

COMPARISON OF ACCURACY MEASUREMENTS IN MOTION SENSORS AND HEART RATE MEASUREMENTS USING ANALYTICAL HIERARCHY PROCESS METHODS

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Abstrak— Penggunaan motion sensor dalam mengukur detak jantung menggunakan aplikasi smartwatch saat ini sedang tren. Setiap orang sangat terbantu untuk pengukuran detak jantung dirinya sendiri. Penelitian ini tentang perbandingan keakuratan dalam motion sensor dan mengukur detak jantung dengan metode *Analytical Hierarchy Process* (AHP). Setiap teknologi dan aplikasi dalam pengukuran motion sensor dalam pengukuran detak jantung mempunyai fitur dan kegunaan yang hampir sama seperti perusahaan Xiaomi, Samsung, dan Apple Inc. Dari perhitungan yang dilakukan peneliti menunjukkan bahwa Lapangan/Stadion yang paling banyak dipilih oleh masyarakat (responden) secara Random Sampling, dengan perolehan nilai 0,490 alias 49,00%. Selanjutnya kedua ialah Treadmill dengan nilai 0,294 alias 29,40% yang terakhir ialah Jalanan dengan perhitungan keseluruhan nilai 0,216 alias 21,60%. Alternatif yang paling banyak dipilih oleh Masyarakat (responden) adalah Lapangan/Stadion. Metode *Analytical Hierarchy Process* dapat memudahkan calon pengguna teknologi untuk dapat mengukur keakuratan motion sensor dan mendeteksi detak jantung, metode AHP membuat pengambilan keputusan produk berdasarkan kriteria dan alternatif yang terdapat dalam hirarki, hasil dari penelitian adalah perusahaan Apple Inc sebagai pilihan responden untuk teknologi yang dipercaya untuk mengukur keakuratan yang lebih baik pada motion sensor dan mengukur detak jantung.

Kata Kunci: AHP, *Motion Sensor*, Pengukur Detak Jantung, Perbandingan Keakuratan.

Abstract— The use of motion sensors in measuring heart rate using smartwatch applications is currently a trend. Everyone is very helpful for measuring their heart rate. This research is about the comparison of accuracy in motion sensors and measuring heart rate using the Analytical Hierarchy

Process (AHP) method. Every technology and application in motion sensor measurement in heart rate measurement has almost the same features and uses as Xiaomi, Samsung, and Apple Inc. From the calculations carried out by the researcher, it shows that the field/stadium that is the most chosen by the community (respondents) is by Random Sampling, with the acquisition of a value of 0.490 aka 49.00%. The second is Treadmill with a value of 0.294 aka 29.40%. the overall value is 0.216 aka 21.60%. The alternative that is most chosen by the community (respondents) is the field/stadium. The Analytical Hierarchy Process method can make it easier for prospective technology users to be able to measure the accuracy of motion sensors and detect heart rates, the AHP method makes product decisions based on criteria and alternatives contained in the hierarchy, the results of the study are Apple Inc. as the respondent's choice for technology that is trusted to measure better accuracy on the motion sensor and measure heart rate.

Keywords: AHP, Motion Sensor, Heart Rate Measurement, Accuracy Comparison.

INTRODUCTION

At the beginning of the 21st century, technology has developed rapidly. Humans, through the intelligence that is in themselves, answer the demands of nature with advances in information technology (Cathrin, 2019). The more severe the challenges of nature, the more sophisticated the technology produced by humans with their creative power in responding to challenges with various innovations in the field of 'technology' which tends to peak over time (Cathrin, 2019). Now technology has penetrated almost all aspects and all areas of human life, both private and public areas. Humans have a relationship with technology. Humans even

'mingle' with themselves and other humans through technology and being together with technology.

Talking about technological developments, there is one technology that is currently the prima donna, namely the development of information technology through a device that is now popular, namely the gadget (Walangare et al., 2012). According to the Cambridge Dictionary, the term 'gadget' has the meaning: a small device or machine with a specific purpose (Cambridge Dictionary). Based on the meaning of the dictionary, it can be seen that the term gadget has a very broad scope because all tools or machines have been used.

Currently, gadget technology, both hardware, and software have developed very quickly (Hapsari, 2018). Every time gadgets are developing with new designs and various new features through the systems that are included in them. One of the latest developments in the form of wearable gadgets currently available is in the form of a smartwatch (smartwatch) and can also be a smart bracelet (smart band) (Rizaldi, 2017). The idea of creating wearable gadgets in the form of smartwatches and smart bands was born from the demands of technology portability. For example, smartphones are now considered less portable because they are still separated from humans (for example, placed in a bag or a pocket) there is a need to create a gadget that integrates with the human body. This gadget attaches, can be used, and manifests in one small device called a smartwatch and smart band.

