IJARESM
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH IN ENGINEERING, SCIENCE & MANAGEMENT

ACTIVITY MONITORING SYSTEM

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Abstract: This paper describes a new device for activity monitoring system for daily use. Monitoring human's physical activity has a wide range of applications. These include helping individuals in maintaining their energy balance by developing health assessment and investigating the connections between common health problems and levels of physical activity like distance walked per day and providing feedback to motivate individuals to exercise. Due to lack of sleep or improper sleep many health problems like insomnia, hypersomnia, hyper tension, anxiety, high blood pressure and diabetes can arise. Similarly lack of daily exercise can also create many health problems. The proposed device uses a motion sensor as the core heart of the device which tracks the individual's wrist motion. The Processor will retrieve the data from motion sensor and will verify whether the data is of pedometer or sleep. This device is to be wore on wrist and is able to collect motion data by individual's movements. The device can be used indoor as well as outdoor, depending on user's demand. The Recent developments in sensor technology as well as data analysis methods have enabled unobtrusive sleeping pattern monitoring and walking pattern at the home. This approach is designed for long term monitoring at home and allowing users to enhance their sleeping pattern and physical health. Along with the proposed device an application for android powered smartphone is developed to provide the daily statics like number of steps walked and duration of sleep in detail. The size of the device is as small as a wrist watch. This device uses Bluetooth low energy 4.0 as a communication link between device and the android smartphone application which reduces the power consumption. Using this device one can also keep an eye on the distance walked per day and amount of calories burnt during activity. Tracking calories consumption can help individual keeping their body fit.

Keywords: **Activity Monitoring System, pedometer, pedometer using accelerometer, smart monitoring, sleep monitoring, Wearable.**

INTRODUCTION

Walk and sleep plays an important role in quality of life, and is an important factor in staying healthy, active, and energetic. Inadequate and irregular sleeping patterns has a serious impact on our health, and can lead to many serious diseases like cardiovascular disease, diabetes, depression, and obesity [01]. While less walk and longtime idle sitting can create body pain. Activity monitoring systems are important to monitor daily

walking activity and to recognize sleeping disorders as early as possible for diagnosis and prompt treatment of disease. They can provide healthcare providers with quantitative data about irregularity in sleeping periods and durations. This information helps to find trends that correlate to certain diseases.

Activity monitoring is the monitoring of human's movement in any condition. Humans activity monitoring is the key to determine wellbeing of a human-being. With the enhancement and growth in electronics and its information systems, it is now possible to retrieve proper physiological information. It is also possible to share them with local or global information systems for the purpose of health monitoring system [02]. Number of prototypes of both wearable as well as implantable devices has emerged in the market to monitor activity [03].

With the increase in awareness in the health care department all over the world, everyone wants to monitor their activity 24x7 so that they can improve themselves every minute [02]. Every sportsperson will be wanting to monitor their fitness, activity, body intake and other parameters which will help them to boost up their performance and confidence too. The wearable device is the solution for them [04].

With growth of micro/Nano electronics, MEMS/NEMS, wireless sensors and actuators in the past few years, it is possible to increase the specifications of wearable device [05]. Gait activity monitor devices typically rely upon sensors placed on the ankle or shoe of a wearer to determine the distance covered by the wearer. Signals to provide real-time feedback to the wearer [04] as shown in fig 1.

In order to monitor such an activity, a wrist watch shaped wearable device is created with physiological sensor which monitors individual's wrist motion and displays the daily statistics on application installed android powered smartphone. The algorithm is also developed for computation of the duration of sleep.

Figure 1: Gait activity tracker wore on shoe

Source: Gait Activity Tracker [01]

Although sleep is a kind of brain activity and our sensor cannot directly measure it, the output of proposed algorithm is close to medically evaluated sleep quantity and quality. Section 2 describes the method of extracting the motion data acquired from motion sensor for counting steps during walk. Sections B describes the algorithm for sleep monitoring using motion sensor. Section C gives the hardware illustration of activity monitoring. The results obtained are illustrated in Section D.

