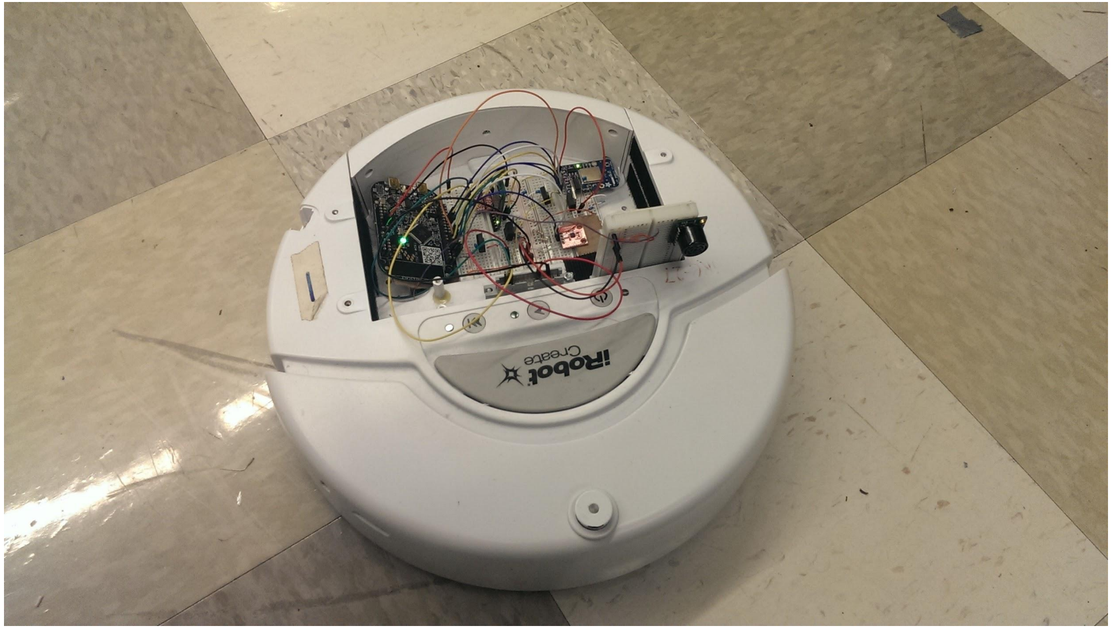
WiFinder



Eric Wu, Chaitanya Aluru, and Sean Roberts

Demo

http://youtu.be/C_c6Be1Nw74

Hardware Setup

- mbed Freescale KL25Z microcontroller
- iRobot Create
- Adafruit CC3000 WiFi breakout as a signal intensity sensor
- Sparkfun BlueSMiRF Bluetooth modem
- Honeywell HMC5883L magnetometer
- Maxbotix ultrasound rangefinder

Modeling and Simulation

- Wanted to evaluate control routine efficacy while using model sensors in simulation

- Made python simulation by calculating an iRobot undergoing collection of small time steps

