Poster Abstract: Radio Signature Based Posture Recognition Using WBSN

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1. INTRODUCTION

A body network of Inertial Measurement Units (IMUs) is a well known solution for posture recognition based on accelerometer and magnetometer data fusion. However sensors and especially the magnetometer can be disturbed by the environment. Considering a Wireless Body Sensor Network (WBSN), we propose to use available radio received power measurements as an alternative to the magnetometer. We show with simulation and real data, that the radio signal used for WBSN communications can also provide useful location information despite highly noisy Received Signal Strength Indications (RSSI). We propose a solution for the static case that leads to a very simple yet efficient algorithm.

2. SIMULATOR

2.1 Framework design

The objective is the development of posture/gesture recognition algorithms based on IMU and radio measurements. However it is not always possible to setup a new experiment to get new data and test different algorithms. So, we have designed our own simulator in order to evaluate geolocation algorithms with scenarios based on generated synthetic data or real data acquired with a motion capture system. Fig. 1 presents the principle of the simulator including inputs and outputs. The advantage of the simulator is the repeatability of the scenarios while modifying any other parameter. Then, with a given scenario we can test different noise models and algorithm configurations to compare and quantify performances.

2.2 Generation of IMU data

The simulator uses BVH files that contain motions of an avatar. This capture is usually made by a motion capture system as Moven [2] or Vicon [1] that are references in the domain. With such a capture, the position and orientation of each joint of the avatar can be computed for each frame. It is then possible to compute ideal values of IMU as if they were located on any segment of the avatar. The real distances between any couple of points on the avatar are also accessible directly by computation. In a second step, for each IMU axis an error compliant with noise models can be added to generate realistic measurements.

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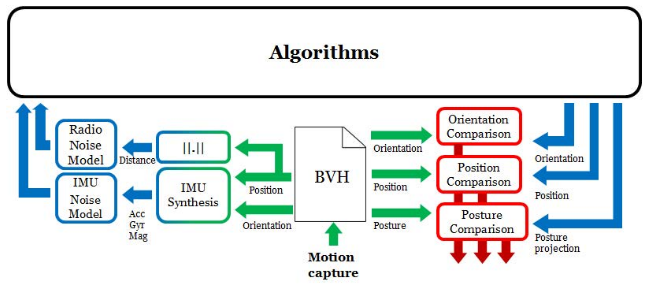

Figure 1: Simulator scheme.

3. POSTURE RECOGNITION SIMULATION RESULTS

3.1 Simulation

Here we present a study based on accelerometer and magnetometer combination. These data are used to determine orientation of each node. Then we apply a classification technique based on Principal Component Analysis (PCA) and a simple Nearest Centroid Classifier (NCC).

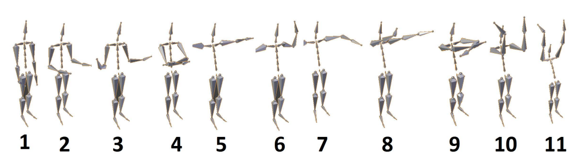

Figure 2: Posture of arms chosen for recognition.

Simulation relies on a scenario. Here we consider a usage case based on a set of 11 arm postures that can be used for remote physical rehabilitation for instance. Recognition is

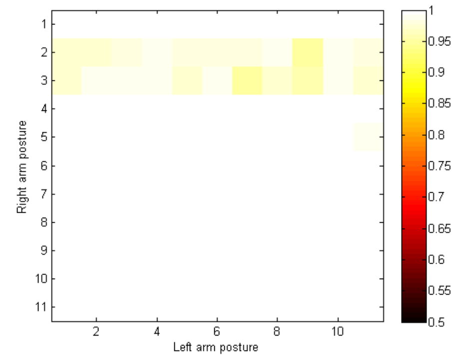

Figure 3: Recognition matrix of posture using accelerometer and magnetometer with simulation

done on postures of arms. For each arm, the 11 postures chosen are depicted in Fig. 2, which leads to an overall of 121 postures to classify. Nodes considered are the shoulder, arm, elbow, wrist, and chest.

3.2 Results

Figure 3 shows the success rate of recognition for all the 121 postures. The average success rate over all postures is 99.6%. As expected, we obtain pretty good results with simple algorithms when we use standard noise models for IMU sensors. However, we know that in practice the magnetometer can be dramatically disturbed. In the following we consider real data.

4. POSTURE RECOGNITION EXPERIMENTAL RESULTS

4.1 Experiment setup

This experiment is based on measurements done with our own prototype called Zyggie, where each node is composed of a low cost IMU (magnetometer, accelerometer, gyroscope) and Zygbee (2.4GHz) wireless communications transceiver. We use a network of 9 nodes to gather IMU data and RSSI between all pair of nodes. RSSI is a metric that is linked to teh radio signal received power which is therefore dependent of the distance between the transmitter and the receiver. A record has been done by a user using this system for all the 121 postures.

4.2 Classification

In the first classification, the same processing as the one used for simulation are applied using accelerometer and magnetometer real data. Results are depicted on Fig. 4 to confirm simulation results and to have a basis for comparison with the second classification.

RSSI provides information about distance between nodes, but experiments with 2.4GHz radio links show very noisy data that make difficult the correlation between RSSI and distances. However we have observed that the RSSI matrix can provide a kind of 2D signature that provides enough information to discriminate postures. The second classification method is based on these RSSI signatures, which are combined with accelerometer data only without magnetometer data. Results are depicted on Fig. 5 and demonstrate that this solution can be used as a relevant complement to the usual accelerometer / magnetometer data fusion.

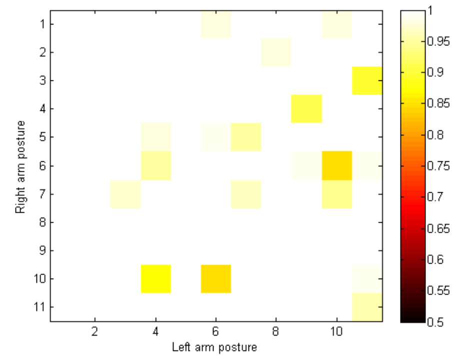

Figure 4: Recognition matrix of posture using accelerometer and radio measurement

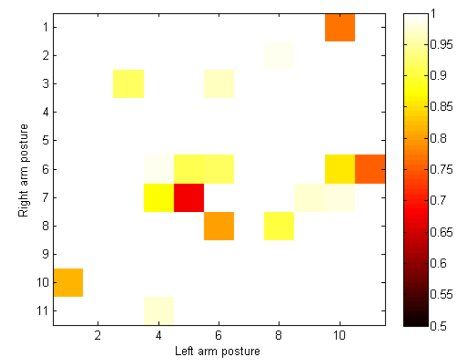

Figure 5: Recognition matrix of posture using accelerometer and magnetometer measurement

5. CONCLUSION

In case of static postures, radio signature can be a really useful data for recognition. RSSI signals are intrinsically available in the context of WSBN. Results show that radio can provide good enough results to compensate magnetometer deficiency. Moreover, accelerometer and radio measurements do not depend on the direction of the magnetic north. Then it can be used directly in the classification without previous data fusion. Moreover, PCA online computation is trivial. Coupled with a motion detection algorithm, this leads to an extremely low cost system. This study is part of a large project that aims to design ultra low power WSBNs for posture and gestures recognition. A complete simulator was developed, to evaluate proposed algorithms, which can be fulfilled with data collected from our WBSN platform.

6. ACKNOWLEDGMENT

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7. REFERENCES

[1] Vicon system. `http://www.vicon.com`
[2] Xsens product.
`http://www.xsens.com/en/general/mvn`