A
Mini Project report on

ADVANCE HAND GESTURE RECOGNITON SYSTEM FOR SIGN LANGUAGE

Submitted To
Nalla Narsimha Reddy Education Society’s Group Of Institutions
In Partial Fulfillment of the Requirements for the Award of Degree of

BACHELOR OF TECHNOLGY

IN

COMPUTER SCIENCE AND ENGINEERING

Submitted By

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CERTIFICATE

This is to certify that the project report titled **"ADVANCE HAND GESTURE RECOGNITION SYSTEM FOR TRANSLATING SIGN LANGUAGE"** is being submitted b y **M.Ramprasad(217Z1A6742),M.Shashank(217Z1A6738)**,and**B.V.S.Gowtham(217Z1A6709)** in Partial fulfillment for the award of **Bachelor of Technology in Computer Science And Engineering** is a record bonafide work carried out by them. The results embodied in this report have not been submitted to any other University for the award of any degree.

Internal Guide	**Head of the Department**
(Mr. S. Ravi Teja)	(Dr.K.Rameshwaraiah)

Submitted for the University Examination held on…………………………….

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DECLARATION

We M.Ramprasad, M.Shashank and B.V.S.Gowtham are students of **Bachelor of Technology in Computer Science And Engineering, Nalla Narasimha Reddy Education Society's Group Of Institutions**, Hyderabad, Telangana State, hereby declare that the work presented in this project work entitled **Advance Hand Gesture Recognition System For Translating Sign Language** is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been undertaking care of engineering ethics. It contains no material previously published or written by another person nor material which has been accepted for the award of any other degree or diploma of the universityor other institute of higher learning.

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ABSTRACT

The abstract presents an advanced hand gesture recognition system designed for sign language translation, aiming to bridge communication barriers between the deaf and hearing communities. Leveraging depth sensors and wearable technology, the system captures intricate hand movements with precision. Through the utilization of machine learning models such as CNNs, RNNs, and transformers, it accurately interprets and translates sign language gestures. Key features include gesture segmentation algorithms for parsing continuous movements, ensuring faithful representation of linguistic nuances. Real-time processing capabilities minimize latency, facilitating seamless communication in dynamic interactions. The translation mechanism converts recognized gestures into corresponding linguistic symbols or text, enabling effective communication. Additionally, the system prioritizes accessibility, offering compatibility with various platforms and customization options. Continuous improvement strategies, including user feedback integration and collaboration with the deaf community, are integral for refining accuracy and relevance over time. This system holds promise for revolutionizing communication accessibility and inclusivity for deaf individuals worldwide.

Keywords: Hand Gesture Recognition , Sign Language Translation, Depth Sensors, Wearable Technology, Machine Learning Models, CNNs (Convolutional Neural Networks)

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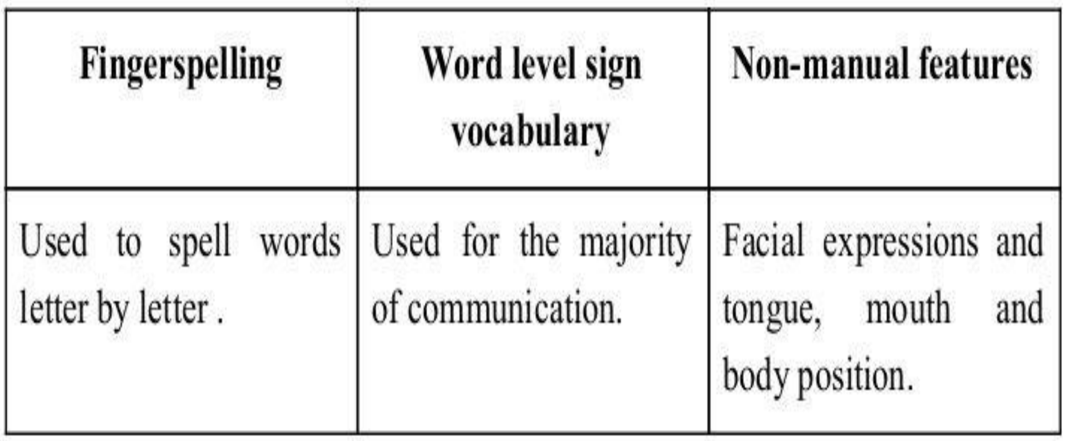
1. INTRODUCTION

American Sign Language (ASL) is the predominant sign language used by the Deaf and Dumb (D&M) community for communication. Since D&M individuals cannot rely on spoken languages, they use sign language, a form of non-verbal communication involving hand gestures, facial expressions, and body movements. These gestures are crucial for D&M individuals to express their thoughts, emotions, and messages. Communication, the exchange of thoughts and ideas, is facilitated through various methods like speech, behavior, and visual signals, with sign language being the most effective tool for D&M individuals. This project explores the use of sign language, specifically focusing on finger spelling gestures, to enhance communication for the D&M community.



Fingerspelling	Word level sign vocabulary	Non-manual features
Used to spell words letter by letter .	Used for the majority of communication.	Facial expressions and tongue, mouth and body position.

1.1 BACKGROUND OF STUDY

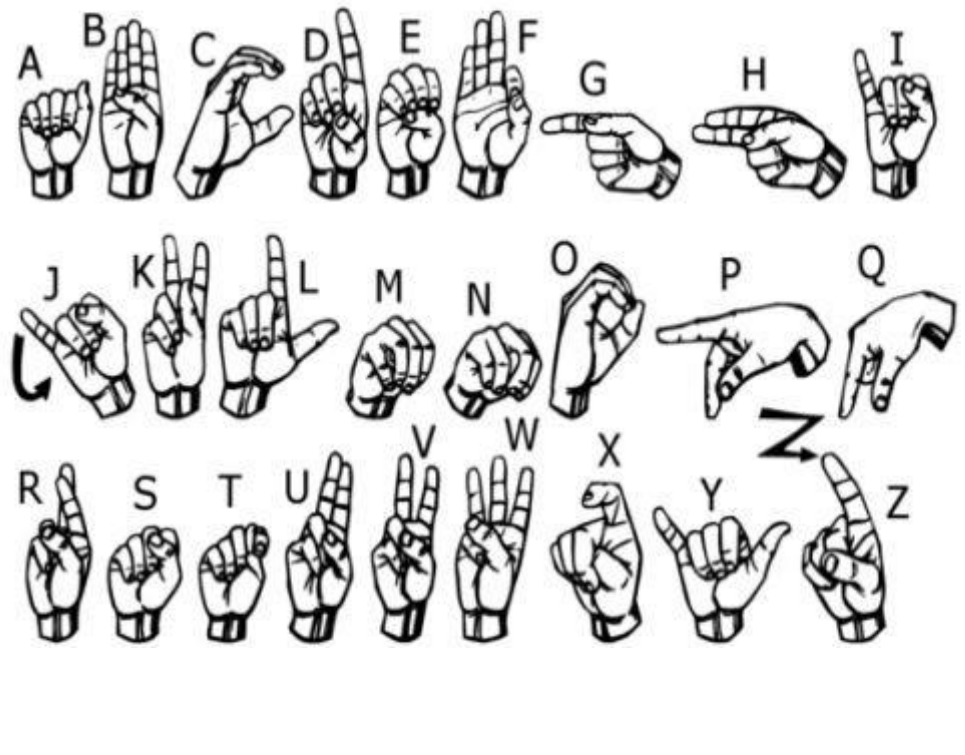
Communication is vital to human interaction, and for D&M individuals, sign language serves as their primary means of expression. D&M individuals rely heavily on hand movements, facial expressions, and body gestures to communicate. These gestures are non-verbal, but they carry significant meaning and are understood visually. Sign language is a structured system that combines various gestures, hand shapes, and movements, allowing individuals to convey complex ideas without spoken words. Contrary to the belief that sign language is universal, it varies by region, with each community developing its own visual language system. This project focuses on

American Sign Language, a widely used system in the United States, emphasizing finger-spelling gestures as a means of forming words.

By developing a gesture recognition model, this project aims to improve the accessibility and ease of communication for the D&M community, utilizing advanced technology to recognize and interpret their gestures.

1.2 PROJECT OBJECTIVE

The objective of this project is to develop a model capable of recognizing finger-spelling-based hand gestures in American Sign Language. By interpreting each gesture, the system will be able to form complete words. The goal is to create a reliable and efficient recognition system that can bridge the communication gap for D&M individuals, allowing them to convey their thoughts through a series of hand gestures accurately. This project focuses on recognizing the specific gestures associated with the alphabet in ASL, enabling the formation of words from individual hand signs.



1.3 MOTIVATION

For interaction between normal people and D&M people a language barrier is created as sign language structure since it is different from normal text. So, they depend on vision-based communication for interaction.

If there is a common interface that converts the sign language to text, then the gestures can be easily understood by non-D&M people. So, research has been made for a vision-based interface system where D&M people can enjoy communication without really knowing each other's language.The aim is to develop a user-friendly Human Computer Interface (HCI) where the computer understands the human sign language. There are various sign languages all over the world, namely American Sign Language (ASL), French Sign Language, British Sign Language (BSL), Indian Sign language, Japanese Sign Language and work has been done on other languages all around the world.

1.4 PURPOSE SCOPE AND APPLICABILITY

The purpose of this project is to develop a real-time sign language recognition system to bridge the communication gap between hearing-impaired individuals and those unfamiliar with sign language. Using computer vision and machine learning, the system translates hand gestures into text. The project's scope includes real-time hand detection via webcam, pre-processing hand images for consistency, and creating a user interface to display recognized gestures. The system focuses on a subset of sign language symbols for demonstration purposes, providing a functional model to showcase its capabilities.

1.5 PROBLEM STATEMENT

Developing a system that can accurately recognize and translate sign language gestures into readable text or speech is a challenging task. The variations in hand gestures, lighting conditions, and background noise make real-time recognition complex. The problem is to design a robust system that can detect and classify hand gestures corresponding to sign language symbols in real-time..

1.6 LIMITATIONS

Hand gesture recognition systems, while powerful, have several limitations that can impact their effectiveness and usability. Here are some common challenges and limitations:

i. **Environmental Factors**
ii. **Sensor Limitations**
iii. **User Variability**
iv. **Gesture Complexity**
v. **Computational Resources**

2.LITERATURE SURVEY

2.1 INTRODUCTION

Sign language recognition has emerged as a significant area of research, aimed at enhancing communication for the hearing-impaired community. Various approaches have been proposed over the years, ranging from sensor-based gloves that detect hand and finger movements to vision-based systems that utilize cameras to capture and analyze gestures.

Sensor-based methods rely on wearable devices equipped with sensors to track motion and hand positions. However, these systems can be cumbersome due to the need for physical devices and sensors. On the other hand, vision-based systems, which use cameras to record and interpret hand gestures, have gained more popularity due to their non-intrusive nature. By applying image processing techniques and machine learning algorithms, these systems can identify and translate hand gestures into readable text or spoken language.

2.2 EXISTING SYSTEM

Vision-based systems utilize cameras to capture hand gestures. Techniques involve image processing, feature extraction, and classification using machine learning algorithms. Challenges include background noise, lighting variations, and complex gestures.

Limitations of Existing Systems:

High cost and complexity

Limited to controlled environments.

Lack of real-time performance.

2.3 PROPOSED SYSTEM

The proposed hand gesture recognition system employs RGB and depth sensors for real-time gesture capture and tracking. It utilizes deep learning models CNNs or RNNs, to process and interpret gestures. The system integrates with user interfaces to perform actions based on recognized gestures, providing immediate feedback. It features a robust data preprocessing pipeline and optimization for low-latency performance. Privacy and ethical considerations include securing user data and ensuring system fairness across diverse user groups.

3.SYSTEM ANALYSIS

3.1FUNCTIONAL REQUIREMENTS

Gesture Detection and Tracking

Gesture detection identifies specific hand movements or positions from video input, while gesture tracking monitors and follows these gestures over time to ensure continuous recognition. Both processes enable interactive systems to respond dynamically to user actions.

Gesture Recognition

Gesture recognition involves identifying and interpreting specific hand movements or positions to perform corresponding actions or commands. It enables systems to understand and react to human gestures, facilitating intuitive user interactions.

Integration with Applications

Integration with applications involves incorporating gesture recognition technology into software or systems to enable gesture-based control and interactions. This enhances user experience by allowing intuitive, touch-free operation within various applications, from gaming to productivity tools.

Data Privacy and Security

Data privacy and security ensure that sensitive information collected during gesture recognition is protected from unauthorized access and misuse. Implementing strong encryption and access controls helps safeguard user data and maintain trust.

Performance and Optimization

Performance and optimization focus on enhancing the efficiency and speed of gesture recognition systems to ensure real-time responsiveness and accuracy. Techniques such as model pruning and hardware acceleration are used to improve system performance and reduce latency.

System Maintenance and Support

System maintenance and support involve regularly updating and troubleshooting gesture recognition systems to ensure they remain functional and effective. This includes applying software patches, addressing user feedback, and adapting to new technologies or changes in hardware.

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3.2 NON FUNCTIONAL REQUIREMENTS

Performance

Performance in gesture recognition refers to the system's ability to accurately and swiftly detect and interpret gestures in real-time. It involves evaluating metrics such as recognition speed, accuracy, and latency to ensure the system operates efficiently and responds promptly to user inputs.

Scalability

Scalability in gesture recognition refers to the system's ability to handle increasing amounts of data, users, or complexity without compromising performance. It ensures that the system can expand its capabilities to accommodate growth, such as supporting more gestures, additional users, or integration with other systems, while maintaining efficiency and accuracy**.**

Reliability

Reliability in gesture recognition refers to the system's consistent performance and accuracy over time and across various conditions. It ensures that the system consistently detects and interprets gestures correctly, with minimal errors or failures, even under diverse environments and varying input conditions.

Compatibility

Compatibility in gesture recognition refers to the system's ability to function seamlessly across different devices, platforms, and software environments. It ensures that the gesture recognition technology integrates well with various hardware configurations and operating systems, allowing it to operate effectively and consistently regardless of the underlying technology**.**

Security

Security in gesture recognition involves protecting the system and its data from unauthorized access, tampering, and misuse. It includes measures such as data encryption, secure authentication, and robust access controls to safeguard user information and ensure that gesture data is handled securely and privately.

Maintainability

Maintainability in gesture recognition refers to the ease with which the system can be updated, repaired, and managed over time. It encompasses the ability to implement software updates, fix bugs, adapt to new requirements, and ensure long-term usability, all while minimizing downtime and maintenance costs.

Compliance

Compliance in gesture recognition refers to ensuring that the system adheres to relevant industry standards, regulations, and legal requirements, such as data protection laws and accessibility guidelines. It involves implementing practices and safeguards to meet these standards and ensure that the system operates within the legal and ethical boundaries.

Performance

Performance in gesture recognition refers to the system's ability to accurately and efficiently detect, interpret, and respond to gestures in real-time. Key aspects include the speed of gesture detection, the accuracy of recognition, and the responsiveness of the system to user inputs. High performance ensures a smooth and intuitive user experience with minimal latency and error rates.

3.3 SOFTWARE REQUIREMENTS

Operating System	: Windows 7 or Higher
Coding Language	: Python 3.12
Development Environment	: Visual Studio Code (VS Code)

3.4 HARDWARE REQUIREMENTS

Processor	: Intel Core i3 or equivalent
Memory (RAM)	: 4 GB or Higher
Storage	: 2 GB or more
Input Devices	: Camera

4.SYSTEM DESIGN

4.1UML DIAGRAMS

UML stands for Unified Modeling Language. UML is a standardized general-purpose modeling language in the field of object-oriented software engineering. The standard is managed, and was created by, the Object Management Group. The goal is for UML to become a common language for creating models of object oriented computer software. In its current form UML is comprised of two major components: a Meta-model and a notation. In the future, some form of method or process may also be added to; or associated with, UML.

The Unified Modeling Language is a standard language for specifying, Visualization, Constructing and documenting the artifacts of software system, as well as for business modeling and other non-software systems. The UML represents a collection of best engineering practices that have proven successful in the modeling of large and complex systems.

The UML is a very important part of developing objects oriented software and the software development process. The UML uses mostly graphical notations to express thedesign of software projects.

Goals:

The Primary goals in the design of the UML are as follows:

Provide users a ready-to-use, expressive visual modeling Language so that they can develop and exchange meaningful models.

Provide extendibility and specialization mechanisms to extend the core concepts.Be independent of particular programming languages and development process. Provide a formal basis for understanding the modeling language.

Encourage the growth of OO tools market.

Support higher level development concepts such as collaborations, frameworks, patterns and components.

4.1.1Data Flow Diagram

A data flow diagram (DFD) maps out the flow of information for any process or system.It uses defined symbols like rectangles, circles and arrows, plus short text labels, to show data inputs, outputs, storage points and the routes between each destination. There are 2 levels in the below diagram.

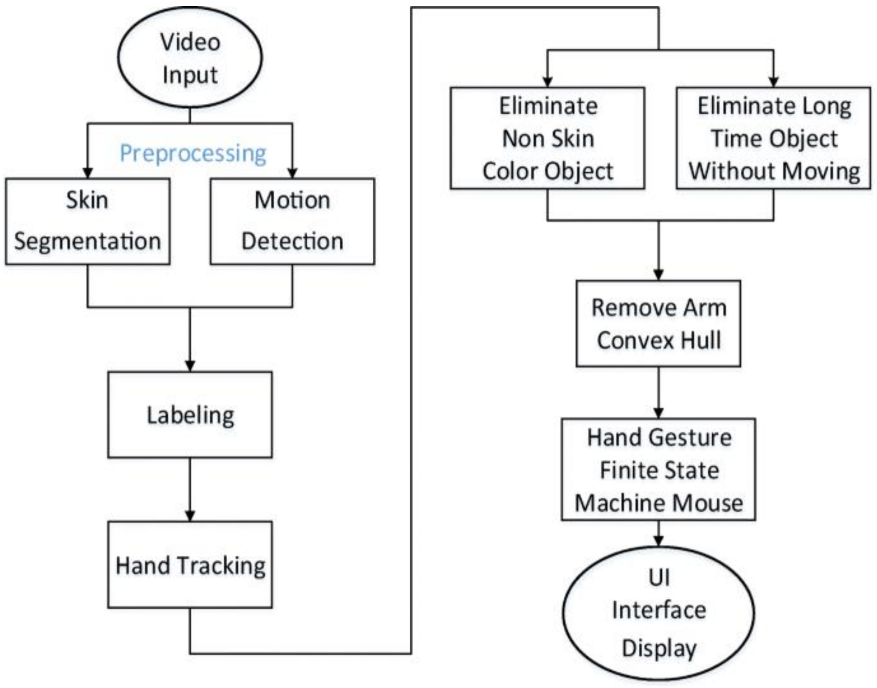


Fig :4.1.1.1 Data Flow Diagram : Level 0

4.1.2 Use Case Diagram:

A use case diagram in the Unified Modeling Language (UML) is a type of behavioral diagram defined by and created from a Use-case analysis. Its purpose is to present a graphical overview of the functionality provided by a system in terms of actors, their goals (represented as use cases), and any dependencies between those use cases. The main purpose of a use case diagram is to show what system functions are performed for which actor. Roles of the actors in the system can be depicted

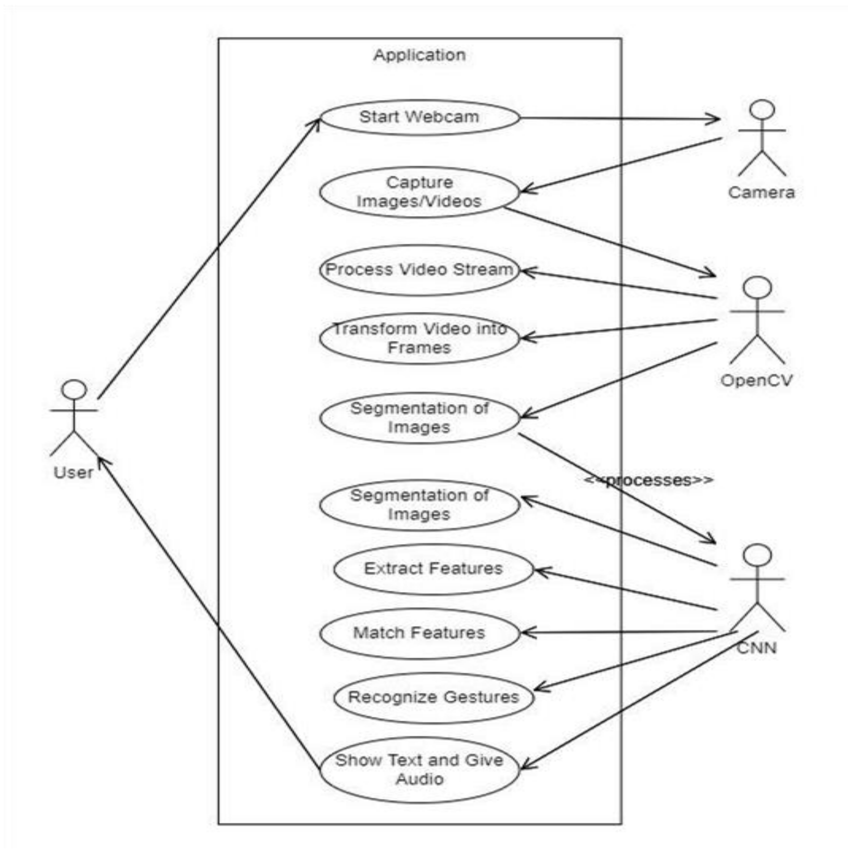


Fig :4.1.2.1 Usecase Diagram

4.1.3 Class Diagram:

In software engineering, a class diagram in the Unified Modeling Language (UML)is a type of static structure diagram that describes the structure of a system by showing the system's classes, their attributes, operations (or methods), and the relationships among the classes. It explains which class contains information.

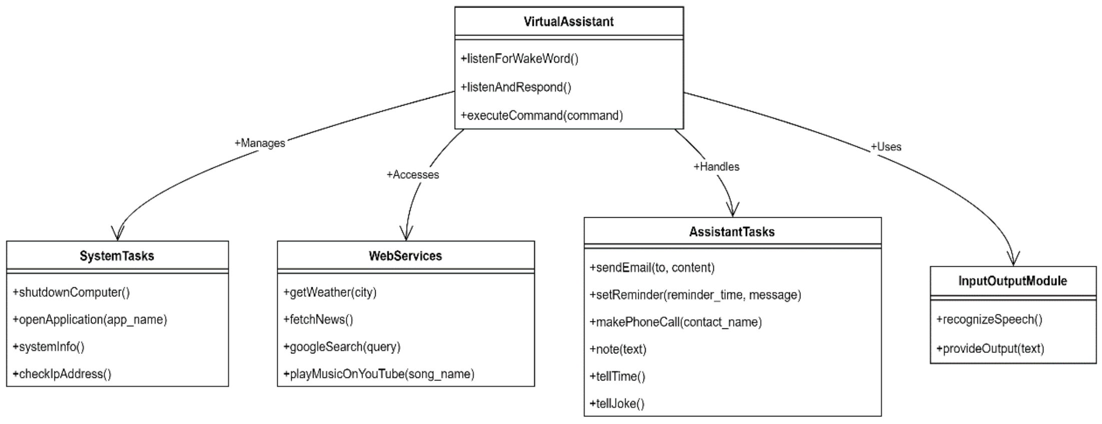


Fig :4.1.3.1 Class Diagram

4.1.4 Sequence Diagram:

A sequence diagram in Unified Modelling Language (UML) is a kind of interaction diagram that shows how processes operate with one another and in what order. It is a construct of a Message Sequence Chart. Sequence diagrams are sometimes called event diagrams, event scenarios, and timing diagrams

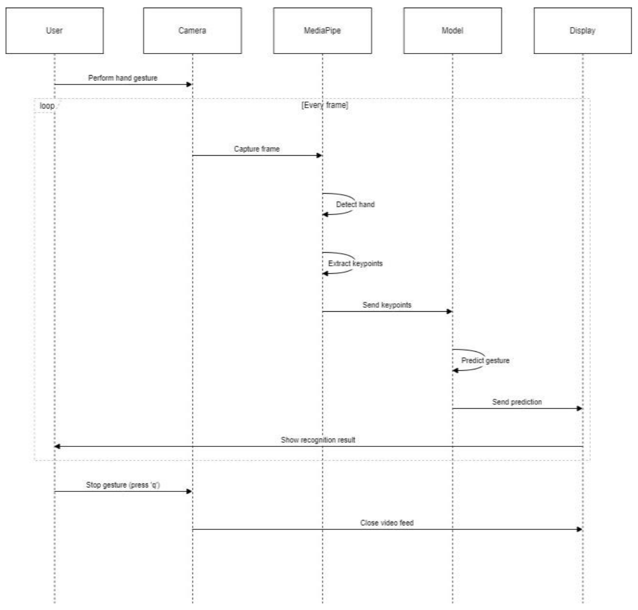


Fig :4.1.4.1 Sequence Diagram

4.1.5 Activity Diagram:

Activity diagrams are graphical representations of workflows of stepwise activitiesand actions with support for choice, iteration and concurrency. In the Unified Modeling Language, activity diagrams can be used to describe the business and operational step-by-step workflows of components in a system. An activity diagram shows the overallflow of control.

