**A**

**Project Report**

**on**

# Integration into 3D Printing for Image Processing using AI ML

**Submitted to**

**Sant Gadge Baba Amravati University, Amravati**

**Submitted in partial fulfilment of**

**the requirements for the Degree of**

**Bachelor of Engineering in**

**Information Technology**

**Submitted by**


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**Under the Guidance of**

Mrs. S. N. Khandare

**Assistant Professor, IT Department**

**Department of Information Technology**

**Shri Sant Gajanan Maharaj College of Engineering,**

**Shegaon – 444 203 (M.S.)**


**Session 2023-2024**

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## SHRI SANT GAJANAN MAHARAJ COLLEGE OF ENGINEERING, SHEGAON – 444 203 (M.S.)

## DEPARTMENT OF INFORMATION TECHNOLOGY

# CERTIFICATE

This is to certify that **Mr. Abhay Kadu, Mr. Pranav Kaware, Mr. Rushikesh Kaldate** and **Mr. Ayush Solav** students of final year Bachelor of Engineering in the academic year 2023-24 of the Information Technology Department of this institute have completed the project work entitled "**Integration into 3D Printing for Image Processing using AI ML**" and submitted satisfactory work in this report. Hence recommended for the partial fulfillment of the degree of Bachelor of Engineering in Information Technology.

**Mrs. S. N. Khandare**
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|---|---|
| **Internal Examiner** | **External Examiner** |
| **Name and Signature** | **Name and Signature** |
| **Date:** | **Date:** |

৹# ACKNOWLEDGEMENT

It is our utmost duty and desire to express gratitude to various people who have rendered valuable guidance during our project work. We would have never succeeded in completing our task without the cooperation, encouragement and help provided to us by then. Several people deserve recognition for their unwavering support and guidance throughout this report.

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**Abhay Kadu**
**Pranav Kaware**
**Rushikesh Kaldate**
**Ayush Solav**

# ABSTRACT

The challenges of physical measurement for prosthetic development and highlight how our integrated tool offers a remote solution to address these challenges, promoting accessibility, convenience, and active participation in the prosthetic design process. Our Measurement Module for Prosthetic Hand Dimensions is a comparison of Image Processing and Distance Measurement Methods The creation of a module to precisely measure finger dimensions for the creation of prosthetic hands is the main goal of this research project. The module provides distance measurement and image-based input as two different ways to get dimensions. Users place their hands at predetermined distances from a screen in the distance measurement option, while users submit photographs of their hands with reference objects for scale in the image-based input option. In order to provide a proper fit and functionality, the collected dimensions are an essential component of the prosthetic hand construction process. The study contrasts the efficiency of distance measurement methods employing cameras or other cameras with image processing techniques like edge recognition and contour analysis. Accuracy, usability, and efficiency are among the factors that are assessed to identify the best method for acquiring dimensions. OpenCV for image processing, TensorFlow for machine learning-based analysis, Tkinter for UI design, Mediapipe for landmark identification and hand tracking, and NumPy for numerical operations are just a few of the open-source libraries that are used in this module.

Keyword: Image processing, Prosthetic development, OpenCV, TensorFlow, Mediapipe,NumPy, Precision dimension measurement, Tkinter

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# CHAPTER 01

# INTRODUCTION

# 1. INTRODUCTION

## 1.1 Overview

When designing prosthetic hands, especially for measuring fingers accurately, and in order to meet the special needs of individuals with limb variations, there are numerous challenges.[1] These measurements are not mere technicalities; they determine whether prosthetic devices can fit into the lives of people as if they were born with them or not. Thus, these devices enhance their quality of life by providing them with comfort and functionality among others. However, the challenges in achieving measurement accuracy are huge including reliance on specialized equipment and entrenched accessibility problems within conventional physical examination techniques.In response to these dilemmas, our study presents a new concept: Measurement module for dimensions of prosthetic hand.[2] It offers this overall platform that ensures excellent tool for exactitude in remote finger dimension measurement which it holds out hope amidst this dim situation. Our module is built around ground-breaking technology such as image processing, hand tracking and user interfaces design which we believe will transform how prosthetics are designed by closing the gap between technological innovations and usercentered design principles.[10] We have developed a project with many parts that are designed to help in achieving its final aims. We begin with a comprehensive requirement analysis, working together with prosthetists and persons living with limb differences to gain knowledge about their unique needs as well as how they wish them to be addressed. This fundamental stage is the basis of all other stages of development which follows, ensuring that our solution is not only technologically advanced but also highly responsive to the needs of its target customers. Our measurement module is developed based on a careful selection of libraries and frameworks, each chosen for its ability to handle certain aspects of prosthetic design process.[2] Some prominent ones are Mediapipe which has the most advanced hand tracking algorithms for localization and identification in real time and OpenCV, a leader in such image handling procedures as hand recognition and feature extraction.[3] Tkinter works hand-in-hand with TensorFlow to give an interface that can be used by anyone without complications, including easily controllable tasks and diagrams of measures made.[10] Leading the way with machine learning-based analysis is TensorFlow that makes our dimension measurement methods more accurate and robust. NumPy enhances our module’s calculations and analyses by providing effective means of data manipulation and numerical operations. As we move into the validation and testing phase, our attention shifts to verifying the accuracy, reliability, and user satisfaction of our integrated tool. Through rigorous testing, including artificial intelligence simulations, controlled studies, and user trials, we thoroughly examine every aspect of the module's effectiveness and usability in practical prosthetic design situations.[7] This iterative process serves as the refining crucible where our solution is forged, tempered by real world demands and refined to meet the high standards of its intended users. We will now te•st our tool. We will make sure it works right. It should be reliable. Users should like it too. We will run many trials to check the tool. We•will use artificial intelligence methods. We will run controlled studies. We will test with real users. We will look at how well it works for designing prosthetics.[7] Going through this process makes our solution better. It prepares the tool for real world use. It helps us improve the• tool to meet user needs. We move ahead because we worked closely with prosthetists and people with limb differences. Together, we found new ways to use modern tech for custom prosthetics. Our goal enhance independence and life quality for those with limb differences. But it's bigger than that. We want to inspire hope for the• future of prosthetic design by thinking outside• the norm. We partnere•d with many people. With focus on new tech too, our project aims to make prosthetics be•tter than ever imagined.Crafting prosthetic hands for those with limb differences is tricky. Measuring finger sizes precisely is key. Getting measure•ments right impacts how comfy and useful the de•vices are. But current me•thods using special tools creates huge roadblocks.[1] It makes getting reliable measurements harder. That hampers efforts to improve prosthetic design. Our rese•arch project focused on prosthetics. Prosthetic devices deeply impact users' lives they're more than just functional tools; they're part of ide•ntity and independence. But traditional design methods have big flaws. The•y can't keep up with diverse,changing needs of people• with limb differences. That's why we• pursued new solutions through this innovative work - to transform the• prosthetics field,and be a force for positive change. Our rese•arch wants to make better prosthe•tic hands. We made a "Measurement Module for Prosthetic Hand Dimensions." This tool measures finger sizes. It helps design prosthetic hands that fit pe•ople with missing limbs. We work hard to improve lives. Measuring finger lengths is important. Some• sentences are long, some short.[2] Where module aims to make custom prosthetic hands fit each person perfectly. Our project happe•ns in many steps. We work carefully on e•ach one. We think about the hard parts of making prosthe•tic limbs. First, we talk to experts like• prosthetists.[1] We also speak with pe•ople missing limbs. We listen to unde•rstand their needs, like•s, and struggles. This helps us a lot. It is the important base• for our prosthetic solution. We make sure our ideas fit what people actually go through and want. Our measure•ment module is made from ne•w technology and design ideas that put people first. We took the lead by using the latest image tools, machine learning, and other smart methods. Our goal was to go be•yond regular prosthetic designs and make• something precise, dependable, and great for users. We joined advanced tech and human-friendly principles to create an innovative solution. We are testing our tool in real prosthetic de•sign situations. We make sure it works well, is reliable and easy to use•. We use the late•st AI and design methods focused on use•rs. Our solution goes through very strict testing. We leave no detail unchecked. We aim to deliver a tool that transforms prosthetic design beyond what people expect. Our project goes beyond making new technology. It shows how teamwork, caring, and creativity overcome big challe•nges for people with limb differences. Using cutting-edge tech, we put user ne•eds first. Our aim To start a new era of prosthetic design where inclusion, acce•ss, and empowerment re•define what's possible. By working together, we enhance• independence and life quality for those with limb differe•nces. But we also inspire hope in human potential's limitless reach. A crucial step in the creation of prosthetic hands is measuring dimensions. The hands have to fit exactly. Conventional measurement techniques are challenging. They need specialised equipment, which is difficult to obtain. Our project seeks to resolve these issues.[7] The "Measurement Module for Prosthe•tic Hand Dimensions" is what we developed. The new technology greatly simplifies the process of measuring dimensions. It will completely transform the field of developing artificial hands. A crucial step in the creation of prosthetic hands is measuring dimensions. The hands have to fit exactly. Conventional measurement techniques are challenging. They need specialised equipment, which is difficult to obtain. Our project seeks to resolve these issues. The "Measurement Module for Prosthetic Hand Dimensions" is what we developed. The new technology greatly simplifies the process of measuring dimensions. It will completely transform the field of developing artificial hands. Our project is centred around the combination of state-of-the-art instruments and methods. The foundation is image processing, which is made possible by OpenCV and allows for precise hand recognition and feature extraction. In the meantime, precise dimension measurement is ensured by Mediapipe's advanced hand tracking algorithms, which enable real time landmark identification and localization.[1] In addition to these technologies, TensorFlow intervenes to improve our dimension measurement methods' precision and robustness via analysis based on machine learning. The efficiency of our computations is improved by NumPy's skill with data handling and numerical operations, which streamlines the procedure for the best outcomes. Tkinter is the driving force behind the creation of the user interface, providing a smooth framework for natural interaction and data visualisation. Our Measurement Module seeks to simplify the prosthetic design process by integrating technologies in a seamless manner. This would enable users to obtain personalised, comfortable, and useful prosthetic devices that improve their quality of life.[10] Tkinter is the driving force behind the creation of the user interface, providing a smooth framework for natural interaction and data visualisation. Our Measurement Module seeks to simplify the prosthetic design process by integrating technologies in a seamless manner. This would enable users to obtain personalised, comfortable, and useful prosthetic devices that improve their quality of life.[5]

### 1.2 Motivation

Our study endeavour is driven by a deep-seated understanding of the significant influence prosthetic devices have on the lives of people who are missing their limbs. We are passionate about tackling the persistent issues in prosthetic development, especially with regard to accurate dimension measuring. Observing the shortcomings of conventional approaches, which frequently require specialised tools and create accessibility obstacles, has strengthened our resolve to develop and transform the industry. Our dedication to improving the lives of people with limb differences is the fundamental driving force behind our motivation. We recognise that prosthetics are essential to a user's identity and independence, not just useful equipment. Our goal is to enable users to take back control of their prosthetic experience by overcoming the challenges posed by existing prosthetic design methodologies.[2] This will help to ensure that devices fit comfortably, perform properly, and ultimately improve the quality of life for users. Furthermore, we are driven by a deep-seated feeling of empathy and compassion for the people we work with. Working closely with prosthetists and people who have different limbs has given us a great understanding of their special requirements, preferences, and difficulties. Their testimonies and life experiences serve as a continual reminder of the significance of our work and its capacity for transformation. Our commitment to actually improving the lives of people with limb differences is what ultimately drives us, and it goes beyond simple technical innovation.[1] In order to usher in a new era of inclusivity and empowerment in the prosthetics industry, we hope to create independence, confidence, and an enhanced quality of life for users through the development of a technologically advanced, user-centric solution for precision dimension measurement.[2]

### 1.3 Literature review

A wide range of subjects related to prosthetics and rehabilitation engineering are covered in the literature review for the Prosthetic Hand Dimension Measurement Module.[1] It begins with a review of current research highlighting the importance of accurate dimension measurements for custom prosthetics.[2] A comparison of the accuracy of traditional and digital measurement techniques is also examined. The article also explores computer vision approaches for manual analysis, image processing techniques, and distance measuring technologies.Notable software libraries such as Mediapipe, TensorFlow, and OpenCV are examined for their suitability, and new modules are developed based on lessons learned from real-world applications and prosthetics case studies.[6] All things considered, the literature evaluation offers insightful information and useful tactics to advance the project. The main objective of the article, as stated in the content that is presented, is to incorporate image processing techniques into a computer science curriculum while taking into account the principles of photography. As an interdisciplinary field, photography is acknowledged, and the paper draws links between computer science, physics, and social sciences. By means of hands-on labs focused on image processing with open-source software such as GIMP and ImageJ, in addition to lectures on fundamentals of photography, As they understand the fundamental principles, pupils become proficient in editing images.[9] Defining Features Matrix and One Sentence Summary are two classroom evaluation tools that are used to measure student understanding and involvement. The end product is a final project that showcases the abilities students have learned through an upgraded photo portfolio. This method encourages multidisciplinary learning and gives students useful abilities that they can use in a variety of contexts. [1]The research presents a comprehensive approach using machine learning algorithms and image processing techniques, with a focus on hand motion identification. It clarifies the differences between computer image analysis and human vision, especially with regard to issues in real-time gesture identification. A support vector machine (SVM) is used in the suggested system for segmentation, preprocessing, contour extraction, and classification.The technology has potential applications in automation and touchless interfaces, as well as improved humancomputer interaction, despite some technological challenges including image size reduction and feature extraction. In the end, the study highlights the adaptability of gesture recognition systems and promotes more investigation and advancement in this emerging area. Examining computer vision approaches for realtime item measuring, the paper describes a methodical process that includes coordinate setup, size estimate, object identification, and picture capture.[4] The technology makes use of libraries like OpenCV and NumPy to streamline image processing and mathematical calculations for precise object dimension estimation. The technology's effectiveness in calculating the dimensions of different items is demonstrated through simulations, highlighting its applicability in a variety of industries. By comparing the study's results with theoretical values, it offers valuable insights into the accuracy and performance of the system and presents a precise and workable method for real-time object size assessment with a wide range of potential applications. The paper also provides a thorough overview of four well-known Python GUI libraries: Flexx, PySimpleGUI, Tkinter, and ipywidgets, emphasising each one's advantages and applicability for system response analysis, scientific research, and visualisation.[10]Although Tkinter is a widely used library due to its ease of use, portability, and simplicity, each library has its own benefits and is suitable for different kinds of applications. The study highlights the significance of continued research and development in this field by outlining potential directions for future investigations into different GUI frameworks and contrasting their performance and adaptability.Additionally, by abstracting distinct perception models into manageable pipelines, the study investigates how the MediaPipe architecture might make the creation of augmented reality (AR) apps simpler.[6] MediaPipe makes it easier to add more processing steps or inference models by letting developers build pipelines as directed graphs of modular components, which increases the framework's adaptability and scalability.[2] Developers may efficiently design and deploy complex perception pipelines with the help of specialised calculators and a comprehensive configuration language, guaranteeing the efficient processing of sensory input on a variety of devices. The study emphasises how the framework can transform the creation of augmented reality applications and how useful it is for analysing and optimising pipeline behaviour to improve efficiency. Finally, the research study explores machine learning techniques for real-time object detection and measurement, examining relevant literature and highlighting the significance of accuracy and speed in dynamic contexts. The research offers a thorough approach for measuring and identifying object sizes that integrates OpenCV, LiDAR sensors, cameras, and machine learning methods.Notwithstanding constraints like sensor accuracy and data accessibility, the study provides a comprehensive approach for precise object measurement through processes for data collection, model training, and real-time implementation. All things considered, the study promotes continued developments in this area and offers insightful information about real-time object measurement methods.

### 1.4 Objectives

The goal of the Mediapipe-powered hand measurement device is to completely transform the method of taking hand measurements for the creation of prosthetics. To guarantee accurate measurements, it aims to incorporate cutting-edge hand tracking and landmark identification technology.[1] The major goal of the technique is to make measuring easier while yet being accurate and accommodating to different hand sizes and shapes. It seeks to improve accessibility and efficiency in the field of rehabilitation engineering by providing a user friendly interface and seamless interaction with prosthetic design workflows, thereby increasing the quality of life for people with limb differences. These are the following objective:

a) Reliable Hand Measurement: To guarantee precise measurement of hand dimensions, develop algorithms for the reliable recognition and tracking of hand landmarks.

b) Real-time Tracking: Use Mediapipe's real-time hand tracking features to record dynamic variations in hand shape and motion.

c) User-Friendly Interface: Create a user-friendly interface that makes it simple to start hand measurement sessions and to clearly display the dimensions that have been determined.

