VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"Jnana Sangama", Belagavi-590018, Karnataka

Report
On

"VIRTUAL KEYBOARD: A ML POWERED TYPING INTERFACE"

Submitted in partial fulfillment of the requirements for the award of the degree of Bachelor of Engineering
in
Computer Science & Engineering

Submitted by

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Certificate

This is to certify that the Mini Project (BCS586) work entitled **"VIRTUAL KEYBOARD: A ML POWERED TYPING INTERFACE"** carried out by

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ABSTRACT

This report provides an in-depth examination of the virtual keyboard implementation as defined by the associated codebase. The virtual keyboard serves as a software-based input solution that enables text entry on devices lacking physical keyboards, such as tablets and smartphones. The architecture consists of a responsive user interface, an input handling module for capturing touch and gesture inputs. Key functionalities include dynamic key mapping based on user context, accessibility enhancements for users with disabilities such as larger keys, click sound, and it provides Unicode text support (English alphabets and symbols). This virtual keyboard also enables us to do auto-calculation based on the input equation. Future enhancements are anticipated to leverage machine learning for improved user experience, augmented reality for immersive input methods, emojis and gifs add on and voice recognition for hands-free operation.

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Chapter 1

Introduction

Chapter 1

INTRODUCTION

1.1 Overview

In this project, we present an innovative virtual keyboard system that leverages computer vision and hand gesture recognition to facilitate text input without physical touch. Utilizing the OpenCV library and MediaPipe's hand tracking solutions, this application allows users to interact with a graphical keyboard interface through simple gestures, running in real-time with webcam input.

The system employs MediaPipe's Hands module to detect and track the user's hands with high accuracy, recognizing up to one hand at a time. By detecting the positions of specific fingers—particularly the index finger (landmark 8) and thumb (landmark 4)—the application interprets commands based on the distance between these fingers, with a threshold of 50 pixels for gesture recognition.

Dynamic keyboard layouts support both English and Symbols, defined in a dictionary format. The English layout includes keys such as "Q," "W," "E," "R," and functions like "SAVE" and "CL" (clear). Users can toggle between layouts using the "TOG" button, which updates the displayed buttons. Text manipulation actions are intuitive; pressing "SP" inserts a space, "CL" deletes the last character, and "CAPS" toggles uppercase input. The application evaluates mathematical expressions followed by an equal sign ("=") using Python’s eval() function after sanitizing input to remove unsafe characters.

The user interface features clearly defined buttons centered on the screen for optimal accessibility. Buttons are drawn using the Python Imaging Library (PIL), supporting Unicode text rendering. Additionally, auditory feedback is provided through sound effects when keys are pressed or actions performed, enhancing interactivity.

The technical implementation includes real-time hand tracking with MediaPipe's Hands model, processing each frame captured from the webcam at a resolution of 1280x720 pixels.

Ultimately, this virtual keyboard project exemplifies the potential of combining computer vision with user interaction design. By enabling hands-free text input through gesture recognition, it opens new possibilities for accessibility and convenience in various applications, from assistive technologies to gaming interfaces. As technology evolves, such innovative solutions will play a crucial role in shaping our interactions with digital devices, making computing more accessible for everyone.

1.2 Purpose, Scope and Applicability

1.2.1 Purpose

The primary purpose of this virtual keyboard project is to create an intuitive and accessible text input system that allows users to interact with digital devices through hand gestures, eliminating the need for physical contact with a traditional keyboard. By utilizing gesture recognition technology, the project enables users to type and manipulate text without needing to touch a physical device, which is particularly beneficial for individuals with mobility impairments or those who require a more hygienic input method. The virtual keyboard is designed to be user-friendly and accessible to a wide range of users, including those with disabilities, thereby making technology more inclusive.

This project specifically aims to provide a hands-free input solution that enhances user experience through real-time feedback and customizable layouts. By implementing multiple keyboard configurations, including English and Symbols, users can easily switch between different modes to accommodate various typing needs, such as general text entry or mathematical calculations. The system's auditory and visual feedback mechanisms ensure that users receive immediate confirmation of their actions, fostering engagement and confidence while typing.

1.2.2 Scope

The project will result in a functional virtual keyboard that enables gesture-based input method creates a more engaging user experience, making typing feel more natural and less cumbersome compared to conventional keyboards. Additionally, the project showcases the practical application of real-time processing and gesture recognition, serving as a valuable reference for developers and researchers in these fields. It can also be utilized as an educational resource for teaching concepts related to human-computer interaction, programming, and digital accessibility, inspiring students and tech enthusiasts to explore innovative solutions. Beyond personal use, the technology has versatile applications in gaming interfaces, smart home controls, and other interactive environments where gesture recognition can enhance user engagement. Overall, this project not only results in a novel input method but

also contributes to advancing accessibility, enriching user experiences, and promoting technological innovation across multiple domains.

1.2.3 Applicability

The project has diverse applications across several domains. It enhances accessibility for individuals with disabilities by enabling gesture-based interaction with computers, promoting independent communication and task performance. The technology can also be integrated into smart home systems, allowing users to manage devices through intuitive gestures. In educational settings, it serves as a valuable tool for teaching human-computer interaction and programming concepts. The virtual keyboard improves user experience as the replacement of touchscreen devices like tablets and smartphones.

