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Real Time Monitoring of Daily Calorie Expenditure Using Smart Phone

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***Abstract**— On a growing scale we use mobile phones for diverse activities in our daily life, such as entertainment, education or information purposes. The main objective of the project is to develop an android application to track the user physical activity and estimate his energy expenditure using 3axis accelerometer and GPS in a smart phone with android operating system. To implement this system, an android application was developed to collect accelerometer data, feature extraction, activity recognition and calorie estimation in android SDK. Here the users performed activities such as running, Cycling, walking etc by keeping the phone in the pants pocket and then are classified user activities on the basis of frequency component present in the acceleration data .The significance of this work is that, without any extra sensor this lets us to get useful information about the daily activity of users and their energy expenditure just by having them carry their smart phones in their pockets.*

***Keywords**— Physical Activity, Energy Expenditure, 3 axis accelerometer, smart phone, android, Fast Fourier Transform, android SDK*

I. INTRODUCTION

With the advancement in technology, mobile phones or smart phones are rapidly becoming the central computer and communication device in people's lives. Smart phones include many sensors such as cameras, microphones, light sensors, temperature sensors, acceleration sensors, GPS, orientation sensors, magnetic field sensors, pressure sensors, proximity sensors. The availability of these sensors will revolutionize many sectors of our economy including healthcare, social networks, environmental monitoring and transportation. This project explores the use of acceleration sensors, that is 3 axis accelerometer and GPS in the smart phones to detect the user physical activity such as walking, running and many more thus estimate the energy expenditure. It is an application implemented for smart phone with android operating system, which is open-source, easy to implement and expected to become dominant OS in the smart phone market.

The need of this project is increasing now a days because today's way of life involves less physically activity. People travel on car and bus, rather than walking, and many people work in offices, where they are sitting still for most of the day. This means that the calories they eat are not getting burnt off as energy and Instead, the extra calories are stored as fat, which is not good for health. Moreover, eating excess calories leads to weight gain Therefore by monitoring their daily energy expenditure, they can balance their weight against food intake. There are many off the shelf solutions available today to measure energy expenditure such as indirect calorimeter, doubly labeled water (DLW), pedometers, heart rate monitors. However, most of these solutions have limitations when it comes to accuracy, system integration, and user feedback.

Physical activity(PA) is defined as any bodily movement produced by skeletal muscles that requires energy expenditure (EE).However PA and EE are not synonymous.PA is a form of behavior, where EE is an outcome of that behavior.PA is quantified in terms of intensity, frequency and duration, whereas EE is measured as energy cost of a given form of PA or as the energy cost associated with PA performed for a specified period of time. Physical activity not only include sports, but also includes non-sports activity such as working, household chores leisure activities, which can all be expressed as total energy expenditure.

The main objective of the project is to develop an android application to track the user physical activity and estimate his energy expenditure using 3axis accelerometer in a smart phone with android operating system. To implement this system, we collected the accelerometer data from different users as they performed activities like walking and running by wearing the phone in the pants pocket and then classified the user activities on the basics of frequency component present in the acceleration data. The algorithm used for activity classification is Fast Fourier Transform (FFT). Also an application was developed to estimate the energy expenditure in Android SDK during a period of 24 hours.

In this project, a real time system to monitor the daily energy expenditure of a person was implemented using 3 axis accelerometer in a smartphone. To implement this system, we have to develop android application to collect accelerometer data, activity recognition and calorie estimation in android Software Development Kit(SDK). Here the user activity is recognized using FFT algorithm, ie, on the basis of frequency component present in the acceleration data.

Based on the recognized activity, we can find the Metabolic Equivalent (METS) value and thus estimate calorie consumption based on the METS conversion method.

The hardware used for this project is a smartphone with android operating system version 4.03, to be precise the device is Samsung Xperia J. It consists of an inbuilt 3 axis accelerometer and GPS which we used in this project. The software required for the development of applications is android Software Development Kit(SDK).The Android SDK provides the tools and APIs necessary to begin developing applications on the Android platform using the Java programming language. Android SDK is a plug-in that has been installed into Eclipse Integrated Development Environment (IDE).