Several smart bands have been released by various technology companies, including the Mi Band, which was released by Xiaomi Inc. from China in 2014 (Ricchio et al., 2018) the superior feature of Mi Band is the ability to detect the wearer's movement (motion sensor), including the ability to detect heart rate. Data that has been done such as exercise and detecting heart rate will be integrated through the Mi Fit application, the official Xiaomi application for Mi Band, where the user will create a medical id, which is a database containing medical information for the watch user, such as weight, height, and so on.

In addition to wearable gadgets (Cathrin, 2019) such as Mi Band, there are also applications for measuring and detecting humans such as (motion sensors) and the ability to detect heart rate, this application before wearable gadgets existed because this wearable gadget was a solution to existing technology. An example of an application that is taken is the Samsung Health application. The Samsung Health app was launched in 2013 by the Korean company Samsung. Samsung Health is also equipped with a feature (motion sensor) that can consistently calculate the movements made during exercise. We know it from the number of every step

we take while cycling to the distance covered when running in one day.

The purpose of the study was to compare the accuracy of the data generated for motion sensors and detect human heart rate and using these there companies, each technology has almost similar features and uses. Companies such as Xiaomi, Samsung, and Apple Inc have technology that can check motion sensors and can also detect human heartbeats.

AHP is a decision-making technique or multivariate optimization (Pratiwi, 2020) used in the above analysis. AHP is a comprehensive decision-making model that takes into account both qualitative and quantitative aspects (Sasongko et al., 2017). AHP is generally used to set priorities from various alternative options and these choices are complex or multi-criteria.

MATERIALS AND METHODS

Data collection

The analytical descriptive method that will be used in this research is to present survey results in the form of a questionnaire (Umar et al., 2018). Secondary data is taken through various media, such as the internet, literature books and journals, and articles (Thalha Alhamid & Anufia, 2019) so that accurate information is obtained regarding the use of motion sensors in measuring heart rate. Furthermore, the data is processed using the Analytical Hierarchy Process (AHP) approach to determine the comparison criteria for accuracy in the motion sensor and measure the heart rate that will be used.

In solving problems with AHP several principles must be understood, namely (Purnomo et al., 2013):

1. Decomposition (creating a hierarchy)
Complex systems can be understood by breaking them down into smaller, easier-to-understand elements.
2. Comparative judgment (assessment of criteria and alternative)
Criteria and alternatives are carried out by pairwise comparisons so that the scale of importance of each criterion against other criteria can be known.
3. Synthesis of priority (determining priority)
4. Logical Consistency (logical consistency)

Research Sample

Sampling or respondents in this study using a technique that is random sampling method. All special samples from the population are at random, the position of each population or community has the same right to be made samples or respondents (Susilo et al., n.d.). In this study, the number of respondents was 15 - 30. To represent the

population as a whole by using a questionnaire to the respondents.

RESULTS AND DISCUSSION

Data Analysis

Questionnaires that have been created and distributed to 30 community resource persons, students, etc. Respondents were taken freely because this study used a random sampling method. All samples are selected from population elements at random where each population or community has the same rights to be samples or respondents. This distribution is carried out through google forms to facilitate filling out and compiling data, criteria and alternatives are made. Regarding the criteria and alternatives that will be used in the study, namely:

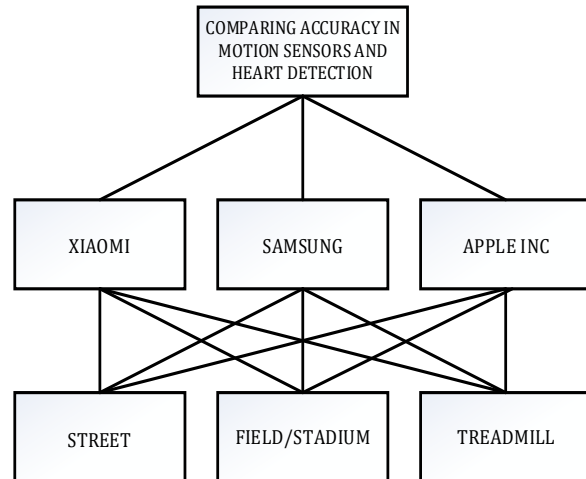
1. MI BAND
The author uses the Mi band (Wearable Gadget) as a tool in sampling to get data and then use it as a criterion.
2. Samsung Health App
The Samsung health application is also used as a tool for sampling to obtain data and then used as criteria because this application is intended to compare its accuracy.
3. Other Wearable Gadgets or Other Sports Apps
The criteria were chosen because to add the types of criteria that are suitable for choice and there are also many examples of wearable gadgets or other sports applications that are suitable for comparison of accuracy.

