Higher accuracy for smartphone positioning: post-processing, centre points and repetition

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Abstract.

The importance of smartphone positioning for contemporary society is on the constant rise, as is the demand and potential for its higher accuracy. National mapping agencies see crowdsourcing by smartphone measurements as an interesting opportunity for data collection in the future. In this study, the purpose was to investigate the reality of smartphone positioning accuracy in the crowdsourcing context. The enhancement of plain real-time smartphone positioning was carried out by post-processing calculations with reference stations, centre point averaging and repeated measurements. The results were benchmarked against professional real-time kinematic measurements, and accuracies below 1.5 m were achieved at best by the mentioned techniques combined. The reached accuracy level is already useful for many mapping purposes and the latest developments in satellite positioning are still about to decrease measurement inaccuracies.

Keywords. Smartphone, Positioning, Accuracy, Crowdsourcing

1. Introduction

Positioning is a fundamental part of today's society, which is integrated in numerous applications. Positioning data can be collected by different smart devices including smartphones. In recent years, there have been many studies related to the positioning capabilities of smartphones (Zangenehnejad & Gao 2021) as they are the most widely spread positioning devices and quite cheap to manufacture. There have also been breakthroughs in this field. For example, a new Android operating system was released to the markets in 2016, making it possible to collect raw GNSS positioning data as required

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for more precise positioning (European GNSS Agency, 2018). Higher positioning accuracy supports more precise mapping for crowdsourcing.

In 2021, the National Land Survey of Finland (NLS) conducted a pilot study to determine if the locations of border markers of the cadastral register index map could be improved using crowdsourcing (Kettunen & Rönneberg 2022). The conclusion was that crowdsourcing did have potential in improving the locations (Kontiokoski 2022). Next, in 2022, another study was conducted to see if the positioning accuracy of smartphones could be improved, especially, using post-processing in coordinate computation (Jussila 2023). This abstract concentrates on the findings of the latter study that simulated a crowdsourcing campaign to collect the measurement data. The method is feasible for technical developers of crowdsourcing applications.

2. Methods

2.1. Test measurements

For this study, the measuring was done in different parts of Finland, where the environment differed from urban to rural areas. The measurements were taken by NLS employees using commonly available smartphones in use at the time. Since the measurements were taken by professionals, the crowdsourcing was more of a simulated experience.

The smartphone measurements were taken from border markers of the cadastral index map using the Marker Quest application in the phones. To calculate the positioning accuracy, accurate reference measurements were made on the border markers using the Real-Time Kinematic technique.

A total number of 1,889 smartphone measurements were collected from 41 different border markers, with 12 different smart devices used to take the measurements. These values are before filtering of the data.

2.2. Processing workflow

The workflow began with data preparation, in which any invalid data was filtered out and the data was formatted into a proper structure. Consequently, the post-processing calculations were run using two different software: SSRPOST by Geo++ and open-source RTKLIB. SSRPOST utilised a realisation of the PPP-RTK positioning technique and a network of reference stations. In RTKLIB, Static and DGNSS positioning modes were used with the nearest reference station data. RTKLIB is openly available but needs time to get familiar with.

In the analysis phase, the post-processed and real-time measurements were compared and analysed. Outliers were removed using the interquartile range method. For each positioning technique, the accuracy of horizontal coordinates was calculated. The positioning accuracy is the Euclidean distance between the smartphone and the reference measurement. Three types of results were analysed: 1) the positioning accuracy of individual measurements, 2) the positioning accuracy of centre points (Figure 1), and 3) the change in positioning accuracy as the number of measurements increases.

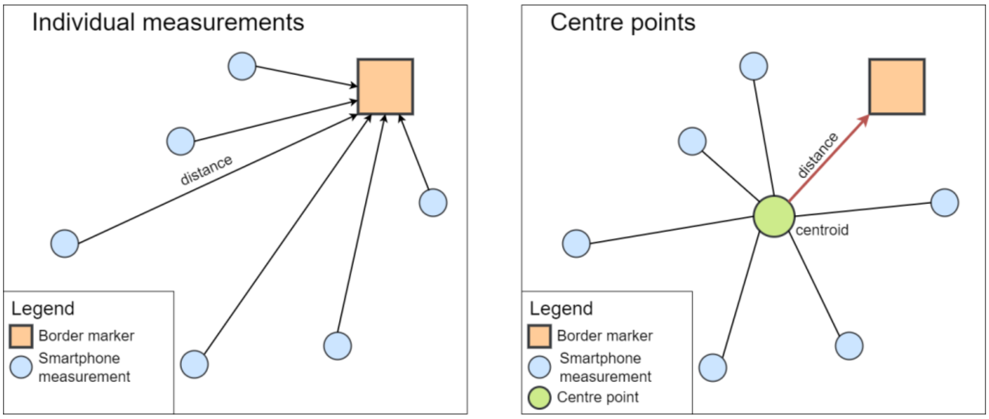

Figure 1. In individual measurements analysis, distance from each smartphone measurement to the border marker is calculated. In centre points analysis, the centre point of the measurements is calculated and distance from the centre point to the border marker is determined.

