Human Hand Tracking System("H2TS=Hatuus") Development Using Python

A Project Report

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BONAFIDE CERTIFICATE

Certified that this project report **"HUMAN HAND TRACKING SYSTEM ("H2TS=Hatuus") DEVELOPMENT USING PYTHON"** is the bonafide work of "**ANANYA SHARMA, MAGAN JYOT KAUR, LOKESH CHOUDHURY"** who carried out the project work under my/our supervision.

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INTERNAL EXAMINER **EXTERNAL EXAMINER**

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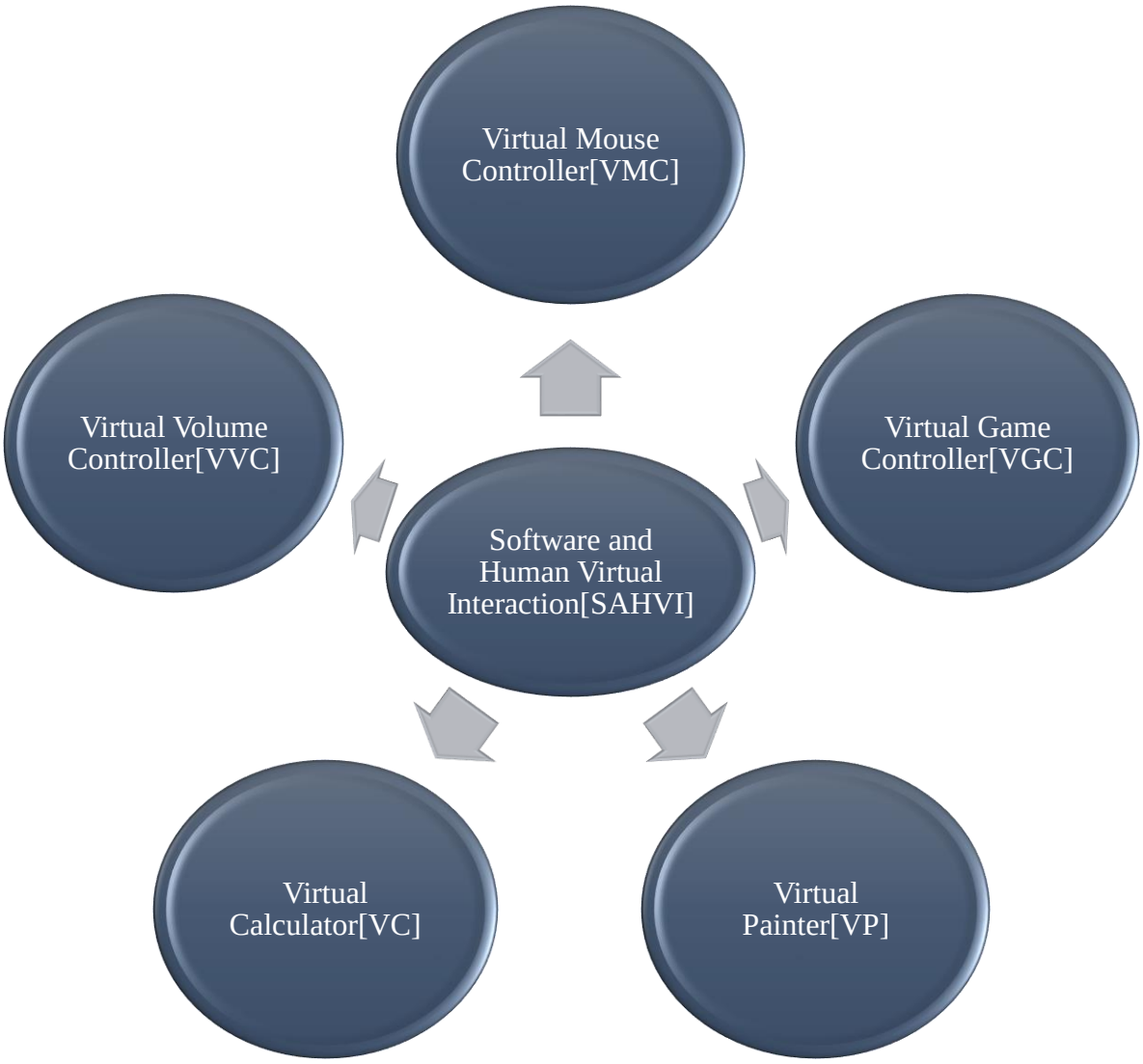
ABSTRACT

Hand tracking system allows user to interact without any physical input to the device by detecting the position and orientation of hands and the configuration of fingers. In this way user's hand act like an external device which inputs the data to execute a specific algorithm. In this work, we present a real-time method for performing different features using hand tracking incorporated into one program. H2TS system is based on a futuristic technological approach which will make human and software interaction much more virtual and convenient without using hardware. The advanced feature which can be incorporated are voice command, touchless operations {which can be done through web cam using hand landmarks' detection (total hand landmarks detection=21)} which will help- in cost saving (Keyboard), less maintenance cost of hardware, enough distance from hardware equipment ultimately better eye care and many more technological advantages. In previous systems, data gloves or markers were used to input data into the system. We have no such limitations when it comes to using the system. So, here **SAHVI (Software and Human Virtual Interaction)** a virtual assistant will help user for features' usages to do each task one by one through voice command like virtual volume controller, virtual mouse controller, virtual game controller, virtual calculator and virtual painter. It is not constrained by the number of tasks we can add more tasks to it.

GRAPHICAL ABSTRACT



ABBREVIATIONS

VVC-VIRTUAL VOLUME CONTROLLER

VMC- VIRTUAL MOUSE CONTROLLER

VGC – VIRTUAL GAME CONTROLLER

VC – VIRTUAL CALCULATOR

VP – VIRTUAL PAINTER

DFD – DATA FLOW DIAGRAM

HCI -HUMAN COMPUTER INTERACTION

SAHVI – SOFTWARE AND HUMAN VIRTUAL INTERACTION

AI – ARTIFICIAL INTELLIGENCE

ML – MACHINE LEARNING

ERD – ENTITY RELATIONSHIP DIAGRAM

CHAPTER 1: INTRODUCTION

Recent advances in computer software and accompanying hardware technology have given consumers with a valuable service. Physical gestures are a strong form of communication in everyday life. They can efficiently express a large number of facts and emotions. Waving one's hand from side to side, for example, might imply anything from "happy goodbye" to "caution." Most human-computer dialogues do not take advantage of the full potential of physical gestures.

Hand gesture recognition is one of the most important and fundamental challenges in computer vision. Thanks to recent developments in information technology and media, automated **Human Computer Interactions (HCI)** systems incorporating hand processing tasks such as hand detection, hand recognition, and hand tracking are being developed. In recent decades, the keyboard and mouse have become increasingly important in HCI. However, new sorts of HCI solutions have been necessary due to the rapid evolution of hardware and software. In the domain of HCI, technologies like speech recognition and gesture recognition receive great attention.

This sparked our curiosity, so we came up with a plan to create an interface system that could recognize human hand motions using computer vision, an artificial intelligence subfield. The aim of our project was to create a virtual computer environment that could perform a variety of touchless operations using a webcam and hand landmark detection, including all tasks being assisted by a virtual voice assistant named SAHVI (Software and human virtual interaction).

We used OpenCV to do computer vision operations and Media Pipe to accomplish the actual hand detection and tracking on our input image.

Palm detection: Media Pipe detects palms on the entire input image and delivers an orientated hand bounding box. It gives the hand landmark model a crisp cropped hand image, considerably decreasing the requirement for data arguments (rotation, translation, and scale), allowing the network to focus on coordinating forecast accuracy.

Hand landmarks' identification: Following palm detection over the entire image, the hand landmark model uses regression to precisely localize 21 3D hand-knuckle coordinates within the detected hand regions, resulting in direct coordinate prediction.

