Volume : 3 | Issue : 5 | May 2014 • ISSN No 2277 - 8179

Designing a Fitness Tracker

Engineering

KEYWORDS : fitness, wearable, pedometer, actigraphy, pulse oximetry, integrated website

Ms.Mirabel James	Electrical department: Electronics & Telecommunication engineering, Veermata Jijabai Technological Institute (VJTI), B.Tech student (Final year)
Ms.SanikaMhaiskar	Electrical department: Electronics & Telecommunication engineering, Veermata Jijabai Technological Institute (VJTI), B.Tech student (Final year)
Ms.AnaghaChaudhary	Electrical department: Electronics & Telecommunication engineering, Veermata Jijabai Technological Institute (VJTI), B.Tech student (Final year)
Ms.PriyaSahani	Electrical department: Electronics & Telecommunication engineering, Veermata Jijabai Technological Institute (VJTI), B.Tech student (Final year)
Ms.HarshaliTalele	Electrical department: Electronics & Telecommunication engineering, Veermata Jijabai Technological Institute (VJTI), B.Tech student (Final year)
Ms.NitaKamble	Electrical department: Electronics & Telecommunication engineering, Veermata Jijabai Technological Institute (VJTI), B.Tech student (Final year)
Mr.RajeshPatil	Electrical department: Electronics engineering, Veermata Jijabai Technological Institute (VJTI), Associate Professor, VJTI, VJTI, H.R.MahajaniMarg, Matunga East, Mumbai

ABSTRACT

In today's digital age, the information and data revolving around us all the time is voluminous but important matters such as our personal health are not given its due importance. Accurate data on whether your body is functioning properly is important information we must receive periodically. To be healthier and fitter the knowledge of your own health is of paramount importance. Lots of research was done, which proves that keeping track of what we do and improving on it by suitable healthcare programs and processes can significantly improve our health and wellbeing. Self-tracking can actually make us follow a healthier diet, better sleep pattern and following a suitable workout / exercise program simply by letting us know the areas we need to improve on. However there is plenty of room for human error in manual recordings. Per contra the Fitness trackers provide this feedback in real time, capturing all the necessary details and then syncing up to deliver a clear picture of your health electronically at the touch of a finger. Several sensors are configured to be attached to a person's torso which will help in measuring a battery of bodily parameters.

INTRODUCTION

Motivation

The world renowned J.F. Kennedy said, "Physical fitness is not only one of the most important keys to a healthy body, it is the basis of dynamic and creative intellectual activity." This clearly shows us the importance of physical fitness. However, if in the past you have been maintaining a sedentary lifestyle (and maintain unhealthy eating habits), you are doing injustice to yourself. Therefore, to keep yourself physically fit, you not only need to have a proper diet, but follow a proper exercise regimen too.

Primary Components of Fitness

1. Cardiorespiratory capacity
The ability of the body to take in oxygen (respiration), deliver it to the cells (circulation) and use it at the cellular level to create energy (bioenergetics) for physical work (activity).

2. Muscular capacity
Spectrum of muscular capability

3. Flexibility
Range of movement or amount of motion that a joint is capable of performing

4. Body composition
The proportion of fat-free mass (muscle, bone, blood, organs, and fluids) to fat mass (adipose tissue deposited under the skin and around organs)

Objectives

While no technology will ever replace diet and exercise, a new class of gadgets can provide key insight into your physical well-being. Known by a litany of terms—fitness trackers, health monitors, activity trackers / wearables. They form a battery of tech toys which share a common goal, to get you into better shape.

The other most important thing is how to get the information that's on the tracker. The fitness tracker has a screen. It can't give you the most granular info, but on built-in screen it can tell you how many steps you've taken, floors you've climbed, and calories you've burned so you will know how are you faring in real time.

It is believed by medical professionals that being aware of your current daily fitness levels will encourage you to make healthy changes to your life. For example, instead of vying for a front row parking spot at the Church / Temple, more people will park further away from the entrance and walk or will take the stairs instead of using the elevator.

METHODOLOGY

The wearable device measures the following:

- Heart rate
- Steps taken
  - o Normal walking
  - o Up Hill / stairs climbing
- Calorie expenditure
- Body temperature
- Sleep efficiency
- Haemoglobin levels

1. Heart Rate
For a non-invasive method, we can use one of three ways:
a) Optical method (Infrared LED and sensor)
b) Force Sensing Resistor (FSR) and

c) Piezoelectric sensor

Among these the piezoelectric sensor made up of pressure sensing ceramic material was chosen because:-
1) Piezoelectric material can sense the pressure more accurately and over a wider range, where as FSR being very delicate, is useful only to measure very light pressure changes and it may easily get damaged.

