RGB-D sensor application for static anthropometry measurement

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Abstract. This study aimed to apply the RGB-D sensor for other alternative static anthropometric measurements. The RGB-D sensor that was used is Kinect Xbox 360 from Microsoft. The study was conducted by running the RGB-D sensor activation program so that it can detect static anthropometric measurements which include height, sitting height, leg length, knee length, hand length, forearm length, shoulder width and hip width. After the system run, the sensor captured objects that can be detected and then become input from the program and produce RGB data and depth (depth) and then processed again to get skeletal tracking. Skeletal tracking obtained if the sensor detects human presence. From the results of this skeletal tracking, the program can produce length data from each body part measured. Information processing results shown on the monitor screen in the form of units of length in centimeters (cm). The research results showed that from 110 anthropometric data that have been taken with this measurement system, the system showed the total absolute absolute error of 2.71%. Error for each anthropology measurement are height 2.53%, knee length 2.94%, foot length 2.97%, shoulder width 2.47%, hand length 2.16%, arm length 2.46%, hip width 2.67%, and sitting height 3.45%. From the results of regression analysis, the average correlation value between the actual value and the system value are 0.91 so that the results of the sensor measurements can be accepted. Can be concluded that the use of the Kinect sensor for anthropometric measurements can be used for anthropometric measurements.

1. Introduction

Ergonomics in general is the science, art and application of technology to harmonize all facilities used both in activity and rest with the abilities and limitations of humans both physically and mentally so that the quality of life becomes better [1]. Ergonomic conditions are very important in every human job so in the design of products and work facilities it is very important to apply ergonomics. A product design is called ergonomic if it is anthropometrically, biomechanically and physiologically compatible with humans who will use or use it. In order for anthropometrically compatible designs, it is necessary to study anthropometrics and their measurements.
Anthropometry can be stated as a study relating to the measurement of the dimensions of the human body and basically humans will have different shapes, sizes, weights and others [2]. To get anthropometric data, measurements are needed to humans. Most anthropometric measurements in Indonesia still use manual methods, namely by direct measurement with measuring devices such as anthropometers, ruler, measuring tape, meter and measuring tape. However, this measurement requires quite a lot of time so that it is inefficient. This makes research to get a more efficient measurement system using sensors, one of which is the RGB-D sensor. The RGB-D sensor was used in the research of [3], in which the RGB-D sensor was used to measure shoulder width and waist width to obtain a suitable dress size. This prompted this study to measure the more static anthropometry measured. RGB-D sensor in addition to producing RGB data, can also produce data depth. Depth is an area's data in 3D regardless of the light conditions in that area. One of the RGB-D sensors currently available is the kinect sensor produced by Microsoft. One of the advantages of this kinect sensor is that it can capture the main joint point of the human body with the skeletal tracking feature that is contained in the sensor [4]. The ability of this sensor can have the opportunity to create a system that can produce anthropometric data from the human body that is more efficient than manual measurements.

2. Methods

2.1. Sensor Calibration

Before calibration is done the conversion value is searched to display the detected length in units of length (cm). The data generated from the sensor in the form of visual data where the results are in the form of pixels. Therefore, the conversion value will be sought to convert pixels into cm. Calibration data retrieval is done by taking hand coordinate data at an angle position 30 for x1, y1, z1 and hand coordinates at an angle position 90 for x2, y2, and z2 with Kinect. Previously taken hand length data with a measuring instrument as a comparison. Samples for calibration amounted to 10 people and data taken in the room that will be prepared for data retrieval.

Then the data will be recorded into a spreadsheet and processed to produce hand length data. Processing using the Euclidean distance formula for each coordinate axis, namely:

\[(p, q) = (p_1 - q_1)^2 + \cdots + (p_n - q_n)^2 \] (1)

Then the data is divided by the actual length data to get the ratio. The average ratio of all data will be the conversion value of pixels to centimeters. After that calibration is then carried out to find out whether the sensor can be used or not.

2.2. Program installation

Stages of the program process for this measurement system starts from initializing the sensor to capture RGB data, depth image. From depth data, it can then initialize skeletal tracking. Data can be captured if detected by humans in front of the sensor. After everything is initialized, then define the distance between the seconds that the data will be retrieved. Then the distance data obtained is multiplied by the conversion value of the calibration results. Display results from the program, can be seen in the program interface that will display the RGB image, depth, skeletal, and anthropometric data obtained.

2.3. Data collection

Data retrieval by the system is carried out in a room equipped with a kinect camera, and a laptop as a monitor and process unit for user interaction with the system. The distance between the subject and the sensor is determined at 250 cm. The ideal distance between kinect and subject is 250 cm with 98% skeletal tracking detection accuracy [5]. The distance of 350 cm and 250 cm is the optimum distance of Kinect with error values of 0.2 and 0.52. However, because the space used is limited to 300 cm, a distance of 250 cm is used for data retrieval [4].

