Developing a Swarm of Independent Cooperating Robots

Computer Science - Senior Project
Willamette University - Spring 2013

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Overview

- Background
  - Swarm Intelligence
  - Swarm Robotics
- My Project
  - Inspiration
  - Original Plan
  - Hardware Design
  - Robot Programming
  - Software Simulation
- Conclusion
  - Lessons learned
  - What I would do differently
  - Future work

Background

- Swarm Intelligence and Swarm Robotics
  - First introduced in 1989
  - Uses a collection of cooperating autonomous agents to accomplish a goal
  - Inspired by nature

Flock of Birds

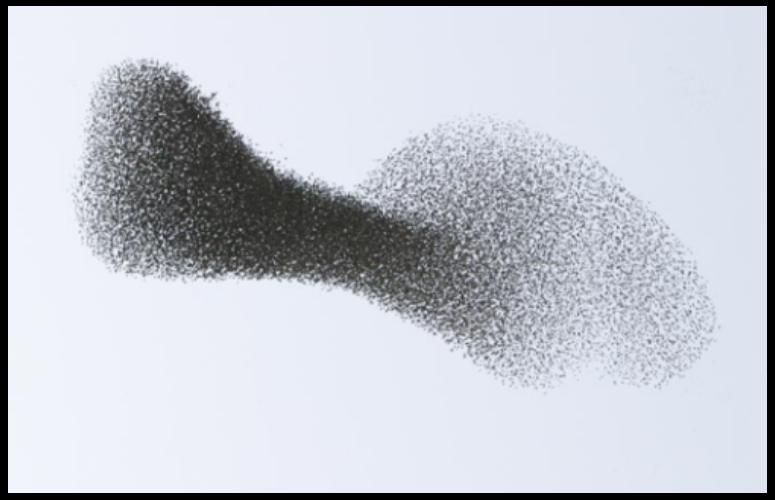
Ant Colony

School of Fish

Background - Swarm Intelligence

- Swarm Intelligence
  - "any attempt to design algorithms or distributed problem-solving devices inspired by the collective behaviour of social insect colonies and other animal societies"

Birds



Locusts

Background - Swarm Robotics

- Swarm Robotics
  - "the study of how large numbers of relatively simple physically embodied agents can be designed such that a desired collective behavior emerges from the local interactions among agents and between the agents and the environment”
  - Uses ideas from Swarm Intelligence