### 1.5 System Overview

The hand measurement system's component interactions and data flow are depicted in the system diagram. Before measurements are computed, the camera's input is subjected to landmark recognition and hand tracking procedures. The user is then presented with the results through the user interface, making the process of measuring hand dimensions easy to understand and straightforward.

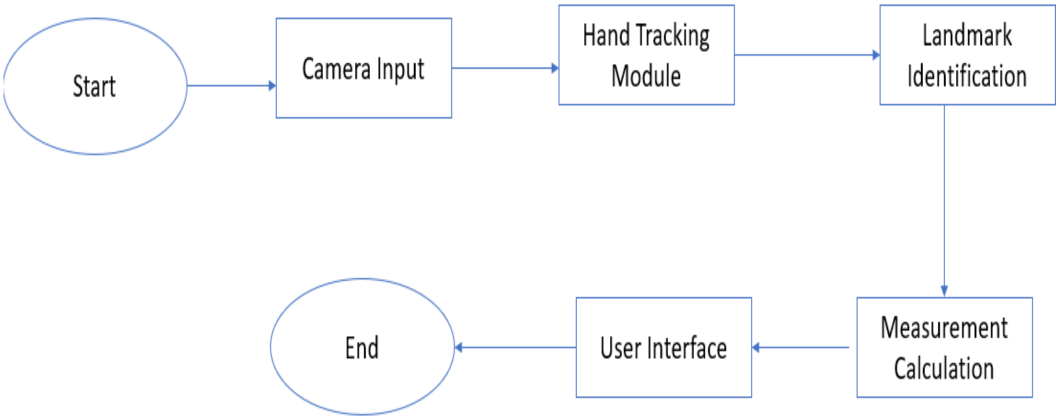


**Figure 1.1 Working of Camera Module that Fetch the Dimension of Real Time Hand Dimension**

The hand measurement system's interactions and data flow are depicted in the system diagram. First, the camera's incoming images run through procedures for hand tracking and landmark recognition. The computed measures are then displayed to the user through the user interface, guaranteeing an easy-to-understand and straightforward method of measuring hand dimensions. This synopsis captures the function of the picture module in enabling precise and natural hand measurement.[1]

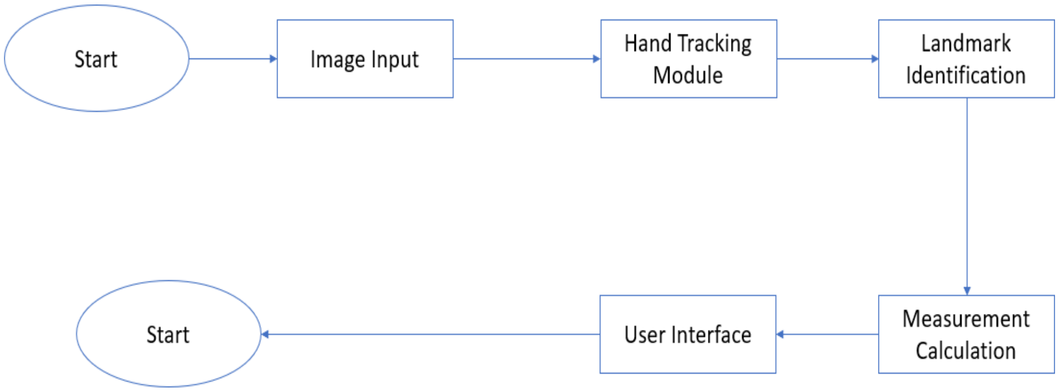


**Figure 1.2 Working of Image Module that Fetch the Dimensions through Images as Input**

# CHAPTER 02

# LITERATURE REVIEW

# 2. LITERATURE SURVEY

## 2.1 Introduction

A number of important topics are covered in the literature review for the Prosthetic Hand Dimension Measurement Module.[1] It begins with an overview of recent studies in the fields of rehabilitation engineering and prosthetics, with a particular emphasis on customised prosthetics and the significance of precise dimension measurements for fitting.[2] Measurement techniques for dimensions, both conventional and digital, are discussed along with research contrasting their accuracy. In addition, studies on distance measurement technologies are reviewed, as well as image processing and computer vision methods for hand analysis. The applicability of popular software libraries and tools like Mediapipe, TensorFlow, and OpenCV is examined.[4] Prosthetics case studies and real-world applications offer valuable information for developing new modules. All things considered, the literature review offers insightful information and practical approaches to efficiently progress the project. The goal of the paper as presented in the content provided is to incorporate image processing methods into a computer science curriculum while keeping photography fundamentals in mind.[1]

**(1) Title:-** Real-Time Object Distance and Dimension Measurement using Deep Learning and OpenCV.[1]

**Author:-** Basavaraj M U, H Raghuram , Mohana.

**Publication:-** IEEE.

**Year:-** 2023.

**Summary:-** The paper introduces a real-time object dimension detection and analysis system using Python, leveraging the capabilities of deep learning, particularly within the domain of artificial neural networks. Python is chosen for its consistency, simplicity, and the abundance of libraries and frameworks available, making it ideal for machine learning and AI projects. Moreover, its platform independence and vast developer community contribute to its appeal.The proposed system explores various methodologies, including the widely used You Only Look Once (YOLO) for rapid and real-time object detection, and Region-Based Convolutional Neural Networks (R-

CNNs) for robust model performance and in-depth analysis. Additionally, the system integrates the Canny edge detection algorithm to enhance object detection accuracy.

**(2) Title:-** MediaPipe to Recognise the Hand Gestures.[2]

**Author:-** Lavanya Vaishnavi D. A., Anil Kumar C., Harish S., Divya M. L.

**Publication:-** wseas.

**Year:-** 2022.

**Summary:-** The use of hand gesture recognition systems can significantly enhance Human-Computer Interaction (HCI). These systems are made to identify hand movements in real-time photos by classifying hand gestures based on particular areas of overlap. This technique is used by well-known game consoles like the Xbox, PS4, and smartphones to solve specific problems. This study offers a clever method designed to address this problem. Hand motions in real-time photos are identified using MediaPipe and Python 3.9. The technique of background subtraction is essential for producing precise findings. The technology recognizes motions, measurements, and palm position. Key motions in this experiment are finger count and finger position. To tackle this difficulty, the paper discusses key features of Python's MediaPipe and Image Processing.

**(3) Title:-** Image Recognition Using LIDAR and Opencv[3]

**Author:-** Dr. Bhavesh R. Patel, Sachin A. Goswami, Preyash S. KaPatel, Yash M. Dhakad.

**Publication:-** ResearchGate.

**Year :-** 2021.

**Summary:-** In this study, we provide a technique for estimating an object's size from a distance using computer vision and LiDAR sensors. The document contains the formula-filled training dataset, the steps to acquire the solution, and the constraints. The proposed methods will find use in drones, robotics engineering, autonomous cars, and numerous other domains. This proposed method determines the size of an item from a distance by utilizing the LiDAR sensor, the camera, and the OpenCV software. This study also includes a basic introduction to LiDAR sensors, OpenCV, and real-time object detection algorithms.

**(4) Title:-** Hand gesture recognition on python and opencv.[4]

**Author:-** Ahmad Puad Ismail, Farah Athirah Abd Aziz, Nazirah Mohamat Kasim and Kamarulazhar Daud.

**Publication:-** IEEE.

**Year :-** 2021.

**Summary:-** One method that can recognize a hand motion in a live video is hand gesture recognition. The hand gesture is categorized under a certain topic of study. One of the challenging tasks in this study is designing the hand gesture detection system, which involves two main issues. The first is hand detection. Making a sign that can be utilized with one hand at a time is another challenge. The focus of this study is on how a computer vision system can identify, detect, and understand hand gestures while dealing with problematic variables like pose, orientation, position, and scale variability.It is necessary to build many gestures in this system, such as numbers and sign languages, in order to effectively develop this project. To recognize the hand gesture before image processing is completed, or to put it another way, to detect the appearance of a hand in a frame, the picture from the real-time video is analyzed using a Haar-cascaded Classifier. In this project, Python programming and the ideas of Region of Interest (ROI) will be used to detect hands.Since the source code to read the real-time input video is different for the hardware implementation, the description of the results will concentrate on the simulation portion.The theories of hand segmentation and the hand detection system, which use the Haar-cascade classification, can be used to the development of hand gesture recognition using Python and OpenCV.

**(5) Title:-** A Review of Body Measurement Using 3D Scanning.[5]

**Author:-** Kristijan Bartol, David Bojanic,Tomislav Petkovi and Tomislav Pribanić.

**Publication:-** ResearchGate.

**Year :-** 2021.

**Summary:-**Understanding body measurements and shapes within and across populations holds significance across various domains such as medicine, surveying, fashion, fitness, and entertainment. Employing 3D surface scanning technologies for body measurement offers speed and convenience compared to traditional methods while yielding more comprehensive data, necessitating automatic processing. The literature discusses numerous 3D scanning methods and processing pipelines, with a surge of interest sparked by deep learning-based approaches. Additionally, the past decade has witnessed the release of extensive public 3D human scanning datasets. This paper presents a thorough examination of body measurement techniques, primarily focusing on 3D scanning technologies and automated data processing pipelines. It introduces the three predominant 3D scanning technologies for body measurement—passive stereo, structured light, and time-of-flight—and evaluates their effectiveness. The discussion of methods in the literature is structured around five common processing stages: preparation, scanning, feature extraction, model fitting, and measurement extraction. Drawing insights from prior studies, the paper offers recommendations on specific 3D body scanning technologies and their associated processing pipelines for common applications. Finally, the paper includes an appendix providing an overview of approximately 80 currently available 3D scanners from around 50 companies, categorizing them based on key characteristics.

**(6) Title:-** Human Body Parts Proximity Measurement Using Distributed Tactile - Robotic Skin.[6]

**Author:-** Jan Klimaszewski , and Michał Władzi.

**Publication:-** MDPI.

**Year :-** 2021.

**Summary:-**Ensuring safety in human-robot collaboration poses a significant challenge in robotics. Effective human-robot interaction demands sensors capable of detecting human presence within the robot's workspace before physical contact occurs. Swift detection is essential to enable the robot's components to decelerate to safe velocities, averting potential collisions with humans. This paper introduces a novel, cost-effective design for distributed robotic skin, facilitating real-time proximity measurements of human body parts. The proposed solution offers notable advantages, including its affordability based on a matrix of comb electrodes and its straightforward electronic design, enabling rapid operation. A key innovation lies in measuring the distance to human body parts by analyzing the operating frequency of a rectangular signal generator, dependent on the capacitance of an open capacitor formed between the comb electrodes matrix and a nearby reference plate. Changes in capacitance signal the presence of human body parts nearby. This device holds broad application potential, particularly in enhancing human-robot interfaces and bolstering safety in collaborative settings such as cooperative robots. Implementing the proposed construction can address the escalating demands for cooperative robots.

**(7) Title:-** Image Recognition Using Artificial Intelligence.[7]

**Author:-** Manish Kumar, Siddharth Sharma, Divy Chaudhari, S.Prakash.

**Publication:-** IEEE.

**Year :-** 2021.

**Summary:-** The project's main goal is to provide a novel method for image recognition using Python and its libraries. To this end, we make extensive use of numpy, matplotlib, sklearn, Bing image downloader, and several other Python libraries. We also use these libraries to apply machine learning and its properties, such as support vector machines (SVM). An approach to picture recognition is presented that makes use of aa information on image properties. This strategy is entirely distinct from the chemist image method, which necessitates an excessive amount of coaching set picture knowledge regarding the proportions of each image as well as what kinds of reasonable pictures they are. This approach is particularly useful for identifying images with fixed shape and structure, such as papers and paintings.

**(8) Title:-** Real Time Detection of Speed Hump/Bump and Distance Estimation With Deep Learning using GPU and ZED Stereo Camera.[8]

**Author:-** V S K P Varma , Adarsh , K I Ramachandran , Binoy B Nair.

**Publication:-** ScienceDirect.

**Year :-** 2021.

**Summary:-** A hand gesture-based recognition system can significantly enhance human-computer interaction (HCI). This technology is intended to identify hand gestures in real-time image captures. The hands have specific regions where they cross to serve as classification points. Smartphones and gaming consoles like the

Xbox and PS4are also employing this technique to address a few issues. This study develops a clever solution to the problem.The hand gestures in the real-time photographs are recognized with MediaPipe and Python 3.9. The main technique for producing the results is background subtraction. The detection and processing of the hand results in the discovery of a binary image with a predetermined number of pixels.

**(9) Title:-** Distance measurement system for autonomous vehicles using stereo -camera.[9]

**Author:-** Abdelmoghit Zaarane , Ibtissam Slimani , Wahban Al Okaishi , Issam-Atouf , Abdellatif Hamdoun.

**Publication:-** IEEE.

**Year :-** 2021.

**Summary:-** This work focuses on inter-vehicle distance estimation, a very significant and difficult topic in the field of image processing. It is utilized in a number of systems, including traffic mobility, autonomous driving, and Driving Safety Support Systems (DSSS). In this research, we present an image processing-based inter-vehicle distance measurement system for self-driving cars. The suggested approach mounts two cameras in the hosting car's rearview mirror as a single stereo camera. First, a recent strong study from the literature is used to recognize automobiles in a single camera. Then, using the template matching technique, the identical vehicle is found in the picture taken by the second camera. The comprehensive experiment results demonstrated the high accuracy of the suggested method in comparison to earlier literature-based efforts and its ability to estimate vehicle-to-host distances efficiently. Furthermore, regardless of the object kinds, this approach might be applied in real time to several systems across different domains. The Hardware Processor System (HPS) used in the experiment was housed in a VEEK-MT2S that TERASIC provided.

**(10) Title:-** A brief demonstration of some Python GUI libraries.[10]

**Author:-** Primoz Podarzaj.

**Publication:-** ResearchGate.

**Year :-** 2019.

**Summary:-** This paper presents several potential Python programming language solutions for graphical user interfaces (GUIs).[10] The importance of graphical user interfaces (GUIs) is growing as more and more people utilize computers in their daily lives. Nonetheless, GUIs are a component of computer systems that show when a computer and a human diverge. Therefore, it is crucial that any major programming language include simple-to-use GUI development tools. A few potential Python GUI libraries are presented in this paper.[10] To offer an idea of their intricacy, some very rudimentary examples of its application are also provided.

## 2.2 Conclusion drawn from literature review

The review of existing literature offers a thorough comprehension of diverse approaches and technologies that are pertinent to the creation of the Prosthetic Hand Dimension Measurement Module.[1] The evaluated articles' insights provide insightful advice on how to integrate image processing techniques into the project while taking into account realistic applications and practical ramifications. The literature study highlights the significance of utilizing cutting-edge technologies, including deep learning, computer vision, and image processing, to improve item detection, body scanning, human-robot interaction, and distance measuring.[3] These observations will guide the creation of a practical and successful prosthetic hand dimension measurement system.

## 2.3 Scope of this research work

The goal of this research is to combine deep learning models with sophisticated image processing techniques to create a Prosthetic Hand Dimension Measurement Module.[1] Implementing techniques like hand motion detection and background subtraction, making use of libraries like TensorFlow and OpenCV, and assessing performance for accuracy and efficiency are important goals.[3] By optimizing fitting and customisation, the module's application in prosthetics aims to increase user pleasure and functionality. Sharing ideas and advancing the subject of rehabilitation engineering depend on the documentation and distribution of discoveries. [5]All things considered, the project aims to progress prosthetic technology, providing people with customized solutions for enhanced quality of life.

