THREE DIMENSIONAL COMPUTER AIDED DESIGN APPLICATION IN UPPER BODY MEASUREMENT STUDY USING KINECT CAMERA

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Faculty of Mechanical and Manufacturing Engineering Technology

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A thesis submitted
in fulfillment of the requirements for the degree of
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DECLARATION

I declare that this thesis entitled "Three Dimensional Computer Aided Design Application In Upper Body Measurement Study Using Kinect Camera" 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. Fadzil bin Mohtar and Mrs. Nor Aini binti Yusop 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

Anthropometric is the study of human body measurement. In recent decades, the process of anthropometry has traditionally been done by trained staff using manual tools like tape measures, calipers, and other equipment of different sizes and shapes. The benefits of using manual anthropometric methods include low cost and convenience, as they can be conducted during daytime. Nevertheless, in recent years, new three-dimensional anthropometric studies have emerged, where body measurements are taken quickly, without physical touch and utilizing 3D scanners. Manual measurement can be quite time-consuming and requires a significant amount of staff to measure all parts of the body. This study objective to study the use of CatiaV5 and Solidworks2020 in measuring upper body limbs, to investigate the error differences between manual and 3D measurements and to collect data using both conventional and 3D Camera Anthropometry System methods. To streamline the process, this study utilizes 3D measurement techniques, such as using software like CatiaV5 and Solidwork2020 for measurement. From the data that has been collected, a comparison between manual measurement and 3D measurement has been done to see if there is a significant difference between them. The conclusion of the study suggests that there are certain improvements in anthropometric measurements obtained using 3D software compared to manual measurements. As a result, this comparison may suggest potential changes in the future study of anthropometry.

Keywords: Catia V5, 3D CAD Measurement, Solidwork, Anthropometric measurement, 3D CAS

ABSTRAK

Antropometrik ialah kajian tentang ukuran badan manusia. Dalam dekad kebelakangan ini, proses antropometri secara tradisinya dilakukan oleh kakitangan terlatih menggunakan alat manual seperti pita pengukur, angkup dan peralatan lain yang berbeza saiz dan bentuk. Faedah menggunakan kaedah antropometrik manual termasuk kos rendah dan kemudahan, kerana ia boleh dijalankan pada waktu siang. Namun begitu, dalam beberapa tahun kebelakangan ini, kajian antropometrik tiga dimensi baharu telah muncul, di mana ukuran badan diambil dengan cepat, tanpa sentuhan fizikal dan menggunakan pengimbas 3D. Pengukuran manual boleh memakan masa yang agak lama dan memerlukan sejumlah besar kakitangan untuk mengukur semua bahagian badan. Objektif kajian ini untuk mengkaji penggunaan CatiaV5 dan Solidworks2020 dalam mengukur anggota badan atas, untuk menyiasat perbezaan ralat antara pengukuran manual dan 3D dan untuk mengumpul data menggunakan kaedah Sistem Antropometri Kamera konvensional dan 3D. Untuk menyelaraskan proses, kajian ini menggunakan teknik pengukuran 3D, seperti menggunakan perisian seperti CatiaV5 dan Solidwork2020 untuk pengukuran. Daripada data yang telah dikumpul, perbandingan antara pengukuran manual dan pengukuran 3D telah dilakukan untuk melihat sama ada terdapat perbezaan yang signifikan antara mereka. Kesimpulan kajian menunjukkan bahawa terdapat peningkatan tertentu dalam pengukuran antropometrik yang diperoleh menggunakan perisian 3D berbanding dengan pengukuran manual. Akibatnya, perbandingan ini mungkin mencadangkan perubahan yang berpotensi dalam kajian antropometri masa hadapan.

Kata kunci: Catia V5, Pengukuran CAD 3D, Kerja Pepejal, Pengukuran antropometrik, CAS 3D

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Last but not least, special thanks to my beloved parents Mr. Fadzil bin Mohtar and Mrs. Nor Aini binti Yusop for their support and pray for me in completing this thesis. Finally, thank you to all the individual(s) who had provided me the assistance, support and inspiration to embark on my study.

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LIST OF SYMBOLS AND ABBREVIATIONS

P – Percentile

n - Number of values in the data set

M = Mean (average).

K = Factor related to normal distribution on (Z tables).

S = Standard deviation.

R = Respondent

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CHAPTER 1

INTRODUCTION

1.1 Background

Anthropometry is the science that defines physical measures of a person's size, form, and functional capacities. Applied to occupational injury prevention, anthropometric measurements are used to study the interaction of workers with tasks, tools, machines, vehicles, and personal protective equipment, especially to determine the degree of protection against dangerous exposures. The core elements of anthropometry are height, weight, head circumference, body mass index (BMI), body circumferences to assess for adiposity (waist, hip, and limbs), and skinfold thickness.

The advancement of anthropometric methods, which is progressively moved from manual to three dimensional (3D Scanning Measurement increase the usage in the anthropometric survey data (Treleaven, 2004).

Figure 1.1 Three-dimensional body scanning anthopometric setup (Treleaven, 2004)

Estimating the pose of a human in 3D given an image or a video has recently received significant attention from the scientific community. The main reasons for this trend are the ever increasing new range of applications (e.g., human-robot interaction, gaming, sports performance analysis) which are driven by current technological advances. Although recent approaches have dealt with several challenges and have reported remarkable results, 3D pose estimation remains a largely unsolved problem because real-life applications impose several challenges which are not fully addressed by existing methods. For example, estimating the 3D pose of multiple people in an outdoor environment remains a largely unsolved problem.

1.2 Problem Statement

In this anthropometric field, the size and shape of a person's body is very influential in making the decision to choose a design. So if there are multiple forms, it will pose some problems in collecting the required data.

First, if we use a manual method to measure it will take quite a long time to measure every limb of one's body using a typical instrument. It will take a long time to measure all the parameters only for one respondent. It also allows us to collect incorrect data due to human error when we want to measure difficult parts such as eyes, mouth, ears and so on.

1.3 Research Objective

The main aim of this research are:

i) To study on measuring method of the upper limb body using CatiaV5 and Solidworks2020

ii) To investigate the error difference between manual measurement using anthropometry tools and 3D measurement using 3D CAD software and its pattern

iii) To collect the measurement data of respondent's upper limb body using conventional and 3D Camera Anthropometry System (3D CAS) method

1.4 Scope of Research

This research will focus on the upper body anthropometric methods. The scope of this project are first all measurement will be conducted in a laboratory in Universiti Teknikal Malaysia, Melaka. The manual measurement have taken place in Makmal Ergonomic in Fakulti Teknologi Kejuruteraan (FTK) while 3D CAS measurement have been taken at Makmal Ergonomic at Fakulti Kejuruteraan Pembuatan (FKP). The parameters that used in this research contains only 15 parameters. The 3D model have been rendered by using Skanect Software.

Next, the respondent has been set up with 30 respondents and the age range are between 22-26 years old. This study focus on the range age group because every people when they get older, their body segment will be different. After all the data has been collected, the data analysis has been done by using statistical method. This method focus on the calculation on mean, standard deviation and percentile. In this research, the percentile that has been use is 5th, 50th and 95th percentile.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Anthropometric measurements are useful in many fields. For example, athletes needs to understand that body size and composition are important factors in their sports performance. In general, anthropometry is the study of the measurement of the human body. By tradition this has been carried out taking the measurements from body, such as circumferences, using simple instruments like calipers and tape measurement. It has been used as an alternative to measuring body height for some group of people, which differs between different races and genders. (Popovic, Bjelica, et al., 2016). Moreover, the anthropometric measurements involved are the size such as weight, surface area, height and volume. Futhermore, the anthropometric measurements that are involve in this research is upper body parameter such as shoulder width, arm length, waist circumference, neck width and breath width.

2.2 Anthropometry History

The history of anthropometry includes its use as an early tool of anthropology, use for identification, use for the purposes of understanding human physical variation in paleoanthropology and in various attempts to correlate physical with racial and psychological traits. The word "anthropometry" is derived from the Greek word "anthropic," meaning "human," and the Greek word "metron," meaning "measure" (Ulijaszek, 1994). In 1883, Frenchman Alphonse Bertillon introduced a system of identification that was given name as "Bertillonage". Bertillon concluded that when these measurements were recorded systematically, every individual would be distinguishable.

Figure 2.1 : Illustration from “The Speaking Potrait”:The principle of Bertillon’s anthropometry (Person’s Magazine, Vol XI, January to June 1901)

2.3 Three-Dimensional Anthropometry

In 1973, the study of the human body as a three-dimensional has been proposed by Lovesey with a light sectoning technique (Lovesey, 1966). As the interpretation of data was extremely take time to collect, it was label as labor intensive. This make that technology evolved to what we known as 3D body scanner. One of the earliest 3D body scanning systems was a shadow scanning method developed by the Loughborough University in the UK, the Loughborough Anthropometric Shadow Scanner – LASS – (Jones et al., 1989).

For the past several years, the technology of anthropometry measurement have been evolving very quick. Now it is possible to have a complex geometrical features like curve or partial volumes because the measurement are not limited, just not like the traditional one-dimensional measurement. This three-dimensional body scanner have make a big impact in anthropometry field. It makes the measurement more accurate, being more practical, less expensive or cheaper and fast, compared to the conventional anthropometry.

2.3.1 3D Genex Camera System

The digital anthropometric measurement are increasingly being use in clinical settings that monitor and manage the patients with obesity and related metabolic disorder. It was admisnistered with three-dimensional (3D) optical devices. It give a new powerful tool to the science of anthropometry when using digital device for body scanning. It allows deeper investigation on human body shape too.

In an experiment that have been done by Seth M. Weinberg, Nicole M. Scott, Katherine Neiswanger , Carla A. Brandon and Mary L.Maratiza , they have compared the anthropometric measurement through 3D photogrammetry system which is Genex and 3dMD. There also use conventional measurrement to evaluate the intraobserver precision across these methods. In this experiment thaey have use 18 mannequin heads with 12 linear distance were measured twice by each of that methods. Next after the measurement has finished they find that no significant differences were recorded for for precision. This experiment is the first attepmt to silmultaneously compared 3D image surface with one another and with conventional anthropometry measurement. The result indicate that overall mean different when use this three methods were small enough to be a little practical importance and in term of the intraobserver precision, all methods fared equally well.

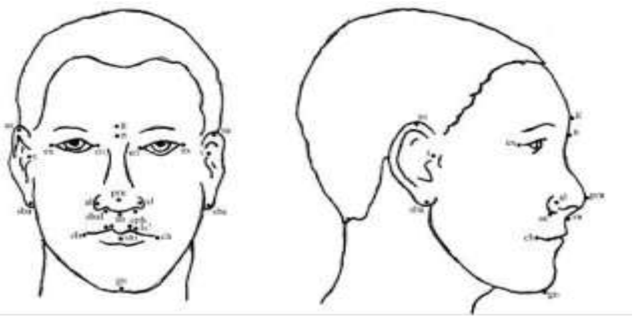

Figure 2.2 : The carniforcal landmarks that have been used in this study(Weinberg et al,. 2001)

As conclusion the result that obtained state that the accuracy prediction that correlated with Genex indicate very high levels of precision and fairly good congruence with conventional measurement. The precision of the Genex camera were superior in many instance copared to the existing 3D alternative system. This finding have suggest that the Genex camera system can performing the required standard for either medical or basic research purpose. It show that this research has already done for surgical outcome assessment in breast reconstruction with good reslut by using the Genex 3D system (Galdino et al.,2002). Furthemore, this system currently being used at University of Pittsburgh for evaluation of facial morphology in families that have a history of oral clefts (Neiswenger et al., 2001).

TABLE 8 Comparison of the Genex Three-Dimensional System to Direct Anthropometry

Variable	Mean Photo*	Mean Calipers*	Difference	Test Stat†	p
n-gn	120.74	120.78	−0.04	−0.09	ns
n-sto	75.41	75.45	−0.04	−0.13	ns
sn-gn	68.62	67.45	1.17	2.74	ns
g-sn	66.91	67.60	−0.69	−53‡	ns
t-n	120.83	123.23	−2.40	−6.22	< .003
t-sn	124.97	127.21	−2.24	−101‡	< .003
t-gn	141.87	138.46	3.41	−0.32	ns
en-en	30.54§	30.68§	−0.14	−0.33	ns
ex-ex	85.70	88.16	−2.46	−5.40	< .003
sa-sba	60.91	63.44	−2.53	−2.67	ns
al-al	34.04	32.65	1.39	2.30	ns
n-sn	55.55	56.33	−0.78	−2.86	ns
sn-prn	21.51	21.45	0.06	0.41	ns
ac-prn	31.89	32.54	0.65	86‡	< .003
cph-cph	12.52	12.53	−0.01	−1.5‡	ns
ch-ch	49.82	51.40	−1.58	−4.99	< .003
sn-sto	20.93	20.21	0.72	3.55	< .003
sbal-ls'	15.69	16.27	−0.58	−79‡	< .003
sn-ch	37.48	37.87	−0.39	−1.82	ns

* Mean from observer 1 measurements with dots.
† Test statistic derived from paired t test unless noted otherwise.
‡ Test statistic derived from Wilcoxon signed rank test.
§ Mean from observer 1 measurements without dots.

Figure 2.3 The data comparision between Genex 3D system with Direct Anthropometry measurement (Galdino et al.,2002)

2.3.2 Kinect-based anthropometric measurement

The Right now, the main concern for anthropometric measurement is to find the tools that can taking measurement efficiently and reliably. The use of conventional measurement in anthropometric has been criticized for being time consuming. The motion capture entertainment tools like Kinect , show some promise in anthropometry for it advantages. The devices is light, easy to use and can be interfaced with computer Microsoft windows operating Systems.

The Kinect devices are suitable for anthropometric measurement. Correlation of the calculated results with the monitoring sample and other anthropometric results allows it to assume that Kinect data is accurate within standard mean variations and variance discrepancies. Even with minor errors exist due to light, distance sensor, and clothes (Espitia Contreras, Sanchez-Caiman and Uribe-Quevedo, 2014). The Kinect sensor enables the computer to immediately detect the third (depth) dimension of playback and the surrounding environment. (Zhang, 2012).

