

HUMAN HEAD MEASUREMENT STUDY USING KINECT CAMERA WITH THREE DIMENSION CAD SOFTWARE



BACHELOR OF MANUFACTURING ENGINEERING TECHNOLOGY WITH HONOURS



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Bachelor of Manufacturing Engineering Technology with Honours

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DECLARATION

I declare that this thesis entitled "HUMAN HEAD MEASUREMENT STUDY USING KINECT CAMERA WITH THREE DIMENSION CAD SOFTWARE" 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.



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.



DEDICATION

This dissertation is dedicated to my beloved parents, my supervisor Dr En Mohd Fa'iz bin Wahid and to those who are unwavering affection, guidance and encouragement have enriched my soul and driven me to undertake and complete this work.



ABSTRACT

Anthropometry is that the systematic study of measurements of the physique. The physique size, shape and composition were measured using anthropometric measurements. This study tells how the measurements process were produced from CAD (Computer Aided Design) software because measurements of a person's anthropometry by using traditional method are complicated and takes lots of your time, direct body measurements using tape scale, spreading callipers and other hand measuring devices. There are several problems during taking the manual measurement because of the human error. 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 purpose of this project is to check anthropometric measurements from CATIA V5R19 Software and Solid works 2020 to compare it with manual measurements. The tactic employed in this study is CATIA V5R19 Software and Solid works 2020. Three dimensional (3D) data obtained from this study is from Camera Anthropometry System (3DCAS). This thesis target linear and circumferences measurement of head. This thesis also studied about the use of CATIA software and Solid work software for measurement that could quickly measure a human body that had been scanned into a 3D model. This thesis could been concluded that manual and 3D measurement were produced with a different reading.

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

ABSTRAK

Antropometri adalah kajian sistematik pengukuran fizikal. Ukuran, bentuk dan komposisi fizikal diukur dengan menggunakan ukuran antropometri. Kajian ini memberitahu bagaimana proses pengukuran dihasilkan dari perisian CAD kerana pengukuran antropometri seseorang dengan menggunakan teknik tradisional adalah rumit dan memerlukan banyak masa yang lama semasa pengukuran badan langsung menggunakan skala pita, penyebar kaliper dan alat pengukur tangan yang lain. Terdapat beberapa masalah semasa mengambil pengukuran manual kerana kesilapan manusia itu sendiri. 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. Tujuan akhir projek ini adalah untuk memeriksa pengukuran antropometri dari CATIA V5R19 Software dan Solid work 2020 bagi memadankannya dengan pengukuran manual. Taktik yang digunakan dalam kajian ini adalah CATIA V5R19 Software. Data tiga dimensi (3D) yang diperoleh dari kajian ini adalah dari 3DCAS yang merupakan sistem antropometri kamera 3D. Tesis ini menyasarkan ukuran linear dan lilitan. Tesis ini juga mengkaji mengenai perbezaan corak 3D pengukuran antropometri pada bahagian kepala. Disimpulkan bahawa semasa kajian ini telah mencapai beberapa peningkatan dengan melakukan pengukuran menggunakan aplikasi dan pengukuran manual. Tesis ini juga mengkaji tentang penggunaan perisian CATIA dan Solid work untuk pengukuran yang boleh mengukur badan manusia dengan pantas yang telah diimbas ke dalam model 3D. Tesis ini dapat disimpulkan bahwa pengukuran manual dan 3D telah menghasilkan nilai yang berbeza.

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Last but not least, from the bottom of my heart I would also like to thank my beloved parents for their endless support, love and prayers. 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.



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APPENDIX

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APPENDIX A

Shows The Flow of Gantt Chart of This Thesis



CHAPTER 1

INTRODUCTION

1.1 Background

Anthropometrics is the study of the human body's measurements. Traditionally, this has been done by using simple equipment like tape measure or calipers to take measurement on the body surface, such as circumferences and widths. Surface anthropometry in three dimensions (3D), research can be extended primarily to 3D shape and morphology of tissues primarily outside the human body. The collection, indexing, transmission, storage, retrieval, questioning, and analysis of body size, form, and area, as well as their changes during growth and development to adulthood, are all part of this process. While 3D anthropometry surface surveying is relatively new, anthropometric surveying using traditional tools, such as calipers and tape measures, is not. Recorded studies of the human form date back to ancient times. Since at least the 17th century1, researchers have attempted to measure the human body for physical characteristics such as weight, height, and center of mass. Martin recorded 'standard' body measurement methods in a notebook in 1928.2 (Jones & Rioux, 1997)

1.2 Problem Statement

We are living in an anthropocentric world, where the size and shape of human body parts influences on creating designs for every object. Dimensions of human head plays an important part in creating objects for safety purpose, health purpose and general purpose.

- To take a measurement of head using traditional or manual measuring consume a lot of time and energy while using basic measuring equipments. There will be high waiting time during measuring session where respondents have to wait for a longer period.
- Physical contact issue is also one of the problem we have to face during conventional body measurement, we have Muslim female students which we did not consider them as respondents and we have to respect their culture.
- Moreover, using traditional or manual method there is a huge possibility to make a human error measuring the straight measurement of human head such as length and width, circumference, and other parts. This will lead to inacurrate reading and since this method is more time consuming it will require the respondent's patience.
- In addition, another issue is the method of using digital 3D photo, such as cameras which will have various flaws such as images created by the camera not being as obvious as the lens used is not the right one and it could be blurry.
- Furthermore, making sure the respondents attend the experiment at given time is a challenge as they could not attend at the time or busy during manual and conventional measurements.

1.3 Research Objective

The main three objective to overcome the problem statement above for this project is:

- a) To collect and compare the measurements data between conventional anthropometry method and by using 3D Camera Anthropometry System (3DCAS) on human's head.
- b) To measure the 3D rendered data by using CATIA V5 and Solidworks 2020 software.
- c) To analyse the data of measurements using statistical method which focused on standard deviation, mean, and percentile (5th, 50th and 95th).

1.4 Scope of Research

The scope of this research is focused on 3D Camera Anthropometry System with the total 18 parameters of the linear and circumference measurement of the head 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 with 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

The head is one among the necessary parts of the human body. There are several very important organs on the head that require to be protected. The protection aims to take care of the organ's safety and security. Safety and security factors are often achieved by coming up with varied products which will shield these organs. Additionally, on top of factors, comfort factors also ought to be considered in order that the created products are in accordance with human desires, to fulfill these three factors, a science in product design is needed. The supposed science is measurement, science that serves to measure the dimension of physical structure, as well as the head. These measurements aim to get information that would be used in planning design products for users' characteristics.

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2.2 CONVENTIONAL ANTRHOPOMETRY SIA MELAKA

In Conventional anthropometric the assurance of human parts measurements can accomplish by utilizing scope of gadgets. Richer has used callipers since 1890, when he first started using them, a standard arrangement of anthropometric equipment has been utilized. Straightforward, speedy, generally non-intrusive apparatuses incorporate weighing scales to decide weight, estimating tapes to quantify boundaries, direct body part measurements, anthropometers to gauge tallness, different cross over widths and profundities of the body, spreading callipers additionally quantify widths and profundities of the body, sliding compasses to quantify brief distances, like the button, ears or hands, and head spanners to quantify the stature of the head (Löffler-Wirth et al., 2016). Traditional strategies decrease the convoluted state of human bodies to a progression of basic size evaluation and inferred wellbeing records, for example, the weight list (BMI), the abdomen hip-proportion (WHR) and midsection by-height0.5 proportion (WHT.5R)(Thelwell et al., 2020). With these customary techniques for gathering anthropometric information, the estimating cycle is tedious, costly and prone to blunders. Additionally, conventional strategies require the individual being estimated to embrace normalized stances are endorsed when are taken and to keep up them during the estimation cycle. These standard estimating stances, characterized in ISO 7250, depend the investigations a few creators, for example, Kroemer and Kroemer (Kroemer et al., 2010) who clarify the standard strategy for estimating a subject ALAYS exhaustively. The essential estimating stance is alluded as "anatomical situation", which the member's body put in characterized, straight, upstanding stance, with the body portions at either 180, 0, or 90 degrees to one another. The head situated at Frankfurt plane, with the students similar flat level and the absolute bottom of right circle is in like manner adjusted اونيوم سيتي تيكنيكل مليسيا ملاك evenly.