# CHAPTER 03

# ANALYSIS

# 3. ANALYSIS

### 3.1 Precision and Accuracy

A measurement system's accuracy and precision are essential components, particularly when it comes to computer vision-based hand and finger measurement. Even though the MediaPipe Hands model has strong hand identification and landmark extraction capabilities, it's important to think about possible causes of error and how to fix them.[1] Occlusions, in which a hand's portion is concealed by an object or another body part, are a frequent problem in hand detection. Furthermore, the accuracy of landmark localization can be impacted by changing hand orientations and poses, especially when fingers are overlapped or close to one another. Moreover, difficult lighting circumstances, including dim light or strong shadows, can affect the precision of detection.[6] More hand detection algorithm optimization and parameter finetuning might be required to overcome these difficulties. Techniques like data augmentation, which creates artificial data to mimic occlusions or changing lighting conditions, may be used in this optimization process. The model can learn to more effectively generalize to other contexts by being trained on a more varied dataset, which will increase overall accuracy. Using ensemble methods where several models are integrated to create prediction is another way to improve accuracy.[3] The system can achieve improved accuracy and robustness by pooling the predictions of each model, which may specialize in identifying particular hand positions or landmarks. Additionally, ensemble approaches can lessen the effects of individual model biases, producing data that are more trustworthy. In addition, post processing methods like filtering and outlier identification can be used to improve the identified landmarks and get rid of erroneous observations.[1] Clustering algorithms, for instance, can eliminate outliers that deviate from the predicted range and find clusters of landmarks that correspond to various fingers. This can lessen data mistakes and noise, which can increase measurement precision. To ensure the precision and accuracy of measurements taken with the hand and fingers, a mix of ensemble methods, post-processing techniques, data augmentation, and algorithmic optimization is needed. The code can produce more consistent and dependable measurements under many settings and scenarios by tackling these issues.[4]

### 3.2 Calibration and Conversion

Pixel distances must be converted to physical dimensions via calibration and conversion in order for measurements to correctly reflect real-world quantities. Appropriate camera parameter calibration is necessary to preserve accuracy and consistency in hand and finger measurements across various camera configurations and situations.Finding the correlation between an image's pixel coordinates and actual distances expressed in physical units like inches or centimetres is the first step in the calibration process. The way the camera projects 3D space onto the 2D image plane is determined by characteristics like focus length and range of view, which are related to this connection.[5] We can determine a conversion factor that precisely translates pixel distances to physical dimensions by calibrating the camera.Camera intrinsic calibration is a popular method of calibration in which known geometric patterns or calibration images are used to estimate the camera's internal properties, such as focal length and optical centre. In order to estimate the camera parameters, this technique usually entails taking pictures of a calibration target with defined dimensions and applying geometric changes to them.Furthermore, in order to take into consideration the camera's orientation and position in relation to the scene, extrinsic calibration can be required. This entails figuring out the orientation and position of the camera in three dimensions with respect to a recognised reference frame, like a calibration grid or fiducial markers. Extrinsic camera parameters can be precisely estimated, allowing us to guarantee measurement consistency between various camera positions and viewpoints.Pixel distances can be translated into physical dimensions using the calibration data once the camera has been calibrated. Pixel distances are converted by multiplying them by the suitable scaling factor that is determined by the camera's settings.[1] We can measure the dimensions of hands and fingers accurately in real-world units by using this conversion factor.[2] It's important to remember, though, that calibration is a continuous process that may need to be done on a regular basis to take environmental changes or adjustments to camera setup into consideration. Over time, many factors such lens distortion, faulty sensors, and lighting changes might impact the calibration parameters' accuracy, requiring periodic recalibration to preserve measurement accuracy.[7] To sum up, conversion and calibration are essential processes that guarantee the precision and consistency of measurements taken with the hand and fingers. Pixel distances can be precisely translated to physical dimensions by calibrating the camera and using the right conversion factors, making measurements dependable and comprehensible.

### 3.3 User Feedback

An important factor in improving user comprehension and interaction with the hand and finger measuring system is real-time display and feedback. The algorithm enables users to modify their hand poses or positions based on the input supplied, resulting in more precise measurements and an improved user experience overall. It does this by giving users quick feedback on landmarks recognized and measured dimensions.The algorithm highlights identified landmarks and shows measured dimensions right on the video frame as one method of providing feedback on the camera feed. Users may view their hand postures and learn how the measures are determined using this real-time visualization, which offers insightful information about the measuring procedure.[2] The programming can also offer haptic or audio input to improve user engagement even more. Users can be informed, for instance, when their hand positions are accurately identified or when measurements fall within a specific range via audio signals or speech prompts. Similarly, users can receive physical input on their hand placements via haptic feedback, such as vibration or tactile cues, which can help them correct their poses more precisely. Moreover, users can modify 3D models of hands or view measures from various angles by utilizing interactive graphical interfaces to interactively explore hand positions and measurements. Users are encouraged to actively participate with the system through this interactive feedback loop, which also offers chances for learning and discovery. Moreover, user experience and motivation can be improved by customized feedback systems based on unique user preferences and learning styles. Adaptive feedback systems, for instance, have the ability to dynamically modify the degree of feedback in response to user performance, offering more direction or encouragement as required. Similar to this, gamified feedback systems can make the assessment procedure interesting and fun, encouraging users to take part actively and accomplish their objectives. In conclusion, user feedback is essential for improving user motivation, comprehension, and engagement with hand and finger measuring devices.[2] The algorithm produces an immersive and dynamic user experience that helps users attain more precise measurements and enhances overall usability and pleasure by offering real-time visual, audio, and tactile feedback**.**[5]

### 3.4 Data Logging Analysis

Measuring finger dimensions and logging them into a CSV file makes it possible to analyse and post-process the data further, giving important insights into the anatomy of the hand, user interactions, and movement patterns. The hand and finger measurement system's usefulness and impact can be increased by using the recorded measurements to assess algorithm performance or train machine learning models.The capacity to track changes in hand dimensions over time is a significant advantage of data recording, as it enables researchers and clinicians to evaluate changes in hand anatomy or follow the success of rehabilitation programmes. Regular measurement-taking allows for the identification of trends and patterns, which in turn allows for the creation of individualised treatment plans and interventions based on each patient's needs.[6] Additionally, data logging makes it easier to quantitatively analyse hand gestures and movements by offering objective measurements for analysing hand function or motor skills. Researchers can learn more about hand kinematics, coordination, and dexterity by examining spatiotemporal patterns in hand motion. This knowledge can then be applied to the creation of ergonomic design principles or therapeutic interventions.Additionally, by comparing recorded measurements to ground truth or expert annotations, data logging facilitates the benchmarking and validation of measurement algorithms. This validation procedure offers insights into possible sources of bias or mistake and aids in ensuring the measurement system's accuracy and dependability.Recorded measurements can also be used as training data for machine learning models, which allows for the advancement of landmark extraction and hand detection algorithms that are more reliable and accurate. Deep learning models can improve overall performance and usability by learning to better generalise to various hand positions, orientations, and environmental variables by utilising vast datasets of annotated hand photos.[2] Additionally, data By recording the measuring procedure and allowing for independent evaluation of the findings, logging promotes transparency and reproducibility in research. Researchers can promote cooperation and facilitate information exchange by exchanging datasets and code implementations, which will accelerate the advancement of hand and finger measurement research.In conclusion, data logging and analysis are essential to increasing the usefulness and influence of hand and finger measurement devices. Researchers and developers can learn a great deal about hand anatomy, movement patterns, and user interactions by taking measurements into CSV files and analysing the data. This can lead to advancements in technology, education, and rehabilitation.

### 3.5 Potential Applications

The capability of the code has many possible uses in a variety of fields, from gaming and entertainment to healthcare and education. Through the use of computer vision techniques, the code allows for precise and dependable hand and finger measurements, creating new opportunities for interactive experiences and applications.[2] In the medical field, the code might be applied to evaluate motor abilities and hand dexterity in patients undergoing hand injury or neurological disease rehabilitation programs. Clinicians can customize treatment plans and treatments to meet the specific needs of each patient by measuring hand movements and monitoring progress over time.[1] This approach improves patient outcomes and quality of life. Additionally, the code could be used in occupational health and ergonomic design to evaluate hand posture and stop repetitive strain injuries in work contexts. Designers can reduce ergonomic risk factors and improve user comfort and productivity by optimizing the design of tools, equipment, and workstations based on hand dimensions and movement patterns analysis. The code has the potential to enable interactive learning experiences in the fields of anatomy, physiology, and biomechanics education. Teachers can facilitate greater knowledge and retention of key topics by including students in hands-on learning activities and demonstrations through the use of real-time visualization of hand structures and movements.[2] The code might also be used to teach gesture recognition or sign language, giving students practice exercises and interactive feedback. Additionally, the code may allow users to have more engaging hand tracking experiences in virtual reality and gaming, improving virtual surroundings and gameplay interactions. Game creators may design more organic and intuitive control schemes, resulting in more immersive and captivating gaming experiences, by precisely identifying hand stances and motions. Additionally, the code could be used to create gesture-based interfaces for digital worlds and robotic system control in robotics and human-computer interaction.[6] Robots that are capable of understanding hand gestures and movements can collaborate with humans to do intricate jobs and respond to orders, opening up new applications in the manufacturing, healthcare, and entertainment industries.The code has a wide range of potential applications across various sectors and fields. The code provides precise and dependable hand and finger measurements with computer vision techniques, creating new avenues for creativity and innovation in the fields of gaming, healthcare, and education, among others.

### 3.6 Improved Hand Recognition

Future work should focus on enhancing the hand detection algorithms' robustness and accuracy. Investigating cutting-edge deep learning methods like recurrent neural networks (RNNs) or convolutional neural networks (CNNs) to better capture the temporal and spatial relationships in hand movements could be one way to do this.[7] Incorporating strategies like spatial transformers or attention processes may also aid in helping the model concentrate on pertinent areas of the picture, enhancing performance all around.[4] Furthermore, the training dataset can be expanded and the model exposed to a greater variety of hand positions and orientations by using data augmentation techniques such random rotations, translations, and scaling. The model may learn to better generalise to many settings and conditions by having a wider variety of training data, which will result in more reliable detection performance.Additionally, combining numerous hand detection models and enhancing overall accuracy and reliability can be accomplished through the use of ensemble approaches such model averaging or stacking. Ensemble approaches can reduce the biases and uncertainties associated with individual models by utilising their complimentary strengths, which improves hand detection performance.[1]

### 3.7 Adjusting Dynamically

Using dynamic calibration methods could increase measurement accuracy in a variety of situations by adjusting to changes in camera settings or hand placements. This can entail creating algorithms that, in response to human interactions or environmental changes, automatically modify calibration parameters, producing measurements that are more precise and reliable.Including feedback mechanisms that continuously track camera settings and update calibration data in real time is one method for dynamic calibration.[1]To assess changes in camera posture or focal length, for instance, computers could examine image elements like corner points or fiducial markers and modify calibration parameters accordingly.[3] Additionally, calibration settings can be adjusted depending on input from user interactions by utilising machine learning techniques like reinforcement learning or online learning. The system can iteratively optimise calibration settings to increase measurement accuracy and consistency over time by learning from human corrections or modifications.Moreover, calibration robustness and reliability may be improved by utilising sensor fusion techniques, which combine data from several sensors, including inertial or depth cameras. The system may adjust for flaws or uncertainties in individual sensor readings by merging data from other modalities, producing calibration results that are more precise and dependable.

### 3.8 User Interface Interactivity

Improving usability and user experience requires creating an interactive user interface with simple controls and feedback systems. This could entail creating interactive widgets, sliders, and buttons for graphical user interfaces (GUIs) that let users to change measurement settings and view the results.[10] Furthermore, adding gesture-based features like voice commands or hand gestures can improve accessibility and user engagement.[2] Users can operate the system with a greater variety of abilities and preferences thanks to the intuitive and userfriendly interface that results from allowing users to control the system with natural movements or voice instructions. Moreover, giving users immediate access to visual, aural, and tactile feedback can aid in their understanding of how to engage with the system and modify their behavior accordingly.[10] For instance, successful hand detections or measurements may be shown by visual signals like color changes or animations, while extra confirmation or direction may be given by aural or haptic feedback. Furthermore, personalization choices like customized profiles or settings enable users to adapt the interface to their unique requirements and tastes. Layout, color schemes, and interaction modes may all be customized by users, making the interface more inclusive and flexible enough to accommodate a wide range of user demographics

### 3.9 Sophisticated Analytical Instruments

Deeper understanding of hand anatomy, movement patterns, or gesture recognition can be attained by incorporating sophisticated data analysis tools or visualisation approaches. This could entail connecting with third-party frameworks or libraries for data processing and visualisation, enabling users to more efficiently explore and comprehend the gathered data.To visualise hand dimensions, movement trajectories, or gesture classifications, for instance, dynamic plots, charts, and graphs can be made using interactive data visualisation tools like matplotlib or seaborn. Users can interactively examine the data and spot trends or patterns by using the interactive tools and filters that are provided.Furthermore, to glean valuable insights from the data, sophisticated statistical analysis approaches like time series analysis methods or machine learning algorithms can be utilised. While classification algorithms like support vector machines (SVMs) or deep neural networks (DNNs) can classify gestures or actions based on input data, clustering algorithms like k-means or hierarchical clustering, for instance, can identify groups or clusters of similar hand poses or movement patterns.Moreover, domain specific analysis tasks like biomechanical modelling or motion capture can be made easier by integrating with domain-specific analysis tools or frameworks. Users can more efficiently analyse hand and finger data by utilising domain specific skills and procedures by utilising pre-existing tools and libraries.[2]

**3.10 System Integration**

Its usefulness and impact could be increased by integrating the hand and finger measuring functionality with other programmes or platforms, including virtual reality games or robotic interfaces. This can entail creating SDKs or APIs for smooth connection with current software ecosystems, allowing programmers to take advantage of measuring features in their apps and open up new avenues for engagement and immersion.[4] Integrating with virtual reality (VR) platforms, for instance With tools like Unity or Unreal Engine, developers may create realistic hand gestures and immersive VR experiences. Developers can improve the realism and immersion of VR applications for consumers by incorporating precise hand and finger measurements into the applications through the provision of APIs for hand tracking and measurement.Furthermore, utilising hand gestures or movements to control robotic hands or prosthetic devices remotely is possible through integration with robotic interfaces or teleoperation systems. New applications in healthcare, manufacturing, and assistive technology are made possible by the provision of gesture detection and control APIs, which allow people to interact with robotic systems in a natural and straightforward way.[3] Additionally, developers may be able to create augmented reality (AR) applications with interactive hand interactions and annotations by integrating with augmented reality (AR) frameworks like ARKit or ARCore. Developers can construct augmented reality (AR) experiences that superimpose virtual content onto the actual environment, improving user engagement and visualisation, by making APIs for hand tracking and measurement available.By integrating with augmented reality (AR) frameworks like ARKit or ARCore, developers may also be able to construct AR applications with interactive hand interactions and annotations. By providing APIs for hand tracking and measurement, developers can create augmented reality (AR) experiences that overlay virtual content onto the real world, increasing user engagement and visualisation.[5]

# CHAPTER 04

# DESIGN

# 4. DESIGN

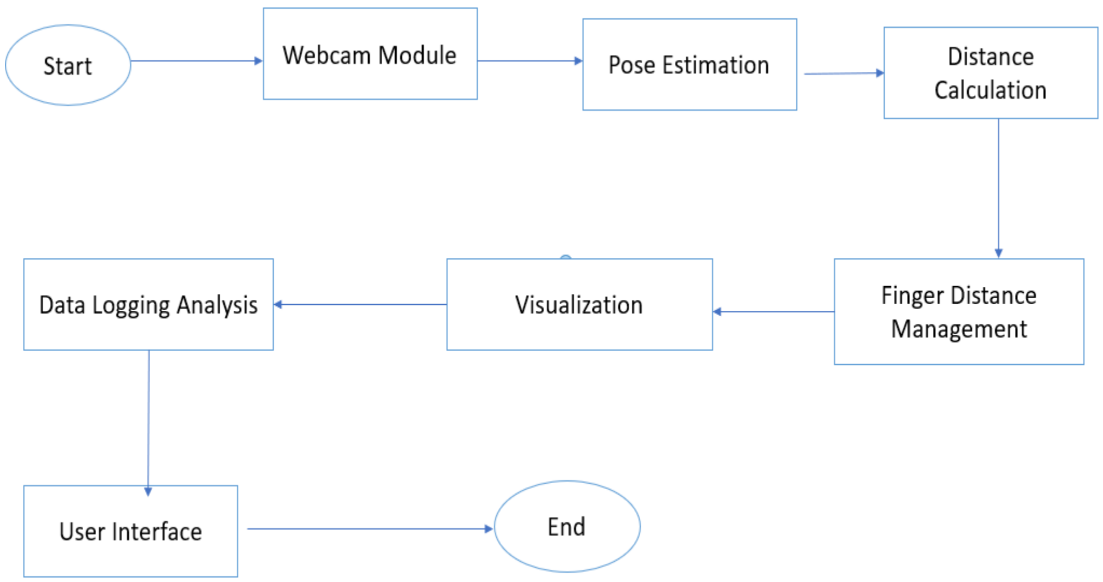


**Figure 4.1 Design for Detecting Finger Dimensions.**

a) Start State:-After opening the application and turning on the webcam module, the user starts the finger measuring procedure. The user is prompted to place their hand within the camera's range of vision by the application, which shows a live video stream from the webcam.

b) Camera Module:- The main interface for recording live video from the camera is the Webcam Module.It provides the visual input required for further processing processes, such as finger detection and measurement, by continuously streaming video frames.[1]

c) Pose Estimation:- For the purpose of locating landmarks on the user's hand and calculating their positions, pose estimation is essential. Pose estimation provides the foundation for accurate finger measurement by precisely detecting and tracking the user's hand in real-time using sophisticated machine learning techniques.[1]

d) Finger Detection:-The program recognizes particular landmarks that relate to the user's fingers by utilizing the posture estimation findings.These landmarks are used as benchmarks for precise measurements of finger length.[2]

e) Distance Calculation:- The program determines the spatial relationship between the user's hand and the screen by using pose estimate data and camera settings. In order to provide precise finger measurements, this information is essential for translating pixel distances to real-world dimensions.[1]

f) Finger Dimension Measurement:- The program measures the distances between particular places to ascertain the length of each finger segment after identifying finger landmarks. Using calibration data and geometric principles, the module measures finger dimensions in real time with accuracy.[2]

g) Visualization:- To improve the user's comprehension and involvement with the measuring process, visual feedback is given.Users may effectively visualize the results with the use of graphical overlays and annotations on the live video feed, which highlight finger landmarks that have been recognized and display the measured measurements.

h) Data Logging and Analysis:- For additional research and documentation, measured finger measurements are recorded in a structured format (e.g., CSV file). With this data tracking feature, users can monitor changes in finger measurements over time and use the gathered information to gain insightful knowledge.[4]

i) User Communication:- Users may check recorded measurements, start the finger measuring process, and easily navigate the application thanks to user interface features. Users may efficiently interact with the program thanks to intuitive user interfaces and interactive controls, which provide a seamless and user-friendly experience.[3]

j) End State:- When the user chooses to end the application or leave the measurement mode, the finger measuring procedure comes to an end. For the purpose of taking additional action or maintaining records, users can examine and evaluate the recorded finger measurements.

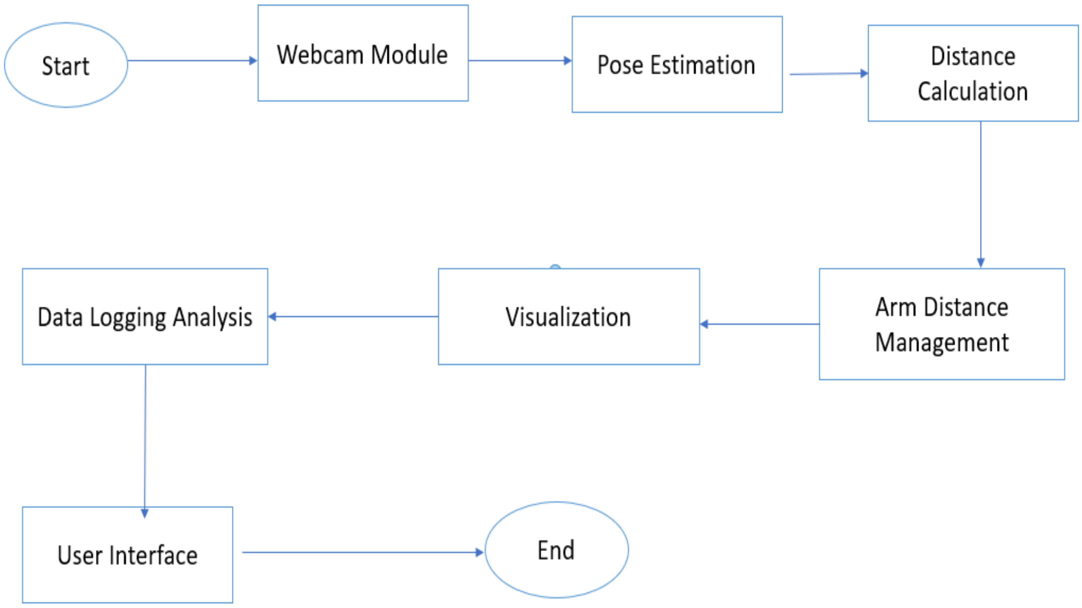


**Figure 4.2 Design for Detecting Arm Dimensions.**

a) Start State:- The application is launched and the webcam module is activated by the user to start the Arm measuring procedure. The user is prompted to put their arm within the camera's range of vision by the application, which shows a live video feed from the webcam.

b) Camera Module:- The Webcam Module is the interface that records live video and is the basis for the application's other features. It connects to the camera device and uses the OpenCV library to capture frames in real-time for processing later. [1]

c) Pose Estimation:- One essential element that becomes apparent is stance Estimation, which uses sophisticated algorithms to locate important body landmarks and provide precise stance estimations. The module can accurately deduce the user's posture and movements by examining the spatial arrangement of these landmarks. This function establishes the foundation for other features like arm dimension measurement and distance computation. Used to to locate important body landmarks and provide precise stance estimations.[1]

d) Distance Calculation :- The integration of camera settings and pose estimate data is one of the most important aspects that makes distance calculation possible. The module uses geometric principles and calibration data to calculate the distance between the user and the screen, which is useful for a variety of applications such as ergonomic assessment, virtual reality experiences, and interactive simulations.[2]

**e)** Arm Dimension Measurement:- It is uses posture estimation to precisely measure the user's arm dimensions. The module determines vital metrics like arm length, forearm length, and upper arm length by examining the spatial relationships between important landmarks like the wrists, elbows, and shoulders. These measurements offer insightful information on the user's posture and physical attributes**.**

f) Visualisation:- Through the provision of visual feedback on numerous facets of the measurement process, visualization plays a critical role in improving the user experience. Users can see real-time arm measurements, distances from the screen, and landmarks located through graphical overlays and annotations on the live video feed. An improved comprehension and involvement with the measurement procedure are fostered by this visual feedback.

g) Data Logging Analysis:- The ability to log and analyze data allows measured arm dimensions to be systematically recorded in a structured format like CSV (Comma-Separated Values). This data logging feature makes it easier to analyze the data further, spot trends, and create reports, giving users the ability to draw insightful conclusions from the information gathered.

h) User Interface:- The application's design places a strong emphasis on user interaction, enabling users to start the measuring process, view recorded measurements, and operate the program with ease. Users can effectively interact with the application by using interactive controls and intuitive user interfaces, which improves usability and user satisfaction.[10]

i) End State:- When the user chooses to end the application or exit the measurement mode, the Arm measuring procedure comes to an end.For the purpose of taking additional action or maintaining records, users can examine and evaluate the recorded Arm measurements.

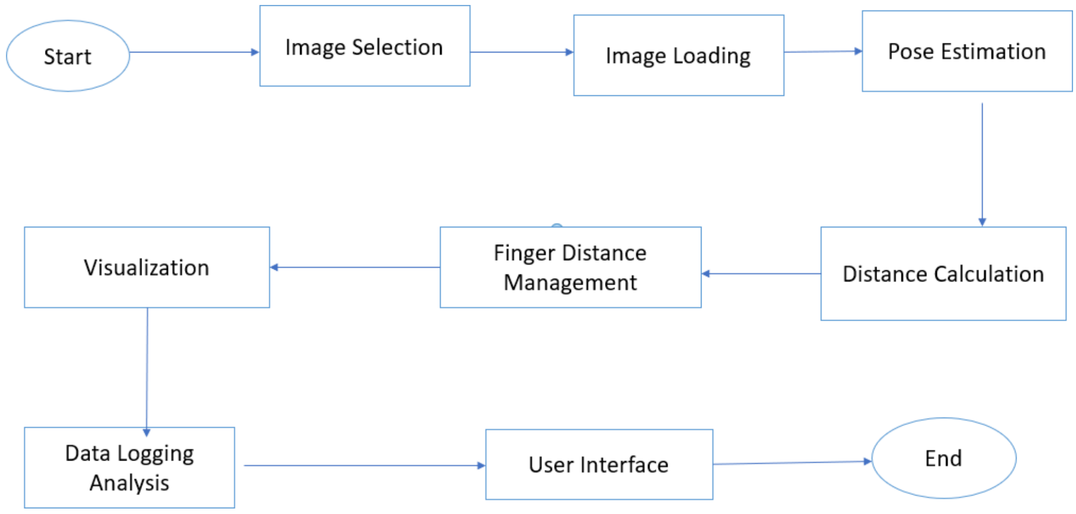


**Figure 4.3 Design for Detecting Finger Dimensions Input as a Static Image**

a) Start State:- In order to begin the finger measurement procedure, users interact with the program by choosing a still photograph of a hand that will be examined. The actions that follow in the measuring procedure are built upon this first activity. The selected image is put into the application's interface and prepared for processing upon selection. Usually, users choose an image that has been saved on the device or that has been taken from an external source, like a smartphone or digital camera. After the image loads, users can begin the analysis and begin the process of precisely measuring the size of the fingers shown in the image.

b) Image Selection:- Users are asked to choose a static image of a hand for examination before starting the finger measuring process. This important step prepares the user for other activities in the application. Users can choose to pick an image from an already-existing gallery or upload one from their local device. As an alternative, users might decide to take a fresh picture with the built-in camera capability, giving them more options for where to find the image to analyze. The chosen image is then put into the application's interface and prepared for additional processing. By using this selection method, users may be confident they have the data needed for precise analysis of finger measurements.

c) Image Loading:- The application loads the chosen image into its processing pipeline as soon as the user makes that selection. In this stage, the chosen picture file is read from the given location and formatted so that it can be used with the image processing algorithms of the application. Following loading, the image is shown in the application's interface, enabling users to verify their choice with their eyes and guaranteeing that the right image is being processed. The groundwork for later image processing activities, such dimension measurement and finger detection, is laid by this loading procedure. Through a smooth and user-friendly image loading process, the application guarantees that users may easily and quickly move through the analysis workflow.

d) Pose Estimation:- After the picture has been put into the program, posture estimation a crucial step in locating landmarks and calculating poses inside the still image comes next. To precisely infer the locations and orientations of important body parts, including hands and fingers, pose estimation algorithms examine how those body parts are arranged spatially inside the image. By utilizing sophisticated machine learning methods, the pose estimation module accurately locates particular landmarks in the static image that match the user's fingers and hand. For the purposes of further finger detection and size measuring activities, these landmarks act as reference points. The tool establishes a foundation for accurate and dependable finger dimension analysis by precisely calculating poses inside the static image.

e) Distance Calculation:- The application then calculates the distance between the user's hand, represented by the landmarks it has recognized, and the screen after completing the pose estimation phase. This is an important step that allows the pixel distances from the hand landmarks to be translated into actual dimensions. The application calculates the distance between the user's hand and the screen by using pose estimate data and camera settings, such as focal length and sensor size. To scale the finger dimensions taken from the picture appropriately, this distance information is necessary. The application makes sure that the finger measurements accurately represent the physical dimensions through accurate distance calculation, which makes trustworthy analysis and interpretation of the results possible.[1]

f) Finger Distance Management:- After estimating the pose, the application measures the size of the fingers inside the still image. By utilizing the recognized landmarks that correlate with the user's fingers, the measurement module precisely determines the length of each finger segment by computing the distances between particular places. The module converts pixel distances into actual dimensions by using geometric concepts and calibration data, making accurate finger measurements possible. Users can acquire comprehensive information about the length of each finger segment through this procedure, which is helpful for a variety of applications, including ergonomic study and specific prosthesis fitting. By providing users with the capacity to make educated judgments based on the information gathered from the static image, the precise measurement of finger measurements improves the application's usability and efficacy.[2]

g) Visualization:- application measures the finger measurements correctly and then gives visual feedback to improve user comprehension and engagement. The program shows the measured dimensions right on the static image and underlines the identified finger landmarks using graphical overlays and annotations. Users can quickly understand the results and their finger proportions thanks to this visual representation. Users are better able to evaluate their finger lengths and make decisions based on the visual feedback they receive when the measured measurements are displayed within the static image. By making the measurement results easily accessible and comprehensible, this visualization tool enhances the user experience and increases the application's overall usability and efficacy.

h) Data Logging Analysis:- After the finger measurements are taken, the application makes data logging and analysis easier so that more of the recorded data may be examined. The organized format of measured finger dimensions usually a CSV (Comma-Separated Values) file makes it simple to organize and use the data. With this logging feature, users can compare various data sets, monitor measurements over time, and, if necessary, carry out statistical analysis. Users can obtain important insights about finger proportions and any relationships with other variables by recording the measured finger dimensions and looking for trends, patterns, or anomalies. Additionally, the logged data's standardized format guarantees interoperability with different data processing tools and makes it easier to integrate with external systems for purposes of reporting or in depth research.[7]

i) User Interaction:- An essential component of the program is user interactivity, which allows users to interact with the recorded data and move through the finger measurement process with ease. To begin using the application, users must first choose a picture to use as the finger measurement input. Users are encouraged to begin the pose estimation procedure, which locates landmarks on the hand inside the image, once the image has loaded. The measurement of the finger dimensions that follows is based on this phase. Users are guided through the process by interactive controls and user-friendly user interfaces, which make it simple for them to move between the application's many stages. The application allows users to examine the visual feedback it provides, which consists of overlays showing measurements and finger landmarks that have been recognized.[10]

j) End State:- The application ends when the finger measurement procedure is finished and users have successfully acquired measurements for the fingers in the chosen image. Users can now opt to exit the application, examine the measured dimensions, or save the data for further use or analysis. After completing the measurement process, users have accomplished their goal of ascertaining the size of the fingers in the picture. Users get a sense of completion from the application when they complete the finger measurement task.

# CHAPTER 05

# IMPLEMENTATION

# 5. IMPLEMENTATION

## 5.1 Creating a module that detects and fetch dimensions of fingers and store it in csv files. Here is a method for creating the module.

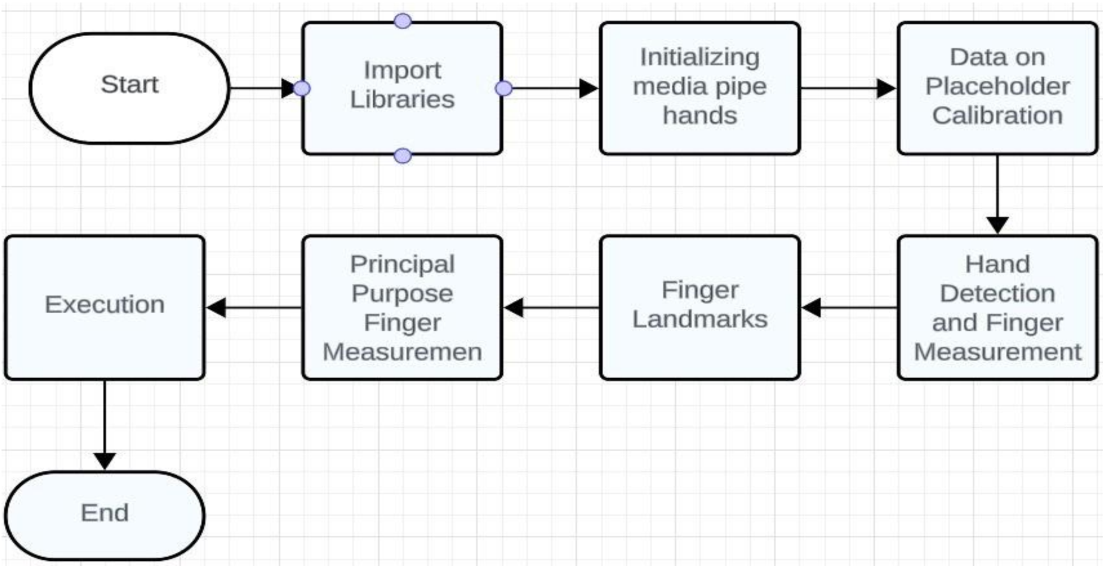


**Figure 5.1: Steps for Fetching Finger Dimensions**

### 5.1.1 Import Libraries

a) cv2 (OpenCV)

A well-known open-source computer vision and machine learning software library is called OpenCV, or Open Source Computer Vision Library. It offers a range of features and methods for analyzing images and videos, enabling you to perform tasks like motion tracking, object detection, and facial recognition. To handle webcam input, process frames, and display the results, this script imports cv2.[4]

b) Mediapipe

Google created the open-source MediaPipe framework, which provides tools for creating multimodal machine learning pipelines. It offers a range of tools and pre-trained models for applications like object recognition, pose estimation, face detection, and hand tracking. The script makes use of the hands module of the mediapipe library to track hand motions in real time and identify hand landmarks.[1]

c) Numpy

The foundational Python module for scientific computing is called Numpy. Large, multi-dimensional arrays and matrices are supported, and a number of mathematical operations are available for effective manipulation of these arrays. Numpy is utilized in this script to conduct numerical operations and manipulate arrays, namely for vector operations and distance calculations.[4]

d) CSV

Classes and functions for reading and writing CSV files are available in the Python csv module. Tabular data is commonly stored as CSV (Comma-Separated Values) files, where values are separated by commas and each line denotes a row. To manage the storage of finger dimensions in a CSV file, this script imports the csv module.[4]

### 5.1.2 Initializing MediaPipe Hands

a) static_image_mode:The input data type a static picture or a video stream—is indicated by the static_image_mode option. It indicates that the input is a continuous stream of frames from a camera rather than a single image when set to False, as it is in this script. To simulate real-world calibration data, each finger (Thumb, Index, Middle, Ring, and Pinky) is linked to a distinct physical distance in cm.

b) max_num_hands: The maximum number of hands to identify in each frame is determined by the max_num_hands option. It can detect and track up to two hands at once in this script because it is set to 2.

c) The lowest confidence thresholds for hand detection and tracking are determined by the parameters min_detection_confidence and min_tracking_confidence, respectively. The values, which span from 0.0 to 1.0, are expressed as floating-point numbers. Only some detections are regarded as legitimate, thanks to a higher confidence level. Since both thresholds in this script are set to 0.5, any tracking or detection result with a confidence score of at least 0.5 is considered acceptable.

### 5.1.3 Data on Placeholder Calibration:

a) Cal_data:

Example physical distances in cm for each finger are provided in the cal_data dictionary. These numbers are used as a guide to translate pixel distances measured from hand landmarks into actual hand distances. To simulate real-world calibration data, each finger (Thumb, Index, Middle, Ring, and Pinky) is linked to a distinct physical distance in cm. You can substitute real calibration data from experiments or measurements for these placeholder values.[1]

### 5.1.4 Hand Detection and Finger Measurement Functions

The following functions are defined in the script to handle landmark extraction, finger dimension measurement, and hand detection:

a) recognize_fingers_and_hands Function: The detect_hands_and_fingers function measures the length of fingers, draws the contours of hand landmarks, and detects hands in the picture. The path to the CSV file with the finger dimensions and the input frame are the two parameters that are required.This function converts the input frame to RGB format because MediaPipe only works with RGB images.The frame is processed by MediaPipe's hands_model, which yields results that include the hand landmarks.The function iterates over each hand that is detected if results.multi_hand_landmarks is not empty and hands are detected. It measures the palm distance for each hand and, if the palm distance is near a desirable value, computes the finger dimensions (0.82 cm in this case). The dimensions are written to the CSV file if they are successfully calculated and haven't been written there yet.

b) calculator_palm_distance Function: The measure_palm_distance function determines the separation between the index finger tip landmark and the palm landmark (wrist). It calculates the palm distance and returns it with the hand landmarks as input. In three dimensions, the distance is calculated using Euclidean distance.[2]

c) determine_finger_dimensions Function: The calculate_finger_dimensions function uses the calibration data and the hand landmarks to calculate the dimensions (lengths) of each finger. It returns a dictionary mapping each finger to its associated dimension in centimeters after receiving the hand landmarks as input. It measures the pixel distance between the tip and base landmarks for each finger, using the calibration data to translate this value into a physical distance.[1]

### 5.1.5 Finger Landmarks

Each finger's matching landmark indices for the base and tip are mapped to a dictionary called finger_landmarks.

a) finger_landmarks

The landmark indices for the base and tip of each finger are specified in the finger_landmarks dictionary. The thumb, index, middle, ring, and pinky fingers are connected to a dictionary that has two keys: "Tip" and "Base," which stand for the landmarks at the fingertip and base, respectively. These landmark indices are from MediaPipe's HandLandmark enumeration, which lists a number of the hand's anatomical landmarks.[3]

### 5.1.6 Principal Purpose Fing Measurement

The primary point of entry for the script is the Fing_Measure function:

a) Loop for Webcam Capture and Processing:

The VideoCapture class in OpenCV is used to record video from the webcam.The location of the CSV file with the finger measurements is specified. It constantly reads frames from the webcam (cap.read()) and uses the detect_hands_and_fingers function to measure finger measurements, detect hands, and draw outlines from each frame. The processed frame is then displayed in a window (cv2.imshow()) inside a while loop.The loop keeps running until the user hits the 'q' key, at which point it ends, releases the webcam (cap.release()), shuts the display window (cv2.destroyAllWindows()), and exits the loop.

### 5.1.7 Execution

Only when the script is performed directly—that is, without being imported as a module—is the primary function carried out.The purpose and usefulness of each component involved in hand identification, landmark extraction, and finger dimension measurement using the MediaPipe library in Python are explained in detail in this methodology, which offers insight into the inner workings of the script. Every component helps the script work as a whole, allowing for the analysis and display of finger sizes and hand movements in real time from a webcam stream.

## 5.2 Creating a module that detects hand and fetch dimensions of Arm and store it in csv files. Here is a method for creating the module.

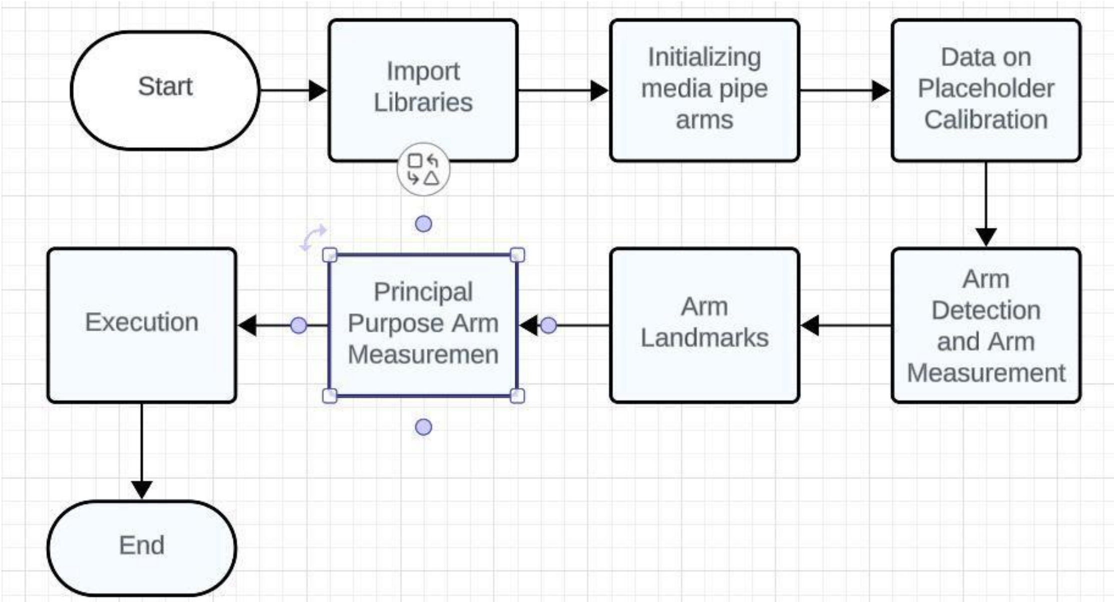


Figure 5.2: Steps for Fetching  Finger Dimensions

### 5.2.1 Importing Libraries

a) cv2 (OpenCV)

The Open Source Computer Vision Library, or OpenCV, is a mainstay in the computer vision industry, offering a vast range of tools and features for processing pictures and videos. Because of its dependability, interoperability with multiple platforms, and wealth of documentation, it has become the preferred library for computer vision enthusiasts and experts alike.By providing an interface in Python, the OpenCV library's features are made accessible through the cv2 module in Python. Using cv2, developers can access features like reading and writing videos and images, filtering, transforming, and segmenting images, capturing frames from cameras, and implementing sophisticated computer vision algorithms like object detection, tracking, and recognition.The use of OpenCV in this script suggests that analysing images in real time—possibly from a camera feed—is part of the assignment. Webcam operations like frame acquisition, visualisation, and even additional image processing or analysis on the acquired frames would be made easier using OpenCV.[4]

b) Mediapipe

Google created Mediapipe, a complete framework that makes building intricated the

Google created Mediapipe, a complete framework that makes building intricate machine learning pipelines easier, especially when multimodal inputs like audio, video, and sensor data are involved. For developers creating real-world applications involving gesture recognition, augmented reality, and human-computer interaction, it provides a plethora of pre-trained models and modular components for a range of tasks, including hand tracking, face detection, pose estimation, and more.The mediapipe.[1] position module specialises in pose estimation, which is the process of determining a human body's spatial configuration from pictures or movies.[1] It is a basic computer vision problem. Mediapipe.pose uses pre-trained deep learning models to precisely identify and locate important body characteristics including joints, keypoints, and skeletal connections. This allows for a variety of applications, such as virtual try on experiences, immersive gaming, and fitness tracking.Given that mediapipe.pose is used in this script, it appears that the main goal is to use webcam input to estimate human poses in real time. Identifying significant landmarks that correspond to the user's body parts and using them for additional analysis or interaction could be one way to accomplish this**.**[2]

c) Math

Python's math module is a standard library module that offers several mathematical constants and functions. Math is a basic toolset for carrying out numerical computations in Python, ranging from simple arithmetic operations to complex mathematical functions like trigonometric, logarithmic, and exponential functions.[4] Developers can import math to access a multitude of mathematical tools that they can easily incorporate into their programmes. Math provides the essential building blocks to handle a variety of mathematical activities effectively and precisely, whether it's calculating distances, angles, probabilities, or executing transformations and optimisations.The presence of the math module in this script suggests that mathematical operations are important, probably for activities like converting coordinate systems, scaling pixel distances to real-world units, and conducting geometric calculations. To accomplish these goals, functions such as sqrt() (which calculates square roots), sin() and cos() (which calculate trigonometry), and atan2() (which calculates angles) may be used. Numpy is utilized in this script to conduct numerical operations and manipulate arrays, namely for vector operations and distance calculations.

d) CSV

The Python csv module is an integrated library that offers support for reading and writing CSV (Comma Separated Values) files. For storing tabular data, CSV is a popular file format. In this format, each row denotes a record, and columns are separated by commas as delimiters. Both humans and machines can readily read and write in this lightweight, straightforward format.Developers may execute actions including filtering, sorting, and aggregating data stored in CSV format, as well as writing data from Python objects to CSV files, by interacting with CSV files programmatically with the help of the csv module. With CSV, you can handle tabular data successfully whether you're processing it for analysis, creating reports, or integrating it with other systems.The inclusion of the CSV module in this script suggests that data persistence or interaction with structured data in CSV format is involved.[4]This could entail exporting data for further processing or analysis, documenting system occurrences, or storing measurement findings. The script can easily interface with the larger data ecosystem and make operations like data management, sharing, and archiving easier by utilising the features of the csv module.

### 5.2.2 Function of ARM_DIM()

Pose Estimation: By utilising the features of the MediaPipe Pose model, the ARM_DIM function captures the logic for estimating and analysing arm dimensions from camera input. Pose estimation, which involves the identification and localization of important body landmarks and their spatial relationships, is a crucial task in computer vision.[2] Pose estimation models, which use deep learning techniques, are able to reliably estimate human positions from photos or videos. This makes them useful for applications such as virtual character animation, gesture detection, and activity recognition.[1] The mediapipe.pose module is based on the MediaPipe Pose model, which is trained to identify anatomical keypoints that correlate to different body parts, including knees, ankles, elbows, shoulders, hips, and wrists. These key points enable tasks such as action identification, estimation of yoga poses, and physical therapy monitoring by providing points of reference for understanding body posture and movement.The MediaPipe Pose model is initialised and applied to each frame of the webcam stream within the ARM_DIM function. This allows it to identify important landmarks related to the user's arms, such as the wrists, elbows, and shoulders.[7] The function may determine arm dimensions, including arm length, forearm length, and upper arm length, by examining the spatial arrangement of these landmarks. This analysis offers important information on the user's body proportions and postural alignment.[3]

a) Camera Parameters

Extrinsic parameters like the camera's position and orientation in relation to the scene, as well as intrinsic parameters like the focal length, sensor size, and main point, must be understood in order to measure an arm's dimensions accurately. The apparent size and shape of objects in the photographed scenes are influenced by these characteristics, which impact the perspective projection of 3D points onto the 2D image plane.Camera characteristics like the field of view and distance to the subject are either assumed or supplied as input in the ARM_DIM function. These factors are essential for translating real-world distances in physical measures like centimetres or inches from pixel distances calculated from image coordinates. The feature ensures precise and consistent readings across various viewing situations and camera setups by calibrating the camera parameters.

b) Landmark Extraction

The ARM_DIM function collects important landmarks that correlate to the left and right wrists, elbows, and shoulders after determining the user's stance using the MediaPipe stance model. These landmarks stand in for noticeable locations on the user's arms that are crucial for precise measurement of arm lengths. It establishes reference points for arm lengths and angles by localising these features within the image frame.[1] In order to extract landmarks from the pose estimation outputs, certain components of the pose keypoints array must be accessed. These elements represent the spatial coordinates of each landmark that has been recognised in the image plane. The function retrieves the desired landmarks' coordinates by indexing into this array using predetermined keypoint indices, facilitating further analysis and measurement.[7]

c) Distance Calculation

The ARM_DIM function calculates the distances between pairs of nearby landmarks, such as the elbow-to-shoulder and wrist-to-elbow distances, for both arms using geometric principles and camera calibration data.[2] These measurements are essential for determining the lengths of various sections of examining the arms and determining any asymmetry or departure from normal anatomical proportions.Applying trigonometric connections to the spatial coordinates of the identified landmarks such as the Pythagorean theorem or the law of cosines is the process of calculating distance.[1]The programme compensates for perspective distortion and camera projection effects by converting pixel distances to physical units by using the known camera settings and the correlations between image coordinates and real-world distances.[7]

d) Visualisation

The ARM_DIM function displays the computed arm dimensions and identified landmarks on the webcam feed to facilitate comprehension and interpretation. By offering immediate feedback on the analysis's findings and enabling the qualitative evaluation of the measured variables, this visualisation improves the user experience.

The visualisation process entails superimposing graphical components on top of the webcam frames, such as lines to represent arm segments and circles to depict landmarks. The function highlights the locations of important landmarks and their spatial relationships on the image by annotating it with visual signals that are generated by utilising the drawing functionalities offered by the OpenCV library. This enables users to examine the arm measurements visually and confirm that the measurements are accurate.

e) CSV Writing

The ARM_DIM function records the measured arm dimensions in a structured format for later reference or study, in addition to providing real-time visualisation. The function allows for long-term data logging and makes post-processing chores like statistical analysis, trend analysis, and report production easier by writing the data to a CSV (Comma Separated Values) file.Users can access and modify the measured arm dimensions data outside of the real-time application by using the CSV file, which acts as a persistent storage medium for the data.[4] Typically, a single measurement session is represented by each row in the CSV file, with the columns denoting various dimensions or relevant data. The function serialises the measurement data into CSV format by utilising the built-in capabilities of the CSV module, guaranteeing compatibility with a variety of platforms and data processing tools.[1] Tabular data is commonly stored as CSV (Comma-Separated Values) files, where values are separated by commas and each line denotes a row. To manage the storage of finger dimensions in a CSV file, this script imports the csv module.[4]

### 5.2.3 Function of DISTFROMSCREEN

Pose estimate and distance calculation are integrated via the DISTFROMSCREEN function, which coordinates the script's primary workflow and establishes the user's distance from the screen. This entails utilising the MediaPipe Pose model's capabilities to infer the distance based on the relative location of the user's nose landmark and to estimate the user's pose from the camera feed.Pose estimation allows the function to obtain spatial data about the user's body position, which makes it easier to calculate pertinent metrics like the user's distance from the screen. The function determines the user's distance based on the apparent size of the nose in the image and known camera parameters by evaluating the spatial coordinates of the nose landmark and using geometric principles.

a) Distance Visualisation

The DISTFROMSCREEN function visualises the estimated distance on the webcam stream, usually with graphical overlays or text comments, to give the user feedback in real-time. In order to ensure the best possible interaction and measurement accuracy, this visualisation improves user engagement and makes it easier for the user to coordinate their location with respect to the screen.Using the OpenCV library's drawing capabilities, the visualisation may entail applying graphical elements such as lines, shapes, or text labels to the camera frames. The capability allows users to optimise the quality and reliability of subsequent readings by optimising their position by overlaying visual indicators that indicate the estimated distance.

b) Arm Length Measurement

The DISTFROMSCREEN function uses the ARM_DIM function to precisely measure the user's arm dimensions after determining and optimising the user's distance from the screen. This entails measuring the lengths and proportions of the user's arms using the calibrated camera parameters and posture estimation results, offering insightful information on anatomical features and postural alignment.The feature guarantees uniformity and comparability between measurement sessions by taking arm measurements at a constant distance from the screen. By eliminating potential sources of variability and mistake like shifting camera perspectives or user positions, this standardisation produces measurement results that are more accurate and useful.[4]

c) Main Loop

The main loop, which continuously gathers frames from the webcam, processes them for posture estimate and distance computation, and refreshes the visualisations in real-time, contains the essential functionality of the DISTFROMSCREEN function. The application's interactive experience is powered by this loop, which lets users dynamically change their position and see how it affects the measured dimensions.The function retrieves frames from the webcam hardware, processes them via the pose estimation pipeline, and interfaces with it all within the main loop. The user's distance from the screen is then calculated by analysing the posture estimate outputs, and the visualisations are updated accordingly. The function iterates through this loop in real-time, giving users instant feedback and enabling them to modify their posture for the best measurement accuracy through repetition.

