The G Forces of the GPS Measurement Accuracy

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Abstract
The present research was directed to examine how G forces effecting the devices influence the accuracy of measurement results, respectively to find out whether the extent of forces correlate with the bigness of measurement errors. Since G sensors are built in nearly every smartphone, we can trace the bigness of the force affecting the device.

Keywords
GPS, GLONASS, Smartphone, Speed Factor, G Sensor

I. Introduction

In the course of our previous researches we studied the accuracy of GPS sensors of different smartphones and tablets under distinct circumstances. Furthermore whether devices using GPS or those using GLONASS and GPS provide more accurate data if we want to measure distance. Our researches are only the initial steps towards the development of an indoor navigation system. To make this system work properly it's essential to know how big error we have to calculate with in each case of a device, also to know what influential factors can interfere with achieving accurate results.
It's necessary for there are smaller distances indoors, which requires greater accuracy froma software. E. g. when using automotive navigation systems 5-10 meters error is acceptable, while indoors this is considered huge, resulting in imprecise navigation.
Beyond that we examined how to separate diffused signal from the originals. Our studies proved that diffused signals greatly influence punctuality and distortion of measurement results. We got the most precise results from the original GPS signals. For this the most suitable solution is the Kalman filter. The algorithm is capable of filtering out the signal of the original satellites in the field of vision from the perplexing signals. With this method we can subdue the rate of measurement error under 5%. The next graph shows the difference of data provided by the two types of signals (Fig. 1).
As we can see on the graph, there is a significant difference between data provided by signals cleared with the algorithm and the raw ones.

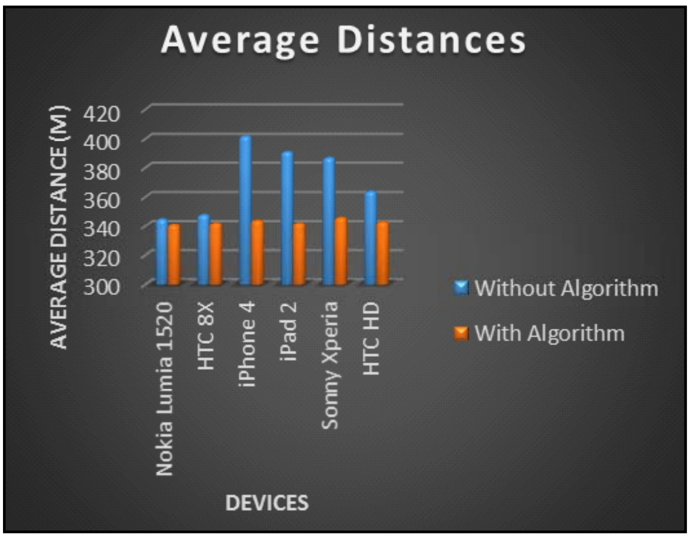

Fig. 1: Average Distances With and Without Algorithm

This is important, because we can meet diffused signal outdoors too, not only indoor. It is enough to think about if we would like to use the Wi-Fi signal of routers for navigation, those signals will come in contact with a countless number of objects, so the proportion of diffused signals will increase as against of the clean signals.
In our present research we continued to examine the influential factors to the accuracy of GPS, among these we studied the effect of G forces affecting the devices.

II. Material and Method

During our research we used Garmin Edge 510, Nokia Lumia 1520, iPhone4 devices. We broadened the list with the Garmin Edge, because this device was developed expressly to measure distance and can handle GPS and GLONASS signals too.

A. Environment of Examination

We chose the primary route on the Southern side of Mecsek Hill as the location of study. The length of the examined distance is 4 kilometers, on which there are 13 curves, as it is shown on the next figure (Fig. 2).

Fig. 2: The Test Area

We kept more viewpoints in mind when choosing the test area to be able to get a real image of the forces affecting the devices. Like the area should contain several curves, not only arching in one way, but to turn to left and also right. A further point was that

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the devices should have a clean line of sight to the sky, so the devices can get GPS and GLONASS signals too.
This is an important aspect because this is how it's possible to observe the effect of forces affecting the devices, since those are equipped with G sensors. During the study we monitored the change of speed in four curves. Naturally we also needed reference values, for that we used a normalized speedometer. In each case we noted the speed at the beginning and at the end of the turns. When a curve was foreseeable (e. g. from a higher road section), we tracked the speed all along.

B. Description of Examination

For measuring we used bicycle and motor-car. We installed the devices on the handlebar with the help of a console to secure them. We performed 40-40 measurements with bicycle and car. We studied the operation of the G sensor with softwares available for free: on Windows phones we used the app Seismograph, and on iPhone we used iSeisometer. These softwares can record movements on X, Y and Z axes, therefore we can observe how much certain forces distort measurement values. Fig. 3 shows the app Seismograph in operation.