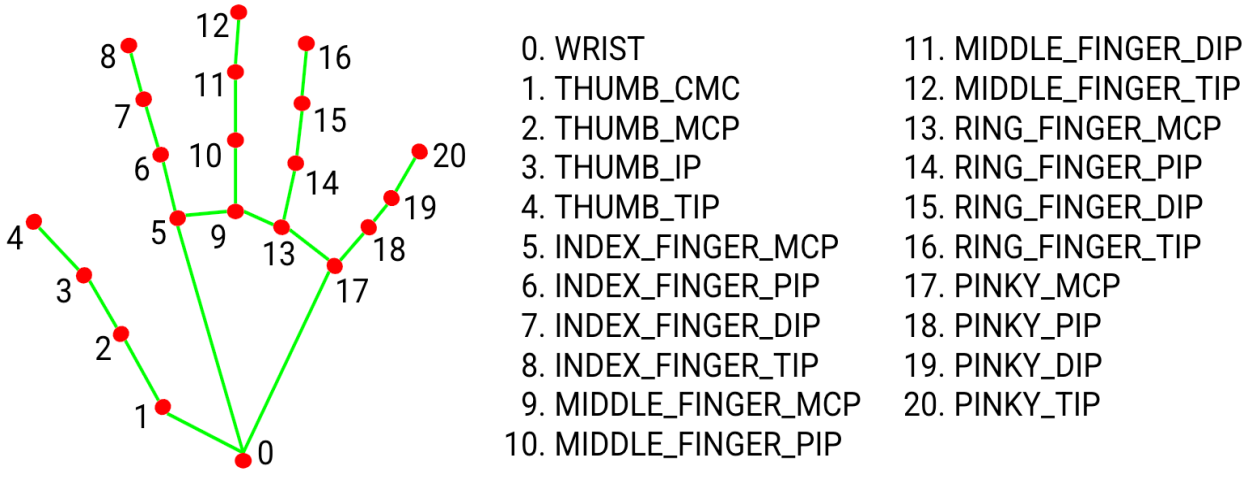


Figure: 1.1: Hand Landmarks' Identification

1.1 INCLUDING IDENTIFICATION OF CLIENT & NEED

As we all recall, when touchscreen technology was first released, many people were ecstatic to no longer have to engage with physical buttons to browse their phones, TVs, and command automobiles, monitors, and other gadgets. This saved us time and was both useful and enjoyable to use. However, client tastes have evolved throughout time, particularly during pandemics. People believe that using a touchscreen, especially in public spaces or on gadgets such as a touch screen monitor or a car navigation system, is unsanitary.

As a reason, HCI is the greatest choice for a touchless system with various functions. According to a survey, the gesture recognition and touchless sensing market is estimated to increase at a CAGR of 22.6 percent from 2021 to 2026, reaching USD 37.6 billion from USD 13.6 billion in 2021. Some of the significant potential for the gesture recognition and touchless sensing market are the growing trend of smart homes and the use of virtual reality in video games.

On the other hand, it will save costs (keyboard, mouse), reduce hardware maintenance costs, provide enough distance from hardware equipment for better eye care, and many other technological positives. Young individuals and working people from the middle and upper classes who are familiar with systems are the target audience.

1.2 RELEVANT CONTEMPORARY ISSUES

Artificial Intelligence: we have developed an AI-based approach for controlling different kind of tasks using python and OpenCV with real-time camera that detects hand landmarks, tracks gesture patterns and perform the specified task.

Economic: - Human computer interaction is a popular field which has an active impact on economic life. Our project can make interaction between human and computer much more pleasant. Depending on its popularity it can majorly contribute in economy.

Society: - With the development of new HCI's, computers accessibility becomes more to people and so are being used more and more in everyday life. For people who find traversing through computer to find a desired function can depend on SAHVI (virtual assistant) to guide them through it.

1.3 PROBLEM IDENTIFICATION

With the development of advanced computing and machine learning current user interaction approaches with the mouse, keyboard and pen are not sufficient. Due to the limitation of these devices the user input command are also set to limited and because of these direct use of hands can be used as an input device for providing natural interaction. With the help of speech recognition technology so many advanced virtual assistant applications are in abundance today but they are also limited to certain tasks. There are some applications available in the market today which has proposed systems that can detect hand gestures and movements but they are not user friendly and they don't provide great interface. Hand tracking and virtual assistants has wide ranging applications. In this project we apply it to an interactive

system to create an easy to understand interaction interface. This interactive system uses advanced Human Computer Interaction(HCI) techniques to provide a more convenient and user friendly interface for detecting hand tracking movements and certain gestures. Hand tracking is based on the concept of Image processing but it has increased costs. So this system is focused more on reducing cost and improve robustness of the proposed system using simple web cam present on pc. Hands can be utilized directly as an input device to provide natural interaction. On the other hand, there are some hand gesture recognition systems, but they're not really available in one location for the user's convenience, thus we solved this problem as well.

Since a substantial portion of consumer purchasing is discretionary during a pandemic, the installation of lockdowns and social distancing measures has harmed the manufacturing sector. All of these reasons are predicted to have a big impact on the market for gesture recognition and touchless sensing.

1.4 TASK IDENTIFICATION

1.4.1 Task Planning

T1) Research: H2TS project started from background study about this technology where we started to gather the knowledge about the developments already done in this field by other software developers. We got the really good guidance from internet to an extent to move ahead with this project in python.

T2) Web Cam operationalization: Web cam operations executed through coding in python.

T3) Hand Tracking Module Creation: In this stage the main task was to track the hand landmarks which are 20 specifically in numbers by creating a hand tracking file.

Now the stage comes where the previous file ("HTMF = Hand Tracking Module File") would be used to create for further specific features of H2TS system which are as follows: -

T4) Virtual Volume Controller (VVC): With the use of previous file (HTMF) a virtual volume controller feature would be created through coding in python.

T5) Virtual Mouse Controller (VMC): With the use of previous file (HTMF) a virtual mouse controller feature would be created through coding in python.

T6) Virtual Game Controller (VGC): With the use of previous file (HTMF) a virtual handle drive controller feature would be created through coding in python.

T7) Virtual Calculator(VC): With the use of previous file (HTMF) a virtual calculator feature would be created through coding in python.

T8) Virtual Painter(VP): With the use of previous file (HTMF) a virtual painter feature would be created through coding in python.

T7) Virtual Assistant ("SAHVI = Software and Human Virtual Interaction")**:** SAHVI is a virtual assistant for this program which will assist the user for features' usages through voice command.

1.4.2 Task Identification (Time Cycle)

Task identification allows us to break down work of project into manageable components so that we can easily determine time, resource and cost estimated. Since this is college project the development costs required for the project is null. Task can be divided into multiple components. On the basis of our development process, we briefly divided tasks into:

1. **Planning:** Project planning is a discipline addressing how to complete a project in a certain timeline, usually with defined stages and designated resources. Time taken to complete this task is 6 days.
2. **Defining Requirement:** Under define requirements we identified, collected, categorized and recorded the requirements needed to complete this project. Time taken to complete this task is 4 days.

3. **Building or developing the project:** Total time taken is 24 days
    a. Hand tracking module: Time taken to complete this task is 4 days.
    b. Virtual Volume Controller (VVC): Time taken to complete this task is 3 days.
    c. Virtual Mouse Controller (VMC): Time taken to complete this task is 3 days.
    d. Virtual Car Racing Game Controller (VGC): Time taken to complete this task is 4 days.

e. Virtual Calculator (VC): Time taken to complete this task is 2 days.
f. Virtual Painter (VP): Time taken to complete this task is 2 days.
g. Software and Human Virtual Interaction (SAHVI): Time taken to complete this task is 6 days.

4. **Testing:** Purpose of this phase is to guarantee that system successfully built and tested in the development phase meet all the requirements and design parameters. Time taken to complete this task is 5 days.

5. **Deployment:** Time taken to deploy our project is 1 day.

1.5 TIMELINE

1.51 TABLE

Stage or Module	Time Taken
1) Planning	6 Days
2) Defining Requirement	4 Days
3) Building or developing the product	Total Days = 24
i. Hand Tracking Module Creation	4 Days
ii. Virtual Volume Controller (VVC)	3 Days
iii. Virtual Mouse Controller (VMC)	3 Days

iv. Virtual Car Racing Game Controller (VGC) v. Virtual Calculator (VC) vi. Virtual Painter (VP) vii. Software And Human Virtual Interaction (SAHVI)	4 Days 2 Days 2 Days 6 Days
4) Testing	5 Days
5) Deployment	1 Day

Table: 1: (Timeline) Table

A detailed plan was created before the starting of project for seamless process while being considerate of customer's expectations to create an errorless product within the completion time.

----------1.5.2 to 1.5.6----------

- **Stage 1: Planning and Requirement Analysis**

In this stage user expectations and needs are determined for a new or modified product. As this is a college project, assumptions and suggestions were made and discussed by us.

- **Stage 2: Defining Requirements**

In this stage documentation process is maneuvered which is further presented in front of stakeholders for approval. As this is a college project, all the

product requirements to be designed and developed during the project life cycle were noted down and analyzed within the team.

- **Stage 3: Building or Developing the product**

In this stage the actual development starts and the product is built. The programming code is generated as per the decisions that were made before in an organized and detailed manner.

- **Stage 4: Testing the product**

In this stage the product is tested by running diverse tests for identification of any bugs and errors in the software before implementation phase begins. The project is going through distinct tests to find its shortcomings and then necessary actions are taken by the team.

