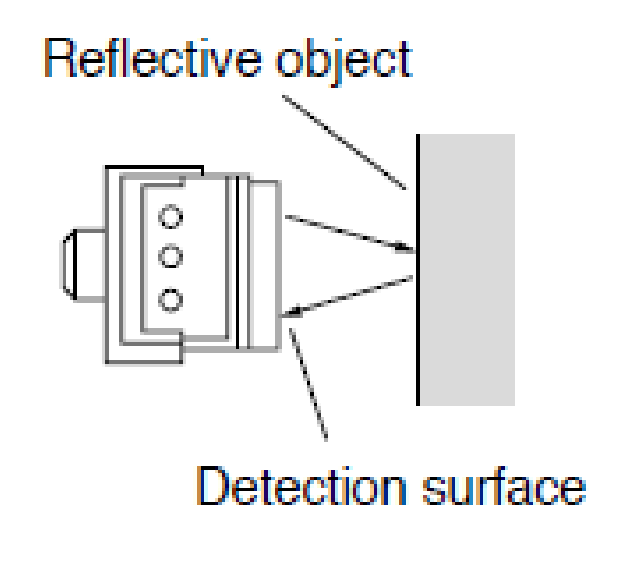


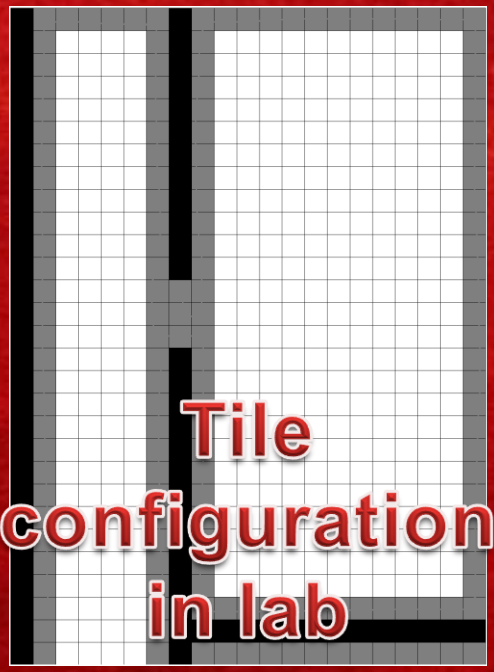


Sensor can detect objects between 4” and 31.5” away.

Reflectivity Sensors

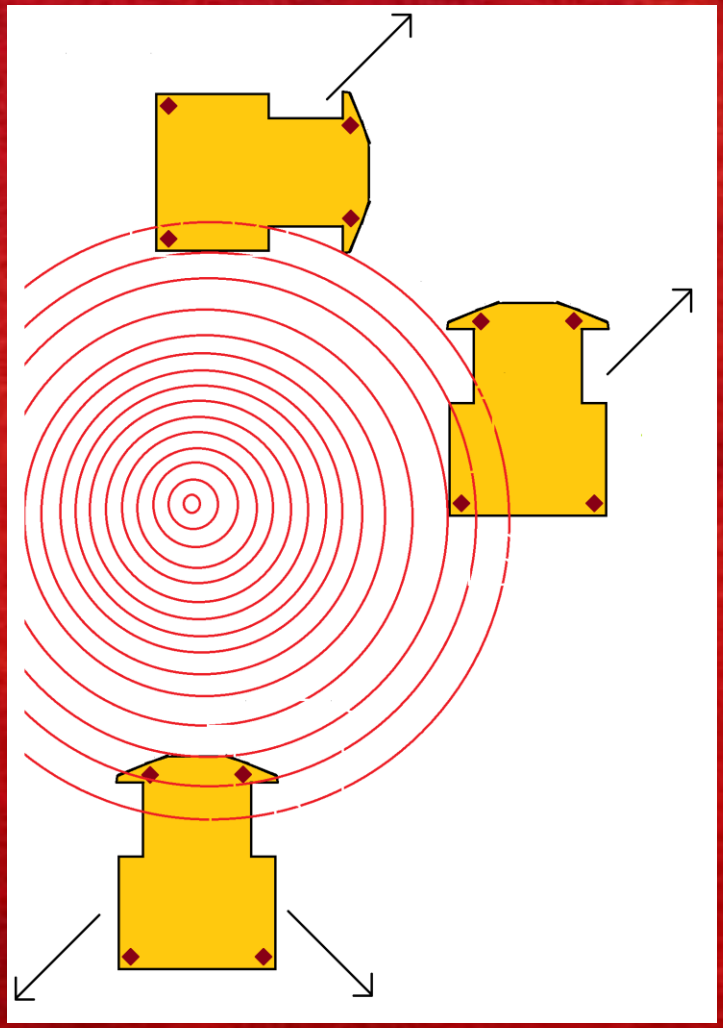
- Used to determine shade of floor tile
  - Dark tiles represent “safety from loud sound”
- Optical sensors mounted on bottom of EBR