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2.3 ANTHROPOMETRIC MEASURING TOOLS

The body parts are measured with anthropometric tools. There are basic components of anthropometric such as anthropometer, personal scale, calliper, sliding calliper, metric tape and many more. These are accurate, standardized originates mechanism to calculate the height, length, width and parameter. (Kopecký, 2014)

2.3.1 ANTHROPOMETER

The tools shown in figures below are to measure vertical dimension of the human body part. These tools made up of aluminium square profiles and double-sided measuring system with reading scale ranging from 50 to 2,133mm. It was designed to measure solely the vertical dimensions of human body part. A spirit level may be included in the anthropometer to guarantee that it is perpendicular. (Kopecký, 2014)



Figure 2-1 Shows the manual measuring tools



Figure 2-2 Shows the Stabalizer and measuring needle with Acromical Height of person

2.3.2 Calliper

More modest callipers, regardless of whether spreading or sliding, are gadgets used to quantify the distance between the inverse sides of a specific item, as does the bigger shaft calliper. On account of the more modest callipers, they are utilized to quantify the length, expansiveness, or profundity of more modest body parts, like the fingers, the hand, the face, nose or ears. The Skinfold calliper estimates the thickness of a piece of skin that is squeezed between the fingers as shown in the below. It's helpful in assessing the measure of muscle to fat ratio an individual is conveying.



Figure 2-3 Shows a Skinfold Callipar

Anthropometric callipers such as shown in below are explicitly intended for estimating living human bodies. The calliper can adjust tips and level edges. It dissimilar to the exceptionally sharp mechanical claimers that have comparative capacities. However it's very sharp too. (Anthrotech Tools of the Trade | Anthrotech, 2020)



Figure 2-4 Shows Anthropometric callipers



Figure 2-5 Shows a sliding callipar



Figure 2-6 Shows morphological height of the face

2.3.3 MEASURING TAPE

In measurement girth dimensions, the tape measure **Figure 7** must follow the girth accurately, for an example, adhere to the body and at the same time not compress the soft tissue. Girth dimensions are determined with the assistance of a one, 500 millimeter measuring tape. It's suggested to feature an extension loop (e.g. made of a thin string) to the tape measure to facilitate the dimension reading. The tape measure ought to endure regular review for accuracy.





Figure 2-8 Shows the application of Girth measurement

2.4 ANTHROPOMETRIC MEASUREMENT

Anthropometry is science and an applied art that determines anatomy's physical geometry, quality qualities, and force capabilities. (Del Prado-Lu, 2007). Anthropometric is a term that refers to a set of quantitative measurements of the muscle, bone, and fatty tissue used to determine body composition. Height, weight, body mass index (BMI), body circumferences (waist, hips, and extremities), and skinfold thickness are the main components of anthropometry. (Bragança et al., 2016)

2.5 BODY COMPOSITION IN ANTHROPOMETRIC

Human biologists have traditionally used anthropometric indicators of body composition. several researchers have tried to develop prediction equations to permit estimates of whole body parameters of body composition from anthropometric dimensions. However, most of those studies are affected by issues of analysis style, rendering the equations basically useless.

Circumference Skin Fold Width UNP Amt the C et C 14 C Call Artista C.

Figure 2-9 Shows body composition

2.6 3D BODY SCANNER

Three-dimensional surface anthropometry empowers to stretch out the investigation on three-dimensional math and also the morphology of basically outer tissues of the human body. In the year 1916 Dubois introduced a model which was the assessment on the surface region of the human body (BSA). Scanning three dimensionaly is a technique which is used to obtain dimensions of the body in a fast and repetitive manner. A total of six sensors will scan 20,000 three dimensional coordinate data on the body surface (Yu et al., 2003). By using a of 3D body scanners, body measurement technology can be non-contact, instantaneous, and accurate. However, how each scanner establishes benchmarks and performs measurements must be determined to achieve standardization of data collection.(Simmons & Istook, 2003)

Three-dimensional scanning is a technique used to obtain the dimensions of the human body quickly and repeatedly. However, if reliable data are to be obtained that can be used in an anthropometric database, the objects from the scan volume is said to be important. The body postures that are used for measurement in the old technique of anthropometry is not suitable when it comes to scanning the body because they obscure a large area of the armpit or crotch. Rather, they must have the abducted arms and legs scanning posture for the image to be captured. The device can see the body the inner surface of the limbs and torso. Compared to measurements obtained with standard anthropometric tools, changes in basic posture can change some measurements. Although the area of coverage is small through the abduction of legs and arms, these body postures cause changes in the shape of the shoulders and in the size of the hips and shoulders. In this study, it has been concluded by the author that as long as the abduction angle is less than 20°, the shoulder height remains stable, and when the abduction angle is greater than about 5°, the shoulder width is smaller.



Figure 2-10 Shows 3D body scan



Figure 2-11 Shows subject position during 3D scan



Figure 2-12 Shows the flow diagram of anthropometric data collection

There are several 3D whole body scanning systems are available on the market, including those presented below.(Bragança et al., 2016)

Company	Product	City, Country	Technique
Cyberware	WBX	Monterey, CA, USA	Laser line
4ddynamics	Mephisto EX- pro or CX-pro	Antwerp, Belgium	Structured light projection
4ddynamics	Gotcha	Antwerp, Belgium	Structured light projection
Vitronics	Vitus Smart LC	Wiesbaden, Germany	Laser line
Vitronics	Vitus Smart XXL	Wiesbaden, Germany	Laser line
TC2	KX-16	Cary, NČ, USA	Infrared
SizeStream	3D body scanner	Cary, NC, USA	Infrared
SpaceVision	Cartesia	Tokyo, Japan	Laser structured light
3dMDbody	Flex8	Atalanta, GA, USA	Stereo photogrammetry

Figure 2-13 Available 3D whole body scanning system

2.6.1 3D LASER SCANNER

Laser-based three-dimensional anthropometric assessments is an effective and simple technique to measuring the surface area of the body which allows large data sets to be collected. Using these procedures, lasers from four different directions scans the propends. An optical triangulation generates a "virtual twin". The virtual twin's point cloud can later be analysed for to biometric data eventually generating a lot of anthropometric data, including the body surface area. After a small study based on repeated measurements the reliability of this evaluation has been determined. (LOEFFLER-WIRTH et al., 2017)(Kuehnapfel et al., 2016). The **Figure 2.14** below shows the starting point for the laser scanning technology.



Figure 2-14 Bilateral Split of 3D body Image by laser scanner

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When 3D scanning is reduced to 1D derived body size, the full potential of 3D body scanning cannot be harnessed. Processing the data in 3D will give more and more detailed information on the body.

The point clouds can be converted to a 3D digital copy of a human with color and shading effects, often called an avatar. The connected to triangles points also called a mesh, and this often decrease the most essential triangles to cover the information of the shape. For example, this means the nose, for instance, has more triangles to cover the shape, than the forehead. These avatars are often used in software for virtual fitting. (Daanen & Psikuta, 2018)



Figure 2-15 Example of a point cloud (left), triangulated mesh (middle), and Gourmand shaded (right) head scan

The concept of elemental analysis can be used to quantify the appearance of a person's head or body. If a 3D body scan data set is available, a human body model can be created and fitted to each scan (Allen et al., 2003). The first element of the concept is related to height, the second is related to weight/weight, and the third is related to the relative length of arms/legs; however, elements of PCA posture can also be expressed, for example the back is clearly convex.