B. Motion data acquisition for calculation of steps during walk

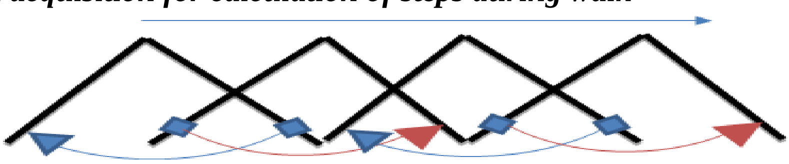
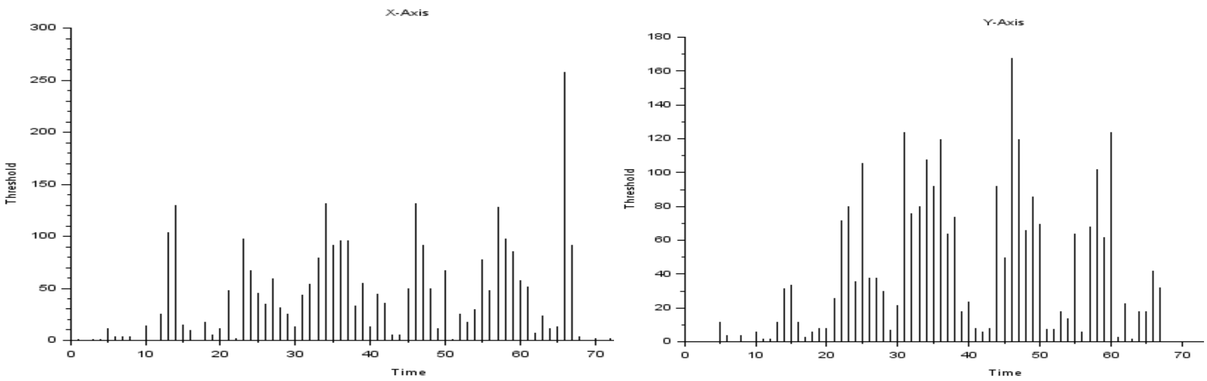


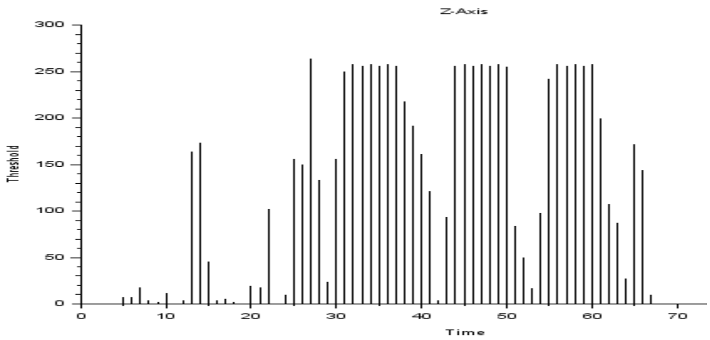
Figure 2: Motion of hand During walk

During walk, hand of individuals creates some oscillations as shown in the fig 2 to balance the body from falling down. This motion is consistent during walk which can be used for analysis of walking pattern. The number of steps walked during activity is obtained from the walking pattern analysis. This motion of hand of individuals can be obtained by the device by wearing it on the wrist with motion sensor.

Motion sensor can consist of multiple sensors like gyroscope and accelerometer which generates electrical signals in x, y and z direction on experiencing some motion as shown in the fig 3 (a), (b) and (c) respectively. However, these values cannot directly provide the required data. These motion data are required some signal processing to extract the useful data.



(a) & (b)



(c)

Figure 3: Sample values of (a) X, (b) Y and (c) Z axis of accelerometer

The motion data are tracked by 3 axis of accelerometer at every 180 milliseconds. The acquisition of 180ms is done because of multiple concerns like battery consumption and accuracy These acceleration values are raw values. Magnitude of motion is computed first as

$$M = \sum\sqrt{x^2 + y^2 + z^2} \quad \text{------} (1)$$

Where, M = Magnitude of Motion data

X = Motion data in the X-direction

Y = Motion data in the Y-direction

Z = Motion data in the Z-direction

Fig 4 shows the graph of magnitude of accelerometer sampled data. As seen in the fig 5 that we obtain some peak values. These values are the edge of oscillation. As we found the oscillation, now we check the threshold of motion. If the threshold is greater than 90 m/s^2, then it is considered as a step else it is discarded. Now we can obtain the number of steps walked by counting the number of oscillation. Further mathematical calculation can show the approximate amount of calories burnt and distance walked during the activity.

