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Analysis and Design of Calories Burning Calculation in Jogging Using Thresholding Based Accelerometer Sensor

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***Abstract*-Jogging has many benefits, and one of them is to lose weight. Calories burned while jogging cause weight loss 90% more than just walking alone. The fact that often happens is that someone is exercising by forcing his body that has passed his normal threshold. This results in over or lower combustion in that person. To overcome these problems, we need a device that can later monitor calorie burning. This calorie burn uses an accelerometer sensor that works based on the pressure from the load received, so that this sensor can count the number of steps someone previously obtained by the thresholding value as a step-determining threshold value. The design of this calorie burning calculation application uses a formula that involves the number of foot steps, time, and weight of the user. It is hoped that this application can provide sportsmen with information on calorie burning in jogging.**

Keywords: Accelerometer Sensor,Thresholding, calorie burning, jogging

I. INTRODUCTION

The paradigm that is very often encountered by the general public that exercising continuously will make someone get the ideal body weight and body shape. This is especially true for people who are obese or overweight. A person is considered to have a tendency to be obese based on his Body Mass Index (BMI). One of the most common sports performed to get the ideal body weight is jogging. Jogging is a sport that is very effective in burning fat or calories in the body. High-intensity exercise such as jogging will stimulate the process of burning more fat than low-intensity exercise. Even if comparing jogging with walking in the same distance, jogging will trigger greater weight loss. This is due to energy expenditure in a state of still body still increasing after running. Calories burned while running cause 90% more weight loss than just walking alone. Because jogging is a very effective sport, an athlete must monitor the calorie burning in his body.

But in reality, sportsmen tend to exercise without measuring the amount of calorie burning during exercise. Though this is very important, because an athlete must necessarily know how many calories there are in his body and what is the ideal number of calories for his body. But the fact that often happens is that a person exercises with his body that has exceeded its normal limits, even though the calorie content in the body is also very necessary. Of course this is very fatal to the person since this can cause over or lower combustion.

To overcome these problems, we need a device that can later monitor a sport, especially smartphone-based jogging. The use of smartphones in the world of sports can also be used to measure movement changes that occur by utilizing the sensors contained in the smartphone. On a smartphone there are several sensors, namely the accelerometer sensor, gyroscope sensor and magnetometer sensor. All of these sensors work together in building an application that can help human needs. With the help of an accelerometer sensor that works based on the pressure from the load received, this sensor can count the number of steps a person has.

In previous research, Dwi (2013) developed a smartphone device using GPS (Global Positioning System) to measure calorie burning [1]. However, this research has not described in more detail about the accuracy of the use of these devices. In addition, Rahman (2017) is known in his research that the detection of steps on android smartphones using the accelerometer sensor is still limited by the Dead Reckoning method [2]. Therefore, researchers are interested in developing an Android-based calorie burning monitoring device with an accelerometer sensor that uses tresholding in counting the number of steps a person has to avoid over or lower combustion.

Based on the problems that have been described previously, the authors are interested in applying the use of thresholding-based accelerometer sensors to calculate calorie burning in an Android-based jogging exercise.

II. LITERATURE REVIEW

2.1 Body Mass Index (BMI)

Body mass index (BMI) is a calculation value between a person's body weight (BW) and body height (BH). BMI correlates directly with measurements of body fat such as underwater weighing and dual energy x-ray absorbtiometry. To find out the value of this BMI, the following formula is used.

$$BMI = \frac{Body\ Weight\ (kg)}{Body\ Height(m)\ x\ BodyHeight\ (m)}$$

2.2 Calculation of Calorie Burning

Basal Metabolic Rate (BMR) is the number of daily calories body needs to survive and perform physical activity. To carry out its functions, all internal organs of the human body burn calories. An average of 60-70% of the total calories is spent a day. To reduce 1 kg of body fat, it requires a calorie deficit of around 7200 kcals. After knowing the obese BMI, it can be seen how many kg of fat must be reduced, so it can also be known how many calories that must be present and must be burned in the body.

