Indoor Guidance & Positioning Using Mobile Sensors

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Introduction

People spend 80-90% of their lives in indoor locations, such as shopping malls, libraries, airports, etc. The wide availability of sensor-rich mobiles has boosted the interest and possibility for a variety of indoor location-based services.

When it comes to outdoor locations, then GPS and similar solutions are the most popular way to provide the user with his/her location.

GPS, however, cannot be used indoors, due to the fact that the crucial part of GPS is measuring the exact time from a certain amount of satellites and the location estimates can get very inaccurate, due to the extra time the signal has to travel through buildings and walls constructed with concrete and metal, not to mention all the environmental factors, such as occlusion, diffraction and scattering.

Media-augmented RFID

When entering into a digitally enhanced building, such as museum with exhibits with RFID-tags, then upon contact of the RFID tag (and based on the client's language preference), information about the exhibit is automatically loaded onto your smartphone screen.

This data can include text, image, audio and video. In addition to this, since the location of the exhibits are usually known in advance, the location estimates can be improved based on the readings.

The map of the building is loaded upon contact with the first RFID.

Positioning algorithm

The sensors can provide data about how the user has moved the phone. Provided we make some assumptions on how the phone is held, we can estimate where the user has moved and which way the user is looking now, i.e. the heading.

The approach chosen was the pedometer algorithm. Pedometers allow to count the steps that a user has taken and taking into account the sensors present in the modern smartphone, then one can extract the number of steps from the linear accelerometer.

Taking into account, however, that different people still walk differently, a calibration mechanism was also put into place.

Step count & length

Since the pedometer outputs the step count, then if we can estimate the step length, then by that one can extract the path traversed, assuming that a heading is also provided.

Heading

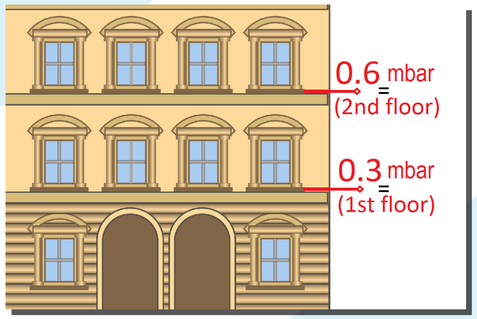
A relative heading can be extracted from the rotation vector sensor, meaning that the heading of the phone points to e.g. north and upon phone rotation, the sensor outputs a value relative to the north. Since the reference line of the user need not be the north direction, but rather a heading within a building, such as an arbitrary corridor, the user offset must also be included within the heading.

Floor pressure difference

The higher an object is, the less pressure is exerted on the object, due to the less amount of air and thus also air pressure.

Based on this fact, we can determine the moment when the user reaches the next floor based on simple math and estimation.

We track if the user is moving up or down, based on the pressure changes in measurements (decreasing vs increasing). Based on the measurement for the corresponding floor, we can determine, if the threshold for a floor is exceeded or not. The next floor can then be auto-loaded, as soon as the user reaches it.



Location

The pseudo-calculations to extract user's location are as follows:

x' = cos(heading) * stepLength
y' = sin(heading) * stepLength
z' = pressure / floorPressureDiff

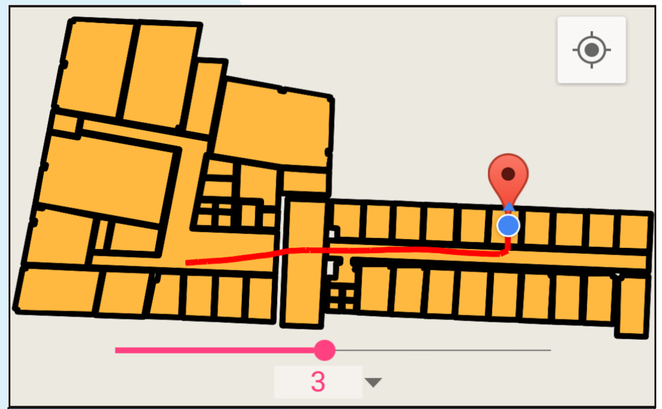
(above calculations used in global navigation map coordinates with real-time error corrections also added)

Results and future

A positioning application based mainly on the user's smartphone and its sensors was created. The accuracy of the system is dependent mainly on the calibrations of the step length, step detector and the floor pressure difference.

Future improvements to alleviate sensor imperfections, cumulative error (and noise) may include:

* WiFi calibration points—no lengthy grip mapping, good possibilities. Interpolation with WiFi must consider structural details of building (WiFi heatmap)
* P2P fixing—fix device A location based on reading from device B, if the two devices are in close proximity, the new reading of device B occured only moments ago and is newer (and thus more accurate) than of device A.



Map with current location, heading, path, floor control, etc.

Repository: https://bitbucket.org/sander9292/indoor-guide/wiki/Home