Project Inspiration

Original Project Plan

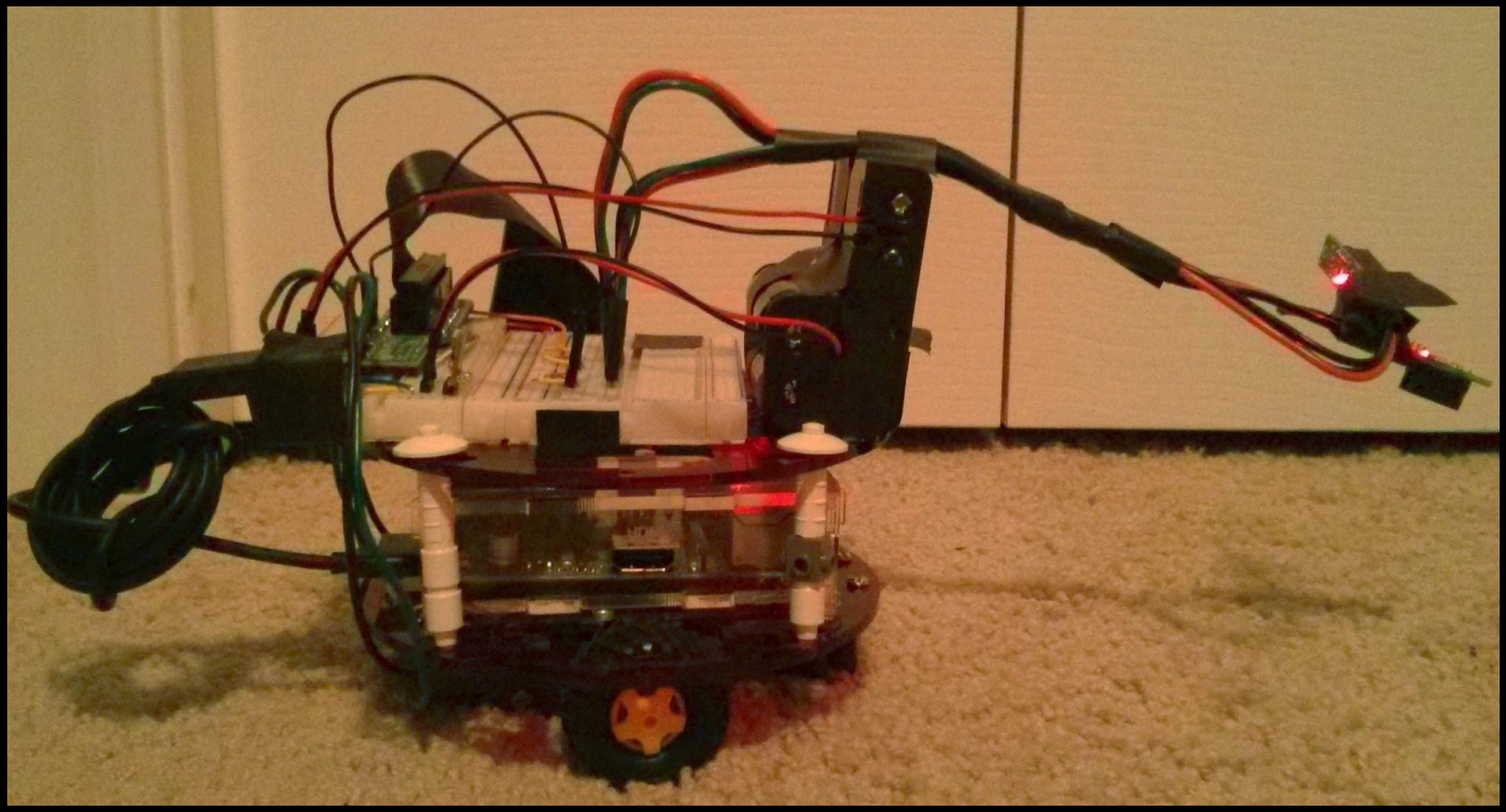
- Design and build a "swarm" of identical robots
- Get the robots to work cooperatively
- Search the area for a specific object and gather around it

Original Project Plan

Steps:

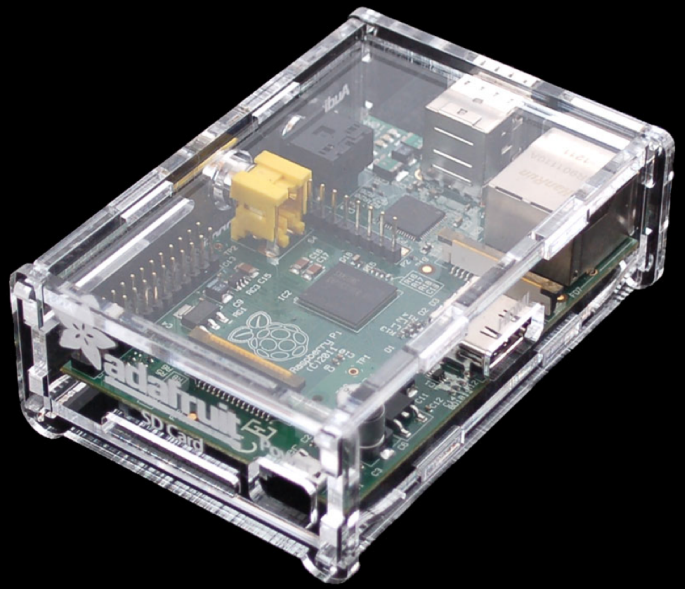
- Design a basic hardware platform for a mobile robot
- Add the required sensors
- Get the robots to communicate, and cooperate to achieve the task