Modeling Assumptions - Kinematics

- iRobot moves instantaneously from one state to another in small increments

$$\Delta x = \frac{lws + rws}{2}\cos\theta$$

$$\Delta y = \frac{lws + rws}{2}\sin\theta$$

$$\Delta\theta = \frac{rws - lws}{Diameter_{wheel}}$$

- No wheel slippage

- Upon hitting a wall, robot stops moving

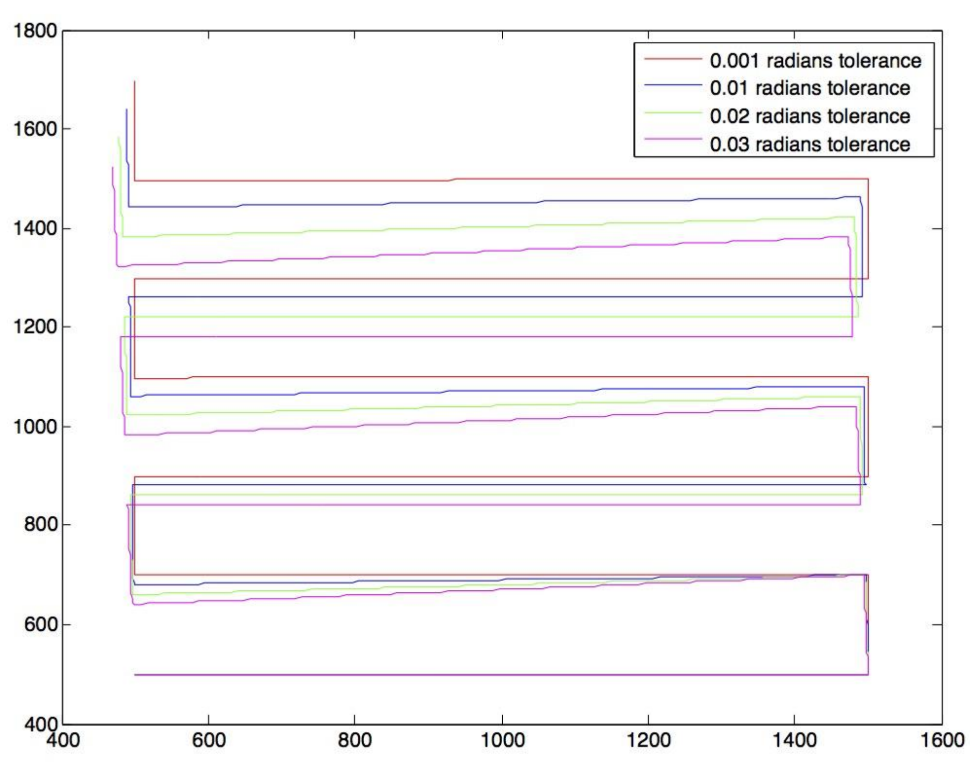
Teyvonia Thomas, https://alliance.seas.upenn.edu/~meam620/wiki/index.php?n=TeyvoniaThomas2011.Final

Modeling Assumptions - Environment

- Approximate wifi by interpolating between known measurements
- 2D plane (floor is flat)
- Stored absolute robot state for simulation
- Returned approximate state to control algorithm (e.g. magnetometer reading)

Varying Turn Angle Tolerance

- Used simulation to determine how well would need to measure angle
- Even small angle errors propagate



Experimental Validation

- Comparing accuracy of accelerometer, ultrasound, and wheel speed for distance measurement
- Calibrating Magnetometer for angle measurement

Accelerometer

- $a_o(t) = a(t) + n(t)$
- $n(t) = r(t) + s(t)$
- Can get rid of $s(t)$ through calibration

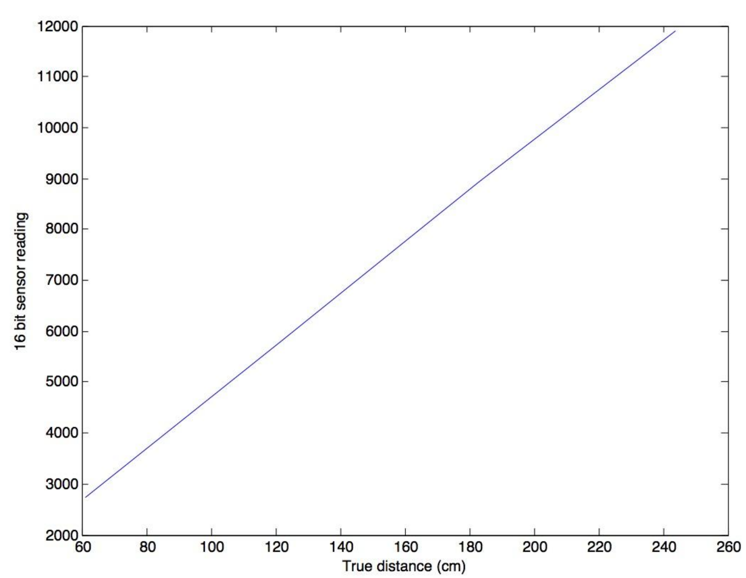
```
aX: -0.007661, aY: -0.019154, aZ: -0.068953
xX: -0.003831, xY: -0.009577, xZ: -0.034477

aX: -0.036392, aY: 0.047884, aZ: 0.007661
xX: -0.029688, xY: -0.004788, xZ: -0.099599

aX: 0.001915, aY: 0.100556, aZ: 0.012450
xX: -0.072784, xY: 0.074220, xZ: -0.154666

aX: -0.026815, aY: 0.009577, aZ: 0.007661
xX: -0.128329, xY: 0.208296, xZ: -0.199677

aX: -0.026815, aY: -0.033519, aZ: -0.006704
xX: -0.210690, xY: 0.330400, xZ: -0.244210

aX: 0.001915, aY: -0.138864, aZ: -0.016281
xX: -0.305500, xY: 0.366313, xZ: -0.300235
```