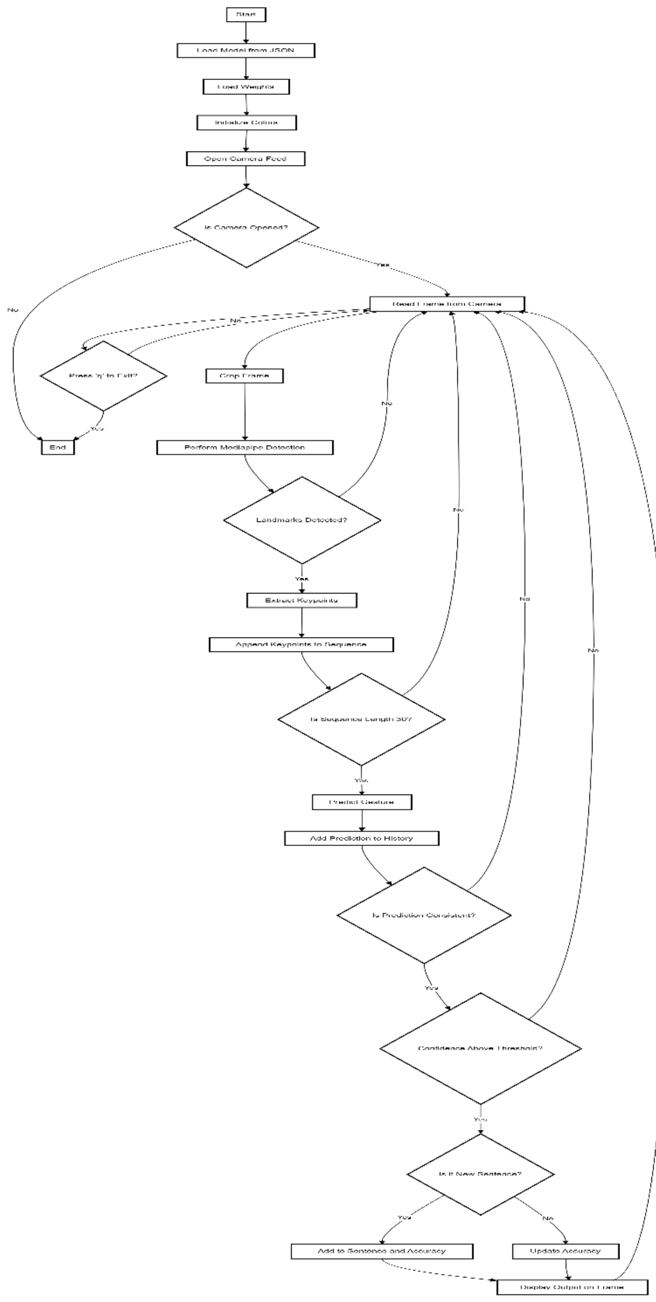


Fig :4.1.5.1 Activity Diagram

4.2 Modules Used in Project :-

TENSORFLOW

A Tensor Flow model is a structured framework used to define, train, and deploy machine learning algorithms, particularly deep learning models. It consists of layers that process input data and adjust weights based on training data to make predictions or classifications. Tensor Flow supports various types of models, including:

1. Sequential Model: A linear stack of layers, suitable for simple, straightforward architectures.

2. Functional API: Allows for more complex architectures with multiple inputs and outputs or shared layers.

3. Model Sub classing: Provides full flexibility to define custom models by sub classing `tf.keras.Model`.

Key Components:

Layer: Building blocks like `Dense`, `Conv2D`, and `LSTM` that process data.

Optimizers: Algorithms like Adam or SGD used to minimize loss functions during training.

Loss Functions: Measures like categorical cross entropy or mean squared error used to evaluate model performance.

Metrics: Metrics such as accuracy or precision that track model performance during training and evaluation.

Training Process:

1. Define Model: Specify the architecture and layers.

2. Compile Model: Set the optimizer, loss function, and metrics.

3. Fit Model: Train the model using training data.

4. Evaluate Model: Assess performance on validation or test data.

Deployment: Models can be saved, loaded, and deployed for real-time inference in various applications, from image classification to natural language processing. Tensor Flow provides tools for optimizing and serving models efficiently..

NUMPY

Numpy` is a crucial library in Python for numerical and scientific computing, providing efficient and versatile tools for working with large arrays and matrices. At its core is the `ndarray`, a powerful N-dimensional array object that supports a wide range of mathematical operations. `Numpy` facilitates complex calculations through its extensive set of functions for arithmetic, statistical analysis, and linear algebra. Its array manipulation capabilities, including reshaping and broadcasting, make it easy to handle and process large datasets. The library is highly optimized for performance, thanks to its underlying implementation in C and FORTRAN. Additionally, `numpy` serves as the foundation for many other scientific libraries, such as `pandas`, `scipy`, and `matplotlib`, enhancing its utility in data science and machine learning. With its broad functionality and efficiency, `numpy` is a fundamental tool in the scientific Python ecosystem.

Open cv

One of the biggest names in computer vision is OpenCV, which stands for Open Source Computer Vision Library. With more than 2500 algorithms, this open-source library is the first choice for developers wishing to include computer vision functionality into their applications. OpenCV, which is maintained by the nonprofit Open Source Computer Vision Foundation, is always changing and enables developers to work on a variety of projects.

OpenCV's ability to handle data in real time is one of its main advantages. This makes it perfect for uses like augmented reality object tracking or gesture recognition that call for instantaneous video processing. The broad range of features offered by OpenCV addresses many facets of computer vision, such as deep learning, object and face detection, picture and video editing, and more.

With support for multiple programming languages, including Python, C++, and Java, OpenCV is user-friendly for programmers. This makes it simpler for developers to include OpenCV into their applications by letting them select the language in which they are most comfortable. Furthermore, OpenCV has a sizable and vibrant community that offers a plethora of resources at developers' disposal in the form of comprehensive documentation, tutorials, and forums.

OpenCV is an invaluable tool to have in your toolbox, regardless of your experience level as a developer or where you are in the process of learning computer vision. Because of its extensive feature set, community support, and open-source nature, it's a great option for developing creative and potent computer vision applications**.**

5 IMPLEMENTATION AND RESULTS

5.1METHOD OF IMPLEMENTATION

5.1.1What is Python :-

Python is currently the most widely used multi-purpose, high-level programming language.Python allows programming in Object-Oriented and Procedural paradigms. Python programs generally are smaller than other programming languages like Java. Programmers have to type relatively less and indentation requirement of the language, makes them readable all the time. Python language is being used by almost all tech-giant companies like – Google, Amazon, Facebook, Instagram, Dropbox, Uber… etc.

The biggest strength of Python is huge collection of standard library which can be used for the following – Machine Learning GUI Applications (like Kivy, Tkinter, PyQt etc.) Web frameworks like Django (used by YouTube, Instagram, Dropbox) Image processing (like Opencv, Pillow) Web scraping (like Scrapy, BeautifulSoup, Selenium) Test frameworks Multimedia

Python

Python is an interpreted high-level programming language for general-purpose programming. Created by Guido van Rossum and first released in 1991, Python has a design philosophy that emphasizes code readability, notably using significant whitespace. Python features a dynamic type system and automatic memory management. It supports multiple programming paradigms, including object-oriented, imperative, functional and procedural, and has a large and comprehensive standard library.

Python is Interpreted − Python is processed at runtime by the interpreter. You do not need to compile your program before executing it. This is similar to PERL and PHP.

Python is Interactive − you can actually sit at a Python prompt and interact with the interpreter directly to write your programs.

Python also acknowledges that speed of development is important. Readable and terse code is part of this, and so is access to powerful constructs that avoid tedious repetition of code. Maintainability also ties into this may be an all but useless metric, but it does say something about how much code you have to scan, read and/or the ease with which a programmer of other languages can pick up basic Python skills and the huge standard library is key to another area where Python excels. All its tools have been quick to implement, saved a lot of time, and several of them have later been patched and updated by people with no Python background - without breaking.

Install Python Step-by-Step in Windows and Mac :

Python a versatile programming language doesn't come pre-installed on your computer devices. Python was first released in the year 1991 and until today it is a very popular high- level programming language. Its style philosophy emphasizes code readability with its notable use of great whitespace.

The object-oriented approach and language construct provided by Python enables programmers to write both clear and logical code for projects. This software does not come pre-packaged with Windows.

How to Install Python on Windows and Mac :

There have been several updates in the Python version over the years. The question is how to install Python? It might be confusing for the beginner who is willing to start learning Python but this tutorial will solve your query. The latest or the newest version of Python is version 3.7.4 or in other words, it is Python 3.

Note: The python version 3.7.4 cannot be used on Windows XP or earlier devices. Before you start with the installation process of Python. First, you need to know about your **System Requirements**. Based on your system type i.e. operating system and based processor, you must download the python version. My system type is a **Windows 64-bit Operating system.**

So the steps below are to install python version 3.7.4 on Windows 7 device or to install Python 3. Download the Python Cheatsheet here.The steps on how to install Python on Windows 10, 8 and 7 are **divided into 4 parts** to help understand better.

Step 1: Go to the official site to download and install python using Google Chrome or any other web browser. OR Click on the following link: **https://www.python.org**

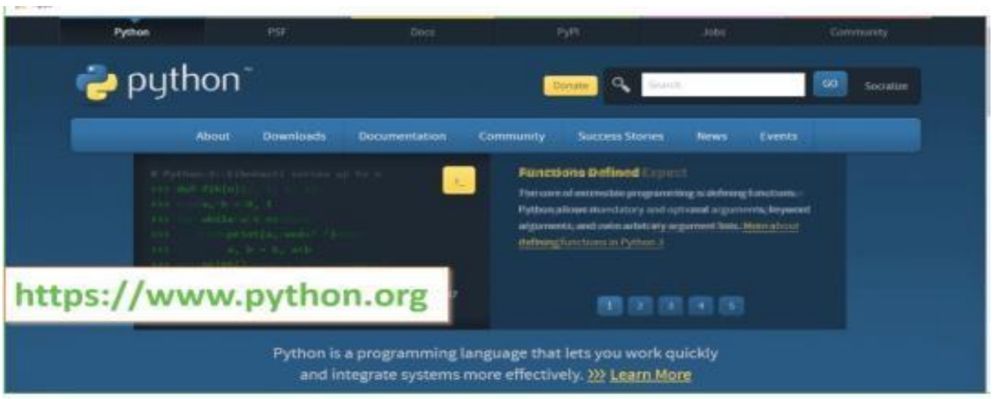
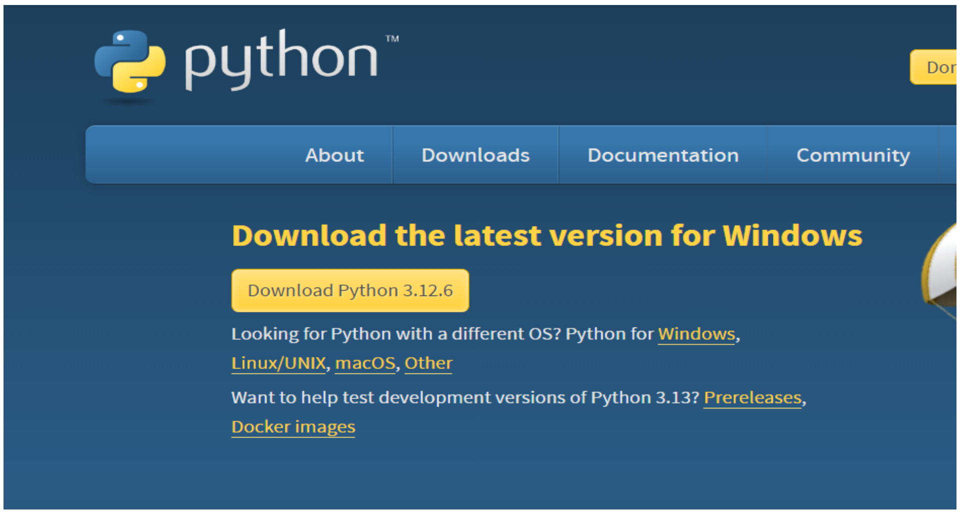


Fig 5.1.1.1: Download Python

Now, check for the latest and the correct version for your operating system.

Step 2: Click on the Download Tab.

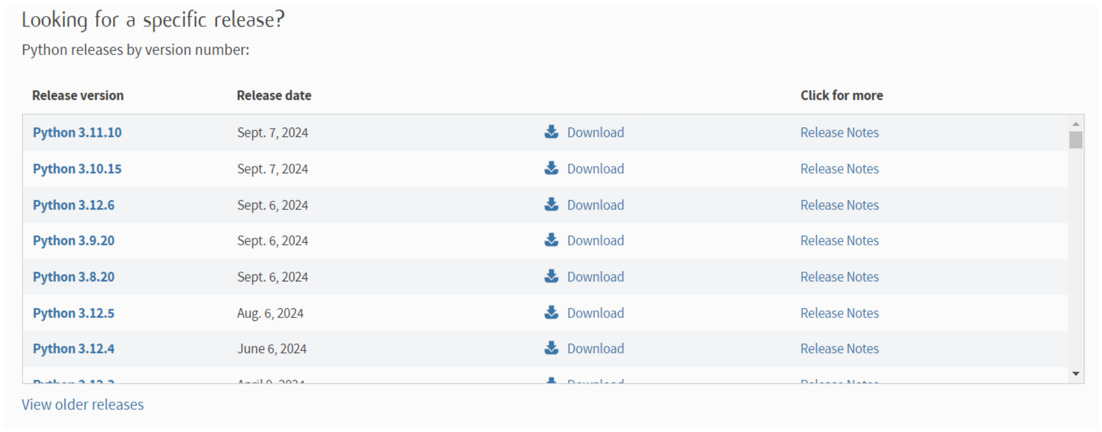


Looking for Python with a different OS? Python for Windows, Linux/UNIX, macOS, Other

Want to help test development versions of Python 3.13? Prereleases, Docker images

Fig 5.1.1.2: Python 3.7.4

Step 3: You can either select the Download Python for windows 3.7.4 button in Yellow Color or you can scroll further down and click on download with respective to their version. Here, we are downloading the most recent python version for windows 3.7.4



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Python releases by version number:

Release version	Release date		Click for more
Python 3.11.10	Sept. 7, 2024	Download	Release Notes
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Python 3.8.20	Sept. 6, 2024	Download	Release Notes
Python 3.12.5	Aug. 6, 2024	Download	Release Notes
Python 3.12.4	June 6, 2024	Download	Release Notes

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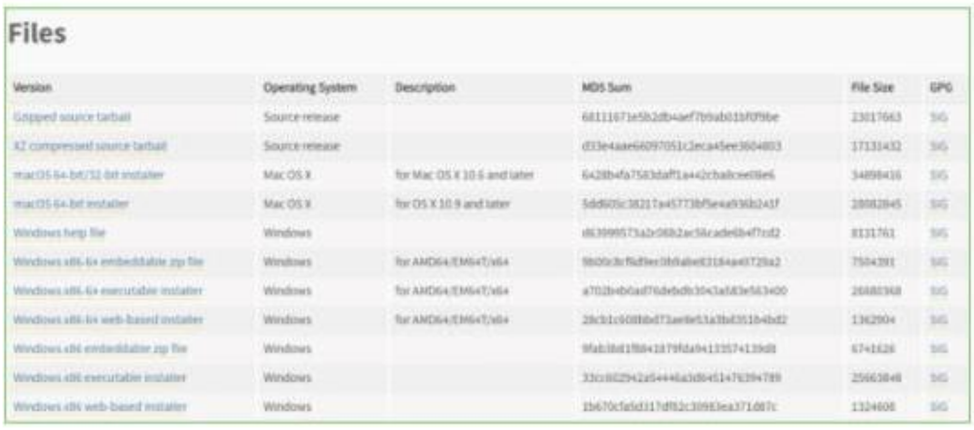
Fig 5.1.1.3: Specific Release

Step 4: Scroll down the page until you find the Files option.

Step 5: Here you see a different version of python along with the operating system.



Files

Version	Operating System	Description	MD5 Sum	File Size	GPG
Gzipped source tarball	Source release		68111671e5b2db4aef7b9ab01bf0f9be	23017663	SIG
XZ compressed source tarball	Source release		d33e4aae66097051c2eca45ee3604803	17131432	SIG
macOS 64-bit/32-bit installer	Mac OS X	for Mac OS X 10.6 and later	6428b4fa7583daff1a442cba8cee08e6	34898416	SIG
macOS 64-bit installer	Mac OS X	for OS X 10.9 and later	5dd605c38217a45773bf5e4a936b241f	28082845	SIG
Windows help file	Windows		d63999573a2c06b2ac56cade6b4f7cd2	8131761	SIG
Windows x86-64 embeddable zip file	Windows	for AMD64/EM64T/x64	9b00c8cf6d9ec0b9abe83184a40729a2	7504391	SIG
Windows x86-64 executable installer	Windows	for AMD64/EM64T/x64	a702b4b0ad76debdb3043a583e563400	26680368	SIG
Windows x86-64 web-based installer	Windows	for AMD64/EM64T/x64	28cb1c608bbd73ae8e53a3bd351b4bd2	1362904	SIG
Windows x86 embeddable zip file	Windows		9fab3b81f8841879fda94133574139d8	6741626	SIG
Windows x86 executable installer	Windows		33cc602942a54446a3d6451476394789	25663848	SIG
Windows x86 web-based installer	Windows		1b670cfa5d317df82c30983ea371d87c	1324608	SIG

Fig 5.1.1.4: Files

To download Windows 32-bit python, you can select any one from the three options: Windows x86 embeddable zip file, Windows x86 executable installer or Windows x86 web-based installer. To download Windows 64-bit python, you can select any one from thethree options: Windows x86-64 embeddable zip file, Windows x86-64 executable installeror Windows x86-64 web-based installer.

we will install Windows x86-64 web-based installer. Here your first part regarding which version of python is to be downloaded is completed. Now we move ahead with thesecond part in installing python i.e. Installation

Note: To know the changes or updates that are made in the version you can click on theRelease Note Option.

Installation of Python

Step 1: Go to Download and Open the downloaded python version to carry out theinstallation process.

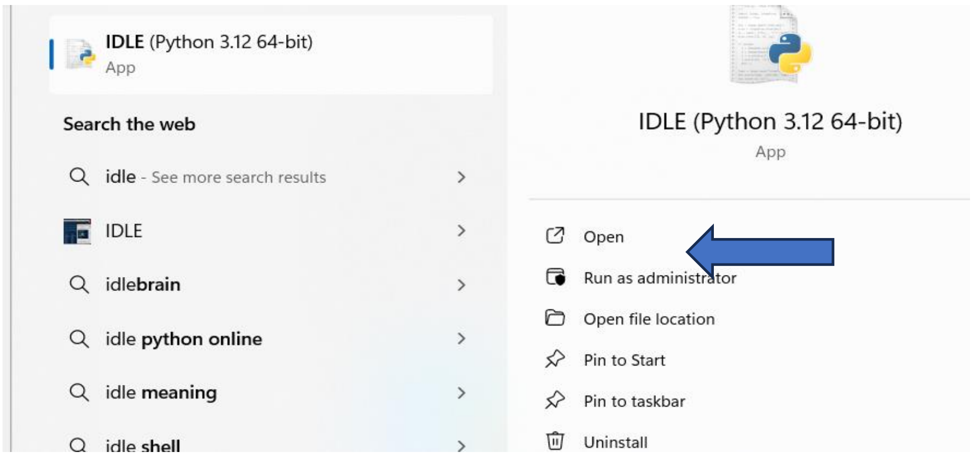
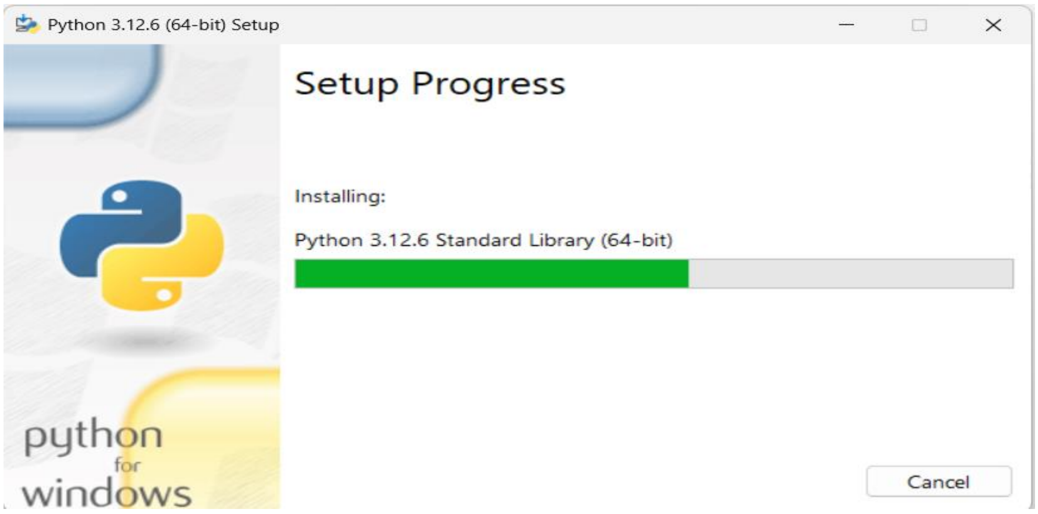


Fig 5.1.1.5: Open Python 3.12.6

Step 2: Before you click on Install Now, Make sure to put a tick on Add Python 3.7 to PATH.


Python 3.12.6 (64-bit) Setup

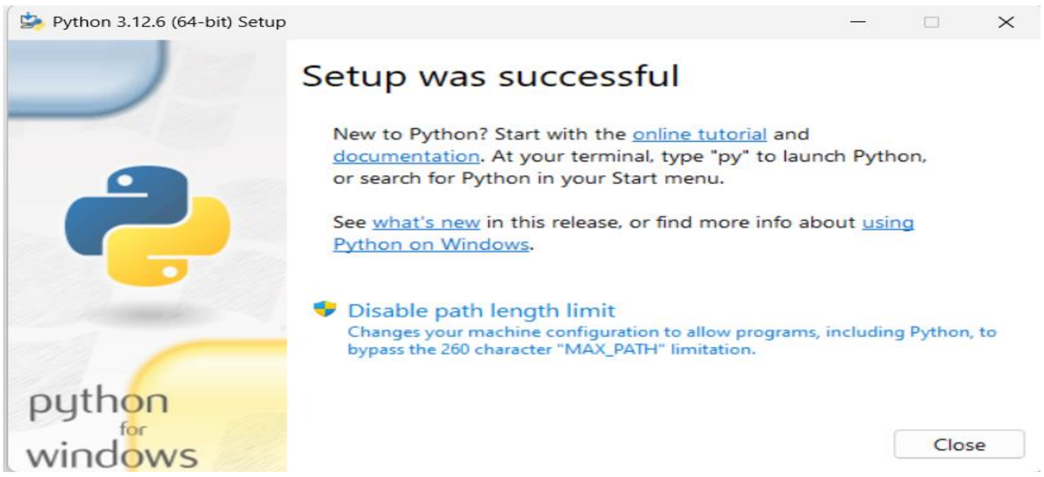
Setup Progress

Installing:

Python 3.12.6 Standard Library (64-bit)

Fig 5.1.1.6: Install Python 3.7.4

Step 3: Click on Install NOW After the installation is successful. Click on Close.


Python 3.12.6 (64-bit) Setup

Setup was successful

New to Python? Start with the online tutorial and documentation. At your terminal, type "py" to launch Python, or search for Python in your Start menu.

See what's new in this release, or find more info about using Python on Windows.

Disable path length limit
Changes your machine configuration to allow programs, including Python, to bypass the 260 character "MAX_PATH" limitation.

Fig 5.1.1.7: Installed Successfully

With these above three steps on python installation, you have successfully and correctly installed Python. Now is the time to verify the installation.

Note: The installation process might take a couple of minutes.

Verify the Python Installation

Step 1: Click on Start

Step 2: In the Windows Run Command, type “cmd”.

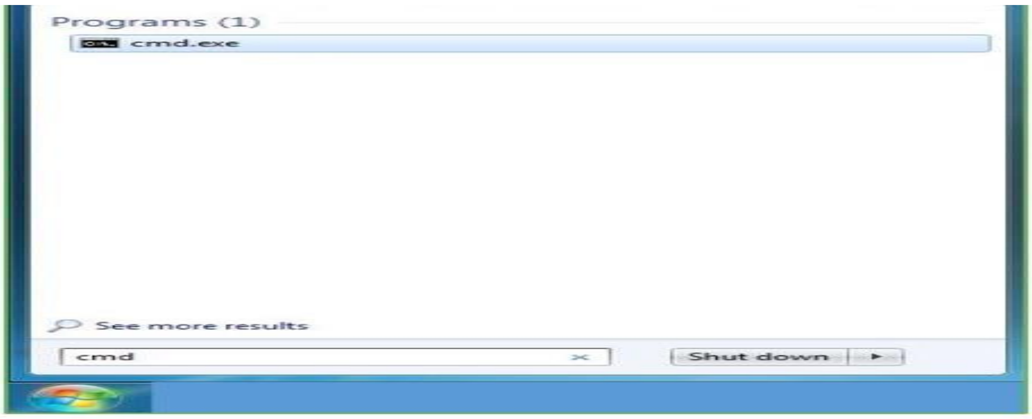
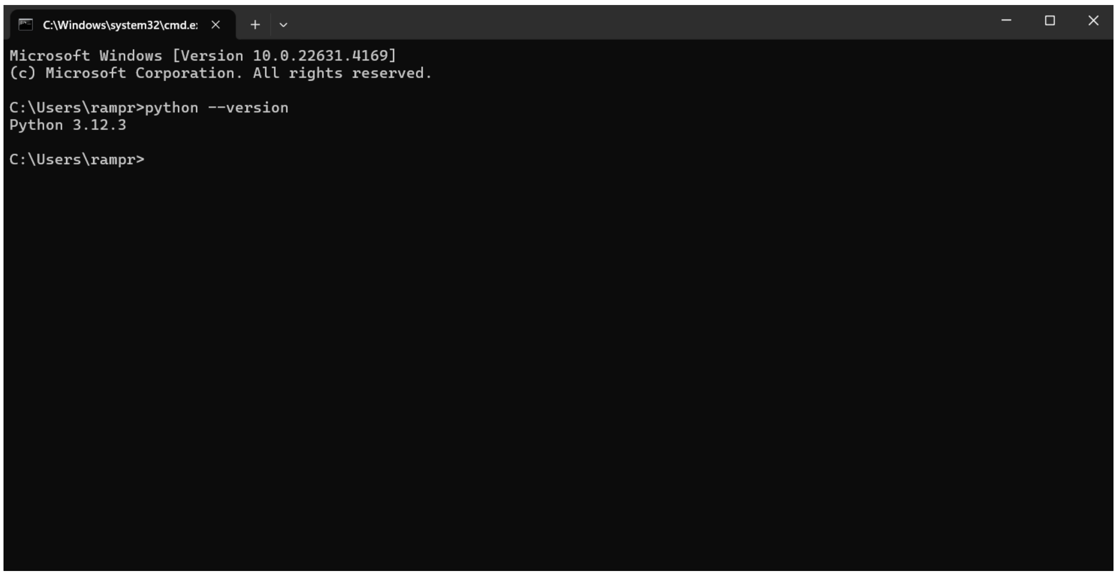


Fig 5.1.1.8: Select Command Prompt

Step 3: Open the Command prompt option.

Step 4: Let us test whether the python is correctly installed. Type **python –V** and pressEnter.



```
Microsoft Windows [Version 10.0.22631.4169]
(c) Microsoft Corporation. All rights reserved.

C:\Users\rampr>python --version
Python 3.12.3

C:\Users\rampr>
```

Fig 5.1.1.9: Search Python Version

Step 5: You will get the answer as 3.12.6

Note: If you have any of the earlier versions of Python already installed. You must firstuninstall the earlier version and then install the new one.

Check how the Python IDLE works

Step 1: Click on Start

Step 2: In the Windows Run command, type "python idle".

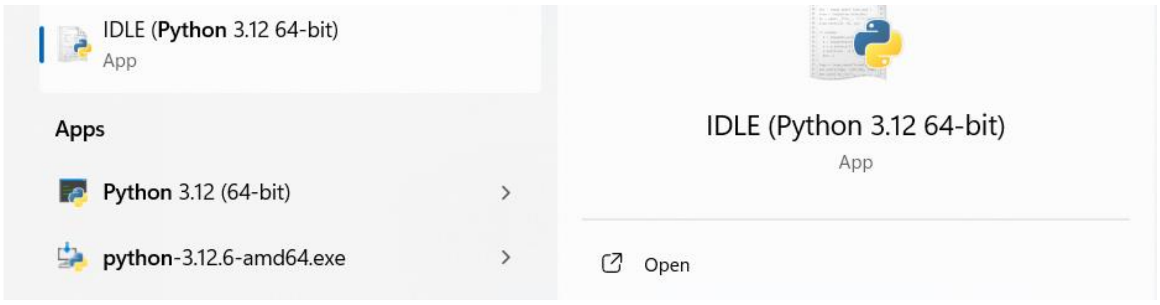
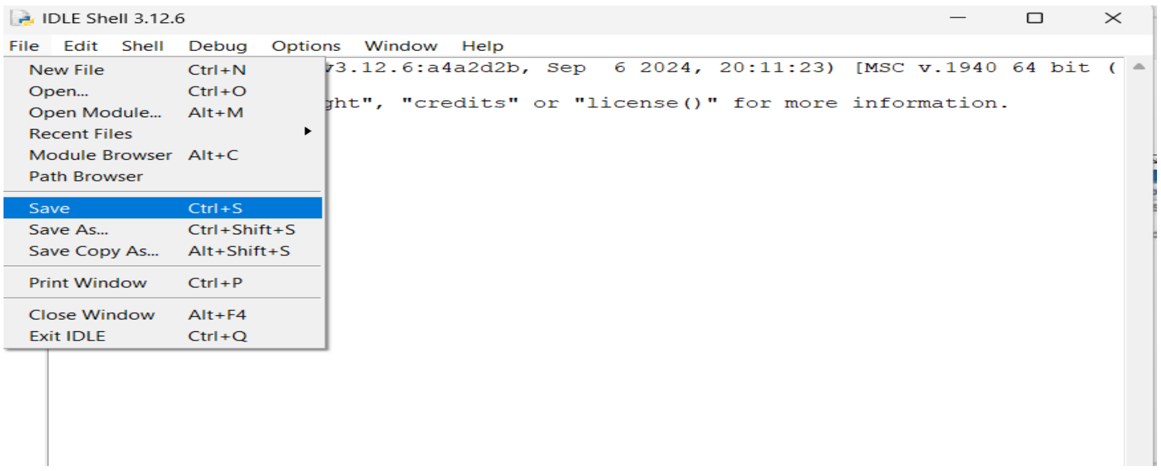


Fig 5.1.1.10: Idle Python 3.12.64



```
v3.12.6:a4a2d2b, Sep  6 2024, 20:11:23) [MSC v.1940 64 bit (
ght", "credits" or "license()" for more information.
```

Fig 5.1.1.11: Save The File

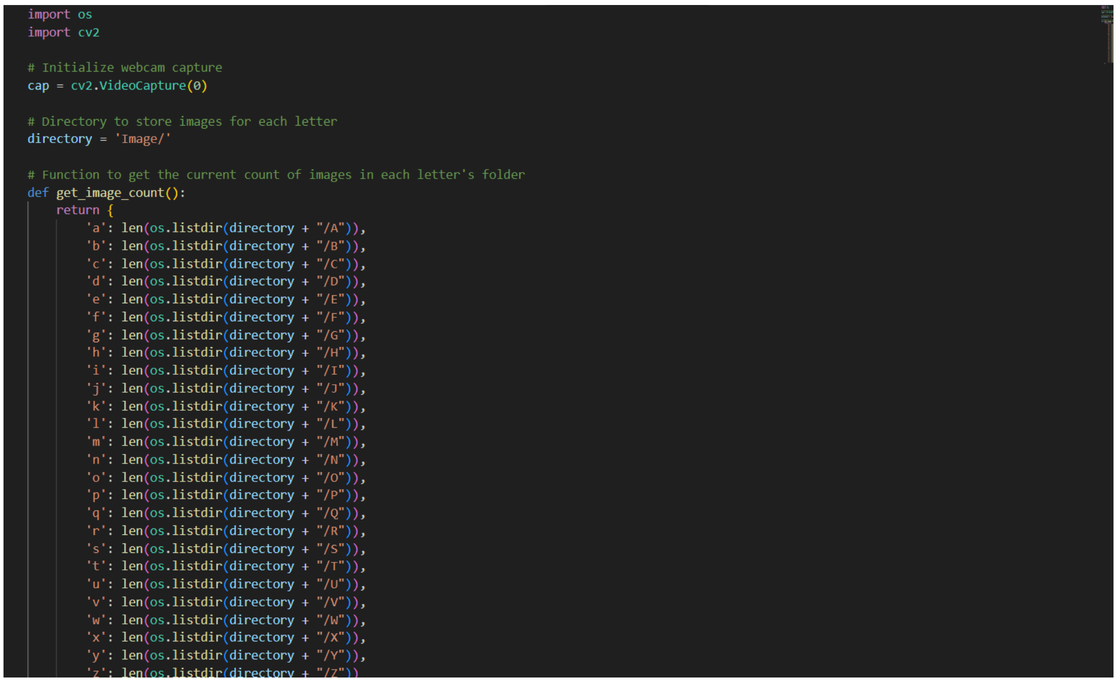
Step 5: Name the file and save as type should be Python files. Click on SAVE. Here I havenamed the files as Hey World.

Step 6: Now for e.g. **enter print.**

5.2 EXTENSION OF KEY FUNCTION:

5.2.0 Initialization and Setup

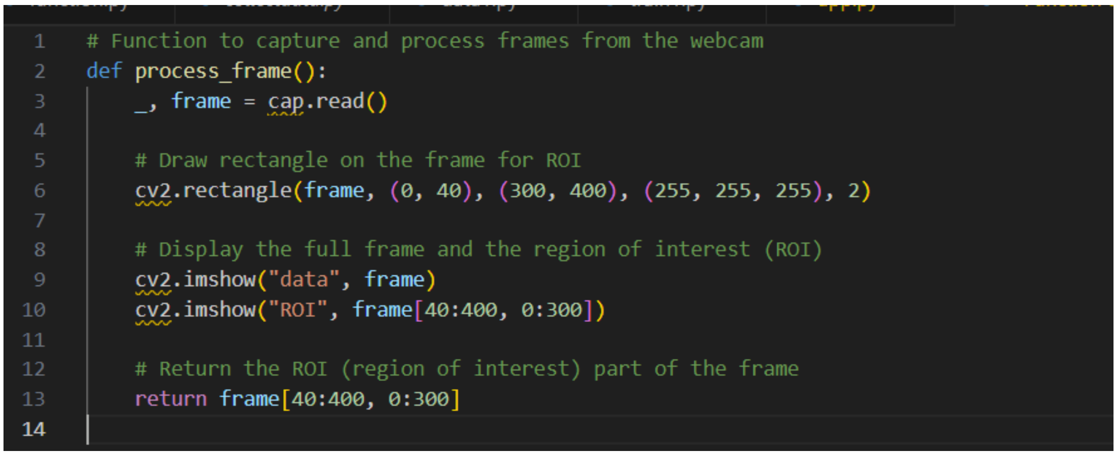
This part initializes the webcam, defines the directory structure, and sets up the image count for each alphabet letter.



```python
import os
import cv2

# Initialize webcam capture
cap = cv2.VideoCapture(0)

# Directory to store images for each letter
directory = 'Image/'

# Function to get the current count of images in each letter's folder
def get_image_count():
    return {
        'a': len(os.listdir(directory + "/A")),
        'b': len(os.listdir(directory + "/B")),
        'c': len(os.listdir(directory + "/C")),
        'd': len(os.listdir(directory + "/D")),
        'e': len(os.listdir(directory + "/E")),
        'f': len(os.listdir(directory + "/F")),
        'g': len(os.listdir(directory + "/G")),
        'h': len(os.listdir(directory + "/H")),
        'i': len(os.listdir(directory + "/I")),
        'j': len(os.listdir(directory + "/J")),
        'k': len(os.listdir(directory + "/K")),
        'l': len(os.listdir(directory + "/L")),
        'm': len(os.listdir(directory + "/M")),
        'n': len(os.listdir(directory + "/N")),
        'o': len(os.listdir(directory + "/O")),
        'p': len(os.listdir(directory + "/P")),
        'q': len(os.listdir(directory + "/Q")),
        'r': len(os.listdir(directory + "/R")),
        's': len(os.listdir(directory + "/S")),
        't': len(os.listdir(directory + "/T")),
        'u': len(os.listdir(directory + "/U")),
        'v': len(os.listdir(directory + "/V")),
        'w': len(os.listdir(directory + "/W")),
        'x': len(os.listdir(directory + "/X")),
        'y': len(os.listdir(directory + "/Y")),
        'z': len(os.listdir(directory + "/Z"))
```

Frame Processing and Display

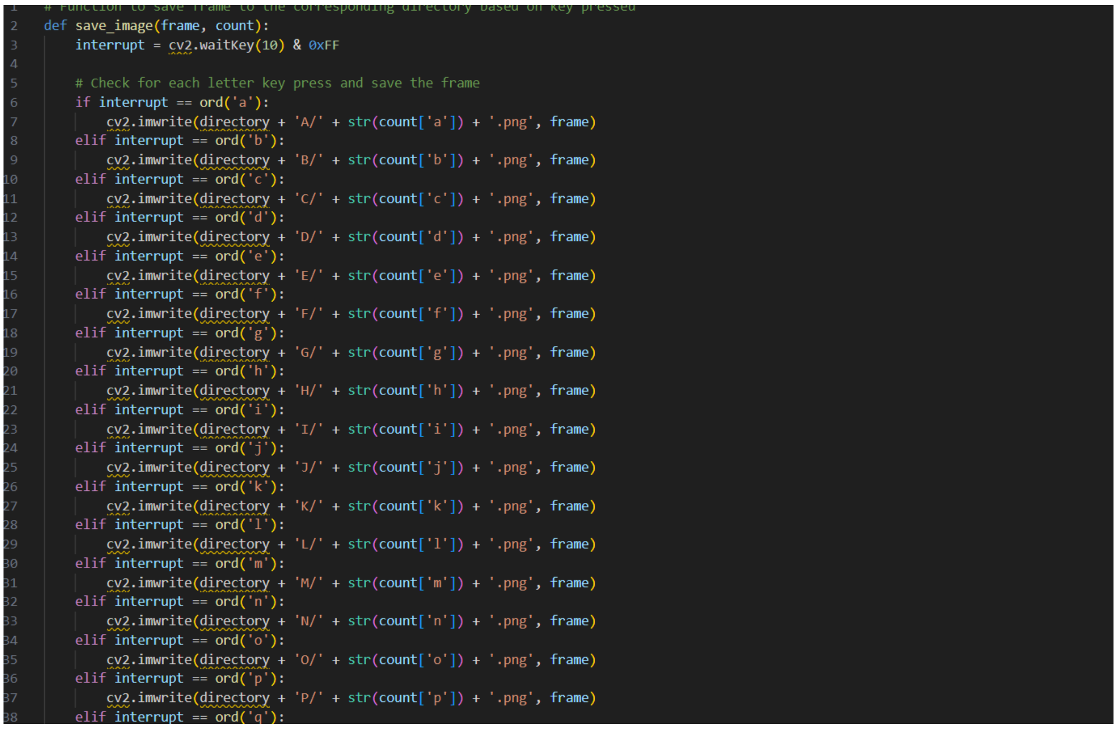
This part captures frames from the webcam, processes the region of interest (ROI), and displays the frames in a window.



```python
# Function to capture and process frames from the webcam
def process_frame():
    _, frame = cap.read()

    # Draw rectangle on the frame for ROI
    cv2.rectangle(frame, (0, 40), (300, 400), (255, 255, 255), 2)

    # Display the full frame and the region of interest (ROI)
    cv2.imshow("data", frame)
    cv2.imshow("ROI", frame[40:400, 0:300])

    # Return the ROI (region of interest) part of the frame
    return frame[40:400, 0:300]

```

Saving Images Based on Key Press

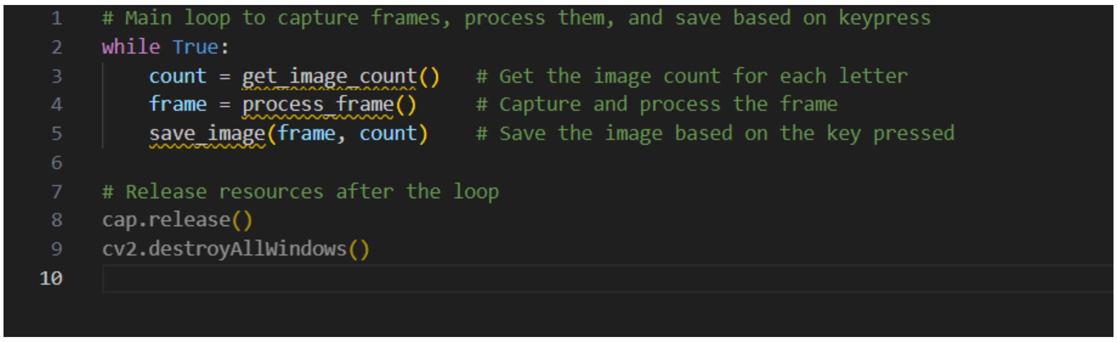
This part listens for specific key presses, saves the frame into the corresponding directory for each letter, and increments the image count.



```python
# Function to save frame to the corresponding directory based on key pressed
def save_image(frame, count):
    interrupt = cv2.waitKey(10) & 0xFF

    # Check for each letter key press and save the frame
    if interrupt == ord('a'):
        cv2.imwrite(directory + 'A/' + str(count['a']) + '.png', frame)
    elif interrupt == ord('b'):
        cv2.imwrite(directory + 'B/' + str(count['b']) + '.png', frame)
    elif interrupt == ord('c'):
        cv2.imwrite(directory + 'C/' + str(count['c']) + '.png', frame)
    elif interrupt == ord('d'):
        cv2.imwrite(directory + 'D/' + str(count['d']) + '.png', frame)
    elif interrupt == ord('e'):
        cv2.imwrite(directory + 'E/' + str(count['e']) + '.png', frame)
    elif interrupt == ord('f'):
        cv2.imwrite(directory + 'F/' + str(count['f']) + '.png', frame)
    elif interrupt == ord('g'):
        cv2.imwrite(directory + 'G/' + str(count['g']) + '.png', frame)
    elif interrupt == ord('h'):
        cv2.imwrite(directory + 'H/' + str(count['h']) + '.png', frame)
    elif interrupt == ord('i'):
        cv2.imwrite(directory + 'I/' + str(count['i']) + '.png', frame)
    elif interrupt == ord('j'):
        cv2.imwrite(directory + 'J/' + str(count['j']) + '.png', frame)
    elif interrupt == ord('k'):
        cv2.imwrite(directory + 'K/' + str(count['k']) + '.png', frame)
    elif interrupt == ord('l'):
        cv2.imwrite(directory + 'L/' + str(count['l']) + '.png', frame)
    elif interrupt == ord('m'):
        cv2.imwrite(directory + 'M/' + str(count['m']) + '.png', frame)
    elif interrupt == ord('n'):
        cv2.imwrite(directory + 'N/' + str(count['n']) + '.png', frame)
    elif interrupt == ord('o'):
        cv2.imwrite(directory + 'O/' + str(count['o']) + '.png', frame)
    elif interrupt == ord('p'):
        cv2.imwrite(directory + 'P/' + str(count['p']) + '.png', frame)
    elif interrupt == ord('q'):
```

Main Loop

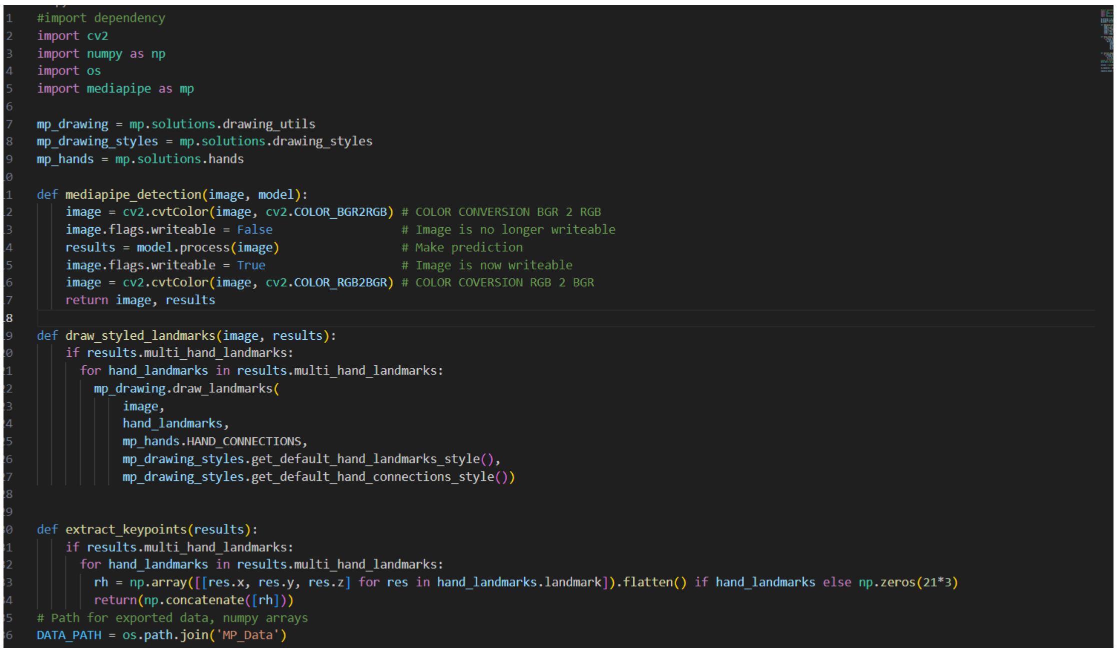
This part is responsible for continuously capturing frames, processing them, and saving them based on the user input.



```python
# Main loop to capture frames, process them, and save based on keypress
while True:
    count = get_image_count()    # Get the image count for each letter
    frame = process_frame()      # Capture and process the frame
    save_image(frame, count)     # Save the image based on the key pressed

# Release resources after the loop
cap.release()
cv2.destroyAllWindows()

```

MediaPipe Hand Detection and Keypoint Extraction

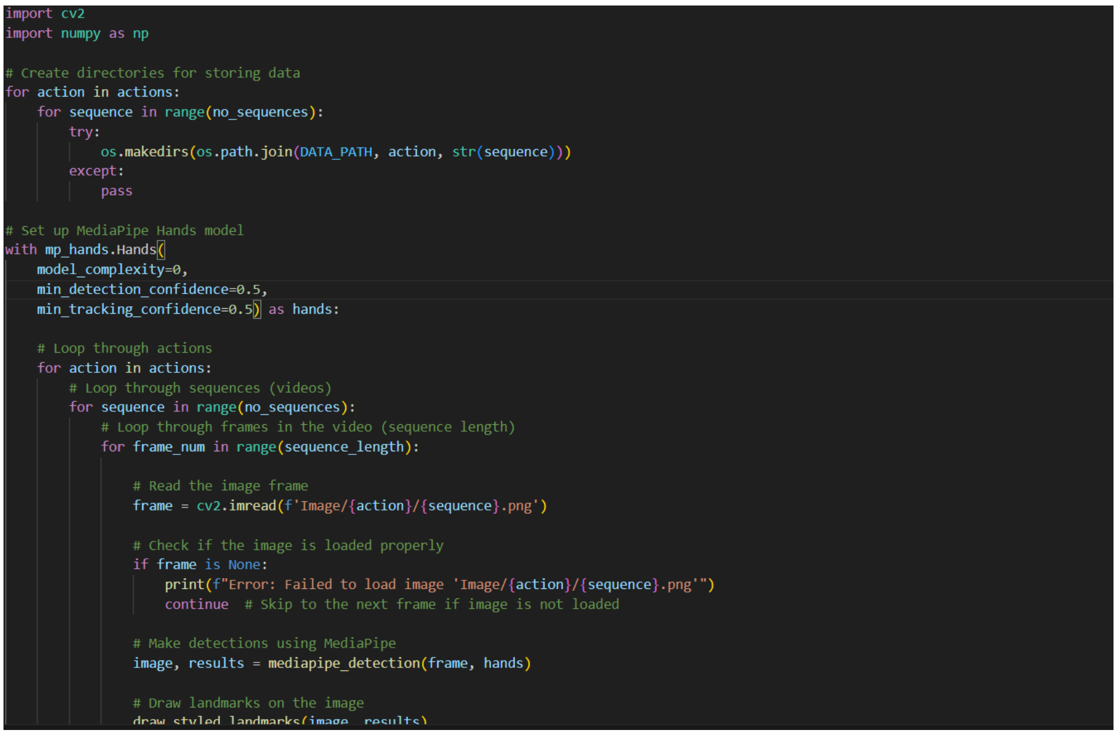
This script sets up a MediaPipe-based hand detection pipeline. It imports necessary libraries, including mediapipe for hand detection and cv2 for image processing. The mediapipe_detection function processes images to detect hands and landmarks. The draw_styled_landmarks function visualizes the detected hand landmarks, while extract_keypoints extracts the hand keypoints, which are used for gesture recognition. Additionally, paths are set up for storing the extracted data as numpy arrays, which are categorized into different actions ('A' to 'Z'). Parameters like no_sequences and sequence_length define the number of sequences per action and the number of frames per sequence.



```python
#import dependency
import cv2
import numpy as np
import os
import mediapipe as mp

mp_drawing = mp.solutions.drawing_utils
mp_drawing_styles = mp.solutions.drawing_styles
mp_hands = mp.solutions.hands

def mediapipe_detection(image, model):
    image = cv2.cvtColor(image, cv2.COLOR_BGR2RGB) # COLOR CONVERSION BGR 2 RGB
    image.flags.writeable = False                  # Image is no longer writeable
    results = model.process(image)                 # Make prediction
    image.flags.writeable = True                   # Image is now writeable
    image = cv2.cvtColor(image, cv2.COLOR_RGB2BGR) # COLOR COVERSION RGB 2 BGR
    return image, results

def draw_styled_landmarks(image, results):
    if results.multi_hand_landmarks:
      for hand_landmarks in results.multi_hand_landmarks:
        mp_drawing.draw_landmarks(
            image,
            hand_landmarks,
            mp_hands.HAND_CONNECTIONS,
            mp_drawing_styles.get_default_hand_landmarks_style(),
            mp_drawing_styles.get_default_hand_connections_style())


def extract_keypoints(results):
    if results.multi_hand_landmarks:
      for hand_landmarks in results.multi_hand_landmarks:
        rh = np.array([[res.x, res.y, res.z] for res in hand_landmarks.landmark]).flatten() if hand_landmarks else np.zeros(21*3)
        return(np.concatenate([rh]))
# Path for exported data, numpy arrays
DATA_PATH = os.path.join('MP_Data')
```

Data Collection and Keypoint Export

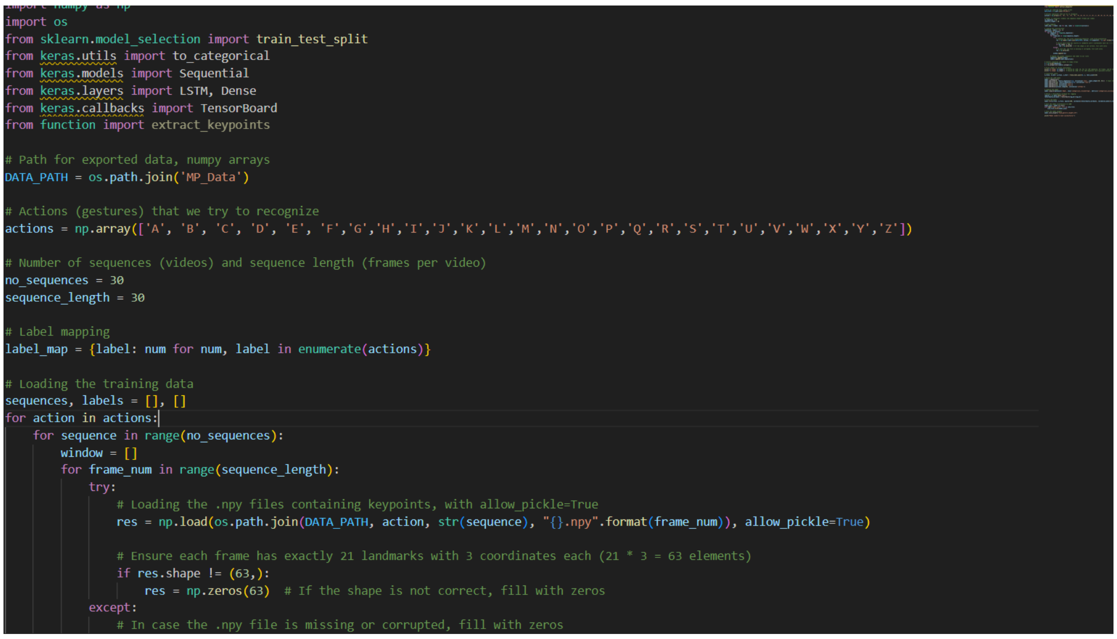
This script collects hand gesture data using MediaPipe's hand detection model and saves the keypoints in .npy files for training. It creates directories for each action and sequence. The mediapipe_detection function processes video frames, and the keypoints are extracted using extract_keypoints. For each action, 30 frames per sequence are processed, and corresponding landmarks are drawn on the frames. These keypoints are then saved in .npy format. The model visually displays feedback during data collection and handles exceptions like missing images. The collected data forms the foundation for training a gesture recognition model.



```python
import cv2
import numpy as np

# Create directories for storing data
for action in actions:
    for sequence in range(no_sequences):
        try:
            os.makedirs(os.path.join(DATA_PATH, action, str(sequence)))
        except:
            pass

# Set up MediaPipe Hands model
with mp_hands.Hands(
    model_complexity=0,
    min_detection_confidence=0.5,
    min_tracking_confidence=0.5) as hands:

    # Loop through actions
    for action in actions:
        # Loop through sequences (videos)
        for sequence in range(no_sequences):
            # Loop through frames in the video (sequence length)
            for frame_num in range(sequence_length):

                # Read the image frame
                frame = cv2.imread(f'Image/{action}/{sequence}.png')

                # Check if the image is loaded properly
                if frame is None:
                    print(f"Error: Failed to load image 'Image/{action}/{sequence}.png'")
                    continue  # Skip to the next frame if image is not loaded

                # Make detections using MediaPipe
                image, results = mediapipe_detection(frame, hands)

                # Draw landmarks on the image
                draw_styled_landmarks(image, results)
```

LSTM Model Training for Gesture Recognition

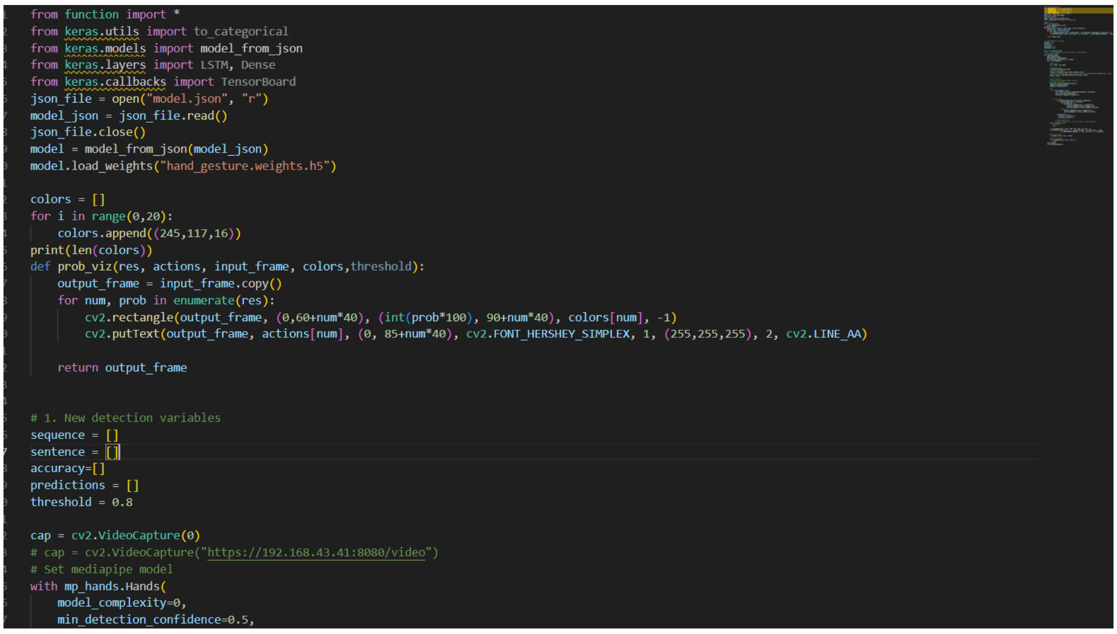
This script loads the saved hand keypoints and trains a deep learning model using LSTM (Long Short-Term Memory) layers to classify hand gestures. The data is split into training and testing sets. The LSTM model captures temporal patterns in the sequences of keypoints, followed by dense layers to refine the classification. The model is compiled with categorical cross-entropy loss and trained for 200 epochs. A TensorBoard callback is used for logging, and the trained model is saved in JSON and .h5 formats for future use in gesture recognition tasks.



```python
import numpy as np
import os
from sklearn.model_selection import train_test_split
from keras.utils import to_categorical
from keras.models import Sequential
from keras.layers import LSTM, Dense
from keras.callbacks import TensorBoard
from function import extract_keypoints

# Path for exported data, numpy arrays
DATA_PATH = os.path.join('MP_Data')

# Actions (gestures) that we try to recognize
actions = np.array(['A', 'B', 'C', 'D', 'E', 'F','G','H','I','J','K','L','M','N','O','P','Q','R','S','T','U','V','W','X','Y','Z'])

# Number of sequences (videos) and sequence length (frames per video)
no_sequences = 30
sequence_length = 30

# Label mapping
label_map = {label: num for num, label in enumerate(actions)}

# Loading the training data
sequences, labels = [], []
for action in actions:
    for sequence in range(no_sequences):
        window = []
        for frame_num in range(sequence_length):
            try:
                # Loading the .npy files containing keypoints, with allow_pickle=True
                res = np.load(os.path.join(DATA_PATH, action, str(sequence), "{}.npy".format(frame_num)), allow_pickle=True)

                # Ensure each frame has exactly 21 landmarks with 3 coordinates each (21 * 3 = 63 elements)
                if res.shape != (63,):
                    res = np.zeros(63)  # If the shape is not correct, fill with zeros
            except:
                # In case the .npy file is missing or corrupted, fill with zeros
```

Real-Time Hand Gesture Recognition

This code implements real-time hand gesture recognition using a pre-trained LSTM model with Keras and OpenCV. It begins by loading the model architecture and weights from JSON and H5 files. Using the webcam, it captures video frames and processes them with MediaPipe to detect hand landmarks. The extracted keypoints are fed into the LSTM model for gesture prediction. If the model's confidence exceeds a set threshold, the predicted gesture is displayed along with its accuracy. The output is shown on the screen in real-time, and the program allows for graceful termination with the 'q' key.



```python
from function import *
from keras.utils import to_categorical
from keras.models import model_from_json
from keras.layers import LSTM, Dense
from keras.callbacks import TensorBoard
json_file = open("model.json", "r")
model_json = json_file.read()
json_file.close()
model = model_from_json(model_json)
model.load_weights("hand_gesture.weights.h5")

colors = []
for i in range(0,20):
    colors.append((245,117,16))
print(len(colors))
def prob_viz(res, actions, input_frame, colors,threshold):
    output_frame = input_frame.copy()
    for num, prob in enumerate(res):
        cv2.rectangle(output_frame, (0,60+num*40), (int(prob*100), 90+num*40), colors[num], -1)
        cv2.putText(output_frame, actions[num], (0, 85+num*40), cv2.FONT_HERSHEY_SIMPLEX, 1, (255,255,255), 2, cv2.LINE_AA)

    return output_frame


# 1. New detection variables
sequence = []
sentence = []
accuracy=[]
predictions = []
threshold = 0.8

cap = cv2.VideoCapture(0)
# cap = cv2.VideoCapture("https://192.168.43.41:8080/video")
# Set mediapipe model
with mp_hands.Hands(
    model_complexity=0,
    min_detection_confidence=0.5,
```

Test Code For Real-Time Gesture Recognition with LSTM and MediaPipe Hand Tracking

