ACSEF 2015-16 ID: MENG-124 (Category 1st Place)

BLUETOOTH POSITIONING DEVICE FOR CHILD MONITORING

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BACKGROUND: THE ISSUE

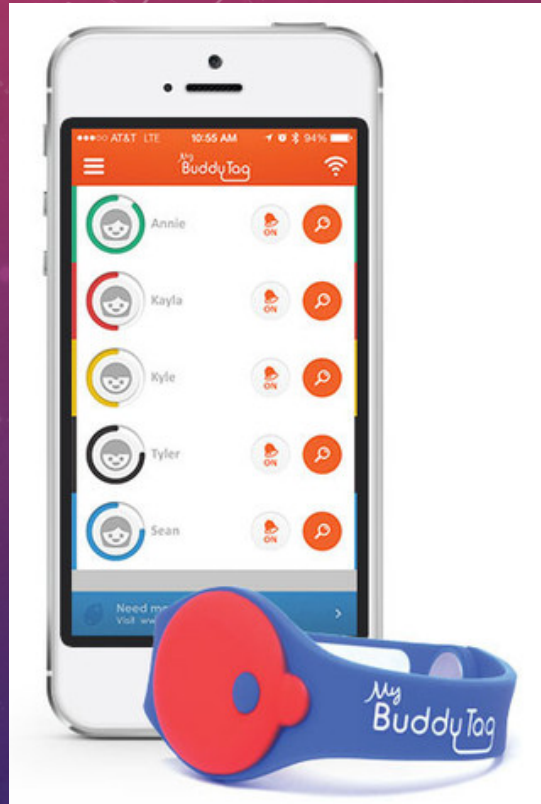
- Misplacing things and looking after young children in public places are often very stressful experiences
- “American children get lost over 2,000 times each day in all kinds of public places such as beaches, amusement parks, fairs and airports”
- People have developed many types of tracking devices for humans and easily lost items
- Types of signals used: Bluetooth, GPS, WiFi

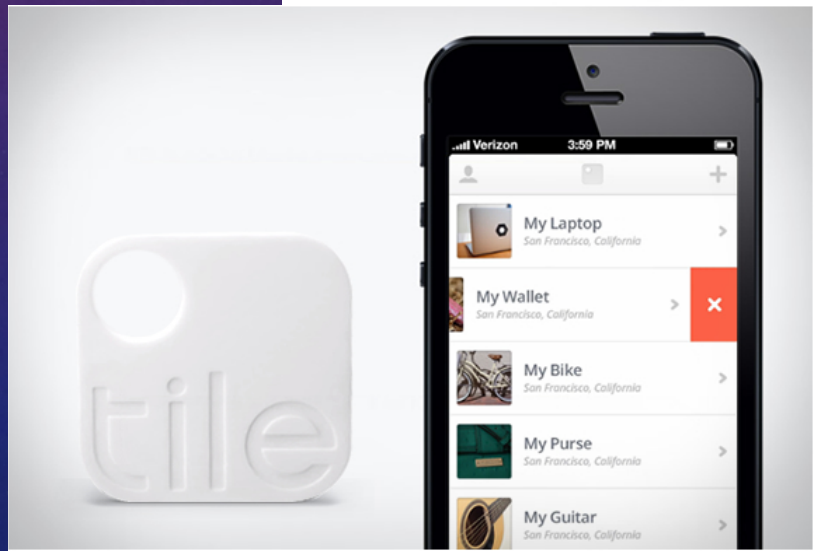
ENGINEERING GOAL:

The design and construction of a Bluetooth device and an accompanying mobile application for parents and caretakers to monitor their children's location in a close-proximity environment.