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Figure 2-16 Shows example model changes for principal component related to body mass

2.7 Microsoft Kinect

Kinect is the preferred distance sensor for Serval's advantages: consumer quality, video speed, people detection and 3D information. It is widely used for 3D reconstruction and commercial motion capture. At the same time, it can automatically and non-contact measure body parameters, such as volume, size, and vital statistics (He et al., 2018). Generally, commercially available Kinect and other similar depth sensors are used for 3D reconstruction. (Lu et al. 2013) The Kinect sensor enables the computer to directly determine the three dimensions (depth) of the player and the environment. It can also understands when users speak, knows who they are when they approach, and can interpret their actions and convert them into a format that developers can use to create new experiences. (Zhang, 2012b) Kinect sensor belongs to the category of devices called as depth cameras. The specific details of the measuring principles of the sensor itself can be found in Khoshelham. (Khoshelham, n.d.). The Kinect combines a standard RGB camera and a depth camera, which can measure the distance to thousands of points in the scene at the same time. Although the Kinect's point cloud capabilities are impressive, its M. Robinson, Estimating Anthropometry with Microsoft Kinect in ability to estimate joint centre locations has made it a revolutionary device. (Shotton et al., 2011) Compared with many traditional motion capture systems, the Kinect does not need to place markers on participants before recording data. This feature greatly reduces data collection time, but also reduces accuracy.
The Kinect sensor absorb several advanced sensing hardware. In particular, it contains a depth sensor, a colour camera, and a four-microphone arrangement that provide full-body 3D motion capture, facial recognition, and voice recognition ability.(Zhang, 2012a)



Figure 2-17 Shows the Microsoft Kinect Sensor

Infrared (IR) projector matrix, colour camera and infrared camera. The content of the depth sensor of the infrared projector is combined with the infrared camera, which is a monochromatic metal oxide semiconductor (CMOS) auxiliary sensor. Authorized by the Israeli company Prime Sense (www.primesense.com).





Although the specific technology has not been disclosed, it is based on basic structured light. In the infrared projector, the infrared laser is converted into a series of infrared points through the diffraction grating. The comparative geometry of infrared projectors and infrared cameras and the projected infrared dot patterns are well known. If you can compare the points observed in the image with the points on the projector template, you can triangulate it back to 3D. Because the dot pattern is relatively random, the matching between the IR image and the projector pattern can be done in a straightforward way by comparing small neighbourhoods using, for example, normalized cross correlation. (Zhang, 2012b)

2.8 3D CAS Anthropometric

The anthropometric dimensions of the character's face are used in criminology, orthodontics, facial imaging, and many other reservations, where the spacing between a set of facial features plays an important role in speculation. The daunting task of defining these dimensions. The aim is to developed fifteen canonical linear measurements between facial landmarks using Kinect camera (Alavani & Kamat, 2016).

Use simple and intelligent instruments to develop an automatic measurement system for the human body with minimal manual assistance. This setting takes two photos of the user, removes body contours and performs measurement extraction. The software will automatically standardize the camera every time the scanning room is checked. The user will select a front view and a side view among the images captured, and specify the height.(Senanayake et al., 2018)

20

2.9 Anthropometric Percentile

The anthropometric ratio of each population is classified by size and called the percentile. It is generally accepted that the female design ranges from the 5th percentile (5%) to the 95th percentile (95%) for men. A male score of 5 in a certain dimension (such as sitting posture, height) is usually the lowest designed score in the crowd; on the contrary, 95% male value may be the largest indicator expected. The range from 5% to 95% covers approximately 90% of the population. For most of the population, a range from the first male to 99% of males can be used. This represent the comparisons of percentile males and females. For a record of more anthropometric measurements of percentile humans. (Openshaw et al., 2006).



Figure 2-19 Shows the relative sizes of different percentile human

2.10 Percentile Formula

"Percentile" is in daily, but there is no universal definition for it. 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 formula from book

Rank =
$$(P/100) \times (n+1)$$

Rank = Ordinal rank of a given value (with the values in the data set scored from Smallest to largest.

n = Number of values in the data set.

P = Percentile.



 $\overline{x} = \sum x / n$

 \tilde{x} = Mean (average).

x = Total sum number.

n = Size of the set.

b. Standard Deviation – is a measure of how spread-out numbers are.

$$\sigma = \sqrt{\sum (x - \overline{x})^2} / n$$

 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.

2.11 Use of Percentiles and Z -Scores in Anthropometry

Percentiles and z-scores are widely used to evaluate anthropometric indicators to assess the growth and nutritional status of children. Compare the concepts and uses of percentiles and z-scores, as well as their advantages and limitations. Compared with percentiles, z-scores have several advantages: first, they are calculated based on the distribution (mean and standard deviation) of the reference population, thereby reflecting the reference distribution; second, as a standardized value, they it is comparable in terms of age, gender, and anthropometric indicators; third, the z-score can be analysed as a continuous variable across studies. In addition, they can quantify extreme growth at both ends of the distribution. However, z-scores are difficult to explain to the public and difficult to apply in clinical settings. In recent years, the use of percentiles has increasingly supported certain growth and obesity goals. We also discussed issues related to the selection of cut points and the method of fitting/smoothing paths to create a reference curve. Finally, some important links about growth. Standards were proposed and compared, including old and new WHO standards/reference materials and CDC 2000 US growth chart.

They are developed based on different principles and data sets, and provide different thresholds for the same anthropometric data. Measurement; so they can give different results. This is to understand and use percentiles and Z -scores based on recent growth references and standards.(Wang & Chen, 2012)

2.12 3D Measurement Software

2.12.1 CATIA Software

Catia software is a mechanical design automation that enables designers to quickly outline ideas, test features and dimensions, and generate detailed models and drawings. Catia uses a 3D design approach where when designing a part, from the initial sketch to the final result, it creates a 3D model. From this model, can create a 2D drawing composed of parts or subdual or mated components to create a 3D assembly. This software can also design 2D drawings of 3D assemblies. The software able to import the following types of files such as Drawing (.dwg), IGES (.iges, igs), Adobe Illustrator (.ai), 3D Object (.obj) and many more.



Figure 2-20 Shows homepage of Catia software

2.12.2 SKANECT Software

Skanect software is a mechanical structure that enables high-speed, simple and low-cost 3D scanning. Using Skanect software to create full-colour 3D models of objects, people or rooms has never been easier or smarter. Able to convert the frame sensor or core frame sensor into an affordable 3D scanner, creating 3D meshes from real scenes in minutes 30 frames per second. In addition, it is also very easy to use for 3D scanning of various scenes, and provides many predefined scenes suitable for most situations. Skanect software leverages consumer-grade 3D cameras like structure sensor and structure core, limiting the hardware cost to a fraction of previous 3D scanning solutions. (Nicolas Tisserand, 2019)



Figure 2-21 Skanect Software

2.12.3 SOLIDWORKS Software

SOLIDWORKS is used to develop mechatronics systems from beginning to end. At the initial stage, the software is used for planning, visual ideation, modeling, feasibility assessment, prototyping, and project management. The software is then used for design and building of mechanical, electrical, and software elements. Solidwork software is one of the well known software for 3D design. This software can be used for sketching, extruding to 3D, rendering, stress analysis and with other useful features.



Figure 2-22 Shows the features on Solidwork

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter describe the research methodology used to attain the study's goal. This methodology explains the entire research process in details including data, collection methods and study analysis. Besides that, there a flow charts constructed to show the flow of the research begin and the ending of the study. Each process of the flow chart is well explained with a proper statement to support process of research conducted. This flow chart is necessary to show the steps of the research to conduct the study.

Moreover, this chapter also mentions the proper method for data collection. It helps to determine analysis and the result of the research. By using various formulas and equations the collected data was analyzed. This chapter's summary is based on the research approach that was used.

3.2 Research Design

The study style could be a technique of specifying the particular of the analysis style that was used throughout the study. Qualitative research and quantitative research are two forms of approaches that used. Qualitative research relies on the assertions that are approved or valid with acceptable proof, like journals, experience, opinions, and different sources. Questionnaires, surveys, interviews, and literature studies supported other's finding will all used to collect this kind of data. Quantitative analysis relies applied mathematics and metaphors. These sorts of data will to live using measurable figures and demonstrated using a type of formulas, calculations and alternative procedure techniques. Below shows the flow chart of study design that's conducted to satisfy the need of objective using the tactic like literature study, measurement of respondent and case study.

