

Wireless Activity Monitoring for Real-Time Classification and Cueing

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1. Introduction

The explosion in number and use of mobile devices like smartphones and music players has enabled deployment of wearable medical sensors and applications for ubiquitous health monitoring. As health awareness increases in society and technology continues to push the boundaries, there is an increasing demand for small low powered state of the art medical devices that provide round the clock assessment of the subject's general well being

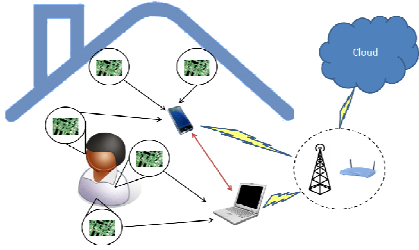


Figure 1: Depicts the idea of a smart environment that enables personal health monitoring

We envision a smart environment infrastructure enabled with motes capable of continuous interaction with various types of mobile devices. The stream of data can be locally processed and anomalies and outliers can then be sent over the internet to a central monitoring station in the cloud that is supervised by a healthcare professional. This kind of telemedicine will be the next generation in personalized health care delivery.

2. Personal Area Network

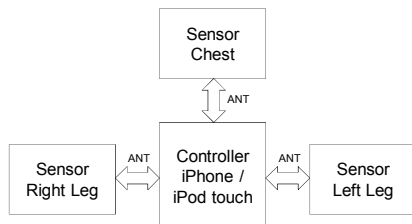


Figure 2: Network Block Diagram

Network Characteristics

- 2.4 GHz ISM band operation
- 50 Hz message rate
- ANT module implements N/w, link and PHY layers
- Implemented p-p and shared modes

3. Activity Monitoring Device

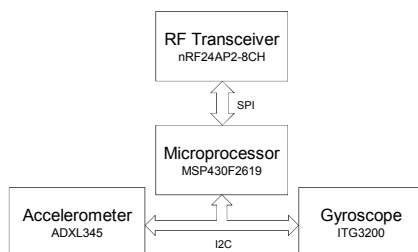


Figure 3: Sensor Device Block Diagram

4. Activity Measurement

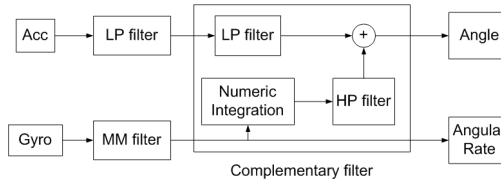


Figure 4: Activity Measurement Block Diagram

- $\text{AccAngle} = \arctan(g_z / (g_x^2 + g_y^2)^{1/2})$
- $Y_{m+1} = \text{median}(\text{mean}(x_1 \dots x_m), x_{m+1}, \text{mean}(x_{m+2} \dots x_{2m+1}))$
- $\text{Angle}(n+1) = \text{HPF} * (\text{Angle}(n) + \text{GyroRate}(n+1) / F_s) + \text{LPF} * \text{AccAngle}(n+1)$

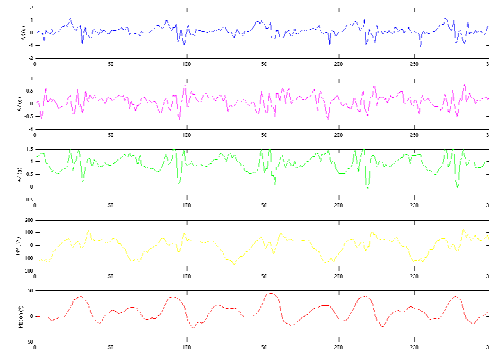


Figure 4: Illustration - Measurement of right leg motion

5. Activity Classification

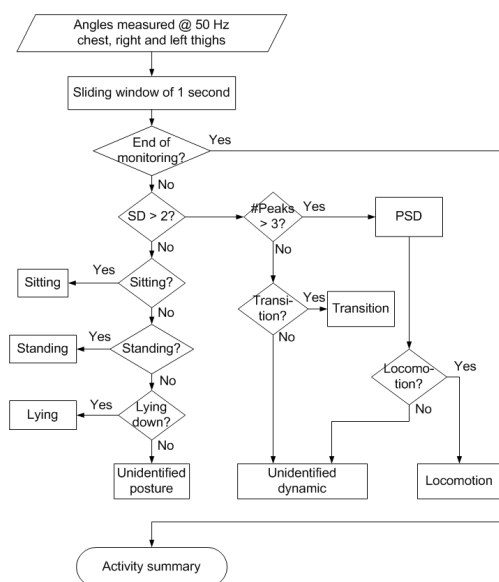


Figure 5: Activity Classification Algorithm Flowchart

SD: Standard Deviation
PSD: Power Spectral Density

6. Demo

- Problem Context:
 - An employee at the baggage services at an airport is the subject.
 - Squatting is generally considered a good way to lift heavy loads.
 - Stooping while lifting a heavy bag can damage the employee's spinal cord as there is no knee bending during lifting with excessive forward lean.
- Problem Solution:
 - The employee can strap on three sensor devices – one on chest and one on each thigh.
 - The algorithm on the phone determines whether the person is squatting and the lean angle of the back.
 - Classify if that posture for lifting weight is dangerous.
 - On determining a danger, the phone then provides an auditory feedback to warn the employee.

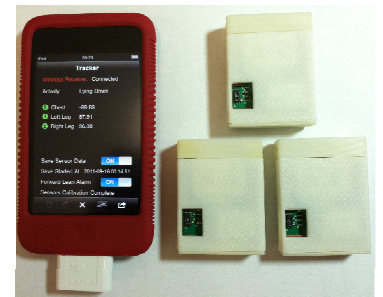


Figure 6: a. iPod touch, b. ANT transceiver c. 3x Activity Monitoring Devices form the PAN

The demonstration shows a prototype of a wireless, low-powered, compact device for activity monitoring of a subject in conjunction with an iPhone / iPod touch. A few other real-time applications of this setup are :-

- Classify activities like lying down, sitting, standing, and locomotion to facilitate fitness monitoring
- Provide real-time auditory feedback by means of external cueing to Parkinson's patient during 'freeze of gait' event
- Detect relative position of limbs during action in sport and suggest improvements. Eg: Pitching in baseball

7. References

- Y. Zhang, I. Sapir, S. Markovic, R. C. Wagenaar, and T. D. C. Little, "Continuous functional activity monitoring based on wearable tri-axial accelerometer and gyroscope", Workshop on Cognitive Sensor Networks for Pervasive Health (CoSN-PH 2011) in 5th Int ICST Conf on Pervasive Computing Technologies for Healthcare (PervasiveHealth 2011), Dublin, Ireland, 2011.
- R. C. Wagenaar, and R. E. A. van Emmerik, "Resonant frequencies of arms and legs identify walking patterns", J of Biomechanics, vol. 33, pp. 853 – 861, 2000.

8. Acknowledgements

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