BASIC DESIGN

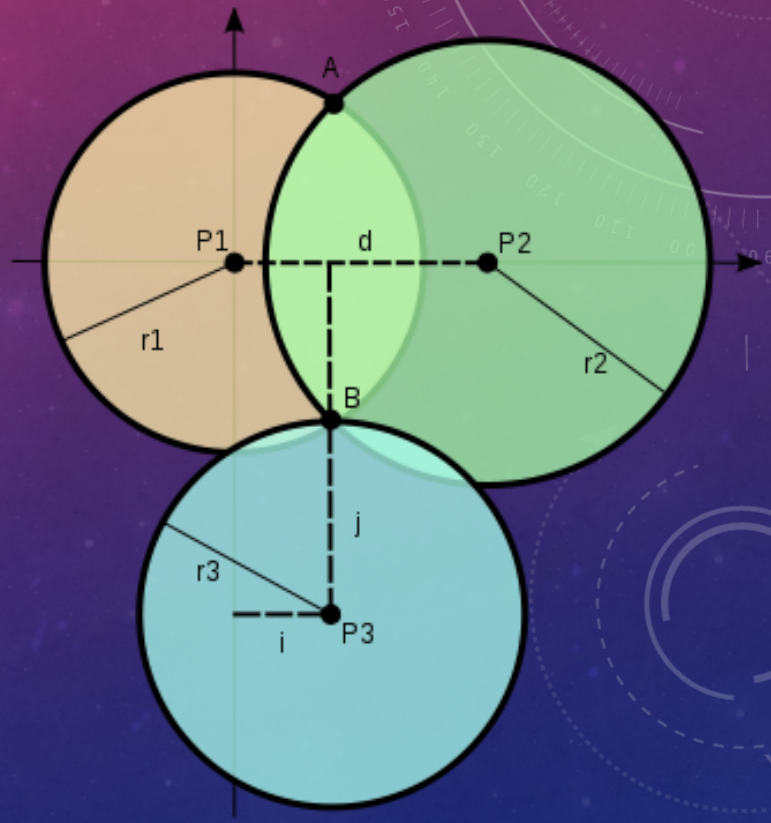
- A small tag or wristband is paired with a smartphone app
- Examples: My Buddy Tag, Tile, Duet
- GPS: long-distance, expensive, inaccurate indoors
- WiFi: not available everywhere, monthly fees
- Bluetooth: inexpensive, close-proximity
  - Uses signal strength (RSSI) to give approximate distance away, but not the direction