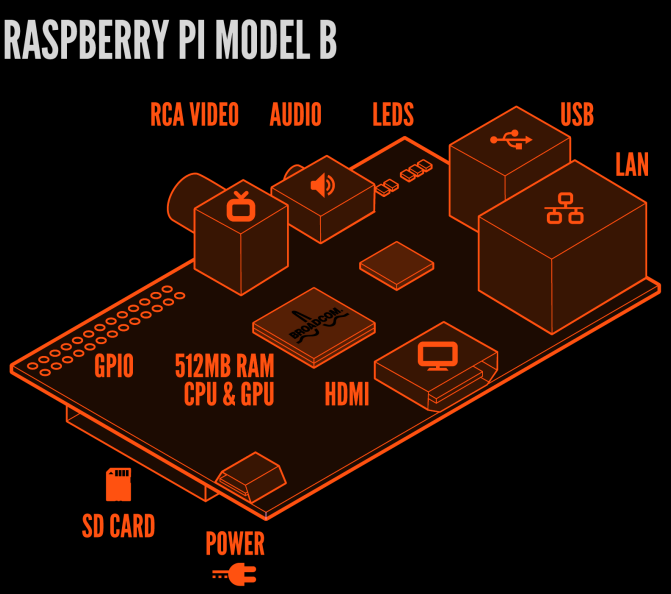
Hardware Design



Design - Microcontroller

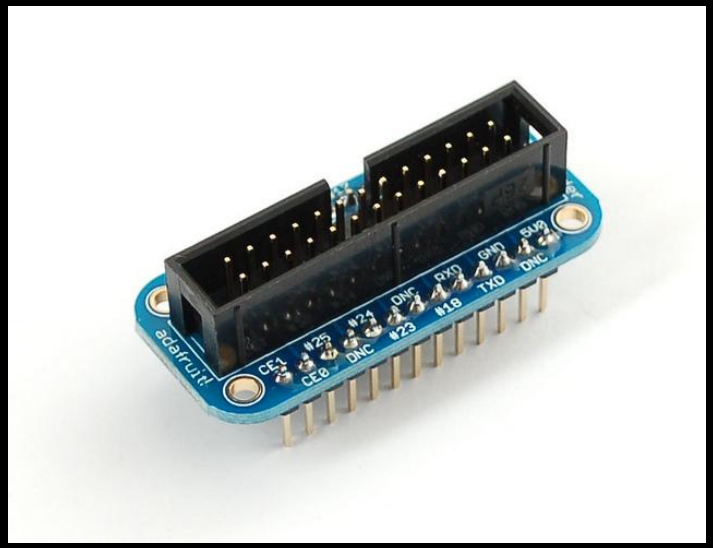
- Raspberry Pi
  - Credit-card sized computer
  - Runs Raspbian, a Debian (Linux) distribution
  - 512 MB ram, 800 MHz ARM processor
  - 26 GPIO Pins