- **Stage 5: Deployment in the Market and Maintenance**

After the product is tested thoroughly, the finished product is deployed in appropriate market. As this is a college project, after completion of testing stage, finalized project will be submitted to the appropriate authority for further examination.

1.6 ORGANISATION REPORT

The material presented in this report is organized into five chapters.

Chapter 1 is the introductory chapter. In this chapter we introduce our project, identify the clients and need of this project, identify the relevant contemporary issues this project affects directly or indirectly, identifies problems that might take place, identifies the tasks and about the timeline of this project.

Chapter 2 is the literature review. It provides us an overview of the previously published work on the same field, what kind of problems or challenges were faced by researchers in the past and what solution they proposed to resolve those problems. In this chapter we also take a close look at problem definition and objectives of this project.

Chapter 3 provides information about the features and design of this project and the constraints which will affect our project. This chapter provides a conceptual solution for the problem that we have stated in the form of requirements which are explained in detail in the chapter.

Chapter 4 summarizes the analysis done on the project. It presents a brief information about what kind of modern engineering tools were used, how the design implementation process took place and about the testing process.

Finally, Chapter 5 presents the conclusion and future scope of this project.

CHAPTER 2: LITERATURE SURVEY

2.1 TIMELINE OF THE REPORTED PROBLEM AS INVESTIGATED THROUGHOUT THE WORLD

Human computer interaction is an area of research and practice that emerged in the late 1970s and early 1980s, initially as an area in computer science. HCI has expanded rapidly and steadily for three decades, attracting professionals from any other disciplines and incorporating diverse concepts and approaches. Communication of humans with computers has always been a challenge. From the early mediums such as perforated cards, people have spent more than half of the past century experimenting with various ways to interact with computers – in pursuit of more efficient and intuitive interfaces.

Problems which are associated with gesture recognition are:

Non-standard backgrounds: Gesture recognition should always work despite of what kind of background it is.

Movement and combination of movements: In past, only static images were able to analyzed whereas computer was not able to recognize dynamic movements.

Lag: The gesture detection system must be designed to eliminate the lag between performing a gesture and its classification. But in the past, there were not many ways to succeed this.

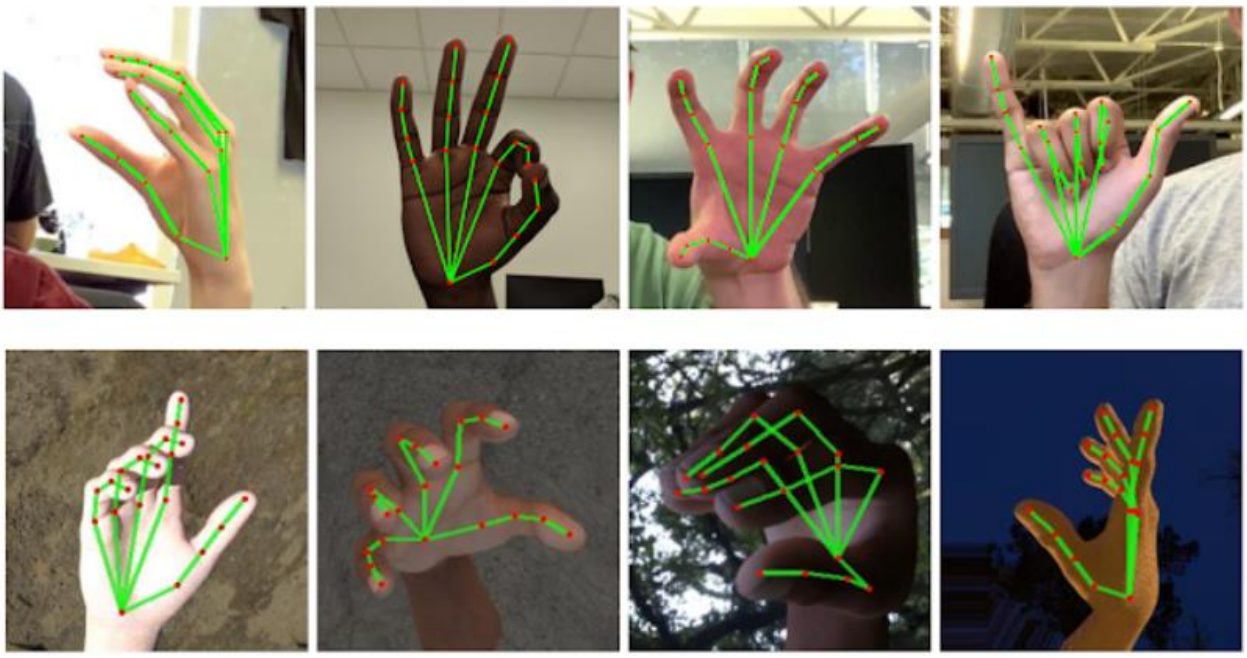


Figure: 2.1: Reported Problems

2.2 BIBLIOMETRIC ANALYSIS

Human-Hand Tracking System is a broad topic of study that includes everything from computer science and engineering to human factors and social science. Researchers and developers working in this multidisciplinary subject strive to master the ability to comprehend the dialogue between humans and computers, reflect on the changes in behavior induced by this interaction, and encapsulate their knowledge to design, develop, and manage systems. Our report attempts to contextualize and highlight the current state of HCI research. To achieve so, we use a bibliometric analysis, which provides a well-carved piece of literature and ensures validity in the portrayal of the research. Following this line of research, we found a data set of 962 papers spanning the years 1970 to early 2017. The study produced a core group of 46 articles that structured four main human hand tracking aspects. HCI design

features, data management, user interface, psychology and cognition, and more current trends in HCI in the workplace, sensors, and wearables are highlighted in the preliminary analysis.

2.2.1 Introduction: -

For more than four decades, Human-Computer Interaction has grown swiftly and steadily. From its humble beginnings in human factors engineering and cognitive science, it has grown into a prestigious discipline that brings together academics and industry experts in a multidisciplinary conversation that incorporates a wide range of methodologies, theories, and practices. The goals of HCI methodology, theory, and practice are all the same: to create interactive artefacts that can be used efficiently, effectively, safely, and with additional user delight.

Social and organizational computing, artificial intelligence, computer vision, motion tracking, accessibility for the aged, intellectually and physically challenged, and all people, and for the largest possible spectrum of human interactions are all examples of Human Hand Tracking System projects.

Hand Tracking quickly grew beyond early graphical and desktop office applications to include medical and pedagogical applications, gamification of education, business and innovation, sustainability and resilience, emergency planning and response, and systems to support collaboration and community to name a few.

Hand tracking is interdisciplinary in behavior and interdisciplinary in its roots of HCI. Therefore, the vast amount of literature accumulated over the last 40 years is drawn from different disciplines and circulates in different outlets. Countless research paradigms and methods, frameworks and models, interface design

technologies and devices, technologies and digital artifacts, multimodal interactions, tool support for model-based user interface specifications, and a variety of new advanced, portable, contextual and virtual interactions. Publications to cover.

2.2.2 Methodology: -

This report aims to deepen the reader's understanding of the research published in the field of hand tracking. To do this, we first searched the database and then searched and analyzed the literature by obtaining a dataset of research publications and citation data for the period 1970-early 2017. The keyword "human-computer interaction" was used in the study, with an emphasis on the areas of "title" and "keywords" of the publication. This process resulted in 1,843 publications across a wide range of distribution channels and research interests. We imposed a qualitative measurement of at least one citation on this data and extracted 962 datasets. We proceeded with our research using advanced bibliometric techniques and obtained four elements that corresponded to more than 80% of the representation of the dataset. A brief description of the bibliometric methodologies used here is the subject of the next section.

2.2.3 Findings: -

Observing the outcomes of this evaluation, it's far obvious that the information set is big containing many interlinked individuals and severe studies clusters that stimulated the HCI hand tracking field. Additionally, whilst the point of interest located at the co-quotation of references the evaluation ended in a cluster-cloud of 100 maximum referred publications. A representative core set of 46 publications,

divided into four elements, was examined for common themes and patterns. This created four explanations that analyzed each element using the representative publications of each group.

2.2.4 Discussion: -

Applying the Factor Analysis in the literature segment provides a distinctive analytical hand tracking into the past, current and future dimensions of HCI research. This finding supports the notion of western and developing countries increased interest in HCI hand tracking research.

Our analysis did not emphasize the new HCI approach, but with well-documented HCI subfields, gaze tracking (Rantanen et al. 2011), facial recognition (Sebe et al. 2005), and emotions. Computing (Kächele et al. 2015; Schels et al. 2014) and the use of sensors in recent studies (Palacios et al.). 2013) and wearables (Rantanen et al. 2011). By complementing the above research and supporting our own experience with HCI hand tracking, we have identified some new trends related to HCI and the workplace.