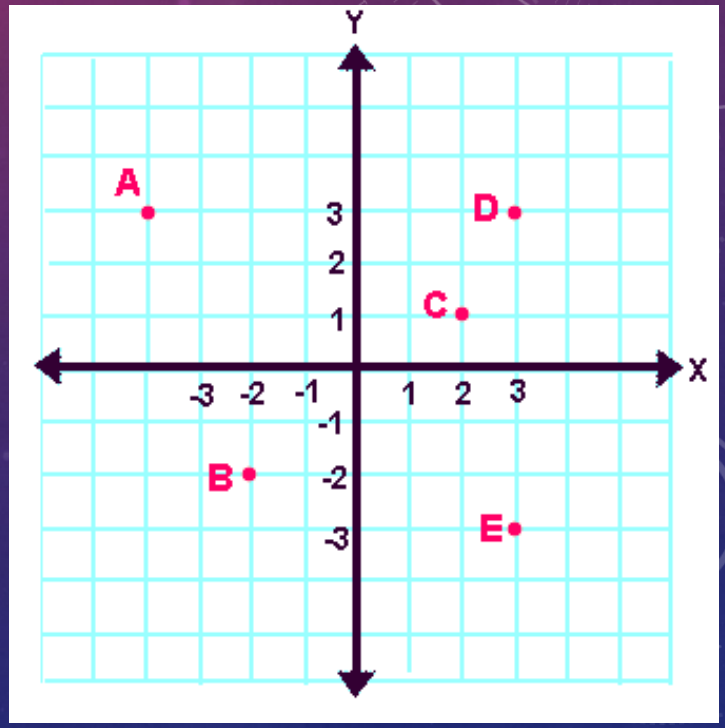
INDOOR POSITIONING METHODS

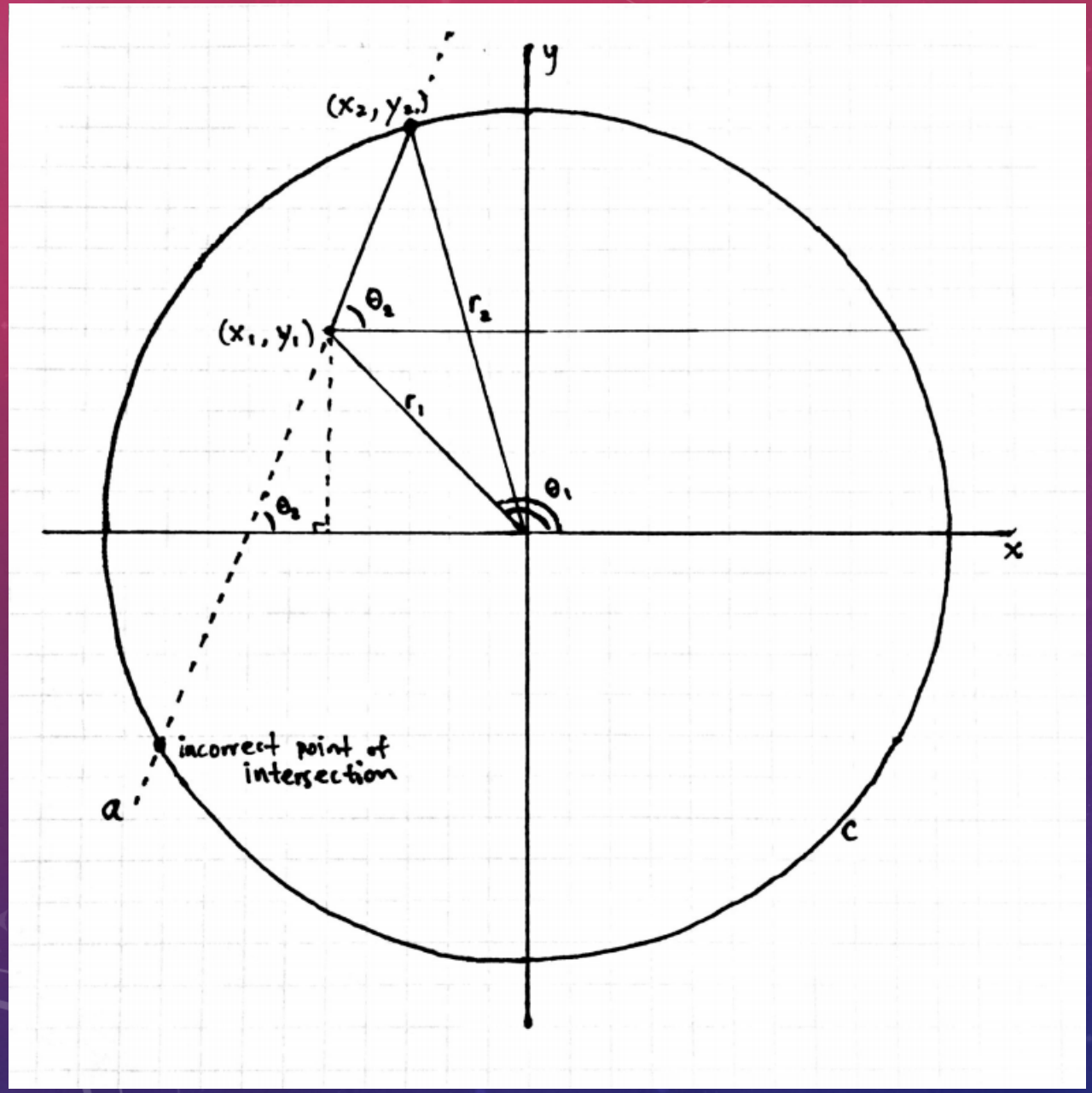
- Trilateration using RSSI
- Fingerprinting (pre-determined database)
- Neural networks
- Pros: greater accuracy
- Cons: requires multiple beacons throughout the room, set location, updated when conditions change
- Good for airports, hospitals, etc.