There are research that have been done about 3D foot scanner using Microsoft Kinect tools. A perfect 360° image can be obtain by rotating the scanner around the subject's foot. To prevent the inconsistent scanning radius or minimum distance between the foot and sensor during the scaning progress, an automatic rotating rig has been build to overcome the problems. The Kinect sensor has been placed onto the scanner rig that rotated by the subject's foot. In less than 30 second, the scanning process are complete. The file then are imported into CAD software for the measurement to be taken. Five parameter for foot anthropometry measurement were performed which is foot length, foot width, heel width, lateral malleolus height and foot width circumference. The result from this experiment are the low cost 3D scanner was proven to be accurate in measuring human foot anthropometry. The scanner will be valuable in producing a custom-made sports shoe at a much lower cost. (Zahari Taha et al,.2013).

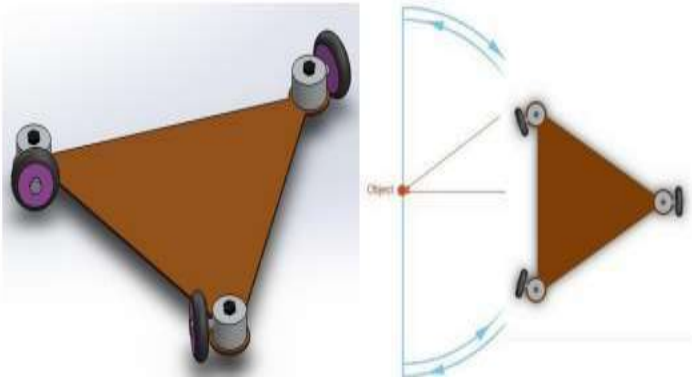

Figure 2.4 : The rotating rig for scanning purpose
(Taha et al,. 2013)

Next, Zhaoxin Li (Li et al,. 2013) team research had also used the rotating 3D scanning method to scanning the subject. They use a static digital camera position and the subject will standing on a rotating disk. While the subject rotating, the camera will captured multiple images of subject's body to generate a 3D body measurement. The parameter measurement that they focus on this research are hip circumference, waist circumference, waist-to-hip ratio, neck circumference, arm circumference and chect circumference. Figure 2.5 show how the rotating scanning techniques has been done.

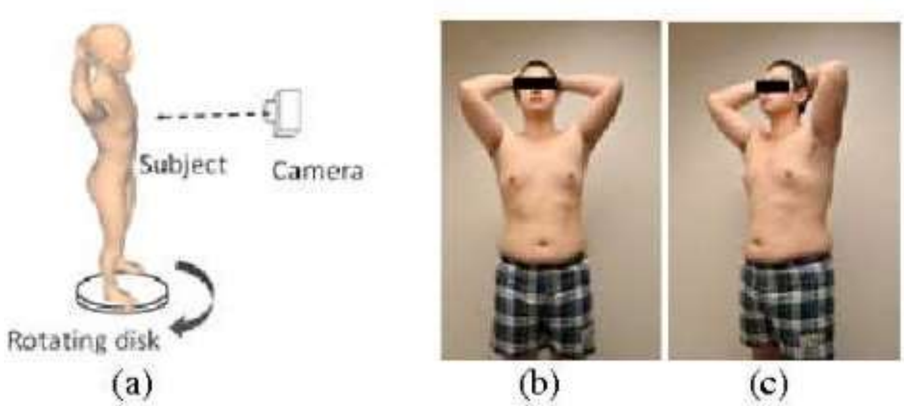

Figure 2.5 : (a) sketch of the system configuration : (b) and (c) : Two of the acquired raw images

2.4 Anthropometric Data Measurement

Anthropometric data measurement are the data on human shape and body; are the basis upon which all digital human models are constructed (Russell Marshall et al,. 2019). The, postures that can be adopted, the pysical size and the tasks that can be done are all influenced by some degree of anthropometry. The objective in applying anthropometric data will be to improve the design of things and spaces for people to use so that they are more comfortable, efficient, easy to use and safer than previous designs.

Anthrapometric data measurement is done while in standing or sitting position according to measurement variable required. There are variety of factors that influence the human body dimension. The diversity of ethnic always be the significant factor that may effect the anthropometric data measurement (Lin et al,.2004).

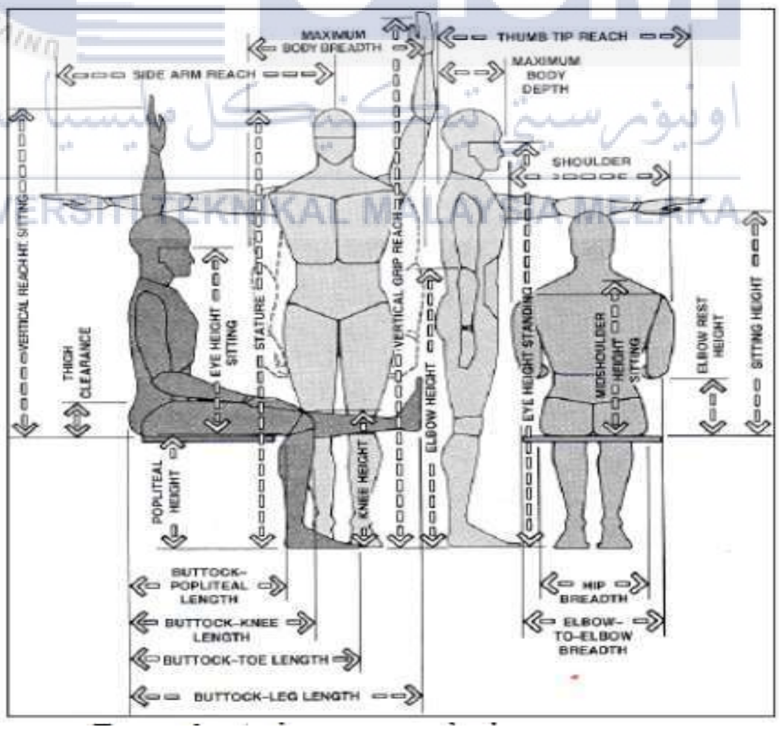

Figure 2.6 : The anthropometric body data measurement while sitting and standing

2.5 Anthropometry of 3D CAS

This Computer aided design software can speed up the process of putting a new model into production and improve the quality of the products. It also can reduces labour intensity and reduces material cost. By using the 3D surface scanning, it has the potential to help change the way a wide range of products that were design and produce. Measurements acquired by 3D scanning device should be checked out for compliance with CAD systems for automatized pattern making procedure (Inga et al,. 2015).

In 2015, this research are about in the garment industry. The computerization of several different processes in the garment industry is necessary to reduce the costs of a product and raise the competitiveness. The scanning technologies such as 3D scanning are being inproved and developed. This technologies can make the collection of digital information on body scanning more efficient. Figure 2.7 shows the process of collecting data in CAD/CAM individual measurement list and production.

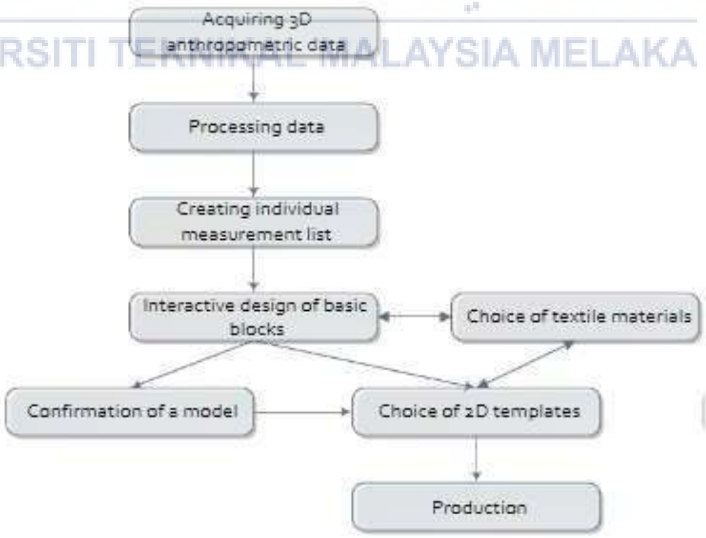

Figure 2.7 : shows the process of collecting data in CAD/CAM individual measurement list and production.

3D body scanning make the data extraction of body measurement recorded in second. Automated extraction of individual measurements to CAD individual measurement list ensures data exchange between 3D body scanning and CAD (Inga et al,.2015). In this experiment, 9 females age range of 20-30 years old , bodies were test, pattern blocks and sample made. All of them was subjective assesed and mostly got 0 or +/-1 points. The software that they were use in this research is Grafis. Grafis is CAD software for marker making and pattern design. It offers creation and modification of pattern pieces, grading and output to printers. It also plot as well as export of the finished pattern in several data formats.

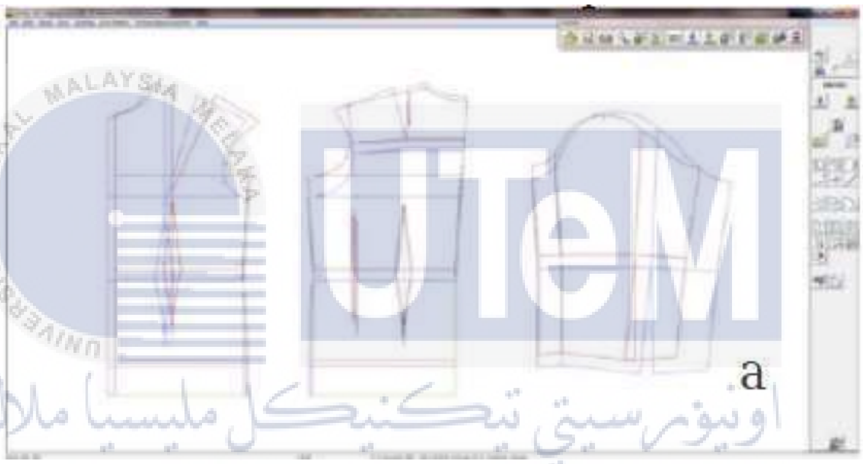

Figure 2.8 : The pattern making by using Grafis software for this experiment (Inga et al,. 2015)

2.6 Catia Software

Video The meaning of CATIA is Computer Aided Three-Dimensional Interactive Application. It is a full software suite which incorporates CAD, CAE (Computer-Aided Engineering) and CAM (Computer-Aided Manufacture). CATIA has been around for more than two decades. CATIA Version 5 is one of the available software that can perform Digital Human Modelling (DHM). It provides a variety process and ergonomics analysis tools that can analyze all factors and provide extensive ergonomics design solution for designer (Ye,Li & Li et al,. 2013)

The entire process of design and turning the product to conducting an integrated analysis and manufacturing can be cover by using the CATIA Version 5. One of them is the entire calculation of special strength reports. This calculation's foundation is a complete mathematical model of replacement parts. Besides that, CATIA software are able to import the following types of files such as IGES (.iges, igs), Adobe Illustrator (.ai), 3D object (.obj), drawing (.dwg) and many more.

Figure 2.9 : The page of CATIA V5

DHM process can be done by using CATIA V5 because it can offers designer with extensive ergonomics technical solution. The use of actual dimension of operating systems is requires a wide range of body size. So the actual human anthropometry is used to replicate the best performance between control center interfaced and human (Luquetti et al,.2013).

In 2021, Saurabh Gunturkar and his team has done a research about ergonomics analysis about the posture of human when cycling. The aim of the research is to find the most hazardous operating posture which is pedaling in standing position or pedaling is sitting position. By using the CATIA V5 software, they have draw the body part of bicycle and assemble all designed parts. They also have perform two most important analysis of bicycle that is RULA & RUBA analysis. Both analysis can be done by using CATIA (Gunturkar et al,. 2021).

Figure 2.10 : The flow of the research by Surabh Gunturkar ,2021

2.7 Solidwork Software

SolidWorks is a solid modeling computer-aided design (CAD) and computer-aided engineering (CAE) application published by Dassault Systèmes. SolidWorks is a solid modeler, and utilizes a parametric feature-based approach which was initially developed by PTC to create models and assemblies. Building a model in SolidWorks usually starts with a 2D sketch. The sketch consists of geometry such as points, lines, arcs, and splines. Dimensions are added to the sketch to define the size and location of the geometry. Relations are used to define attributes such as tangency, parallelism, perpendicularity, and concentricity. The parametric nature of SolidWorks means that the dimensions and relations drive the geometry, not the other way around. The dimensions in the sketch can be controlled independently or by relationships to other parameters inside or outside the sketch.

In 2013, this study was about the use of highly complex surgical procedures includes joint replacement involving the distal femur since this will entail the precise positioning of well-fitted implants and sufficient alignment of the surrounding soft tissues (Goldberg, Figgie and Figgie, 1989). Joint replacement involving the distal femur requires the use of highly complex surgical techniques, as this would involve the accurate placement of well fitted implants and adequate balancing of the surrounding soft tissues. However, no known literature has previously identified the measurements of the majority of the population located in many Southeast Asian countries, such as Malaysia, Singapore, Indonesia, and so on, which consist primarily of the Malay population. In this study, a four-row multi slice CT (Somatom, Volume Zoom, SIEMENS) scanner set with fixed scanning parameters of 3 mm slice thickness, 1.5 mm recon increment, 1.25 mm collimation, 12 mm feed per rotation, 90 mAs and 120 kV has been used (Hussain et al., 2013).

Using the raw data obtained from the scanned images obtained by the use of AMIRA 4.0 software, three-dimensional (3D) models of the knee joint were reconstructed. The anteroposterior and medio lateral measurements were carried out using the SolidWorks 2009 analysis method, as shown in Figure 2.11 (Hussain et al., 2013).

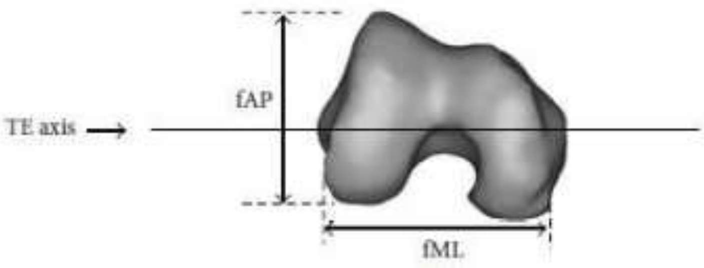

Figure 2.11 : The medio lateral and anteroposterior measurement (Hussain et al., 2013)

2.8 Parameters of Anthropometric

Anthropometric parameters can be used to describe the body as a whole or to subdivide the body into compartments. Anthropometric data can be utilized directly such as body weight to estimate lean or fat mass or to predict energy and protein needs (Saltzman et al,.2001).

The parameter measurement is the examination of the physical measurement of human body. These parameter were use to differentiate the groups based on their age, gender, races and body type. This happen because every human have a very unique form of body measurement and type, whether it is large, small or obesity. The parameter also can be affected by an individual’s age. When human grows up, it will becomes more distinct and distinctive. Parameter of human body arre split into five major segment which is head, neck, arm, hand and leg.

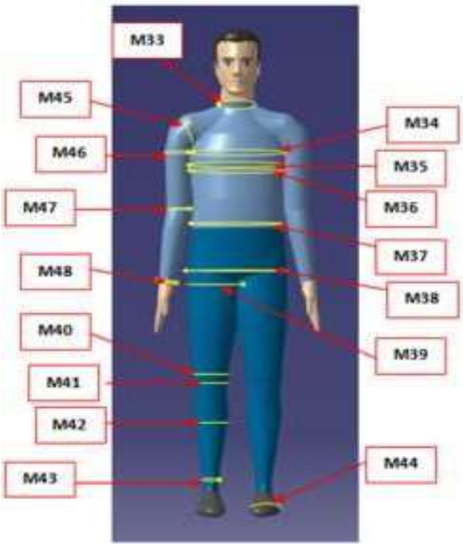

Figure 2.12 : The parametes of human body

2.9 Percentile of Anthropometric

Percentile is the percentage of people who are smaller than a given size. It is typically designs are specified to fit from 1st,2nd,5th percentile to 95th,98th,99th percentile. A case study from Y. Wang & Chen (2012), they have state that the term of percentile and the associated term percentile rank are widely used in descriptive statistics and the analysis of results from standard cited examinations.

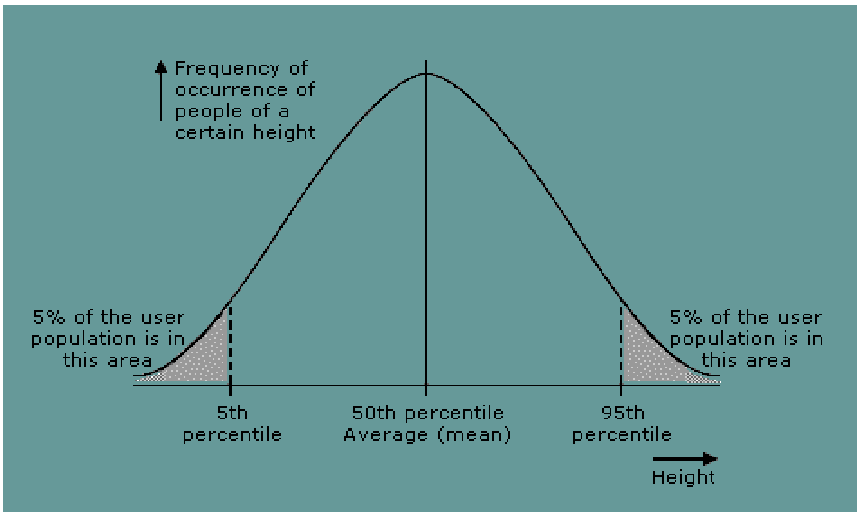

Figure 2.13 : The standard distribution curve for certain height of people

As we can see on Figure 2.13, the graph has shown the distribution curve for certain height of people. Most of us are at 5th or 95th percentile region as shown in the graph. So 50% of people are in the average height of taller people and 50% are in the average height of shorter people. The graph tails off to either end because there are some people that are extremely tall or very short. Beside, percentile and percentage are two different things. They should not be mistaken because the above is used to represent percentages of the total, whereas the percentiles are the levels in which a certain proportion of the data is contained in the data collection.

The general definition of a percentile is a number where a certain percentage of scores fall below that number. Percentile for values in the data set can be calculated using the book's formula (Kroemer et al,. 2017). The formula as below:

$$\text{Rank} = \left(\frac{P}{100}\right) x\ (n + 1)$$

Rank = Ordinal rank of a given value (with the values in

the data set scored fromSmallest to largest.

P = Percentile.

n = Number of values in the data set.

$$P = m + ks$$

P = Percentile.

M = Mean (average).

K = Factor related to normal distribution on (Z tables).S = Standard deviation

a. Mean

$$\tilde{x} = \frac{\sum x}{n}$$

$\tilde{x}$ = Mean (average).

x = Total sum number.

n = Size of the set.

b. Standard Deviation

$$\sigma = \sqrt{\frac{\sum(x - \tilde{x})^2}{n}}$$

σ = Standard deviation.

X = Set of numbers mean is the average of the set of numbers.

$\tilde{x}$ = Mean (average)

n = Size of the set.

2.10 Percentiles and Z-Scores in Anthropometry

Z-scores is the number of standard deviation (SD) away from the mean, when the distribution is normal. Percentiles and Z-scores in anthropometric measurements have been widely used to aid in the assessment of young people's nutritional status and growth. It include the undernutrition such as underweight or stunting, and overnutrition like overweight or obesity.

Z-scores using the standard deviation to measure how outstanding an individual is relative to the mean of a population and define the scale (Youfa Wang et al,.2012). Compared to the percentile, Z-scores have several advantages. Firstly, Z-score are calculated based on the distribution of the reference population which is standard deviation and mean. Thus reflect the reference distribution. Next is Z-scores can be compared based on individual ages, gender or anthropometric measurement. Lastly, it also can be analysed as continuous variable to determine the standard deviation and mean. However, this system were not straightfoward when explain to public and are hard to use in clinical settings.

For percentiles it may be correlate to some of variation in both Z-scores amd absolute measures within the measurement distribution. Moreover, the values of percentile cannot be defined at the extremities of the reference distribution. For example the absolute values can be different for people in the uppermost 1st percentile. Different from Z-score , percentile are more easier to utilise research. . The widely used cutting points of each are not quite equal in their Z-score and percentile levels.

2.11 Summary

Anthropometric measurements are noninvasive quantitative measurement of the human body. The main elements pf the anthropometric measurements are weight, height, body mass index (BMI), head circumferences, body circumferences to asses for adiposity (limbs, hip and waist) and skinfold thickness.

In a nutshell, this chapter two is a literature from present various of the case study that published information about the subject area at a given moment. Moreover, in this chapter has given some review about the differences of measurement in anthropometry such as conventional measurement and 3D measurement. There are many kind of devices that can be use to take measurement like Microsoft Kinect. Furthermore, the use of software like CATIA and Inventor, make the collection of data and parameters more easy to get.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter, it will give a clear explanations on the research methodology used to attain the study's goal. A flow chart analysis method is made for research from the beginning to the end of the project. This flow chart is important because it will show every steps to conduct this research and to enhance a successful technique. Furthermore, in this chapter also will explain more in depth the method of collecting data for this study . The perfect study design allow the author to address the right approach and can provide a significant findings. Beside that, by using various formula and equation , it helps to determine analysis and result of the research.

3.2 Research Design

Research design is a framework of research techniques and methods that will used during the study. The design will allow researchers to hone in on research methods that suitable for the set up of their study for success. The two types of approaches that were use in this research is quantitative and qualitative research. Quantitive research is based on metaphors and statistical. The information can be measure by using variety of formula, calculation and other computational techniques. Next, the qualitative research is based on other research that have been validated and authorized with evidence such as journals.

3.3 Proposed Methodology

To achieve the research objective, the process flow of the research methodology that show all steps that must be taken is shown in the flowchart below.

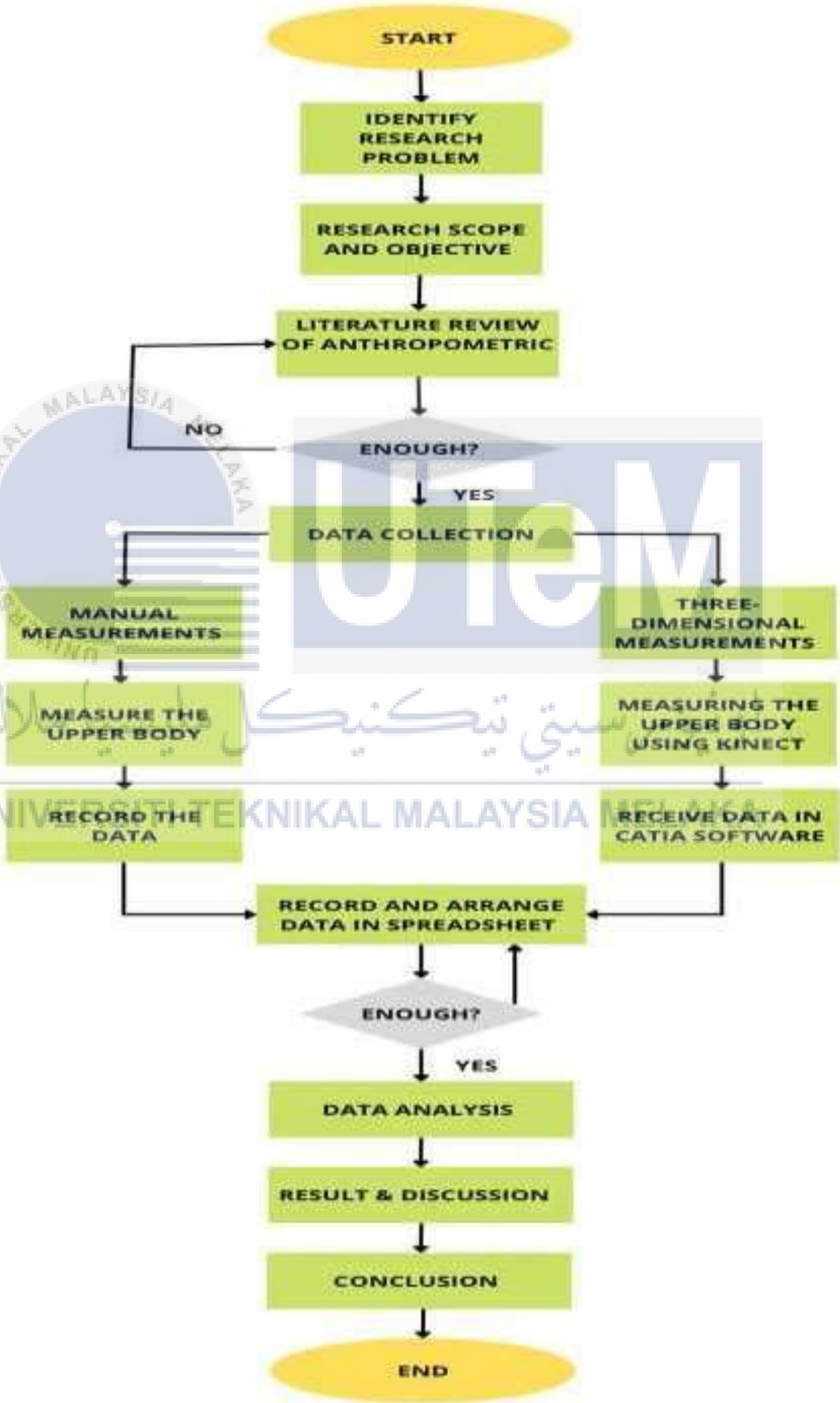

Figure 3.1 : Detail process flow for this research

Based on the figure 3.1, it shows the overall step that must be carried out to make sure all the activities and objectives are based on our plan. Before we go through the research, we must find the root cause of the problem that can happen in the three-dimensional and manual measurement. So, by go through the literature about other research in anthropometry, it will enchance knowledge about this topic before started the research. After finish all the measurement including manual and 3D measurement, all the data will be recorded in a spreadsheet by using Excel.

3.3.1 Experimental Setup

For the experimental setup, it will have a several process to make the experiment. First, all the measurement of 30 respondents, including manual and 3D measurement, will be carried out at ergonomic lab in Universiti Teknologi Malaysia, Melaka. This research will have 15 parameters that must be measured to achived the objective. Next, all respondents will be measure by manual process. They have been measured by using anthropometric apparatus such as measuring tape, calipers and anthropometer. After that, all respondents were scanned to get the measurement by using the 3D camera, which is Microsoft Kinect. Figure 3.2, figure 3.3 and figure 3.4 show the equipment that will be use when taking the 3D measurement. Then all the data of manual and 3D measurement will be put in a spreadsheet and compared the different between the two process.

Figure 3.2 The chair that use for respondent sit

Figure 3.3 The rotational base

Figure 3.4 The 3D equipment use to get the measurement

3.3.1.1 Parameters

In this research, it will have about 15 parameters that need to be measured from 30 respondent. This parameter are used to study the different between groups such as age, gender and body type. The body segment parameters are including the height, mass, volume and center of mass. The human body are split into several different major part which is head, body, arm, leg and foot. For this research, we will utilized the upper body segment parameter measurement which is including neck, body and tight. The all section are measured for the height, body circumference measurement, length and width. Each particular section of the body measurement are shown as below :

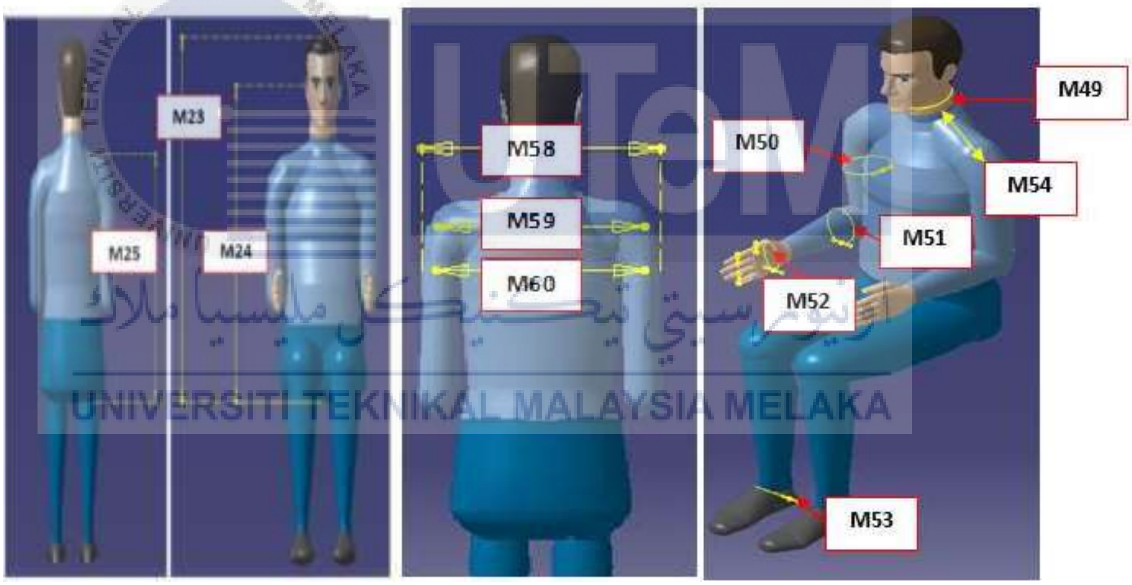

Figure 3.5 : Parameters of respondent while sitting

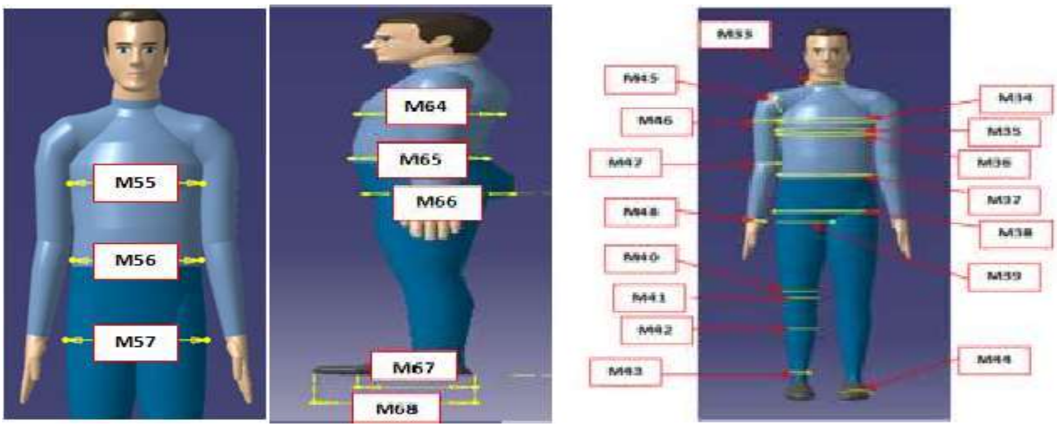

Figure 3.6 : Parameters of respondnet while standing

Table 3.1 : Parameters involve in this research

No	My Ref	Segments
1	M25	Length of shoulder to buttock
2	M34	Circumference of chest at scye
3	M35	Circumference of chest
4	M36	Circumference of chest under breadth
5	M37	Circumference of waist
6	M49	Neck circumference
7	M55	Length of chest breadth
8	M56	Length of waist breadth
9	M57	Hip breadth,standing
10	M58	Back upper shoulder
11	M59	Back middle shoulder
12	M60	Back lower shoulder
13	M64	Depth of chest
14	M65	Depth of waist
15	M66	Depth of buttock

3.3.1.2 Equipment

To measure the body part as conventional measurement, several anthropometry equipment can be use but in this research we only use the measuring tape and calipers because we need to measure the upper body only. This equipment can give the accurate and make the measurement process easy. For 3D measurement, in this research we will use Microsoft Kinect.

i) Caliper

Figure 3.7 : The calipers use to measure the upper shoulder

ii) Measuring tape

Figure 3.8 : Measuring tape use to measure the circumference of chest

iii) Microsoft Kinect

Figure 3.9 : Microsoft Kinect that been use in 3D measurement

3.4 3D measurement procedure

3.4.1 Procedure using Catia V5

i. First open the CatiaV5 software

ii. Then click file , select shape and click digitized. Then import file into Catia V5.

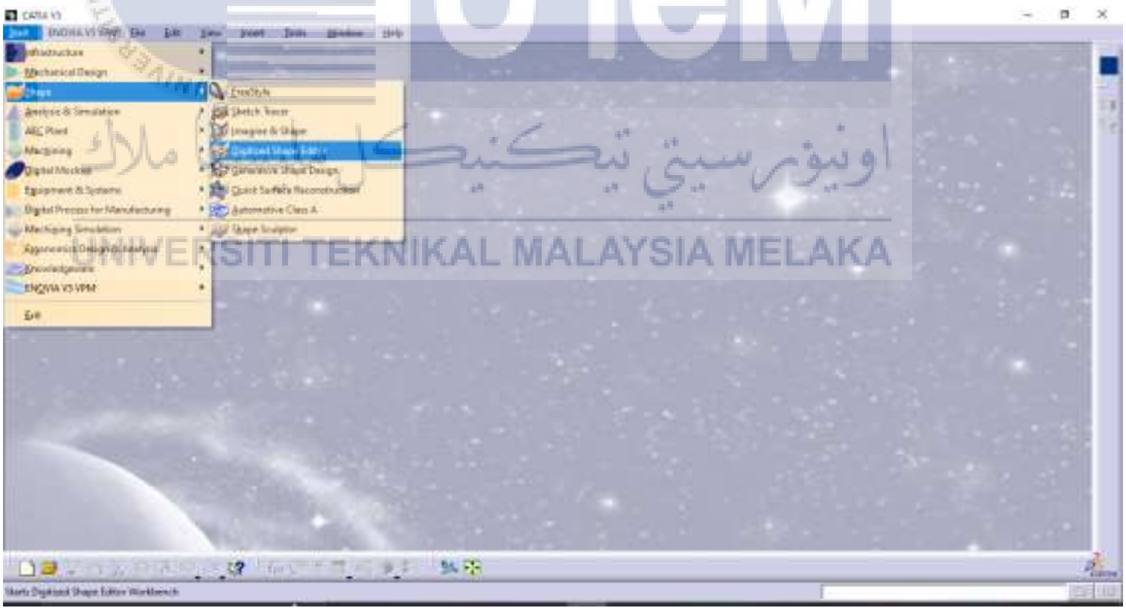

Figure 3.10 : Import file into Catia

iii. After the model appear, change the position of the model

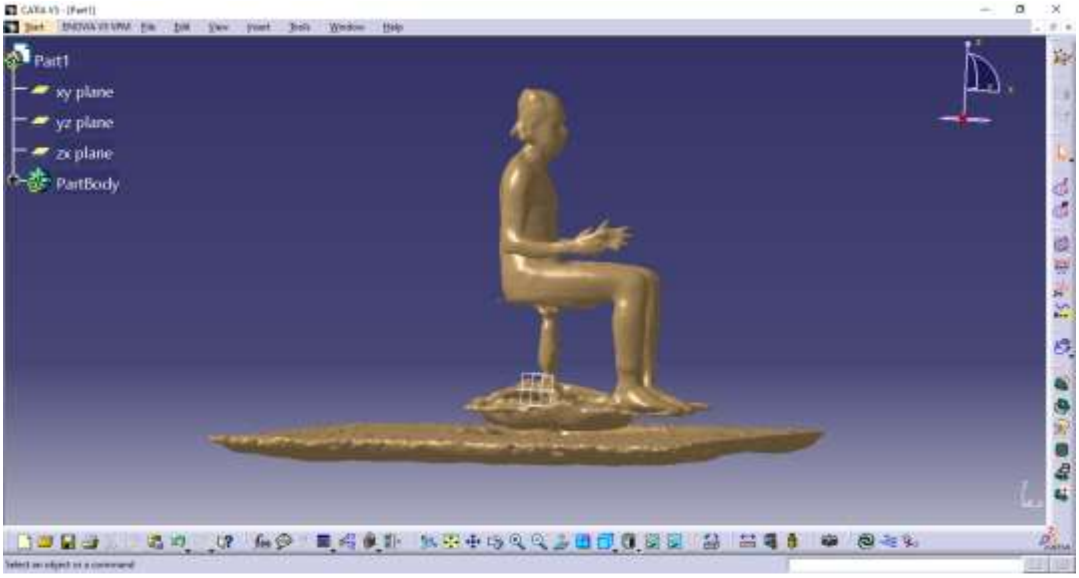

Figure 3.11 : 3D model have been done setting position

iv. Then use measure tools to measure the distance from landmarks point

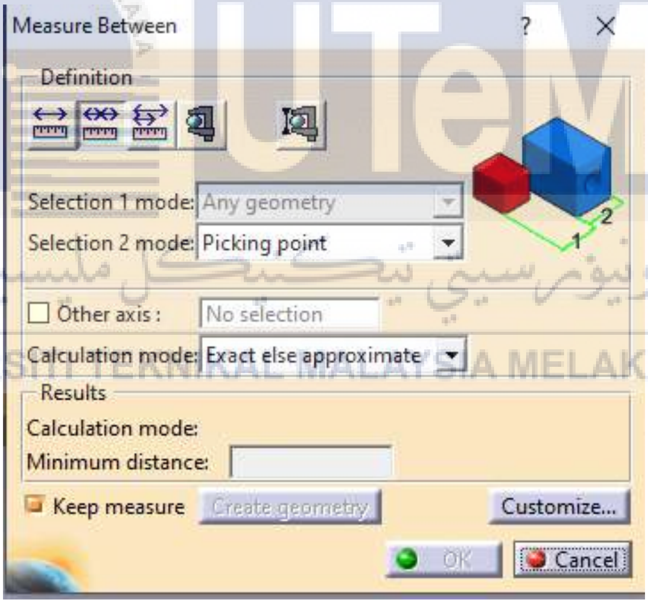

Figure 3.12 : Measurement definition

v. Select any geometry and click part body

vi. Picking landmark point of each parameters to measure.

vii. Record the data in Microsoft Excel's spreadsheet

3.4.2 Procedure using Solidwork 2020

i. First open the Solidwork software

ii. Then click open file in stl. to import the 3D model

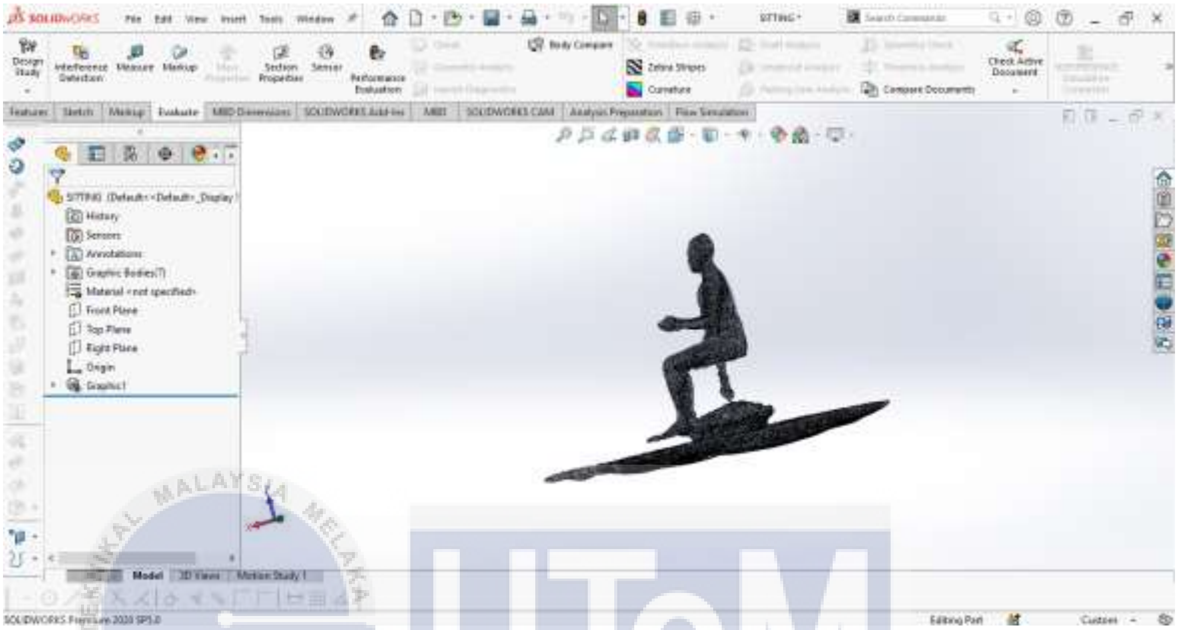

Figure 3.13 : 3D model appear in Solidwork

iii. After the model appear, change the position of the model.

iv. Click on evaluate bars and pick measure.

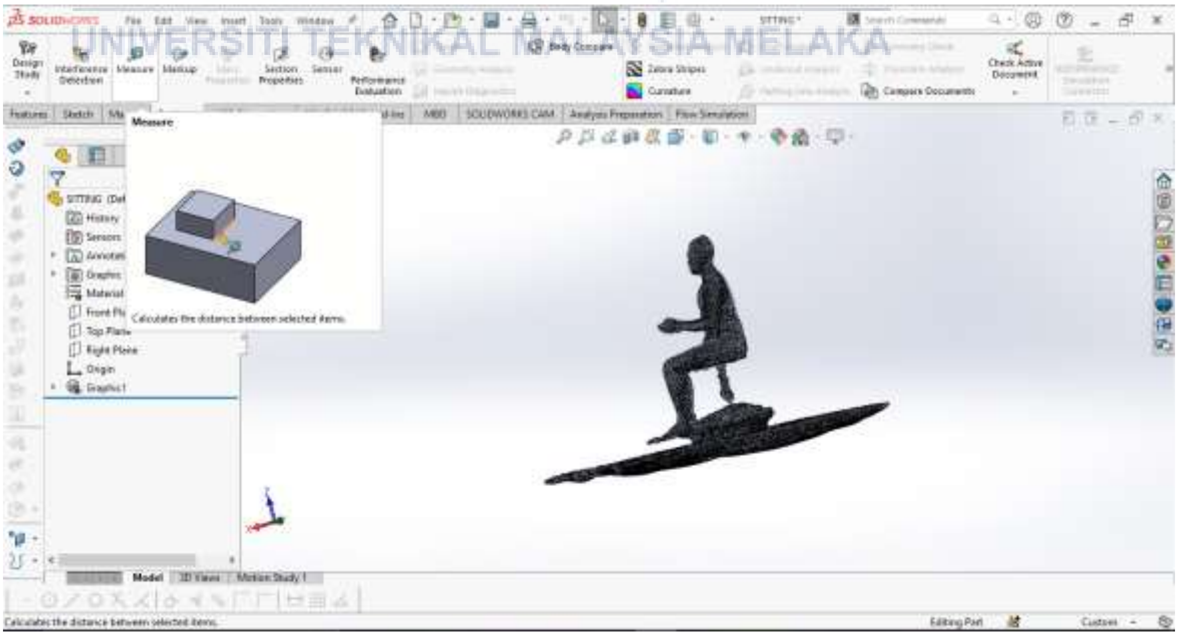

Figure 3.14 : Click measure tool

v. Choose the point on the 3D model

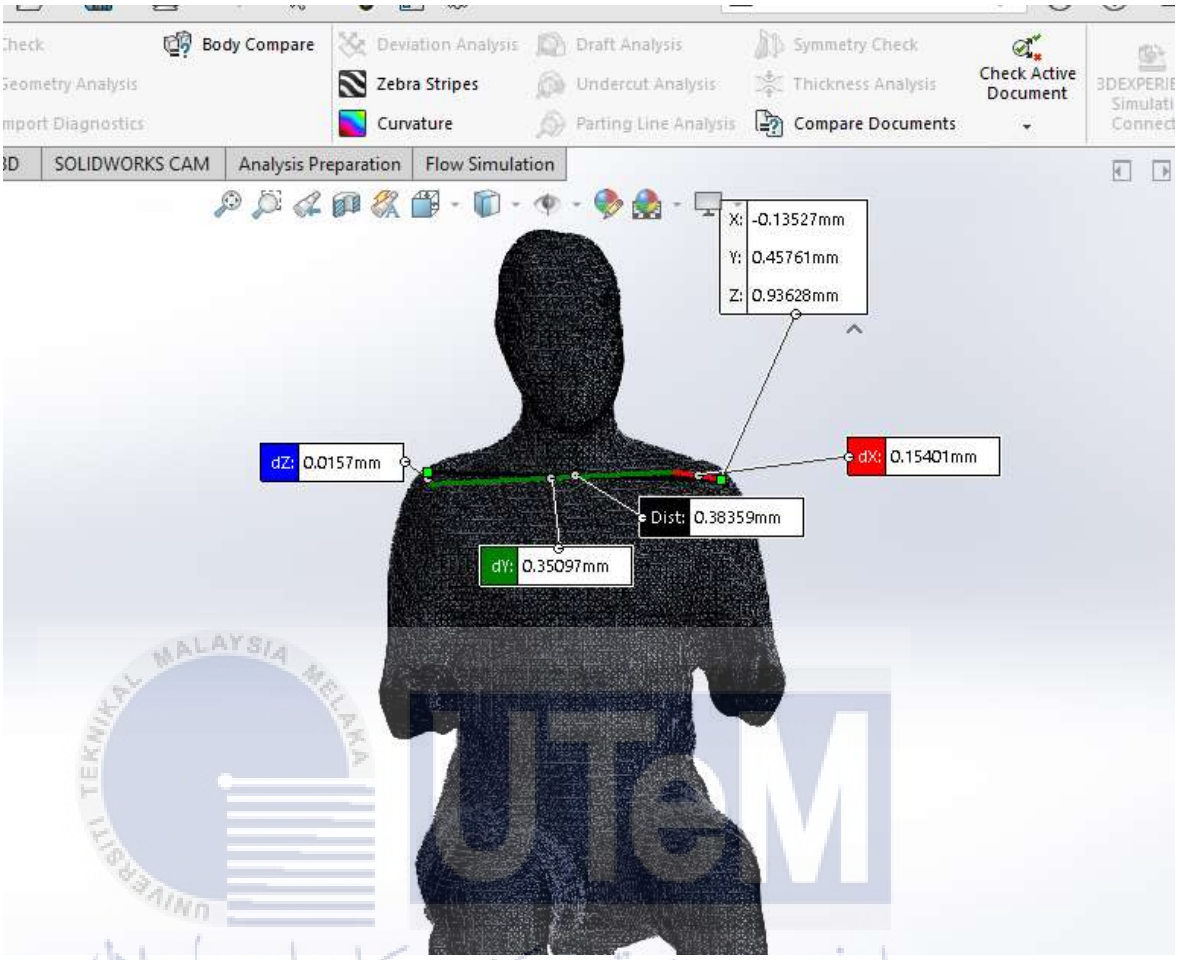

Figure 3.15 : The distance show after select point

vi. Collect the data in Microsoft Excel's spreadsheet

3.5 Limitation of Proposed Methodology

In any research conducted, limitations in an experiment are inevitable. In this research, it is critical to keep the scope of limitations as narrow as possible. This is because, the measurements taken are only from male respondents only. This is because, male respondents are more comfortable to be measured than female. Moreover, when measurements are taken, respondents need to wear tight clothing to get an accurate reading. So it is difficult for female respondents because of the limits of aurat that need to be taken care of. Next, the lack of skills in operating a 3D measurement system is also a limitation faced in this research. It is necessary for more time to add knowledge and experience in operating the equipment.

3.6 Summary

As conclusion, this chapter can be an essential chapter because it will explained the details about the process of our research. By creating a flowchart, it will make our research go step-by-step and will prevent any un-necessary process and prevent any misleading information that should not be taken into the studies. The experimental setup also play a important role to make sure the process to get all measurement are correct. By using the conventional measurement, it may take some time to get all the data than use the 3D measurement. The 3D measurement will help a lot in collecting the data. Then the measurement for both method will be arrange and compared. Analysis will be made to make a valid comparison between the conventional and 3D measurement method.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

In this chapter, all measurement processes and data will be collected from experiments that be conducted in the laboratory. The process of collecting data will be use in two ways which is conventional measurement and 3D CAD measurement. The results were presented systematically to address the problem statement and objective. The analysis of 3D CAD and manual data measurement involved the use of calculation of Percentile, Mean and Standard Deviation (SD) as well generating the difference.

4.2 Data Collection for Manual Measurement and 3D CAD using Spreadsheet

In this section, it will be the data collection for manual measurement and 3D CAD measurement that were gathered during the experiment conduct. The data will be compiled in Microsoft Excel. The data required in this study is about 30 parameters of upper body from 30 respondents. During the taking of data for the manual measurement, the measurement have been take three times to obtain each parameter's average. Each measurement have been done by using measuring tools from Ergonomic Labaratory at FTK.

Figure 4.1 : Manual measurement of respondent

The collection of data is done by using manual data measurement and also software data measurement which is CatiaV5 and Solidworks2020. All the information then compiled together to find the differences. The tools that have been used to take 3D measurement is Kinect camera and Skanect Software. The Kinect camera were connected to Skanect to generate the 3D model.

Figure 4.2 : The Skanect software render the respondent

4.2.1 Process of manual measurement

Before making a manual measurement, must have some respondents that able to measure. The process of manual measurement must be done in an open area to facilitate the measuring session. Before the measuring activity started, the tools that to be used must be adequate and in good condition. The tools that need to be used to measure are specialized instruments such as tapes and anthropometry calipers. Next during the measuring session, it must do in the correct procedure so that the data obtained from the process is accurate. During the taking of data for the manual measurement, the measurement have been taken three times to obtain each parameter's average. This was a long process and tendious because it used human resources to measure.

Next, during the measuring session, the work of collecting data is also done. Data were collected and recorded in Microsoft Excel. this is done to ensure that data is not easily lost and is recorded accurately. After this process, proceed to another method, which is data collection. In data collection must have all aspects in terms of dimension and so on. If the data is complete, can proceed to the next step.

Figure 4.3 Taking manual measurement using anthropometric tool

4.2.2 Process of 3D CAS measurement

After completing the manual measurement, the process of measuring using 3D CAS software is carried out. Among the tools used in this process are the Microsoft Kinect camera and Skanect software. Before starting the measuring process, the respondents involved are required to wear tight shirts and pants. This is necessary to avoid getting wrong parameters when the process is run. After that, the respondent was asked to be on the rotator and will be told to make some postures according to the procedure that has been set when the measuring process was carried out.

Figure 4.4 Setting the respondent’s posture

The software used to measure the respondent's body is Skanect sofware. In Skanect software, after it generates the 3D model, some editing has been done by simplifying and filling holes to make sure the 3D model is smooth. Then the files are saved as obj. etc. to be able to open it in CatiaV5 and Solidwork2020 software.

Figure 4.5 The scanning process of 3D CAS

Figure 4.6 : 3D model that has been generate thru Skanect Software

4.2.3 Process of 3D CAD measurement

With the data collected, the process of measuring using 3D CAD software can be done. The software used is CatiaV5 and Solidwork2020. First, insert data from the Skanect file into the software. After that, fix the position of the model and use the measuring tool available in each software. Make sure each measurement point and parameter is correct and the same as when taking measurements manually.

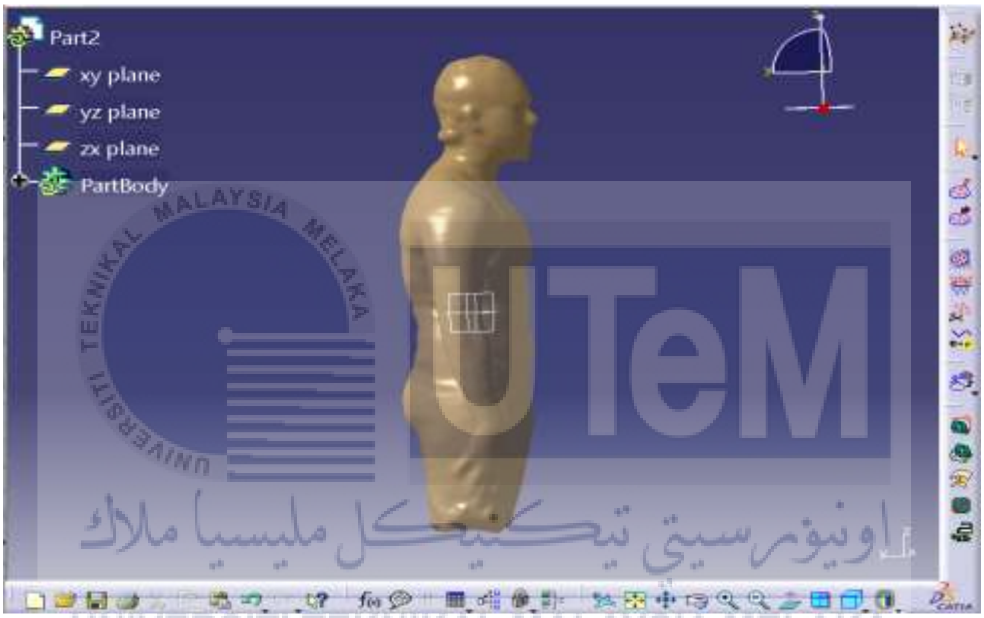

Figure 4.7 : 3D model in Catia V5

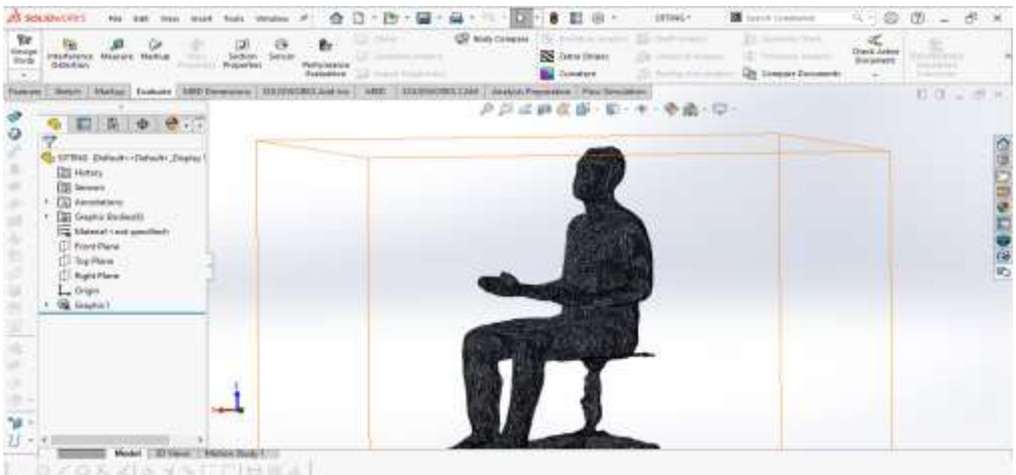

Figure 4.8 : 3D model in Solidwork2020

Table 4.1 (a) : Data collection of measurement for manual , CatiaV5 and Solidwork2020

Parameter	Hasif (R1)			Syafiq (R2)			Aiman (R3)			Zulhimi (R4)			Nizam (R5)		
	Measurement			Measurement			Measurement			Measurement			Measurement		
	Manual	Catia	Solidwork	Manual	Catia	Solidwork	Manual	Catia	Solidwork	Manual	Catia	Solidwork	Manual	Catia	Solidwork
M25	64.50	65.8	67.9	60	63.2	62.2	63	58.3	67.1	66	68.5	70.3	62	64.7	67.8
M34	91.20	96.7	98.3	91.5	93.4	96.4	96	105.8	106.4	95.8	97.4	100.3	96.3	98.5	110.9
M35	88.00	93.4	97.2	90	95.3	98.5	90	100.3	95.3	95	97.7	99.3	96.9	99.3	101.2
M36	82.30	84.5	83.2	85	86.3	85.7	87.7	93.2	92.3	87	89.3	90.4	94.4	96.4	98.5
M37	87.20	89.5	87.4	80.3	82.9	85.8	82.6	89.5	90.4	84.8	86.7	89.8	81.5	83.5	94.5
M49	34.50	37.7	38.1	36	37.4	39.3	37.5	38.8	40.1	35.5	37.9	40.3	35.3	38.9	41.92
M55	28.30	30.8	36.9	28.2	29.3	32.7	29.4	34.0	36.3	30	32.4	38.3	30.5	33.5	35.3
M56	28.10	30.4	33.2	26.8	27.4	28.2	26.1	31.6	33.7	27.3	31.2	36.4	29.3	32.4	30.1
M57	33.00	37.3	39.9	31.4	32.5	36.1	30.2	34.4	37.2	30.7	34.5	37.9	31.3	34.4	36.2
M58	39.50	43.7	46.4	39.5	42.3	44.9	41	47.8	49.1	40.7	42.3	44.8	41	45.3	48.3
M59	42.00	46.7	50.6	41.3	43.8	48.2	42.9	43.6	42.8	43.3	44.9	46.4	43.2	46.3	50.8
M60	40.00	43.9	46.4	42	45.2	49.1	41.5	42.7	45.4	44.5	46.5	47.5	43.5	47.1	53.6
M64	18.00	20.8	24.3	18.4	20.4	21.3	19.6	26.2	28.9	18.7	20.3	22.1	18	20.3	22.7
M65	18.70	23.1	22.2	18.3	21.2	22.7	17	23.7	24.1	20.1	22.9	23.8	17	19.7	21.4
M66	22.50	25.4	24.4	20.5	22.1	23.8	21	27.2	29.8	22	23.1	24.2	20.2	23.5	25

Table 4.2 (b) : Data collection of measurement for manual , CatiaV5 and Solidwork2020

Parameter	Luqman (R6)			Aiman syukri (R7)			Iskandar (R8)			Hakim (R9)			Fizwan (R10)		
	Measurement			Measurement			Measurement			Measurement			Measurement		
	Manual	Catia	Solidwork	Manual	Catia		Manual	Catia	Solidwork	Manual	Catia		Manual	Catia	Solidwork
M25	68	72.1	77.3	66.5	69.2	**M25**	68	72.1	77.3	66.5	69.2	**M25**	68	72.1	77.3
M34	98	100.2	113.4	96.5	99.2	**M34**	98	100.2	113.4	96.5	99.2	**M34**	98	100.2	113.4
M35	95	96.2	100.3	91.7	95.6	**M35**	95	96.2	100.3	91.7	95.6	**M35**	95	96.2	100.3
M36	90.8	94.5	99.8	80.5	83.2	**M36**	90.8	94.5	99.8	80.5	83.2	**M36**	90.8	94.5	99.8
M37	88.3	90.1	101.6	89.9	93.7	**M37**	88.3	90.1	101.6	89.9	93.7	**M37**	88.3	90.1	101.6
M49	35.3	37.2	42.4	37.6	40.5	**M49**	35.3	37.2	42.4	37.6	40.5	**M49**	35.3	37.2	42.4
M55	28.5	30.8	31.7	28.4	30.5	**M55**	28.5	30.8	31.7	28.4	30.5	**M55**	28.5	30.8	31.7
M56	27.5	29.9	32.6	29.6	31.8	**M56**	27.5	29.9	32.6	29.6	31.8	**M56**	27.5	29.9	32.6
M57	30.3	34.2	37	31	35.6	**M57**	30.3	34.2	37	31	35.6	**M57**	30.3	34.2	37
M58	42.1	43.9	45.8	42	45.3	**M58**	42.1	43.9	45.8	42	45.3	**M58**	42.1	43.9	45.8
M59	43.3	46.8	49.4	43.5	48.9	**M59**	43.3	46.8	49.4	43.5	48.9	**M59**	43.3	46.8	49.4
M60	42.7	45.2	46.3	43	47.3	**M60**	42.7	45.2	46.3	43	47.3	**M60**	42.7	45.2	46.3
M64	17.9	20.3	19.4	18.9	20.7	**M64**	17.9	20.3	19.4	18.9	20.7	**M64**	17.9	20.3	19.4
M65	16.9	18.7	19.2	20.5	23.1	**M65**	16.9	18.7	19.2	20.5	23.1	**M65**	16.9	18.7	19.2
M66	17.6	19.8	20.1	21	24.6	**M66**	17.6	19.8	20.1	21	24.6	**M66**	17.6	19.8	20.1

Table 4.3 (c) : Data collection of measurement for manual , CatiaV5 and Solidwork2020

Parameter	Arif (R11)			Wan (R12)			Zahede (R13)			Afiq (R14)			Ejay (R15)		
	Measurement			Measurement			Measurement			Measurement			Measurement		
	Manual	Catia	Solidwork	Manual	Catia	Solidwork	Manual	Catia	Solidwork	Manual	Catia	Solidwork	Manual	Catia	Solidwork
M25	65.8	73.2	74.9	65	74.5	75.8	67	69.2	72.3	63	65.3	67.4	65.7	67.7	69.6
M34	98.6	102.3	103.2	88	91.2	102.3	84	85.4	90.1	91.8	95.3	98.2	93.1	95.3	99.4
M35	95.7	100.1	101.2	86	90.3	100.1	80.1	82.1	85.1	85.4	86.7	89.1	90.6	93.2	96.1
M36	81	86.2	89.6	82.5	86.9	90.2	79.5	81.2	84.2	79.7	80.6	82.8	85.2	87.9	89.2
M37	92.4	94.6	97.7	85.6	88.7	94.6	74.5	75.2	78.7	76.6	78.2	79.3	86.5	90.3	93.2
M49	37.2	39.2	41.4	36.7	39.6	40.3	36.2	37.7	40.1	37.6	38.9	40.1	39	43.2	47.8
M55	28.5	30.3	31	27.6	29	30.9	28.6	29.9	32.4	26	29.8	28.9	27.5	29.7	31.7
M56	27	28.2	29.3	28.7	27.2	28.2	29	31.2	32.3	23.4	25.7	24.6	28.6	30.1	32.6
M57	29	33.2	35.8	32.1	34.2	38.8	30.5	34.5	37.3	31.1	35	35.9	32.7	35.7	34.2
M58	41.5	43.5	45.2	42	45.1	46.5	43.5	44.9	47.8	41	43.1	44.2	44	48.9	47.7
M59	44.5	47.3	48.9	43.7	44.8	47.3	44.4	48.2	50.3	42.4	44.6	47.7	45.5	47.3	48.6
M60	43	48.2	50.1	42.8	45.2	48.2	41.7	43.8	46.9	43.5	45.8	48.9	43	46.7	48.3
M64	18	20.1	22.7	20	22.1	21.1	15.1	16.3	17.2	16.8	19.4	19.9	18	20.3	21.2
M65	22	24.3	24.9	21	24.5	25.3	17	18.1	19.5	20	23.1	24.3	21	23.6	24.7
M66	21.7	25.6	26.7	21.5	25.6	27.6	17.5	18.9	20.1	20.2	24	24.8	24.3	26.4	25.9

Table 4.4 (d) : Data collection of measurement for manual , CatiaV5 and Solidwork2020

Parameter	**Tee (R16)**			**Azami (R17)**			**Ling (R18)**			**Subra (R19)**			**Frank (R20)**		
	Measurement			**Measurement**			**Measurement**			**Measurement**			**Measurement**		
	Manual	Catia	Solidwork	Manual	Catia	Solidwork	Manual	Catia	Solidwork	Manual	Catia	Solidwork	Manual	Catia	Solidwork
M25	67	70.2	74.5	72	74.3	77.2	62	63.5	65.8	69	70.8	71	69	71.9	73.1
M34	97.5	102.4	103.7	104.5	108.4	109.6	91.6	95.8	99.6	112	112.6	110.5	97.4	99.2	102.3
M35	96.5	100.8	101.3	103.8	107.5	108.6	89	94.8	96.9	107.3	110.3	113.2	87.6	88.7	92.6
M36	91	94.3	97.9	98	101.2	103.1	85	90.4	93.5	95.2	98.2	101.6	85.4	87.3	90.4
M37	89.3	93.2	96.7	94	96.2	98.4	88	93.2	97.3	98	102.2	104.3	86.3	88.2	91.4
M49	38.2	42.3	44.6	42	45.3	47.2	35	36.9	38.4	39.5	40.3	42.5	36.2	37.8	39.2
M55	29.5	32.4	30.2	32	33.7	35.9	28.2	30.5	29.9	32.5	33	35.2	28.4	29.6	32.1
M56	28.8	31.2	29.8	30.7	32.8	34.3	28.6	30.9	31.5	33	35.1	34.3	29.8	31.8	30.2
M57	32.8	35.6	34.2	33	35.4	34.3	30.4	33.1	32.4	34	36.2	37.8	29.3	30.1	31.3
M58	40.6	43.8	45.1	44.7	45.3	46.9	40.6	42.8	44.7	45.5	46.9	50.1	40.3	42.1	41.5
M59	44	49.7	47.8	46.6	48.1	47.3	42.4	45.6	46.6	49.7	52.6	53.4	46.8	47.3	48.5
M60	45	50.2	48.4	47.6	48.7	49.2	45	47.8	49	52	54.3	55.9	48.2	48.9	49.8
M64	22	23.7	24.3	22.3	24.3	23.2	19	21.4	21.9	21.5	22.7	26.6	19.3	21.1	22.2
M65	22.5	25.2	25.9	23.2	25.4	24.4	18.7	19.9	20.8	22	25.5	24.7	20.2	22.3	24.3
M66	21.6	24.7	25.4	25.4	26.8	24.1	19.5	21.7	22.3	23	25.2	27.8	21.7	23.1	24.1

Table 4.5 (e) : Data collection of measurement for manual , CatiaV5 and Solidwork2020

Parameter	Amir (R21)			Azrul (R22)			Farhan (R23)			Fikri (R24)			Kavi (R25)		
	Measurement			Measurement			Measurement			Measurement			Measurement		
	Manual	Catia	Solidwork	Manual	Catia	Solidwork	Manual	Catia	Solidwork	Manual	Catia	Solidwork	Manual	Catia	Solidwork
M25	63	65.3	67.7	62	65	68.4	65.6	67.2	71.9	64.8	65.6	72.3	68	70.4	73.3
M34	96.7	98.2	99.3	80.7	81.3	84.3	98.5	102.3	99.2	91.4	93.2	99.1	98.3	99.2	98.2
M35	97.8	99.7	98.2	74.8	76	77.9	85.6	88.2	88.7	88.1	89.3	95.8	95.4	97	100.1
M36	94.4	95.4	87.9	70.3	72.1	76.3	82	83.3	87.3	82.4	84.7	84.2	91.8	92.5	82.8
M37	81.5	83.2	90.3	70.9	71.2	72.2	92.7	94.4	88.2	87.6	88.9	87.7	89.3	90.8	79.3
M49	35.3	37.5	43.2	31.3	30.2	31.8	37.7	40.9	37.8	34.6	35.4	40.1	35.8	36.7	40.1
M55	30.3	31.2	29.7	23.7	24.8	25.8	28.4	30.7	29.6	28.3	29.4	31.4	28.6	29.5	28.9
M56	29.9	30.2	30.1	21.3	21.9	22.6	27.9	28.3	31.8	28.7	29.8	30.3	27.2	28.1	29.6
M57	31.3	32.2	35.7	26.4	26.5	27.8	29.6	31.2	30.1	33.4	34.1	37.3	31.3	34.7	35.9
M58	41.6	45.3	48.9	39.2	40	42.8	41.4	42.7	42.1	39.5	40.2	47.8	42.7	43.6	44.2
M59	42.2	46.2	47.3	37.5	38.5	39.9	44.7	45.9	47.3	42.2	43.5	50.3	43.8	44.6	47.7
M60	44.5	45.8	46.7	35	37.4	36.2	43	44.1	48.9	40.8	41.2	46.9	42.3	43.9	48.9
M64	18.2	19.2	20.3	15.2	17.2	18.3	18.2	19.2	21.1	17.8	18.9	17.2	18.9	19.3	19.9
M65	20.3	21.3	21.8	16	16.8	17.5	22.1	23.4	22.3	18.6	19.8	19.7	17.9	18.9	20.3
M66	20.2	21.1	22.4	16.8	17.3	17.9	23	24.5	23.1	22.2	23.1	20.1	18.6	19.7	20.8

Table 4.6 (f) : Data collection of measurement for manual , CatiaV5 and Solidwork2020

Parameter	**Nantha (26)**			**Sharvesh (R27)**			**Sharvin (R28)**			**Siva (R29)**			**Rusaidi (R30)**		
	Measurement			**Measurement**			**Measurement**			**Measurement**			**Measurement**		
	Manual	Catia	Solidwork	Manual	Catia	Solidwork	Manual	Catia	Solidwork	Manual	Catia	Solidwork	Manual	Catia	Solidwork
M25	67	70.5	69.2	66	69.2	68.4	68	70.8	72.5	64.5	67.4	70	59	63.2	67.5
M34	97.5	101.9	100.5	94.8	95.4	96.7	92	96	100.2	97.5	100.2	103.2	84.8	87.6	90.3
M35	96.8	99.4	98.9	95.9	96.7	99.9	85.5	87.6	90.4	92.7	96.3	98.3	81	82.1	85.3
M36	92	93.4	94.2	94.8	95.4	98.3	79.9	82.1	87.4	81.5	83.2	85.7	75.9	76.5	83.5
M37	89.9	93.2	91.9	81.9	82.4	83.2	76.9	77.6	80.2	88.9	89.7	90.8	71.3	73.3	80.2
M49	38.7	39.6	40.2	36.5	37.5	38.5	38.6	39.2	39.6	37.9	39.3	42.4	33.5	34.9	38.3
M55	30	32.4	33.6	33.4	33.1	34.8	26.4	28.4	30.4	28.8	30.1	31.1	25.3	29.7	31.2
M56	29.2	30.4	31.8	27.9	28.9	30.1	24.4	25.7	28.4	29.9	32.8	34.7	24.7	26.5	35.7
M57	33.8	34.5	34.9	31.7	31.8	33.4	31.8	32.5	34.5	32.4	34.3	36.2	28.3	30.1	31.2
M58	40.9	41.2	40.6	40.5	42.3	45.7	41.9	43.2	44.2	42.3	43.2	45.1	37.9	38.9	42.9
M59	44.2	46.8	44.7	43.5	44.6	45.9	42.4	44.1	47.8	43.4	45.3	46.2	39.3	40.3	43.4
M60	45.3	47.5	46.6	44.8	46.8	47.5	43.3	44.9	49.5	43.9	46.8	49.2	38.7	40.1	43.2
M64	22	23.2	23.6	19.7	21.1	20.1	17.8	18.2	19.2	18.7	20.5	19.5	16.4	17.7	19.8
M65	22.8	23.3	22.8	21.2	22.2	23.7	19	22.2	22.9	21.5	23.9	22.8	17.2	18.2	20.8
M66	21.9	22.8	23.7	23.6	24.7	24.9	20.8	23.8	24.8	22	24.1	23.4	18.2	19.7	21.2

4.3 Data analysis

After the data have been collected in Microsoft excel, a data analysis need to be done. In this section, the differences, mean, standard deviation and percentile were calculated for both manual and 3D measurement. It is important to highlight that manual data was taken about months ago at Ergonomic Laboratory in Fakulti Teknologi Kejuruteraan. After finish all the manual data, then continued with 3D CAS measurement that have been done at Fakulti Kejuruteraan Pembuatan. This process take some time to done because the parameters used in this study are many and the time available by each respondents were limited.

Moreover, a root cause could be found from the results gain from the data analysis. It is essential to noted that the data analysis is an instrumental to be recognized as it can help to prevent error when measuring in the software. As a result, the value that contains the negative is the value that have reduction from manual to 3D data measurement, while increase

4.3.1 Calculation and comparison of differences between manual measurement and 3D CAD measurement

In this topic, the measurement from manual, CatiaV5 and Solidwork2020 that have been recorded in the spreadsheet in Microsoft Excel have been calculate. The comparison between the manual measurement and 3D CAD measurement were carried out to see the differences from the data collected. The purpose to do this comparison is because to know the best method to do the measurement and the differences of the all data. There are three comparison which is between manual measurement and CatiaV5, manual measurement and Solidwork2020, and lastly is between CatiaV5 and

Solidwork2020. Table 4.7, 4.8 and 4.9 are the data recorded for the differences measurement.

Table 4.7 : Differences between CatiaV5 and manual measurement (cm)

Para-meter	**Differences between Catia V5 and manual measurement (cm)**																													
	R1	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**R11**	**R12**	**R13**	**R14**	**R15**	**R16**	**R17**	**R18**	**R19**	**R20**	**R21**	**R22**	**R23**	**R24**	**R25**	**R26**	**R27**	**R28**	**R29**	**R30**
M25	1.3	3.2	-4.7	2.5	2.7	4.1	2.7	5.3	4.1	1.7	7.4	9.5	2.2	2.3	2	3.2	2.3	1.5	1.5	2.9	2.3	3	1.6	0.8	2.4	3.5	3.2	2.8	2.9	4.2
M34	5.5	1.9	9.8	1.6	2.2	2.2	2.7	4.3	3.5	2.3	3.7	3.2	1.4	3.5	2.2	4.9	3.9	4.2	0.6	1.8	1.5	0.6	3.8	1.8	0.9	4.4	0.6	4	2.7	2.8
M35	5.4	5.3	10.3	2.7	2.4	1.2	3.9	3.2	5.3	2.1	4.4	4.3	2	1.3	2.6	4.3	3.7	5.8	3	1.1	1.9	1.2	2.6	1.2	1.6	2.6	0.8	2.1	3.6	1.1
M36	2.2	1.3	5.5	2.3	2	3.7	2.7	1.9	2.8	2.9	5.2	4.4	1.7	0.9	2.7	3.3	3.2	5.4	3	1.9	1	1.8	1.3	2.3	0.7	1.4	0.6	2.2	1.7	0.6
M37	2.3	2.6	6.9	1.9	2	1.8	3.8	2.3	3	3.3	2.2	3.1	0.7	1.6	3.8	3.9	2.2	5.2	4.2	1.9	1.7	0.3	1.7	1.3	1.5	3.3	0.5	0.7	0.8	2
M49	3.2	1.4	1.3	2.4	3.6	1.9	2.9	3.2	3.5	2.6	2	2.9	1.5	1.3	4.2	4.1	3.3	1.9	0.8	1.6	2.2	-1.1	3.2	0.8	0.9	0.9	1	0.6	1.4	1.4
M55	2.5	1.1	4.6	2.4	3	2.3	2.1	5.2	4.3	3.6	1.8	1.4	1.3	3.8	2.2	2.9	1.7	2.3	0.5	1.2	0.9	1.1	2.3	1.1	0.9	2.4	-0.3	2	1.3	4.4
M56	2.3	0.6	5.5	3.9	3.1	2.4	2.2	4.8	3.2	2.1	1.2	-1.5	2.2	2.3	1.5	2.4	2.1	2.3	2.1	2	0.3	0.6	0.4	1.1	0.9	1.2	1	1.3	2.9	1.8
M57	4.3	1.1	4.2	3.8	3.1	3.9	4.6	2.9	6.2	2.3	4.2	2.1	4	3.9	3	2.8	2.4	2.7	2.2	0.8	0.9	0.1	1.6	0.7	3.4	0.7	0.1	0.7	1.9	1.8
M58	4.2	2.8	6.8	1.6	4.3	1.8	3.3	2.2	2.7	2	2	3.1	1.4	2.1	4.9	3.2	0.6	2.2	1.4	1.8	3.7	0.8	1.3	0.7	0.9	0.3	1.8	1.3	0.9	1
M59	4.7	2.5	0.7	1.6	3.1	3.5	5.4	0.9	3.1	0.7	2.8	1.1	3.8	2.2	1.8	5.7	1.5	3.2	2.9	0.5	4	1	1.2	1.3	0.8	2.6	1.1	1.7	1.9	1
M60	3.9	3.2	1.2	2	3.6	2.5	4.3	1.6	2.5	3.7	5.2	2.4	2.1	2.3	3.7	5.2	1.1	2.8	2.3	0.7	1.3	2.4	1.1	0.4	1.6	2.2	2	1.6	2.9	1.4
M64	2.8	2	6.6	1.6	2.3	2.4	1.8	0.8	2	1.8	2.1	2.1	1.2	2.6	2.3	1.7	2	2.4	1.2	1.8	1	2	1	1.1	0.4	1.2	1.4	0.4	1.8	1.3
M65	4.4	2.9	6.7	2.8	2.7	1.8	2.6	2.1	0.8	2.4	2.3	3.5	1.1	3.1	2.6	2.7	2.2	1.2	3.5	2.1	1	0.8	1.3	1.2	1	0.5	1	3.2	2.4	1
M66	2.9	1.6	6.2	1.1	3.3	2.2	3.6	3.1	3.7	2.8	3.9	4.1	1.4	3.8	2.1	3.1	1.4	2.2	2.2	1.4	0.9	0.5	1.5	0.9	1.1	0.9	1.1	3	2.1	1.5

Table 4.8 : Differences between Solidwork2020 and manual measurement

Para-meter	Differences between Solidwork2020 and manual measurement (cm)																													
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21	R22	R23	R24	R25	R26	R27	R28	R29	R30
M25	2.2	2.2	4.1	4.3	5.8	9.3	7	9.8	6.3	5.6	9.1	10.8	5.3	4.4	3.9	7.5	5.2	3.8	2	4.1	4.7	6.4	6.3	7.5	5.3	2.2	2.4	4.5	5.5	8.5
M34	3	4.9	10.4	4.5	14.6	15.4	4.8	8.2	5.8	3.2	4.6	14.3	6.1	6.4	6.3	6.2	5.1	8	-1.5	4.9	2.6	3.6	0.7	7.7	-0.1	3	1.9	8.2	5.7	5.5
M35	2.1	8.5	5.3	4.3	4.3	5.3	7.6	7.7	7.4	5.6	5.5	14.1	5	3.7	5.5	4.8	4.8	7.9	5.9	5	0.4	3.1	3.1	7.7	4.7	2.1	4	4.9	5.6	4.3
M36	2.2	0.7	4.6	3.4	4.1	9	9	5	6	4.8	8.6	7.7	4.7	3.1	4	6.9	5.1	8.5	6.4	5	-6.5	6	5.3	1.8	-9	2.2	3.5	7.5	4.2	7.6
M37	2	5.5	7.8	5	13	13.3	9.1	5.7	7.4	6.9	5.3	9	4.2	2.7	6.7	7.4	4.4	9.3	6.3	5.1	8.8	1.3	-4.5	0.1	-10	2	1.3	3.3	1.9	8.9
M49	1.5	3.3	2.6	4.8	6.62	7.1	6.7	4.4	6.2	7.5	4.2	3.6	3.9	2.5	8.8	6.4	5.2	3.4	3	3	7.9	0.5	0.1	5.5	4.3	1.5	2	1	4.5	4.8
M55	3.6	4.5	6.9	8.3	4.8	3.2	2.8	3.4	7.5	6.8	2.5	3.3	3.8	2.9	4.2	0.7	3.9	1.7	2.7	3.7	-0.6	2.1	1.2	3.1	0.3	3.6	1.4	4	2.3	5.9
M56	2.6	1.4	7.6	9.1	0.8	5.1	6.1	3.2	6.1	5.5	2.3	-0.5	3.3	1.2	4	1	3.6	2.9	1.3	0.4	0.2	1.3	3.9	1.6	2.4	2.6	2.2	4	4.8	11
M57	1.1	4.7	7	7.2	4.9	6.7	5.2	3.8	7.7	6.3	6.8	6.7	6.8	4.8	1.5	1.4	1.3	2	3.8	2	4.4	1.4	0.5	3.9	4.6	1.1	1.7	2.7	3.8	2.9
M58	-0.3	5.4	8.1	4.1	7.3	3.7	7.9	5.4	2.2	8.8	3.7	4.5	4.3	3.2	3.7	4.5	2.2	4.1	4.6	1.2	7.3	3.6	0.7	8.3	1.5	-0.3	5.2	2.3	2.8	5
M59	0.5	6.9	-0.1	3.1	7.6	6.1	8.9	3.4	6.7	5.3	4.4	3.6	5.9	5.3	3.1	3.8	0.7	4.2	3.7	1.7	5.1	2.4	2.6	8.1	3.9	0.5	2.4	5.4	2.8	4.1
M60	1.3	7.1	3.9	3	10.1	3.6	7.2	4.7	4.2	4.2	7.1	5.4	5.2	5.4	5.3	3.4	1.6	4	3.9	1.6	2.2	1.2	5.9	6.1	6.6	1.3	2.7	6.2	5.3	4.5
M64	1.6	2.9	9.3	3.4	4.7	1.5	5.9	1.9	3.3	2.5	4.7	1.1	2.1	3.1	3.2	2.3	0.9	2.9	5.1	2.9	2.1	3.1	2.9	-0.6	1	1.6	0.4	1.4	0.8	3.4
M65	0	4.4	7.1	3.7	4.4	2.3	5.3	1.8	1.7	4.5	2.9	4.3	2.5	4.3	3.7	3.4	1.2	2.1	2.7	4.1	1.5	1.5	0.2	1.1	2.4	1	2.5	3.9	1.3	3.6
M66	1.8	3.3	8.8	2.2	4.8	2.5	2.2	4.3	5	5.2	5	6.1	2.6	4.6	1.6	3.8	-1.3	2.8	4.8	2.4	2.2	1.1	0.1	-2.1	2.2	1.8	1.3	4	1.4	3

Table 4.9 : Differences between CatiaV5 and Solidwork measurement (cm)

Para-meter	Differences between Catia V5 and Solidwork measurement (cm)																													
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21	R22	R23	R24	R25	R26	R27	R28	R29	R30
M25	-1.3	-1	8.8	1.8	3.1	5.2	4.3	4.5	2.2	3.9	1.7	1.3	3.1	2.1	1.9	4.3	2.9	2.3	0.2	1.2	2.4	3.4	4.7	6.7	2.9	-1.3	-0.8	1.7	2.6	4.3
M34	-1.4	3	0.6	2.9	12.4	13.2	2.1	3.9	2.3	0.9	0.9	11.1	4.7	2.9	4.1	1.3	1.2	3.8	-2.1	3.1	1.1	3	-3.1	5.9	-1	-1.4	1.3	4.2	3	2.7
M35	-0.5	3.2	-5	1.6	1.9	4.1	3.7	4.5	2.1	3.5	1.1	9.8	3	2.4	2.9	0.5	1.1	2.1	2.9	3.9	-1.5	1.9	0.5	6.5	3.1	-0.5	3.2	2.8	2	3.2
M36	0.8	-0.6	-0.9	1.1	2.1	5.3	6.3	3.1	3.2	1.9	3.4	3.3	3	2.2	1.3	3.6	1.9	3.1	3.4	3.1	-7.5	4.2	4	-0.5	-9.7	0.8	2.9	5.3	2.5	7
M37	-1.3	2.9	0.9	3.1	11	11.5	5.3	3.4	4.4	3.6	3.1	5.9	3.5	1.1	2.9	3.5	2.2	4.1	2.1	3.2	7.1	1	-6.2	-1.2	-11.5	-1.3	0.8	2.6	1.1	6.9
M49	0.6	1.9	1.3	2.4	3.02	5.2	3.8	1.2	2.7	4.9	2.2	0.7	2.4	1.2	4.6	2.3	1.9	1.5	2.2	1.4	5.7	1.6	-3.1	4.7	3.4	0.6	1	0.4	3.1	3.4
M55	1.2	3.4	2.3	5.9	1.8	0.9	0.7	-1.8	3.2	3.2	0.7	1.9	2.5	-0.9	2	-2.2	2.2	-0.6	2.2	2.5	-1.5	1	-1.1	2	-0.6	1.2	1.7	2	1	1.5
M56	1.4	0.8	2.1	5.2	-2.3	2.7	3.9	-1.6	2.9	3.4	1.1	1	1.1	-1.1	2.5	-1.4	1.5	0.6	-0.8	-1.6	-0.1	0.7	3.5	0.5	1.5	1.4	1.2	2.7	1.9	9.2
M57	0.4	3.6	2.8	3.4	1.8	2.8	0.6	0.9	1.5	4	2.6	4.6	2.8	0.9	-1.5	-1.4	-1.1	-0.7	1.6	1.2	3.5	1.3	-1.1	3.2	1.2	0.4	1.6	2	1.9	1.1
M58	-0.6	2.6	1.3	2.5	3	1.9	4.6	3.2	-0.5	6.8	1.7	1.4	2.9	1.1	-1.2	1.3	1.6	1.9	3.2	-0.6	3.6	2.8	-0.6	7.6	0.6	-0.6	3.4	1	1.9	4
M59	-2.1	4.4	-0.8	1.5	4.5	2.6	3.5	2.5	3.6	4.6	1.6	2.5	2.1	3.1	1.3	-1.9	-0.8	1	0.8	1.2	1.1	1.4	1.4	6.8	3.1	-2.1	1.3	3.7	0.9	3.1
M60	-0.9	3.9	2.7	1	6.5	1.1	2.9	3.1	1.7	0.5	1.9	3	3.1	3.1	1.6	-1.8	0.5	1.2	1.6	0.9	0.9	-1.2	4.8	5.7	5	-0.9	0.7	4.6	2.4	3.1
M64	0.4	0.9	2.7	1.8	2.4	-0.9	4.1	1.1	1.3	0.7	2.6	-1	0.9	0.5	0.9	0.6	-1.1	0.5	3.9	1.1	1.1	1.1	1.9	-1.7	0.6	0.4	-1	1	-1	2.1
M65	-0.5	1.5	0.4	0.9	1.7	0.5	2.7	-0.3	0.9	2.1	0.6	0.8	1.4	1.2	1.1	0.7	-1	0.9	-0.8	2	0.5	0.7	-1.1	-0.1	1.4	0.5	1.5	0.7	-1.1	2.6
M66	0.9	1.7	2.6	1.1	1.5	0.3	-1.4	1.2	1.3	2.4	1.1	2	1.2	0.8	-0.5	0.7	-2.7	0.6	2.6	1	1.3	0.6	-1.4	-3	1.1	0.9	0.2	1	-0.7	1.5

From the Table 4.7, there are some amount of difference that can be observed between the manual measurement technique and the catiav5 measurement. The result shows that third respondent has four parameters that are far different from the other respondents which are M34, M35, M64 and M65. This difference occurs due to the 3D parameters of the respondent's model being slightly large compared to others.

