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Sensibility of Sensors in Smartphones

Zoltan Horvath

University of Pecs, Faculty of Sciences, Hungary

Abstract

Nowadays every second person uses a smartphone but very few know what sensors work inside the mobile. The demand is growing for indoor navigation softwares. This topic is very hot because we have a lot of sensor but we can't use them for indoor positioning. The other problem is that the sensors are too sensitive and we must find a good algorithm what can filter the data and which can present a solution without errors.

Keywords

Indoor Navigation, Geo Localization, Magnetometer, Smartphone Sensors, Kalman Filter

I. Introduction

In our researches we examined the reliability and accuracy of built-in sensors of smartphones. Our previous researches were aimed at GPS and GLONASS systems used for navigation [1]. These researches highlighted the fact that the accuracy of the measured result depends on numerous interfering factors; furthermore operating systems also influence the measurement outcome if we use only raw data [9]. However, these distorting factors can be reduced with the help of different algorithms. The final goal of our study is to develop an indoor navigational software which is operational without the aforementioned sensors [2, 4]. It is also important, because indoors, where we have no clear view of the sky, the conventional navigational methods do not work. So we have to rely on the built-in sensors of smartphones or use a hybrid solution [6, 11]. Nowadays there are three operation systems on the mobile market (iOS, Android and Windows Phone), these have multiple versions available. Therefore our first step was to examine whether using different operating systems cause any difference in the sensors' operation [8].

II. Material and Method

In our experiments we worked with the software developed by Lanoga Kft., which records the data from built-in sensors of phones (like accelerometer, magnetometer and gyroscope) and then saves them to a server; on fig. 1 we can see the software in operation. After launching the application, the phone locates our position as a first step, but we need internet connection for this. Then we can select the sensor which we want to examine. Before we do that, we can also adjust the sampling frequency.

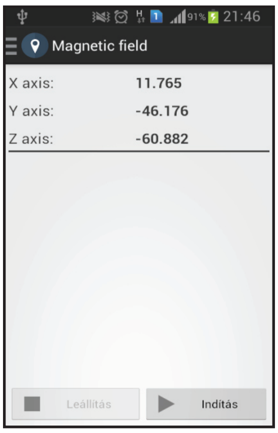
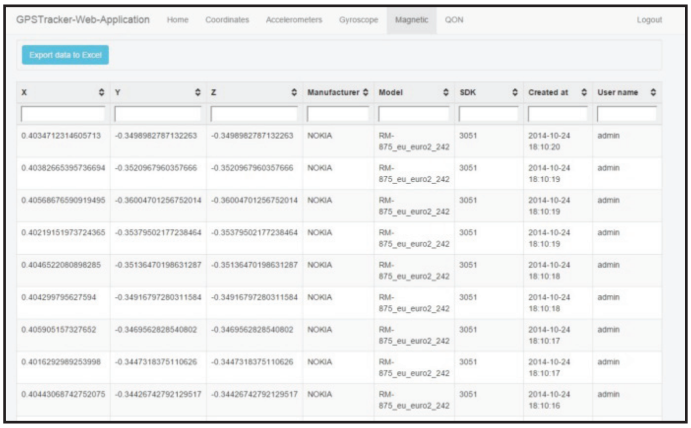


Fig. 1: GPS Tracker Software

As it can be seen on the figure above, the software uses the magnetometer [5]. When measuring, we can determine the density of sampling. In our experiments we used 1/20 sec as the interval between samplings [10]. Upon completing the sampling, our measurements immediately appear, as we can see it on fig. 2.



X	Y	Z	Manufacturer	Model	SDK	Created at	User name
0.4034712314605713	-0.3498982787132263	-0.3498982787132263	NOKIA	RM-875_eu_euro2_242	3051	2014-10-24 18:10:20	admin
0.40382665395736694	-0.3520967960357666	-0.3520967960357666	NOKIA	RM-875_eu_euro2_242	3051	2014-10-24 18:10:19	admin
0.40568676590919495	-0.36004701256752014	-0.36004701256752014	NOKIA	RM-875_eu_euro2_242	3051	2014-10-24 18:10:19	admin
0.40219151973724365	-0.35379502177238464	-0.35379502177238464	NOKIA	RM-875_eu_euro2_242	3051	2014-10-24 18:10:19	admin
0.4046522080898285	-0.35136470198631287	-0.35136470198631287	NOKIA	RM-875_eu_euro2_242	3051	2014-10-24 18:10:18	admin
0.404299795627594	-0.34916797280311584	-0.34916797280311584	NOKIA	RM-875_eu_euro2_242	3051	2014-10-24 18:10:18	admin
0.405905157327652	-0.3469562828540802	-0.3469562828540802	NOKIA	RM-875_eu_euro2_242	3051	2014-10-24 18:10:17	admin
0.4016292989253998	-0.3447318375110626	-0.3447318375110626	NOKIA	RM-875_eu_euro2_242	3051	2014-10-24 18:10:17	admin
0.40443068742752075	-0.34426742792129517	-0.34426742792129517	NOKIA	RM-875_eu_euro2_242	3051	2014-10-24 18:10:16	admin

Fig. 2: Server State

To process the data we can export them to an excel table.We measured 158.760 records from multiple locations per sensor [7]. We wanted to examine whether the system can tell the corners of the rooms apart (Fig. 3.).