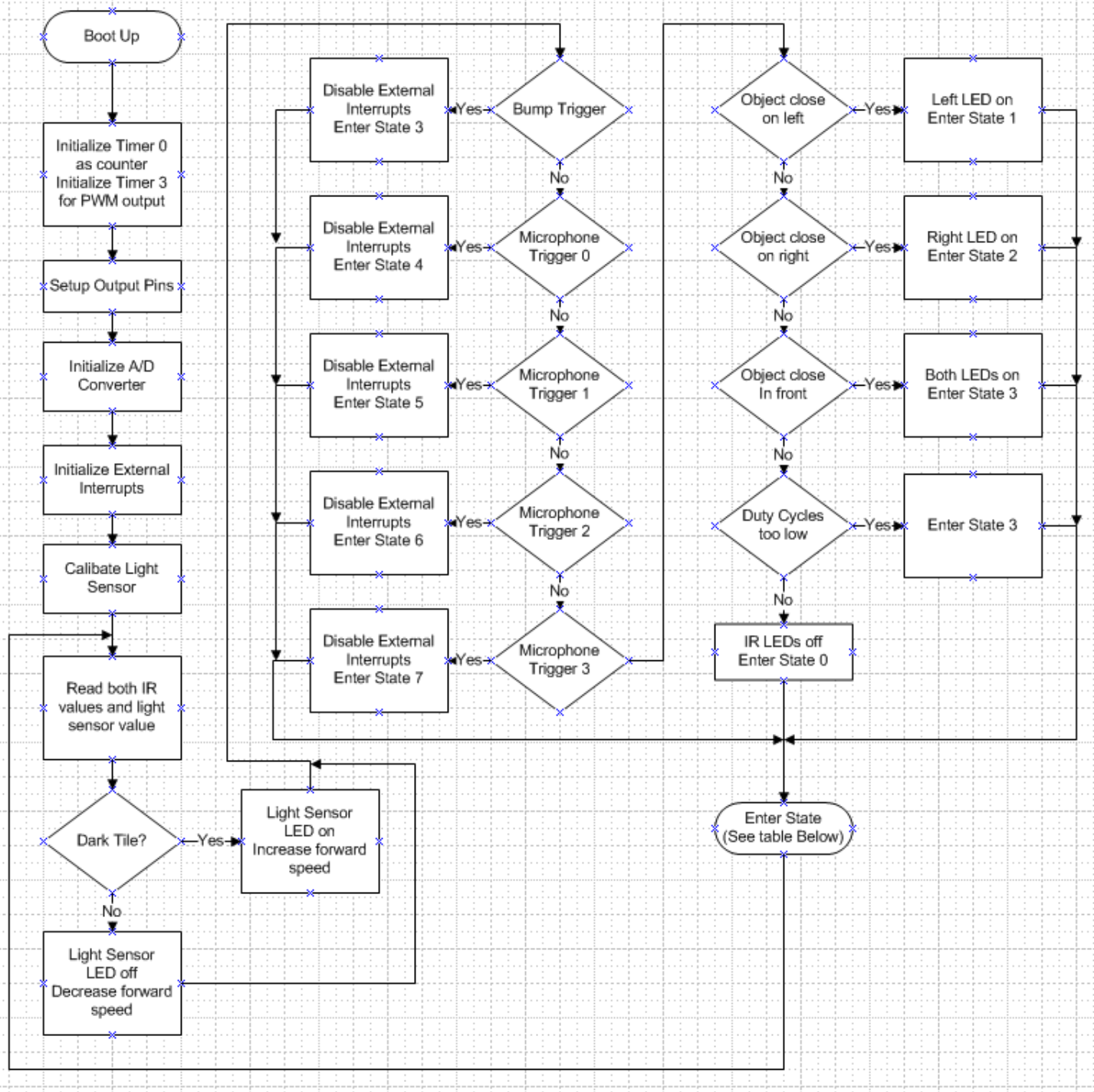


Microphones

- Used to detect the source of a loud sound
- Array of four microphones
- First microphone to detect determines direction of source
- EBR will travel away from source



Software Flowchart



Software Flowchart - States

State	Situation	Action
0	No triggered events	Drive forward, adjust duty cycle to avoid close objects
1	Object too close on left	Reverse for 250ms, rotate clockwise for 500ms, go to state 0
2	Object too close on right	Reverse for 250ms, rotate counter-clockwise for 500ms, go to state 0
3	Object too close in front/Bump sensor triggered/Duty cycles too low	Reverse for 1000ms, rotate counter-clockwise for 700ms, (if bumped) clear interrupt and turn off Bump LED, go to state 0
4	Microphone 0 triggered (front left)	Reverse for 500ms, rotate clockwise for 700ms, clear interrupt, turn off Mic 0 LED, go to state 0
5	Microphone 1 triggered (front right)	Reverse for 500ms, rotate counter-clockwise for 700ms, clear interrupt, turn off Mic 1 LED, go to state 0
6	Microphone 2 triggered (rear left)	Rotate clockwise for 300ms, clear interrupt, turn off Mic 2 LED, go to state 0
7	Microphone 3 triggered (rear right)	Rotate counter-clockwise for 300ms, clear interrupt, turn off Mic 3 LED, go to state 0

Parts List

Part	Part number	Quantity	Price	Total	Site
Motor	0-BHG31	2	$ 23.99	$ 47.98	Robot Marketplace
Wheels	0-DAV5540	2	$ 8.99	$ 17.98	Robot Marketplace
Hub	0-MHUB04	1	$ 8.49	$ 8.49	Robot Marketplace
H-Bridge	Use H-Bridge from Mini Project				
Microphone	CMB-6544PF	5	$ 0.72	$ 3.60	Digi Key
IR Sensor	Sharp GP2Y0A21YK	4	$ 12.50	$ 50.00	Acroname
Reflective Sensor	365-1510-1-ND	2	$ 2.90	$ 5.80	Digi Key
Push Button	149948	8	$ 0.29	$ 2.32	Jameco
	Total			$ 136.17	