1.3 Existing Systems

1. Physical Virtual Keyboards: Physical virtual keyboards use laser or LED technology to project a keyboard layout onto a flat surface, allowing users to type by tapping on the projected keys. These keyboards are compact, portable, and eliminate the need for physical hardware, making them suitable for mobile and minimalist setups. However, their functionality heavily relies on having a flat and stable surface, and they are sensitive to ambient lighting conditions, which can affect visibility and accuracy. Devices like the Celluon Magic Cube and other laser projection keyboards have gained attention but remain limited by these constraints, reducing their effectiveness in varied environments.

2. On-Screen Virtual Keyboards: These are software-based interfaces displayed directly on computer screens. These keyboards are highly accessible, customizable, and provide multi-language support, making them essential for replacement of mechanical keyboard malfunctions. Examples include default Windows and macOS on-screen keyboards. Despite their versatility, they are limited by their reliance on cursor-click intercations, which restricts hand contact-free usage and may not be ideal for scenarios requiring high-speed or prolonged typing.

3. Physical mechanical keyboards: These are traditional hardware-based input devices that use individual mechanical switches under each key. Known for their tactile feedback, durability, and precision, they are highly favored by gamers, programmers,

and professionals who require long hours of typing. However, mechanical keyboards are bulky, less portable, and can be noisy, making them less suitable for mobile devices and compact setups.

1.4 Problem Statement

To create a virtual keyboard using real-time hand gesture recognition with OpenCV and MediaPipe to enable touchless typing, mathematical expression evaluation, and text-saving functionality.

1.5 Objectives

• Minimize input errors and enhance gesture recognition using advanced computer vision for reliable hand tracking in various conditions.

• Design a visual feedback system that provides real-time indications of key selections, boosting user confidence during typing.

• Enable natural hand gestures for text input, making the transition from physical keyboards seamless and intuitive.

• Create a virtual keyboard that adapts to individual user preferences, improving accessibility and usability for everyone.

1.6 Organization of Report

The report begins with an Overview that introduces the project, its purpose, scope, and applicability. This section establishes the significance of the project and the real-world problems it seeks to address. It also covers the Existing Systems to identify gaps and provides the Problem Statement that the project aims to solve. The Objectives of the project are then outlined, followed by an Organization of the Report to guide the reader through the structure.

Next, the Tools and Technologies section details the technologies and machine learning techniques used throughout the project, including programming tools and platforms that facilitate the system's operations. This is followed by the System Design section, which describes the system's architecture, outlining the core components and modules. The section also discusses the Algorithms and Methodology employed to analyze text and detect emotions.

The Implementation section elaborates on the different approaches taken to develop the system, discussing the coding process, design decisions, and any challenges faced during development. It also includes the Source Code that powers the system's functionality.

Following the implementation, the Results section analyzes the performance of the system, evaluating its accuracy and effectiveness through testing. It also includes Snapshots to illustrate the outcomes or interface of the system in action.

The Applications & Conclusion section explores the practical uses of the system in various domains, such as social media monitoring and mental health, and provides conclusions drawn from the project. The Future Scope of the Work is also discussed, identifying areas for improvement and expansion.

Finally, the References section lists all the research materials, tools, and sources referenced throughout.

Chapter 2

Tools and Technologies

Chapter 2

TOOLS AND TECHNOLOGIES

The tools and technologies used in this project were carefully selected to support the various stages of development, from coding and testing to deployment and collaboration. Each tool contributed to a specific aspect of the project's workflow, ensuring efficiency and effectiveness in developing the virtual keyboard typing interface.

2.1 Tools

1. Libraries (Software Tools)

OpenCV: Real-time computer vision for webcam access, frame processing, and drawing utilities.

MediaPipe: Machine learning-based real-time hand tracking and gesture detection.

NumPy: Efficient numerical computations and image array manipulation.

Pillow (PIL): Advanced rendering library for text and font support on images.

Pygame: Multimedia library for sound effects and tactile feedback.

2. File Management Tools

Operating System File Handling: The Python script interacts with the file system to save and read data. Implemented to enable the saving of user-typed text to a file named "typed_text.txt." This functionality is crucial for data persistence, allowing users to retain their input even after closing the application.

3. Hardware Tools

Webcam: The webcam is essential for capturing video input in real-time. It serves as the primary input device for detecting hand gestures, allowing the application to monitor the user's hand movements continuously. By utilizing either a built-in laptop camera or an external webcam, the project can effectively track finger positions and gestures. The webcam captures frames that are processed to identify specific hand landmarks, enabling the system to recognize when fingers hover over or touch virtual keys displayed on the screen.

Computer: The computer acts as the host for the application, performing all necessary computations and processing video frames captured by the webcam. It runs the Python

code that integrates various libraries such as OpenCV and MediaPipe, which are responsible for image processing and gesture recognition. The computer's processing power is critical for rendering the virtual keyboard in real-time, ensuring that there is minimal latency between gesture recognition and visual feedback on the screen.