3.3 Flowchart

Based on the **Figure 3.1**, the planning flowchart and process flowed of researched methodology was contained all the steps to complete a thesis in a certain timeframe. Project planning was part of the project management, which relates to the used of schedules and subsequently report progress within the project. The main reasoned to determine the flowchart to form a suggestion for the task have to be done throughout of this project. Normally, the research problem should identify before establishing the objectives of the project. Because to find the caused of the problem that happens in 3D and traditional method.

After that, it all started with a literature review, which was the simplest approached to study on anthropometry skill. Then, the data all gathered by used Microsoft Excel spreadsheets. Once, the study of data analysis on how to overcome the problem that occurs when measured body parts. The next step the 3D CAS measurement and manual measurement by used the data analysis for the outcome of this project and it was important to made some discussion about it. Finally, the progress of report submission was done.



Figure 3-1 Shows the flow chart of the Methodology

3.4 PARAMETER SELECTION

The measurement parameter is the analysis of the human body's physical measurement. These parameters were used to research are male and average type of body. 18 parameters of the body section include verticle measurement, horizontal measurement and circumference measurement. For this study, it were required to do the straight sitting posture measurement on the head. All segments including height, length, breadth, and circumference.

For the manual measurement it was done at the ergonomic laboratory FTK. This process of performing measurement manually required the 30 male respondents and along with the measuring equipments available in the laboratory. There were 18 parameters to be measured in this manual process.

PARAMETER	NAME
M75	HEAD LENGHT
M77	BITRAGION BREADTH HEADBOARD
UM78 RSITI T	BIZIGOMATIC BREADTH HEADBOARD
M79	BIGONIAL BREADTH HEADBOARD
M80	HEAD BREADTH
M81	INTERPUPILLARY BREADTH
M85	GLABELLA TO BACK OF HEAD
M88	INFRAORBITALE TO BACK OF HEAD
M89	TRAGION GO BACK OF HEAD
M90	PRONASALE TO BACK OF HEAD
M91	STOMION TO BACK OF HEAD
M92	MENTON TO BACK OF HEAD
M93	MENTON TO TOP OF HEAD
M94	PROMENTON TO TOP OF HEAD
M95	STOMION TO TOP OF HEAD
M96	PRONASALE TO TOP OF HEAD
M97	TRAGION TO TOP OF HEAD
	HEAD CIRCUMFERENCE

Table 3-1 Table shows the parameter for head measurement



Figure 3-2 Parameters of Head



Figure 3-3 Parameters of Head

3.5 Manual measurement process

Small Anthropometric tools was used to measure the facial anthropometric. All the 30 respondents have been brought to Ergonomic Lab FTK for manual measurement process. First they have kept their head position parallel. Respondents also was sitting an upright relaxed position and looked at distant object during the measurement process. Measurements was performed using traditional methods of physical anthropology by using conventional instruments.



Figure 3-4 Tools used for manual measurement



Figure 3-5 Head measurement using manual method

After measurement of all 18 parameters on 30 male respondents, the data was recorded on Excell spreadsheet. This manual measurement process took a very long time to complete the data collection.

3.6 3D CAS Measurement process

3.6.1 Setting up Skanect software Skanect software and camera kinect is used to scan human head to be used for 3D model in Catia and Solidwork software to measure the parameters. All the same respondets were brought to FKP ergonomic lab for 3D measurement. The skanect software need to be set to

1x1x1 box for a close 3D image capture of the head thus, clear rendered image could be obtained.

To start the scanning process, preparation of the setting is importand. Body is choosen, and the bounding box needed to be set and the path for the file to be saved must be correct to save the recorded scan.

Riepare	Record	Reconstruct	o" Proce	55
Herr Lord Settings License License License License Aspect ratio Path Config file Sourt Path	Citizet: Room Hiel Room 1x1x1 meters Hieldt x2 5 CEAR/2023-01-04_15_44_83.44 None Bis Start to apply the new settings.			
Figure 3- 3.6.2 Setting up Camera	6 Shows the settin	ng up of Skanect	software اونیوس	

The Kinect camera need to scan the respondents head to be rendered in Skanect software. Respondents were sitting on the rotator station with the right posture. After that, the image transferred into Skanect Software and imported to the Catia Software and Solidwork software to study the measurements.



Figure 3-7 Rotator used for respondents to sit in correct posture



Figure 3-8 Equipment used for 3D Measurement



Figure 3-9 Microsoft Kinect used to capture the head 3D image

Before starting the scanning process, respondents need to be asked to sit in the right posture with head cap to hide respondents hair and prevent scanning it. For the head posture the respondents were asked to sit straight and look parallel to a further object to make sure no unwanted movement during scanning.



Figure 3-10 Shows the right sitting posture during head scanning

After the sitting position of respondents was adjusted, next the distance need from camera to respondents need to be adjusted. This is to obtain a good image scanning without failiure. The respondent's image need to be green colour to proceed the head 3D scanning for a better result. The Kinect camera need to be moved up and down using control remote and adjust it until green image of respondents are obtained.



Figure 3-11 Shows the adjustment on Kinect Camera



Figure 3-12 Shows green image of respondents has been obtained

3.6.3 3D CAD Measurement Process

This section is about how the measurement was taken for 3D model that was rendered using Skanect Software to Catia and Solidwork software. Using these software to measure the human parts are way faster, easy to route made to measure. By using the Catia and Solidwork software measurement of the human body could be done automatically without physical contact in time. The entire head was scanned by one parameter to another.

By using these software as stated above, it required to some editing such human size as the scale need to adjust the measurement of human actual size. Then the 3D solid body need to be scaled up or down by using the scale feature. Finally needed to adjust the measurement based on isometric view.



Figure 3-13 Shows dekstop image of Catia software

Based on the figure above, first we have to open Catia Software that was installed. Then click the icon "START". Go to "Shape" and select "Digitized shape editor".



Figure 3-14 Shows the print screen of next step

A table of will appear to enter our part name. Name the file and select "OK".

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Figure 3-15 Shows print screen of file extraction

Choose the STL file of head to start the measurement. Select "OPEN" to invite the file for the next step.



Figure 3-16 Shows print screen of rendered image of respondent

STL rendered image of head from Skanect will appear as shown in figure above.



Figure 3-17 Shows the measuring process

Next we have to choose "measure between". For the measuring we have to select "Picking point" to allow us to choose from which point to which point we would like to measure. After the result is obtained transfer the data to Excell spreadsheet.

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Figure 3-18 Shows the main page of Solidwork software

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	Desktop V CPERBOUT	Quick Filter	
	File name: HEAD		
SOLIDWORKS Premium 2020 SP1.0			<u>\$</u>

Figure 3-19 Shows the extraction of STL file

From the "Open" icon import the rendered STL head file for measurement.



Figure 3-20 Shows the rendered image of head measurement

Based on the figure the rendered image from skanect software is imported to Solidwork



Figure 3-21 Shows measuring technique

By using the "measure" icon select point to point for for the desired parameter to be measured. Repeat this process for each respondents and gather the dat to be input in Excell spreadsheet.

3.6.4 MICROSOFT EXCEL(SPREADSHEET)

Spreadsheet is one of the most useful and simplest programs to store information, summarize, formulate and calculate it. The collection of data from factory majority was based on computerized method and provide information using this format. Therefore, the obtained can be sorted and summarized then later used by adding the required formulas for calculation process. Microsoft Excel was used, which can support big data and the formulas can be added manually into the spreadsheet.



Figure 3-22 Excel Homepage

Data Analysis is the second part of data collection where the gathered and arranged data will be now interpreted and calculated to achieve the second objective. Data analysis is an important aspect in research as it allows to produce results which can be obtain by pointing out the problem statement, summarize the gathered data, formulate and calculate the data and then finally suggest on the future improvement. There are several data analysis methods that can be carried out on this study. Measuring the percentile of the values in the data set.