For every sport movement, the MET (metabolic equivalent of task) value is sought,which is the estimated number of calories burned while doing sports activities within a certain time.And then it is compared with the estimated body muscle mass volume. In addition to finding calories burned while exercising, we can also use the same calculation to calculate how many calories are burned for daily activities. The basic formula is as follows:

$$EC = \left\{ METx\ 7.7\ x \frac{(BWx\ 2.2)}{200} \right\} x \frac{Duration}{60}$$

Explanation:

$EC = ExerciseCalories, the\ result\ of\ calories\ burning\ calculation$

$MET = MetabolicEquivalent\ of\ Task, estimated\ calories\ that\ are\ burnt\ while\ doing\ certain\ sport.$ $(MET\ Value\ for\ jogging\ is\ 2.8\ according\ to\ Indonesia\ Sport\ Nutritionist\ Association\ (ISNA))$

$BW = Body\ Weight(kg)$

$Duration = Time\ needed\ for\ doing\ sport\ (in\ second)$

2.3 Accelerometer Sensor and Threshold Magnitude

An accelerometer sensor is a device for measuring acceleration. Accelerometers are currently electromechanical devices that can measure static and linear/dynamic acceleration. By utilizing static acceleration, the accelerometer sensor can be used to detect the tilt in the form of the angular values of the X, Y, and Z axes. These angular values are converted in the form of a waveform graph to easily determine the upper and lower threshold at an angle that forms the wave value. Of the three acceleration values is taken one of the axes, then the threshold value is determinedfor the upper and lower limits or can also be called the threshold above and below threshold. When conducting a trial run, the X-axis reads data from the foot movements.If the upper and lower threshold values correspond to the specified threshold, a foot step is detected. Then when walking, the resulting steps are multiplied by the average width of the foot when walking to calculate distance. The size of the footsteps alone is 78cm on average or is assumed to be a human step along the 0.7m. To calculate the number of calories burning, it needs the number of steps, time taken, and initial body weight.

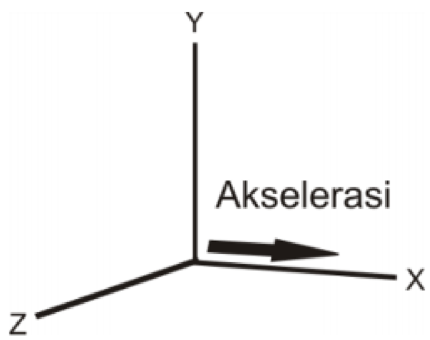

Figure 1. Accelerometer Axis

Threshold Magnitude is the easiest way to detect footsteps in jogging. With this, the value of acceleration in each phase or condition of a person when walking can be seen, and then compare it with a predetermined threshold value (Ω), which can be explained as follows.

1. The accelerometer used in this study measures the acceleration values in three axes, namely the x, y, and z axes, each of which is symbolized in Ax, Ay, and Az. Of the three acceleration values, the magnitude value can be found
2. When the accelerometer is mounted on the foot, it can be known the pattern of the output signal when someone walks. The value of the output magnitude displayed by the accelerometer is also influenced by the value of the acceleration due to gravity, where the value of the output magnitude from the accelerometer reading shows the stepping magnitude of the foot. When the foot is in the stance phase, the foot acceleration is zero (0). Ideally, the value of magnitude is equal to the acceleration of gravity when the foot is in the stance phase
3. A person experiences a stepping process when there is a phase shift from the stance to the swing phase. So, someone's footsteps can be detected if there is a change in the value of A = 1.

The system will be given a threshold which is obtained from experiments and analysis conducted previously that refer to the value of the accelerometer sensor on footsteps. After the threshold value is known, the threshold becomes a reference to know the foot step.

If when the foot step counter is mounted to the user's foot and the accelerometer sensor value exceeds the threshold, the system will count as a foot step (value 1). If the accelerometer sensor value is less than the threshold, the system will recognize that the user is not stepping (value 0).

