Remote Monitoring

PROJECT OUTLINE

Intro

The Remote Monitoring project is aimed at providing remote homecare to elderly people. The system uses 24h real time location information to detect risk situations (falls, loss of consciousness) and alert the user, his family, or health care providers.

In this foundation project, we are going to work with real data from users. We could see that the data are different depending on the home environment and on the user's behavior. We need to develop some algorithms and models that work for every user.

As this is a non-intrusive project, we could not assign real labels to the user behavior, so we must mostly focus on unsupervised learning methods.

Sensors and set up

To collect the location data, we use:

- 1 beacon attached to the user
- 4 to 6 static sensors, connecting to the beacon and sending the power signal to a gateway
- A gateway collecting the sensors data and sending them to a SQL database via wifi or GSM
- A set of algorithms to process the signals and to extract meaningful information from it

Usually the user has the beacon attached to his body 24h. All users have at least four sensors located at: living room, kitchen, bedroom, bathroom. Some users have two additional sensors located in other rooms (we call these rooms custom1 and custom2).

The sensors are BLE emitters and receptors. They get a signal from the beacon and then send to the gateway data on the signal strength (RSSI). The RSSI data unit is dB, and the values range from roughly -30 dB (maximum strength) to -100 dB. The closer the beacon to a sensor, the biggest RSSI value.

The sensors check the beacon status every 2-3 seconds and then send the RSSI readings to the gateway. Every 10 seconds the gateway writes to the database the average RSSI value from each sensor for the previous 10 seconds.

Reading all the RSSI values at a given time we can infer the approximate location of the user. Looking at the changes in the readings we can infer if the user is moving or not.

Project Tasks

1- Noise reduction

BLE signals suffer from different sources of noise and distortion. We also see signal gaps (short time periods without signal due to reading errors, etc.). Noise levels are very different form one user to another. If we want to measure users movement we need to look at signal changes, so we need to reduce noise. Any remaining noise should be similar from one user to another.

The fist approach is using a Kalman Filter to filter noise. The filter has proven able to adapt to different noise levels and to give as output a similar signal for every user.

Challenge:

The Kalman filter needs some time to become steady. When we have signal loses or gaps the filter introduces some variation in the signal that could be misunderstood as user movement. More signal processing is needed prior to get more accurate insights.

Some approaches could include signal processing, dimension reduction.

Tasks:

- To check the current Kalman filter and try to improve it.
- To suggest and implement other noise reduction solutions.

2- Measuring movement or activity levels

If we could measure the users movements from the location data we could: 1)know if he is resting or active 2)detect unusual states that could point to any issue or accident, 3)measure daily activity to make follow up of the user health.

There are several approaches to measure movement from RSSI variation signal, for example

- Signal variance for the previous minutes (mean of every sensor, only the sensor with the biggest signal, only sensors with signal above a threshold, etc.).

- Spearman correlation between the RSSI levels (measure if signals level order is changing or not), or other correlation measures.
- Frequency domain analysis (Fast Fourier Transformation, etc.).

But no single variable has proven able to clearly differentiate activity levels.

Challenge:

To be able to measure activity levels for different uses, for example:

- To differentiate if the user is wearing the beacon or not
- To differentiate if the user is asleep or not
- To differentiate if the user is resting but conscious (for example watching tv) or if he is completely motionless.

Tasks:

- To propose an activity detection algorithm and to implement it
- To evaluate performance and to select the best solution.

3- Event pattern recognition

Using some rules combining location, activity level and time of the day can be used to detect some usual situations as getting up, resting, sleeping, etc. and some emergency situations (for example staying motionless at the bathroom for too much time at time).

Challenge:

The next step should be to use pattern mining and behavior recognition to learn behavior patterns for every user and to detect unusual behavior and emergencies.

Approaches: pattern recognition, complex event processing, deep learning.

Tasks:

- To propose a behavior processing and recognition algorithm and to implement it.

4- Location

Exact location is not necessary to fulfill the project goals. However, improvements in location can help in all the other challenges.

Challenge:

To design a non intrusive location algorithm able to perform well in all the users.

Tasks:

To propose a location algorithm and to implement it.

The data set

The data set rssi_data.csv includes the data from 12 users during one week (from 2017-01-15 to 2017-01-21).

The variables are:

user_id: A number from 1 to 12 to identify every user

living_room: RSSI value from the living room sensor

kitchen: RSSI value from the kitchen sensor

bedroom: RSSI value from the bedroom sensor

bathroom: RSSI value from the bathroom sensor

custom1: RSSI value from the first custom room sensor

custom2: RSSI value from the second custom room sensor

datetime: Date and time of the reading

A NA value in any of the room variable could mean:

a. The beacon is too far from the sensor, so the BLE signal does not reach the sensor, or

b. The reading has not reached the gateway for any reason (packet collision, sensor errors, gateway errors, etc.), or

c. There has been some error when sending the data from the gateway to the data base or when writing the values into the data base.