e-ISSN 2460-0040
p-ISSN 2407-7658
Vol. 5, No. 2, November 2018

Scientific Journal of Informatics

Scientific Journal of Informatics
e-ISSN 2460-0040
p-ISSN 2407-7658

Vol 5, No 2 (2018)

November 2018

DOI: https://doi.org/10.15294/sji.v5i2

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Articles

Scientific Journal of Informatics
Vol. 5, No.2, Nov2018

p-ISSN 2407-7658 http://journal.unnes.ac.id/nju/index.php/sji e-ISSN 2460-0040

Push-Up Detector Applications Using Quality Function Development and Anthropometry for Movement Error Detection

Ari Muzakir[1], Christofora Desi Kusmindari[2]

[1]Information Engineering, Universitas Bina Darma, Indonesia
[2]Industrial Engineering, Universitas Bina Darma, Indonesia
Email: [1]arimuzakir@binadarma.ac.id, [2]desi_christofora@binadarma.ac.id

Abstract

Push-up is the simplest and most widely performed sport. Although simple, it also has a high risk of injury risk if done not in accordance with the rules. Push-up detector is a good push-up motion monitoring solution. In this way, nonstandard movements can be detected and corrected immediately. It has two motion sensors integrated with Arduino-based microcontroller. From this detector tool got the data of push-up result from sensor mounted. Sensor data will be displayed in the application in real-time. Quality function development is used to determine the criteria of the user. The sample data involved 200 participants who followed the testing of this tool and got 90% who can do the push-up correctly. Factors that affect the height, age, and weight. Tests conducted on adolescent boys aged 18-23 years. The results of this study is an application capable of monitoring each push-up movement to position in accordance with the provisions to minimize injuries resulting from movement errors.

Keywords: Design of Push-Up Detector, Quality Function Development, Anthropometry, Movement Errors Detection

1. INTRODUCTION

Push-up is one technique or how to exercise that must have been done. However, there are still many people who do not really understand how to do the right push-up, most people just do it without realizing it does not produce benefits for the body. From these statements to push-up sports is increasingly provide positive benefits, it is necessary to make a tool that can overcome the unresponsiveness or error of movement and position of push-up. This tool needs to be designed considering that this sport is the most common sport for both lay and athlete[1].

The expected goal of this research is to build a push-up detector application to facilitate the trainer or user in monitoring the position of push-up properly and correctly so that the health benefits obtained can be maximized by using a computer device[2],[1]. In previous research has been made tool push-up detector with specification microcontroller ATMega8 and 16x2 LCD interface. But the problem is the data generated can not be stored in realtime when the number of participants push-up too much so that the report making becomes a constraint. In addition, the interface provided in the form of 16x2 LCD screen is too small to inhibit the monitoring process[3],[2].

Anthropometry is a study of human body dimension measurement of bone, muscle and adipose or fat tissue[1]. Anthropometry data is used as the basis for the design of push-up detectors. In addition to using anthropometric data, the quality fuction development (QFD) method is used to collect expert opinion and input from customers on the application to be made [4], [5], [6]. From this method it is expected to determine the top priority in the design of the push-up detector. Push-up detector application are determining the top priority for athlete to push-up detector product and getting the size for ergonomic push-up detector design which has two main objectives such as increasing the effectiveness and efficiency of work and other activities and increasing the desired value of the work including improving security, reducing tension and stress, increasing comfort and job satisfaction and improving quality of life.

2. METHODS

The process of designing the application of push-up required a systems development method that is used as a reference in the development process. The development method used is using prototyping model with activity coverage from prototyping model consist of [8].

2.1. Data Collection

Anthropometric data measurements taken in athletes aged 18-23 years and male sex. Data collection was conducted in two phases: Distribution of questionnaires for the QFD method and Anthropometric data collection by direct measurement.

2.2. Analysis and Design System

The system built a desktop-based application built using Visual Basic .NET programming language, whereas for arduino microcontroller using the C programming language [9],[10]. The architecture of a system built shown in Figure 1.