III. RESEARCH METHOD

3.1 Prototyping

Prototyping is one approach in software design engineering that directly demonstrates how in the future to build a system that will work in its environment before the actual construction stage is carried out. The following are the stages of the Development Process in the Prototype Model, namely:

1. Collection of needs, including identifying allneeds and outline of the system to be made.
2. Building prototyping, namely by making temporary designs that focus on needs (for example by making input and output formats).
3. Evaluation of prototyping, carried out by the customer, whether the prototyping that has been built is in accordance with the wishes of the customer or not. If it is suitable, then the next step will be taken. But if not, prototyping is revised by repeating the previous steps.
4. System encoding. At this stage the system is in progress.
5. Test the system, after the system has become a ready-made software, then the Testing process is carried out. This test is done by White Box and Black Box.
6. System Evaluation, this stage is carried out to see whether the ready-made software matches what is expected
7. Using the system, this final step is done after the software is tested and accepted by the customer ready for use.

3.2 Proposed Design

3.2.1 Use Case Diagram

Use Case Diagram illustrates how users interact with the system to be created. In this application, the user in this case a sportsman, can do 4 interactions including: Login, Use the Jogging Application, See the result of burning calories and Look at health articles. More details can be seen in Figure 2 below.

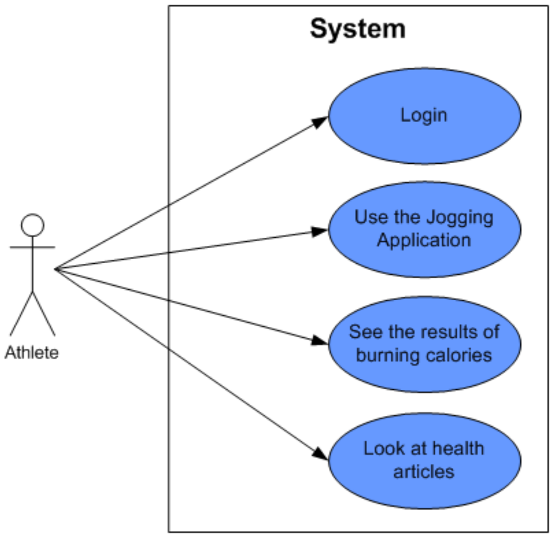

Figure 2. Use Case Diagram

3.2.2 State Chart Diagram

The following is a state diagram for designing a calorie-burning system application for athletes as shown in Figure 3.

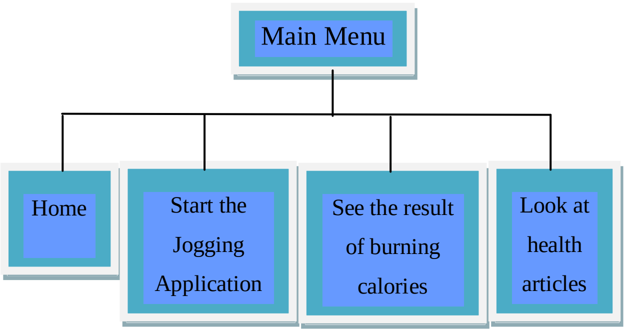

Figure 3. State Chart Diagram

3.2.3 Activity Diagram

In this modeling, activity diagrams can be used to explain business and operational workflows in step-by-step in terms of the components of a system. Activity diagram shows the overall flow of control. Here is the activity diagram of the calorie burning calculation application that was built.

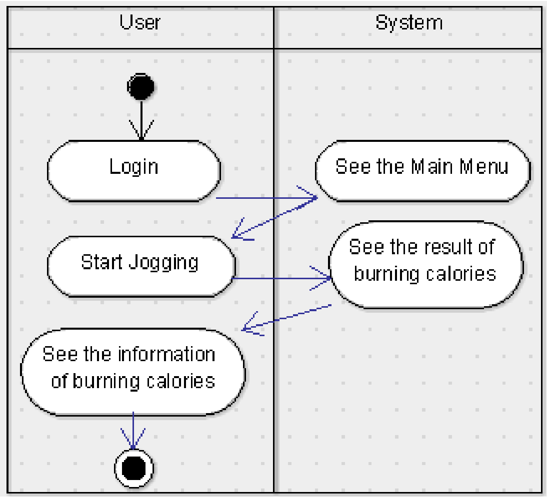

Figure 4. Diagram Activity of Calorie Burning Information

3.2.4 Application Flowchart

In the application process, the android smartphone must be placed in a moving body part when jogging, in this case the smartphone can be placed in a pants pocket or skirt. Then the user inputs the amount of weight and height. Furthermore, the sensor starts reading the data. If the accelerometer sensor value exceeds the threshold, the system will count as a foot step, and if there is footprint detection data, the application will renew the display of the number of steps and then calculate the distance. And at the same time the application will display the amount of calorie burning that occurs during jogging at a certain time period.

