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BikeNav System

A SMARTPHONE-BASED INERTIAL NAVIGATION SYSTEM FOR BICYCLES

Problem

Currently, in Africa, millions of people suffer every day from diseases, which propagate easily due to poor life and healthcare conditions. Syndromic Surveillance is a project which aims to collect data in order to monitor and predict diseases in a certain African geographical area. Community Health Workers are volunteers who travel by bicycle between villages, collecting georeferenced data with their smartphones. The GPS receivers embedded on these smartphones make localization easier; unfortunately, GPS signal is not always available, due to factors such as terrain elevations or the lack of 3G networks to provide AGPS data.

Goals

The idea is to create a cheap, lightweight solution for bikes that can use an inertial navigation system (INS), or, in other words, a system that uses motion and rotation sensors to estimate position, orientation and velocity of the cyclist. Nowadays, all smartphones have (at least) these sensors, and they are much cheaper and available than any other kind of sensors (e.g. LIDARs, SONARs).
To achieve this goal, concepts of sensor fusion and signal processing were applied to the data received from the smartphone's sensors to calculate the position, speed and orientation of the cyclist, and show all of this using Google Maps.

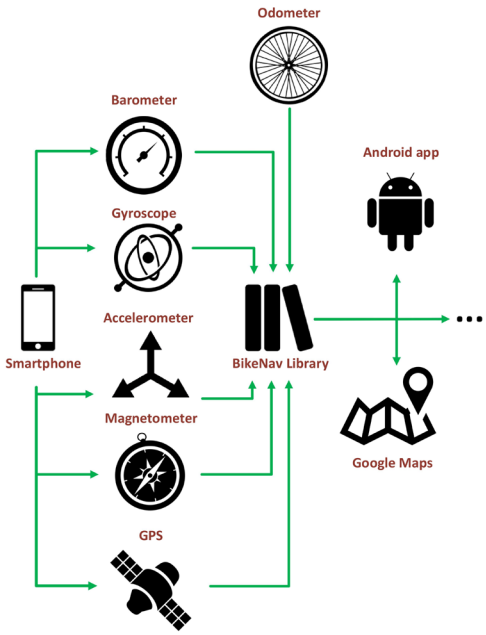

Fig1. BikeNav system architecture.

Solution

The developed solution integrates:

- An inertial navigation system – since smartphones are largely used worldwide (although, as expected,

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Requirements

- Smartphone running Android 4.3+, with Bluetooth Low Energy (BLE) support
- BLE speed sensor for bicycles

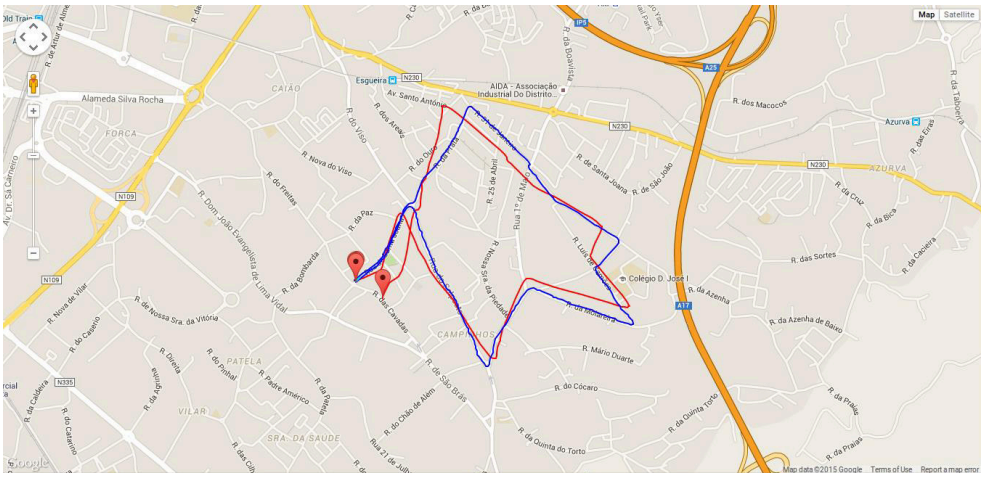

Fig2. Sample test output. In blue, the GPS data. In red, the INS-calculated positions.

more in first-world countries), we can reuse the hardware already embedded in these devices, namely its accelerometer, gyroscope, magnetometer and barometer. Gyroscope and magnetometer are used to calculate heading. Barometer (when available) is used to calculate altitude through air pressure, since it is more accurate than detecting altitude variations through the accelerometer/gyroscope pair;

- An odometer attached to the bicycle being monitored, connected to the smartphone which is processing and integrating its data. Since phone sensors suffer from high noise, which directly affects the calculation of displacement, in order to have better accuracy, the odometer is used to give more precise readings of distance and instant speed, improving the overall system precision and effectiveness;
- A global navigation satellite system (GNSS), using the GPS receiver which is also available on smartphones; although it may not be available everywhere, due to satellite visibility issues, the system supports it, since its precision is high without the need for any additional components (the INS is, in short, a fallback mechanism when GPS signal is not available).

Test Methodology

The BikeNav library, core of the project, was fully tested by using unit testing libraries to inject that data previously collected into the system, accelerating the whole test process.

Fig3. BLE Speed Sensor mounted in the test bicycle.

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