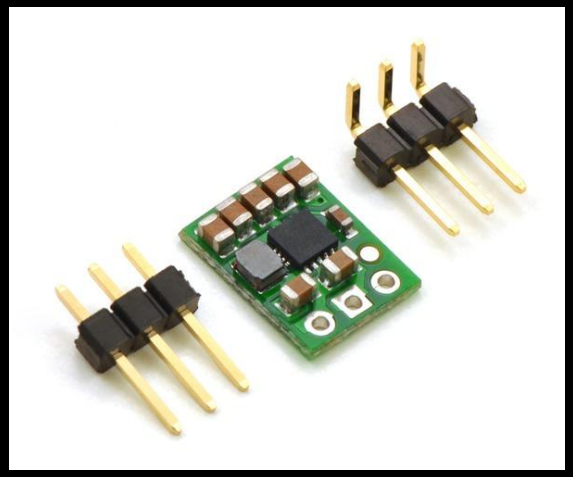


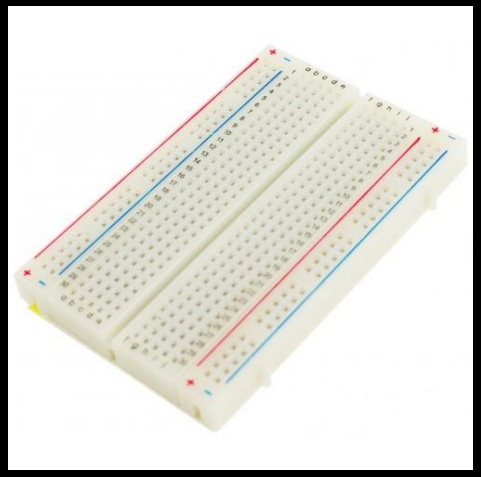


Hardware Design - Microcontroller

- Supporting hardware
  - Pi Cobbler Breakout Kit
  - Breadboard
  - Step-Up/Step-Down Voltage Regulator
  - 2-AA Battery Holder
  - Usb Port