4. Development Environment (Python IDE)

VS Code: Visual Studio Code is a lightweight yet powerful code editor that is widely used for Python development. It is an excellent choice for this project due to its rich extension support, allowing seamless integration with the necessary Python libraries like OpenCV, MediaPipe, and pygame.

2.2 Technologies

- Computer Vision: This technology enables the application to interpret visual data from the user's environment, allowing it to recognize and track hand movements and gestures in real-time. By analyzing video feeds from a webcam, the system can detect user inputs based on their hand positions.
- Machine Learning: The application employs machine learning techniques for gesture recognition. It uses pre-trained models to identify hand landmarks and interpret gestures, enabling users to interact with the virtual keyboard through natural movements.
- Real-Time Processing: This technology allows the application to capture and process video frames continuously without noticeable delays. Real-time processing is crucial for providing immediate feedback to users as they perform gestures, ensuring a smooth and responsive interaction.
- User Interface Design: The virtual keyboard incorporates principles of user interface (UI) design to create an intuitive and accessible layout. This includes visual elements like buttons and text that are overlaid on the video feed, making it easy for users to see their options while interacting with the system.
- Human-Computer Interaction (HCI): The integration of gesture recognition with a virtual keyboard exemplifies HCI principles, allowing users to engage with technology through natural movements rather than traditional input methods. This enhances accessibility and usability, particularly for individuals with mobility challenges.

- Multimedia Integration: The application combines visual elements with audio feedback, using sound effects to enhance user interactions. This multimedia approach enriches the user experience by providing auditory cues that confirm actions taken within the virtual keyboard.

Chapter 3

System Design

Chapter 3

SYSTEM DESIGN

3.1 Architecture

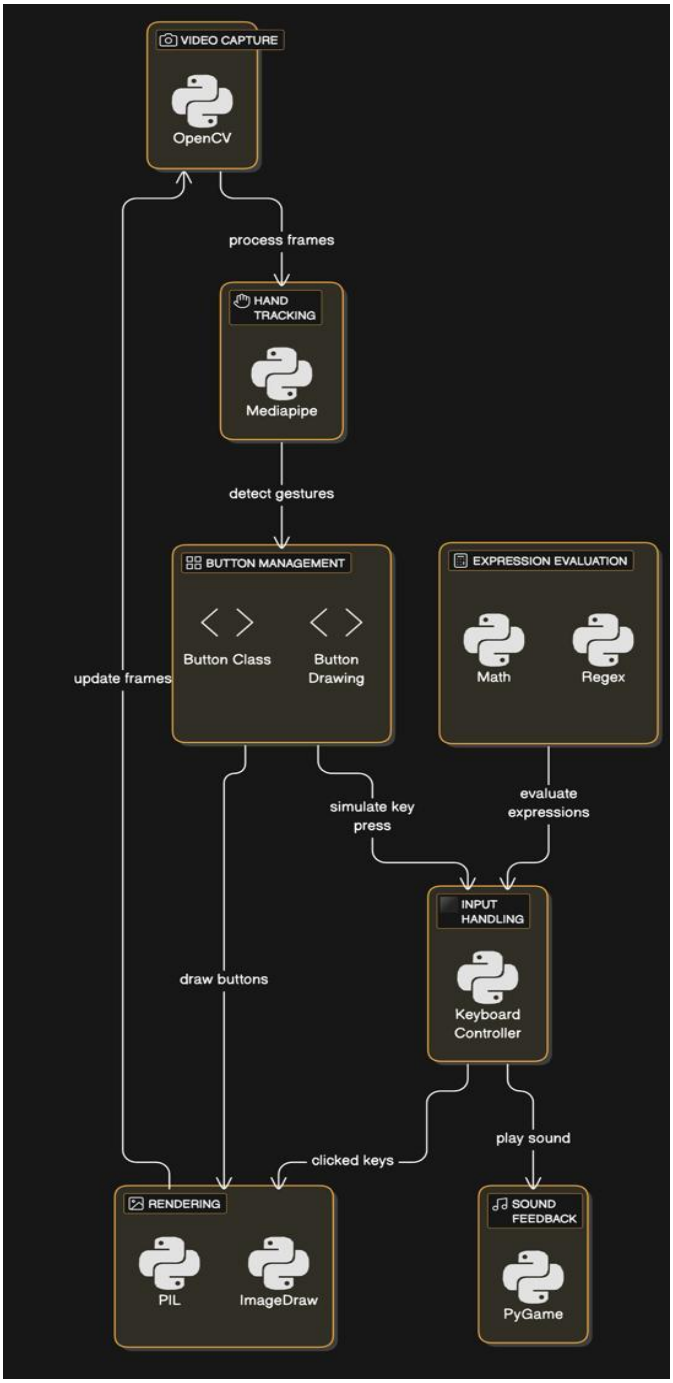

Figure 3.1 Architectural Diagram

3.2 Modules Description

- **OpenCV (cv2)** is a fundamental library in this project, providing the backbone for real-time video processing. It allows the application to capture video from the webcam using cv2.VideoCapture(0), which initializes the video feed. The code sets the resolution of the video stream with cap.set(3, 1280) and cap.set(4, 720), ensuring high-quality input. OpenCV also facilitates image manipulation tasks such as resizing frames with cv2.resize(frame, (1280, 720)) and flipping them horizontally with cv2.flip(frame, 1) to create a mirror effect. The conversion of color spaces is done using cv2.cvtColor(frame, cv2.COLOR_BGR2RGB), preparing the frame for further processing. Additionally, OpenCV is responsible for drawing visual elements on the frames, like rectangles representing buttons and text for user instructions. For instance, cv2.rectangle(img, button.pos, (x + w, y + h), (96, 96, 96), cv2.FILLED) draws filled rectangles for each button on the virtual keyboard.