DEAD RECKONING

- Method of navigation used by sailors/pilots since 17th century
- Location is determined by the direction and speed of movement in relation to previous known locations
- Bluetooth signal strength used to determine distance traveled from parent device
- Magnetometer (aka compass) used to determine direction traveled





Given: last known position (x,y) and current distance r, direction θ

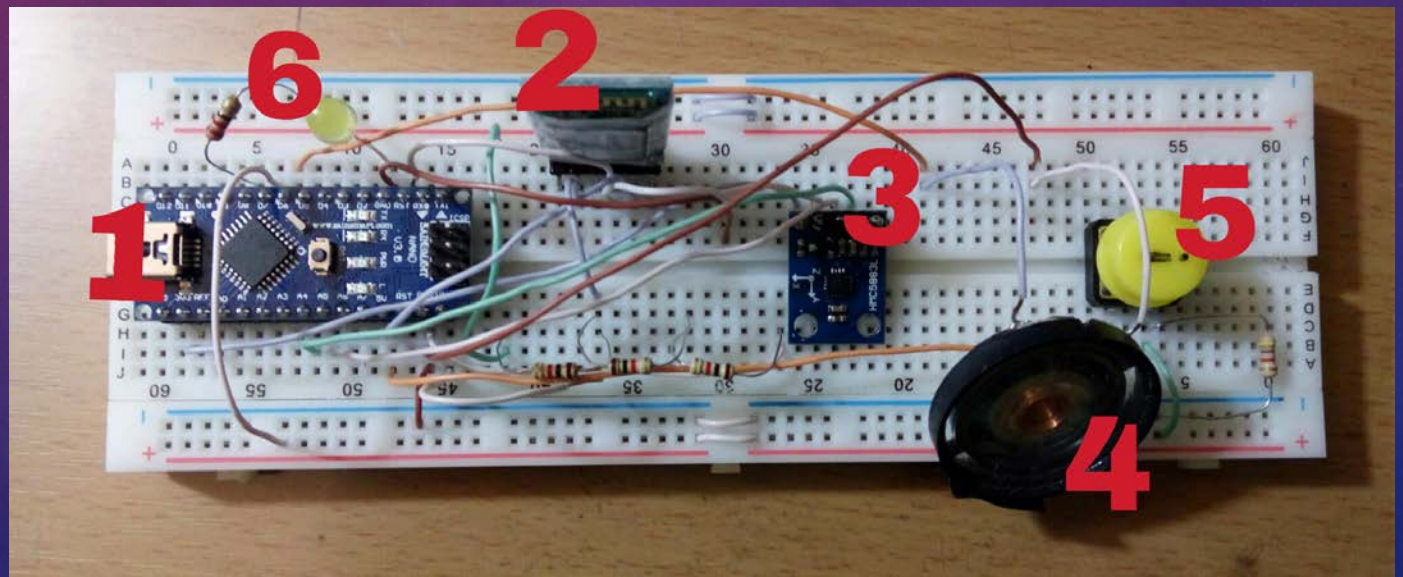
Create 2 equations with info: circle with radius r and linear line

Solve for intersection(s)

