Automate the Calculation of Human Body Height using a Matlab-Based Kinect Camera for Estimating Body Size: A Pilot Study

by Choirul Anam

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A. Naufal, C. Anam, C. E. Widodo, and G. Dougherty

Automate the Calculation of Human Body Height Using a Matlab-Based Kinect Camera for Estimating Body Size: A Pilot Study

A. Naufal[1], C. Anam[1, a)], C. E. Widodo[1] and G. Dougherty[2]

[1]*Department of Physics, Faculty of Sciences and Mathematics, Diponegoro University, Jl. Prof. Soedarto SH, Tembalang, Semarang 50275, Central Java, Indonesia*
[2]*Department of Applied Physics and Medical Imaging, California State University Channel Islands, Camarillo, CA 93012, USA*

[a)]Corresponding author: anam@fisika.fsm.undip.ac.id

Abstract. Body size is one of the important information in radiological examinations. In general, body size measurements are carried out in a conventional way which still relies on direct contact. Size measurements can be remotely performed using a Kinect camera. This study aims to develop a Matlab-based software that can be used to automatically measure the height to estimate the size of the human body without direct contact. The Kinect camera emitted infrared and received its reflection to obtain a depth image of an object. The camera was calibrated for various object-Kinect distances. The system was implemented to measure the heights of 147 participants. The depth image was automatically segmented and normalized into a binary image. The software calculated the height of the participants from the segmented image. The heights of the participants were also measured using a ruler. The Relationship between height and weight was established. It is found that the depth value and size of the image pixel are linearly correlated with the distance of the object. The difference of measured height with the Kinect from height measured using a ruler is about 1.0 %, indicating that the height measurement using the Kinect camera is quite accurate. It is also found that the height of the participants is well correlated with the size of the human with values of R^2 of 0.453. The software for automatically measuring the height of the human has been successfully developed. The system is able to accurately measure the height. Due to the linear correlation between size and height, therefore the system is also able to estimate body weight.

INTRODUCTION

One of the important parameters in radiological examination is body weight. For instance, body weight is used in consideration of the iodine dose in CT examination. In CT angiography, good images are tailored to patient weight [1,2]. Radiation dose optimization can be set to a weight tailored protocol in abdominal CT examination. For heavier patients, the radiation dose is usually increased to obtain a good image [3]. Obese patients are exposed to significantly higher radiation in CT [4-6].

However, measurement of body weight is not always possible, especially if the patient is critically ill. Hence, medical staff often estimate the patient's weight visually which presents its risks [7,8]. Therefore, an alternative method to estimate body weight is needed. The Kinect camera emitted infrared and received the reflection to a sensor to obtain the depth of an object and represent it as depth images, which may be used as one alternative for this estimation. The camera has a sampling rate of 30 frames per second (fps), so the depth images of human body can be obtained in real-time [9]. Height measurements are related to body weight, although it is better to include a specific population to have the same meaning when applied to all individuals [10]. This depth information acquired from the Kinect is useful to automatically measure the height of human body, as well as estimating the weight more accurately [11].

Lee *et al* [12] has developed a software to estimate height using the Kinect camera by adding up all the skeleton points of the entire body. However, because this method does not utilize segmentation, background noise affected the

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estimation results. In a previous study, Afrieda *et al* [13] has developed a software to automatically segment patient's bodies from the image of the Kinect. This study aims to develop a software to calculate the height of human bodies using a Kinect camera with an automatic segmentation method to estimate body weight.

MATERIALS AND METHODS

Research Procedure

The research procedure was depicted in **Fig. 1**. A total of 147 participants of various ages were measured for height and weight using a ruler and scale. Data collection was carried out in August 2020. The Kinect camera was used as a height measurement instrument connected to a laptop where the body size calculation software was already installed. The camera was positioned with a height of 1.33 meters in front of the participant who stands upright at distance of 2.5 meters so that the whole body can be captured in a single image frame. Depth images of all participants were taken, and subsequently the height was calculated. Finally, the relationship between height and weight was established. In this study, relationships between both male and female participants were also developed.

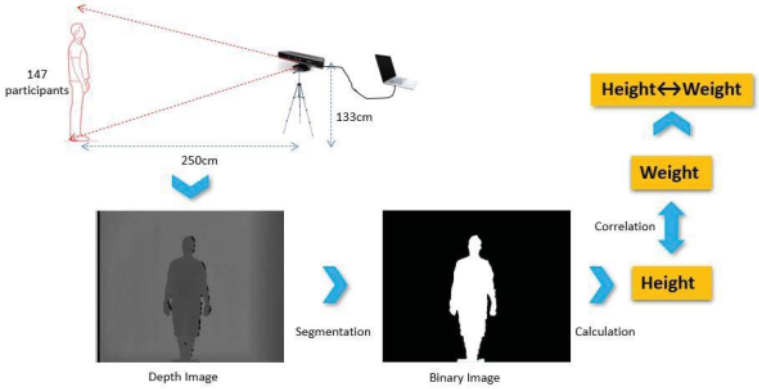

FIGURE 1. Research procedure. A depth image of the participant was taken using the Kinect. The image was then automatically segmented. Subsequently, the height of the participant was automatically calculated. At the same time, the weight was measured. All measured height data were correlated with all weight data.