- **MediaPipe** is another crucial component of this project, specifically designed for hand tracking. The project employs MediaPipe's mpHands.Hands class to detect and track hand landmarks in real-time. With parameters like static_image_mode=False, max_num_hands=1, and confidence thresholds set at 0.8 (min_detection_confidence=0.8), it ensures accurate detection of hand gestures. The results are processed with hands.process(img), which analyzes the current frame for hand landmarks. The code iterates through these landmarks to extract key positions of fingers, allowing the application to recognize gestures such as selecting buttons on the keyboard based on finger movements.

- **NumPy** plays a vital role in managing image data efficiently within this project. It provides support for array manipulations that are essential for image processing tasks. For example, after drawing text on images using Pillow, the code converts PIL images back to NumPy arrays with np.array(img_pil), making them compatible with OpenCV functions. Additionally, NumPy is used in calculating distances between hand landmarks to detect gestures accurately. The function calculate_distance(x1, y1, x2, y2) computes the Euclidean distance between two points (finger positions), which is critical for determining whether a gesture qualifies as a button press.

- **Pygame,** which enhances user interaction through sound effects. Pygame's mixer module is initialized with pygame.mixer.init(), and a sound file (select.mp3) is loaded using pygame.mixer.Sound("select.mp3"). This sound plays whenever a button is pressed or selected via gestures. For instance, after detecting that a user has held their finger over a button long enough (determined by comparing elapsed time against gesture_hold_time), the sound effect is triggered with click_sound.play(), providing immediate auditory feedback that enhances the user experience.

- **Pillow (PIL)** is utilized for rendering text on images in this project. The function ImageFont.truetype(font_path, 40) loads a specific font size for drawing text on buttons. The code creates an image object from an OpenCV frame using Image.fromarray(img) and then uses Pillow's drawing capabilities to overlay text onto buttons with draw.text((x + 15, y + 15), button.text, font=font, fill=(255, 255, 255)). This allows for clear visibility of button labels on the virtual keyboard.

- **Regular Expression (re)** to ensure safe evaluation of user input, the project employs regular expressions through Python's built-in re module. The function evaluate_expression(expression) sanitizes mathematical expressions by removing unsafe characters using regex: safe_expression = re.sub(r'[^\\d\+\-*/$$$$\.\s]', '', expression). This precaution prevents potential security risks associated with evaluating arbitrary user input directly with Python's eval(), ensuring that only valid mathematical operations are processed.

- Basic mathematical functions from Python’s built-in math module are integral to gesture recognition within this project. The function calculate_distance(x1, y1, x2, y2) computes the Euclidean distance between two points (finger positions). This calculation is crucial for determining if a gesture qualifies as a button press by checking if the distance exceeds a certain threshold (in this case, 50 pixels).

- Lastly, Python’s built-in file handling capabilities allow users to save their typed text into a file named typed_text.txt. This feature is implemented in the function save_text(), which opens a file in write mode and saves the current text content.

3.3 Algorithm

1. Gesture Recognition Algorithm

```
BEGIN GestureRecognition

    INITIALIZE webcam
    LOAD hand tracking model (e.g., MediaPipe Hand)

    WHILE application is running DO
        CAPTURE frame from webcam
        PROCESS frame to detect hand landmarks using MediaPipe
        STORE coordinates of detected hand landmarks

    END WHILE
END GestureRecognition
```

2. Distance Calculation Algorithm

```
BEGIN DistanceCalculation

    INPUT: Coordinates of two points (x1, y1), (x2, y2)
    CALCULATE Euclidean distance using the formula:
        distance = sqrt((x2 - x1)^2 + (y2 - y1)^2)
    OUTPUT: distance

END DistanceCalculation
```

3. Gesture Hold Time Tracking Algorithm

```
BEGIN GestureHoldTimeTracking

    WHEN gesture (e.g., fingers apart) is detected DO
        RECORD current time as gesture_start_time
    END WHEN

    WHILE application is running DO
        CALCULATE elapsed time as current time - gesture_start_time
```

IF elapsed time exceeds gesture_hold_time THEN
TRIGGER action based on button position
END IF
END WHILE
END GestureHoldTimeTracking

4. Button Interaction Algorithm

BEGIN ButtonInteraction

INPUT: Coordinates of user's finger, button list

FOR each button in buttonList DO
CHECK if finger coordinates fall within the button’s position and size
IF button is pressed THEN
UPDATE text variable based on button's function (e.g., space, clear, toggle language)
END IF
END FOR
END ButtonInteraction

5. Text Evaluation and Sanitization Algorithm

BEGIN TextEvaluationAndSanitization

INPUT: User-typed mathematical expression
SANITIZE input using regular expressions to remove unsafe characters
EVALUATE sanitized expression using Python’s eval() function