II. BLOCK DIAGRAM

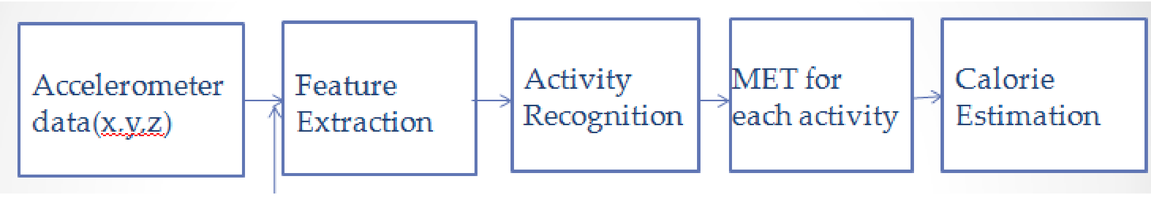

Fig 1: Block Dig

III. BLOCK DIAGRAM DESCRIPTION

1.Accelerometer Data

The device used in this project is Sony Xperia J .In order to collect data, we created an application for the device using android SDK. This application accesses the hardware components via hardware package provided by Android SDK. The training data was collected by having users perform an instructed task (eg: walking, running,) while the data along with corresponding timestamp is written to the SD card . For hardware implementation, 256 samples of accelerometer data was collected in a buffer. For this application, SENSOR_DELAY_ FASTEST with an update frequency of 10ms was used. In order to implement this we need 4 different layers: Sensor Listener Layer, Sensor Manager Layer, User Interface Layer, and Functionality Layer.

Sensor listener layer: It is the interface between the software developed and the API layer for sensors provided by Android. This will trigger the events such as change in acceleration or shake events.

Sensor manager layer: This layer provides access the sensors embedded into a smart phone. It controls all the activity.

User interface layer: This is for interaction between a human and an application.

Functionality layer: It contains methods that create a new thread of execution to run common tasks such as acquiring data, processing the data.

2.Feature Extraction

Feature Extraction was the process used to extract the key elements from a processed signal which made the signal distinct. Here, the data captured is in time domain. The magnitude of acceleration varies with the pace of the activity and is different for different users. So here, the extracting feature is frequency since the frequency ranges does not vary much with users. The fundamental frequency of a signal is obtained by performing Fast Fourier Transform (FFT) on a signal.
The formula for calculating FFT is given below:

$$X(k) = \sum_{n=0}^{N-1} x(n).\, e^{-jk\pi n/N} \qquad 0 \le k \le (N-1)$$

3.Activity Recognition

After collecting data and extracting some features from these data by applying mathematical operations mentioned in feature extraction section, we developed a classification algorithm for activity recognition.

4.Metabolic Equivalent (MET) for each activity:

A unit of metabolic equivalent, or MET, is defined as the ratio of a person's working metabolic rate relative to the resting metabolic rate. METS values correlate with oxygen requirements. Starting with 1, which is the least amount of activity (such as resting), the values increase with the amount of activity. Here the calories are estimated based on metabolic equivalent (METS) conversion method. For each activity, there is a corresponding MET value.

TABLE I

CONTEXT	METS
IDLE	0.9
WALK	0.272*WALKING SPEED(M/MIN)+1.2
RUN	0.93*RUNNING SPEED(M/MIN)-4.7

METS VALUES AND USER CONTEXT

5.Calorie Estimation

Based on this METS value ,we can estimate the energy:

Energy(kcal)=1.05×METS×Weight(kg)×Exercisetime(hr)

Total energy expenditure (TEE) is also estimated. It is the addition of calories burned due to each activity. After offline implementation, hardware implementation was done.