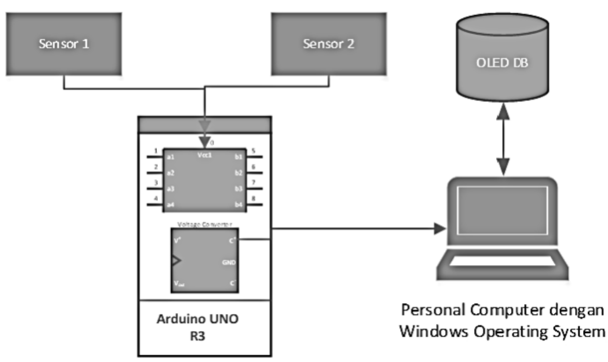


Figure 1. System architecture on push-up detector

Figure 1 illustrates the workflow of the system are made, namely:

1. The design of the push-up detector uses 2 motion sensors that will be mounted on a stick.
2. The microcontroller board uses arduino UNO version 3 as the input output processing (I/O)[11].

Processing results from microcontroller will be connected in real-time with a personal computer based on windows operating system using Microsoft Access database.

2.3. Interface Design

The design interface is used as the monitoring of movements captured by the sensor, processed by a microcontroller, and displayed on a computer screen in order to facilitate the monitoring coaches in push-up. Figure 2 shows the design of the interface of this application.

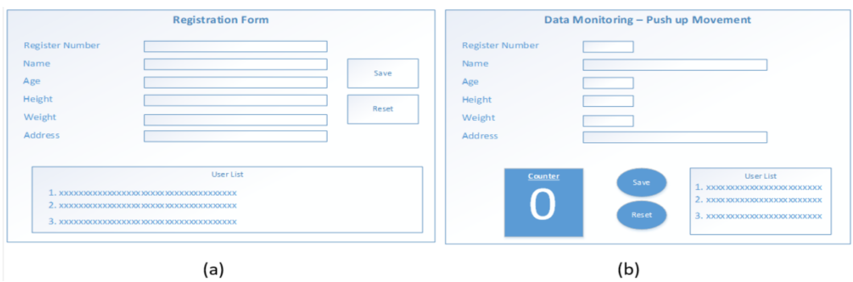


Figure 2. Interface design: (a) participant data collections (b) push-up calculation process.

3. RESULTS AND DISCUSSION

Data collection with QFD method is done by giving a number of questions to the resource person [12],[4],[13]. The resource persons are those who are experts in product design and the correct push-up position. From the results of data collection in get 11 attributes, push-up detector as in Table 1.

Table 1. Design attribute push-up detector

No	Requirement
1	Type of sensors
2	Light
3	The economic life of the material
4	Strength of material
5	Comfort
6	Models choice
7	Size variations
8	Color variations
9	Ease of operation
10	Material selection
11	Multifunctional

Furthermore, the criteria that have been obtained are changed into questionnaires to be asked to potential users of push-up detector. After the questionnaire distributed and tested the validity of reliability then the result of the test measuring tool is the value of Cronbach's alpha = 0.823 so that the measuring tool is reliable. The eleven attributes that have been obtained are calculated on average to obtain the level of importance of the user. The average value is calculated by the following formula 1, and then the result of the processing based on the importance level according to table 1 above can be seen in Table 2 below.

$$Average\ value = \frac{(5+3+4+\cdots+5)}{111} = \frac{444}{111} = 4.00 \quad (1)$$

Table 2. User interest level push-up detector

No	Product Attributes	Value Avarage	Sequence Interests	Level Interests
1	Type of sensors	4.17	1	5
2	Light	3.50	8	4
3	The economic life of the material	3.69	7	4
4	Strength of material	3.93	3.5	4
5	Comfort	3.93	3.5	4
6	Models choice	3.42	9	4
7	Size variations	3.27	10	4
8	Color variations	2.85	11	3
9	Ease of operation	3.85	5	4
10	Material selection	3.77	6	4
11	Multifunctional	4.00	2	4

Measuring the level of customer satisfaction of the product is intended to measure how the level of customer satisfaction after the use of products to be analyzed. For example, to calculate the level of customer satisfaction of the weight attribute push-up the light detector is a formula (2).

$$Weight\,average\,performance = \frac{\sum[(1x2)+(2x2)+(3x22)+(4x34)+(5x51)]}{(111)} \quad (2)$$

$$= \frac{463}{111} = 4.17$$

For the calculation, result of consumer satisfaction level from other attributes can be seen in Table 3 below.

