UNIVERSITI TEKNIKAL MALAYSIA MELAKA

HUMAN HAND MEASUREMENT STUDY USING THREE-DIMENSIONAL CAMERA (3D) ANTHROPOMETRY SYSTEM WITH 3D CAD APPLICATION

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in fulfillment of the requirements for the degree of
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2023

DECLARATION

I declare that this thesis entitled "Human Hand Measurement Study Using Three Dimensional Camera (3D) Anthropometry System With 3d Cad Application" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Manufacturing Engineering Technology with Honours

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DEDICATION

A special dedication to my beloved parents Mr. Ahmad bin Kasmuri and Mrs. Masripah binti Mohd Hamdan for their support and pray for me in completing this final year project. They always supporting me and give very good advices. Not forgetting also to Mr. Mohd Fa'iz who helped a lot, gave encouragement, understood and gave guidance during the process of preparing this report.

ABSTRACT

Anthropometrics is the study of the measurements of the human body. Initially, anthropometrics was used to help scientists and anthropologists understand physical variation among humans. Anthropometrics is a set of direct quantitative measurements of the external dimensions of the human body that can be used as a proxy for body composition. In general, they use tools such as calipers and measuring tapes to take measurements on the body, such as height, width and girth. However, nowadays, a device has been designed with which it can perform measurements in 3D without touch. Although a relatively new technique, advanced systems using three -dimensional (3D) scanners are now in use due to some limitations of conventional manual techniques for the collection of body measurements. The purpose of this study was to collect and compare the circumference parameter data on the hands of the respondents by using the method of Conventional and 3D Camera Anthropometry System (3D CAS) which Kinect camera and also using Statistical Analysis. This experiment was conducted on 30 male respondents. During the experiment, respondents will first be measured using tools such as calipers and anthropometers for conventional methods, after which CATIA and SOLIDDWORKS software is used for experimental measurements in 3D. As a result of the data, calculations, analysis and comparison between standard deviation, mean and percentile were performed. The use of computer-aided design (CAD) software, such as CATIA, can improve efficiency and accuracy when measuring the human body by reducing the need for manual labor and decreasing measurement time. This is because CAD software allows for the quick and accurate measurement of a 3D scanned image of the human body, which can be done in a fraction of the time it would take to manually measure the body using anthropometry tools. Additionally, the differences identified in this research can serve as a basis for future studies aimed at improving the measurement process. The final objective of this project is to study the best way to measure the respondent's hand during the 3D Camera Anthropometry System (3DCAS) and the results of the study shows that the use of Catia software is a better way for measuring the human body compared to using Solidworks software.The expected result for this thesis is, conventional methods have taken a long time to perform measurements while this CATIA software can facilitate to perform measurements on the human body.

Keywords: 3D CAS, CATIA software, SOLIDWORKS Software, Kinect camera, Statistical Analysis.