Before entering the room, the sample will be measured manually to get the actual data. Then the sample enters the room for anthropometric data retrieval with a system that has been made. The stages of data retrieval by the system are as follows:

- Kinect captures RGB image information, data depth of each frame. If there people at depth frames, then Kinect will do skeletal tracking.
- RGB images and skeletal tracking will be shown to users through the program interface.
Skeletal tracking will give the position of each joint in the coordinates of the skeleton space.

The feature taken is the depth of the selected joints.

Based on the position of the skeletal point to be retrieved, the distance between these points will be sought and will get the length of each part that will obtain the data.

Data length of each section will be displayed through the interface in the form of length in units of cm.

2.4. Data processing

Data obtained from the system will be recorded into a spreadsheet for further processing. For processing, system data will be compared with the actual data to find errors from the system. To determine the error, the absolute error formula is used as follows:

\[
\text{error absolut} = \frac{|\text{actual data} - \text{system data}|}{\text{actual data}}
\]

3. Results and Discussion

3.1. Result

System capture data can be viewed through a program interface that can show RGB images, depth images, skeletal tracking, and length of program processing results that can be seen in figure 1.

![Figure 1. Example of the system capture on the subject](image-url)
From the sensor catches, the length data of each body part is obtained, as shown in Table 1.

Table 1. Example of data retrieval from sensor in cm.

|          | Height | Knee length | Foot length | Shoulder width | Hand length | Forearm length | Hip width | Sitting height |
|----------|--------|-------------|-------------|----------------|-------------|----------------|-----------|----------------|
| L1       | 165.39 | 44.08       | 84.12       | 33.64          | 54.63       | 31.84          | 29.21     | 124.61         |
| L2       | 183.63 | 45.53       | 100.57      | 34.72          | 62.41       | 33.61          | 30.28     | 127.84         |
| L3       | 183.63 | 51.29       | 97.79       | 32.57          | 62.08       | 35.78          | 29.21     | 136.38         |
| L4       | 183.09 | 50.88       | 99.77       | 36.33          | 61.24       | 36.25          | 31.36     | 133.46         |
| L5       | 153.24 | 44.32       | 81.05       | 30.98          | 56.23       | 33.64          | 29.21     | 115.77         |
| P1       | 160.22 | 35.85       | 89.58       | 32.05          | 57.15       | 33.81          | 28.68     | 105.74         |
| P2       | 141.44 | 40.72       | 73.48       | 31.06          | 55.38       | 30.45          | 28.68     | 107.94         |
| P3       | 153.78 | 42.08       | 85.55       | 29.39          | 55.20       | 31.49          | 27.60     | 109.57         |
| P4       | 157.00 | 47.13       | 86.90       | 28.32          | 58.53       | 31.05          | 27.07     | 116.49         |
| P5       | 166.65 | 42.37       | 90.13       | 18.68          | 60.57       | 36.99          | 22.24     | 118.15         |

In the process of measuring with sensors, the program can capture subjects well and can display anthropometric data.

3.2. Discussion

In the process of measuring with sensors, the program can capture the subject well and can display anthropometric data, but there are some subjects that still have quite high errors. That is because the data taken is the result of a capture or screenshot so it is not the best result that can be caught due to the high level of sensor sensitivity so that the displayed value is not stable.

The data that has been obtained is then compared between the actual data (manual) with sensor measurement data. This comparison aims to find the value of system errors and the correlation between actual data and system data. Processing to determine the error is done by using the absolute error formula. The results of processing errors can be seen in Appendix 2 to Appendix 5.

At height, the lowest error is 0% and sitting height is 0.01% or around 0.2 mm. The lowest error foot length is 0.02% or around 0.02 mm and knee length 0.02% or around 0.1 mm. At the lowest hip width error 0.04% or around 0.001 mm and shoulder width obtained 0.01% or around 0.003 mm. For hand length, the lowest error is 0.02% or around 0.002 mm and forearm length the lowest error is 0.15% or 0.006 mm. The average error in each section can be seen in Table 2.

From the statistical analysis that has been shown, it is concluded that the correlation values obtained are good, so that the results of these measurements can be accepted. Obtained the smallest correlation value of 0.83 and the largest of 0.97 and an average of 0.91. Correlation value obtained in the measurement of sitting height gets the smallest value because the error of the measurement is highest among other body parts. However, the height also obtained a smaller correlation value than the part with a higher error. That is because the diversity of errors at height that can be seen in the graph whose points are scattered from the trendline and can be compared to knee height whose errors are larger but the points are evenly distributed from the trendline.
Table 2. Average of error in the measurement system

| Measured Body Parts | Average Error (%) | Standard Deviation (%) |
|---------------------|-------------------|------------------------|
| Height              | 2.53              | 2.16                   |
| Knee length         | 2.94              | 2.01                   |
| Foot length         | 2.97              | 2.31                   |
| Shoulder width      | 2.47              | 2.04                   |
| Hand length         | 2.16              | 1.89                   |
| Forearm length      | 2.46              | 1.84                   |
| Hip width           | 2.67              | 1.55                   |
| Sit height          | 3.45              | 2.59                   |

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4. References

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