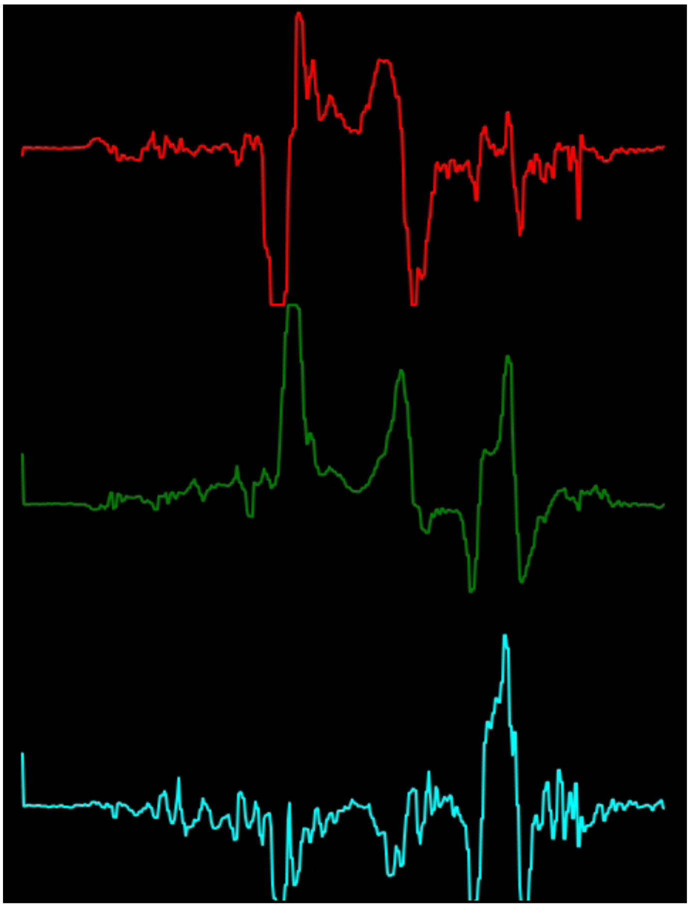

Fig. 3: Seismograph Software

We can see the bigness of forces affecting the device on axes X, Y and Z in the figure above. The software mentioned above is capable of monitoring the forces affecting the devices on all three axes. We could also save it to a file, so after the measuring we had time to fully analyze the forces almost centimeters accurately, since the frequency of sampling can be adjusted in the software settings. In the course of our measurements we set 0.5 millisecond as sampling interval. As a result we could compare the bigness of forces to the measured speed values; also we assigned the real speed to these.

III. Results

In the course of the measurement we got the surprising result that the G forces do affect the measurement output in a quite dramatic way.
It was most observable in the case of the device Garmin Edge 510. We can see how our momentary speed changed according to the device in sharp turns. According to the measured data the measured speed often decreased by 10-12 km/h, while in reality there was no such deceleration. The next graph shows the values measured by a bicycle (Fig. 4). Unfortunately we couldn't set the initial speed so accurately as we could in the measurings with a car, but it had no disturbing effect on the measurings.

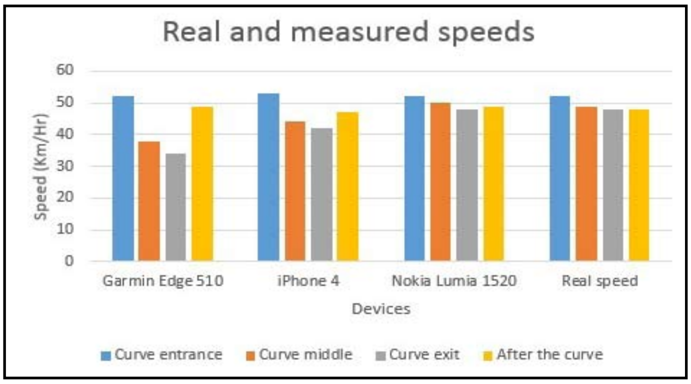

Fig. 4: Real and Measured Speeds by Bicycle

As we can see on the figure above, only the device Garmin Edge gave huge differences. The others provided relatively even data.
As we can see on the next figure (Fig. 5)the accuracy of data provided by Garmin Edge showed no progress in measures carried out by a car. However the initial speed could be perpetuated to 60 km/h.

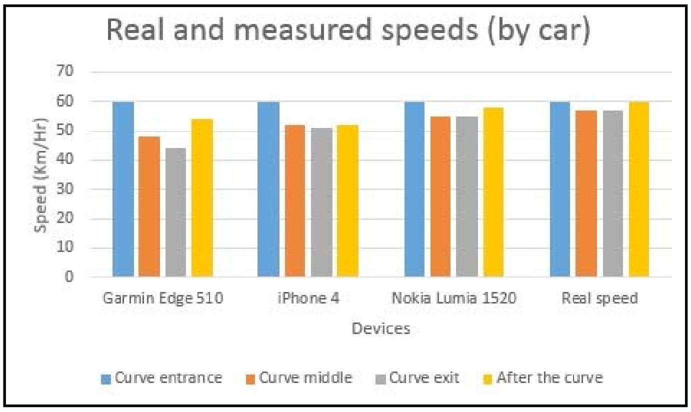

Fig. 5: Real and Measured Speeds by Car

The achieved results suggested that sensors in the devices are posited in different ways; so they deflect in varying degrees under the effects of forces. While there is more space in Garmin Edge 510 than in the smartphones we used, so it's conceivable that the antennae can shift because of the forces affecting it. This causes the distortion of the measurement results. There was only one time out of 80 measurings when this devices detected we stopped, so the speed decreased to 0. This rough error occurred during the measurements by bicycle.

V. Conclusion

Our studies pointed out a feature of GPS that G forces influencing the devices affect the measurement result and its accuracy. The greater the force affecting the device, the greater the distortion in data compared to real data. These results culminated mostly in the measurements with bicycles. Shows how G force affected the measured results at different sections of a curve. The values in the table give the average of the data from the 80 measurements.

Table 1: Average Values From the 80 Measurements and G Force

	Curve entrance	Curve middle	Curve exit	After the curve
Garmin Edge	58	41	46	49
Nokia 1520	56	54	53	55
iPhone4	57	52	48	51
Real speed	57	55	54	56
G force	0	2.1	1.7	0

As we can see in the table, the greatest force occurred in the middle of the curve, so accordingly we experienced the greatest distortion between measured and real speed. It's clear from the result of our studies that the distorting impact of G forces does not influence whether a device is only capable of handling only GPS or GPS and GLONASSsignals too. In this regard there is no significant difference between different devices.

VI. Acknowledge

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