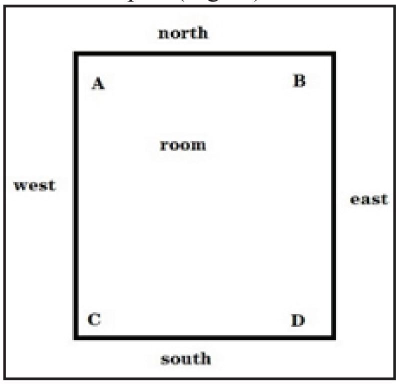


Fig. 3: A Test Room

During our study we used mobile phones and tablets using different operating systems. These were the followings:

- Nokia 1020 (Windows Phone)
- Nexus 5 (Android 4.4.4)
- HTC One Max (Android 4.4.4)
- HTC 8X (Android 4.4.4)
- iPhone 4 (iOS)
- iPad mini (iOS).

To eliminate the distorting factors we tried many methods when filtering the measurement results, such as linear regression, which could correct the level of error, but was inapplicable to terminate it [3]. Furthermore we examined the dispersion and what happens when we use the average of the measurement results, but these methods came to little.

III. Results

When processing the measurement results we compared the data from each corner to determine any resemblance or characteristic

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pattern among dispersions. These filtered results can be seen on the following figures. These results were measured in corner ’D’.