Alternatives

1. Street
The street is a means or one of the right places to try to do sports in comparing motion sensors and detecting heart rate either after or before exercising.
2. Field/ Stadium
The field/stadium is also a means or one of the right places to try to do sports in comparing motion sensors and detecting heart rate either after or before
3. Treadmill
Treadmills are also a great place to exercise if you want a quiet and safe place to compare motion sensors and detect heart rate either after or before exercising.

Hierarchical Structure

To find out the comparison of accuracy in motion sensors and heart rate detection using the AHP method, see Figure 1 below.



Source: (Novier et al., 2021)

Figure 1. Hierarchical Structure

Pairwise Comparison Matrix

Based on the results of the questionnaires that have been distributed to respondents by random sampling, they are then used in the form of a comparison matrix to obtain scores on the criteria that have been made (Andriyani & Hafiz, 2018). To make the estimates easier, the estimates are made in tabular form and each value is rounded off from the comparison matrix that has been created. Then the data that has been obtained can be worked out to produce the consistency ratio and consistency index values. Therefore, the results of the paired matrix for each criterion and alternative will be known in the following table 1:

1. Main Criteria

Paired matrices for each main criterion based on questionnaire data will be obtained in table 1 below:

Table 1. Paired Matrix Main criteria

Criteria	Main Criteria Column Value		
	Xiaomi	Samsung	Apple Inc
Xiaomi	1.000	0.798	0.673
Samsung	1.253	1.000	1.037
Apple Inc	1.486	0.964	1.000
Total	3.739	2.762	2.710

Source : (Novier et al., 2021)

The element in each column is divided by the number of columns, then the normalized value is obtained. While the eigenvector value is obtained from the average value of each row. The normalized values are in table 2 below:

Table 2. Paired Matrix for all Normalized Criteria

Criteria	Xiaomi	Samsung	Apple Inc	Jumlah
Xiaomi	0.267	0.289	0.248	0.805
Samsung	0.335	0.362	0.383	1.080
Apple Inc	0.397	0.349	0.369	1.116

Source : (Novier et al., 2021)

Because $CR < 0.100$ means that the respondent's preference is consistent, the results from the calculations in the table show that other Wearable Gadgets or other Sports Applications are the best or trusted tools chosen by the community (respondents) to measure accuracy and detect heart rate by obtaining a value of 0.372 alias 37.20%, then those chosen by the community (respondents) with a value of 0.360 or 36.00% are the Samsung health application and Mi Band with a value of 0.268 or 26.80%.

2. Xiaomi Criteria

Paired matrices on satisfaction criteria based on questionnaire data are shown in table 3 below:

Table 3. Xiaomi Criteria Paired Matrix

	STREET	FIELD/ STADIUM	TREADMILL
Street	1.000	0.406	0.619
Field/ Stadium	2.463	1.000	1.543
Treadmill	1.616	0.648	1.000
Total	5.079	2.054	3.162

Source : (Novier et al., 2021)

The elements in each column are divided by the number of columns to obtain a normalized value. While the eigenvector value is obtained from the average value of each row. The normalized values are in table 4 below:

Table 4. Matrix of Normalized Xiaomi Criteria Factors

	STREET	FIELD/ STADIUM	TREADMILL	TOTAL	EIGEN VECTOR
STREET	0.197	0.198	0.196	0.591	0.197
FIELD/ STADIUM	0.485	0.487	0.488	1.460	0.487
TREADMILL	0.318	0.316	0.316	0.950	0.317

Source : (Novier et al., 2021)

Because $CR < 0.100$ means that the respondent's preference is consistent, the results from the calculations in the table show that the Field/Stadium is the Mi Band Criteria, which is the best or trusted tool chosen by the community (respondents) to measure accuracy and detect heart rate by obtaining a value of 0.486 aka 48.60%, then those chosen by the community (respondents) with a value of 0.317 alias 31.70% are Treadmills and Streets with a value of 0.197 aka 19.70%.

