Indoor Mobile Robot Localization and Mapping

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Outline

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Introduction

Goal of project is to implement XBee modules to to localize a mobile robot using Cayley-Menger determinant's based on signal strength.

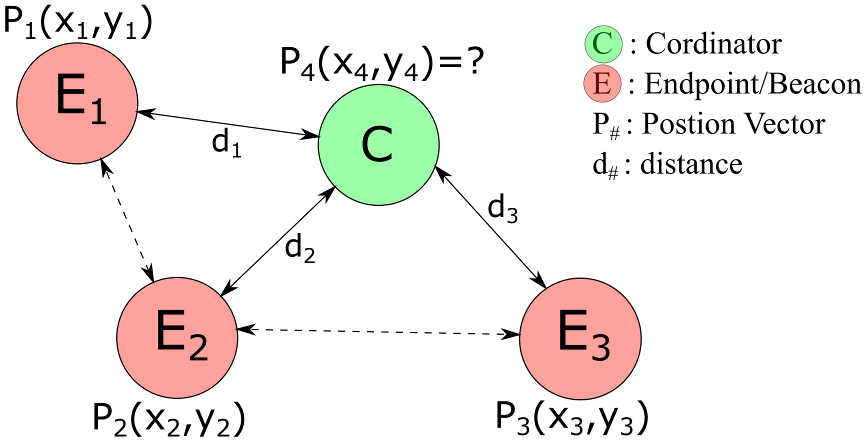

Figure: ZigBee network diagram

DB - Remote AT Command

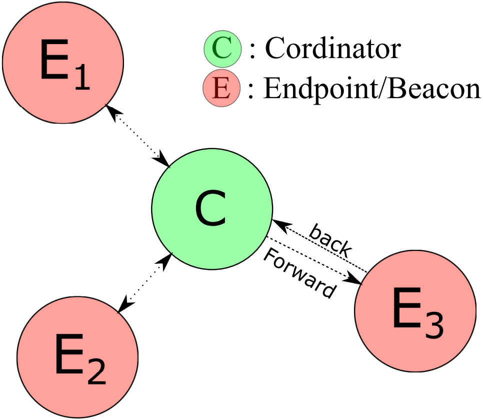

Figure: Getting RSSI with Remote AT Command

Previously Done

- XCTU
- Powershell
- Backbone to XBee (linux c code)
- Calculate Distance - Ongoing

Previously Done

```
debian@beaglebone:~/localization/Darrah$ ./TestTableProg
| Beacon # |    RSSI     | Distance |
|----------|------------|----------|
| Beacon 1 | -0x0C dBm | 0.039573m |
| Beacon 2 | -0x24 dBm | 0.627185m |
| Beacon 3 | -0x2D dBm | 1.767649m |
```

Figure: RSSI+Distance(FreeSpace) Output Table

```
debian@beaglebone:~/localization/Darrah$ ./TestTableProg
| Beacon # |    RSSI     | Distance |
|----------|------------|----------|
| Beacon 1 | -0x0C dBm | 7.079458m |
| Beacon 2 | -0x26 dBm | 0.354813m |
| Beacon 3 | -0x2F dBm | 0.125893m |
```

Figure: RSSI+Distance(Miah Paper) Output Table

Note: Need to double check "Miah Paper" solution is implemented correctly

Current Progress

- Matrix Determinants Added - Ongoing
- File loading for beacon positions
- Trilateration equation implemented and Tested
- Code documented and added

Current Progress

```
debian@beaglebone:~/localization/Darrah$ ./TestProg.a
900.000000,540.000000,360.000000,8100.000000
Cordinator Position: (3.000000, 2.000000, 0.000000)
```

Example 4.6: Localization using trilateration

Suppose that an RF (radio frequency) beacon receiver mounted on an indoor wheeled robot receives RF signal strength measurements from three RF beacons with their 16-bit IDs, 0x$FFFA$, 0x$FFFB$, 0x$FFFC$, which are spatially placed at 3D positions $\mathbf{p}_1 = [x_1, y_1, z_1]^T = [5, 4, 3]^T$ m, $\mathbf{p}_2 = [x_2, y_2, z_2]^T = [3, 8, 3]^T$ m, and $\mathbf{p}_3 = [x_3, y_3, z_3]^T = [-3, 5, 3]^T$ m. Assume that the RF signal strength measurements correspond to noise-free line-of-sight distances (not a practical assumption though!) between the robot and three beacons given by $d_1 = \sqrt{17}$ [m], $d_2 = \sqrt{45}$ [m], and $d_3 = \sqrt{54}$ [m], respectively. Determine the robot's 2D position on the ground.

Solution. *Note that the vectors* $\mathbf{v}_1 = [-2, 4, 0]^T$ m *and* $\mathbf{v}_2 = [-8, 1, 0]^T$ m. *Therefore,* $\mathbf{v}_1 \times \mathbf{v}_2 = [0, 0, 30]^T$.

$D(\mathbf{p}_1, \mathbf{p}_2, \mathbf{p}_3) = 900.$

$D(\mathbf{p}_1, \mathbf{p}_2, \mathbf{p}_3, \mathbf{p}_4) = 8.1 \times 10^3.$

$D(\mathbf{p}_1, \mathbf{p}_2, \mathbf{p}_3; \mathbf{p}_1, \mathbf{p}_3, \mathbf{p}_4) = 540.$

$D(\mathbf{p}_1, \mathbf{p}_2, \mathbf{p}_3; \mathbf{p}_1, \mathbf{p}_2, \mathbf{p}_4) = 360.$

$$\mathbf{p}_4 = \mathbf{p}_1 + \frac{1}{D(\mathbf{p}_1, \mathbf{p}_2, \mathbf{p}_3)} \cdot \Big(-D(\mathbf{p}_1, \mathbf{p}_2, \mathbf{p}_3; \mathbf{p}_1, \mathbf{p}_3, \mathbf{p}_4) \cdot \mathbf{v}_1 + D(\mathbf{p}_1, \mathbf{p}_2, \mathbf{p}_3; \mathbf{p}_1, \mathbf{p}_2, \mathbf{p}_4) \cdot \mathbf{v}_2 - \sqrt{D(\mathbf{p}_1, \mathbf{p}_2, \mathbf{p}_3, \mathbf{p}_4)} \cdot (\mathbf{v}_1 \times \mathbf{v}_2) \Big) = [3, 2, 0]^T$$

Therefore, the robot's 2D position $(x, y) = (3, 2)$ m.

Figure: Example problem output and book solution

Current Progress

```
0.1 0.1 0.0
0.1 -0.1 0.0
-0.2 -0.2 0.0
```

Figure: Formatting example for cords.txt

```
debian@beaglebone:~/localization/Darrah$ ./Compile.sh Trilateration.c
Compiling Trilateration.c ...Done.
debian@beaglebone:~/localization/Darrah$ ./TestProg.a
Cordinator Position: (nan, nan, nan)
```

Figure: Output of Trilateration Program

Future Directions

- Fix/Check Distance Calculation
- Finish debugging Trilateration program
- Putting together some API documentation
- Wiki Page