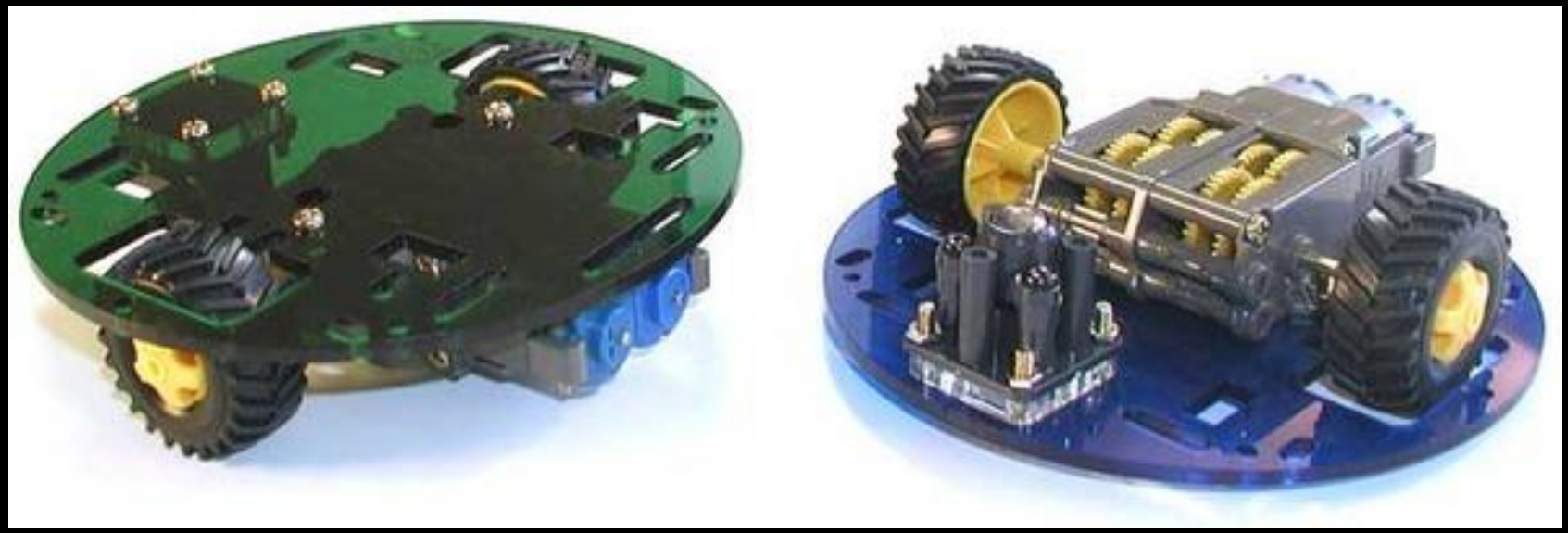






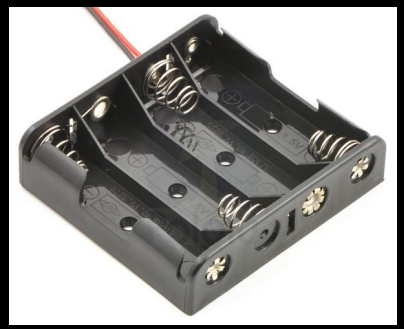
Hardware Design - Chassis

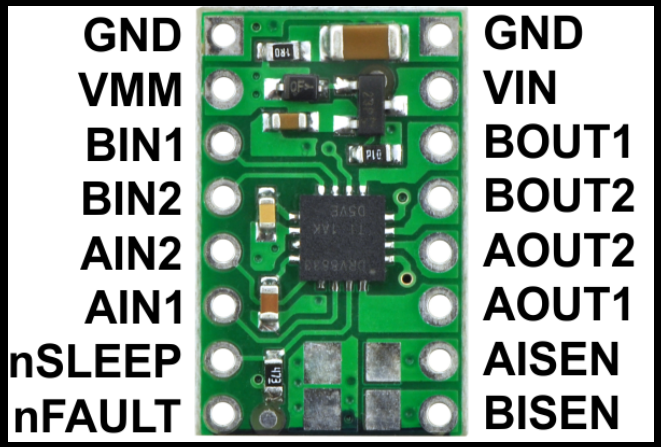
- Robot Chassis Plate
- Ball Caster
  - Ball bearing to provide balance to the robot, while still allowing it to spin in place



Hardware Design - Chassis

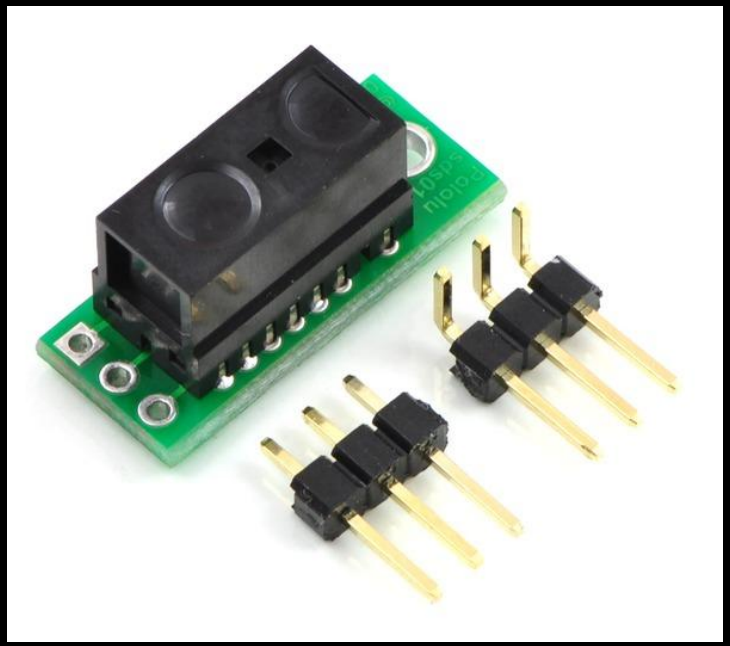
- Motors
  - Twin-Motor Gearbox
    - Two separate motors in one gearbox to drive the robot
  - Dual Motor Driver Carrier
    - Converts signals from the Raspberry Pi, in order to drive each of the motors
  - 4-AA Battery Holder
    - Power the Motors





Hardware Design - Sensor

- Digital Distance Sensor
  - Detects object between 2 cm and 10 cm away
  - Used to avoid running into things, and driving off the edge of something



Robot Programming

- Obstacle-avoiding robot
  - A robot able to move forward, backward, spin in place, and detect obstacles in front of it and the floor below it.
  - Written in Python

Robot Programming

```
def leftWheelForward():
    GPIO.output(16, True);
    GPIO.output(18, False);

def leftWheelBackward():
    GPIO.output(16, False);
    GPIO.output(18, True);

def leftWheelStop():
    GPIO.output(16, False);
    GPIO.output(18, False);
```