2) Piezoelectric material is handy, whereas attaching infrared LED and sensor may not be comfortable as a fitness tracking device is intended for daily use.

Algorithm:
1. Heart rate is measured by performing follow
ing operations on the output voltage from piezo :-

a. Analog Filter and Amplifier
Input signal is amplified using a 7th order low pass filter with an amplification of 10^7.

b. Dynamic Threshold
The system continuously updates the maximum and minimum values of the signal in every 50 samples. The average value (Max + Min) /2 is called the dynamic threshold level. For the following 50 samples, this threshold level is used to calculate heart beats. In addition to dynamic threshold, dynamic precision also used for filtering.

A heart beat will be considered if there is a negative slope of signal plot when the curve crosses below dynamic threshold.

2. The heart rate is given by:-
Heart rate = (Beats /sec)*60

2. Steps taken (similar to pedometer)
It is implemented using ADXL 345. During natural walking, at least one axis of accelerometer will have relatively large periodic acceleration changes, no matter how the pedometer is worn, so peak detection and a dynamic threshold-decision algorithm for acceleration on all three axes are essential for detecting a unit cycle of walking or running.

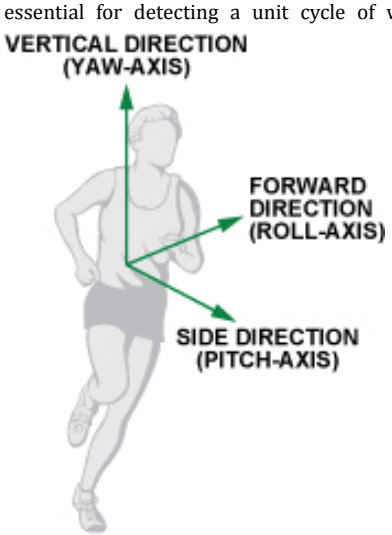

Figure 1: Direction of each axis.
Source: http://www.analog.com/library/analogdialogue/archives/44-06/pedometer.html

Algorithm
1. Steps taken are measured by performing the following operations on the accelerometer data:

a. Digital Filter:
The filter smoothens the signals using averaging technique

b. Dynamic Threshold:
The system continuously updates the maximum and minimum values of the 3-axis acceleration after every 50 samples. The average value, (Max + Min)/2, is called the dynamic threshold level. For the following 50 samples, this threshold level is used to decide whether steps have been taken. In addition to dynamic threshold, dynamic precision is also used for further filtering. A linear-shift-register and the dynamic threshold are used to decide whether an effective step has been taken. The linear shift-register has two registers, a new sample register and an old sample register. The data in these are called new sample and old sample, respectively. When a new data sample comes, new sample is shifted to the old sample register unconditionally. However, whether the result will be shifted into the new sample register depends the changes in acceleration being greater than a predefined precision otherwise no shifting occurs. The shift register group can remove the high-frequency noise and make the decision more precise.

A step will be defined as occurring if there is a negative slope of the acceleration plot (new < old) when the acceleration curve crosses below the dynamic threshold.

c. Peak Detection:
The step counter calculates the steps from the x-axis, y-axis, or z-axis, depending on which axis's acceleration change is the largest one. If the changes in acceleration are too small, the step counter will be discarded. Time window is used to discard the invalid vibrations. We assume that people can run as rapidly as five steps per second and walk as slowly as one step in every two seconds.
2. The distance is calculated by the formula:
Distance = number of steps × distance per step
Distance per step depends on the speed and the height of user. So, we use the steps counted in every two seconds to judge the current stride length.
3. The walking speed is given by:
Speed = steps per 2 s × stride/2 s

3. Calorie expenditure measurement
Calories are not bad in totality. Our body needs calories for energy however eating too many calories — and not burning enough of them off through activity — can lead to weight issues.

All foods and drinks contain calories, for example foods such as lettuce, contain few calories (1 cup of shredded lettuce has less than 10 calories). Whereas, ½ cup of peanuts has 427 calories.

Having a look at the nutrition facts label, we can find out the calories along with the components present, carbohydrate, protein, fat etc.

1 gram of each contains:
- carbohydrate — 4 calories
- protein — 4 calories
- fat — 9 calories

Our algorithm estimates calories expended using an approximation:
Calories (C/kg/h) = 4.5 × speed (m/s)

4. Body temperature measurement
Temperature is measured using IC LM35 whose analog output is proportional to the body temperature and needs no additional processing.