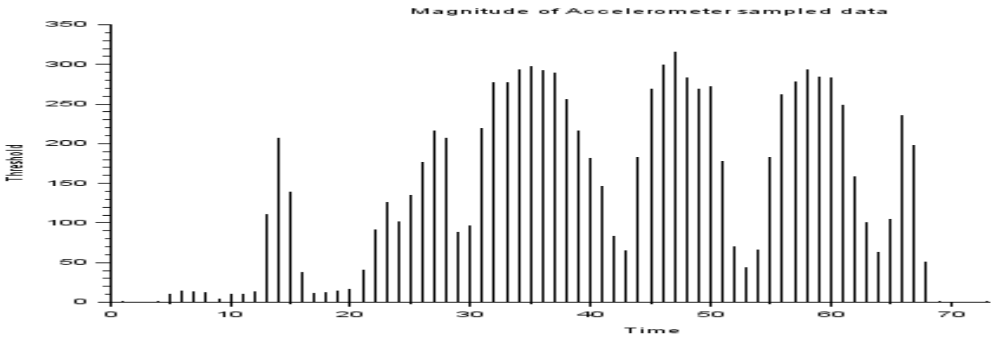


Figure 4: Magnitude of accelerometer sampled data

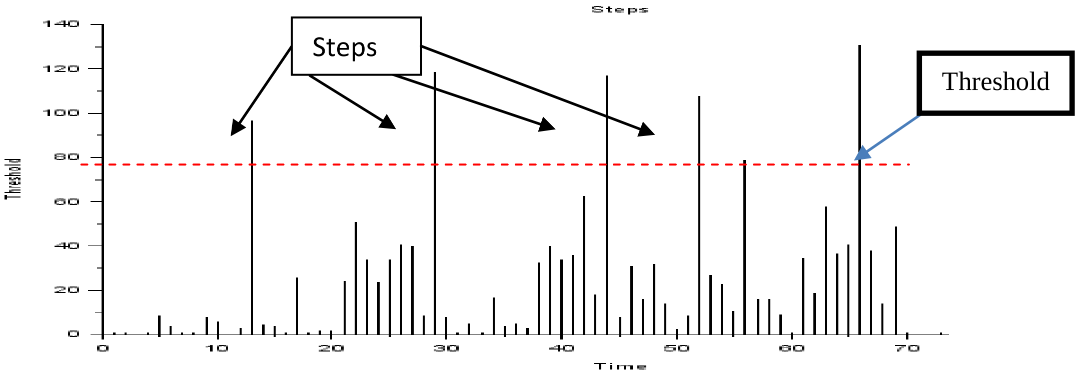


Figure 5: Step detected

Generally, the calories burnt per step [06] is equal to,

$$C = \frac{weight\ of\ individual\ (lbs)}{3500} \times (No.of\ steps\ walked) \quad \text{------} \quad (2)$$

However, the calorie burnt depends on type of walk and length of stride during walk which can be obtained from the same acceleration values as of walk as in equation 2 shown above. During running the amount of calories burnt is highest, while a bit low during jogging and lowest during general walk.

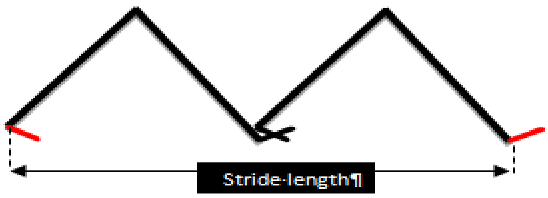


Figure 6: Stride length of a step

For calculation of distance walked, stride length is required. Stride length is the distance that the user walks per step [07] as shown in fig 6. For stride length user must manually input the number of steps occurred in 10 meters in the smartphone application. This data should be provided by the user for the first time use. This data can be updated later on user's demand. Using this value, the approximate distance walked is computed.

C. Algorithms for Sleep monitoring

The hypothesis for implementing the sleep algorithm is: The state of Sleep and Wake can be inferred from the amount of body movement during sleep. Deeper the sleep, lesser the body movement [08]. Proposed device monitors the motion during sleep and on the basis of that

 ISSN : 2394-1766

the duration of sleep is decided. Algorithm for monitoring sleep is similar as of pedometer. There are only two differences in monitoring walk and sleep, that are:

1) Pedometer uses accelerometer as sensor and
2) The threshold was high.

While in sleep monitoring we have used Gyroscope because of it very fast response. It can detect a motion with very small intensity [05] which is helpful in detecting very small motion occurring during sleep. Fig 7 shows the motion comparison of gyroscope and accelerometer.

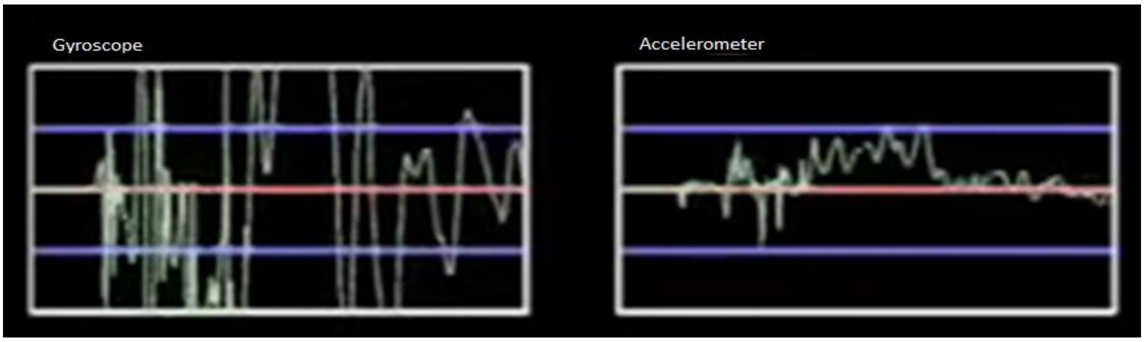


Figure 7: Gyroscope vs Accelerometer sensitivity

A very small acceleration results in very large change in gyroscope values. In pedometer the threshold was very high while in sleep the threshold is very low. This algorithm also detects the interruption and motion during sleep. If the motion is below the threshold of sleep then it is considered as sleep.