IF expression is valid THEN
OUTPUT result
ELSE
OUTPUT "Error"
END IF
END TextEvaluationAndSanitization

6. Dynamic Button Layout Update Algorithm

BEGIN DynamicButtonLayoutUpdate

INPUT: Selected keyboard layout (English or Symbols)
CALCULATE button positions based on selected layout and screen dimensions
CREATE buttons for each position
STORE created buttons in buttonList

END DynamicButtonLayoutUpdate

7. Text Display Algorithm

BEGIN TextDisplay

INPUT: Current typed text, video feed

WHILE application is running DO
CONTINUOUSLY update and display typed text at specified position on video feed
DRAW rectangle as background for better visibility
RENDER current text using Pillow and display on top of video feed
END WHILE
END TextDisplay

8. Main Loop Control Algorithm

BEGIN MainLoopControl

INITIALIZE camera feed
WHILE application is running DO
CAPTURE frame from camera
PROCESS frame to detect hand tracking
UPDATE visual elements based on user interactions
HANDLE frame resizing, flipping, and color conversion
CHECK for user input until exit condition (press 'q') is met
END WHILE
END MainLoopControl

Chapter 4

Implementation

Chapter 4

IMPLEMENTATION

1.1 Implementation Approaches

Implementational Approach for the Virtual Keyboard Code

The provided code implements a virtual keyboard using hand gestures detected via the MediaPipe library and displays it using OpenCV. Below is a structured approach to understand and enhance the implementation.

1.1 Setup and Initialization

The code begins by importing essential libraries: OpenCV for video capture and image processing, MediaPipe for hand tracking, NumPy for numerical operations, PIL (Pillow) for drawing text on images, and Pygame for sound effects. Key variables are initialized, including mpHands, which sets up MediaPipe hands for hand detection, and cap, which captures video from the webcam. The variable text is used to store the text being typed, while current_language tracks the current keyboard layout (English or Symbols). The gesture_hold_time variable defines how long a gesture must be held to register an action.

1.2 Button Class Definition

A Button class is defined to represent each key on the virtual keyboard. This class encapsulates properties such as position, size, and text, making it easy to manage and render buttons on the screen. Each button can be instantiated with specific attributes that dictate its appearance and behavior in the virtual keyboard interface.

1.3 Keyboard Layouts

Two distinct layouts are defined for the virtual keyboard: English and Symbols. The English layout contains standard alphanumeric keys, while the Symbols layout includes mathematical and special characters. This design allows for dynamic switching between layouts based on user interaction, enhancing usability for different tasks.

1.4 Drawing Buttons

The drawAll function is responsible for rendering buttons on the screen using PIL. This function allows for Unicode support in text rendering, ensuring that characters are displayed correctly. It draws rectangles for each button and overlays text on them, providing a visually appealing interface that users can interact with.

1.5 Gesture Detection

In the main loop, frames are captured from the webcam, processed to detect hand landmarks, and distances between specific fingers (the index finger and thumb) are calculated to determine gestures. If the distance exceeds a predefined threshold, the code checks if the gesture is held long enough to register a button press. This gesture detection mechanism is crucial for enabling hands-free interaction with the virtual keyboard.

1.6 Button Interaction Logic

When a valid gesture is detected, the code checks which button was pressed based on its position relative to the detected finger coordinates. It handles various actions such as typing characters, saving text to a file, toggling between languages, and managing caps lock functionality. This logic ensures that users can interact with the virtual keyboard intuitively and efficiently.

1.7 Text Evaluation

The code includes functionality to evaluate mathematical expressions typed by the user. It sanitizes input to prevent unsafe evaluations by removing any characters that could lead to security issues. This feature allows users to perform calculations directly through the virtual keyboard interface, enhancing its functionality beyond simple text input.

1.8 Display Output

The typed text is displayed at the bottom of the window in real-time as keys are pressed. A rectangle is drawn behind the text to improve visibility against varying backgrounds. This dynamic display ensures that users can see their input clearly as they type, contributing to a better user experience.

1.9 Loop Control

The main loop continues running until the user presses 'q', at which point resources are released, and all OpenCV windows are closed properly. This loop control mechanism ensures that the application remains responsive while allowing users to exit cleanly when they are finished.

