2019-T2- NC 812/ESD 812 / Internet of Things
Assignment 2
Pedestrian Navigation System (PNS)
Applications in indoor and outdoor environments using IMU data

Today's Internet and wireless networks have drastically improved, thereby enhancing the capabilities of smart phones. Mobile Navigation services are those applications that help users in navigating to a particular destination based on their current location. But based on the context in which a user is placed, there is a need to influence the way in which these services are presented, since different context requires different navigational aspects.

While it is perfectly acceptable to locate to some few metres in an outdoor environments, but for indoor environments or blocked path environments, we need something extra for pedestrians. Pedestrians normally move in sidewalks where the buildings shadow the GNSS signals, in tree shadowed environments and in indoor three-dimensional environments like multi-storeyed hotels, hospitals, etc. The mapping of indoor environments is also much more complex and dynamic requiring tridimensional mapping that is not generally required for road applications. Also to support public transportation, the routes and the frequency or the timetable of the public transports must be supported making the database and the routing algorithms more complex.

While finding several applications in Indoor like patient trajectories in hospitals, visitor tracking in museums or looking after a sports person's training analysis to determine its position, movement, fitness, etc., there have been a great research in utilizing IMU data to build such applications. Pedestrian Navigation applications are typically implemented as standalone running on mobile device, where some are supported as dynamic navigation functionality, while some of them are built on top of context awareness of the place where it will be used. Additionally, these applications will benefit significantly from the use of augmented reality technologies.

Pedestrian Navigation Services
If broadly seen the various goals of Pedestrian Navigation systems, it is possible to classify them into following categories:

1. Location finding
2. Optimal path finding
3. Orientation
4. Positioning
5. Way-finding

This is what forms an attempt by *Kasebzadeh, et al* under the paper, *IMU Dataset for Motion and Device Mode classification*, to collect such data which will be useful for developing such applications.

Various cases considered under the paper

The paper discusses differentiates and considers the combination of two different modes to generate the data:

1. **Device Mode:** This mainly talks about the placement of the device, while performing the activity. It has 4 different values: mobile device held fixed in hand, swinging hand, mobile device kept inside pocket and mobile device kept inside the backpack. This mode forms an important implication on the received signals of the IMU sensors. Also, the bias is different. The elimination of bias enables the use of dead-reckoning principles to integrate acceleration and angular rate into a precise trajactory.

2. **Motion Mode:** This explains about the activity being performed by the human under observation. The various activities that could be performed are as, standing still, walking and running.

When it comes to classifying the motion mode and device mode simultaneously, the combination of device modes and motion modes, forms the labels of classifier. The main design considerations is to determine the step length and step detection threshold, when the magnitude of the acceleration is deemed to be caused by a step.

Motion Mode / Device Mode	Standing Still (SS)	Walking (W)	Running (R)
Fixed hand (1)	Class SS	Class W1	Class R1
Swinging hand (2)		Class W2	Class R2
Pocket (3)		Class W3	Class R3
Backpack (4)		Class W4	Class R4

The experiment involved the subjects to walk along three different paths, with a mixture of different motion modes. For each path, the subject holds a different set of device modes i.e. the subject holds one mobile phone in the hand, two more phones in front and back pockets, and one in the backpack. Following are the scenarios and cases that fall under each of them:

Scenario-1 [Outdoor only][Standing still, walking and running]

This is performed in complete outdoors, where GPS signals are clearly available. This corresponds to Case-1.

Scenario-2 [Outdoor-Indoor][Walking]

This involves subject to walk from outside track and then gets into the building and walks through corridor. Under this, device mode is fixed, i.e. subject covers whole path with smart phone as fixed in hand, which forms Case-2.

Scenario-3 [Outdoor-Indoor][Standing still, walking and running]

This represents the complex behavior in terms of motion modes and experimentation path. In this, the subject starts outside the building, then gets into the building, takes the stairs and walks a certain distance, then stairs down and gets back to the starting point.

Case-3 is formed by fixed phone with simply walking along path, while Case-4 involves swinging hand holding the phone along with all motion modes, i.e. Walking, runing and standing still.

Scenario	Device Mode	Motion Mode	Participants	Duration (average) [s]
Case 1	1,2,3,4	W,R,SS	5 Males 2 Females	190
Case 2	1,3,4	W	6 Males 2 Females	200
Case 3	1,3,4; 2,3,4	W Upstairs Downstairs	6 Males 2 Female	280
Case 4	1,3,4; 2,3,4	W,R,SS Upstairs Downstairs	6 Males 2 Female	270

Hotel Indoor Services Recommendation based on Navigation System

Goal: The goal of the application is to identify the movement of guests inside hotel and recommend various services like spa, gym, restaurants, playrooms, meeting rooms, etc. The target users of this application are big chains of hotels like Marriot, etc. where there are multiple restaurants and a huge set of services offered.

The idea is to combine the IMU data along with Dead Reckoning. It is the process of estimating one's current position based upon a previously determined position, by advancing position based upon known or estimated speeds over elapsed time and course. The IMU data helps to detemine acceleration/speed and directions, specifically, Accelerometer helps to determine speed/distance as integrals, while Gyroscope and Magnetometer helps to determine directions.

Design: The fingerprints and map of the hotel are saved in the database, which act as navigation and fingerprints are used to determine the distances. The RSSI measurements are used to measure the relative distances from the fingerprints already collected. IMU data i.e. accelerometer, gyroscope and magnetometer are used to determine the speed, direction and steps, that are used to calculate further coordinated. The position determination is done, by merging the positions obtained and the update is sent to the map displayed.

The **case-2** of the given dataset suits this, because inside hotel, it is most likely that a guest won't be running inside, so just walking mode is fit for this application. Also, it will have stair cases, so we need the observations for stairs climbing up and stairs climbing down.

Flow of the application: