SIGN LANGUAGE TO SPEECH AND TEXT TRANSLATION

UCS503 SOFTWARE ENGINEERING PROJECT REPORT

END-SEMESTER EVAULATION

SUBMITTED BY:

102203714 – KUSHAGR SHARMA

102203801 – JIYA

BE THIRD YEAR, COE

GROUP NO:

3CO18

SUBMITTED TO:

DR. MANISH KUMAR

COMPUTER SCIENCE AND ENGINEERING DEPARTMENT

TIET, PATIALA

December, 2024

TABLE OF CONTENTS

1. Project Selection Phase

1.1 Software Bid

Name	Roll No	Project Experience	Programming Language used	Signature
KUSHAGR SHARMA	102203714	Cartoonification of image, Digit recognition using KNN, Basic encryption website	Python, Javascript	*Kushagr Sharma*
JIYA	102203801	Cartoonification of image, Digit recognition using KNN, Drum-kit web app	Python, Javascript	*Jiya*

Programming Language / Environment Experience

List the languages you are most comfortable developing in, **as a team**, in your order of preference. Many of the projects involve Java or C/C++ programming.

1. Python
2. Javascript

Choices of Projects:

	Project Name	Unique Selling Point
First Choice	Restaurant recommender web app	Offers personalized dining suggestions based on user preferences, enhancing the dining experience
Second Choice	Sign language to speech	Bridges communication gaps by converting sign language gestures into spoken language resulting in better interaction between hearing and deaf communities
Third Choice	Fake news detection	Tackles the issue of misinformation by classifying news article as real or fake, helping users trust online info
Fourth Choice	QuickCab	Helps users find the fastest taxi service by comparing the estimated arrival times to your pickup point across different platforms

1.2 Project Overview

The Sign Language to Speech and Text Converter is a standalone system that leverages machine learning and computer vision technologies to recognize and translate sign language gestures into both spoken words and text. It is designed to facilitate communication between individuals who use sign language and those who do not. The system processes video input from a camera to detect hand movements, maps these gestures to predefined sign language dictionaries, and converts them into corresponding audio output using speech synthesis as well as text display.

This system functions as an independent software product but relies on third-party hardware such as cameras for gesture input, speakers for speech output, and displays for text output. The system processes the recognized gestures in parallel, simultaneously generating both speech and text outputs. This dual-output approach ensures accessibility for a wider range of users, including those who may prefer or require text-based communication.

Additionally, the system may interact with external services, such as cloud-based machine learning APIs or language translation services, to enhance gesture recognition and multi-language support for both speech and text outputs. The text conversion feature allows for real-time captioning of sign language, which can be displayed on various devices or integrated with other text-based communication tools.

The text output component of the system offers several advantages:

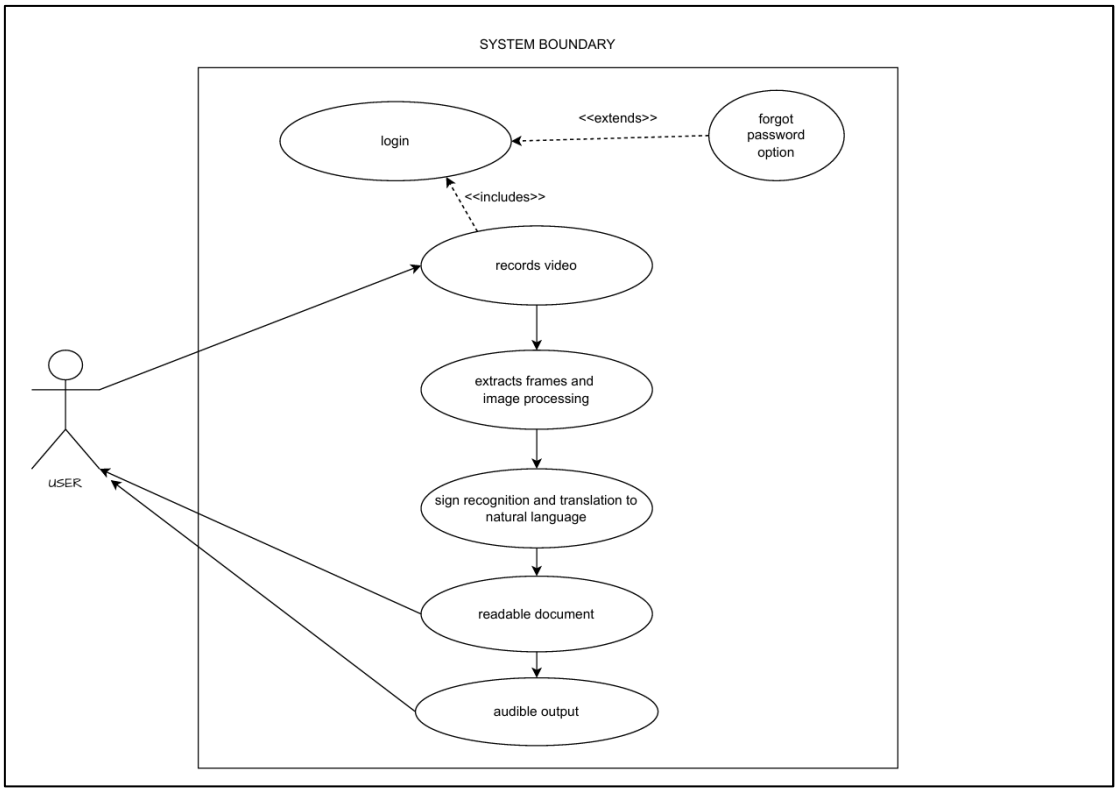
1. **Silent Communication:** In environments where audio output might be disruptive, users can rely on the text display for communication.
2. **Record Keeping:** The text output can be easily saved, copied, or shared for future reference or documentation purposes.
3. **Multi-modal Learning:** For individuals learning sign language, having both audio and text outputs can reinforce understanding and aid in the learning process.
4. **Integration with Other Systems:** The text output can be easily integrated with other text-based systems, such as chat applications, email, or document editors.

By providing both speech and text outputs, the system ensures a more comprehensive and flexible solution for sign language translation, catering to diverse user needs and environmental contexts.

2. Analysis Phase

2.1 Use Cases

2.1.1 Use Case Diagram



2.1.2 Use Case Template

1. USE CASE TITLE	SIGN LANGUAGE TO TEXT AND SPEECH CONVERSION
2. ABBREVIATED TITLE	SIGN LANGUAGE TRANSLATION
3. USE CASE ID	1
4. ACTORS	USER

5. DESCRIPTION

With this facility, one user can communicate easily using sign language. The model captures video and translates it to appropriate text and synthesizes speech.

5.1. PRE CONDITIONS:

- The system is powered on and operational.
- The camera is properly calibrated and functioning.
- The user is positioned in view of the camera.

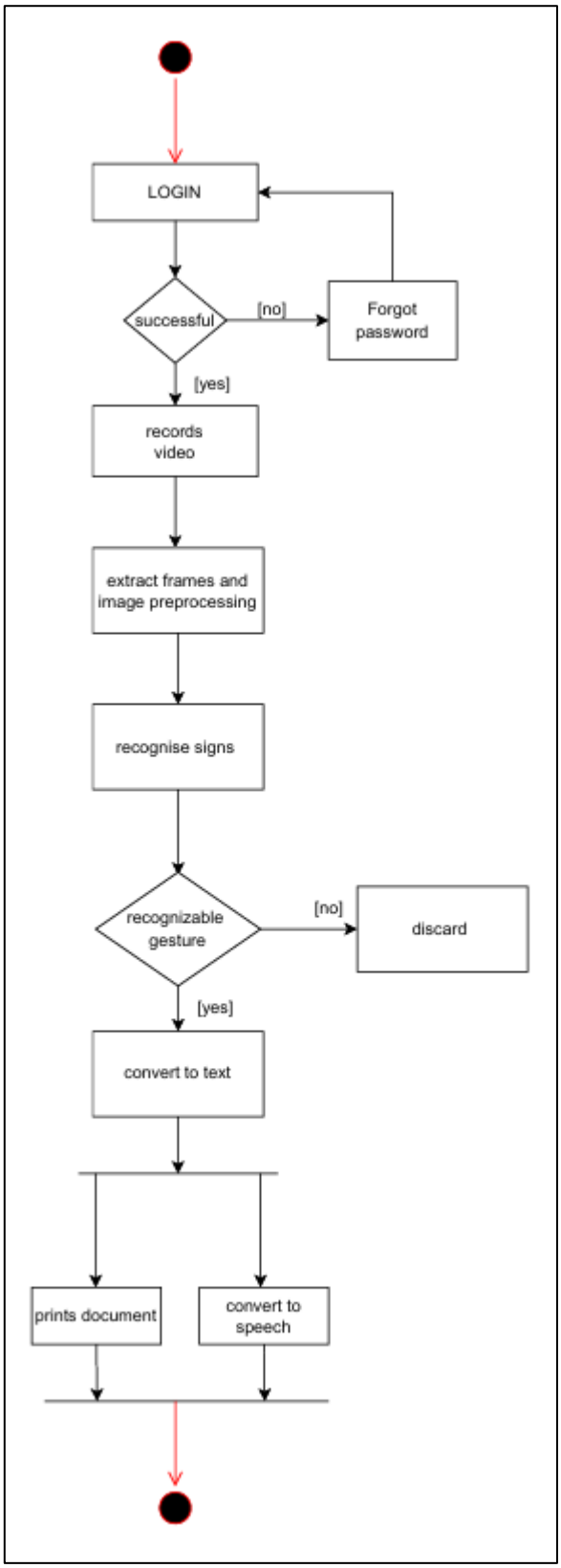
5.2. TASK SEQUENCE:

- The user logs in
- The user begins performing sign language gestures in front of the camera.
- The system captures the video feed of the user's gestures.
- The system processes the video frames and recognizes the signs.
- The system converts the recognized signs into text.
- The system synthesizes speech from the generated text.
- The system prints the generated text as a document.
- The system plays the synthesized speech through the speaker.
- The system provides the printed document to the user.

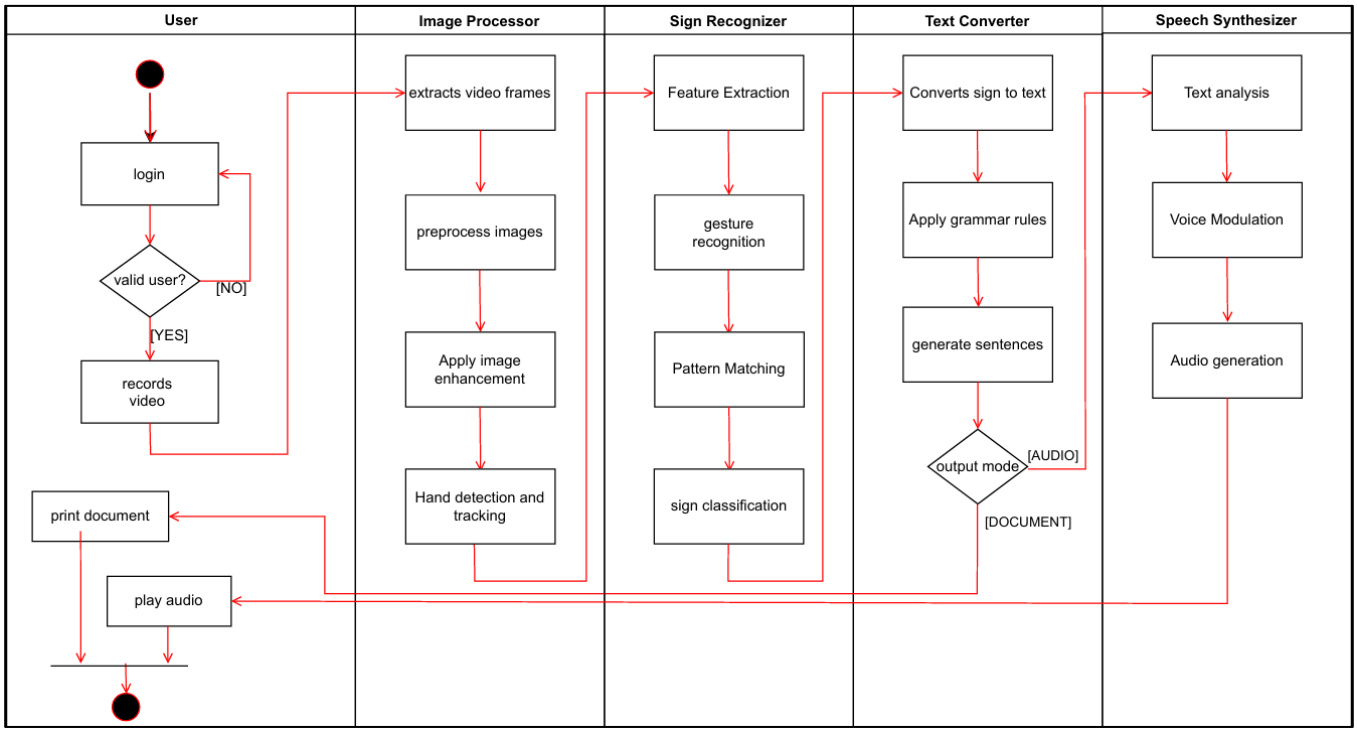
5.3. POST CONDITIONS:

- The user has received audio output of their sign language input.
- The user has received a printed document of their sign language input.

2.2 Activity and Swimlane Diagrams



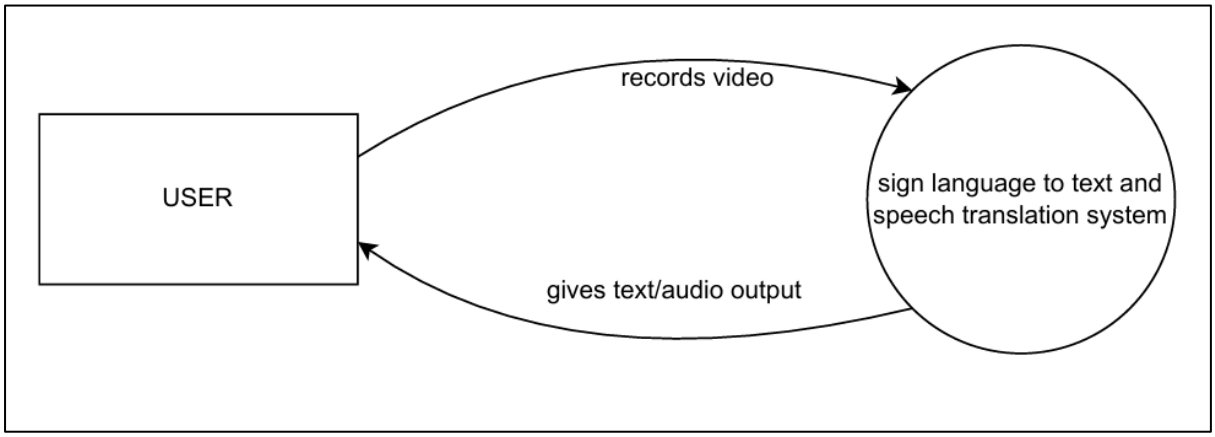
Activity Diagram



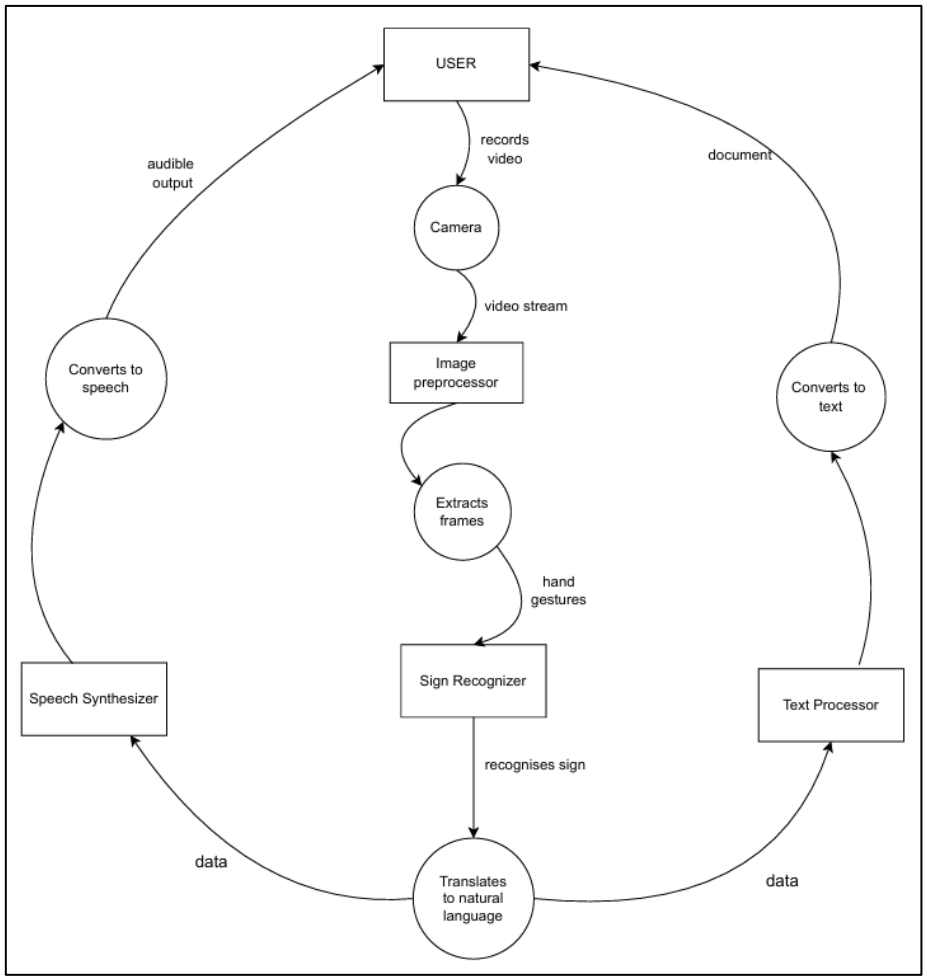
Swimlane Diagram

2.3 Data Flow Diagrams (DFDs)

2.3.1 DFD Level 0

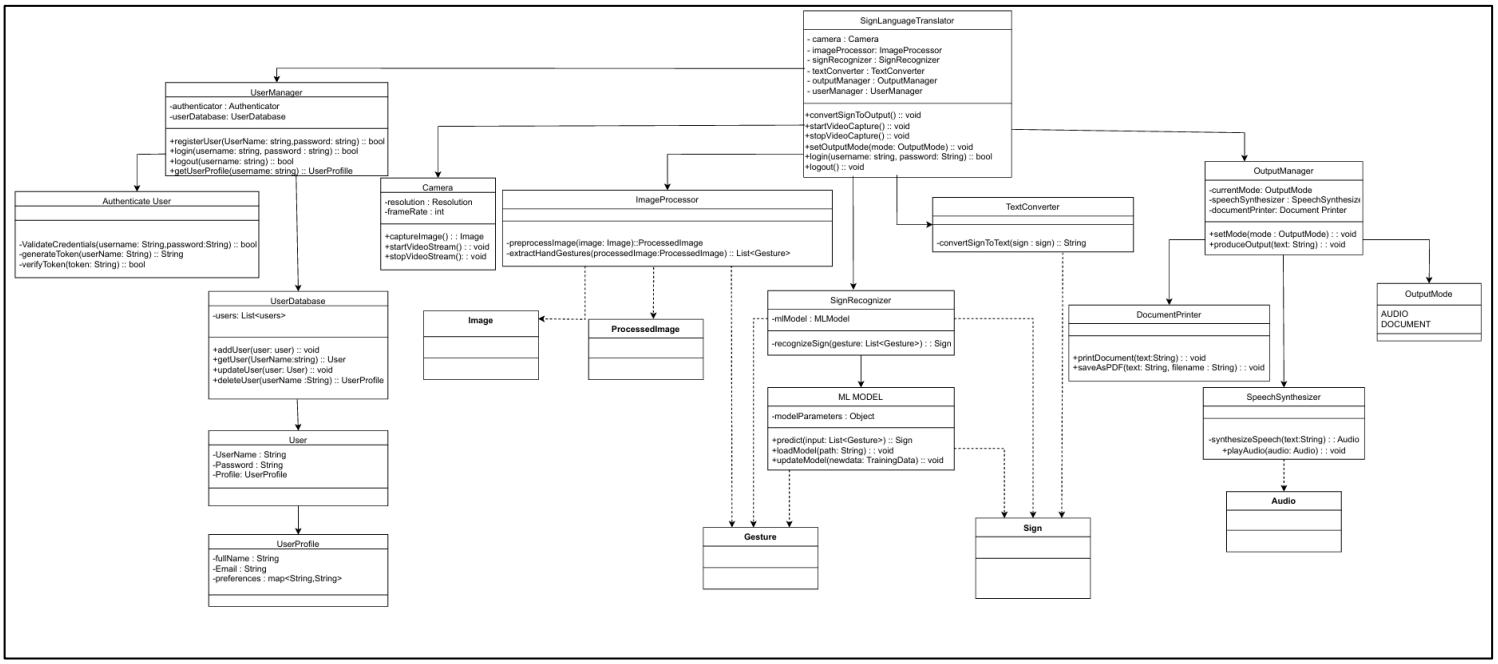


2.3.1 DFD Level 1

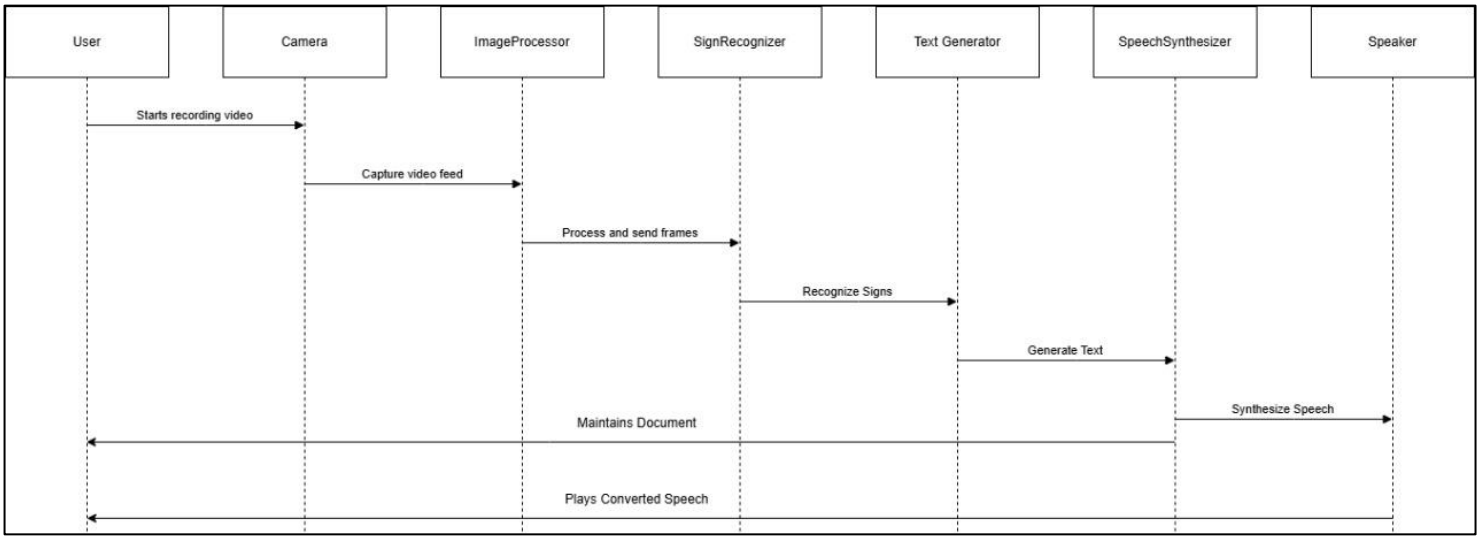


3. Design Phase

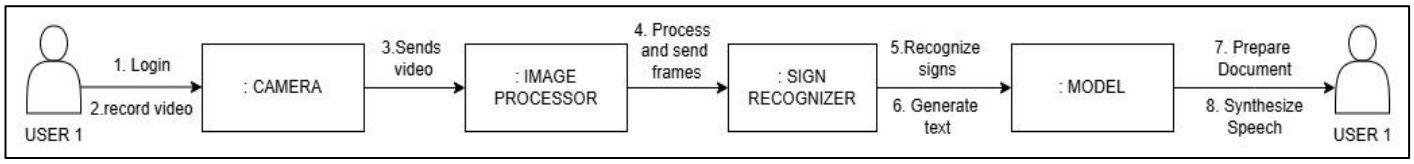
3.1 Class Diagram



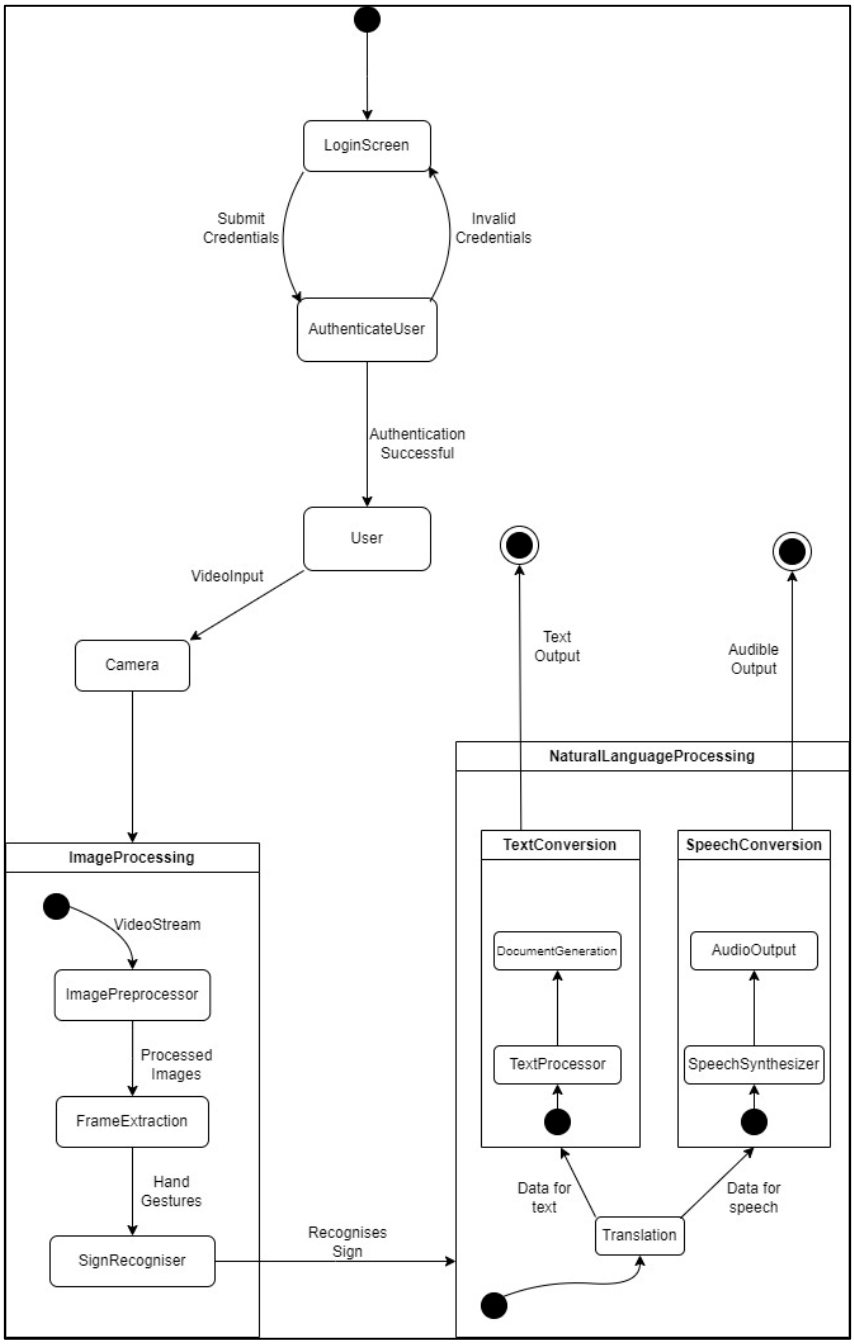
3.2 Sequence Diagram



3.3 Collaboration Diagram

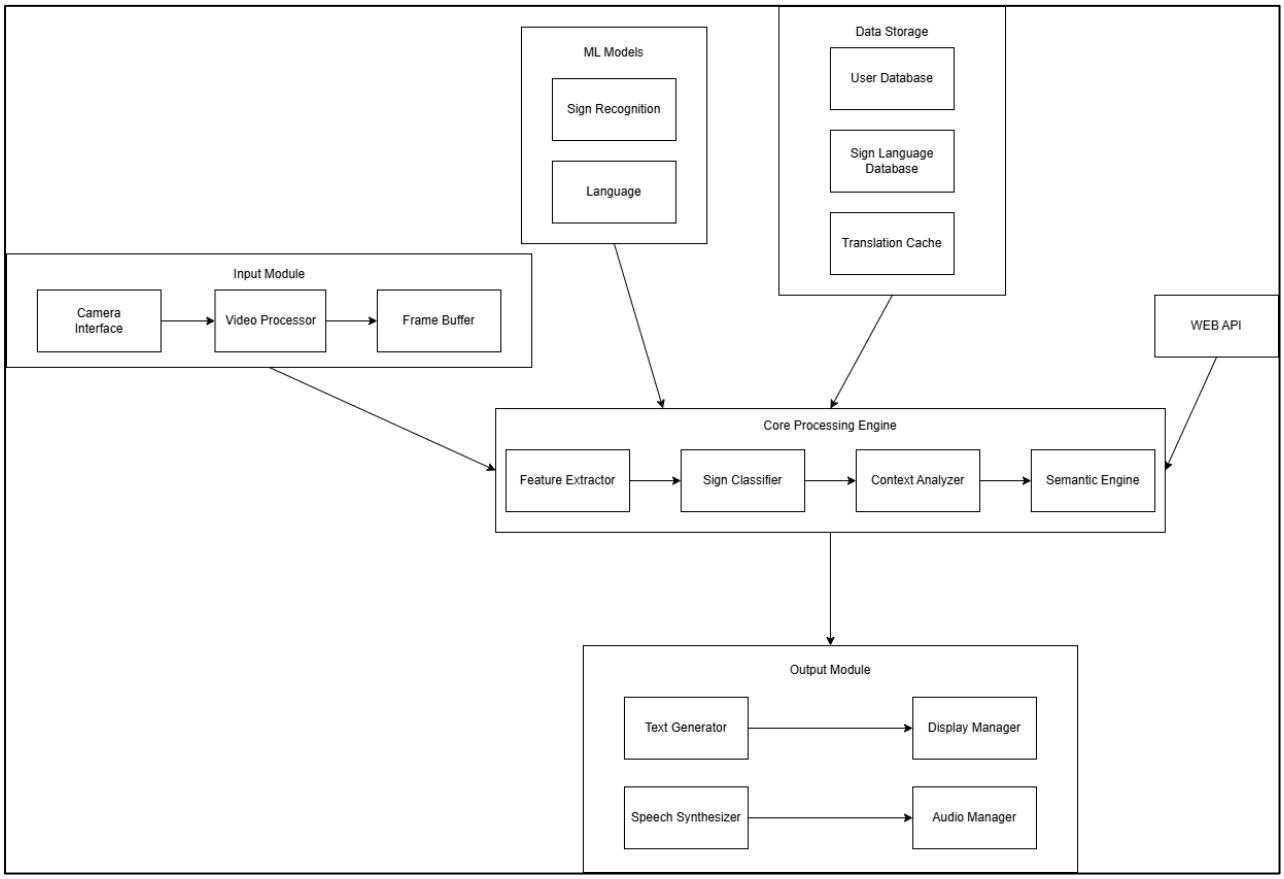


3.4 State Chart Diagram

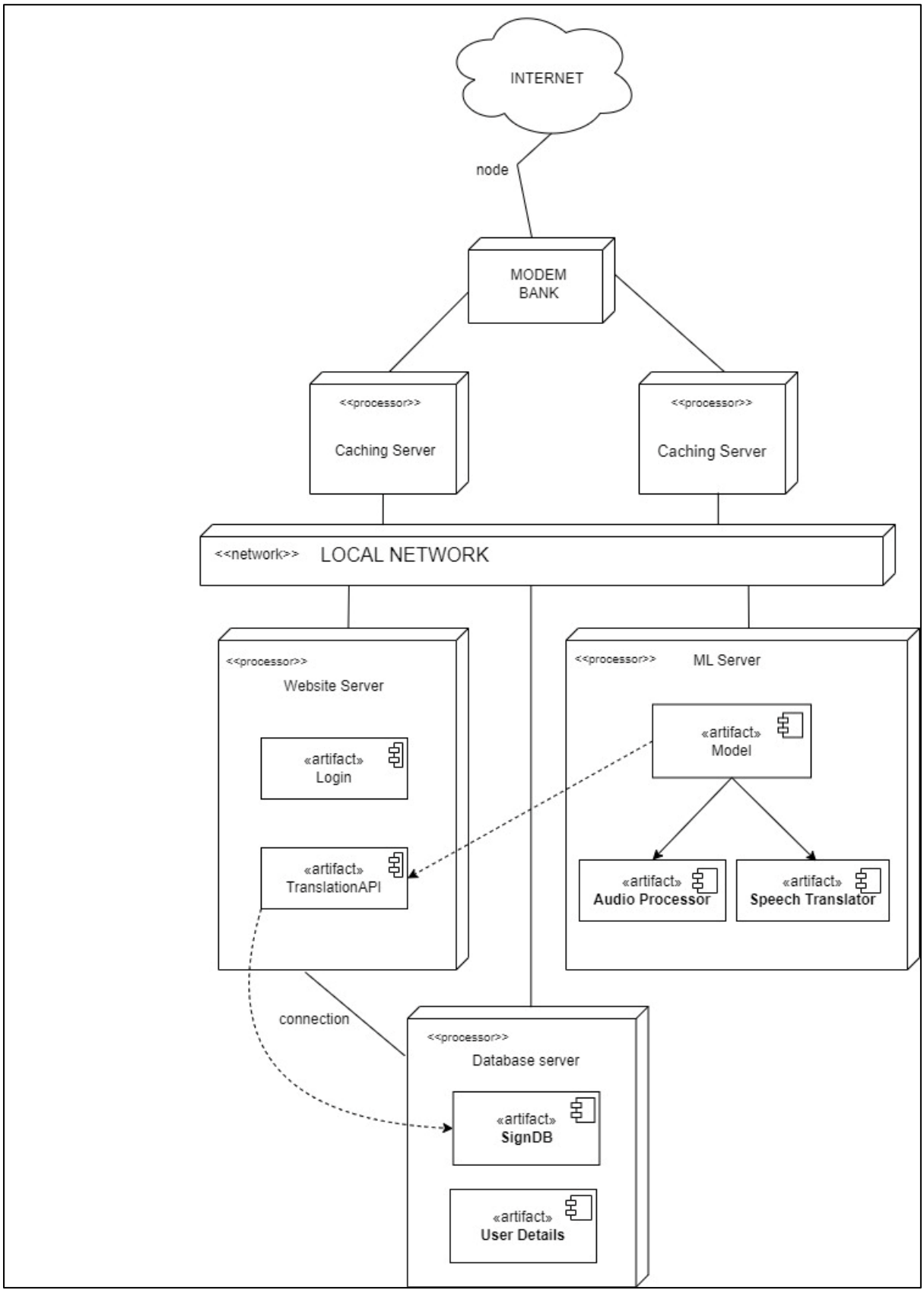


4. Implementation

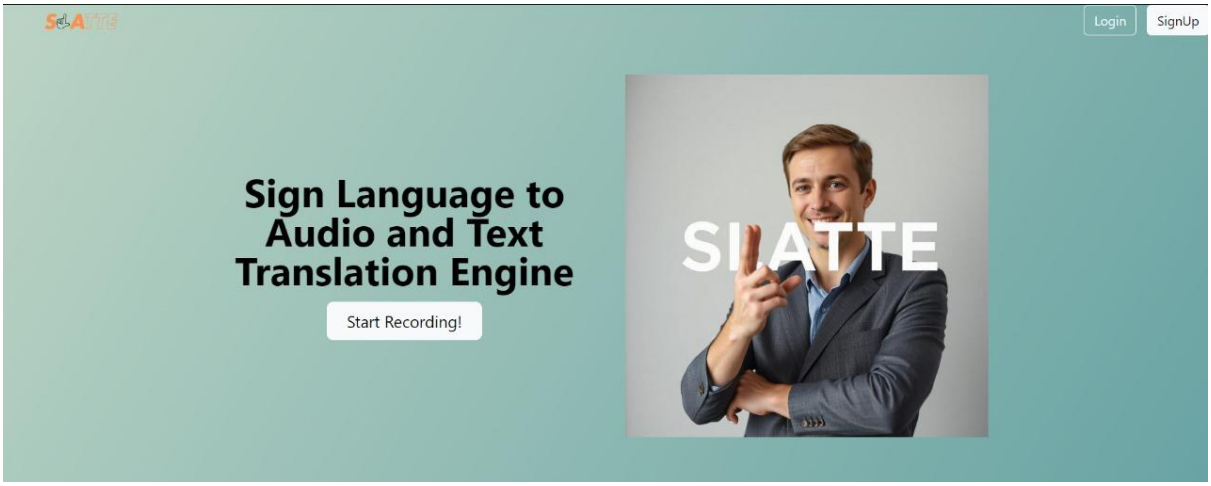
4.1 Component Diagram