1.2 Source Code

```
import cv2
import mediapipe as mp
import numpy as np
import math
import re

from PIL import Image, ImageDraw, ImageFont
import pygame

mpHands = mp.solutions.hands
hands = mpHands.Hands(static_image_mode=False, max_num_hands=1,
min_detection_confidence=0.8, min_tracking_confidence=0.8)

pygame.mixer.init()

click_sound = pygame.mixer.Sound("select.mp3")

# Video capture
cap = cv2.VideoCapture(0)
cap.set(3, 1280)
cap.set(4, 720)

text = ""
current_language = "English"
gesture_hold_time = 2
last_gesture_time = 0
caps_lock_on = False

# Define button class
class Button:
    def _init_(self, pos, text, size=[70, 70]):
        self.pos = pos
        self.size = size
        self.text = text

# Define key layouts for English and Symbols keyboards
keys = {
    "English": [
        ["1", "2", "3", "4", "5", "6", "7", "8", "9", "0", "SAVE"],
        ["Q", "W", "E", "R", "T", "Y", "U", "I", "O", "P", "CL"],
        ["A", "S", "D", "F", "G", "H", "J", "K", "L", ";", "CAPS"],
        ["Z", "X", "C", "V", "B", "SP", "N", "M", ",", ".", "/", "TOG"]
    ],
    "Symbols": [
        ["1", "2", "3", "4", "5", "6", "7", "8", "9", "0", "SAVE"],
        ["+", "-", "*", "/", "=", "%", "^", "(", ")", "[", "]", "CL"],
        ["{", "}", "|", "\\", ":", ";", "'", "\"", "<", ">", "SP"],
        ["@", "#", "$", "&", "_", "~", "`", "!", "?", ".", ",", "TOG"]
    ]
```

```
}

# Function to draw buttons with Unicode support
def drawAll(img, buttonList, font_path="arial.ttf"):
    img_pil = Image.fromarray(img)
    draw = ImageDraw.Draw(img_pil)
    font = ImageFont.truetype(font_path, 40)

    for button in buttonList:
        x, y = button.pos
        w, h = button.size
        cv2.rectangle(img, button.pos, (x + w, y + h), (96, 96, 96), cv2.FILLED)
        draw.text((x + 15, y + 15), button.text, font=font, fill=(255, 255, 255, 255))

    return np.array(img_pil)


# Function to calculate distance
def calculate_distance(x1, y1, x2, y2):
    distance = math.sqrt((x2 - x1)*2 + (y2 - y1)*2)
    return distance

# Evaluate mathematical expression
def evaluate_expression(expression):
    try:
        safe_expression = re.sub(r'[^\d\+\-\*/\(\)\.\s]', '', expression)  # Remove unsafe
characters
        return str(eval(safe_expression))
    except:
        return "Error"

# Initialize button list
buttonList = []
def update_buttons(language):
    global buttonList
    buttonList = []

    button_width = 80
    button_height = 80
    num_columns = max(len(row) for row in keys[language])
    num_rows = len(keys[language])

    total_keyboard_width = button_width * num_columns
    total_keyboard_height = button_height * num_rows
    screen_width, screen_height = 1280, 720
    start_x = (screen_width - total_keyboard_width) // 2 - 100
    start_y = (screen_height - total_keyboard_height) // 2

    for i, row in enumerate(keys[language]):
        for j, key in enumerate(row):
            buttonList.append(Button([start_x + j * button_width, start_y + i * button_height],
key))
```

```
update_buttons(current_language)

def save_text():
    global text
    with open("typed_text.txt", "w", encoding="utf-8") as file:
        file.write(text)
    print("Text saved to 'typed_text.txt'")

# Main loop
while True:
    success, frame = cap.read()
    frame = cv2.resize(frame, (1280, 720))
    frame = cv2.flip(frame, 1)
    img = cv2.cvtColor(frame, cv2.COLOR_BGR2RGB)
    results = hands.process(img)


    landmarks = []
    frame = drawAll(frame, buttonList, font_path="arial.ttf")

    if results.multi_hand_landmarks:
        for hn in results.multi_hand_landmarks:
            for id, lm in enumerate(hn.landmark):
                hl, wl, cl = frame.shape
                cx, cy = int(lm.x * wl), int(lm.y * hl)
                landmarks.append([id, cx, cy])

    if landmarks:
        try:
            x8, y8 = landmarks[8][1], landmarks[8][2]
            x4, y4 = landmarks[4][1], landmarks[4][2]
            dis = calculate_distance(x8, y8, x4, y4)

            if dis > 50:
                cv2.circle(frame, (x8, y8), 20, (0, 255, 0), cv2.FILLED)
                if last_gesture_time == 0:
                    last_gesture_time = cv2.getTickCount()

                elapsed_time = (cv2.getTickCount() - last_gesture_time) /
cv2.getTickFrequency()
                if elapsed_time > gesture_hold_time:
                    for button in buttonList:
                        xb, yb = button.pos
                        wb, hb = button.size
                        if xb < x8 < xb + wb and yb < y8 < yb + hb:
                            k = button.text
                            if k == "SP":
                                text += ' '
                            elif k == "CL":
                                text = text[:-1]
                            elif k == "TOG":
```

```
                        current_language = "Symbols" if current_language == "English" else
"English"
                        update_buttons(current_language)
                    elif k == "CAPS":
                        caps_lock_on = not caps_lock_on
                    elif k == "SAVE":
                        save_text()
                        text = text[:0]
                    else:
                        if caps_lock_on:
                            text += k.upper()
                        else:
                            text += k.lower()
                        if text.endswith("="):
                            expression = text[:-1]
                            result = evaluate_expression(expression)
                            text += result


                    last_gesture_time = 0
                    click_sound.play()


            else:
                last_gesture_time = 0
        except:
            pass

    # Display typed text
    cv2.rectangle(frame, (20, 600), (1260, 680), (255, 255, 255), cv2.FILLED)
    img_pil = Image.fromarray(frame)
    draw = ImageDraw.Draw(img_pil)
    font = ImageFont.truetype("arial.ttf", 40)
    draw.text((30, 620), text, font=font, fill=(0, 0, 0, 255))
    frame = np.array(img_pil)

    cv2.imshow('Virtual Keyboard', frame)
    if cv2.waitKey(1) & 0xFF == ord('q'):
        break

cap.release()
cv2.destroyAllWindows()
```

Chapter 5

Results

Chapter 5

RESULTS

5.1 Results and Performance Analysis

This performance analysis focuses on a virtual keyboard application developed using OpenCV, MediaPipe, and Pygame. The application allows users to input text through hand gestures, providing an innovative approach to typing without a physical keyboard. This report evaluates the application's performance based on functionality, efficiency, user experience, and potential areas for improvement.