5. Sleep efficiency
Actigraphy approach will be adopted using an accelerometer sensor. The same device will be used with accelerometers active but placed under one's pillow. Relevant data will be extracted and processed using a microcontroller.

The sensor captures the intensity of user's activity throughout the night. As the user becomes more active, the intensity of activity increases, producing easily detectable peaks, indicating the lightest sleep throughout the night. Activity above a cer-

tain level indicates full awakening, such as getting out of bed. Doublingitasabio-sensoralarm,itwillfindtheoptimaltimetowake you up during a 30 minute window that ends at your set alarm time.

As you sleep you go through different phases, ranging from deep sleep to light sleep. The phase you are in when your alarm goes off is critical for how tired you will feel when you wake up.

This product wakes you when you are in your lightest sleep phase which means you feel refreshed.

6. Haemoglobin level measurement
Pulse oximetry is a non-invasive measurement of the oxygen saturation (SpO2). Oxygen saturation can be defined as the measurement of the amount of oxygen dissolved in blood, based on the detection of Haemoglobin and De-oxy haemoglobin.

Two different light wavelengths are used to measure the actual difference in the absorption spectra of HbO2 and Hb. The bloodstream is affected by the concentration of HbO2 and Hb, and their absorption coefficients are measured using two wavelengths 660 nm (red light) and 940 nm (infrared light). De-oxygenated and oxygenated haemoglobin absorb different wavelengths. De-oxygenated haemoglobin (Hb) has a higher absorption at 660 nm and oxygenated haemoglobin (HbO2) has a higher absorption at 940 nm.

7.Integrated website
Wanting to know how far you have come in the fitness training efforts is natural, as it helps to keep up the motivation levels.

An exclusive website can be made to track progress. This can help in keeping a record of the statistics, generate reports and present graphics. Streaming of your daily activities can be made possible by syncing the device's readings. Contextualized with pretty graphics and minute details about your body, it will break everything down to the minute and you can compare your heart rate versus calories burned etc. for instance, or any variation of the aforementioned and that too, over a period of time. This is facilitated by maintaining a log of your activities. A social twist can be added to the exercise routine. Get extra encouragement, cheer on your buddies or start a little friendly competition through the website.

CONCLUSIONS
When anyone starts an exercise routine, it is extremely important to set realistic goals that are achievable. Moving from a totally sedentary lifestyle to ultimate fitness in four weeks is not a realistic plan for most of us. A fitness tracker helps us set and achieve reasonable goals according to tested time frames, so that we don't get demotivated quickly and quit halfway through the process. Additionally, the measurements are performed with a body-worn monitor that is comfortable, lightweight, and low-profile, making it particularly well suited for people who are moving about.

The user has the following benefits from Fitness Tracker:

a. Motivation
b. Accountability
c. Planning
d. Consistency
e. Online Fitness Tracking

REFERENCE

[1]Muhammad Atif, SerkanSerdaroğlu (2011), "A Measurement System for Human Movement Analysis". | [2]Neil Zhao (June 2010), Analog Dialogue, Volume 44. | [3]Ian Lloyd (May 2006), Build Your Own Website The Right Way Using HTML & CSS, Sitepoint. | [4] Atmel, "Atmega328 microcontroller," http://www.atmel.com/devices/atmega328.aspx. | [5]Harvard Health Publications (September 2009), Harvard Health letter. | [6]Shalima Mehta, Jaspal Singh (2013), Indicating Human Activity Intensity using Accelerometer, Journal of Electronic Design Technology, Volume 4, Issue 2. | [7] A. Ribeiro, C. Fernandes, D. Salvado, L. Lacerda, M. Costa, R. Henriques, G. Evans, P. Almeida and H. A. Ferreira (November 2011),Combined use of electrocardiography and accelerometry to evaluate the physical condition of a subject. | [8] SanoritaDey, Nirupam Roy, WenyuanXu, Romit Roy Choudhury and SrihariNelakuditi (February 2014), AccelPrint: Imperfections of Accelerometers Make Smartphones Trackable. | [9] ADXL Digital accelerometer (2009-2013), Analog devices (datasheet) | [10] "Arduinounosetup," http://www.arduino.cc/en/Main/ArduinoBoardUno/. | [11]Texas Instruments (May 2013),Low-Power Pedometer Using an MSP430™ MCU, Application report. |