A survey of underlined HCI topics, especially the use of technology in professional workspaces and the monitoring and improvement of performance and psychological fatigue, and efficient fatigue management initiatives primarily related to desk jobs. Seems to be trending to expand the research agenda.

2.2.4 Conclusion: -

Today, hand tracking is a vast and diverse community, connected by an evolving concept of ease of use and an essential effort to assess human activity and experience as a major driver of technology.

Over the last few decades, there has been a growing interest in hand tracking and HCI, and more literature. Literature born from various fields and connecting them. We observe this trend of dissemination in the form of productive discussions, experiments and results, and the collection of academic conferences and journals is increasing. We went through the bibliometric route in the literature review to give an overview of the interdisciplinary hand tracking literature and to gain a deeper and deeper understanding of HCI issues.

Our analysis initially targeted the period from 1970 to 2017. The data were analyzed in terms of year of publication, subject researcher, and publisher. In addition, we reviewed the literature, mapped HCI's most influential authors and origins in relation to the dataset, and provided a clear overview of the topic.

Nonetheless, the novelty of this report derives from the results of exploratory focus analysis of representative datasets and reveals interesting facts about HCI hand tracking as an evolving field of study. We used factor analysis to identify key areas of report: theoretical concepts, design aspects, user problem associations, detection systems and sensors. Therefore, you can follow the methodology used here to explore one or more interesting aspects of HCI in detail.

2.3 PROPOSED SOLUTION BY DIFFERENT RESEARCHERS

Since its beginning, the area of human computer interaction has expanded considerably. Today, technology has infiltrated every area of our life. Even if a person does not directly own or use a computer, computers have an impact on their lives. Therefore, making sure there is a seamless errorless interaction between human and computer is important. With time technology is being modified to make it more efficient. Researchers keep proposing new researches which make the system more efficient. Some of the solutions to basic problems proposed by the researchers are:

Non-standard backgrounds: In past, due to non-standard background it was lot harder to use gesture recognition as the computer wasn't able to detect properly. Machine learning gives us a way to teach machine to tell the hand apart from the background consistently. By uploading and analyzing large amount of data computer was able to move forward from this problem.

Movement and combination of movements: With technology advancement, big changes were made in field of human computer interaction. Researches proposed the idea of building modules which can detect different hand gestures at real time. This solved the problem of static image input.

Fighting the lag: Adoption of hand gestures can only be encouraged by showing how consistent and instantaneous it can be. There is really no other reason to start using gestures if they don't make your interaction faster and more convenient. Ideally, researchers came through with solutions to decrease lag by modifying already existing modules.

To make sure that the output of the input image is accurate, a multi-modal large-scale dataset was analyzed to create an error free module.

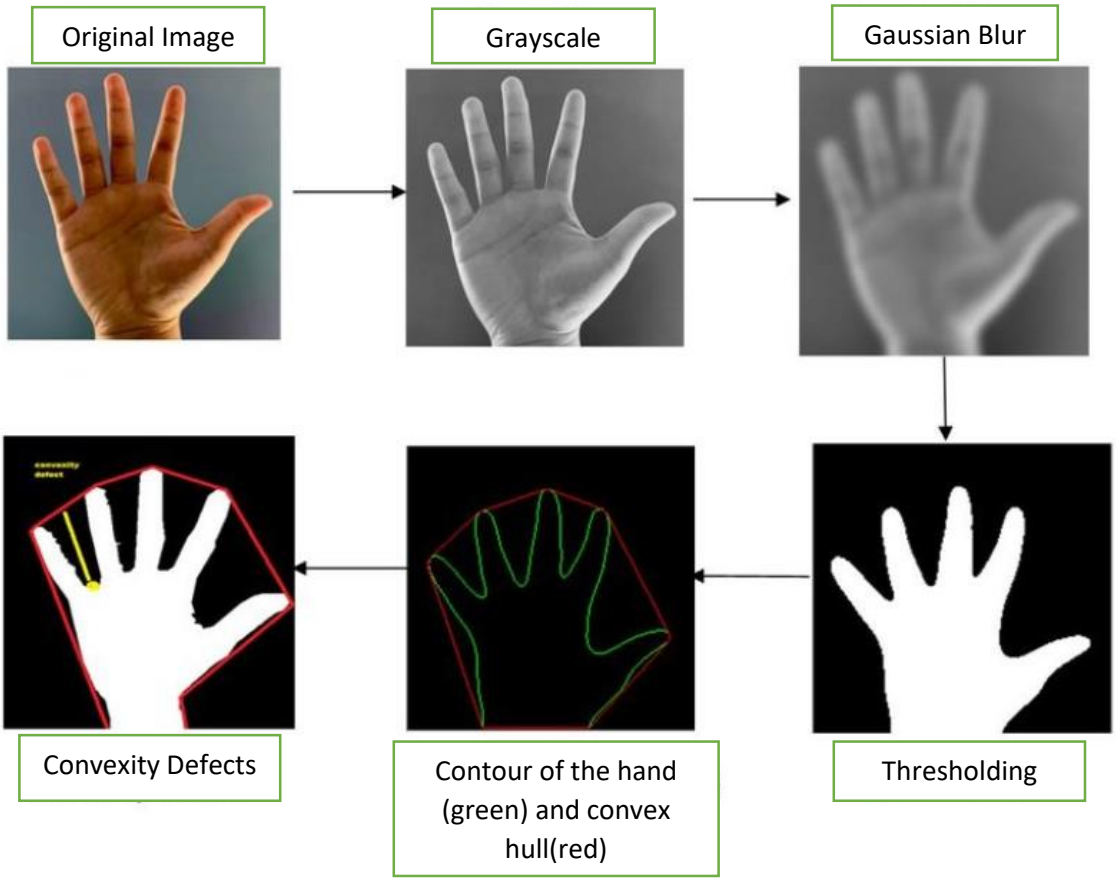


Figure: 2.2: Reported Solutions

2.4 SUMMARY LINKING LITERATURE REVIEW WITH THE PROJECTS

In this literature review we aimed to describe the current state of human computer interaction, analyze measurable attributes such as effectiveness, efficiency and value, the reported problems which were investigated throughout the world and their solutions proposed by the researchers. So, after doing all the research about it, we came to know that there are many systems of hand tracking related to human computer interaction, but because all of them are not available at one place, we have

come up with a solution named SAHVI (Software and Human Virtual Interaction) a virtual assistant. SAHVI will help user for features' usages to do each task one by one through voice command. Currently it will assist five different tasks like -

- Virtual Volume Controller
- Virtual Mouse Controller
- Virtual Game Controller
- Virtual Calculator
- Virtual Painter

It is not constrained by the number of tasks we can add more tasks to it. As hand tracking system is a good option to eliminate interaction with hardware and with the use of virtual assistant the interaction with the software will be very smooth.

2.5 PROBLEM DEFINATION

Biometric technologies make use of fingerprints, expressions, faces, hand gestures, and movement to identify people. Hand gesture recognition is garnering more and more attention in the biometric industry due to the requirement for security in law enforcement agencies as well as private sectors such as surveillance systems. Hand gestures are vital in intelligent human-computer interaction(HCI), and fast and effective hand gesture detection algorithms are necessary to construct completely automated systems that interpret information contained in images. One of the systems that can recognize a hand motion in real time video is hand gesture recognition. Hand gestures are classified according to their subject matter. Designing hand gesture recognition is one of the most difficult jobs in this subject, as it involves two primary issues. The first is the detection of a person's hand. Another issue is

creating a sign that can only be utilized by one hand at a time. This research focuses on how a webcam may be used to detect, recognize, and interpret hand gesture recognition. The theories of hand segmentation and the hand detection system can be applied to the development of hand gesture recognition utilizing Python and OpenCV.

2.6 GOALS & OBJECTIVES

2.6.1 Goals: -

The goal of this project is to create a real-time gesture classification system that can recognize motions automatically in natural illumination. To achieve this goal, a real-time gesture-based system is being created to recognize motions.

H2TS system is based on a futuristic technological approach which will make human and software interaction much more virtual and convenient without using hardware. The advanced feature which can be incorporated are voice command, touchless operations {which can be done through web cam using hand landmarks' detection (total hand landmarks detection=21)} which will help- in cost saving(Keyboard), less maintenance cost of hardware, enough distance from hardware equipment ultimately better eye care and many more technological advantages.

Our project's main goal was to construct a virtual computer environment that could execute a range of touchless activities using a webcam and hand landmark detection, with all tasks aided by a virtual voice assistant named SAHVI (Software and human virtual interaction).