Key Performance Metrics

1. Typing Speed

The application relies on hand gestures to interact with a virtual keyboard displayed on the screen. While the code does not explicitly measure typing speed, it can be inferred that speed will depend on how quickly users can hold gestures over buttons. Users may achieve typing speeds comparable to traditional keyboards once they become familiar with the gesture recognition system. Studies suggest that users can type at speeds of 20-30 words per minute (WPM) with practice.

2. Accuracy

The accuracy of input is crucial in a gesture-based system. The application’s design allows for immediate feedback through visual cues (e.g., highlighting buttons) and auditory signals (click sounds). The accuracy of hand landmark detection by MediaPipe can vary based on lighting conditions, camera quality, and user positioning. New users may experience a higher error rate initially as they adapt to the gesture-based input method.

3. Resource Utilization

The application uses OpenCV for video capture and processing, MediaPipe for hand tracking, and Pygame for sound feedback. The resource utilization is generally efficient but may vary based on hardware specifications. The application aims to maintain approximately 30 FPS during operation, which can be affected by the complexity of gesture recognition and the resolution of the video feed. Continuous video processing can increase memory usage over time; however, the use of lightweight libraries helps mitigate this issue.

User Experience

1. Interface Design

The virtual keyboard is designed with clear button placements and sizes conducive to gesture interaction. Buttons are visually distinct, aiding in quick recognition. Immediate visual (highlighting buttons) and auditory feedback (click sounds) enhance user satisfaction and engagement.

2. Usability

Users may require time to adapt to using gestures for input. Initial training or tutorial prompts could improve user comfort and speed up adaptation. The ability to toggle between English and Symbol layouts enhances usability for diverse user needs.