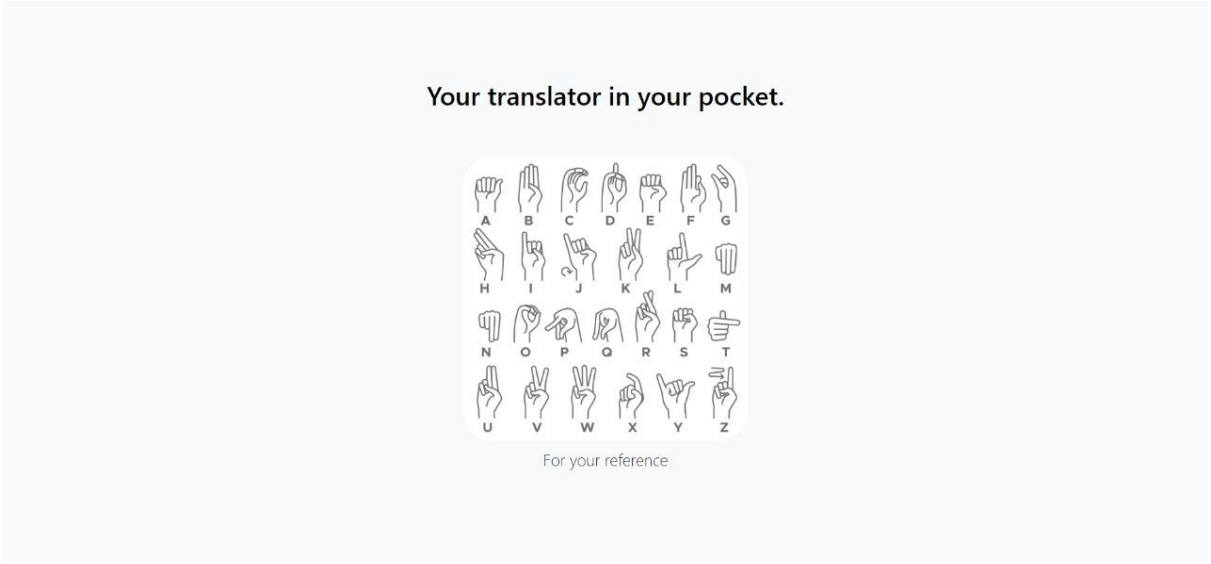


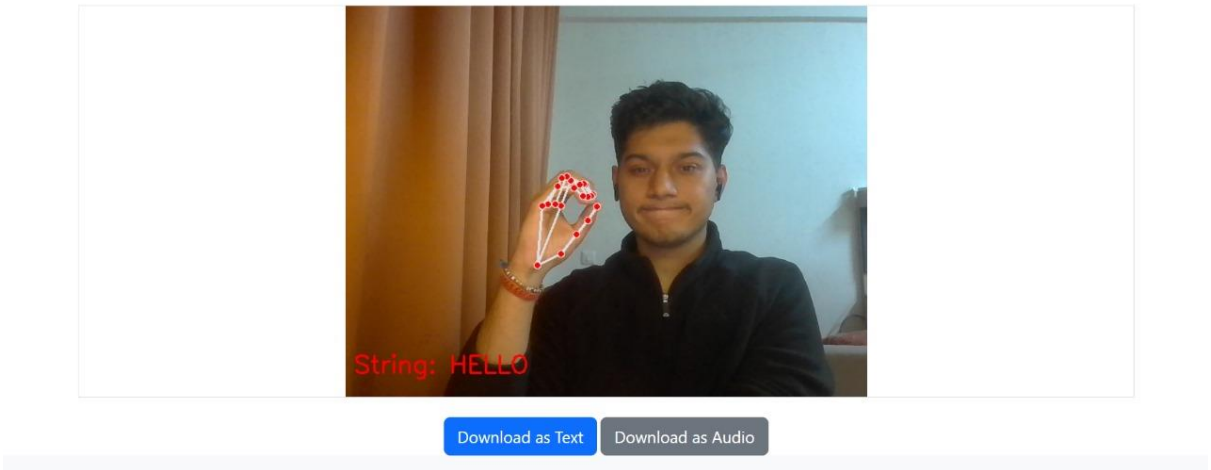
4.2 Deployment Diagram



4.3 Screenshots







5. Testing

5.1 Test Plan

5.1.1 Test Objectives

The objective is to verify the functionality of the "Sign Language to Speech and Text Translator" system, ensuring it meets all specified requirements. The tests will focus on accuracy in gesture recognition, text and speech outputs, system performance, and usability.

5.1.2 Key Points

- Data for training and testing the model must be preloaded and validated.
- Exploratory testing will ensure smooth operation under different environmental conditions.
- Performance testing will assess the response time and recognition accuracy.