ABSTRAK

Antropometrik ialah kajian tentang ukuran badan manusia. Pada mulanya, antropometrik digunakan untuk membantu saintis dan ahli antropologi memahami variasi fizikal di kalangan manusia. Antropometrik ialah satu set pengukuran kuantitatif langsung bagi dimensi luaran tubuh manusia yang boleh digunakan sebagai proksi untuk komposisi badan. Secara umumnya, mereka menggunakan alat seperti angkup dan pita pengukur untuk mengambil ukuran pada badan, seperti tinggi, lebar dan lilitan. Walau bagaimanapun, pada masa kini, peranti telah direka bentuk yang mana ia boleh melakukan pengukuran dalam 3D tanpa sentuhan. Walaupun teknik yang agak baharu, sistem termaju menggunakan pengimbas tiga dimensi (3D) kini digunakan kerana beberapa batasan teknik manual konvensional untuk pengumpulan ukuran badan. Kajian ini bertujuan untuk mengumpul dan membandingkan data parameter lilitan pada tangan responden dengan menggunakan kaedah Sistem Antropometri Kamera Konvensional dan 3D (3D CAS) iaitu kamera Kinect dan juga menggunakan Analisis Statistik. Eksperimen ini dijalankan ke atas 30 orang responden lelaki. Semasa eksperimen, responden terlebih dahulu akan diukur menggunakan alat seperti angkup dan antropometer untuk kaedah konvensional, selepas itu perisian CATIA dan SOLIDDWORKS digunakan untuk pengukuran eksperimen dalam 3D. Hasil daripada data tersebut, pengiraan, analisis dan perbandingan antara sisihan piawai, min dan persentil telah dilakukan. Penggunaan perisian reka bentuk bantuan komputer (CAD), seperti CATIA, boleh meningkatkan kecekapan dan ketepatan semasa mengukur badan manusia dengan mengurangkan keperluan untuk buruh manual dan mengurangkan masa pengukuran. Ini kerana perisian CAD membolehkan pengukuran pantas dan tepat bagi imej imbasan 3D tubuh manusia, yang boleh dilakukan dalam sebahagian kecil daripada masa yang diperlukan untuk mengukur badan secara manual menggunakan alat antropometri. Selain itu, perbezaan yang dikenal pasti dalam penyelidikan ini boleh menjadi asas untuk kajian masa depan yang bertujuan untuk menambah baik proses pengukuran. Objektif akhir projek ini adalah untuk mengkaji cara terbaik mengukur tangan responden semasa Sistem Antropometri Kamera 3D (3DCAS) dan hasil kajian menunjukkan bahawa penggunaan perisian Catia adalah cara yang lebih baik untuk mengukur badan manusia berbanding menggunakan perisian Solidworks.Hasil yang diharapkan untuk tesis ini ialah, kaedah konvensional telah mengambil masa yang lama untuk melakukan pengukuran manakala perisian CATIA ini dapat memudahkan untuk melakukan pengukuran pada badan manusia.

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LIST OF SYMBOLS AND ABBREVIATIONS

P	-	Percentile
n	-	Number of values in data set
σ	-	Population standard deviation
X	-	Datapoint value
μ	-	Mean
N	-	Population size
	-	
	-	

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CHAPTER 1

INTRODUCTION

1.1 Background

Anthropometry is an ergonomics field of study that deals with body size and shape. People available in a variety of sizes, and it's essential to consider for these differences in physical parameters when designing anything for them to use, from a pencil to a chair or an automobile. Anthropometry may be described as the measuring of human beings in more detail. Gender differences, ethnic disparities, growth and development, ageing, socioeconomic status, and employment are all factors that impact anthropometric measures (S. M. and S. 2013).

1.2 Problem Statement

This thesis focuses on the manual measuring process and the 3D camera system. Several key measurements for designing products and tools for the hand are missing from conventional anthropometric studies. The problem is, while conducting this experiment, high waiting time for respondents during the measurement session where respondents here wait a long time to measure all parameters. As a result, readings obtained using manual measurement tools like rulers, measuring tapes, and others are taking more time. In order to make the measurement process much easier, the 3D camera system was created. If the images the camera generates are not as clear, the cameras flaws become limitations, which are not as obvious as the lens is not totally accurate. In addition, the issue of touching between the respondent and the conventional body measurement time surveyor, especially for Malaysians, which is mostly for Malay Muslims in particular. So, measuring has become more challenging.

1.3 Research Objective

The primary objective of this study to achieve the problem statement above this project is:

a) To collect the measurement data of linear and circumference parameter on respondent's hand by using conventional and 3D Camera Anthropometry System (3D CAS) method.

b) To analyze on the comparison between the data obtained from conventional method and 3D CAS method with statistical analysis.

c) To study the best way to measure the respondent's hand during the 3D Camera Anthropometry System(3DCAS)

1.4 Scope of Research

The scope of this research is focused on 3D Camera Anthropometry System with the total 15 parameters of the linear measurement of the hand anthropometry. This study was conduct at conventional measurement in Ergonomics Laboratory in Faculty of Mechanical and Manufacturing Engineering Technology and 3D scanning in Faculty of Manufacturing Engineering. This experiment was done out with a 30 of male respondents aged 22 to 26 years old. The measurements were obtained using CATIA and SOLIDWORKS software and also 3D rendered device such as a 3D Camera Anthropometry System (3D CAS) which is Kinect Camera. The calculation both conventional and 3D measurement using Statistical Analysis which is standard deviation, mean and percentile (5th,50th and 95th).