3. Samsung Health Application Criteria

Paired matrices on satisfaction criteria based on questionnaire data are shown in table 5 below:

Table 5. Samsung Criteria Paired Matrix OPTIMIZED VALUE

	STREET	FIELD/ STADIUM	TREADMILL
STREET	1.000	0.537	0.811
FIELD/ STADIUM	1.862	1.000	1.486
TREADMILL	1.233	0.673	1.000
Total	4.095	2.210	3.297

Source : (Novier et al., 2021)

The elements in each column are divided by the number of columns to obtain a normalized value. While the eigenvector value is obtained from the average value of each row. The normalized values are in table 6 below:

Table 6. Normalized Samsung Criteria Factor Matrix OPTIMIZED VALUE

	STREET	FIELD/ STADIUM	TREADMILL	TOTAL	EIGEN VECTOR
STREET	0.244	0.243	0.246	0.733	0.244
FIELD/ STADIUM	0.455	0.452	0.451	1.358	0.453
TREADMILL	0.301	0.305	0.305	0.911	0.304

Source : (Novier et al., 2021)

Because $CR < 0.100$ means that the respondent's preference is consistent, the results from the calculation in the table show that the Field/Stadium is the Samsung Health Application Criteria which is the best or trusted tool chosen by the community (respondents) to measure accuracy and detect heart rate by obtaining a value of 0.452 alias 45.20%, then those chosen by the community (respondents) with a value of 0.304 alias 30.40% are Treadmills and Streets with a value of 0.244 alias 24.40%.

4. Criteria for Other Wearable Gadgets or Other Sports Applications

Paired matrices on satisfaction criteria based on questionnaire data are shown in table 7 below :

Table 7. Apple Inc . Criteria Matrix

	STREET	FIELD/ STADIUM	TREADMILL
STREET	1.000	0.416	0.699
FIELD/ STADIUM	2.404	1.000	2.133
TREADMILL	1.431	0.469	1.000
Total	4.835	1.885	3.832

Source : (Novier et al., 2021)



The element in each column is divided by the number of columns, then the normalized value is obtained. While the eigenvector value is obtained from the average value of each row. The normalized values are in table 8 below:

Table 8. Apple Inc. Factor Matrix

	STREET	FIELD/ STADIUM	TREADMILL	TOTAL	EIGEN VECTOR
STREET	0.207	0.221	0.182	0.610	0.203
FIELD/ STADIUM	0.497	0.531	0.557	1.585	0.528
TREADMILL	0.296	0.249	0.261	0.806	0.269

Source : (Novier et al., 2021)

Because $CR < 0.100$ means that the respondent's preference is consistent, the results from the calculations in the table show that the Field/Stadium is a Criteria for Other Wearable Gadgets or Other Sports Applications, which are the best or trusted tools chosen by the community (respondents) to measure accuracy and detect heart rate with obtained a value of 0.528 or 52.80%, then those chosen by the community (respondents) with a value of 0.269 or 26.90% were Treadmills and Streets with a value of 0.203 or 20.30%.

Research Result

After calculating the data from the results of filling out the questionnaire then it is used as a comparison matrix, then from the whole calculation, the results can be seen in table 9 below:

Table 9. Final Results

AVERAGE CRITERIA				
0.26822568	Street	0.216	3	
0.35994056	Field/ Stadium	0.490	1	
0.37183375	Treadmill	0.294	2	
		1.000		
		Average Score Each Alter		
	Street	0.1970	0.2443	0.2033
	Field/ Stadium	0.4867	0.4527	0.5283
	Treadmill	0.3167	0.3037	0.2687

Source : (Novier et al., 2021)

From the calculations that have been carried out by the author, it shows that the Field / Stadium the most chosen by the community (respondents) is by Random Sampling, with the acquisition of a value of 0.490 aka 49.00%, then the second is Treadmill with a value of 0.294 aka 29.40%, then the last one is Streets with a total value of 0.216 aka 21.60%. Based on the information above, the most chosen alternative by the community (respondents) is the field/stadium.

CONCLUSION

The Analytical Hierarchy Process (AHP) method can make it easier for prospective technology users to be able to help measure accuracy in motion sensors and detect heart rates that exist in technology at companies such as Xiaomi, Samsung, and Apple Inc. The AHP method makes product decisions based on criteria and alternatives contained in the hierarchy. The result of this study is the company Apple Inc., as the respondent's choice for technology that is believed to measure better accuracy in motion sensors and measure heart rate.

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