IV. ALGORITHIM

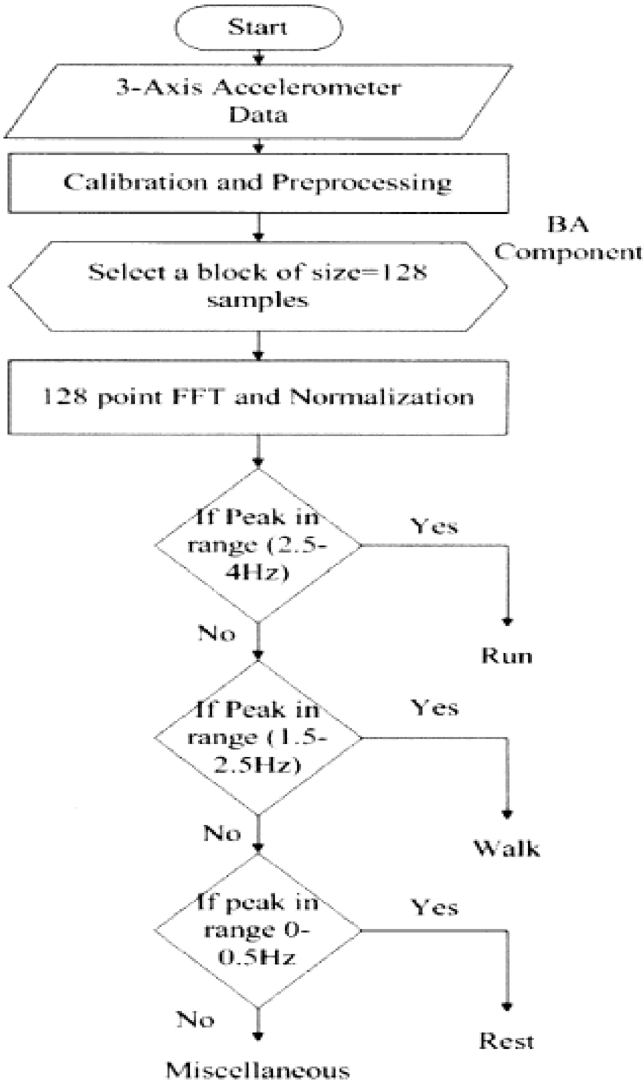

Fig .2:Algorithim Flow Chat

V. SOFTWARE REQUIREMENTS

The software required for the development of an application in android device is Software Development Kit (SDK). The Android SDK provides tools and the APIs necessary to begin developing applications on the Android platform using the Java programming language. Android software development kit (SDK) is a plug-in that has been installed into Eclipse IDE. The SDK includes a comprehensive set of development tools such as debugger, libraries, handset emulator, documentations, a sample code, and tutorial.

VI. HARDWARE REQUIREMENTS

The hardware required for this project is a smartphone with android platform .Here the device used is Sony Xperia J. The android smartphone consists of many sensors such as cameras, microphones, light sensors, temperature sensors, acceleration sensors, GPS, orientation sensors, magnetic field sensors, pressure sensors, proximity sensors. This project explores the use of acceleration sensors ,that is 3 axis accelerometer in the smart phones.

1.THREE AXIS ACCELEROMETER

To monitor physical activity, the body movements need to be detected using the accelerometer. For that, the accelerometer was used. The accelerometer in Android phones measures the acceleration of the device on the x (lateral), y (longitudinal), and z (vertical) axes and is shown in Fig 4.2. The data received from the accelerometer in smartphone was in the form of three-valued vector of floating point numbers that represented the individual accelerations of the smartphone device in the X, Y, and Z axes subtracted by the gravity vector G. The acceleration values were recorded in meters per second square(m/s2). The expected reading of accelerometer would be approximately [0,0,9.81] when it was placed on a flat surface.

X-axis (lateral): Sideways acceleration (left to right) for which positive values represent the movements to the right whereas negative ones represent to the left.

Y-axis (longitudinal): Forward and backward acceleration for which positive values represent forward whereas negative values represent backward.

Z-axis (vertical): Upward or downward acceleration for which positive represents movements such as the device being lifted.

Commonly used accelerometer in smart phones is Bosch BMA220.

5.1.1 BMA 220

The BMA220 is an ultra small triaxial, which is aiming for low power consumer market applications, is low-g acceleration sensor with digital interfaces . It uses for measurement of accelerations in 3 perpendicular axes and thus senses vibration in cell phones, tilt, motion, shock and handhelds, computer peripherals, game controllers, virtual reality features and man-machine interfaces. Its features are shown in Table 4. 2.

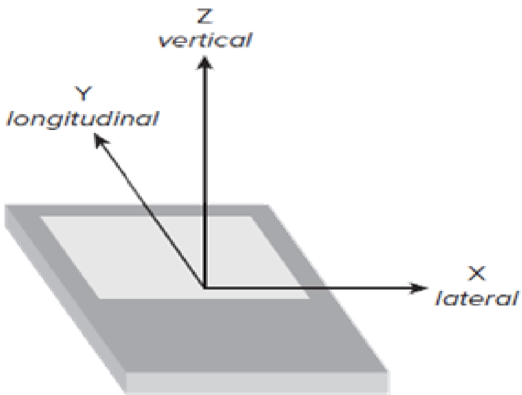

Fig 3: Acceleration Axes

Sampling frequency and accuracy of sensors

Android SDK allows to setup accuracy of the accelerometer with sensor manager. The sensor manager has provision for sampling the data at 4 different frequencies. They are Delay Fastest, Delay Game, Delay Normal and Delay User Interface. The actual physical sampling capabilities of the accelerometers likely vary from device to device, so these sampling rate options are used more as guidelines than as actual physical sampling rates. The four sampling frequency for Sony Xperia J is given below:

SENSOR_DELAY_NORMAL = (4-5) Hz

SENSOR_DELAY_UI = (8-9) Hz

SENSOR_DELAY_GAME = (16-17) Hz

SENSOR_DELAY_FASTEST = (99-100) Hz

VII.**RESULTS**

The system was first simulated in AVD(Android Virtual Device Manager) and later implemented on Hardware.

1 CALORIE ESTIMATION

User	Weight (Kg)	Context	Speed (km/hr)	METS	Time (min)	Energy (kcal)
1	45	WALK RUN	4.02 5.28	2.8 3.8	1 1	2.65 2.95
2	54	WALK RUN	3.48 7.3	2.7 4.5	1 1	2.55 6.51
3	60	WALK RUN	5.7 7.8	3.8 7.39	1 1	3.99 7.75
4	63	WALK RUN	3.6 5.28	3 4.1	1 1	3.23 5.73
5	74	WALK RUN	4.08 5.1	2.9 3.9	1 1	3.71 4.98

Tab 1:Result Data of 5 person

The test were conducted on five persons by wearing the smartphone in their pants pocket and collected 20 samples of data from these users and out of which 19 samples gives the correct result. The data were collected for the activities walking and running.

2 HARDWARE IMPLEMENTATION

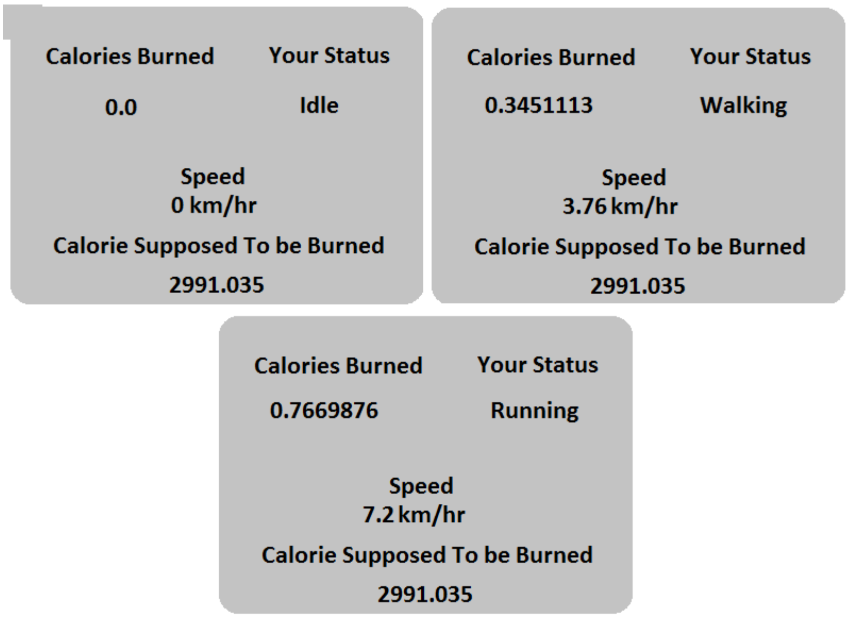

Fig 4:Hardware Screen Shot For Different Activities

To implement this system in smartphone, an android application was developed to collect accelerometer data, activity recognition and calorie estimation in android SDK. The .apk file is installed in the phone. Fig 6.1 shows the screen shot of the application. It contains welcome screen, registration form, registration summary, and different status of user with calories burned.

VIII.**CONCLUSION**

Here a real time system for monitoring daily calorie expenditure of a person is designed using smartphone. This system will be very useful for the people who are suffering from cardiovascular disease, obesity, type 2 diabetic's mellitus to balance their dietary intake and calories burned. Here the tests were conducted by keeping smart phones in pants pocket.

ACKNOWLEDGMENT

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The need of this project is increasing now a days because today's way of life involves less physically activity. People travel on buses and cars, rather than walking, and many people work in offices, where they are sitting still for most of the day. This means that the calories they eat are not getting burnt off as energy. Instead, the extra calories are stored as fat. Moreover, eating excess calories leads to weight gain Therefore by monitoring their daily energy expenditure, they can balance their weight against food intake.

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