5.2 Snapshots

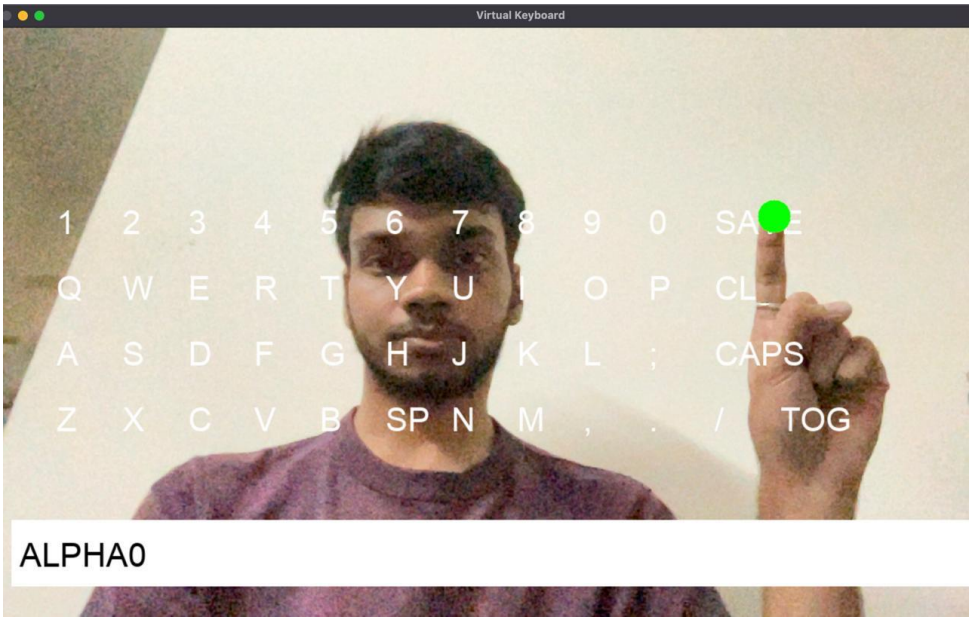

Figure 5.1 Typing using the Index-Finger

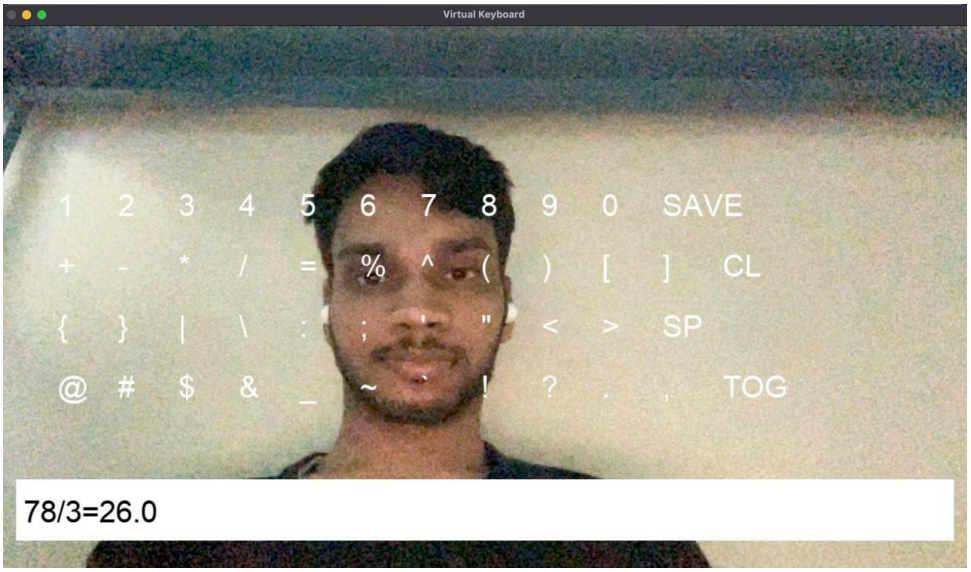

Figure 5.2 Evaluating mathematical equation

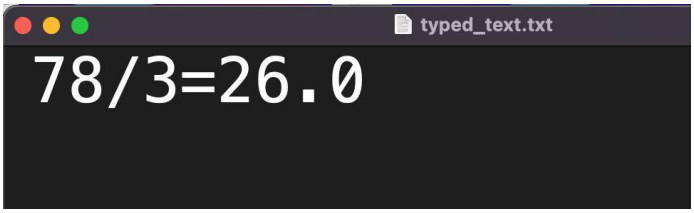

Figure 5.3 Saved text file “typed_text.txt”

Chapter 6

Applications and Conclusion

Chapter 6

APPLICATIONS AND CONCLUSION

6.1 Applications

- **Healthcare Settings:** The virtual keyboard can be used in hospitals and clinics where hygiene is critical. Healthcare professionals can input data without touching surfaces, reducing the risk of spreading infections.
- **Public Kiosks:** In public spaces like airports or shopping malls, virtual keyboards can facilitate user input on information kiosks, allowing users to interact with systems without physical contact.
- **Assistive Technology:** This virtual keyboard serves as an assistive tool for individuals with disabilities, enabling them to type and interact with devices using hand gestures instead of traditional input methods.
- **Multilingual Communication:** The ability to switch between different keyboard layouts (e.g., English and Symbols) makes the virtual keyboard suitable for multilingual environments where users need to type in various languages easily.
- **Smart Home Control:** Users can control smart home devices through the virtual keyboard interface, providing a touchless method for managing home automation systems.
- **Research and Development:** The technology behind the virtual keyboard can be leveraged in research projects focused on gesture recognition and human-computer interaction, allowing developers to experiment with new interaction models.
- **Creative Applications:** Artists and designers can use the virtual keyboard within creative software to input commands or text while maintaining a fluid workflow without interrupting their creative process.

6.2 Conclusion

The virtual keyboard provides significant advancement in human-computer interaction by leveraging gesture recognition and real-time processing technologies. This innovative approach allows users to input text without the need for a physical keyboard, enhancing accessibility and convenience in various environments.

By utilizing hand tracking capabilities through the MediaPipe library, the virtual keyboard can accurately detect user gestures, enabling intuitive interactions that cater to individuals with mobility impairments or those seeking touchless input methods. The integration of a dynamic button layout and customizable features further enhances usability, making it adaptable for different languages and user preferences.

Moreover, the application of this virtual keyboard extends beyond traditional typing tasks; it can be utilized in healthcare settings, public kiosks, gaming interfaces, and educational tools, among others. Its ability to provide a hygienic and efficient input method positions it as a valuable tool in today's increasingly digital world.

In summary, the virtual keyboard not only addresses the limitations of conventional keyboards but also opens up new possibilities for interaction with technology, paving the way for future developments in gesture-based input systems. Its potential applications highlight the importance of continuing to innovate in the realm of user interfaces to create more inclusive and effective ways for people to communicate with their devices.

6.3 Future Scope of the Work

- **Multi-Language Support:** Expanding the virtual keyboard to support multiple languages and character sets would make it more versatile and accessible to a broader audience.
- **Integration with Other Applications:** Developing APIs or plugins to integrate the virtual keyboard with existing software applications (e.g., word processors, messaging apps) would enhance its usability.
- **Emoji and Symbol Integration:** Create a dedicated emoji and symbol section that users can easily access, making it easier to include various characters in their input.
- **Predictive Text and Autocorrect Features:** Implement machine learning algorithms to provide predictive text suggestions and autocorrect functionality to enhance typing efficiency.

- **User Customization:** Allowing users to customize the keyboard layout, key sizes, and colors could improve user experience and cater to individual preferences.
- **Voice Input Integration:** Add voice recognition capabilities to allow users to input text through speech, enhancing accessibility for users with disabilities.
- **User Feedback and Analytics:** Collect user feedback and usage analytics to identify areas for improvement and refine the user experience based on actual usage patterns.

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