Student Assistant / Thesis

Determine the Movements of Smartphone Users Using Sensor Fusion Techniques

Problem Statement
Nowadays, smartphones have become an integral part of our daily lives and are equipped with various sensors, including accelerometers, gyroscopes, magnetometers, and GPS sensors. In the Harmonizing Mobility (Har-Mobi) project [1], smartphones will be utilized as data collection devices to determine user movements. A user’s acceleration can be directly measured by the phone’s accelerometer. To estimate velocity, the measured acceleration can be integrated over time. However, this method is susceptible to cumulative errors, leading to a drift in the velocity estimation. To combat this, the GPS sensor can be used to measure velocity, as it is more robust against long-term drift. However, it is less accurate for small, rapid movements and is unreliable in areas with poor GPS signals. A solution to address both shortcomings is to correct the velocity obtained through integration with GPS data using sensor fusion techniques. The same principle applies to the estimation of the user’s position. Since the smartphone can be in various orientations, such as being inside the user’s pocket, determining the smartphone’s orientation is a prerequisite for accurate state estimation. This can be achieved by fusing measurement data from the accelerometer ($\mathbf{a}$), gyroscope ($\mathbf{w}$), and magnetometer ($\mathbf{B}$). The entire methodology is illustrated in Fig. 1, where phyphox [2] is a free app used for visualizing and exporting measurement data.

Your Tasks
► Implement a filter, particularly an AHRS (attitude and heading reference system) filter, for determining smartphone orientation
► Transform the acceleration data from smartphone coordinate system to geographic coordinate system
► Develop a method to compensate for motions that do not contribute to the actual movements of smartphone users, such as the pedaling of a cyclist while the smartphone is placed in the pocket
► Develop a sensor fusion technique to correct the velocity and position data with GPS data

Your Profile
► Experience in programming is required
► Experience/knowledge in fusion techniques is advantageous
► Affinity to mathematics is a plus

Contact
Please read our instruction for Applications.

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[2] https://phyphox.org/de/home-de/