BASE STATION SYSTEM FOR TRACKING POWDER VALLEY NATURE CENTER COPPERHEAD SNAKES

Presented by Josh Peck, Dan Rosenberg, and Abbie Wolfe
PRESENTATION OUTLINE

Background Information
Project Objectives
Technical Approach
Code Logic
Testing
Results
Future Studies
Background Information
Our goal was to design and implement a system that calculates the coordinates of an implantable tracking device. Specifically, we aimed to track an implant that does not contain a GPS unit.
Base Station Code Logic (Arduino Level)

**General Operation**
- Transmitter Data
  - Snake ID, Sequence ID, Ping ID, Temperature, Voltage
- Base station Receives Message (passive listening)
- Base station appends GPS data (location, timestamp)
- Base station forwards complete packet to main station
- Results are sent via serial to Raspberry Pi
- Raspberry Pi runs algorithm

**Timing and Locating**
- GPS data acquisition (10 Hz)
- Storage of most recent data
- Extrapolating milliseconds (last received GPS time and Arduino clock)

**Addressability**
- All secondary stations share address
- Main Base Station and controller each have unique address
- All snake addresses sequentially increase
Algorithm Logic and Data Flow

**Input data with timestamp and GPS**

**Receiving Python Algorithm**
- Call algorithm on snake_id ready for processing
- Store received data by snake_id (a)
- Update when a snake is ready for processing (a)

**TDOA Algorithm: Preprocessing**
- Clear old data after processing (w)
- Log of input data (a)

**TDOA Algorithm: Postprocessing**
- Most recent location of each snake (w)
- New output results (a)

**Old Data Cleanup Tool**
- Clean input data older than 3 days
- Clean output results older than 14 days

**Transmit to map**
- Transmit all 3 output csv files to dashboard
- Read previous outputs for updating

**Crontab: run at midnight**

**Algorithm Notes**
- Not shown: script that runs hourly and upon reboot to ensure the receiving algorithm is always running
- Orange box: Python
- Blue box: action
- Green box: csv file
- Blue arrow: algorithm
- Gray arrow: data
- (a) = append to csv file
- (w) = write to csv file

Past 14 days of all snake locations (w)
TDoA Algorithm Block Diagram

1. Input data with timestamp and GPS
2. Order data by IDs
3. Select 3 closest gateways
4. Convert to meters from geo.
5. Calculate time difference
6. Chan’s Algorithm
7. Convert back to geo. coord
8. Average output over sequence
9. Merge and format data
10. Save as output

Temperature, Snake ID, etc.

Repeat as necessary for each measurement
### Indoor Testing

#### Round 1
- GPS accuracy of single station
- Communication between Feathers
- Power consumption calculations

#### Round 2
- Addressability between stations
- Control panel menu options
- Enclosure prototyping

#### Round 3
- Power consumption live testing
- "Dowsing Rod" efficacy
Power Consumption and RSSI Results
Mudd Field Testing

Sample input data from our testing

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Freq</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>2021-04-25</td>
<td>17:39:53</td>
<td>53.393</td>
<td>20, 11, 71, 10</td>
<td>38.648755</td>
<td>-090.309912</td>
</tr>
<tr>
<td>2021-04-25</td>
<td>17:39:55</td>
<td>55.091</td>
<td>20, 11, 71, 10</td>
<td>38.64834</td>
<td>-090.310595</td>
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Timing Discrepancy

Signal Bouncing
Results

Mudd Field Testing of Locating the Transmitter

<table>
<thead>
<tr>
<th>Point</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual Location (blue dot)</td>
<td>38.648823 (N)</td>
<td>-90.310377 (W)</td>
</tr>
<tr>
<td>Calculated Location (green dot)</td>
<td>38.648899 (N)</td>
<td>-90.305587 (W)</td>
</tr>
<tr>
<td>Base Station 1 (closest to the DUC)</td>
<td>38.648254 (N)</td>
<td>-90.310425 (W)</td>
</tr>
<tr>
<td>Base Station 2 (closest to Simon Hall)</td>
<td>38.648342 (N)</td>
<td>-90.310597 (W)</td>
</tr>
<tr>
<td>Base Station 3 (closest to Olin Library)</td>
<td>38.648756 (N)</td>
<td>-90.30991 (W)</td>
</tr>
</tbody>
</table>
Overall Accomplishments

Trilateration TDoA Algorithm
Future Endeavors

- Timing Accuracy
- Signal Bouncing
- Upgrade User Dashboard
Questions
References