Determine final correct position

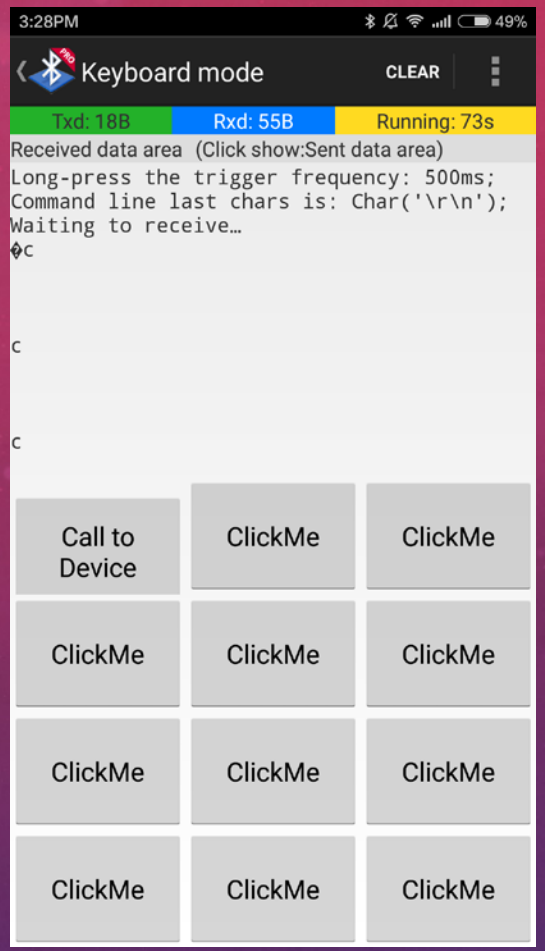
MATERIALS

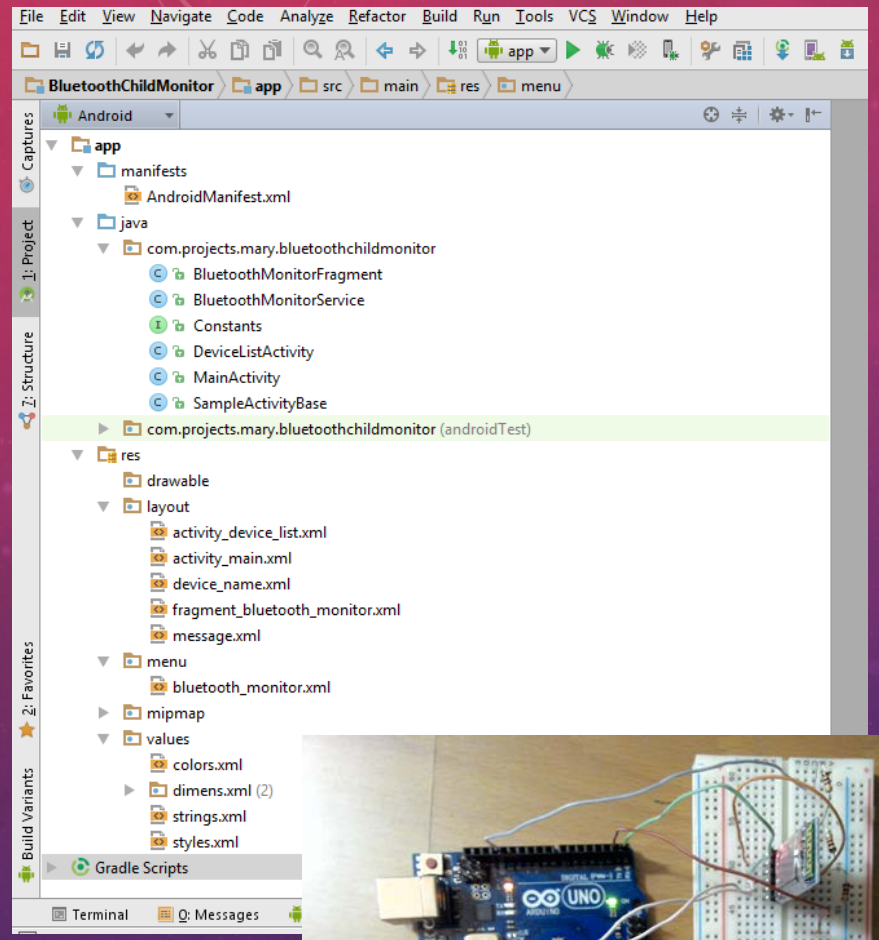
- *Software:* Android Studio IDE (programming phone application: Java), Arduino IDE (programming microcontroller), “Bluetooth spp pro” application (testing Bluetooth communication)
- *Hardware:* Ardunio Nano powered Bluetooth device: (1) Ardunio Nano microcontroller, (2) HC-05 Bluetooth module, (3) HMC5883L magnetometer, (4) alarm speaker, (5) panic button, (6) warning LED.