After gather all the respondent data, was calculate the both of manual and 3D measurement average to get the differences before taking to next analysis. Then the average data gather to get the percentile. The mean, standard deviation also calculated in order to get 5th, 50th and 95th percentile for manual and 3D measurement from the parameters.

3.7 Summary

In nutshell, this chapter explained the flow process and steps on conducting this research. It is started by creating a flowchart that is able to summarize the flow process for the study conducted. In the flowchart notes down the main topics that were needed to focused in whole UNIVERSITITEKNIKAL MALAYSIA MELAKA research.

The content of the flowchart is started with the identification of research problem. Based on this, the scope and objective were created. The objective was to solve the problems that are stated. Next using the key point of the study, the literature review was studied and summarized. The resource for literature review is obtained based on the objective of the study which was collected, analysed and compared the measurements by using conventional and 3D measurement

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

In this chapter it explains on the results that were obtained from experiments that conducted in the ergonomic lab FKP and ergonomic lab FTK. There are two sets of data collection which are manual measurement and 3D measurement. 3D measurement was obtained from 3D camera Kinect to skanect software and imported to Catia and Solidwork software to obtain the 3D measurement of the parameter. Manual measurement was obtained using traditional method by using measuring tools and convert the data to Microsoft excel spreadsheet. This enable the result to be seen clearly from mean, median, standard deviation together with 5th, 50th and 95th percentile that was calculated using Excel spreadsheet. From this, difference between manual measurement and 3D camera Kinect measurement to be identified.

4.2 3D CAD OUTCOME EKNIKAL MALAYSIA MELAKA

The 3D model has been rendered and scanned..by using Skanect software and imported to Catia and Solidwork software successfully. This process is important to measure so that the manual measurement can be compared and analysed with 3D CAD measurement. The steps taken for a successful outcome stated as below.



Figure 4-1 Shows that 3D Catia measurement is succesfully obtained



Figure 4-2 Shows that 3D Solidwork measurement is successfully obtained

4.3 Data Collection for Manual and 3D Measurement Using Spreadsheet

This chapter describes that how the data for manual and 3D measurement was gathered and summarized in Microsoft Excel. These data relate to PSM and include 18 head parameters from 30 male respondents. Each of the parameters was taken once for manual and 3D measurement to saw the percentage differences in values of each parameters. Next gathered all the data from 30 respondents, then calculate both of manual and 3D measurement mean, standard deviation and percentiles for 5th, 50th and 95th to compare the difference.



4.3.1 Head Manual Measurement Data

MANUAL HEAD MEASUREMENT	Y.Y.	2	3	4	5	6	7	8	9	10
M75	16.29	18.9	18.3	18.7	18.9	20	20.5	18	18.5	19.3
M77	14.8	14.1	5 14	14.3	13.7	14	15.3	15.2	14.8	15
M78	13.2	12.5	12.8	12.7	12.4	13.3	13.5	14.4	13	13.5
M79	11.7	11.4	11.4	12.3	11.3	12.7	12.9	13.2	12	13.2
M80	16.3	14.7	16.1	15.3	16.3	15.7	16.9	16.5	15.5	16.4
M81	6.5	7.7	6.9	6.7	7.1	6.3	7.7	6.7	6.7	6.8
M85	18.4	19.6	18.5	18.1	18.9	19.9	20.6	18	18	19.2
M88	18.3	18	17.6	16.5	16.2	18.9	18.5	17.2	17.1	18.2
M89	9.5	9.8	10.4	9.6	8.7	9.8	11.2	8.5	7.5	8.2
M90	19.3	19.4	20	19.9	21.3	20.6	22.2	19	19.1	20.1
M91	16.9	19.5	18.4	17.5	20.5	21	21.1	17.8	18.1	20.2
M92	14.7	17	15.8	17	18.1	18	20.3	15.4	15.9	17.4
M93	22.3	21.2	21.6	21.5	23.2	22.6	20.4	21.9	21.9	22.1
M94	20.4	20.1	21.1	22.7	21.5	19.5	22	18.7	20.2	21.3
M95	18.6	16.3	18.9	18.4	16.9	16.6	16.5	16.2	16.9	17.1
M96	15.1	11.7	13.4	12.5	13	13	13	11.5	13.4	14.4
M97	13.4	12	13.3	12.5	11	13.7	13.7	13.2	13.2	14.3
HEAD CIRCUMFERENCE	56	54	53.5	55	57	58	60	55.5	54	58

Table 4-1 Shows the Head Manual Measurement for First 10 Batch Male Respondents

MANUAL HEAD MEASUREMENT	11	12	13	14	15	16	17	18	19	20
M75	18.5	18.2	18.6	18.1	18.5	19.5	18.7	19.6	18.2	20.2
M77	14.4	13.6	13.6	13.9	13.7	15.1	14.4	14.4	13.4	14.2
M78	12.6	11.6	12	12.3	12.2	13.4	12.9	13.4	13.1	13.3
M79	11.3	10.3	10.9	11.3	12.2	12.1	12.5	13	12.1	12.7
M80	15.9	15.7	15.6	15.4	15.5	16.2	16.6	16.3	15.8	15.5
M81	6.4	7.5	6.6	7	6.9	7.1	7.3	6.2	5.7	6.3
M85	18.2	18.1	18.2	17.9	18.4	19.4	18.6	19.5	19	19.9
M88	17	16.7	16.7	16.1	17.9	17.5	18	18.2	17.2	18.9
M89	7.6	8.4	8	8.1	7.7	8	7.5	9.9	9.5	9.7
M90	18.9	19.2	19.5	19.5	19.5	19.9	19	20	20.2	20.6
M91	17.1	17.2	18	17.1	17.6	17.6	17.7	18.5	17.4	21
M92	15.6	16.5	16.8	15.5	14	16.7	16.2	15.8	16.8	18
M93	21.8	20.8	20.4	20.5	19.2	20.3	19.7	21.8	21.6	22.3
M94	19.6 💻	18.5	18.9	19.5	18.4	18.6	19.9	18.9	17.3	19.5
M95	16.5	14.8	15.5	16.3	15.6	15.2	16.9	14	16.2	16.5
M96	13.2	12.8	12.3	A11.5	AL10 Y S	11.2	11.5	11.3	10.6	13
M97	13.2	12.7	12.5	13.6	11.2	10	12.4	12.2	11.2	13.7
HEAD CIRCUMFERENCE	54	54.5	53	53	53	56	54.5	55.5	53	58

Table 4-2 Shows the Head Manual Measurement for Second 10 Batch Male Respondents

MANUAL HEAD MEASUREMENT	21	22	23	24	25	26	27	28	29	30
M75	18.9	18.2	18.2	17.9	19.2	18.7	17.9	17.9	19.7	18.7
M77	13.2	15	14.4	13.6	13.6	13.9	13.7	15.1	14.4	14.4
M78	12.1	13.2	12.6	11.6	12.4	12.3	12.2	13.1	12.9	13.5
M79	11.2	3.4	11.5	10.2	10.9	11.3	12.4	12.1	12.5	13
M80	14.4	15.4	15.4	15	15.1	15.1	14.8	15.8	16.3	15.7
M81	5.8	5.5	5.5	5.5	5.4	6.4	6.5	6.9	5.7	6
M85	19	18.2	18.6	18.5	19.5	19.2	17.9	19.1	20	18.5
M88	17.7	16.5	17.7	17.4	18.5	18.7	17.2	17.8	19.1	18
M89	9.5	7.2	9.7	8.2	7.5	11.2	8.2	11.6	9.4	9.5
M90	20.4	20.8	19.5	21.7	22.2	21	19.5	20.2	20.5	19.7
M91	17.6	18.3	18	19.3	17.5	20	15.6	17.5	18.7	18.8
M92	17.3	17	17.2	17.3	17.6	17.9	15.8	16.9	18	18
M93	19.7	19.5	18.4	20.3	19.5	19.5	22.5	22.5	21.6	25.7
M94	16.1	17.4	17.2	19	18.1	17.2	19.6	18.9	23.6	17.2
M95	14	14.5	14.4	17	14.6	15	15.1	18.6	20.6	17.5
M96	12	11.5	10.6	11.2	12.1	11	13.4	14.1	14.4	12.9
M97	9.5	12	9.5	10	10.6	12	12.7	14.3	10.4	11.9
HEAD CIRCUMFERENCE	54	58	53	54.5	54	53	53	52	54.5	49