5 consecutive accelerometer readings at rest over 5 seconds. Readings are after calibration

Ultrasound

- Reading scales linearly with actual distance
- Accurate between 2 and 10 feet

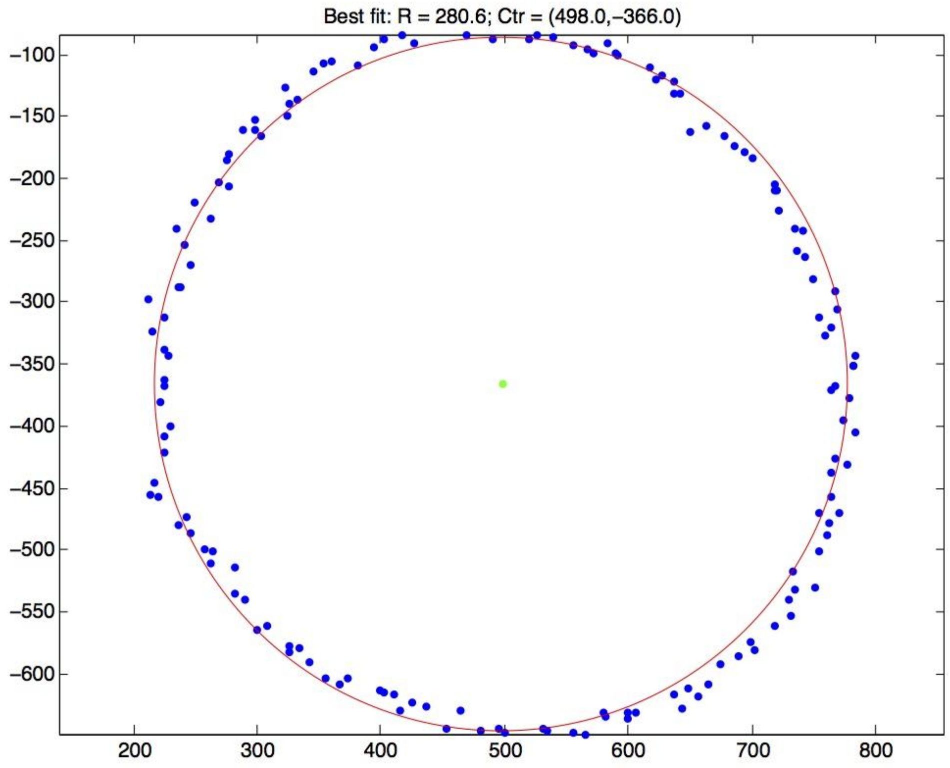
$$f(x(t)) = \begin{cases} 50x(t) - 292 & if L \leq x(t) \leq H \\ 15000 & if x(t) > 300cm \\ 2750 & if x(t) < 60cm \end{cases}$$



Ultrasound reading vs actual distance.