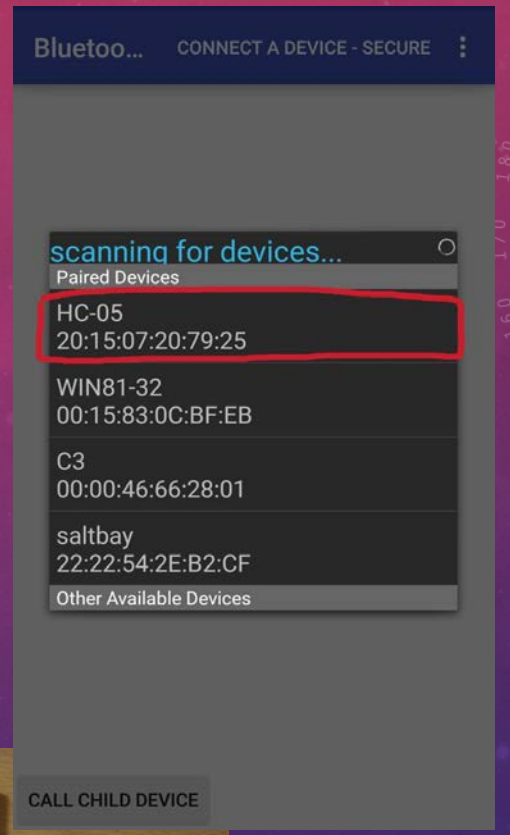


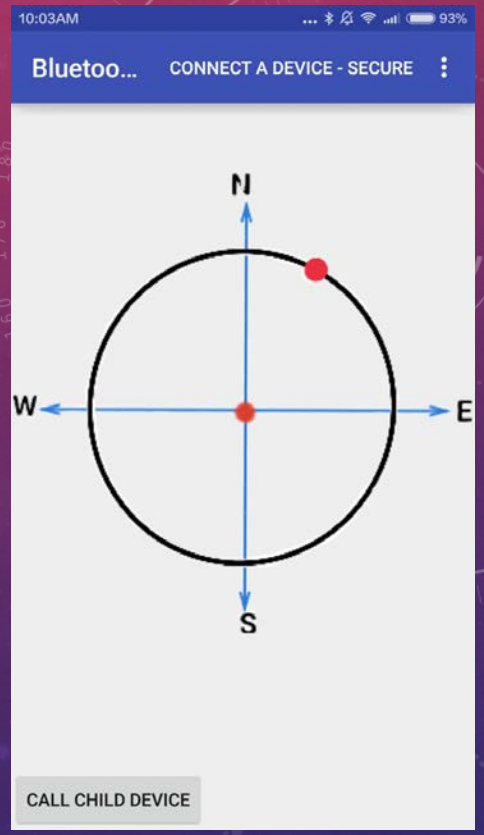
DESIGN CRITERIA

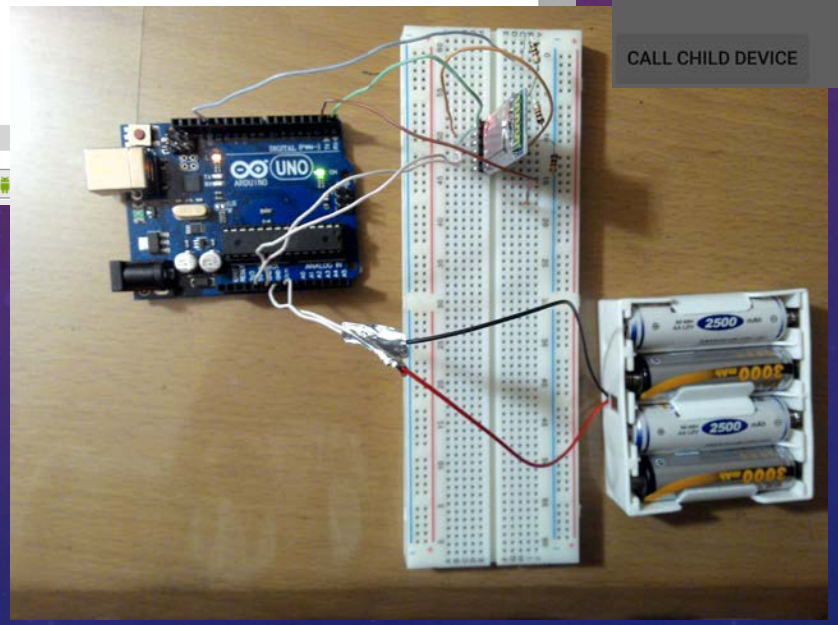
- Breadboard model of wearable device for child
  - Pairs with parent's phone, constantly provides Bluetooth signal and magnetometer readings, contains an alarm and a panic button for basic communication (~30 USD)
- Application for Android smartphone/tablet (Bluetooth compatible)
  - Opening screen prompts user to connect to wearable, processes received data, displays position on graphical interface, notification for "out of range"
- Bluetooth connection range: Class 2 (10 m), extended with antenna to ~30-50m (depends on phone range)