Next, the three parameters that have the largest difference have been identified through this comparison. The three parameters are M35, M34 and M 25. It shows where the M35 parameter for third respondent which is Aiman, is different from the manual data where it differs by 10.3 cm from the manual measurement. This may occur due to the M35 parameter for 3D models imported from Skanect having relatively large surfaces. M34 parameters also for third respondent is the largest among other respondents while M25 parameter is from the 12th - respondnet with a value of 9.5 cm difference between manual and 3D measurement. This is because due to problems with the 3D model. It also can happen due to human errors.

Next from Table 4.8 which is the differences between Solidwork2020 and manual measurement, the data shown that it also have some amount of difference that can be observe. The M34 parameter for R6 and M37 parameter for R25 is the parameters that stands out the most which the value is 15.4cm and -10cm respectively. The three large value of parameters that the data shows are M34, M37 and M60. The largest parameters was observed is the M34 parameters which has three respondents that have the highest value. The biggest value was from the sixth respondent which is 15.4cm. This difference occurs due to the 3D model imported into solidwork software, the scale is quite large. So it has influenced to some extent the measurements made. It is likely to occur due to human error and the higher precision of the software's measuring tools.

Lastly the table 4.9 which is the Solidwork2020 measurement and CatiaV5 measurements, from the data that has been calculated and collected, it shows that each parameter has a different measurement. The largest parameter value is on parameters M34, M35 and M37 with the most significant value being on the sixth respondent with a value of 13.2cm. The reason for this discrepancy is the variations in the scale used by each software, which leads to the resulting values being different. When there is little variation in the measurement values obtained from using different methods, it is likely that the methods have similar precision and accuracy, as the body segment landmarks being measured are clearly identifiable and consistently located.This is due to the difference in measuring tools in each software.

4.3.2 Calculation and analysis of Mean and Standard deviation for manual, CatiaV5 and Solidwork2020 measurement

Table below show the mean and standard deviation of each parameters from all respondents. The data shown that each method have different mean and standard deviation.

Table 4.10 : Mean and standard deviation for manual, CatiaV5 and Solidwork2020

Parameter	Mean			Standard Deviation		
	Manual	CatiaV5	Solidwork 2020	Manual	CatiaV5	Solidwork2020
M25	65.05	67.95	70.58	3.13	3.89	3.73
M34	94.31	97.22	100.11	6.85	7.27	7.25
M35	90.86	93.87	96.20	7.89	8.30	7.94
M36	85.51	87.90	89.89	7.46	7.53	7.19
M37	84.67	87.12	89.64	8.02	8.49	8.72
M49	36.47	38.42	40.70	2.29	2.79	2.96
M55	28.49	30.70	31.98	2.26	2.11	2.59
M56	27.73	29.64	31.10	2.76	3.17	3.22
M57	31.06	33.48	35.01	2.03	2.28	2.52
M58	41.22	43.32	45.38	1.77	2.31	2.81
M59	43.28	45.49	47.35	2.63	3.06	2.91
M60	43.20	45.59	47.68	3.46	3.51	3.76
M64	18.73	20.51	21.44	2.14	2.35	2.74
M65	19.70	21.80	22.55	2.31	2.60	2.30
M66	20.89	23.14	23.80	2.34	2.65	2.74

From the table above, the data shown that M64 parameter has the small value of mean which is 18.73 when measure using the manual measurement method. The biggest amount for mean is M34 parameters that were determined by using Solidwork 2020 which is 100.11.

For the standard deviation, the smallest value among the 15 parameters is the M58 which is 1.77 which is measured using manual measurement. While the largest value is the M37 parameter with a value of 8.72. A slight difference in value can be seen between the methods that were used.

4.3.3 Calculation and analysis of 5th, 50th and 95th percentile for manual CatiaV5 and Solidwork2020 measurement

In anthropometry data, percentiles are shown and tell whether the measurement given in the tables relates to the average of individual or someone in a certain dimension who is above or below average. After the data collection is taken from the 30 respondents, the percentile needs to be made to get one dimension that is suitable for everyone. The percentile used in this study are the 5th, 50th and 95th percentiles. Table below show the data collected for the percentile for each parameter.

Table 4.11 : Percentile for manual, CatiaV5 and Solidwork2020

Parameter	Manual			CatiaV5			Solidwork2020		
	5th	50th	95th	5th	50th	95th	5th	50th	95th
M25	59.45	65.65	69	62.60	68.85	73.81	64.98	13.11	13.03
M34	82.19	96.15	103.375	83.97	98.35	107.46	86.91	19.26	19.18
M35	77.14	91.15	102.18	79.13	95.90	105.66	82.41	18.88	18.81
M36	72.64	85.10	95.02	74.69	87.60	97.39	78.64	17.54	17.47
M37	70.68	86.40	96.2	73.25	89.20	99.50	77.49	18.16	18.09
M49	32.42	36.35	39.275	34.57	38.85	42.80	38.03	7.78	7.71
M55	24.34	28.50	32.275	27.85	30.40	33.87	28.90	6.20	6.13
M56	22.52	28.60	31.415	24.71	30.15	34.07	25.82	6.34	6.27
M57	27.23	31.30	33.8	29.44	34.25	35.98	30.60	6.67	6.60
M58	38.49	41.00	44.385	40.09	43.20	47.40	40.60	8.52	8.44
M59	38.18	43.45	46.91	39.31	45.75	49.34	42.80	8.89	8.81
M60	36.58	43.15	47.93	39.33	46.15	49.62	40.78	9.25	9.17
M64	15.15	18.55	22.165	16.98	20.30	24.03	17.34	4.63	4.56
M65	16.27	20.15	22.8	17.67	22.60	25.31	18.71	4.56	4.49
M66	17.12	21.25	24.575	19.04	23.30	27.02	20.10	4.98	4.91

4.4 Discussion

When the data collection process is being carried out, there are some problems encountered when the process of measuring manually and 3D measurement is carried out. For manual measurement, there are some problems encountered. The first is human error. This human error occurs when the researcher wants to measure the respondent as quickly as possible and will result in small problems such as eye level is not perfect either linear to read the measurement correctly. This matter to some extent will affect the data collected even the measurements are taken three times for each parameter. Apart from that, how to operate the tool to measure the respondent's body is also one of the problems faced at the beginning of the process because it is necessary to adapt to use the tool.

Next, the process of measuring in 3D CAS also faces some problems. One of the main problems is the availability of the respondent. To use the lab, the time given is from 8 am - 5 pm but the respondents are busy with their classes and daily work. So the process to collect 3D CAS data takes quite a long time. Apart from that, the rotator in the laboratory was broken and it took 2 weeks to wait for a replacement. Next is the lack of skills in operating 3D CAS machines and Skanect Software. Each respondent needs to reset the height for the parameter scan. So it takes a long time to get a good result.

In addition, before the measurement process is carried out, the respondent is asked to wear a shirt and tight pants. The problem faced here is that the clothes worn by the respondent do not follow their body shape as desired. So it affects the 3D surface of the model as the figure shown below. On the other hand, respondent position is also an issue as they could not maintain the same position for a while because they get tired.

Figure 4.9 wrinkled surface on respondent shirt

In addition, after the calculation is done, there are differences from manual data and 3D measurement. The possible cause for the several measurement different value are could be influenced when the 3D model was imported into the 3D CAD software, especially during the process of scaling down the 3 model. Next, the limitation of manual measurement versus limitations of 3D CAD measurement with 3D CAS have been discovered. In the determination of the body landmark or bony point, it is difficult to do during the 3D CAD measurement possibly because of the tight cloth was not tight enough for them and cause wrinkled. Thus, it will influenced the shape of the 3D model where the body segment could not be seen clearly and it is confusing to determine the landmark.

4.5 Summary

In summary, the differences between manual measurement and 3D CAS measurement have been demonstrated. For parameters with small measurement value differences, it can be inferred that the three methods are likely to be similarly accurate as the landmarks of the body segment being measured are easily identifiable. To determine this, calculations such as mean, standard deviation and percentile difference were used. It is important to thoroughly investigate all possible causes before making suggestions for improvement, in order to ensure that any proposed changes will effectively address existing issues. From the data collected, it can be inferred that there are multiple reasons for the disparities between manual and 3D measurements.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

To conclude, the use of Computer-Aided Design (CAD) software can enhance the precision and speed of measuring the human body, by eliminating the manual effort and shortening the time required for measurements. Furthermore, the variations observed in this study can be used as a starting point for further research aimed at enhancing the measurement process.

It can be seen that Catia V5 software was an appropriate choice for this study. This is because traditional measurements of the human body were often performed manually, which required physical effort and was time-consuming. By using Catia V5 software, it was possible to efficiently measure a human body that had been converted into a 3D model through scanning. Moreover, it is crucial to understand the procedures involved in conducting measurements using this CAD software. Through this study, it is evident that the primary objective was to examine the distinctions between manual measurement utilizing anthropometry equipment and 3D data measurement through the use of Catia and Solidwork2020 software, in terms of linear and circumference measurements was achived.

The third objective of this study was to collect measurement data of the upper limb body of the respondents using both conventional methods, such as manual measurements with anthropometry tools and the more advanced 3D Camera Anthropometry System (3D CAS) method. In order to accomplish this task, various solutions were identified and implemented. The final objective of the study was to analyze all of the collected anthropometry data using statistical methods. Through a thorough comparison of the data gathered from manual measurements and 3D measurements, it was possible to identify and understand the disparities between the two methods. These findings can provide valuable insights for future studies in the field of anthropometry measurements, and for researchers who are looking for a more efficient and accurate method for measuring the human body.

5.2 Future research

Thus, several recommendations for future research have been provided with explanations for each. The first suggestion is to conduct further research into SolidWorks software in order to gain a more comprehensive understanding of its capabilities. Additionally, research could be done to improve the distance between the object and camera in order to obtain clearer and more accurate data. The third suggestion is to find a more appropriate 3D camera for 3D CAS measurements. Currently, the measurement process for 3D objects can be challenging if the object is not clearly visible and difficult to measure. Another recommendation is to ensure that the tools in the laboratory are fixed and easy to use, this will ease the measurement process. Lastly, to ensure that the software used is able to collect data without interruption or upgrading existing software, this can increase the reliability of the measurement process using CAD software and save time.

REFERENCES

Weinberg, S. M., Scott, N. M., Neiswanger, K., Brandon, C. A., & Marazita, M. L. (2004). Digital three-dimensional photogrammetry: Evaluation of anthropometric precision and accuracy using a Genex 3D camera system. Cleft Palate-Craniofacial Journal, 41(5). https://doi.org/10.1597/03-066.1

Weinberg, S. M. et al. (2006) 'Anthropometric precision and accuracy of digital threedimensional photogrammetry: Comparing the genex and 3dMD imaging systems with one another and with direct anthropometry', Journal of Craniofacial Surgery, 17(3), pp. 477– 483. doi: 10.1097/00001665-200605000-00015.

Taha, Z., Aris, M. A., Ahmad, Z., Hassan, M. H. A., & Sahim, N. N. (2013). A low cost 3D foot scanner for custom-made sports shoes. Applied Mechanics and Materials, 440. https://doi.org/10.4028/www.scientific.net/AMM.440.369

Wells, J. C. K., Treleaven, P., & Charoensiriwath, S. (2012). Body shape by 3-D photonic scanning in Thai and UK adults: Comparison of national sizing surveys. International Journal of Obesity, 36(1). https://doi.org/10.1038/ijo.2011.51

Popovic, S., Bjelica, D., Georgiev, G., Krivokapic, D., & Milasinovic, R. (2016). Body height and its estimation utilizing arm span measurements in macedonian adults. Anthropologist, 24(3). https://doi.org/10.1080/09720073.2016.11892070

Openshaw, S. and Taylor, E. (2006) 'Ergonomics and Design A Reference Guide', Allsteel design to work build to last, pp. 1–2. Available at: www.allsteeloffi%5Cnce.com/ergo.

Ulijaszek, S., & Komlos, J. (2010). From a history of anthropometry to anthropometric history. In Human Variation: From the Laboratory to the Field. https://doi.org/10.1201/9781420084740

Mohd Fa'iz Wahid., Seri Rahayu Kamat., Dian Darina Indah Daruis., (2018). Improvement of a Visual-based Anthropometry Measurement System using Microsoft Kinect and a Rotating Platform

Li, B., Han, C., & Bai, B. (2019). Hybrid approach for human posture recognition using anthropometry and BP neural network based on Kinect V2. Eurasip Journal on Image and Video Processing, 2019(1). https://doi.org/10.1186/s13640-018-0393-4

Fu, F., & Luximon, Y. (2022). Comfort and fit perception based on 3D anthropometry for ear-related product design. In Applied Ergonomics (Vol. 100). https://doi.org/10.1016/j.apergo.2021.103640

Teh, P. L., Ahmed, P. K., Goonetilleke, R. S., Au, E. Y. L., Cheong, S. N., & Yap, W. J. (2015). Technology Acceptance and Hand Anthropometry (TAHA) Model: Insights from Somatosensory Technology. Procedia Manufacturing, 3. https://doi.org/10.1016/j.promfg.2015.07.395

APPENDICES

APPENDIX A
GANTT CHART PSM 2

Bil	Activity	Planning vs Actual	Week														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	PSM 2 briefing	Plan															
		Actual															
2	Manual measurement	Plan															
		Actual															
3	Discussion with SV	Plan															
		Actual															
4	3D CAD measurement	Plan															
		Actual															
5	Data analysis	Plan															
		Actual															
6	Chapter 4	Plan															
		Actual															
7	Chapter 5	Plan															
		Actual															
8	Submit draft	Plan															
		Actual															
9	Summary writing	Plan															
		Actual															
10	presentation	Plan															
		Actual															