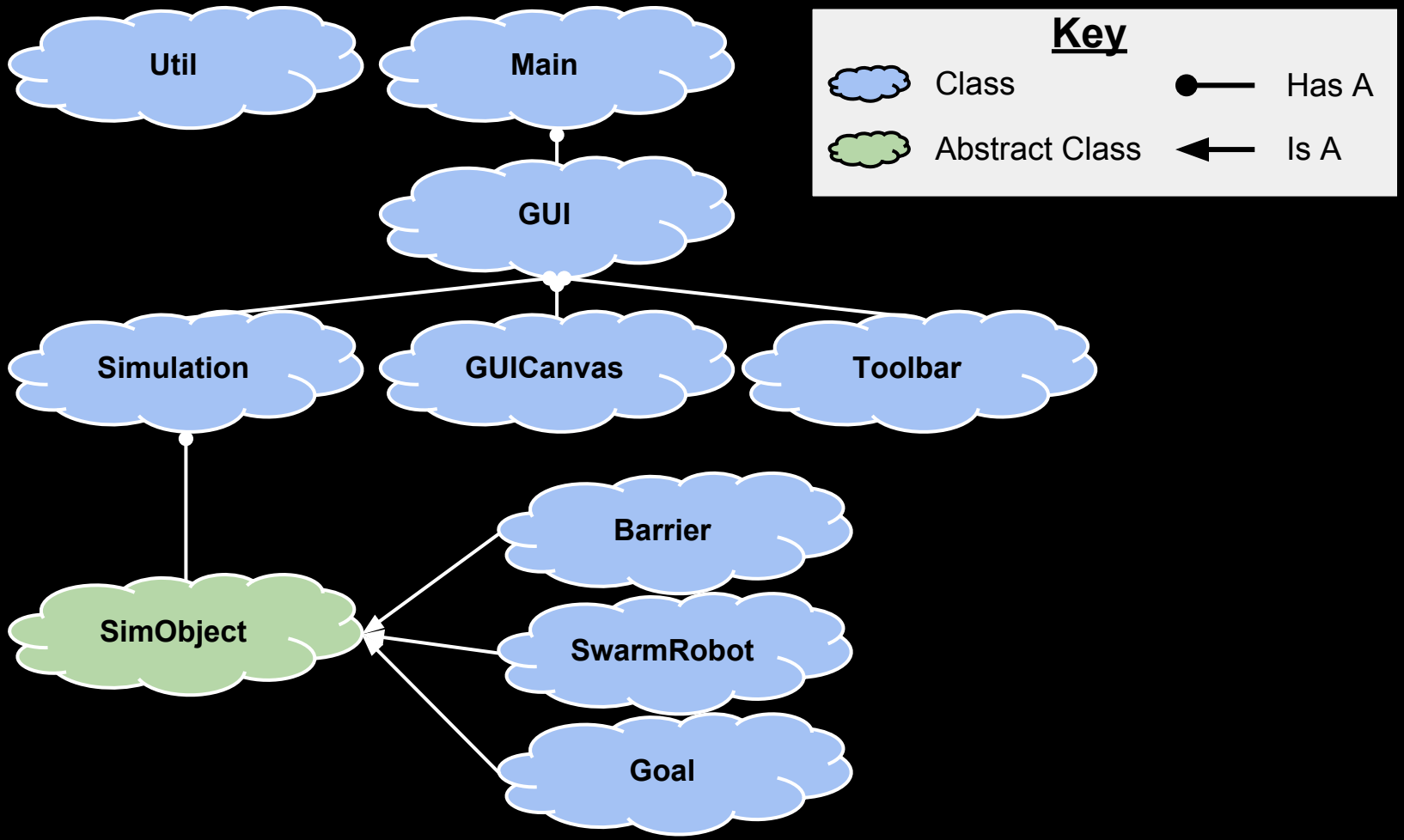
```
def rightWheelForward():
    GPIO.output(24, False);
    GPIO.output(26, True);

def rightWheelBackward():
    GPIO.output(24, True);
    GPIO.output(26, False);

def rightWheelStop():
    GPIO.output(24, False);
    GPIO.output(26, False);
```