3:28PM
49%
Keyboard mode
CLEAR
Txd: 18B
Rxd: 55B
Running: 73s
Received data area (Click show:Sent data area)
Long-press the trigger frequency: 500ms;
Command line last chars is: Char('\r\n');
Waiting to receive…
Call to Device
ClickMe


File Edit View Navigate Code Analyze Refactor Build Run Tools VCS Window Help
BluetoothChildMonitor app src main res menu
Android
app
manifests
AndroidManifest.xml
java
com.projects.mary.bluetoothchildmonitor
BluetoothMonitorFragment
BluetoothMonitorService
Constants
DeviceListActivity
MainActivity
SampleActivityBase
com.projects.mary.bluetoothchildmonitor (androidTest)
res
drawable
layout
activity_device_list.xml
activity_main.xml
device_name.xml
fragment_bluetooth_monitor.xml
message.xml
menu
bluetooth_monitor.xml
mipmap
values
colors.xml
dimens.xml (2)
strings.xml
styles.xml
Gradle Scripts
Terminal
0: Messages


Bluetoo...
CONNECT A DEVICE - SECURE
scanning for devices...
Paired Devices
HC-05
20:15:07:20:79:25
WIN81-32
00:15:83:0C:BF:EB
C3
00:00:46:66:28:01
saltbay
22:22:54:2E:B2:CF
Other Available Devices
CALL CHILD DEVICE

