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Use It Free: Instantly Knowing Your Phone Attitude

The main objective of this paper lies in **finding out the altitude of the phone and thereby of the individual using it**. The authors propose A^3 which is an accurate and automatic attitude detector. A^3 makes use of the gyroscope, but then makes use of the accelerometer and magnetometer to select the best sensing capabilities and derive the most accurate attitude estimation. The authors claim 3× improvement on the accuracy of attitude estimation over prevalent methods.

The authors motivate the uses for phone altitude such as dead reckoning based localization, 3D photography, mobile gaming, gesture recognition among other examples.

The altitude is generally measured using Inertial Measurement Units (IMU) which comprise of Gyroscope, Accelerometer and Compass (Magnetometer). There are android API's that can easily find out the Rotation matrix for calculations.

Although the existing methods make use of MEMS gyroscope, it has been blamed for poor accuracy. Several works such as **UnLoc** have mentioned that "...the error accumulates over time…" and have provided error values of about 20 metres over a time duration of 3 minutes. Some of the reason for these poor performances could be due to using poor quality gyroscopes and might be even due to a poor implementation of the API's that are calculating the rotation. The authors note that the error is almost linearly proportional to the acceleration and angular velocity and using the gyroscope in high-speed motion could affect the values.

Alternate methods for estimating the altitude could be using accelerometer and magnetometer. While the extraction is accurate when phone motion is low in an accelerometer, it gets complicated during high-frequency motion. Thus, it suffers from issues. Regarding magnetometer, the estimation is accurate outdoors but gets complicated indoors due to magnetic interference.

The authors propose using a combination of the two as mentioned earlier. Use gyroscope to track orientation where errors will accumulate (drift) as mentioned earlier). Next, reset the errors with accelerometer

/magnetometer (When the phone is static and there is no magnetic interference). There exists another issue here. How often do we get opportunities to reset? This is where the authors discuss opportunistic resetting.

For evaluation, the authors use three smartphones and compare them in two scenarios - walking in hand and in the pocket. They compare between basic A^3 (where the opportunistic calibration is not incorporated), A^3, API and x-AHRS (Attitude Heading Reference Systems - which is the state of the art method when the comparison was made) and compare with existing apps that are available. It is observed that walking in hand performs better due to better signal quality than when in the pocket (expected). It is observed that A^3 performs the best across all but one point (H, where basic A^3 and x-AHRS perform slightly better). In the comparison with smartphone apps, the proposed method outperforms all the existing smartphone apps.

Thus, in a nutshell, the paper has provided studies to understand the mobile phone IMU sensors. A combination of gyroscope along with using accelerometer/magnetometer as required is used. The phone attitude estimation method which has been proposed performs better than existing methods.

However, there were a few points that needed more clarity :

Questions :

1. The people who are using/ objects may not pause very often (which is one of the conditions where A^3 works well) and thus, determining those moments will definitely produce some false positives and false negatives which can hamper the accuracy of the system. How do we resolve this issue?
2. As mentioned above, A^3 's performance is good only in certain types of movements. Along with this, some components of the Inertial Measurement Unit information remain unused. Can we make use of these additional information at all times?
3. Suppose there exists a condition where the accelerometer's magnitude is varying constantly. In this case, A^3 Thus, the state of "rotation but no acceleration" also occurs rarely. It would be useful for it to work in real world environments with more robustness.
4. Since the paper proposes to use gravity as the main point, by having gravity getting mixed up with linear motion (accelerometer), it could get more difficult to extract a very precise global orientation. How do we resolve this issue?

More details about the paper

Zhou, P., Li, M., & Shen, G. (2014, September). Use it free: Instantly knowing your phone attitude. In Proceedings of the 20th annual international conference on Mobile computing and networking (pp. 605-616).