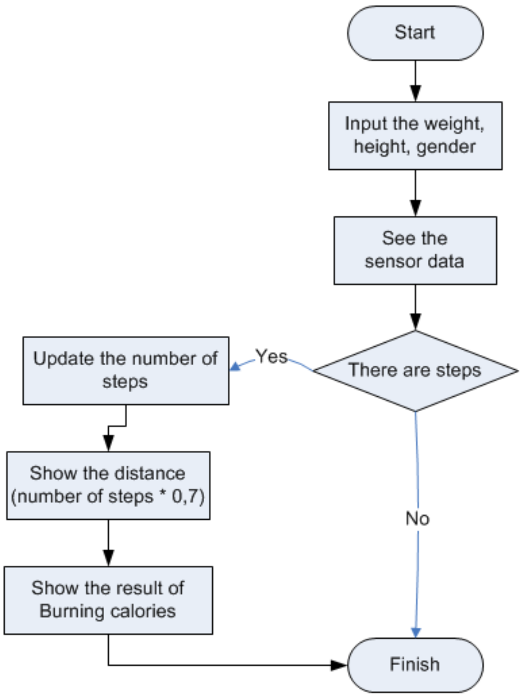

Figure 5. Application Flowchart

IV. RESULTS AND DISCUSSION

To be able to know the results of calories burning, there are several steps that must be done. We must first determine the value of the magnitude. This value is used to determine the value of acceleration in three axes, namely the x, y, and z axes, each of which is symbolized in Ax, Ay, and Az.

1. Determine the value of magnitude

Here is the formula for finding the magnitude value:

$$ATt = \sqrt{aX^2 + aY^2 + aZ^2}$$

After the magnitude value is known, then the following curve is formed:

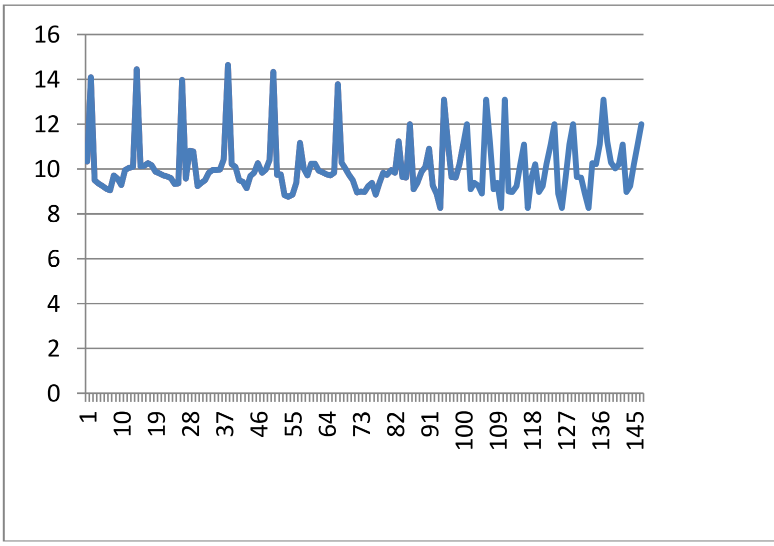

Figure6. Sample data graph

2. Determine the Threshold Value

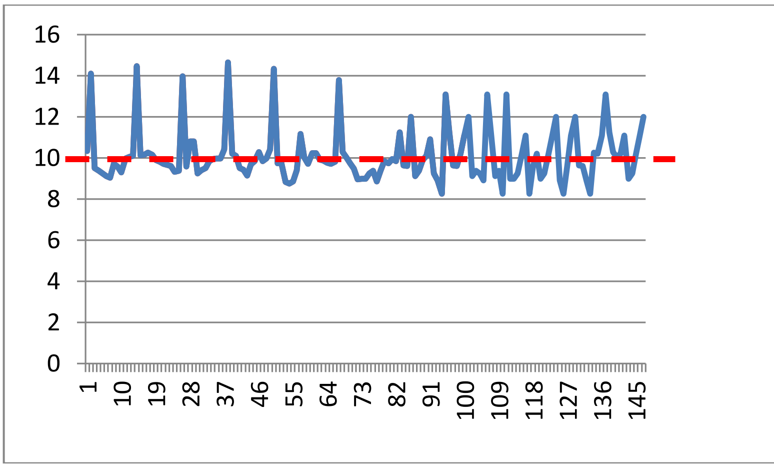

Figure 7. Graph when threshold value is at 10

After the magnitude value is obtained, the next step is to look for the threshold value. Threshold value is used to determine steps. In this case the threshold value used is 10. If $\Omega > 10$, then given a value of 1, and if $\Omega < 10$ then given a value of 0. Furthermore, the threshold value of 1 is calculated as 1 step. Then the total steps are obtained by adding up all the threshold values of 1. Then 55 steps are obtained,and the curve becomes in the form of zero (0) and one (1) logic pulse signals. Thus the condition of the curve will be like the following figure.

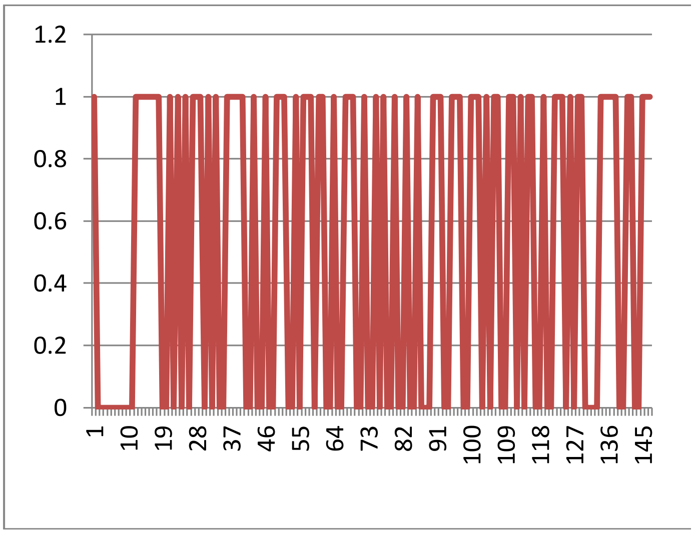

Figure 8. Graph when threshold value becomes 0 and 1

3. Determine the Total Jogging Distance

After getting the number of footsteps, the total distance traveled can be found. When walking, the resulting steps are multiplied by the average width of the foot when walking to calculate distance. The size of the footsteps alone is on average 70cm or it is assumed that a human step is 0.7m long. So the formula for determining distance is as follows.

$$Distance = number\ of\ footsteps\ x\ 0.7$$

So the distance traveled for jogging is 55 x 0.7 = 38.5 m.

4. Determine the Result of Calorie Burning

Besides displaying distance, the application will also display the results of burning calories. The following is the formula for calculating the calorie burning symbolized by EC or Exercise Calories.

$$EC = \left\{ METx\ 7.7\ x \frac{(BBx\ 2.2)}{200} \right\} x \frac{Duration}{60}$$

$$EC = \left\{ 2.8x\ 7.7\ x \frac{(65x\ 2.2)}{200} \right\} x \frac{120}{60}$$

$$= 21.56\ x\ 0.715\ x\ 2$$

$$= 30.8308 \text{ kcal}$$

V. CONCLUSION

It is expected that this research can be used as a reference in analyzing the design of an Android-based calorie burning calculation application. With the application, the researchers hope the application built will make the athletes easier to get calorie burning information. Data on the results of jogging will be displayed on the Android application about the number of footsteps, distance traveled during jogging, time spent, and most importantly the result of calorie burning calculation.

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