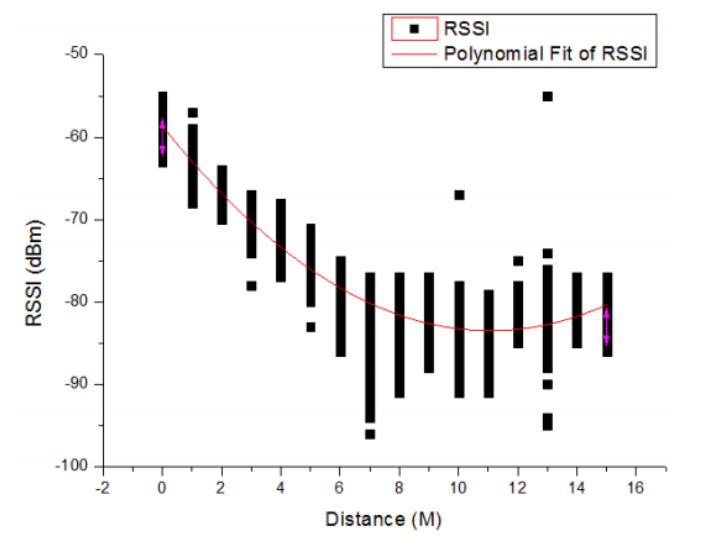

10:03AM
93%
Bluetoo...
CONNECT A DEVICE - SECURE
N
W
E
S
CALL CHILD DEVICE

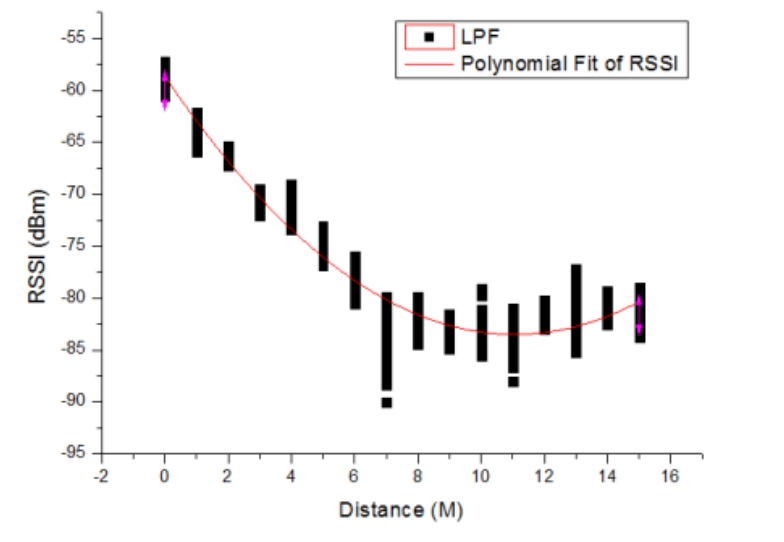

UNO

PROGRESS

SIGNAL PROCESSING

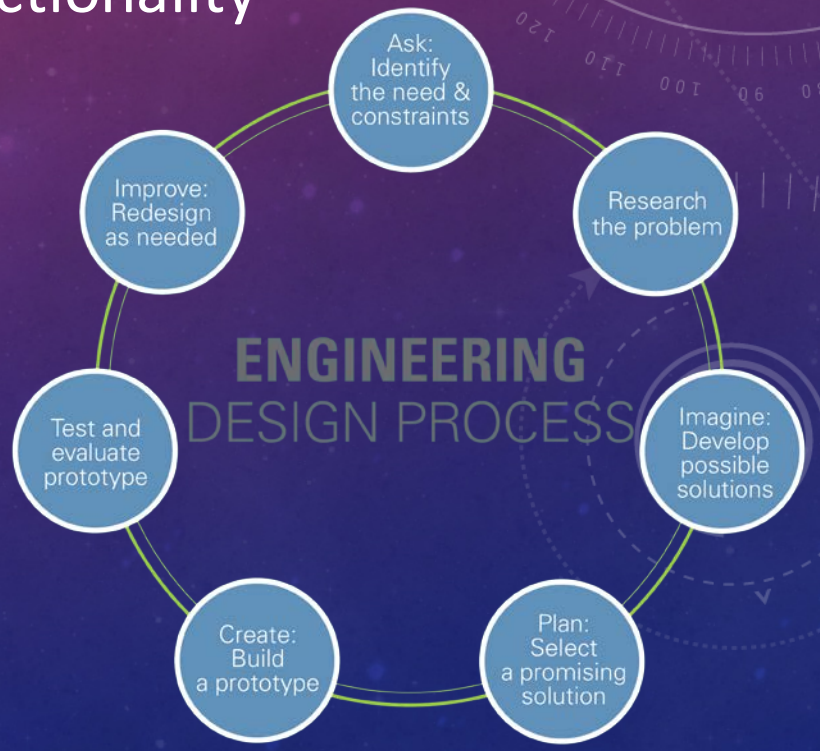
- Magnetometer readings → compass heading → degrees/radians
  - arccos (sin (heading)) = degrees
- Bluetooth signal strength (dBm) → physical distance (m)
  - Taking physical samples to find relationship, not very accurate
  - Low pass filter (LPF) equation reduce data deviation ($P_n = \alpha P_{n-1} + (1-\alpha)T_n$)





CHALLENGES/CONCLUSION

- Android app programming
  - Bluetooth class lacks continuous RSSI display functionality
- Magnetometer calibration/troubleshooting
- Bluetooth to distance inaccuracy
- Trial and error
- Continuous project
- Learning experience



FUTURE RESEARCH/IMPROVEMENTS

- Adding an accelerometer to improve accuracy when obstructions affect Bluetooth signal
- Create a “searching mode”: allows parent to move around in search for child
  - Also used to search for stationary item (ex. misplaced keys)
- Improve range: 2nd device to act as signal bridge, radio signal, cellular network
- Reduce size and package of device (custom PCB)
- Improve Android application interface & functionality

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