2.6.2 **Objectives: -**

- First objective of this project is to allow the communication between human and computer by the use of gestures and hand movements to be more intuitive.
- Second objective of this project is to create a complete system to detect, recognize and interpret the hand gestures through computer vision.
- Third objective of this project is to do more and more work on the computer with the help of hand gestures such as to control volume of the system, mouse control, game control and many more.

CHAPTER 3: DESIGN FLOW/PROCESS

3.1 CONCEPT GENERATION

The first step of concept generation of this project is to understand the problem this is basis for all the problems if the project is not managing to get this one right then it will render the whole development process. Before generating new solutions for hand tracking system the project is exposed to available information that is preset in different research papers. There is a reason why many people are not turning to this system maybe they need a customized solution maybe there is nothing available in the market that is user friendly. We looked out for similar scope of the project and bringing in the idea from different projects that helps immensely. Although implementing an idea that solves a similar solution needs to be adjusted but it's a good start for starting a project. The project is focusing to the younger generation people as they are more adaptive to the current hand tracking applications and technology.

3.2 EVALUTION & SELECTION OF SPECIFICATION/FEATURES

The features and characteristics of a project are defined as that the project must be specific they must be measurable, achievable, relevant, efficient and the objectives must be achieved. The proposed project provides certain features and characteristics which makes this project distinct then other projects. This project allows users to interact with the system without using any physical input device like keyboard, pen or mouse. The proposed project detects the position and orientation of hands and the

configuration of fingers to perform certain tasks which are available in in the project. In this project the user's hand act as an external device which inputs the data by performing a certain movement of user's hands and then the webcam present in the system captures it frame by frame on real time and performs image processing algorithm. The H2TS system is based on a futuristic technological approach which will make human and software interaction much more virtual and convenient without using hardware. The advanced features which are incorporated in this project are voice command which can be used to open different tasks present in the project and touchless operations which will help in reducing hardware cost thus saving less maintenance cost of hardware. So the proposed system uses SAHVI (Software and Human Virtual Interaction) which is a virtual assistant that will help user for features usages to perform each task one by one through voice command.

Currently it will assist five different tasks: -

1) **Virtual Volume Controller (VVC):** Under this feature we develop an interface which will capture human hand gesture dynamically and will control volume level by thumb and index figure positioning. It detects our hand with 21-point landmarks so as it can see the distance between our thumb fingertip and index fingertip. We can manipulate devices volume by increasing and decreasing distance between out thumb fingertip and index fingertip. When we increase the distance between thumb fingertip and index fingertip the volume will increase and when we decrease the distance between thumb fingertip and index fingertip the volume will decrease.

2) **Virtual Mouse Controller (VMC):** Under this feature we develop an interface or a mouse simulation system which will capture human hand

gesture dynamically and will perform all the functions performed by mouse corresponding to hand movements and gestures. It retrieves necessary data and executes in absolute notation that is acceptable by predefined notations which are stored in the computer. The fingertip of the finger which we're using as a replacement of cursor is detected by the program and then all the work is done by that suspected finger. Selection can be done by clicking index fingertip and middle fingertip.

3) **Virtual game Controller (car) (VGC):** Video gaming is a form of entertainment which is at its peak. A major part of population uses gaming as a way to release their stress or a way to escape their problems. For higher involvement in the game, we use human computer interaction to attract audience. Human computer interaction enhances their experience. The camera detects landmarks points of index fingertip, finger joint point and wrist. The angle between these landmarks is calculated and based on the angle between these landmarks, the game can be played by the user.

4) **Virtual Calculator:** Under this feature we develop a system for virtual calculator that uses finger movements or gestures to operate. The camera detects the landmark points of index fingertip and middle fingertip (fingers which are used to operate virtual calculator). Calculator is visible on the top right side of the screen where the user can move around their fingers any perform any calculation they want. By clicking middle fingertip and index fingertip user can select an operand or operator to perform the desired operation.

5) **Virtual Painter (VP):** We develop virtual paint application which empower user to virtually paint in the air by using their fingers which are detected by the webcam. It can be used to draw on our system screen based on the position of our index finger movements (landmarks are detected beforehand). For drawing mode or active mode, user needs to show their index finger. To select different color or the eraser the user must select it by clicking their index fingertip and middle fingertip together at top of the icon of the function user wants to use. To erase a drawing user can just slide the eraser on top of the drawn picture after selecting the eraser function.

6) **Virtual Assistance (SAHVI):** SAHVI stands for software and human virtual interaction. It is a virtual assistance for this program which will assist the user select features through voice command. It gives a preface about the features and helps the sure to transvers through the project. User can ask their assistance to direct them to a specific feature.

3.3 DESIGN CONSTRAINTS

Design constraints are requirements that must be met in order for a project to succeed. When establishing a project, design limitations help to reduce down options. Design limitations may appear to be a negative thing at times, yet they help mould the project to meet the client's particular requirements. We'll discuss how design constraints shape our H2TS project. Let's take a look at some of the project's common challenges.

3.3.1 Economic: -

Human computer interaction is a popular field which has an active impact on economic life. Our project can make interaction between human and computer much more pleasant. Depending on its popularity it can majorly contribute in economy.

3.3.2 Social: -

With the development of new HCI's, computers accessibility becomes more to people and so are being used more and more in everyday life. For people who find traversing through computer to find a desired function can depend on SAHVI (virtual assistant) to guide them through it.

3.4 ANALYSIS AND FEATURE SUBJECT TO CONSTRAINTS

There are six major constraints in project management to consider.

3.4.1 Time: - The project completion is well defined and it will be completed before the due date. All the necessary features and requirements will be completed in order for proper working of the project. The project is currently in the testing stage and we are making some necessary changes for making the project more user friendly to the user. The project is tested by project members which will then be discussed and will rely on to work on some solutions in order to deliver the project before the due date. The project documentation is also getting reviewed up to date. Once the project outcomes are documented and the necessary services and objectives are set out to accomplish then we are finally getting closer to the successful project completion.

3.4.2 Cost: - The original schedule of activities and events that caused changes to the schedule are reviewed to see how the use of contingency reserves and disruption is caused by those events. A review of budget estimates for the cost of work and time scheduled is compared to the actual time and costs. The original estimates of contingency time are reviewed to determine if the time duration, costs and float are accurate. Most of the additional work is added to the end of the project so as this the cost estimation may differ. The end of this process will determine the size and features dependencies of the project. As this is college project the development costs required for the project is null.

3.4.3 Scope: - H2TS system is based on a futuristic technological approach which will make human and software interaction much more virtual and convenient without using hardware. The advanced feature which can be incorporated are voice command, touchless operations {which can be done through web cam using hand landmarks' detection (total hand landmarks detection=21)} which will help- in cost saving(Keyboard), less maintenance cost of hardware, enough distance from hardware equipment ultimately better eye care and many more technological advantages.

3.4.4 Quality: - This system is come up with many qualities of advanced technology for users' interface. It recognizes serval gestures with the very less interval of time, means it's decision making power for different gestures is smooth and strong enough so that user will interact by gesturing in the view of the camera. It's camera resolution is 640x480 and video frame rate is 30fs with pixel depth minimum 1.3 mega pixels. It is an ideal system so it does not need any kind of gloves, sensors, USB cables, markers but a human hand only

with any kind of skin color. Gesture recognition can also provide better ergonomics for consumer devices.

3.4.5 Benefits: - As we know the time when the touchscreen technology was introduced, many people were excited to stop interacting with physical buttons to navigate their phone, TVs and to instruct cars system, monitors and other devices by switching to smart screen's technology. This saved our time and was very suitable and entertaining to use. But with time customer preferences have changed, especially in times of the pandemic. People think it's unhygienic to use a touchscreen mainly in public places or devices like touch screen monitor, car navigation system, etc.

So, we come with the solution of Human Hand Tracking System with many benefits in it. Firstly, you can access it through the voice commands that control many features and perform different tasks on real time. Secondly, you can do all these tasks by just using different hand gestures, it means there is no need of mouse, keyword and this is the big benefit for the user. There are also some other comforts with this system of hand tracking such as, this system is quit hygienic as there are several contact-less operations with the software and it is easy to install in our system with immensely affordable prices.

3.4.6 Risk: - The risk involved in this project is that while working on various programs and features repeatedly sometimes it might get hanged and the program needs to be restarted in order for proper working of the project. It was also found during the testing that if the system was once fully trained for all the gesture types then it gives us accurate results otherwise if it was just

trained for a single or two gestures and then tested then it performs erroneous processing or mistaken assumptions. It is also found that sometimes if the user wants to switch from one program to another then the current program in which the user has switched does not work properly and thus leading to program failure.