Table 4-3 Shows the Head Manual Measurement for Third 10 Batch Male Respondents

4.3.2 Head Catia 3D Measurement

			the second								
3D CATIA HEAD	2	1	2	3	4	5	6	7	8	9	10
MEASUREMENT	A.										
M75	2	18.43	20.9	19.1	19.4	21.42	19.93	20.8	18.8	19.94	18.74
M77		13.82	14.95	14.1	15	14.09	15.1	16.9	14.4	15.54	16.05
M78		14.87	14.8	14.74	14.72	14.67	15.58	15.7	13.9	15.18	15.5
M79	2	8.4	7.86	8.03	8.21	7.72	10.4	13.1	8.05	7.18	8.2
M80	0	15.5	16.21	16.36	16.7	17.01	16.95	17.6	14.83	16.77	16.4
M81	18 N	5.23	6.42	5.43	6.28	6.67	5.54	7.4	5.59	6.1	5.2
M85	-31	19.1	21	19.16	19.6	20.2	21.06	22.1	18.86	19.75	21.5
M88	1.1	18.5	19.89	16.52	17.48	16.73	18.62	20.3	15.56	18.43	16.68
M89	esc.	10.6	12.78	9.1	8.2	8.21	8.8	11.4	5.48	9.56	6.6
M90		20.2	23.65	19.15	20.5	20.95	21.95	23.3	18.95	20.94	20.43
M91		21.2	24.38	17.58	18.94	19.37	21.4	22.2	17.92	20.09	19.62
M92		18.56	19.98	15.62	17.53	17.68	18.21	20.7	16.47	17.92	18.322
M93		20.21	21.32	23.1	24.95	25.37	21.32	21.6	22.94	23.79	23.5
M94		18.56	20.1	21.92	22.08	23.17	22.27	19.7	20.39	21.36	20.97
M95		15.68	16.59	18.45	18.56	20.39	19.93	15.7	17.73	18.86	18.65
M96		11.3	12.1	15.9	14.88	16.33	15.6	12.5	15.42	14.78	14.52
M97		12.1	14.18	13.7	13.45	13.17	14.51	13.2	14.307	13.85	13.95
HEAD CIRCUMFEREN	NCE	51.85	51.43	51.72	52.63	53.4	55	65	46.3	52.6	55.32

Table 4-4 Shows the Head 3D Catia Measurement for First 10 Batch Male Respondents

3D CATIA HEAD	11	12	13	14	15	16	17	18	19	20
MEASUREMENT										
M75	19.53	20.59	18.66	20.5	19.45	18.86	19.56	19.78	20.2	20.55
M77	15.62	14.54	14.84	15.18	14.85	16.05	15.63	15.91	16.43	15.01
M78	15.2	13.29	14.65	15.46	14.16	15.62	15.18	15.84	15.44	14.77
M79	9.3	9.46	6.8	8.62	6.65	7.77	9.4	8.66	10.3	7.92
M80	17.11	17.25	16.17	16.65	16.08	16	17.11	17.3	18.24	17.25
M81	5.5	5.99	5.53	6.53	5.73	5.38	6.07	5.94	7.63	5.63
M85	19.3	21.04	18.95	21.37	19.31	21.07	19.35	21.2	20.26	20.66
M88	17.88	18.26	17.34	20.03	16.85	16.6	17.99	17.66	19.05	19.21
M89	9.95	9.49	8.88	11.45	8.96	6.3	9.95	8.9	10.9	10.65
M90	21.7	21.47	20.2	23.34	19.78	20.76	21.56	21.25	20.2	23.07
M91	21.3	20.31	19.68	22.31	18.75	19.62	21.06	20.01	19.63	22.86
M92	19.55	18.08	18.97	20.43	15.14	18.35	19.53	18.73	18.05	20.97
M93	21.77	23.28	21.255	22.1	21.23	23.49	21.74	22.94	23.38	23.42
M94	19.7	21.92	18.3	20.4	20.6	20.95	19.75	21.12	22.16	20.75
M95	16.72	18.57	16.19	17.47	17.58	18.83	16.74	17.63	18.95	17.51
M96	12.97	16.05	12.66	13.3	17.13	14.56	12.97	13.74	15.44	12.96
M97	14.2	14.32	13.5	14.01	14.23	13.94	14.22	13.58	12.82	14.26
HEAD CIRCUMFERENCE	52.6	54.2	50.7	52.2	50.41	50.28	53.7	54.4	56.8	54

 Table 4-5 Shows the Head 3D Catia Measurement for Second 10 Batch Male Respondents

3D CATIA HEAD	21	22	23	24	25	26	27	28	29	30
MEASUREMENT										
M75	17.5	20.1	18.15	19.45	19.18	18.07	20.55	19.19	19.68	19.66
M77	14.6	14.95	13.86	15.03	16.34	13.74	15.16	17.4	16.55	15.59
M78	14.3	14.8	14.76	14.78	12.02	13.2	14.83	16.55	15.81	14.32
M79	8.3	7.88	8.03	8.07	9.25	6.8	8.66	11.59	12.45	12.11
M80	16.4	16.17	16.45	16.72	14.73	16.17	16.64	16.67	16.67	15.24
M81	5.1	6.56	5.47	6.2	4.35	5.64	6.52	5.7	7.06	6.22
M85 💾	20.15	21.04	19.19	19.63	19.14	18.99	21.37	19.23	20.15	20.19
M88	17.4	19.91	16.64	17.55	18.24	17.32	20.04	18.84	19.68	18.95
M89	9.5	12.72	9.08	8.15	10.52	8.88	11.41	8.64	10.49	8.8
M90	21.19	23.55	19.12	20.7	20.47	18.34	21.7	21.82	21.55	21.33
M91	21.05	24.28	17.65	18.85	19.91	19.65	22.3	22.48	23.14	22.24
M92	18.68	20.02	15.6	16.86	16.65	18.97	20.46	15.82	15.4	19.93
M93	20.44	21.5	23.11	24.93	22.93	21.24	20.5	22.81	21.33	20.41
M94	18.73	20.2	21.85	21.09	20.65	19.05	20.4	20.46	19.35	19.16
M95	15.77	16.71	18.53	18.53	18.88	16.19	17.45	16.99	17.21	16.88
M96	11.56	12.09	15.01	14.82	15.18	12.66	12.6	13.46	12.31	13.55
M97	11.2	13.8	13.85	13.32	11.68	13.15	12.8	9.24	10.27	13.05
HEAD CIRCUMFERENCE	51.7	51.4	51.7	52.59	48.12	50.42	52.13	51.2	52	47.7

 Table 4-6 Shows the Head 3D Catia Measurement for Third 10 Batch Male Respondents

