Higher accuracy for smartphone positioning

Post-processing, centre points and repetition

Location Based Services 2023, Ghent, Belgium

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Background

- Smartphones are widely spread and cheap to manufacture
- Public and private sectors are interested in the positioning capabilities of devices
- NLS is interested in their application from the crowdsourcing point of view
- Pyykkijahti smartphone game by projects of the National Land Survey of Finland
  - Luore 2021, Matko 2022-2023
- Master’s Thesis (Tech.) 2023
Objectives

- Study the positioning accuracy of common smartphones using real-time and post-processing positioning techniques
- Improve accuracies using centre points of measurements
- Study how positioning accuracy changes when the number of measurements increases
Pyykkijahti
Marker Quest

• Web-based mobile game for enhancing location accuracies of border markers in the Finnish cadastral index map by crowsourcing.

• Players measure inaccurate markers in the terrain or mark them missing.
Measurements

• Study areas in different parts of Finland
• Simulated crowdsourcing environment
  • NLS employees
  • Different kinds of environments
  • Most commonly used smartphones
• Border markers of the cadastral index map
  • Smartphone measurements
  • RTK reference measurements
Statistics of data collection

- Before filtering of data
  - 41 border markers
  - 1889 measurements
  - 12 smart devices

<table>
<thead>
<tr>
<th>Smartphone types</th>
<th>Measurement count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Google sdk gphone</td>
<td>1</td>
</tr>
<tr>
<td>Motorola Moto G(60)</td>
<td>100</td>
</tr>
<tr>
<td>Samsung SM-A202F</td>
<td>7</td>
</tr>
<tr>
<td>Samsung SM-A326B</td>
<td>494</td>
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<tr>
<td>Samsung SM-A405FN</td>
<td>279</td>
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<td>Samsung SM-A526B</td>
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<td>Samsung SM-A528B</td>
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<td>Samsung SM-A750FN</td>
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<td>Samsung SM-G398FN</td>
<td>443</td>
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<tr>
<td>Samsung SM-G960F</td>
<td>3</td>
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<tr>
<td>Samsung SM-G970F</td>
<td>22</td>
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<tr>
<td>Wheatek RT1</td>
<td>118</td>
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</tbody>
</table>
Process workflow

### Pre-process data
- Pyykkijahti data: real-time measurements
- FINPOS-station names and coordinates
  - Data filtering
  - Data formatting
  - Coordinate transformation: WGS84 -> TM35FIN

### Post-processing
- PYYKKIJAHTI
- FINPOS: base stations
- Geo++, SSRPOST
- Static measurements
- DGNSS measurements
- SSRPOST measurements

### Analysis
- Data manipulation process
  - Processing of data
  - Outlier removal
  - Basic statistics: mean, std, median
  - Positioning accuracy of individual measurements
  - Positioning accuracy of center points
  - Positioning accuracy change when number of measurements increases

- Data
  - Real-time
  - Real-time DGNSS corrected
  - Post-processed (static)
  - Post-processed (DGNSS)
  - Post-processed (SSRPOST)
RTKLIB workflow
Positioning accuracy

1. Individual measurements
2. Center points
3. Increasing number of measurements
## RESULTS
Positioning accuracy of individual measurements

### Positioning accuracy of positioning techniques

<table>
<thead>
<tr>
<th></th>
<th>mean (m)</th>
<th>st dev (m)</th>
<th>median (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real-time</td>
<td>9.66</td>
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<tr>
<td>Real-time DGNSS corrected</td>
<td>10.24</td>
<td>13.03</td>
<td>5.27</td>
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<tr>
<td>Static</td>
<td>6.38</td>
<td>7.85</td>
<td>3.96</td>
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<tr>
<td>DGNSS</td>
<td>4.19</td>
<td>3.18</td>
<td>3.47</td>
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<tr>
<td>SSRPOST</td>
<td>3.92</td>
<td>3.44</td>
<td>2.95</td>
</tr>
</tbody>
</table>

### Graph

- **Real-time**
- **Real-time DGNSS corrected**
- **Post-processed (Static)**
- **Post-processed (DGNSS)**
- **Post-processed (SSRPOST)**

The graph illustrates the positioning accuracy for different techniques.
### Positioning accuracy of positioning techniques

<table>
<thead>
<tr>
<th></th>
<th>mean (m)</th>
<th>st dev (m)</th>
<th>median (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real-time</td>
<td>5.66</td>
<td>6.15</td>
<td>3.18</td>
</tr>
<tr>
<td>Real-time DGNSS corrected</td>
<td>6.19</td>
<td>6.31</td>
<td>3.76</td>
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<tr>
<td>Static</td>
<td>3.58</td>
<td>3.49</td>
<td>2.31</td>
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<tr>
<td>DGNSS</td>
<td>2.45</td>
<td>1.81</td>
<td>2.09</td>
</tr>
<tr>
<td>SSRPOST</td>
<td>1.46</td>
<td>0.88</td>
<td>1.34</td>
</tr>
</tbody>
</table>

![Positioning accuracy of center points graph](chart.png)
Increasing number of measurements

Post-processed (SSRPOST) measurements effect on positioning accuracy

- Iteration 1
- Iteration 2
- Iteration 3
- Iteration 4

Distance (m) vs Number of measurements
Conclusions

• The results show the potential of crowdsourcing applications in improving positioning accuracies of measurement points.

• SSRPOST post-processing produced the most accurate results at 1.46 meters.

• Above 10 measurements per position ensure the highest accuracy.

• Issues with the smartphone measurement: variation in accuracy, phone types, variation of the environment, etc.

• Further research: optimization of workflow, longer field measurement time, study most commonly available smartphones.
Publications about Pyykkijahti


Advancing together