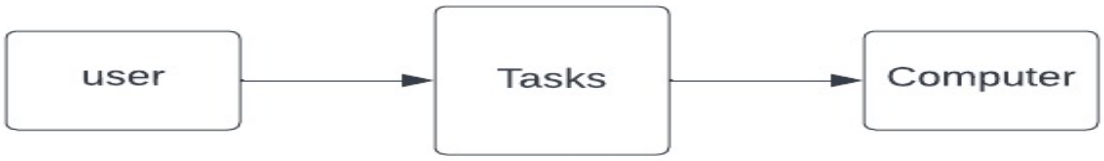
Constraints Identification for this project:

- Can't be used for long distance
- Brightly lit place is must
- Requires decent webcam
- Detection of more than one or two palm can result into ambiguous outcomes
- System maybe hang with maximum usage.

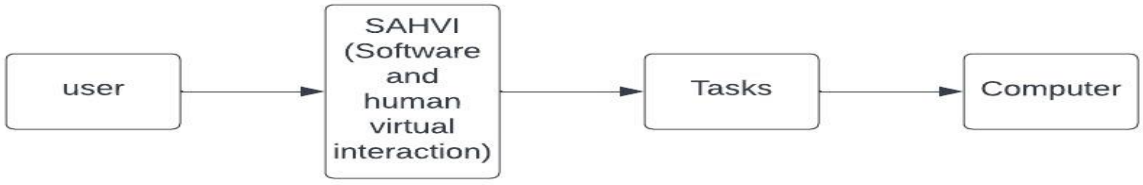
3.6 DESIGN FLOW

1. Data Flow Diagram (DFD):

- **Level Zero**



- **Level One**



- **Level Two**

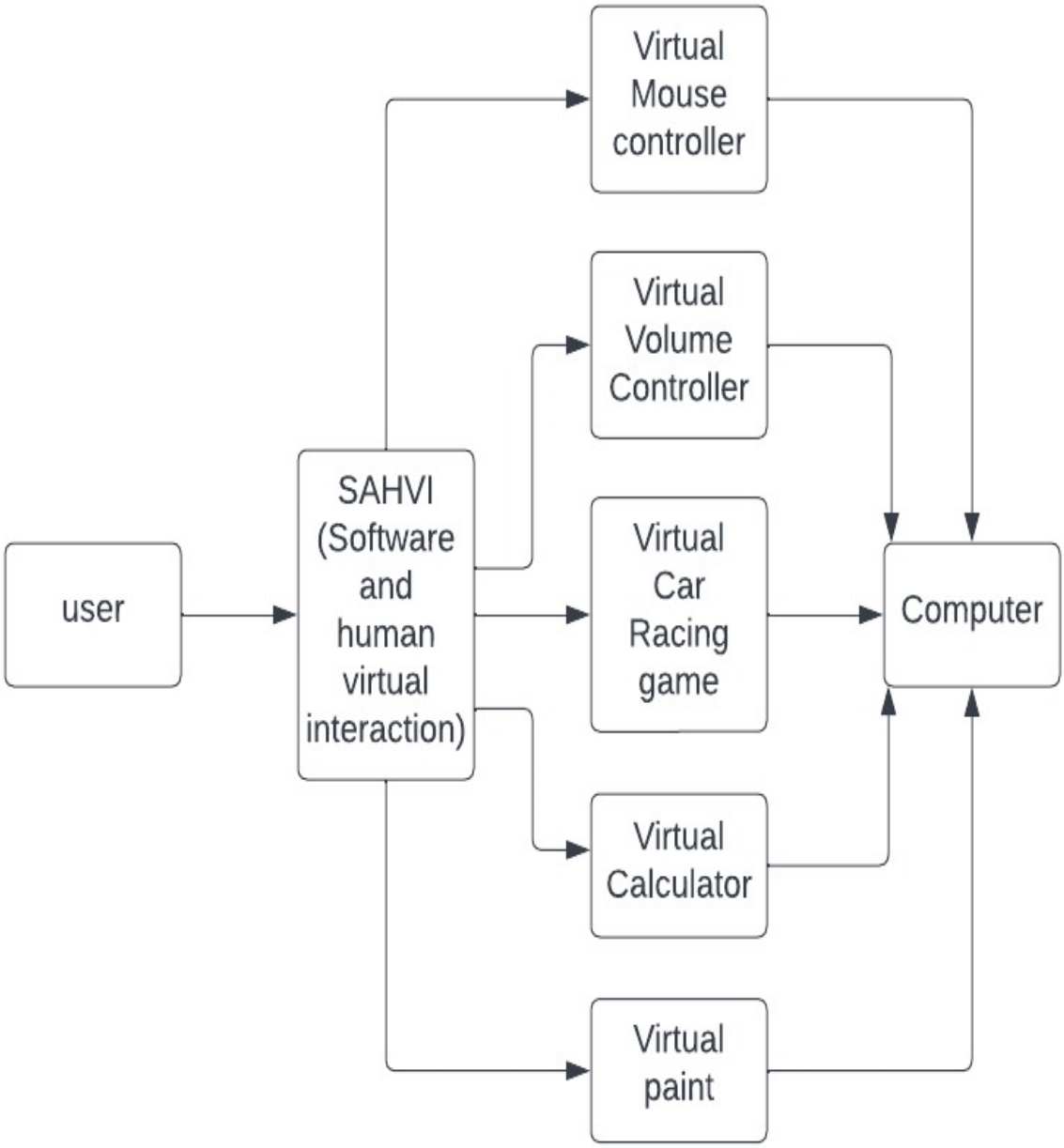


Figure: 3.1: DFD Diagram

2 Sequence Diagram:

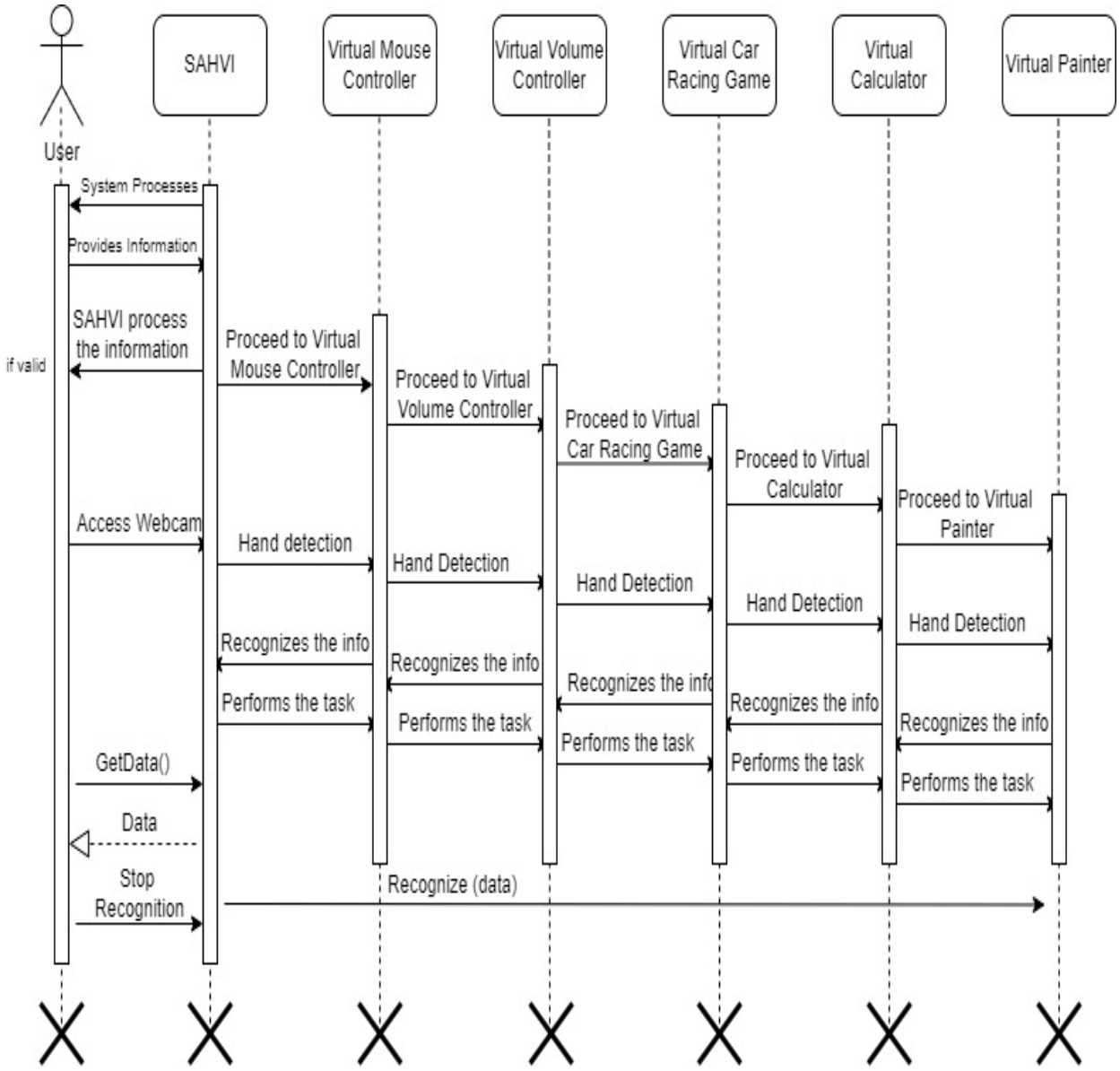


Figure: 3.2: Sequence Diagram

3.6 BEST DESIGN SELECTION

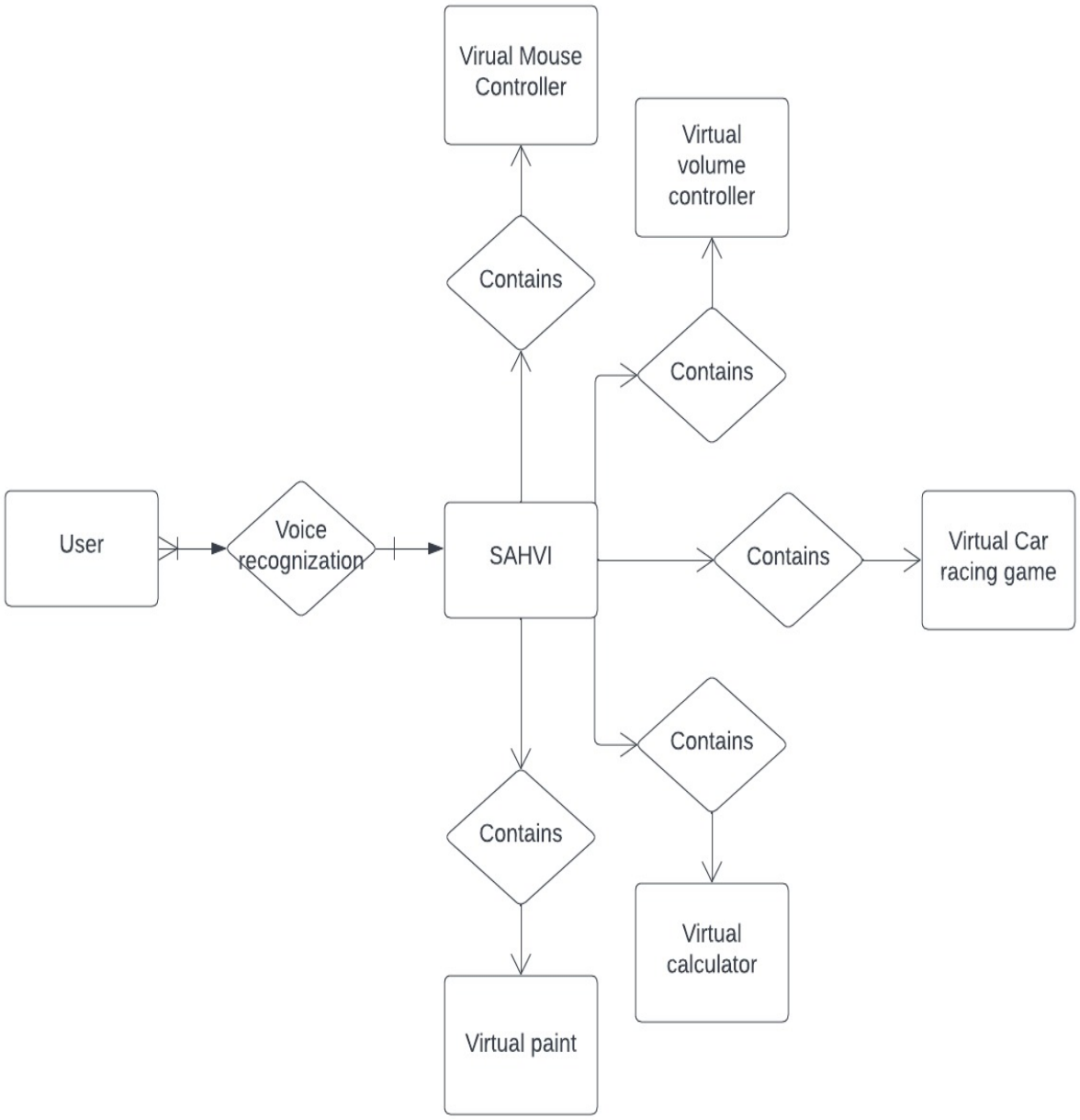


Figure: 3.3: Entity Relationship Diagram

3.7 IMPLEMENTATION PLAN (FLOWCHART)