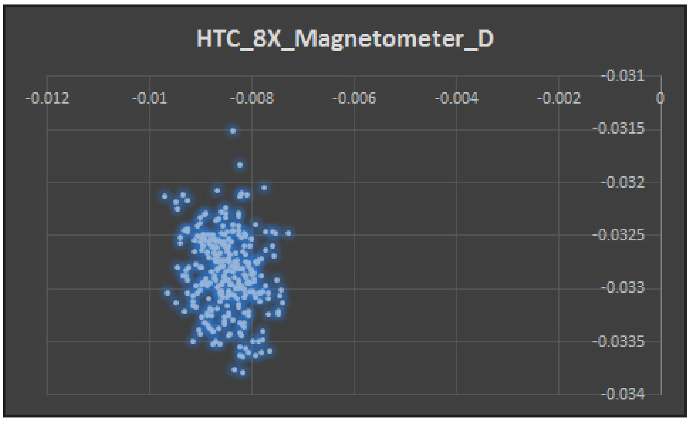

Fig. 4: HTC 8X

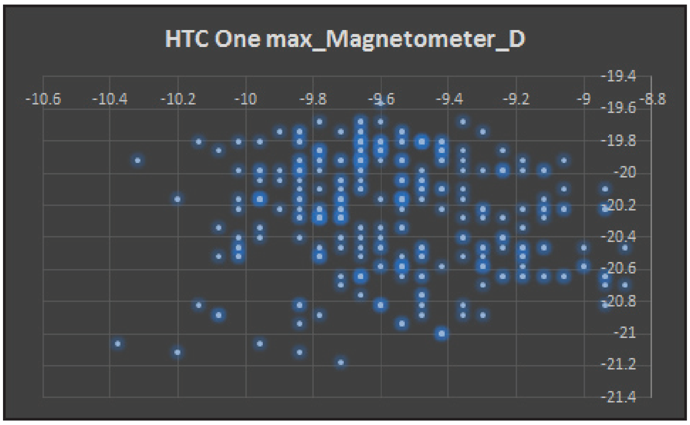

Fig. 5: HTC One Max

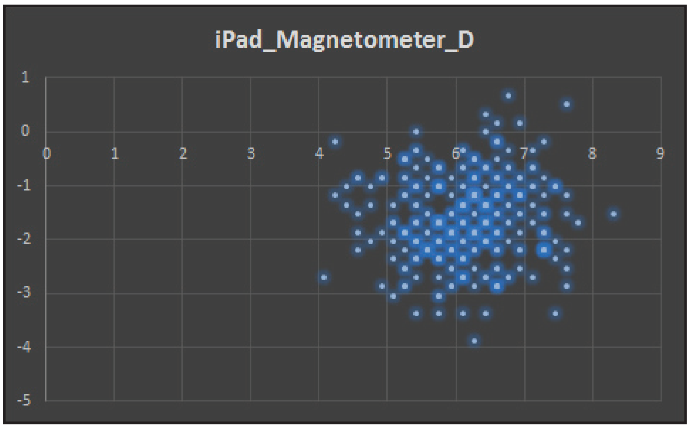

Fig. 6: iPad Mini

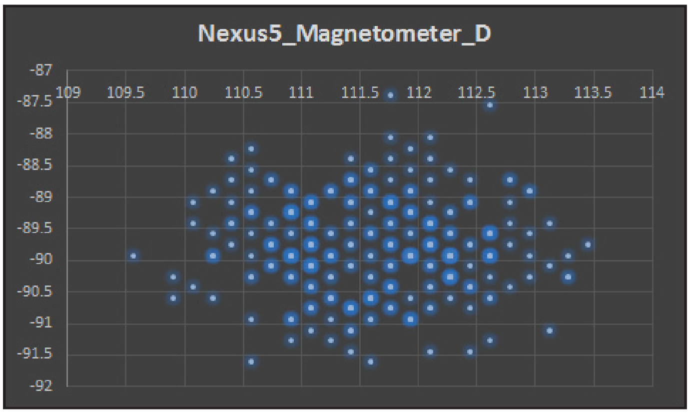

Fig. 7: Nexus 5

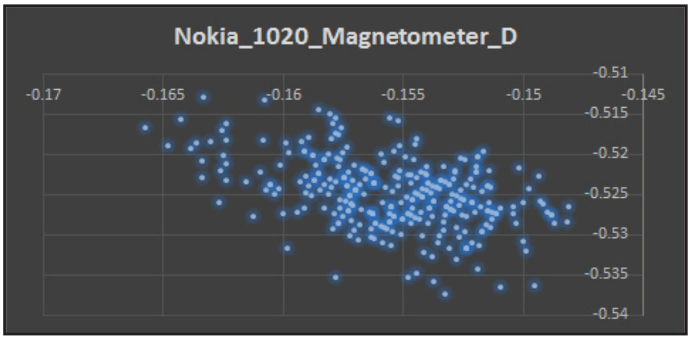

Fig. 8: Nokia 1020

In our researches we couldn’t find any resemblance between measures in the same corners. We can also declare that there is no similarity in pattern if using devices with the same sensors but with different operating systems, like in the case of the two HTC mobile phones. Neither same operating systems give similar measurement results. We don’t know the cause of this, but we noticed more distractions. Since these sensors are very sensitive, nearbyelectrical devices or live wires in the walls influence the measurement result. Beyond the interference we examined the effect of the presence of water-conduits, but there was no significant difference.

After we studied the corners, we wanted to determine how much we can isolate them and whether it is possible to estimate the size of the room from it. On the figures below we can see the more interesting results. Maybe the most interesting results were given by the iPad mini.

However, we should note that the data shown are row data, so we did not apply any filter or any correction on the measurement results. We examined the raw data to see the sensitivity of sensors. As we can see on the graphs, the iPad mini detected corners ’C’ and ’D’ to be very close what’s more, it didn’t sense any significant differences.