4.3.3 Head Solidwork 3D Measurement

3D SOLIDWORK HEAD	1	2	3	4	5	6	7	8	9	10
MEASUREMENT	LAYS									
M75	18.47	21.1	19.12	19.42	21.42	19.96	21.21	18.83	19.94	18.72
M77	14.71	14.98	14.33	15.03	14.09	15.3	17.05	14.3	15.52	16.04
M78	14.98	14.7 7	14.79	14.78	14.67	15.677	15.24	13.93	15.18	15.5
M79	8.432	7.81	8.03	8.17	7.72	10.38	6.71	8.09	7.22	8.2
M80 💾	16.54	16.38	16.48	16.76	17.01	16.97	17.63	14.83	16.77	16.5
M81	5.27	6.51	5.47	6.21	6.67	5.52	5.84	5.59	6.1	5.2
M85	19.38	21.01	19.19	19.69	20.2	21.06	21.05	18.86	19.75	21.5
M88	18.07	19.91	16.67	17.55	16.73	18.62	21.73	15.56	18.44	16.63
M89	10.65	12.72	9.08	8.18	8.21	8.8	13.97	5.48	9.56	6.6
M90	21.17	23.58	19.12	20.7	20.95	21.95	25.1	18.95	20.91	20.43
M91	21.07	24.38	17.62	18.91	19.37	21.31	22.06	17.92	20.09	19.62
M92	18.64	20.02	15.58	17.57	17.68	18.21	22.18	16.44	17.94	18.322
M93	20.47	21.48	23.09	24.93	25.37	24.11	23.83	22.94	23.79	23.49
M94	18.76	20.16	21.86	22.03	23.17	22.27	21.9	20.39	21.44	20.97
M95	15.77	16.73	18.52	18.522	20.39	19.94	18.91	17.73	18.86	18.63
M96	11.41	12.06	15.06	14.81	16.33	15.63	13.96	15.44	14.78	14.52
M97	12.14	14.15	13.82	13.31	13.17	14.44	15.17	14.307	13.88	13.96
HEAD CIRCUMFERENCE	51.9	51.4	51.7	52.6	53.4	55	63	46.3	52.6	55.4

Table 4-7 Shows the Head 3D Solidwork Measurement for First 10 Batch Male Respondents
3D SOLIDWORK HEAD	11 AV 07	12	13	14	15	16	17	18	19	20
MEASUREMENT	Viene old						1			
M75	19.56	20.59	18.66	20.52	19.45	18.89	19.56	19.76	20	20.57
M77	15.62	14.54	14.86	15.15	14.88	16.04	15.625	15.91	16.41	15.03
M78	15.16	13.29	14.68	15.46	14.16	15.69	15.16	15.82	15.47	14.78
M79	9.3	9.46	6.8	8.64	6.69	7.77	9.3	8.66	10	7.9
M80	17.11	17.25	16.17	16.65	16.08	16	17.11	17.29	18.24	17.25
M81	5.5	5.99	5.53	6.52	5.75	5.33	6.09	5.935	7.66	5.63
M85	19.35	21.04	18.99	21.37	19.31	21.07	19.35	21.2	20.26	20.68
M88	17.99	18.26	17.34	20.03	16.85	16.63	17.99	17.66	19.05	19.21
M89	9.95	9.49	8.88	11.41	8.92	6.3	9.95	8.9	10.9	10.69
M90	21.7	21.47	20.2	23.34	19.75	20.74	21.59	21.22	20.2	23.07
M91	21.3	20.31	19.68	22.29	18.73	19.62	21.04	20.03	19.64	22.86
M92	19.53	18.08	18.97	20.46	15.14	18.322	19.53	18.73	18.05	20.97
M93	21.77	23.35	21.255	22.1	21.23	23.49	21.77	22.94	23.38	22.35
M94	19.7	21.96	18.3	20.4	20.63	20.97	19.77	21.12	22.13	20.75
M95	16.74	18.57	16.19	17.47	17.56	18.83	16.74	17.65	18.97	17.49
M96	12.97	16.08	12.66	13.3	17.13	14.56	12.97	13.74	15.42	12.96
M97	14.4	14.32	13.144	14.01	14.23	13.96	14.21	13.6	12.82	14.26
HEAD CIRCUMFERENCE	52.6	54	50.7	52.2	50.4	50.2	53.7	54.2	57	54

Table 4-8 Shows the Head 3D Solidwork Measurement for Second 10 Batch Male Respondents

3D SOLIDWORK HEAD	21	22	23	24	25	26	27	28	29	30
MEASUREMENT										
M75	17.3	20.3	18.12	19.42	19.18	18.05	20.52	19.21	19.67	19.68
M77	14.7	14.98	13.88	15.03	16.34	13.75	15.15	17.1	16.54	15.57
M78	14.5	14.7	14.79	14.78	12.02	13.2	14.85	16.55	15.81	14.34
M79	8.3	7.81	8.03	8.07	9.25	6.8	8.64	11.59	12.45	12.11
M80 🔲	16.2	16.2	16.48	16.76	14.73	16.17	16.65	16.67	16.67	15.24
M81	5.1	6.51	5.47	6.21	4.35	5.63	6.52	5.7	7.06	6.22
M85	20.1	21.03	19.19	19.69	19.14	18.99	21.37	19.24	20.14	20.18
M88	17.4	19.91	16.67	17.55	18.27	17.34	20.03	18.84	19.71	18.91
M89	9.5	12.72	9.08	8.18	10.6	8.88	11.41	8.64	10.51	8.82
M90	21.17	23.58	19.12	20.7	20.48	18.34	21.7	21.83	21.51	21.35
M91	21.07	24.28	17.62	18.85	19.91	19.68	22.29	22.48	23.14	22.24
M92	18.64	20.02	15.58	16.86	16.63	18.97	20.46	15.85	15.4	19.91
M93	20.47	21.48	23.09	24.93	22.93	21.255	20.5	22.81	21.35	20.44
M94	18.76	20.2	21.86	21.09	20.68	19.06	20.4	20.49	19.37	19.18
M95	15.77	16.73	18.52	18.522	18.85	16.19	17.47	16.97	17.21	16.88
M96	11.41	12.06	15.06	14.81	15.15	12.66	12.6	13.48	12.32	13.55
M97	11.4	13.8	13.82	13.31	11.68	13.144	12.9	9.22	10.27	13.08
HEAD CIRCUMFERENCE	51.9	51.4	51.7	52.6	48	50.4	52.1	51	52	47.8

 Table 4-9 Shows the Head 3D Solidwork Measurement for Third 10 Batch Male Respondents

4.3.4 Mean Head Measurement Comparison

Head Measurement	Head Manual	Head Catia 3D	Head Solidwork 3D
Parameter	Measurement MEAN	Measurement MEAN	Measurement MEAN
M75	18.72	19.55	19.57
M77	14.3	15.24	15.28
M78	12.88	14.82	14.82
M79	11.98	8.83	8.61
<mark>M</mark> 80	15.93	16.50	16.55
M81	6.89	5.95	5.90
M85	18.75	20.13	20.11
M88	17.47	18.13	18.18
M89	8.8	9.47	9.56
M90	19.8	21,10	21.19
M91	18.43	20.65	20.64
M92	16.48	18.23	18.28
M93 VERS	_21.28	22.39	22.54
M94	19.98	20.57	20.65
M95	16.51	17.66	17.77
M96	12.48	13.94	13.96
M97	12.67	13.26	13.33
HEAD CIRCUMFERENCE	55.34	52.45	52.37

 Table 4-10 Shows Mean Diffrence Between Manual Measurement and 3D CAD Measurement

4.3.5 Standard Deviation Head Measurement Comparision

Head Measurement Parameter	Head Manual Measurement STDEV	Head Catia 3D Measurement STDEV	Head Solidwork 3D Measurement STDEV
M75	0.907	0.920	0.969
M77	0.569	0.930	0.868
M78	0.669	0.897	0.886
M79	0.838	1.661	1.483
M80	0.554	0.763	0.738
M81	0.445	0.704	0.651
M85	0.778	0.948	0.874
M88	0.828	1.268	1.365
M89	1.113	1.687	1.844
M90	0.856	1.370	1.490
M91	1.396	1.831	1.824
M92	1.427	1.693	1.791
M93		MAI 1.401 IA ME	1.398
M94	1.287	1.207	1.201
M95	1.270	1.233	1.185
M96	1.245	1.554	1.507
M97	1.092	1.244	1.284
HEAD CIRCUMFERENCE	1.972	3.239	2.992

Table 4-11 Shows Standard Deviation Diffrence Between Manual Measurement and 3D CAD Measurement