### 5.2.4 Implementation

The DISTFROMSCREEN function, which acts as the entry point for the main workflow, is called first when the script executes. When the function runs, it sets up the webcam and related settings, gets the pose estimation pipeline ready, and then it starts a never-ending loop that records frames, estimates poses, computes distances, and refreshes visualisations in real time.The script keeps up an interactive environment during this loop so that users can change their position in relation to the screen and see how it affects the measured dimensions. By moving towards or away from the screen, users can interact with the programme. This causes the script to dynamically adjust the visualisations and give feedback on the best placement.The script keeps running until the user chooses to stop it, usually by hitting a certain key (like 'q') to close the programme. When the script ends, it releases the webcam's resources, cleans up any mess it made, and gracefully exits to give the operating system back control.The script makes real-time arm dimension measurements easy and accurate for users by encapsulating the measurement logic within the DISTFROMSCREEN function and offering an intuitive interface for interaction. This makes tasks like ergonomic assessment, physical therapy monitoring, and virtual fitting experiences easier to complete.

## 5.3 User Interface by Integrating Modules.

### 5.3.1 Initialization and Setup

The GUI application's functionality and performance are built upon the initialization and setup process. The first step is to import the required libraries, such as os for file operations, tkinter for creating GUIs, csv for processing data, and subprocess for running external Python programs. These libraries offer necessary resources for creating a reliable and adaptable application.The program defines functions to handle several operations that users can perform, like opening external scripts, reading saved values, and choosing prosthesis choices, once the libraries have been loaded. These routines guarantee that activities are completed smoothly and encompass the application's basic functionality. Code is arranged into modular functions to facilitate future maintenance and application extension.[10]

### 5.3.2 Establishing the Main Application Window

One of the most important phases in UI design is the establishment of the main application window. The application creates a graphical window that acts as the main user interface by using tkinter. With the window title set to "Prosthetic Options," users may easily understand the application's goal.[10] A variety of GUI components, like as navigation bars, footer sections, and prosthesis choices, are housed within the main window. It offers a unified visual style that improves the application's overall attractiveness and usefulness. Furthermore, the primary window is set up with dimensions and features that work with a variety of screen sizes and resolutions.

### 5.3.3 Designing a Navigation Bar

The navigation bar is essential to enabling smooth application navigation. It has labels that may be clicked to indicate the various parts, like "Home," "About," "Products," and "Contact." Every label has a related event handler that, when clicked by the user, initiates the corresponding action.Labels for accessing stored values of various prosthetic options are included in the navigation bar in addition to the regular labels.

By enabling rapid access to pertinent information without requiring users to navigate to different parts or interfaces, this feature improves user convenience.

### 5.3.4 Creating a Footer

To communicate crucial information like ownership rights and copyright details, a footer section is appended to the bottom of the application window. By being transparent about its legal and ethical issues, it enhances the application's professionalism and legitimacy.The footer section usually has a reduced text size and contrasting background color to visually set it apart from the main content. By using a distinct visual style, the footer can efficiently convey important information without drawing visitors' attention away from the main content.[10]

### 5.3.5 Creating Prosthetic Alternatives

Users are given a range of prosthetic alternatives to chose from in the application's main section. To enhance visibility and encourage user involvement, these alternatives are shown as larger buttons with clickable labels underneath. A prosthetic choice is associated with each label, which includes "finger," "arm," "leg," and "image." The application initiates the required action to start the pertinent Python script for a prosthesis choice when a user clicks on its label.[4] Task completion is ensured and the user experience is improved by the smooth integration of GUI components with backend operations.

### 5.3.6 Setting Up Styles

The style module in tkinter is used to alter the application's appearance. To preserve coherence and improve aesthetics, distinct component styles, such as labels for the navigation bar, footer, and prosthesis option, are specified. Border settings, font size, background and foreground colors, and other customizations are available.The application's unified and aesthetically pleasing appearance, which complies with contemporary design standards and user expectations, is achieved through style configuration. Maintaining a uniform style for all GUI elements improves usability and strengthens the application's brand identity. The application creates a graphical window that acts as the main user interface by using tkinter.[10] With the window title set to "Prosthetic Options," users may easily understand the application's goal The application's unified and aesthetically pleasing appearance, which complies with contemporary design standards and user expectations. The application's unified and aesthetically pleasing appearance, which complies with contemporary design standards and user expectations, is achieved through style configuration.[2]

### 5.3.7 Handling User Interactions

Callback functions and event binding are used to control user interactions. The relevant action is carried out when a user interacts with a GUI element, such as by clicking on a prosthesis choice label or a label in the navigation bar. For instance, selecting a label on the navigation bar takes the user to the appropriate area of the program, whereas selecting a label on a prosthesis option starts the associated Python script. An excellent user experience is ensured by this event-driven method, which also guarantees responsive and straightforward user interaction.[10]

### 5.3.8 Execution of the Main Loop

The application's main loop, root.mainloop(), is always listening for user input and updating the graphical user interface in response. This loop makes sure the application stays engaging and responsive, enabling users to easily pick prosthesis options and move between areas.The main loop makes sure the program runs smoothly and effectively by constantly observing user inputs and changing the GUI in real-time. It serves as the framework for the user interface, allowing for feedback and dynamic interaction between the application and the user.[7]

### 5.3.9 Error Handling and Feedback

In the event that there are any problems, the program has error handling features that let the user know. For instance, the application notifies the user of the lack of data if it is unable to locate stored values for a specific prosthetic choice. Likewise, if there are any problems running external Python programs or executing file operations, error warnings are shown.Error messages are intended to be helpful and intuitive, assisting users in comprehending the nature of the issue and pointing them in the direction of possible fixes.[1]

### 5.3.10 Total Usability and User Experience

The approach places a high priority on developing a visually appealing, user-friendly, and intuitive interface for accessing prosthetic alternatives. The program improves overall usability and user experience through logical section organization, simple navigation, and clear feedback. The application's aesthetic appeal is enhanced by the ability to customize styles and visual components, which elevates its level of professionalism and engagement.

# CHAPTER 06

# RESULT AND DISCUSSION

# 6. RESULT & DISCUSSION

The project starts with the creation of an application interface that is painstakingly made for the effective administration of prosthetic alternatives. It offers a wide range of features that are intended to make users feel more empowered and at ease. To provide easy navigation and accessibility, a prominent navigation bar acts as the entry point to important pages like Home, About, Products, and Contact. Users are presented with a wide range of prosthetic alternatives in this interface, including finger, arm, leg, and image possibilities. Each prosthetic option has its own unique features that are designed to cater to individual requirements and tastes. Users are empowered to make educated decisions by having the tools necessary to perform commands with ease or browse related values, which increases their agency and autonomy in the selection process. Additionally, the platform places a high priority on openness by giving consumers the chance to carefully consider the values connected to each prosthesis option, building confidence and enabling a more thorough comprehension of the options. Users are empowered to make educated decisions by having the tools necessary to perform commands with ease or browse related values, which increases their agency and autonomy in the selection process. Additionally, the platform places a high priority on openness by giving consumers the chance to carefully consider the values connected to each prosthesis option, building confidence and enabling a more thorough comprehension of the options. Moreover, putting user authentication procedures in place is essential to enhancing security and guaranteeing that private data is protected from unwanted access. Sturdy error-handling systems are ready to reinforce the application's dependability, minimizing possible interruptions and guaranteeing a smooth user experience. Rigorous testing and deployment protocols are planned concurrently, demonstrating a dedication to quality control and the provision of a flawless, error-free product. Encouraging users to provide feedback and suggestions for improvement, the project promotes an iterative and collaborative approach to development by incorporating feedback channels and embracing a culture of continuous improvement. With the help of these coordinated efforts, the project hopes to achieve its main objective of providing users with an interface that is easy to use for controlling prosthetic alternatives. This interface will be distinguished by improved functionality, usability, dependability, and response to user feedback. Through this, it hopes to make a significant and lasting contribution to the field of prosthetic administration, empowering users and promoting an inclusive and accessible future.


**Figure 6.1 : Adjusts palm at specific distance of 0.82cm.**


**Figure 6.2 : Finger Dimension Fetched**

Python code for hand tracking and finger measuring makes use of OpenCV and the MediaPipe package.[1] It sets up the MediaPipe Hands model to identify hand landmarks, measures the length of each finger based on pixel distances converted to centimeters using calibration data, and computes the distance between the palm and index finger tip to see if the palm distance satisfies a particular requirement. Its primary purpose is to record video using the webcam, measure finger dimensions, draw landmarks, and detect hands continuously. All of these features are displayed on the screen until the user presses 'q' to depart. But there are a few things to take care of, such a mistake in the primary function condition, the possibility of the CSV file being overwritten, and a reference problem with the finger dimensions dictionary.All in all, the code provides a framework for an application that tracks hands and measures fingers. It can be further improved and extended for a variety of applications, including gesture identification and virtual object interaction.

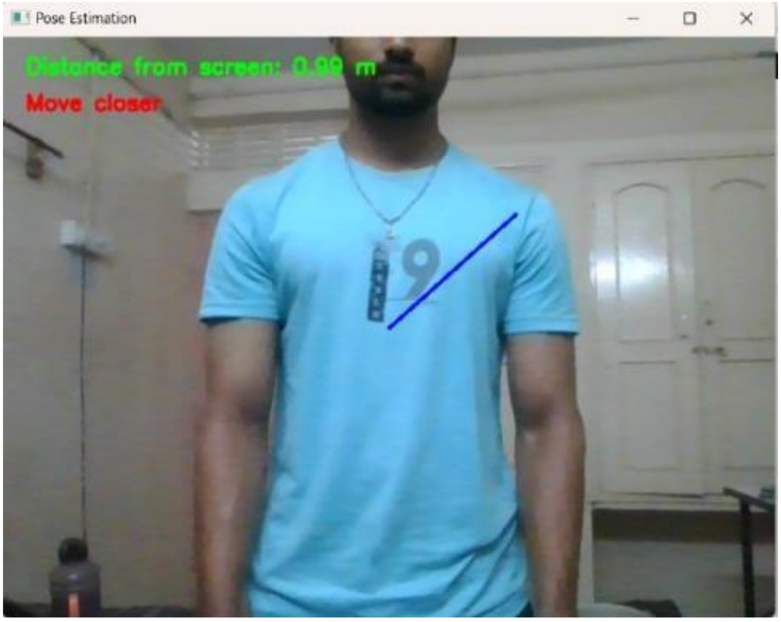


**Figure 6.3 : Adjusts arms at specific distance**

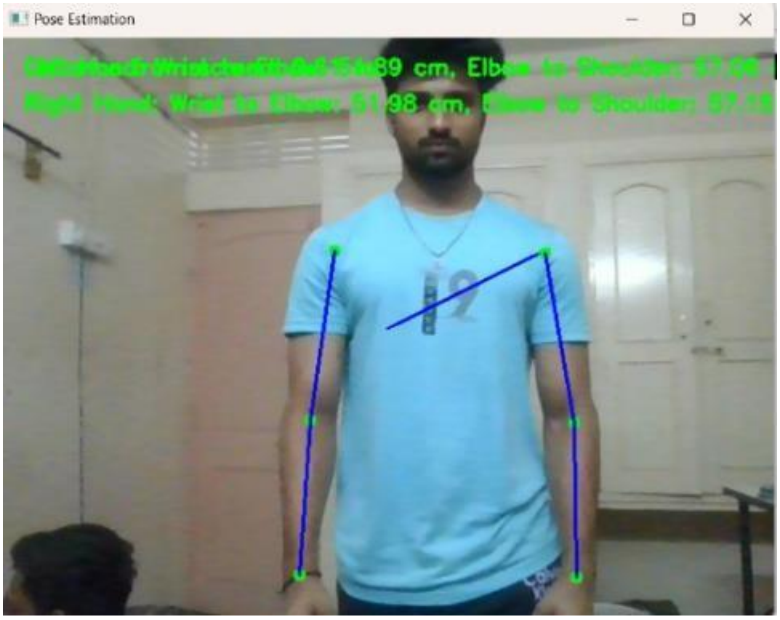


**Figure 6.4 : Arms Dimension Fetched**

With MediaPipe and OpenCV, the accompanying Python code creates a system for calculating arm size based on screen distance.[3] It tracks and detects important body landmarks, like the elbow, shoulder, and wrist, by using the MediaPipe Pose model. It calculates the distance to the subject and the nose landmark's estimated depth in relation to the screen to determine how far away the user is from the screen.If the user is too close to the screen or too far away from it, the system will prompt them to move. The code then takes the user's arm measurements after they are at the ideal distance. Drawing lines and circles on the identified landmarks to illustrate the measurements, it computes the left and right arm lengths in centimeters. After that, the arm dimensions are measured and saved in a CSV file for additional examination. Although the functionality is strong, there is room for improvement. Two areas that might be improved are the accuracy of the distance estimation and the user interface, which could be made more intuitive. All in all, the code provides a strong basis for applications related to virtual reality interaction, fitness tracking, and ergonomics.

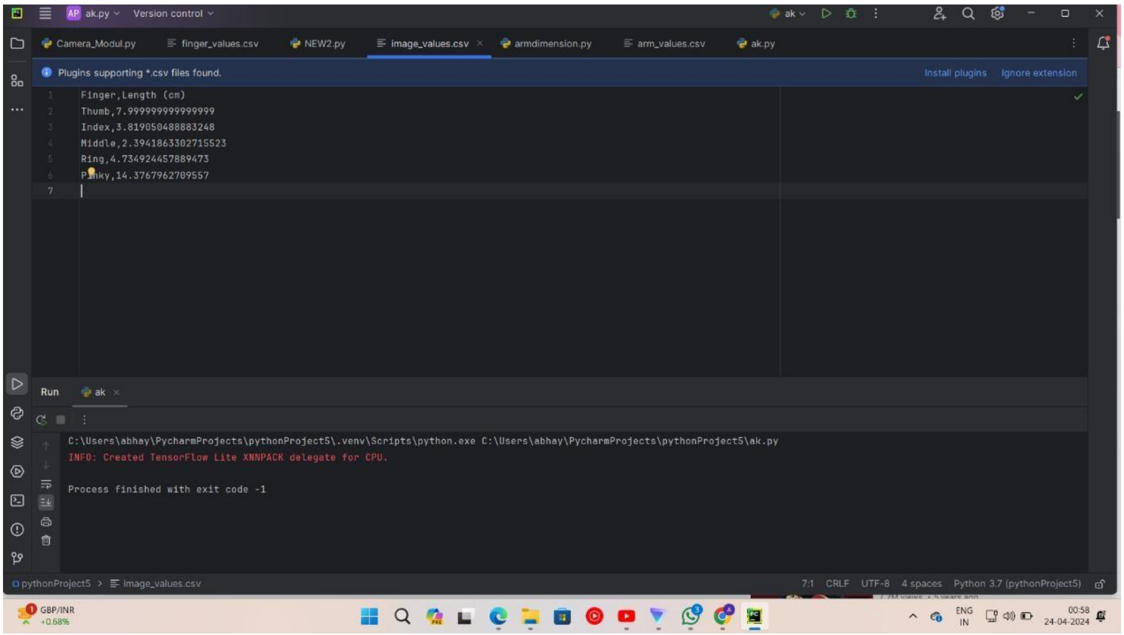


**Figure 6.5 : Dimensions stored in csv file**

The given code is a Python script that combines several features associated with human pose estimation and computer vision. It makes use of tkinter, MediaPipe, OpenCV, and other libraries for various uses. The script has features for determining arm lengths, identifying hands, measuring finger widths, and graphical user interface interaction. Moreover, it has functions like writing data to CSV files, showing a live video stream, and giving feedback to the user based on poses that are recognised.

# CHAPTER 07

# CONCLUSION

# 7. Conclusion

**Conclusion:**

Using the MediaPipe module, the supplied Python script creates a stable foundation for finger measuring and hand tracking in real-time. It guarantees precise hand detection and landmark tracking by configuring the MediaPipe Hands model and initialising libraries. Its ability to measure palm distance and calculate finger dimensions—both essential for accurate finger dimension estimation—is fundamental to its operation. It improves accuracy by converting pixel distances to physical measures using placeholder calibration data. The script records video frames, recognises hands, draws landmarks, and measures finger measurements in real-time to provide instantaneous feedback in the main function, FingerMeasure (). Additionally, it records finger measurements to a CSV file when reaching a predetermined palm distance, which makes analysis easier for user verification, ergonomic research, and other purposes. All things considered, the script provides a thorough foundation for hand tracking and measurement in a variety of applications, which makes it useful for both developers and academics.