Table 3. Levels of customer satisfaction

No	Requirement	Questionnaire Results					Total	Level
		Measurement Scale					Score	Satisfaction
		1	2	3	4	5		
1	Type of sensors	1	2	22	34	51	463	4.17
2	Light	1	7	51	40	12	388	3.50
3	The economic life of the material	5	7	34	36	29	410	3.69
4	Strength of material	0	8	30	35	38	436	3.93
5	Comfort	0	9	34	24	44	436	3.93
6	Models choice	3	19	38	30	21	380	3.42
7	Size variations	8	23	32	27	21	363	3.27
8	Color variations	12	34	34	21	10	316	2.85
9	Ease of operation	6	11	35	29	29	394	3.55
10	Material selection	0	14	32	30	35	419	3.77
11	Multifunctional	4	1	31	30	45	444	4.00

Having obtained the values of the weight of the importance of each attribute, then the next done the calculation of the relative weight (relative weight). This relative weight helps in prioritizing customer requirements to be developed shown in Table 4.

Table 4. Relative weight interest

No	Product Attributes	TK	G	IR	SP	IW	RW
1	Type of sensors	5	5	1.05	1.5	7.5	13.6
2	Light	4	4	1.14	1.2	4.8	8.42
3	The economic life of the material	4	4	1.08	1.2	4.8	8.42
4	Strength of material	4	4	1.02	1.2	4.8	8.42
5	Comfort	4	4	1.02	1.2	4.8	8.42
6	Models choice	4	4	1.17	1.2	4.8	8.42
7	Size variations	4	4	1.22	1.2	4.8	8.42
8	Color variations	3	3	1.05	1.2	3.6	6.32
9	Ease of operation	4	4	1.13	1.2	4.8	8.42
10	Material selection	4	4	1.06	1.2	4.8	8.42
11	Multifunctional	4	5	1.25	1.5	7.5	13.6
Total						57	

Description:

TK = rate of interest IR = Improvment ratio IW = Improvment Weight
G = goal SP = sales point RW = Relative Weight

The 200 respondents consisted of athletic athletes from Palembang and Sekayu areas. All respondents taken were men between 18-23 years old. It is intended that the anthropometric data collected is homogeneous. The data collected in this study is the anthropometric data needed to design the push-up detector. But since one of its aims is to create an anthropometric database, anthropometry data collection is performed for all dimensions. This anthropometry data collection were obtained by direct measurement of the dimensions of the body of the athlete based on the rules of ergonomics as many as 200 people. After the body dimension data is obtained, then do some statistical test that is testing the adequacy of the data, the data uniformity test, normality test data and percentiles. Because the anthropometric data used in push-up detector is only 2: Hand Reach (JKT) and High Sit up (TDT), then the data processing for both dimensions is shown in Table 5 below.

Table 5. Sufficiency and uniformity test result data

No	Dimension	$\bar{X}$	σ_x	BKA	BKB	N	N'	Description
1	JKT	77	1.62	75	84	200	2	Data Sufficient and uniformly
2	TDT	89.91	1.28	85.86	95.16	200	1	Data Sufficient and uniformly

Percentile calculations are performed to divide in population segments for the benefit of the researcher. Percentile calculations are performed using the following formula (3), (4), and (5).

$$\text{Persentile5} = \bar{X} - 1{,}645\,\sigma_x \quad (3)$$

$$\text{Persentile50} = \bar{X} \quad (4)$$

$$\text{Persentile 95} = \bar{X} + 1{,}645\,\sigma_x \quad (5)$$

Percentile calculation results are presented in Table 6 below:

Table 6. Percentile value of anthropometric data

No	Dimension	P5	P50	P95
1	JKT	77	77	82
2	TDT	88	89.91	92

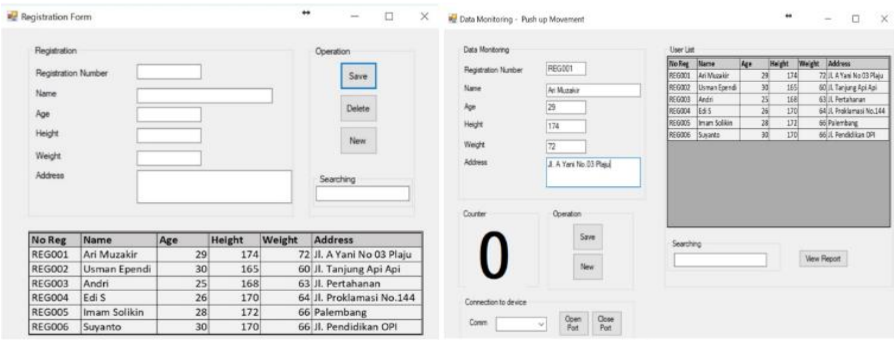
From result of antropometri data processing can analysis about push-up detector design (see Figure 5 point b), that is:

a. Based on Figure 2 the push-up detector process is a simple and easy to operate tool. This tool calculates through the number of push-up sensors that correspond to the correct push-up position.
b. The size of the tool has been adapted to the dimensions of the results of anthropometric data processing tailored to the user's body posture, thereby reducing the risk of fatigue and increasing comfort and user satisfaction.