4.3.6 5th Percentile Head Measurement Comparision

Head Measurement Parameter	Head Manual Measurement 5th Percentile	Head Catia 3D Measurement 5th Percentile	Head Solidwork 3D Measurement 5th Percentile
M75	17.74	18.10	18.08
M77	13.6	13.83	13.97
M78	11.94	13.24	13.24
M79	10.8	6.8	6.75
M80	15.21	15.01	15.01
M81	6.28	5.14	5.14
M85	17.98	18.96	18.99
M88	16.18	16.55	16.63
M89	7.5	6.43	6.43
M90	18.98	19.02	19.02
M91 ==	17.07	17.77	17.75
M92	14.59	15.49	15.48
M93 MERS	19.62	20.42	20.47
M94	18.48	18.63	18.76
M95	14.68	15.73	15.95
M96	11.02	11.79	11.70
M97	10.85	10.68	10.77
HEAD CIRCUMFERENCE	53	47.88	47.89

Table 4-12 Shows 5th Percentile Diffrence Between Manual Measurement and 3D CAD Measurement

4.3.7 50th Percentile Head Measurement Comparision

Head Measurement Parameter	Head Manual Measurement	Head Catia 3D	Head Solidwork 3D			
MAL	50th Percentile	Measurement 50th	Measurement 50th			
2	11 C.	Percentile	Percentile			
M75	18.65	19.54	19.56			
M77	14.35	15.06	15.09			
M78	12.85	14.8	14.79			
M79	12.05	8.25	8.18			
M80	16	16.64	16.65			
M81	6.85	5.83	5.79			
M85	18.45	20.15	20.12			
M88	17.55	18.11	18.03			
M89	8.45	9.29	9.28			
M90	19.5	21.07	21.17			
M91	17.9	20.2	20.2			
M92	16.35	18.33	18.32			
M93	21.55	22.45	-22.87			
M94	19.75	20.53	20.65			
M95	16.5	17.54	17.60			
M96	12.65	13.64	13.85			
M97	12.95	13.64	13.81			
HEAD CIRCUMFERENCE	54.75	52.06	52.05			

Table 4-13 Shows 50th Percentile Diffrence Between Manual Measurement and 3D CAD Measurement

4.3.8 95th Percentile Head Measurement Comparision

Head Measurement Parameter	Head Manual Measurement	Head Catia 3D	Head Solidwork 3D
2	95th Percentile	Measurement 95th	Measurement 95th
8		Percentile	Percentile
M75	20.07	20.85	21.19
M77	15.21	16.74	16.96
M78	13.63	15.82	15.81
M79	13.2	12.29	12.02
M80	16.64	17.46	17.57
M81	7.7	7.24	6.99
M85	20.00	21.44	21.37
M88	18.56	20.03	20.03
M89	10.52	12.14	12.72
M90	21.43	23.45	23.58
M91	21.01	23.76	24.09
M92	18.43	20.59	20.88
M93	22.69	24.94	24.93
M94	22.10	22.22	22.24
M95	18.64	19.48	19.78
M96	14.50	16.20	16.29
M97	13.79	14.31	14.43
HEAD CIRCUMFERENCE	58.3	56.13	56.74

Table 4-14 Shows 95th Percentile Diffrence Between Manual Measurement and 3D CAD Measurement

4.3.9 Analysis of Mean, Standard Deviation and Percentile

WALAYS !.

The data sets have successfully collected and the necessary calculations have been done to identify the mean, standard deviation and the percentile using Excell Spreadsheet formula. Upon analysing the mean that was obtain, there was a significant difference between manual measurement and 3D CAD measurement. The difference between Catia and Solidwork measurement for mean on all parameters have only slight difference. This may due to human error during manual measurement and with lose hair. The head circumference parameter shows a huge difference among manual measurement and 3D CAD measurement and 3D CAD measurement and measurement and 3D CAD measurement and with lose hair. The head circumference parameter shows a huge difference among manual measurement and 3D CAD measurement with more than 3cm in difference. Wearing head cap gave a major impact to the measurement.

For the 5th percentile which consider as only 5% of the data below the value. For an example for the parameter M91 Stomion to back of head around 2 respondents only have the measurement in the range of 17.00cm - 17.77cm. As for the 50th percentile where 50% of the data less than and 50% data more than the than value, the average measurement for M91 Stomion to head is 20.2 cm according to 3D CAD measurement Solidwork and Catia and 17.9cm according to manual measurement. The 95th percentile means the value where 5% of data has the larger value. In this case according to manual measurement 21.01cm is the 95th percentile for Stomian to back of head M91.

4.3.10 Discussion

Head Measurement Parameter	Head Manual Measurement MEAN	Head Catia 3D Measurement	Head Solidwork 3D
		MEAN	Measurement MEAN
M79	11.98	8.83	8.61

Table 4-15 Shows the parameter with big measurement difference

Table above shows the parameter with the biggest margin difference between manual measurement and 3D CAD measurement which was 3.15 cm in between them. M75 is the parameter of BIGONIAL BREADTH HEADBOARD. This parameter measurement is taken from jaw to jaw of respondents. Movement of jaw during manual measurement when they feel uncomfortable to them or when they not in the still mode could have caused this huge difference. While 3D CAD measurement no interference occurred to the respondents thus, the 3D measurement just had a slight difference of 0.22 cm.

 Table 4-16 Shows the parameter with huge measurement difference

Head Measurement	Head Manual	Head Catia 3D	Head
Parameter	Measurement MEAN	Measurement	Solidwork 3D
UNIVERSI	TI TEKNIKAL MALA	YSIA MELAK	Measurement MEAN
HEAD CIRCUMFERENCE	55.34	52.45	52.37

Another parameter with huge measurement difference is HEAD CIRCUMFERENCE with huge margin of 2.89cm in between them. This huge difference could be because of during manual measurement the respondent wasn't wearing the head cap which help to make the respondents hair compact. Even though, manual measurement was taken with lifting up the hair for respondents with long hair, this statistical analysis shows that it gave a huge impact on the measurement between manual and 3CAD software.

CHAPTER 5

CONCLUSION

5.1 INTRODUCTION

The overall main goal of the project was explained in this chapter. Whether or not the goal stated at the beginning of the studied was met. Aside from that, this section also discusses the summary of findings gathered during the researched process.

5.2 CONCLUSION

In conclusion, it could be seen that the use of software such as CATIA V5R19 and Solidwork 2020 was the right tool to be used in this study. This was because the human body measurement was usually done manually, which was a measurement that use human energy and took longer time for the process. By using the CATIA and Solidwork software could quickly measured a human body that had been scanned into a 3D model.

It was cleared that, the first goal of this project in completing this study was to identify about the differences between 3D measurements and manual measurements based on human head parameters. The data has been taken and identified the big difference in parameter and cause of it.

The second objective have been achieved as 3D CAD measurement data was successfully taken using CATIA and Solidwork software. The steps for the measurement in CAD software has been identified and able to measure the data as the requirement of the parameter. Finally, the data collected for manual measurement and 3DCAD measurement was successfully able to identify the mean, standard deviation and percentile (5th, 50th and 90th) as per third objective. The data was tabulated in Excel Spreadsheet and calculated the required reading the Excel. This will able to give a clear vision on the difference between manual measurement and 3D CAD measurement. and manual measurements on human head.

5.3 SUGGESTION FOR FUTURE STUDIES

The first suggestion, is to use a tighter head cap and prevent respondents with long or very thick hair. This affects the measuring study, because the hair of the respondents makes the head cap pushed outward and shows an abnormal head shape when 3D scan rendering. Another suggestion is to come up with a software update to prevent lagging and add a new feature of tabulating data in the software itself. This will make the data to be seen even clear and well organised.

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APPENDICES

ACTIVITY		PSM 1 (2022) PSM 2 (2022-2023)															
		Ma	rch	Ap	oril	Μ	ay	Ju	ne	Octe	ober	Nove	mber	Dece	mber	Janı	lary
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Problem Statement Identification	EKIN				N.Y.A												
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Report Submission																	
Data Collection																	

APPENDIX A Shows The Flow of Gantt Chart of This Thesis

I.	Manual measurem	ent														
II.	Convert to excel															
III.	3D measurement		- 1	LAYS	100											
			A Second		4	2										
IV.	Convert to Catia	E.				5										
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