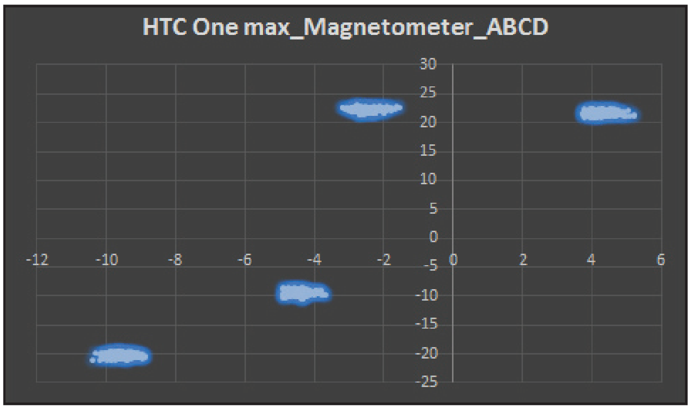

Fig. 9: Data From the Corners Measured by HTC One Max

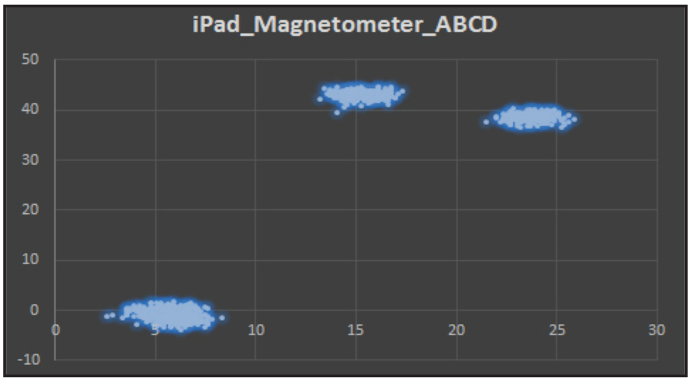

Fig. 10: Data from the Corners Measured by iPad mini

Contrarily, HTC One Max was able to detect four different corners, although it is hard to locate the measured value in space, so it is not suitable to specify the sizes of the room. On the figures we represented every corner with 4700 value.

The following graphs show what happens if we filter raw results. In this case we applied one of our own algorithms; its result are shown on Fig. 12, while Fig. 11. shows the raw data.

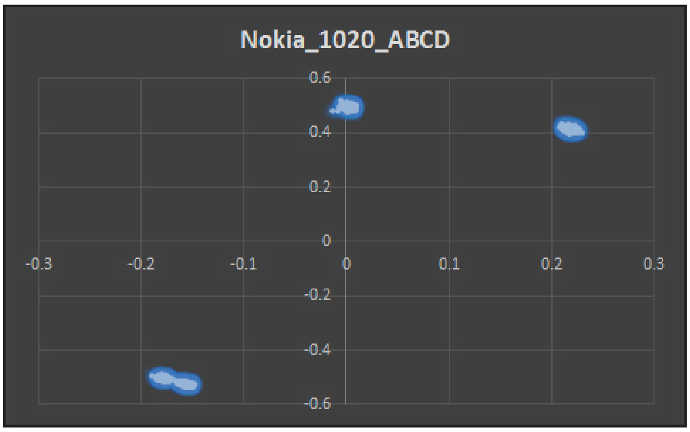

Fig. 11: Original Data Without Filtering

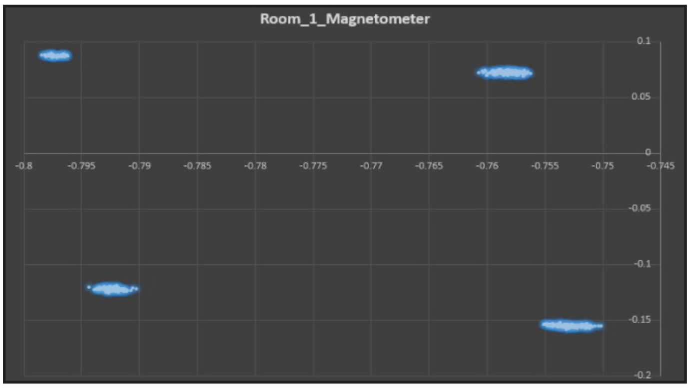

Fig. 12: Data Filtered With Algorithm

This result is important, because the researcher who performed the calculations did not see the room, so couldn't know its size either. After the measuring, the estimated lengths of the room walls are 430 cm and 400 cm. Manual measurements proved that the actual lengths are 450 cm and 410 cm. The inaccuracy was probably caused by the angles between walls not being right angles, but we couldn't determine the exact cause of the distortion.

In our measurements we studied whether we can find any correlation if the test areas are placed further from each other. Though these were more than ten kilometres afar, there was no significant difference. The measured coordinates are located in the same range, just like the two test areas were only a room away.

IV. Conclusion

In our researches we clearly proved that the sensors built in smartphones are very sensitive and are not suitable for accurate indoor positioning independently.

We mainly used the magnetometer, where we ascertained that it does not make a difference between points more kilometres between them. But if we conduct a measure in one premise, then it can isolate the points. However, we have to remember that raw data can lie so close to each other that they appear to be one point when they are represented on a graph. During our studies we developed an algorithm, with which we can determine the dimensions of a room with up to 90% accuracy, not even being there. But even now there might still be such interfering factors which we cannot eliminate. During our researches we collected hundreds of thousands of data, and in its light we can say that the coordinated operation of more sensors, in other words, a hybrid solution is needed for a successful indoor positioning system.

V. Acknowledgement

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Zoltan Horvath had his PhD comprehensive examination in remote sensing at University of Veszprem, Keszthely, Hungary in 2008. He has been an assistant professor at the Department of Informatics, University of Pecs, Faculty of Sciences since 2010. His research interests include digital signal processing, indoor navigation techniques, remote sensing. He is a visitor professor at Kasetsart University, Bangkok and editor at the Journal of Communications and Information Sciences and at the Journal of Computer Engineering (COES&RJ-JCE).