3. Results

First, the positioning accuracy of individual smartphone measurements was calculated. The results show a variation depending on the positioning technique used (Table 1, Figure 2). The least accurate results were produced by real-time techniques with 10-meter mean accuracy. The high standard deviation indicates wide dispersion of measurements around the border markers. Post-processing techniques produced results with positioning accuracies between 4–6 m. SSRPOST had the most accurate result at 3.92 m.

Second, the centre points of the measurements around the border markers were used. The results show an improvement in the positioning accuracy in all cases (Table 1, Figure 2). The real-time results improved to around 6 metres with a high standard deviation between the border markers. The post-processing accuracies improved to a range of 1.5–4 metres with SSRPOST at 1.46 m and a low standard deviation between border markers.

	Individual measurements		Centre points	
Technique	Mean (m)	Std (m)	Mean (m)	Std (m)
Real-time	9.66	12.81	5.66	6.15
Real-time DGNSS corrected	10.24	13.03	6.19	6.31
Post-processed (Static)	6.38	7.85	3.58	3.49
Post-processed (DGNSS)	4.19	3.18	2.45	1.81
Post-processed (SSRPOST)	3.92	3.44	1.46	0.88

Table 1. Positioning accuracy of individual measurements and centre points

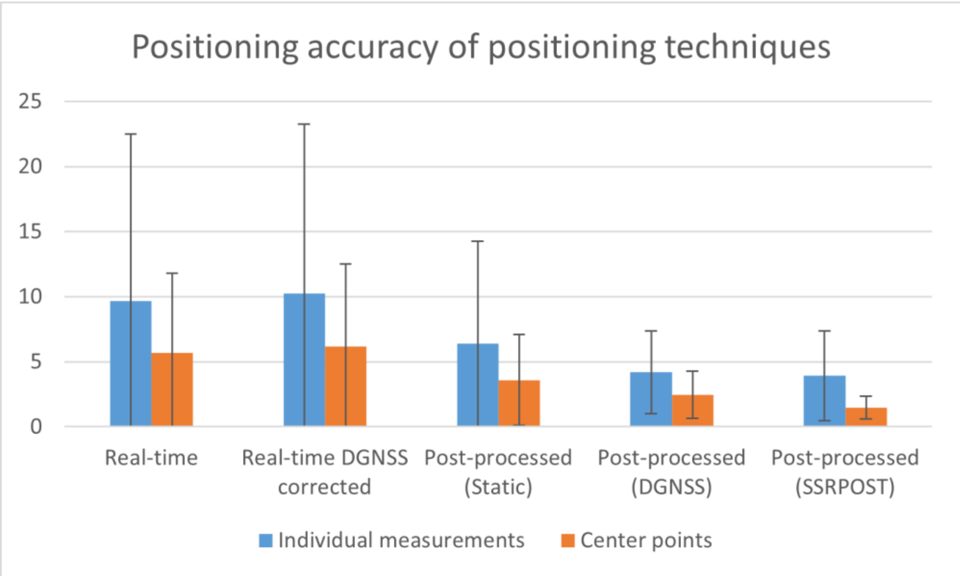

Figure 2. Positioning accuracy of individual and centre points

Lastly, this study observed the positioning accuracy change when the number of measurements increases at a border marker. The centre points of measurements were used and the order of measurements was randomised. Four different iterations were done with different sampling to see how the pattern changes, with the results showing that the most improvement occurs when around two to three measurements are used (Figure 3). The improvement slows down gradually, and after around 10 measurements the change is minimal.

Figure 3. Positioning accuracy change when number of measurements increases

4. Conclusion

This case study investigated smartphone positioning capabilities, with the results showing the potential of post-processing for developers of crowdsourcing apps. The most accurate results were achieved through post-processing and using centre points in accuracy calculations. At 1.46 metres, the SSRPOST technique produced the most accurate results. Nevertheless, there are aspects that still require improvement and further research. Therefore, the positioning accuracy of commonly used smartphone types should be further studied. New methods or the improvement of old methods to enhance accuracies are required. Moreover, in the future, the reason for any difference between the positioning accuracies between different border markers should be investigated. Overall, the results of this study prove that the applied methods can be used to improve the positioning accuracy of smartphones in the crowdsourcing context. Future satellite positioning techniques, such as Galileo's High Accuracy Service, are to still decrease positioning inaccuracies.

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