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Anthropometry is the study of taking systematic measurements of the human body. In the 19th century, physical anthropologists employed anthropometry to examine human diversity and evolution in both living and extinct groups. Historically, such anthropometric measures have been used to link ethnic, cultural, and psychological traits to physical traits. Human dimensions, such as height, surface area, weight, and volume, as well as structure, such as shoulder, standing vs. sitting height, and hip breadth, arm/leg length, and neck circumference, and composition, such as water content, body fat percentage, and lean body mass, are all anthropomorphic metrics (Biologydictionary.net Editors., 2017).

2.2 Conventional Method Anthropometry

Conventional methods for obtaining anthropometric measures from the hand, such as using a caliper and tape measure, have been used in a variety of studies. The tape measure is used to record the lengths of the human body at surface measurements such as circumferences, whereas the calipers is used to obtain linear measurements such as length and depth.(Seifert and Griffin 2020). To determine an individual's health, conventional anthropometrics are widely employed in medical field and epidemiological studies. Conventional methods, on the other hand, compress the complex structure of human bodies to a series of simple size measurements and health indices, like the body mass index (BMI), waist-hip-ratio (WHR), and waist-by-height0.5 ratio (WHT.5R). Three-dimensional (3D) imaging technologies can collect

accurate and detailed measurements of the exterior human form, and they have the potential to outperform existing health-care assessments (Thelwell et al. 2020).

The distance between body landmarks (usually bony points like the acromion and patella) is measured using a variety of equipment such as stadiometers, anthropometers, sitting-height tables, and the tape measure in conventional techniques of collecting anthropometric data. Stadiometers and similar devices need to be calibrated (particularly after transit), and measurements are only as precise as the person taking them (Sims et al. n.d.). Several important measurements for designing things and tools for the hand are unavailable from conventional hand anthropometric studies. Finger lengths, crotch depths, palm and padding, back of hand, and wrist opening are all anthropometric hand data that can help increase dexterity, gripping, hand entry, adduction, abduction, and squeezing in hand products like gloves (Griffin et al. n.d.).

2.3 Anthropometric Measuring Equipment

Using equipment to acquire specified measures, anthropometric data are collected from the hand. Conventional methods such as caliper and tape measure, as well as three-dimensional scanning such as the Kinect camera, are available to acquire anthropometric data from the hand (Seifert and Griffin 2020).

2.3.1 Large Sliding Caliper

The anthropometer's upper segment is usually used for this equipment. It has two straight branches that can be used to measure big bone breadths like the Biiliocristal and Biacromial. These branches are coupled to a rigid metal scale, which is important because significant pressure is required for measuring bone dimensions. To confirm that it has been assembled correctly, the distance between the branches should be verified (Norton, 2018).

Figure 2.1 Large Sliding Caliper (Lafayette, 2017)

2.3.2 Small Sliding Caliper

The Biepicondylar humerus and Femur breadths are measured with this caliper. It's the perfect tool for these measurements. Longer arms on these calipers allow them to cover the biepicondylar breadth of the femur and humerus, and they are quite accurate (to within 0.1 mm). Branch lengths of at least 10 cm and a 1.5-cm application face are required (Norton, 2018).

Figure 2.2 Small Sliding Caliper (ferreestoolsinc, n.d.)

2.3.3 Measuring Tape

For girths, a measuring tape with millimeter gradations calibrated in centimeters is recommended. Because non-metal tapes can stretch over time, regular calibration against a steel tape is essential if fiberglass tapes are used. Any other tape should be non-extensible, flexible, no wider than 7 mm, and have a stub (blank area) of at least 4 cm before the zero line if it is to be used. An anthropometric tape is needed to precisely find several skinfold sites and mark distances from bony landmarks in addition to analyzing girth measurements. It is best if the tape is kept in a casing that retracts automatically (Norton, 2018).

Figure 2.3 Measuring Tape (Habdirect, n.d.)