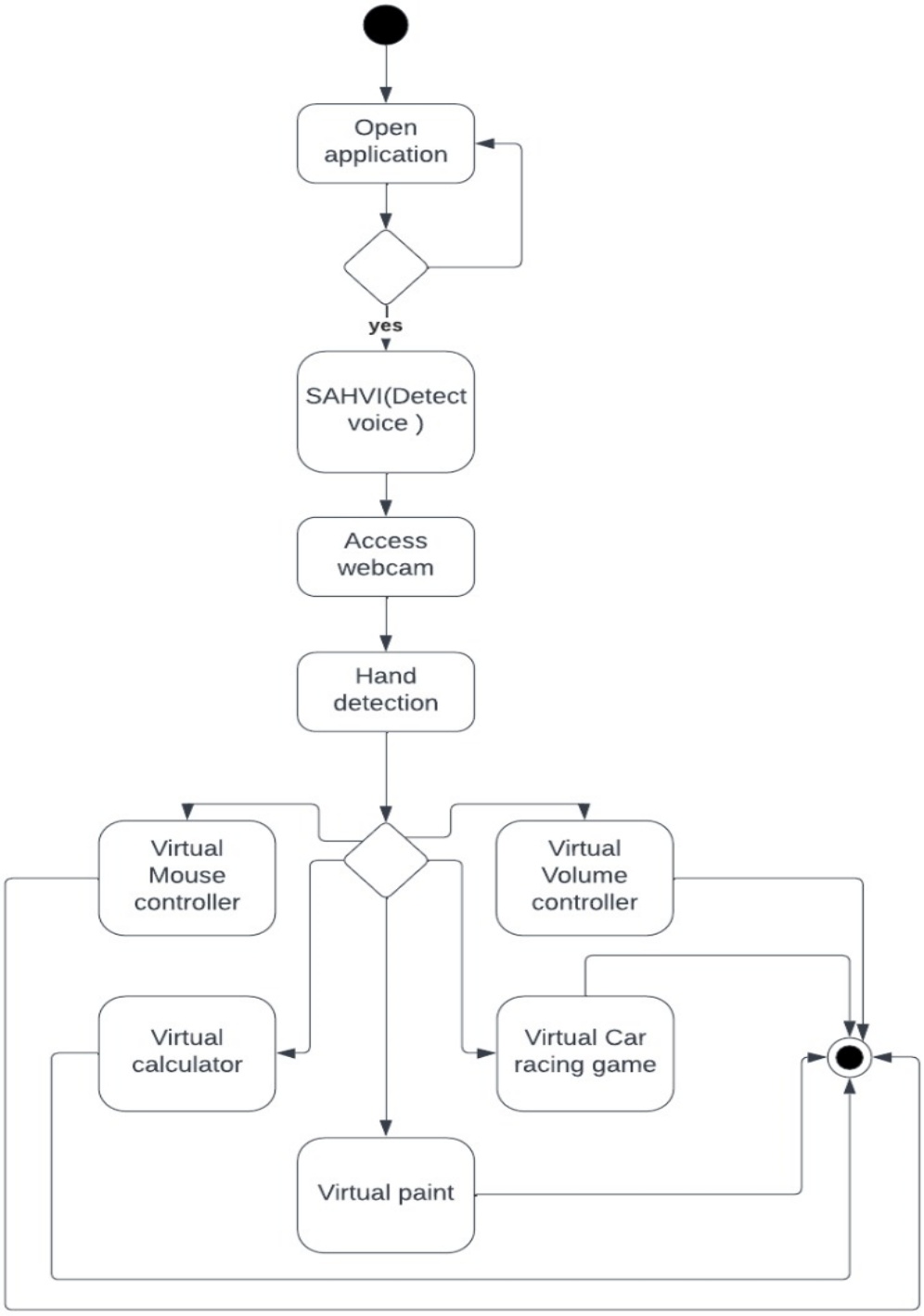


Figure: 3.4: Implementation Plan(Flowchart)

CHAPTER 4: RESULTS ANALYSIS AND VALIDATION

4.1 RESULTS ANALYSIS

Our technology is a real-time gesture categorization system that can automatically recognize gestures in natural lighting. So, here's a virtual computer environment that can perform a variety of touchless tasks utilizing a webcam and hand landmark detection, all with the help of a virtual voice assistant dubbed SAHVI (Software and human virtual interaction). The interface is also efficient, user friendly and customizable that it can include more and more number of tasks in the future. Overall quality of the project is optimized then other proposed projects and the cost of the system has been reduced.