c. Based on the design of the push-up detector, the height of the sensor can range from 77 to 82 cm. This figure is taken from the value of percentile 5 to 95 percentile range of body dimensions of hand. The length between 88-92 cm horizontal sensor whose value is taken from a high-dimensional body sitting upright.

3.1. Application Testing

As has been done in the system design in the previous figure, it will get the results computerized as in Figure 3 below.



(a) (b)

Figure 3. Results of the application interface made. (a) The registration process of push-up participants. (b) An integrated push-up monitoring process with a push-up detector tool.

In Figure 3, the general process of integration of push-up tool to the application has been completed. But to be able to use the tool required configuration by determining the computer network communications port used as in Figure 4.

Figure 4. Determination of communication path between computer with device push-up detector

Furthermore, to see the schematics of the circuit of the sensors used in the push-up detector to be integrated with the built application can be seen in Figure 5. This push-up detector device uses motion sensor E18-D80NK model, which is generally compatible with arduinouno microcontroller.

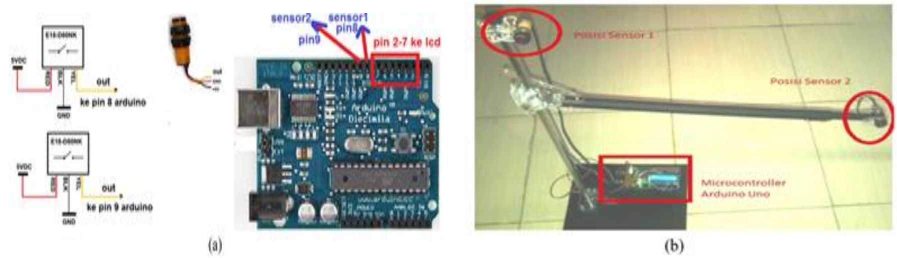


Figure 5. Schematic sensor circuit with arduino microcontroller. (a) a series of sensors and a microcontroller arduino. (b) Complete device push-up detector

3.2. Testing Success Rate

The purpose of this test is to determine the success rate of the application made to the data received from the sensor when variations of movement are made. When performed by participants with a certain height and also a certain weight. The height of the participant affects the reach of the hand (JKT) to the height of the installed sensor; if only one sensor detects movement then the application will not respond or give value. Value will be added at the up position below in table 7 shows the results of testing the variation of movement on the response of the application.

Table 7. Testing movement variation to application response

Data Sample			The success rate of push-ups				
Age	Height	Weight	10 times	15 times	20 times	25 times	30 times
20	158	57	9	14	16	22	26
21	160	57	9	13	18	23	27
19	164	65	10	14	18	24	27
23	170	90	8	12	15	21	24
22	175	88	10	15	19	24	28
23	176	104	9	13	17	23	26
23	179	110	7	11	16	23	25
20	180	90	10	15	19	24	28

From the data is taken a sample to measure the success of the movement of several variables used. Average success rates tested, namely 10, 15, 20, 25 and 30 times. Of processing data obtained some of the problems that affect the success rate of movement of push-ups. From the analysis results obtained that, weight is not proportional to height (ideal body posture). For example, from the data height 179 and body weight 110 results posture is not ideal. Weight affects movement during up position that affects the hand reach (JKT) and elevated sitting height (TDT).

4. CONCLUSION

The main priority for the consumer to push-up product quality characteristic of the detector are: the selection of sensors with a relative weight value of 51.6%, the election kompenen with relative weight value by 56.6%, making tools with a value relative weighting of 1.7%.The research that has been done can be concluded that this study focused on the use of push-up tool detector which can be integrated in real time with a desktop application is made. The final result is to analyze the sample data, where the ideal posture is very influential on the success of the push-up movement itself. While the design of the tool height detector sensor push-up can range between 77-82 cm, this figure is taken from the value of percentile 5 to 95 percentile body dimensions jangkuan hand. The length of the horizontal sensor between 88-92 cm whose value is taken from a high-dimensional body sitting upright.

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