Robot Demo

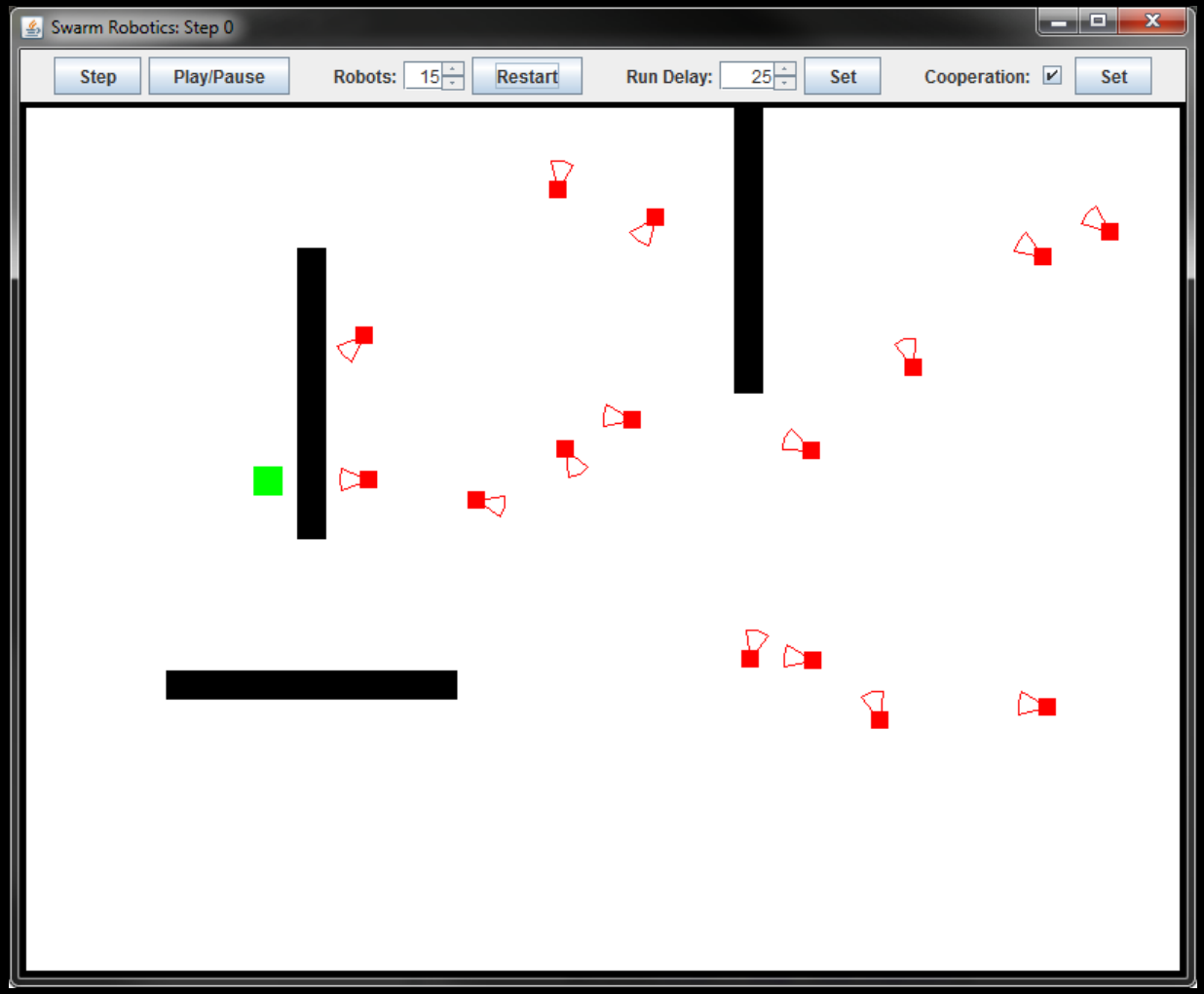
Software Simulation

- Finish the original goal of the project:
  - Create a swarm of individual virtual robots which work cooperatively to search the area for a specific object and gather around it

Class Diagram



Simulation Demo



Conclusion

- Knowledge Gained
- Lessons Learned
  - Working with microelectronics a lot longer than I expected
  - Soldering often isn't easy
  - Don't add a program with an endless loop to an uninterruptible boot process
- What would I do differently

Conclusion

- Future Work
  - Add obstacles that block sight into the simulation
  - Add more complicated tasks to the simulation
  - Add the required hardware and get the robots to accomplish their goal
- Any Questions?

All of my code and documentation can be found on my github account at: https://github.com/tgriswol/SwarmRobotics