Magnetometer

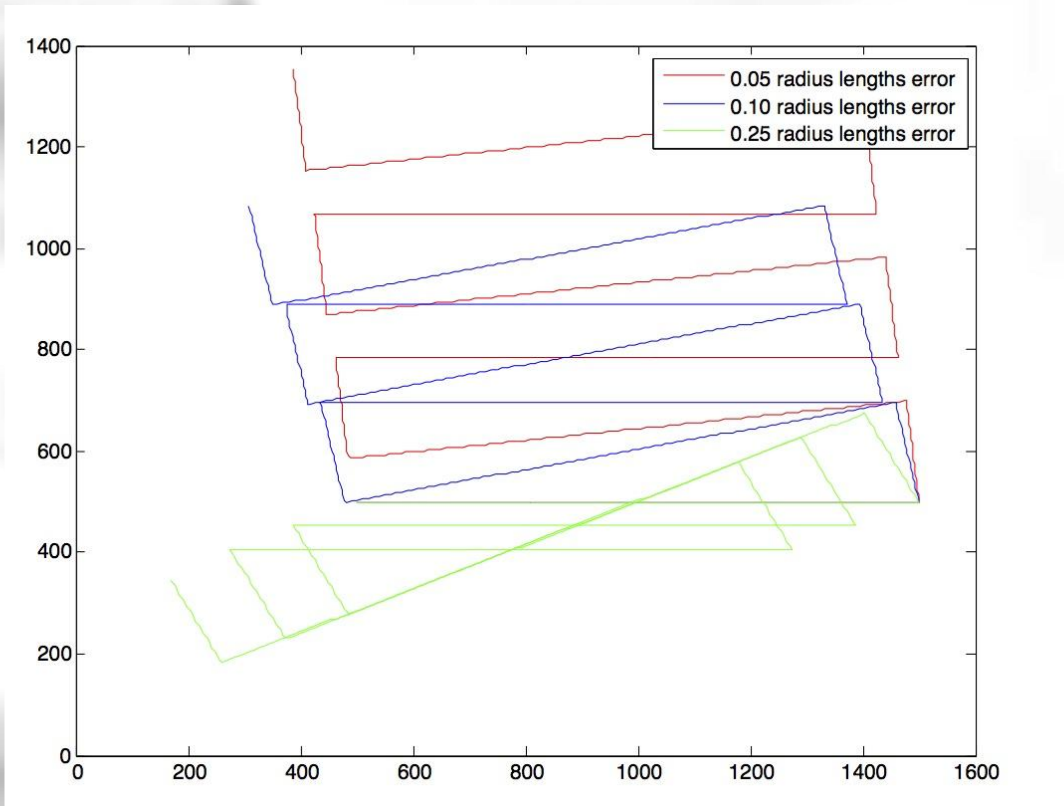
- Reads angle from Earth's magnetic field
- Must be calibrated to offset hard iron and soft iron



Honeywell Hard-Iron and Soft-Iron Calibration Product Training Manual: http://dkc1.digikey.com/us/en/tod/Honeywell/Hard-Soft-Iron-Calibration/Hard-Soft-Iron-Calibration.html

Simulated Effects of Magnetometer Error

- We simulated grid patterns with an improperly calibrated magnetometer
- Matched real world trials



Wheel Speed to the Rescue

- Fix wheel speed
- Measure approximate time taken to travel one foot
- Measure approximate time taken to turn 90º
- Use these to ensure faulty sensor measurements are not used

Forward Movement

<u>Idea</u>

- Test wheel speed numbers against actual speed
- Find approximate amount of time to go one foot with given wheel speed
- Use this information to give an approximate time bound on movement

Rotation

- Robot's wheelbase is constant
- Calculate the circumference when turning in place
- 90º turn = ¼ the circumference
- Now use same method as forward motion