4.2 IMPLEMENTATION OF DESIGN USING MODERN ENGINEERING TOOLS IN ANALYSIS

Hand tracking is the process in which a computer uses computer vision to detect a hand from an input image and keep focus on the hand’s movement and orientation. In this project we have used python language for implementation of project. Python is often used as a support language for software developers, for build control and management, testing, and in many other ways. We made use of OpenCV to perform operations associated with computer vision and Media Pipe to perform the actual hand detection and tracking on our input image.

- **OpenCV:** is a tool for image processing and performing computer vision tasks. It is mainly used here to process input image to identify hands movement.
- **Media Pipe**: It is an open-sourced, cross-platform library that provides many ready-to-use machine learning solutions for solving computer vision problems. We use python for implementation of our project as it is the best fit for machine leaning and AI-based projects include simplicity and consistency, flexibility, access to powerful AI and ML libraries and frameworks and platform independence.

4.3 TESTING

In this stage the product is tested by running diverse tests for identification of any bugs and errors in the software before implementation phase begins. The project is going through distinct tests to find its shortcomings and then necessary actions are taken by the team.

4.3.1 Unit Testing: -

The internal processing logic was the focus of the unit test. A module's statements have all been tested at least once. The interface module was put through its paces to confirm that data was flowing correctly into and out of the software unit under test.

4.3.2 Integration Testing: -

Integration testing is a method for building the software architecture and executing tests to find interface issues. The goal of the testing was to see if any of the components were fully functional or not. As a result, I combined all of my unit

components to see if the system worked effectively as a whole. The information flow between the components was double-checked.

4.3.3 Recovery Testing: -

The system can fail in a variety of ways, but it must be appropriately recovered. When a human tries to train the system with his gestures and it fails, the system displays an error message stating that the system was not correctly trained, and it continues to do so until it finds a legitimate gesture (that the system accepts for distinction). Only until the system has been thoroughly trained can we expect it to provide accurate findings.

4.3.4 Sensitivity Testing: -

Invalid input classes may result in instability or incorrect processing. During sensitivity testing, it was discovered that if the system was fully taught for all gesture types before being tested, it produced accurate results; but, if the system was only trained for one or two gestures before being tested, it produced incorrect findings.

4.3.5 Voice Assistant Testing: -

This project confines of several issues which will be fixed in the future. We have been facing issues in executing different tasks for this project. The project needs to be improved at the runtime environment. Whenever the user runs a program by using voice command then after that the system cannot process the next program we have to start it again from the beginning and again use voice command for playing the next program.

4.4 DESIGN DRAWINGS

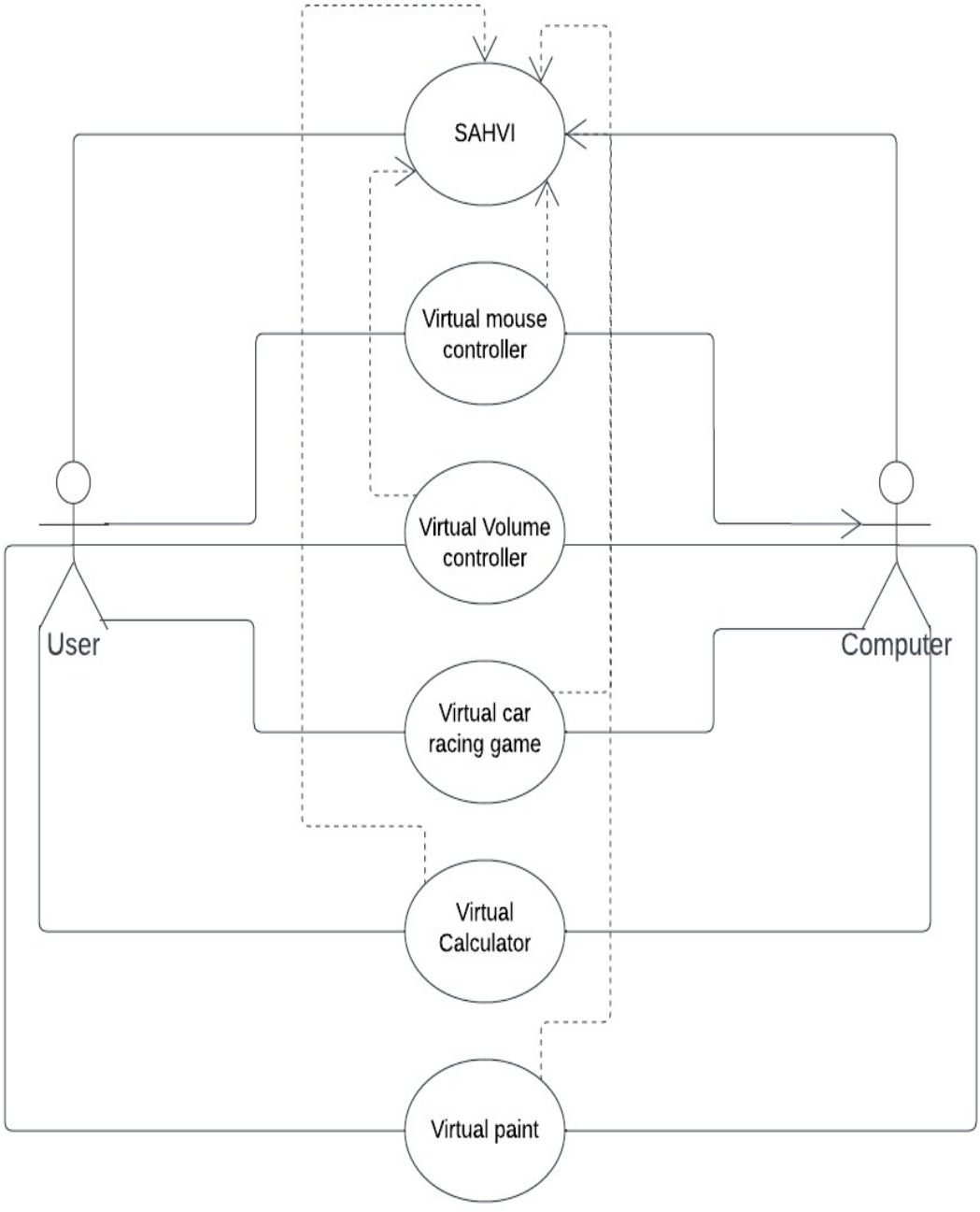


Figure: 4.1: Design Drawing

CHAPTER 5: CONCLUSION AND FUTURE WORK

5.1 CONCLUSION AND FUTURE WORK

5.1.1 Conclusion: -

The paper proposes a virtual assistant based human hand tracking system that can recognize hand movements and gestures throughout the different tasks of the software. The proposed system uses a webcam and hand detection algorithm to perform different tasks which are used in everyday life and makes it easy for young generation to adapt this technology. The system makes use of the OpenCV and Media Pipe which makes it very efficient in executing different tasks of the project as the features of this libraries are fast and easily calculable. Our system is focused more on making it user friendly using voice based command and also making it faster as compared to other hand detection recognition rate. The system is also focused more on reducing cost and improve robustness of the system as compared to other proposed system. Further improvements will be focused more on including more number of tasks and making it more efficient and lag free system.

5.1.2 Future Work: -

Our goal is to provide a complete benchmark comparison between the previous method and our method in future work. Nevertheless, our system has some limitations as explained. Our future work aims to overcome these limitations and improve hand / finger tracking algorithms. We also aim to improve the stability and accuracy of our tracking system, which allows us to get the exact position of our fingertips. This makes advanced applications like floating virtual mouse more

practical than just gimmicks. We also plan to add more advanced voice recognition assistant to the system. It can easily solve the problem of self-occlusion and also provides valuable depth information that can represent the detected hand in a 3D model. Finally, we aim to extend the domain scenario and apply tracking mechanisms to digital TV and mobile devices and gaming consoles.

5.2 USER MANUAL

For this project no user manual is present as we have made use of SAHVI our virtual assistant which will guide the users through the whole project by voice commands.

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