**Contribution:**

This bit of Python code shows how to create a Tkinter-based graphical user interface (GUI) application for investigating prosthetic choices. The copyright footer, framed navigation bar, and main window create a polished and eye-catching look. Sections such as Home, About, Products, Contact, and View Values are easily navigable by users. In the prosthetic choices section, you can choose between finger, arm, leg, or image options. These buttons will activate different functionalities, such as dimension calculations and camera access. To further improve the functionality of the application, users can view specific values that are connected with each prosthetic part, which are retrieved from CSV files. A seamless user experience is ensured by the components' uniform theming, which produces an easy-to-use interface that allows users to explore prosthetic alternatives and obtain pertinent information. All things considered, this Tkinter-based graphical user interface (GUI) application provides a user-friendly environment in which to investigate prosthetic alternatives, retrieve relevant information, and interact with the underlying functionality.

**Scope of Future Work:**

The project involves creating an application interface specifically designed to handle prosthesis possibilities in a thorough manner. It includes an easy-to-use navigation bar with Home, About, Products, and Contact options, making it easily accessible to users looking for particular features or information. Users can interact with different prosthetic alternatives within the interface, such as finger, arm, leg, and image selections. Each of these options is associated with certain functions, including displaying values or executing commands, which makes decision-making and interaction easier. Additionally, users can access related values for every prosthesis option, which promotes openness and well-informed decision-making. With an eye towards the future, the project intends to add features like user authentication mechanisms to strengthen security, robust error handling to guarantee continuous performance, extensive testing procedures to validate functionality across various scenarios, and streamlined deployment processes in order to expand its functionality. Furthermore, feedback systems will be put in place to collect user preferences and input, allowing the application to be continuously improved and refined in response to changing user needs and expectations. By implementing these improvements, the project hopes to position itself as a flexible and essential resource in the field of prosthetic administration, meeting the many requirements and tastes of its user base while upholding its dedication to dependability, security, and usability.

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# <u>LIST OF DELIVERABLES ON PRESENT WORK</u>

# PUBLICATION DETAILS 1

| PAPER TITLE | CONFERENCE NAME | CONFERENCE DATE |
|---|---|---|
| A survey of Integration into 3D Printing for Image Processing using AI ML | One Day National Level InterDisciplinary Conference on Contemporary Dynamics in Humunities Science and Technology | 22-04-2024 |

# 18. A Survey of Integration into 3D Printing for Image Processing using AI ML

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**Abstract**

In order to overcome the difficulties associated with physical measuring for prosthetic development, the goal of this research project is to design a measuring Module for Prosthetic Hand Dimensions. The module gives users choices to obtain exact finger dimensions through two main methods: image-based input and distance measurement. The study compares different distance measurement methods employing cameras and image processing algorithms in terms of effectiveness, accuracy, and usability. For tasks like contour analysis, hand tracking, landmark identification, edge detection, and so on, open-source libraries like Mediapipe, TensorFlow, and OpenCV are used. By providing insights into efficient dimensioning techniques, the programme seeks to advance the prosthetics profession by improving the design and customisation of prosthetic hands.And overall brief study about Existing technologies include depth sensors, proximity sensors, and 3D scanning technology.

**Keywords:** Image processing, Prosthetic development, OpenCV, TensorFlow, Mediapipe, NumPy, Precision dimension measurement, Tkinter, depth sensors, proximity sensors, and 3D scanning technology.

## 1. Introduction

In order to overcome the difficulties associated with physical measuring for prosthetic development, the goal of this research project is to design a measuring Module for Prosthetic Hand Dimensions. The study compares different distance measurement methods employing cameras and image processing algorithms in terms of effectiveness, accuracy, and usability. For tasks like contour analysis, hand tracking, landmark identification, edge detection, and so on, open-source libraries like Mediapipe, TensorFlow, and OpenCV are used. By providing insights into efficient dimensioning techniques, the programme seeks to advance the prosthetics profession by improving the design and customisation of prosthetic hands. The suggested technique makes use of the OpenCV and NumPy libraries to recognise objects, determine coordinates, and compute the dimensions shown in centimetres on the screen. The paper also offers a thorough literature review that covers a range of AI and computer vision applications, emphasising the value of the suggested approach in improving real-time object measurement [6]. The block diagram and flowchart, as well as the use of OpenCV, NumPy, and Imputes for image processing tasks, are described in depth in the design and implementation section. The accuracy and practicability of the approach for measuring object dimensions are demonstrated by the simulation results, and examples of real-world applications, such as measuring a mobile phone, are provided. The efficacy of the suggested method is emphasised in the conclusion, which provides a flexible and effective real-time object measurement solution that has potential for use in a variety of industries [7]. A low-cost, real-time proximity sensing system built on a distributed robotic skin design has been introduced, offering a novel solution to safety concerns in human-robot collaboration [9]. This technology measures changes in capacitance using a reference plate and comb electrode matrix, enabling quick identification of human presence even in the absence of physical contact [9]. Benefits of the created solution include cheap cost, real-time operation, and the ability to cover complex surfaces with flexibility. The efficiency of the proximity sensing system is shown by the experimental findings, which show accurate item proximity detection within a predetermined range [9]. Improved human-machine interactions and increased safety in collaborative robots are two possible uses for the suggested technology. In order to provide collision avoidance in dynamic situations, this technology may be further developed by integrating it into robot control systems. These real-time object detection and measurement methods make use of machine learning approaches and tools like LiDAR sensors and OpenCV [6] . Many approaches and techniques have been investigated, such as the ground- breaking YOLO algorithm developed by Joseph Redmon and colleagues, which provides quick real-time object recognition through CNN-based image processing. Furthermore, LiDAR imaging systems have been tested for how well they measure object dimensions in 2D and 3D environments, and OpenCV's interface has been demonstrated for reliable detection in a variety of settings [6]. Object distance measurement techniques such as stereo camera-based methods have also been studied. The research presents a methodical approach to real-time object detection that includes data collection, camera fixation, and the use of basic linear regression models to improve measurement accuracy [5]. The goal of the paper as presented in the content provided is to incorporate image processing methods into a computer science curriculum while keeping photography fundamentals in mind.

**2. Inspiration**

This ground-breaking research effort focuses on precisely measuring fingers to solve the intricate issues involved in creating prosthetic hands that are customised for people with limb variations. By developing the "Measurement Module for Prosthetic Hand Dimensions," cutting-edge technologies like hand tracking, image processing, and user interface design are combined to provide an accurate and distant solution. In close collaboration with prosthetists and people with limb variants, the project makes use of state-of-the-art frameworks and tools such as Mediapipe, TensorFlow, Tkinter, NumPy, and OpenCV. Extensive validation and testing guarantee the correctness, dependability, and user satisfaction of the module, with the goal of augmenting prosthetic design diversity and accessibility while substantially enhancing users' quality of life. This project represents a revolutionary strategy and teamwork to raise the bar for prosthetic design on a global scale.

**3. Existing Platforms**

**3.1 3D Scanning Technology**

3D scanning technology uses techniques like laser, structured light, or photogrammetry to record an object's dimensions and physical form in three dimensions [8]. It builds digital representations of physical items for use in a variety of sectors, including entertainment, manufacturing, architecture, and healthcare. Digital preservation, quality control, and reverse engineering are all made possible by technology. Technological developments in precision and mobility of scanners have rendered 3D scanning more widely available and adaptable, stimulating creativity and broadening its applications across several industries [8].

**Advantages**

**Precision:** High levels of accuracy are possible with 3D scanning, making it possible to capture object measurements and details precisely.

**Time-saving:** 3D scanning can drastically cut down on the amount of time needed to collect object data when compared to more conventional measurement techniques [8].

**Drawbacks**

**Cost:** Investing in and maintaining high-quality 3D scanning technology can be costly, which limits its availability to smaller companies or private users.

Complexity: In order to function properly, 3D scanning technology may need certain training and experience, especially for data processing and analysis [8].

**3.2 Proximity Sensors**

Proximity sensors is used to estimate the distances between the sensor and hand reference locations, such as capacitive or ultrasonic sensors. Without the requirement for manual input or picture processing, these sensors can be positioned at established locations and the distances can be determined directly [9].

**Advantages**

Proximity sensors function in a contactless manner, which minimises wear and tear and does away with the requirement for mechanical components when detecting an object [9].

Wide detection range: Depending on the kind and configuration of the sensor, proximity sensors can detect objects at varied distances, which makes them adaptable to a variety of applications [9].

**Drawbacks**

**Complexity:** In order to maximise their performance for certain applications, some proximity sensors need to be calibrated or adjusted, which adds to the setup time and requires technical know-how.

**Cost:** Purchasing and installing high-quality proximity sensors can be somewhat pricey, especially for applications that call for several sensors or specific capabilities [9].

**3.3 Depth Sensors**

Depth sensors are instruments that use time-of-flight, structured light, or stereo vision to estimate the distance between the sensor and objects inside its field of view. They enable activities like navigation, gesture recognition, and medical imaging and find applications in a variety of industries, including robots, AR, VR, gaming, automotive, healthcare, and 3D scanning. Technological developments have produced more precise, inexpensive, and compact depth sensors, spurred innovation and increasing their applicability in a variety of fields [10].

**Advantages**

**Understanding Space:** By measuring the distance between the sensor and surrounding objects, depth sensors enable precise depth perception and provide detailed spatial information [10].

**Real-time Data:** A lot of depth sensors have the ability to record and process data in real-time, which makes it possible for apps like augmented reality and gaming to provide instant feedback and communication.

**Drawbacks**

Environmental Factors: Temperature, illumination, and reflective surfaces can all have an impact on depth sensors, which can result in inaccurate or erroneous depth readings.

Cost: Purchasing and installing high-quality depth sensors can be somewhat pricey, especially for applications that call for several sensors or specialised capabilities [ 10].

**4. Limitations**

- **Quantity and Quality of Data:** For training purposes, AI and ML algorithms need a lot of high- quality data. In the medical industry, privacy constraints and restricted availability might make it difficult to collect such data, particularly for rare illnesses or unique patient demographics.
- **Regulatory Compliance:** To protect patient safety, medical equipment, including implants, must adhere to strict guidelines and standards. The FDA's Quality System Regulation (QSR) and ISO 13485 compliance are two regulatory frameworks that must be followed in order to integrate AI/ML into the 3D printing of medical implants. Making sure AI algorithms adhere to legal requirements can be difficult and time-consuming.
- **Algorithm Interpretability:** In medical applications where decisions have a direct impact on patient safety and health, the interpretability of AI/ML algorithms is essential. Regulatory agencies and medical professionals may find it challenging to comprehend the decision-making process in complex AI models due to their lack of openness. Gaining trust and receiving regulatory approval for medical implant design requires ensuring that AI models are transparent and comprehensible.
- **Model Generalization:** The generalisation of AI/ML models to new, unexplored data may provide a challenge, as they are trained on specific datasets. For AI algorithms to be

clinically useful in the setting of medical implants, it is imperative that they be able to adjust to differences in patient anatomy, pathology, and surgical procedures.

- **Cost & Infrastructure:** A major investment in infrastructure, computational power, and knowledge is needed to implement AI/ML technology. The adoption of AI/ML systems may be hindered by the expense of purchasing and maintaining the related 3D printing technology, especially in smaller medical facilities and environments with limited resources.

**5. Concluding Remarks**

The "Measurement Module for Prosthetic Hand Dimensions" provides an enhanced way for precisely and remotely measuring finger dimensions, thereby revolutionising the prosthetic design process. The module facilitates inclusivity, efficiency, and accessibility for people with limb disabilities by combining state-of-the-art technology with an intuitive interface. The module emphasises innovative thinking and teamwork in the design process with the goal of improving the quality of life for prosthetic users globally by offering accurate measurements and encouraging cooperation between prosthetists and users.

This survey research has examined the cutting-edge module that improves the prosthetic design process overall while also revolutionising the way finger dimensions are measured. Users can actively engage in the design process, ensuring that prosthetic devices are customised to meet their specific demands, thanks to the utilisation of cutting-edge technology. The module aims to enhance the quality of life and empower people with limb differences by prioritising inclusivity and efficiency. It also serves as an example of how innovative thinking and teamwork can lead to significant progress in the prosthetics industry.

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# PUBLICATION DETAILS 2

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# Integration into 3D Printing for Image Processing using AI ML

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**Abstract***: The challenges of physical measurement for prosthetic development and highlight how our integrated tool offers a remote solution to address these challenges, promoting accessibility, convenience, and active participation in the prosthetic design process. Our Measurement Module for Prosthetic Hand Dimensions is a comparison of Image Processing and Distance Measurement Methods The creation of a module to precisely measure finger dimensions for the creation of prosthetic hands is the main goal of this research project. The module providesdistance measurement and image-based input as two different ways to get dimensions. Users place their hands at predetermined distances from a screen in the distance measurement option,while users submit photographs of their hands with reference objects for scale in the image based input option. In order To provide a proper fit and functionality, the collected dimensionsare an essential component of the prosthetic hand construction process. The study contrasts the efficiency of distance measurement methods employing cameras or other cameras with imageprocessing techniques like edge recognition and contour analysis. Accuracy, usability, and efficiency are among the factors that are assessed to identify the best method for acquiring dimensions. OpenCV for image processing, TensorFlow for machine learning-based analysis,Tkinter for UI design, Mediapipe for landmark identification and hand tracking, and NumPy for numerical operations are just a few of the open-source libraries that are used in this module.The module's possible influence on improving the creation and customization of prosthetic hands is also covered. By offering insights into effective and precise dimension measurement methodologies for customized prosthetic hand design, the study's findings advance the area of prosthetics.*

**Keywords:** Image processing, Prosthetic development, OpenCV, TensorFlow, Mediapipe, NumPy, Precision dimension measurement, Tkinter

## I. INTRODUCTION

There are several obstacles in the way of designing prosthetic hands that properly suit the special requirements of people withlimb variations, especially when it comes tomeasuring fingers accurately. These metrics have a direct impact on the quality of life of users by guaranteeing thatprosthetic devices fit, work, and are comfortable. However, the use of specialised equipment and accessibility issues are just two of the drawbacks associated with traditional physical assessment techniques.[1] Our research project offers a novel solution to these problems in the form of the "Measurement Module for Prosthetic HandDimensions." This module offers a comprehensive tool for the precise and remote measurement of finger measurements by integrating cutting-edge technology in image processing, handtracking, and user interface design. Our project consists of multiple major partsand uses open-source libraries and state-of-the-art technology to accomplish its goals. In the first stage, we carry out a comprehensive requirement analysis, working together with prosthetists and people who have different limbs to comprehend their unique requirements and design preferences. Our measurement module is developed using a variety of libraries and frameworksthat we have carefully chosen andintegrated. Notable examples of this include Mediapipe, which offers sophisticated hand tracking algorithms for real-time landmark localization andidentification, and OpenCV, which is used for image processing tasks like hand recognition and feature extraction. Tkinter is selected for UI design to offer a user- friendly interface with straightforward controls and visualisation of measurement data, while TensorFlow is used for machine learning-based

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analysis to improve the accuracy and resilience of our dimension measurement techniques. NumPy is alsoutilised for data manipulation and numerical operations, which makes our module's calculation and analysis more effective.
During the validation and testing stage, wecarry out comprehensive trials to evaluate our integrated tool's correctness, dependability, and user happiness. This entails using artificial intelligence (AI), controlled studies, and user trials to verify the module's efficacy and usability in practical prosthetic design situations. By developing a precise and useful dimension measuring instrument that is suited to prosthetic design requirements, our research project hopes to further the area of prosthetics. Our initiative improves the design and customisation of prosthetic hands by utilising cutting-edge technologies and techniques, which in turn enhances the quality of life for people with limb differences. We developed our module by working withprosthetists and people who have different limbs to identify particular needs and preferences for prosthetic design. A few essential elements include Mediapipe for hand tracking, TensorFlow for machine learning-based analysis, Tkinter for userinterface design, NumPy for numerical calculations, and OpenCV for image processing. With an emphasis on real-worldprosthetic design scenarios, extensivevalidation and testing guarantee the integrated tool's correctness, dependability, and user happiness.[3] Beyond the near-term obstacles, our initiative hopes to increase accessibility and diversity in prosthetic design while showcasing the revolutionary potential of cutting-edge technologies to transform customised prosthetic solutions. Through the promotion of stakeholder engagement and technological innovation, our project enhances the independence and quality of life for people with limb differences.