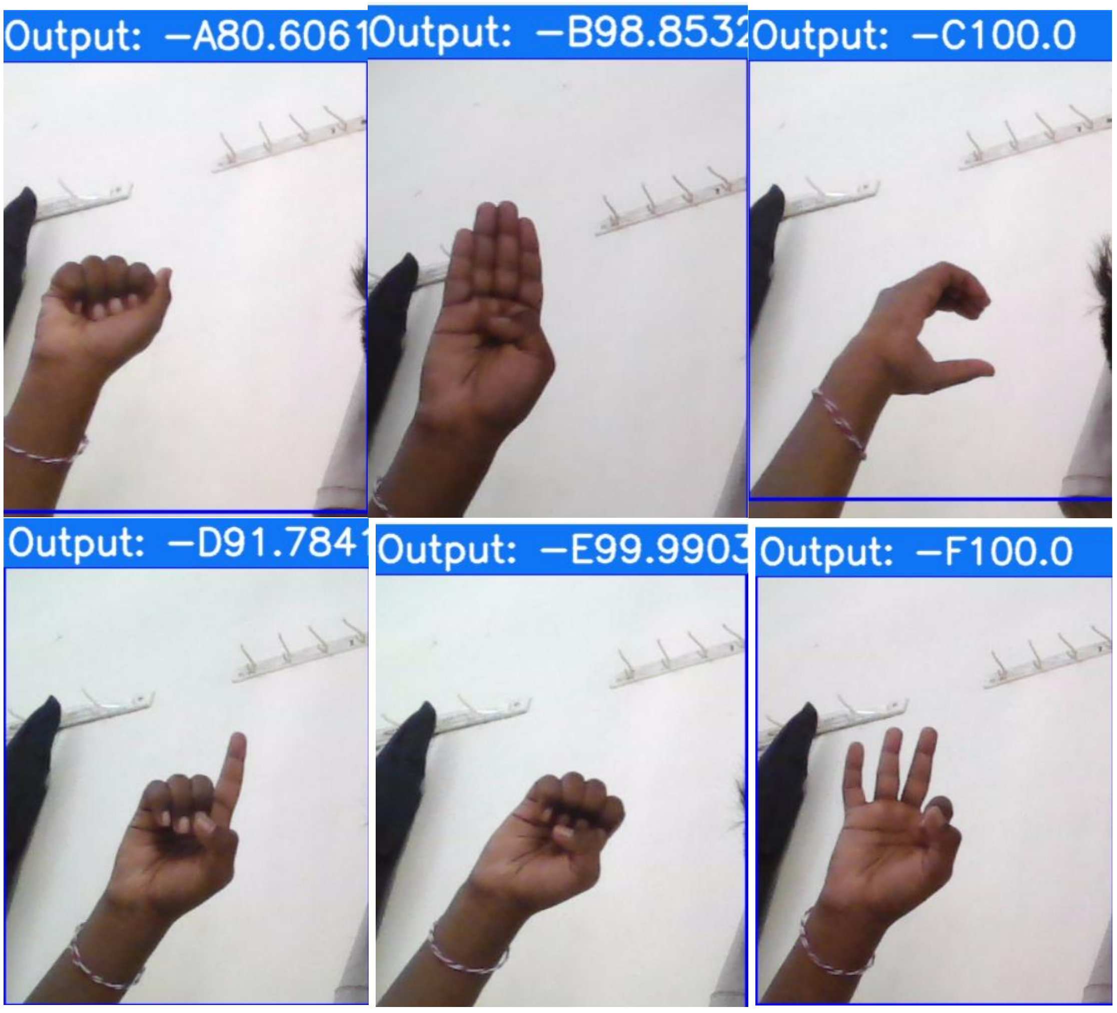
```
from function import *

from keras.utils import to_categorical

from keras.models import model_from_json

from keras.layers import LSTM, Dense

from keras.callbacks import TensorBoard

json_file = open("model.json", "r")

model_json = json_file.read()

json_file.close()

model = model_from_json(model_json)

model.load_weights("hand_gesture.weights.h5")


colors = []

for i in range(0,20):

   colors.append((245,117,16))

print(len(colors))

def prob_viz(res, actions, input_frame, colors,threshold):

   output_frame = input_frame.copy()

   for num, prob in enumerate(res):

          cv2.rectangle(output_frame, (0,60+num*40), (int(prob*100), 90+num*40), colors[num], -1)

                 cv2.putText(output_frame, actions[num], (0, 85+num*40), cv2.FONT_HERSHEY_SIMPLEX, 1, (255,255,255), 2, cv2.LINE_AA)
```

```
    return output_frame


# 1. New detection variables

sequence = []

sentence = []

accuracy=[]

predictions = []

threshold = 0.8


cap = cv2.VideoCapture(0)

# cap = cv2.VideoCapture("https://192.168.43.41:8080/video")

# Set mediapipe model

with mp_hands.Hands(

    model_complexity=0,

    min_detection_confidence=0.5,

    min_tracking_confidence=0.5) as hands:

    while cap.isOpened():


        # Read feed

        ret, frame = cap.read()


        # Make detections

        cropframe=frame[40:400,0:300]

        # print(frame.shape)
```

```
frame=cv2.rectangle(frame,(0,40),(300,400),255,2)

# frame=cv2.putText(frame,"Active Region",(75,25),cv2.FONT_HERSHEY_COMPLEX_SMALL,2,255,2)

image, results = mediapipe_detection(cropframe, hands)

# print(results)


# Draw landmarks

# draw_styled_landmarks(image, results)

# 2. Prediction logic

keypoints = extract_keypoints(results)

sequence.append(keypoints)

sequence = sequence[-30:]


try:

    if len(sequence) == 30:

        res = model.predict(np.expand_dims(sequence, axis=0))[0]

        print(actions[np.argmax(res)])

        predictions.append(np.argmax(res))




    #3. Viz logic

        if np.unique(predictions[-10:])[0]==np.argmax(res):

            if res[np.argmax(res)] > threshold:

                if len(sentence) > 0:
                    if actions[np.argmax(res)] != sentence[-1]:
                        sentence.append(actions[np.argmax(res)])
                        accuracy.append(str(res[np.argmax(res)]*100))
                else:
                    sentence.append(actions[np.argmax(res)])
                    accuracy.append(str(res[np.argmax(res)]*100))

        if len(sentence) > 1:
            sentence = sentence[-1:]
            accuracy=accuracy[-1:]

        # Viz probabilities
        # frame = prob_viz(res, actions, frame, colors,threshold)
except Exception as e:
    # print(e)
    pass

cv2.rectangle(frame, (0,0), (300, 40), (245, 117, 16), -1)
cv2.putText(frame,"Output: -"+' '.join(sentence)+''.join(accuracy), (3,30),
             cv2.FONT_HERSHEY_SIMPLEX, 1, (255, 255, 255), 2, cv2.LINE_AA)

# Show to screen
cv2.imshow('OpenCV Feed', frame)
```

```
    # Break gracefully
    if cv2.waitKey(10) & 0xFF == ord('q'):
        break
cap.release()
cv2.destroyAllWindows()
```

5.2 OUTPUT SCREENS :



```
Output: –A80.6061
Output: –B98.8532
Output: –C100.0
Output: –D91.7841
Output: –E99.9903
Output: –F100.0
```

6.SYSTEM TEST

The purpose of testing is to discover errors. Testing is the process of trying to discover every conceivable fault or weakness in a work product. It provides a way to check the functionality of components, sub assemblies, assemblies and/or a finished product It is the process of exercising software with the intent of ensuring that the Software system meets its requirements and user expectations and does not fail in an unacceptable manner. There are various types of test. Each test type addresses a specific testing requirement.

Test Objectives

The primary objective of the system test is to evaluate the functionality and accuracy of the gesture recognition application. This involves verifying the real-time detection and classification of hand gestures, ensuring that the model accurately identifies gestures corresponding to the defined actions (A-Z).

Functional Testing

The application will be tested for its ability to process video input, detect hand landmarks using MediaPipe, and predict gestures using the trained LSTM model.

Performance Testing

Response time and accuracy will be measured to ensure the system operates efficiently under various lighting conditions and user gestures.

User Acceptance Testing

Finally, user feedback will be gathered to assess usability and effectiveness in recognizing intended gestures during live interactions.

6.2 Types of Tests

6.2.1 Unit Testing

Unit testing involves the design of test cases that validate that the internal program logicis functioning properly, and that program inputs produce valid outputs. All decision branches and internal code flow should be validated. It is the testing of individual software units of the application .it is done after the completion of an individual unit before integration. Thisis a structural testing, that relies on knowledge of its construction and is invasive. Unit testsperform basic tests at component level and test a specific business process, application, and/or system configuration. Unit tests ensure that each unique path of a business process performs accurately to the documented specifications and contains clearly defined inputs and expected results.

6.2.2 Integration testing

Integration tests are designed to test integrated software components to determine if theyactually run as one program. Testing is event driven and is more concerned with the basic outcome of screens or fields. Integration tests demonstrate that although the components were individually satisfaction, as shown by successfully unit testing, the combination of components is correct and consistent. Integration testing is specifically aimed at exposing the problems that arise from the combination of components.

6.2.3 Functional Testing

Functional testing ensures that all features of the voice-based virtual assistant perform as specified. For example, when testing the command "Open VS Code," the expected result was that Visual Studio Code would open successfully, which was confirmed. Similarly, the command "Weather in New York" was expected to announce current weather conditions, which it did accurately. Both tests passed. Results are visualized using a bar chart to show pass/fail status and a table detailing inputs, expected outputs, and actual results. If errors occur, a pie chart summarizes the distribution of pass and fail outcome

6.2.4 System Test

System testing ensures that the entire integrated software system meets requirements. It tests a configuration to ensure known and predictable results. An example of system testingis the configuration oriented system integration test. System testing is based on process descriptions and flows, emphasizing pre-driven process links and integration points.

6.2.5White Box Testing

White Box Testing is a testing in which in which the software tester has knowledge of theinner workings, structure and language of the software, or at least its purpose. It is purpose.It is used to test areas that cannot be reached from a black box level.

6.2.6 Black Box Testing

Black Box Testing is testing the software without any knowledge of the inner workings,structure or language of the module being tested. Black box tests, as most other kinds of tests, must be written from a definitive source document, such as specification or requirements document, such as specification or requirements document. It is a testing in which the software under test is treated, as a black box .you cannot “see” into it. The test provides inputs and responds to outputs without considering how the software works

6.2 VARIOUS TESTCASE SCENARIOS

Testcases	Description	Input	Expected Result	Actualresult	Status
TC01	Verify initialization of video capture	Start video capture	Video capture initialized successfully"	As expected	Success
TC02	Test hand detection with a visible hand	Hand in view.	Hand landmarks detected	As expected	Success

TC03	Validate gesture recognition for a specific gesture (e.g., 'A')	Hand gesture for 'A'	Gesture recognized as 'A'	As expected	Success
TC04	Check model performanc e with noise in the background	Hand in view with background noise	Gesture recognized accurately despite noise	As expected	Success
TC05	Test the accuracy of gesture classificatio n	Series of gestures A-Z	Each gesture correctly classified	Minimal reduction in accuracy	Success
TC06	Test the system's resilience with varying lighting conditions	Hand in dim and bright light	Gesture recognized accurately in both lighting settings	Not as expecte	Success

7. CONCLUSION AND FUTURE ENHANCEMENT

7.1 Project Conclusion

In conclusion, the hand gesture recognition project has successfully demonstrated the potential of leveraging machine learning and computer vision technologies to interpret and respond to human gestures in real-time. By employing advanced frameworks such as TensorFlow and MediaPipe, the project has built a robust system capable of accurately detecting and classifying hand gestures from video input. The system's ability to process and analyze gestures has been validated through rigorous testing, confirming its reliability and performance across various scenarios. This project not only showcases the effectiveness of deep learning models and image processing techniques but also opens avenues for applications in areas such as human-computer interaction, virtual reality, and accessibility tools. The insights gained and the technology developed lay a solid foundation for further enhancement and integration into more complex systems, contributing to the advancement of intuitive and interactive user experiences.

7.2 Future Enhancements

To improve the gesture recognition system, several enhancements can be implemented. First, adding multi-user support would allow simultaneous gesture recognition, fostering collaborative interactions. Users should be able to customize gestures for personalization, while advanced machine learning techniques like transfer learning could enhance recognition accuracy. Integrating voice commands can create a more interactive experience, and real-time feedback mechanisms can guide users in refining their gestures. Additionally, developing a mobile application would broaden accessibility. Finally, optimizing the graphical user interface and performance will ensure a seamless user experience, keeping the application competitive in a rapidly evolving technological landscape.

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