Calibration of the Kinect Camera

Before implementation of the Kinect camera, relationships of distance-pixel value and distance-pixel size were calibrated. We used a Kinect box as an object with dimensions of 15 x 12 x 37 cm positioned with distance variation. At each distance, the image was captured, and subsequently the pixel value and the number of pixels on the sides of the box were determined. Finally, the linear relationships of distance-pixel value and distance-pixel size were developed. The results of this calibration may vary depending on the computer and camera used. Therefore, for each measurement, it is better to do a calibration first.

Calculating Height

Automatic human segmentation in the image of the Kinect camera was adapted from the method proposed by Afrieda *et al* [13]. The depth image was segmented with a threshold of 65 - 85 so that it becomes a binary image with a background value was 0 and an object value was 1. The height was simply calculated by finding the maximum value from the sum of the pixel values with the same x-coordinate. Once the maximum value in the pixel unit was found, the height in the cm unit was found, by multiplying the height in the pixel unit by the pixel size.

RESULTS AND DISCUSSION

Height Measurement

The height data from the Kinect camera and a ruler as the gold standard are obtained. The height measured by a ruler from 147 participants was 150.70 ± 11.447 cm and the weight was 46.18 ± 13.605 kg. The height data from both measurement methods are compared. **Figure 2** describes the height differences from both methods. Most of the data have a percent difference of 1%, and nothing more than 6%. These results indicate that the height measurement using the Kinect camera is accurate. Statistically, the p-value is 0.0096 which less than 0.05, indicating that the two measurement methods are not significantly different.

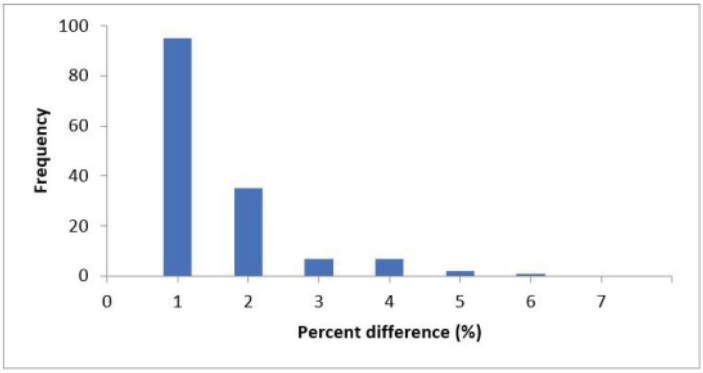

FIGURE 2. The histogram graph of the percentage difference of measured height by a ruler and Kinect camera.

Relationship between Body Height and Weight

Relationships between heights from the Kinect and weight for male, female, and all participants are depicted in **Fig. 3.** It shows that the increased height correlates linearly with the weight. The R^2 for male, female, and all participants are 0.2219, 0.5855, and 0.453, respectively. These results infer that we can estimate human body weight using a body measurement parameter such as height because both parameters are related. However, the value of the relationship between both parameters can be seen above.

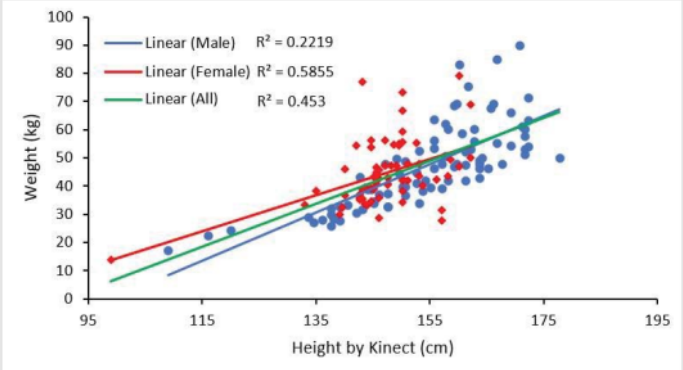

FIGURE 3. Relationship between body height from the Kinect and weight for male, female, and all participants.

It is found that R^2 for all participants is about 0.5. The value of R^2 is low, this is because the weight can not only be related by one variable in the term of the height but also, by other parameters such as a person's fat. In fact, even with the same height, a person's weight difference can be up to 2x or more. Thus, weight estimation is more accurate if 2D parameters (area of a person) or 3D parameters (the volume of a person) are considered. In the next study, will develop a software to calculate the area and volume of a person from the depth image of the Kinect camera.

The difference in R^2 values between male and female participants in this study shows that R^2 for female participants is greater than men. This shows that estimating body weight using height is more suitable for women, although the relationship is not that high. Moreover, this really depends on the statistical conditions of the participants. For a more accurate result, the number of participants should be increased so that it is considered statistically sufficient.

In this study, the height obtained using the Kinect camera is slightly higher than using a ruler. This is because the depth image is obtained from participants standing on a step wedge with a height of about 20 cm. Initially, we designed the height measurement with the Kinect camera so that participants could stand on the ground. However, because the segmentation technique uses a threshold that represents depth, the software recognizes several parts of the ground surface as part of the participant's body. Therefore, we took the initiative to use a step wedge in order to limit the scope of the plane and minimize calculation errors. However, the height results from the Kinect camera are still accurate, with discrepancies from the ruler are about 1%.

CONCLUSIONS

The software for automatically measuring the height of the human from the depth image of the Kinect camera has been successfully developed. The system is able to accurately measure the height. Due to the linear correlation between size and height, the system is also able to estimate body weight with R^2 is about 0.5.

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