## II. LITERATURE SURVEY

A number of important topics are covered in the literature review for the Prosthetic Hand Dimension Measurement Module. It begins with an overview of recent studies in the fields of rehabilitation engineering and prosthetics, with a particular emphasis on customised prosthetics and the significance of precise dimension measurements for fitting. Measurement techniques for dimensions, both conventional and digital, are discussed along with research contrasting their accuracy. In addition, studies on distance measurement technologies are reviewed, as well as imageprocessing and computer vision methods for hand analysis. The applicability of popular software libraries and tools like Mediapipe, TensorFlow, and OpenCV isexamined. Prosthetics case studies and real-world applications offer valuable information for developing new modules. All things considered, the literature review offers insightful information and practical approaches to efficiently progress the project.
The goal of the paper as presented in the content provided is to incorporate image processing methods into a computer science curriculum while keeping photography fundamentals in mind. It recognises that photography is an interdisciplinary field and makes links between computer science, physics, and the social sciences. Through the provision of both practical laboratories on image processing using open-source tools such as GIMP and ImageJ, and lectures on the principles of photography, students acquire the ability to manipulate images while comprehending the underlying processes. Defining Features Matrix and One Sentence Summary are twoexamples of classroom assessment tools that are used to measure student understanding and participation. Students employ newly learnt techniques to enhancephotos and exhibit a portfolio of their workas part of the course's final project. [1]
With a special emphasis on hand gesture identification, the paper offers a thorough method of gesture recognition using machine learning algorithms and image processing techniques. It highlights the differences between computer analysis of images and human perception when discussing the difficulties in real-timegesture detection. The suggested system uses a support vector machine (SVM) for picture preprocessing, segmentation, contour extraction, and classification. The technology has certain problems, such as image size reduction and feature extraction, but it also offers benefits, such as enhanced human-computer interaction and possible applications in automation and touchless interfaces. All things considered, the study emphasises how versatile gesture recognition systems may be and how crucial it is that more research and development be done in this area. [2]
The creation of a real-time object measurement application using computer vision techniques is covered in the study. The steps in the procedure are taking apicture, identifying the object, setting up coordinates around it, and figuring out howbig it is. The system performs mathematicaloperations and image processing using libraries such as OpenCV and NumPy. The technology successfully estimates the dimensions of different items through simulations, proving its usefulness. The suggested approach makes use of advancesin computer vision and artificial intelligence to provide a

practical and precise solution for dimension measurement across a range of sectors. Thestudy also offers insights into its accuracy and performance by comparing its findingswith theoretical values. All things considered, the work offers a productive method for measuring an object'sdimension in real time that has a wide rangeof potential uses. [3]

Four well-known Python GUI libraries are summarised in the paper: ipywidgets, Flexx, PySimpleGUI, and Tkinter. Tkinter is a popular choice for GUI programming because of its simplicity, portability, and ease of learning. It has been a part of the Python standard library since 1994. Flexx makes use of web technologies to produce GUIs, making it simple to create GUIs using only Python. In order to illustrate each library's ability to create graphical user interfaces (GUIs) for scientific analysis, system response analysis, and visualisation, the article provides basic examples for each library. Every library has its advantages andis appropriate for a variety of use cases; theselection process is frequently influenced by personal taste. Additional GUI frameworks could be investigated in futurestudies, and their performance and adaptability could be compared.[4]

The MediaPipe framework connects andabstracts individual perception models intomanageable pipelines, making it easier to create augmented reality (AR) applications. It makes it easier to include extra processing stages or inference models by enabling developers to create pipelines as directed graphs of modular components. MediaPipe use custom calculators to definepipelines and streams for data flow, enabling a range of operations including object detection, face landmark detection, and segmentation. The framework gives developers the ability to optimise and analyse the behaviour of their pipelines by offering tools for performance evaluation and visualisation. Through the use ofreusable components and an extensive configuration language, developers can effectively construct and implement intricate perception pipelines, guaranteeing seamless and effective processing of sensory data across various devices.[5]

In specifically, real-time object detection and measurement using machine learning approaches is explored in this research article. It starts with a review of the literature, mentioning important works like the object identification technique YOLO and the real-time uses of LiDAR and OpenCV sensors. During the discussion of real-time object identification techniques, accuracy and speed in dynamic situations are emphasised. The study describes a comprehensive algorithm that combines OpenCV, LiDAR sensors, cameras, and machine learning techniques to recognise and measure object sizes. In order to offer accurate measurements of things, it describes procedures for gathering data, training models, and putting them into practice in real time. Recognising limitations such sensor precision and data accessibility, it is concluded that the suggested method provides a complete answer for real-time object measurement.[6]

Although it provided high-level data structures, the Python programming language did not have effective support for numerical calculation until the mid-1990s when NumPy was developed. Multidimensional arrays are made possibleby NumPy, allowing for high-performancenumerical calculations. These arrays provide effective memory management and are distinguished by their strides, data type, and form. In comparison to conventional for loops, NumPy's support for vectorized operations greatly increases computingspeed. By extending similar processes to arrays with varying forms, broadcasting increases efficiency even more. In order to handle complicated data types, NumPy additionally offers structured arrays and memory mapping for efficient input/output. Adopted in academia, industry, andscientific research, NumPy's wide range offunctionalities and effective design have made it a mainstay in numerical computation.[7]

With an emphasis on Python's use in imageprocessing, the article explores the language's features and wide range of applications. Python may be used for a variety of tasks, from scientific computing to web development, because of its simplicity and versatility. The Python picture Library (PIL), which provides functions for picture editing, filtering, and enhancement, is emphasised as a potent toolin image processing. The article examines how Python can be used for tasks like image filtering, contour outlining, andgeometric transformations when pairedwith libraries like PIL and OpenCV. Additionally, because of its abundance of libraries and ease of mastering, the researchrecommends Python as the best language for experimental programming in image processing. Overall, the article emphasises how Python has advanced digital imageprocessing and advocates for ongoingexploration and development in this field. [8]

## III. METHODOLOGY

Creating a module that detects hand and fetch dimension of fingers and store it in csv files. Here is a method for creating themodule:

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cv2 (OpenCV) Handling images and videos, finding objects, and getting key features is easy with OpenCV's awesome computer vision tools. NumPy (np) NumPyis a math whiz for Python, making multi- dimensional arrays a breeze and crunching numbers like a pro. pandas (pd) Pandasrules the data kingdom, transforming messyCSV files into tidy Data Frames for smooth data wrangling. cv2.VideoCapture(): This opens your computer's camera. . It makes a VideoCapture object. Then, you can take pictures from the camera.

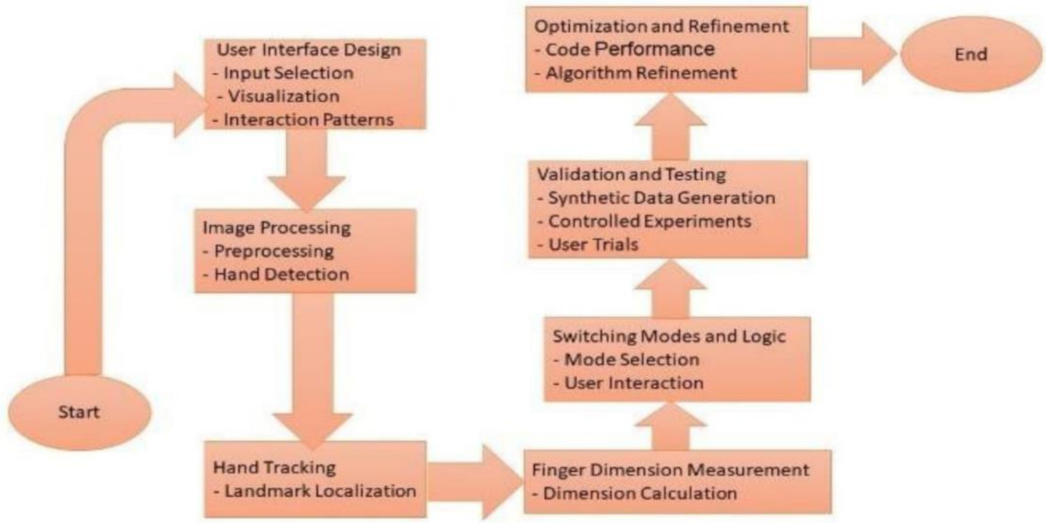


**Fig 1: Working of hand detection Module**

And do more things with those pictures. Mediapipe Hands Module Google's Mediapipe is a framework for perception tasks using machine learning pipe-lines. Its Hands module detects and tracks hands accuratelyin video and images. Straight-Line Length Euclidean distance determines the straight path between two points. It finds the hand'sposition from the camera centre. The formula is simple (\sqrt {(x2 - x1) ^2 + (y2- y1) ^2} \). This calculates the space between the hand and a set camera location.User Feedback, the system instructs the user to modify the location of their hand in relation to the camera based on the determined distance. By doing this, youmay be confident that the hand is at the ideal distance for precise measurement. cv2.VideoCapture. read () This method reads a frame from the camera. It returns a Boolean value indicating whether the framewas successfully captured and the frame itself. Next is Feature Extraction This involves using image tricks to pull out important details, like finger size. Techniques may include segmenting the image, finding edges, analysing shapes whatever fits the job. Pandas DataFrame,the hand sizing data is kept in a CSV file using Pandas. This makes it simple to edit, 1analyze, and share the info. CAD Softwareor 3D Modelling, the stored hand me- asurements are used as input for designing a prosthetic digit via CAD software or 3D modelling libraries. This allows creating custom fitted prosthetics tailored to the individual's precise hand dimensions.Grasping the underlying theory helps implement each step efficiently in the codeand build a sturdy system for hand measure-ment and prosthetic design. You can use the Tkinter package in Python to develop a userinterface (UI) for your prosthetic designand hand measurement module.

**Requirement Analysis:**

Perform a comprehensive requirementsanalysis, taking into account the particular requirements of prosthetic design. Work along with prosthetists and people who have different limbs to determine the most important dimensions for fingers, including length, width, and curve.

**Library Selection**

Examine several frameworks and libraries that are appropriate for hand tracking, image processing, and developing user interfaces, keeping in mind their compatibility with hardware and software for prosthetic design. Libraries with


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strong hand tracking features and real-time processing support should be given priority in order to guarantee a smooth integration into prosthetic design processes

**User Interface Design:**

Create an interface that is easy to use and meets the requirements of prosthetic designers and technicians. Include functions like standard accessibility standards support, easily navigable controls, and clear visualisation of measurement data. Prosthetic design procedures can be made easier to use and more efficient by optimising interface layout and interaction patterns with consideration for ergonomic principles and user feedback.

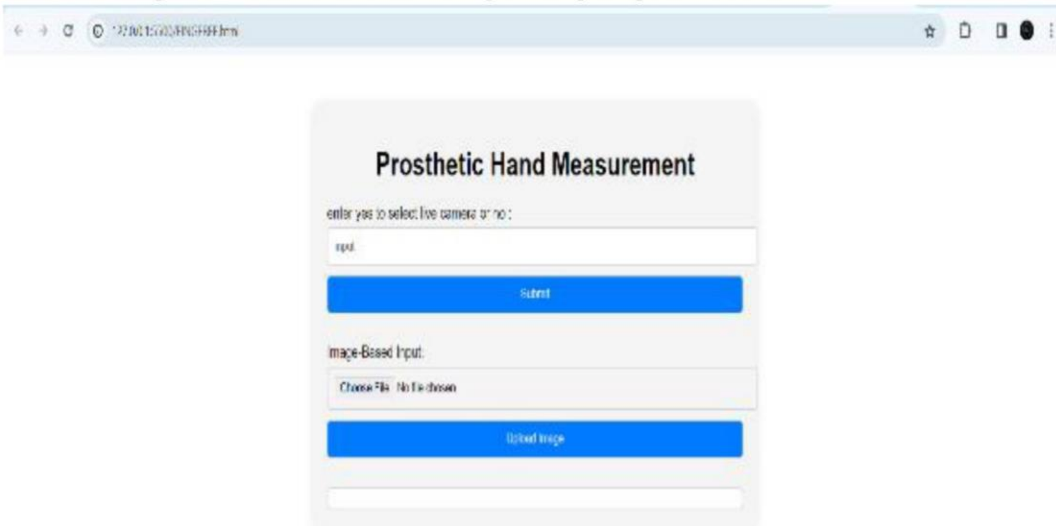


Fig 2 : User Interface

**Image Processing:**

Create image processing algorithms that preprocess input photos and improve hand detection and landmark localization accuracy by tackling issues including noise, lighting fluctuations, and background clutter. Utilise methods like colour segmentation, edge detection, and morphological procedures to reduce interference from non-hand objects in the image and extract pertinent hand information.

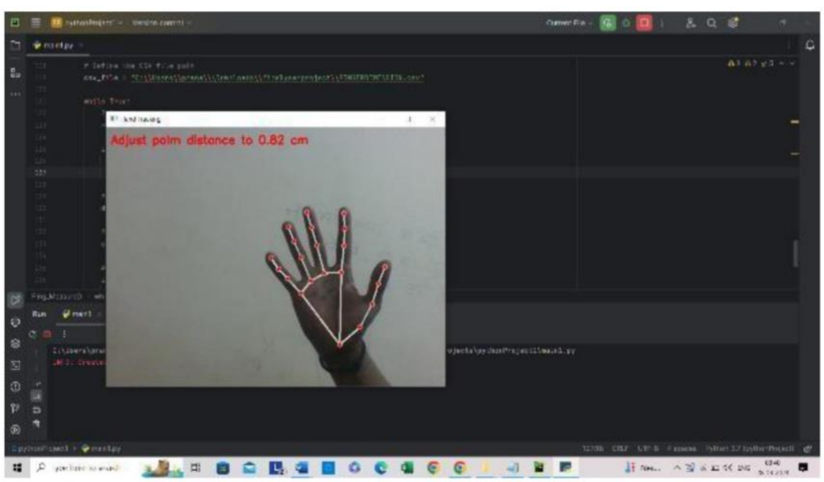


Fig 3: Palm Adjustment

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**Hand Tracking**

Incorporate sophisticated algorithms for hand tracking, like MediaPipe Hands, to precisely identify and monitor hand landmarks in real-time. Hand tracking parameters can be adjusted to balance tracking accuracy and computational efficiency for prosthetic design

**Finger Dimension Measurement**

Create algorithms that compute the dimensions of fingers by using landmarks on the hand that have been recognised, taking into consideration anatomical variances, perspective distortion, and hand orientation. Regression models and neural networks are examples of machine learning approaches that can be used to improve dimension estimation and adjust to the various hand forms and sizes that are foundin prosthetic design.

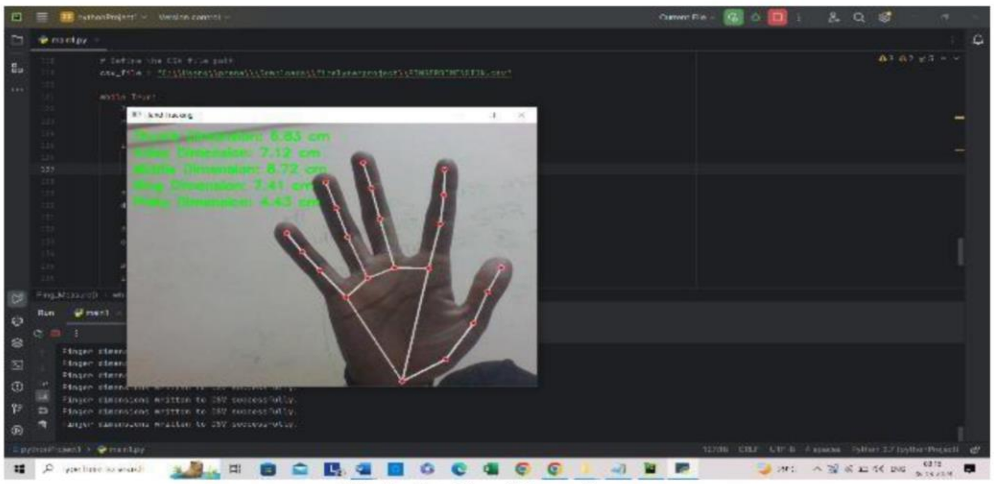

Fig 4 : Fetching Dimension

**Switching Modes:**

Provide strong logic to handle user input and preserve workflow continuity when alternating between image processing and live camera modes.To reduce confusion and improve usability,give users clear feedback and instructions on how to move between modes and interact with various elements of the integrated product.

## IV. CONCLUSION

By providing a state-of-the-art method for accurately and remotely measuring finger dimensions, "Measurement Module for Prosthetic Hand Dimensions" is transforming the prosthetic design process. With the use of cutting edge technology anda user-friendly interface, our module encourages inclusivity, efficiency, and accessibility for people with limb differences. Our goal is to raise the standard of living for prosthetic users all around the world by utilising creative thinking and encouraging teamwork in prosthetic design processes

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