Before going to sleep user has to manually select sleep mode by pressing physical button on the device for better accuracy. Sampling of motion is done at a frequency of 1Hz i.e. at every 1 second. Sampling at 1 second also resolves the battery hunger problem.

D. Hardware for activity monitoring.

The proposed device monitors the activity of individual for 24x7 along with an android powered smartphone application [10]. The device runs on a single coin cell battery cr2032 and can run for 6 months uninterruptedly. To make device, CC2650STK Sensortag [09] is used which is provided by the Texas Instruments.

Sensortag is small in size with big features. Sensortag comprises of processor embedded with Bluetooth 4.0 low energy in a very small package and many on board sensors like barometer, humidity sensor, light sensor, motion sensor and temperature sensor. However, only the motion sensor MPU9250 is used in the proposed device for activity monitoring.

As discussed earlier that motion sensor comes with multiple axis sensor, this motion sensor mpu9250 comes with 9-axis motion sensor that are 3-axis of accelerometer, 3-axis of gyroscope and 3-axis of magnetometer.

At present, device is made up on a development board and looks like as shown in Fig 8. Afterwards it can be deployed on a chip and size can be reduced. Using this device, walking steps and duration of sleep can be monitored. The device keeps the log of activity for 30 days. To see the activity, the user need to sync the data on device with smartphone.

Figure 8: Picture of wearable device for activity monitoring

The fig 9 shows the screenshot of proposed android application. When the application is opened for first time, it prompts for data input that user need to feed. User can set daily goal for activity like the amount of calories to be burned per day, distance to be walked, or number of steps to be walked daily. User can change the goal by choosing the configuration option from the menu.

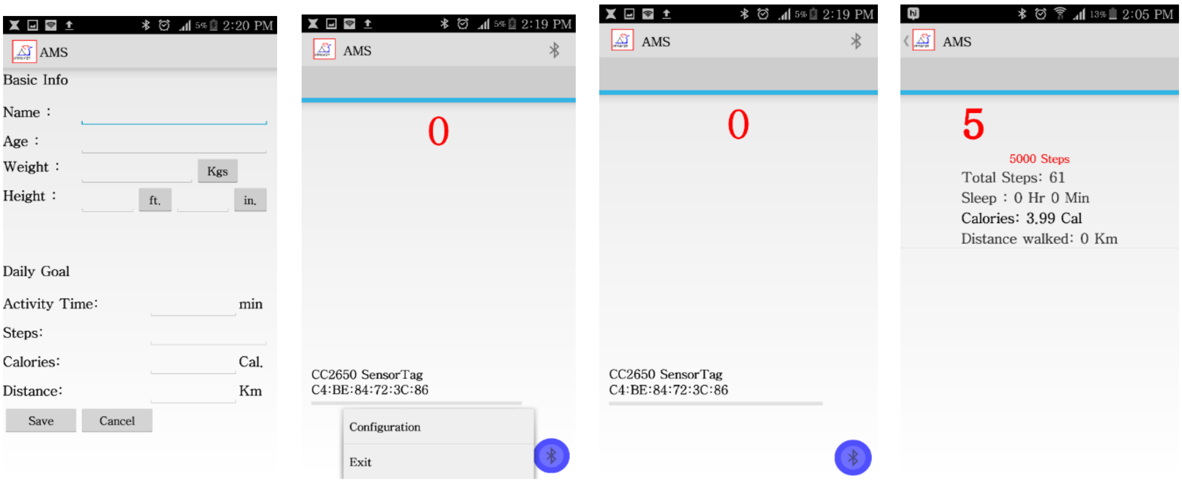


Figure 9: Android Application Layout Pages

To connect the device and app user need to turn on the smartphone's Bluetooth and press the blue button at bottom right provided in the GUI at homepage. Simultaneously the user need to advertise on the device by pressing the advertise button on the device. After the connection, the data is synchronized between the device and the android application.

CONCLUSION

- Proposed device is good enough for home purpose use as pedometer has an accuracy of 88% which is 8 % less accurate compared to device wore on ankle.
- It also achieved an accuracy of 79 % for monitoring sleep activity.
- Proposed android smartphone application is working flawlessly on various devices as verified on Gionee elife s5.5, HTC desire 516c and Samsung galaxy s4.

ACKNOWLEDGEMENT

Many people have cooperated in testing this proposed device. We appreciate for their cooperation. We thank to Dr. Mita Paunwala and Naitik Mehta for their support in completing this project successfully.

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