2.3.4 Wide Spreading Caliper

This tool, which is made up of two curved arms, is utilized to determine the depth of the chest from front to back. To enable the caliper's arms to be placed over the shoulder and reach the appropriate anatomical landmarks, they should extend at least 25 cm beyond the measurement scale. (Norton, 2018).

Figure 2.4 Wide Spreading Caliper (Seritex, n.d.)

2.4 Measurement Anthropometric

Anthropometric measurements were taken using a standardized methods by trained examiners. A stadiometer was used to measure the participants height without shoes to the nearest centimeter. With structured medical scales, participants bodyweight was measured to the nearest 0.1 kg while wearing light indoor clothing and no shoes. BMI was computed by multiplying weight by height squared (kg/m2) (Petkeviciene et al. 2015). Weight, height, BMI, body circumference (arm, waist, hip, and calf), waist to hip ratio (WHR), elbow amplitude, and knee-heel length were among the anthropometric measurements (Sánchez-García et al. 2007a).

2.5 Composition of Body in Anthropometric

Anthropometry was the only method for measuring body size and proportions more than seven decades ago. Equations for determining body fat using measures of body length, width, circumference, and skinfold thickness were developed as early as 1921 (Wang et al. n.d.). An anthropometric measurement by a qualified medical professional is cheap, non-invasive, and provides extensive information on the various components of body structure, particularly muscle and fat components. Anthropometric measurements reflect differences in body composition between men and women at various phases of life. Some scientific studies

have looked on changes in body composition in people over the age of 60 (Sánchez-García et al. 2007a).

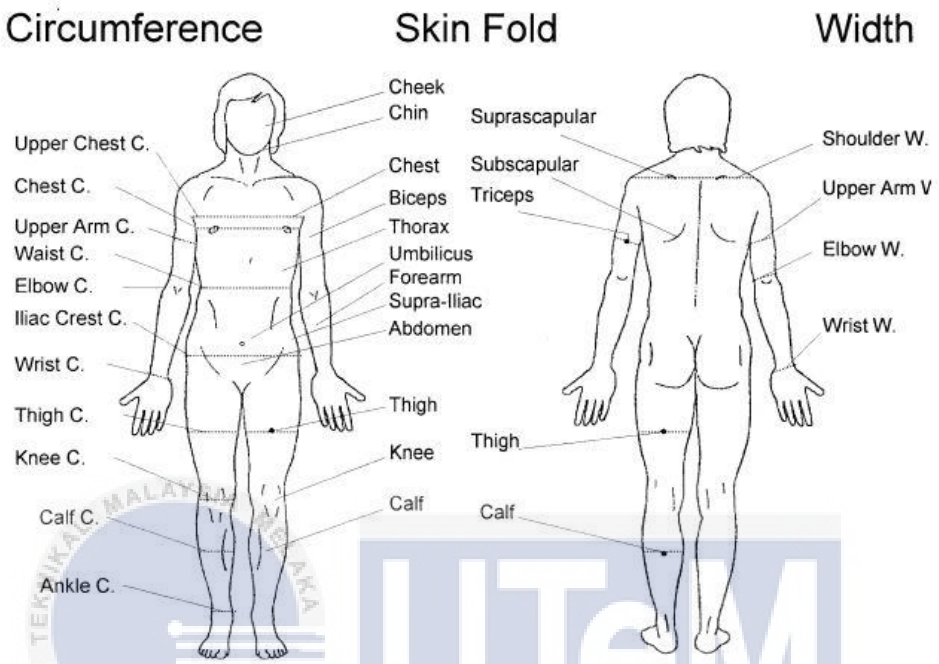

Figure 2.5 Sites for anthropometric measurement (Ujević et al., 2006)

Skinfold thickness is measured at over 19 different sites. Figure 2.5 1 shows the sites that are used at center point as well as many other research facilities. Because it is easy to access, reproducible, and can measure large differences among people, the site over the triceps was used more regularly than other sites (Sánchez-García et al. 2007b). There are high level accuracy reference methods as well as actual methods that vary in validity because they always represent indirect body composition measurements. Multi-component models, particularly the 4-component model based on measurements of body density such as hydrodensitometry, total body water such as deuterium dilution method, and bone mineral such as dual energy X-ray