5.1.3 Test Principles

- Testing will be methodical, with a focus on repeatability and measurability.
- Each phase will have clearly defined goals, from unit tests to integration tests.
- Emphasis will be placed on user scenarios to validate practical usability.

5.1.4 Data Approach

- Gesture recognition will be tested using a dataset of predefined sign language gestures.
- Speech synthesis and text outputs will be compared against expected results.
- Both valid and invalid inputs will be used to evaluate error handling.

5.1.5 Scope and Levels of Testing

- Unit Testing: Validates individual components (gesture recognition, speech synthesis, text output).
- Integration Testing: Ensures seamless interaction between modules.
- System Testing: Tests the system as a whole for compliance with requirements.
- User Acceptance Testing: Validates the system's usability and functionality from an end-user perspective.

5.2 Test Cases

Test Case #: 1
Test Case Name: User Registration
System: Sign Language to Audio and Text Translation
Subsystem: User Management
Designed by: Jiya
Design Date: 12/11/2024
Executed by:
Execution Date:
Short Description: Test new user registration process

Pre-Conditions:

1. System database is operational
2. Registration form is accessible
3. Email service is functional
4. System displays welcome screen

Step	Action	Expected System Response	Pass/Fail	Comment
1.	Click "Register New User"	System displays registration form		
2.	Enter valid username "testuser"	System checks username availability		
3.	Enter valid email "test@email.com"	System validates email format		
4.	Enter password "Test@123"	System checks password strength		
5.	Enter matching confirm password	System enables registration button		
6.	Click "Register" button	System updates password in database		
7.	Enter invalid email format	System shows "Link expired" message		
8.	Enter weak password "123"	System shows password requirement message		
9.	Enter existing username	System shows “username taken” message		

Post-Conditions:

1. User account is created in database
2. Verification email is sent
3. User is redirected to login page

Test Case #: 2
Test Case Name: User Login
System: Sign Language to Audio and Text Translation
Subsystem: Authentication
Designed by: Jiya
Design Date: 12/11/2024
Executed by:
Execution Date:
Short Description: Test user login functionality

Pre-Conditions:
1. System database is operational
2. Reset form is accessible
3. Email service is functional
4. System displays welcome screen

Step	Action	Expected System Response	Pass/Fail	Comment
1.	Click "Login"	System displays login form		
2.	Enter valid username/email	System accepts input		
3.	Enter valid password	System validates credentials		
4.	Click "Login" button	System grants access to dashboard		
5.	Check post-condition 1			
6.	Enter incorrect password	System shows "Invalid credentials" message		
7.	Click "Forgot Password"	System displays password reset form		
8.	Enter invalid username	System shows "User not found" message		
9.	Try 3 failed login attempts	System temporarily locks account		

Post-Conditions:
1. User successfully logged in
2. Login activity logged
3. Session token generated

Test Case #: 3
Test Case Name: Translation History and Export
System: Sign Language to Audio and Text Translation
Subsystem: Profile Management
Designed by: Jiya
Design Date: 12/11/2024
Executed by:
Execution Date:
Short Description: Test user profile settings and history

Pre-Conditions:
1. System database is operational
2. Profile settings are accessible
3. Email service is functional
4. User profile page is accessible

Step	Action	Expected System Response	Pass/Fail	Comment
1.	Access Translation History	System displays list of past translations		
2.	Filter by date range	System shows filtered results		
3.	Search specific words	System displays matching translations		
4.	Export as TXT	System generates text file download		
5.	Delete selected entries	System removes selected history items		
6.	Update email preferences	System saves notification settings		
7.	Share translation	System generates shareable link		
8.	View usage statistics	System displays accuracy metrics		

Post-Conditions:
1. Export files generated correctly
2. History updates reflected
3. Shared links functional

Test Case #: 4 **Test Case Name:** User Profile Management

System: Sign Language to Audio and Text Translation **Subsystem:** Profile Management

Designed by: Jiya **Design Date:** 12/11/2024

Executed by: **Execution Date:**

Short Description: Test user profile settings and history

Pre-Conditions:

1. System database is operational
2. Profile settings are accessible
3. Email service is functional
4. User profile page is accessible

Step	Action	Expected System Response	Pass/Fail	Comment
1.	Access Profile settings	System displays user profile page		
2.	Update display name	System saves new display name		
3.	Change password	System validates credentials and updates password		
4.	View translation history	System displays past translations		
5.	Delete translation history	System removes selected history items		
6.	Update email preferences	System saves notification settings		
7.	Upload profile picture	System validates and saves image		
8.	View usage statistics	System displays accuracy metrics		

Post-Conditions:

1. Profile changes are saved
2. User settings updated
3. History changes reflected

Test Case #: 5 **Test Case Name:** Password Recovery

System: Sign Language to Audio and Text Translation **Subsystem:** User Security

Designed by: Jiya **Design Date:** 12/11/2024

Executed by: **Execution Date:**

Short Description: Test the password recovery and reset process

Pre-Conditions:

1. User account exists in system
2. Email service is functional
3. Reset token generation is working
4. System is in stable state

Step	Action	Expected System Response	Pass/Fail	Comment
1.	Click "Forgot Password"	System displays password recovery form		
2.	Enter registered email	System validates email existence		
3.	Submit recovery request	System sends reset link email		
4.	Click reset link	System displays password reset form		
5.	Enter new password	System validates password strength		
6.	Confirm new password	System updates password in database		
7.	Try expired reset link	System shows "Link expired" message		
8.	Enter unmatched passwords	System shows error message		

Post-Conditions:

1. Password successfully updated
2. Old password invalidated
3. User notified of password change

Test Case #: 6
Test Case Name: System Settings and Preferences
System: Sign Language to Audio and Text Translation
Subsystem: System Configuration
Designed by: Jiya
Design Date: 12/11/2024
Executed by:
Execution Date:
Short Description: Test user-specific system settings

Pre-Conditions:
1. Profile settings are accessible
2. Email service is functional
3. User profile page is accessible

Step	Action	Expected System Response	Pass/Fail	Comment
1.	Access System Settings	System displays settings page		
2.	Change UI theme	System updates interface appearance		
3.	Adjust text size	System updates display font size		
4.	Toggle auto-correction	System updates correction settings		
5.	Set default export format	System saves preference		
6.	Configure auto-save interval	System updates save frequency		
7.	Reset to defaults	System restores default settings		
8.	Save changes	System applies and stores all settings		

Post-Conditions:
1. Settings saved to user profile
2. Changes applied immediately
3. Settings persist across sessions

Test Case #: 7
Test Case Name: Normal Application Shutdown
System: Sign Language to Audio and Text Translation
Subsystem: State Management
Designed by: Jiya
Design Date: 12/11/2024
Executed by:
Execution Date:
Short Description: Test proper application shutdown and state saving

Pre-Conditions:
1. User is logged in
2. Active session exists
3. Unsaved work may be present
4. System is in stable state

Step	Action	Expected System Response	Pass/Fail	Comment
1.	Click "Exit" button	System prompts to save unsaved work		
2.	Save current work	System saves all pending changes		
3.	Close active session	System logs out user properly		
4.	Save user preferences	System stores current settings		
5.	Clear temporary files	System removes temporary data		
6.	Log shutdown event	System records shutdown timestamp		
7.	Close database connections	System closes connections safely		
8.	Complete shutdown	System terminates processes properly		

Post-Conditions:
1. All data saved
2. Session ended properly
3. Resources released

Test Case #: 8 **Test Case Name:** Unexpected Shutdown Recovery

System: Sign Language to Audio and Text Translation **Subsystem:** Recovery Management

Designed by: Jiya **Design Date:** 12/11/2024

Executed by: **Execution Date:**

Short Description: Test system recovery after unexpected shutdown

Pre-Conditions:

1. User is logged in
2. Active session exists
3. Unsaved work may be present
4. System is in stable state

Step	Action	Expected System Response	Pass/Fail	Comment
1.	Force close application	System activates crash detection		
2.	Restart application	System detects previous crash		
3.	Check auto-saved data	System loads last auto-saved state		
4.	Restore session	System recovers last session data		
5.	Check data integrity	System verifies recovered data		
6.	Display recovery status	System shows recovery report		
7.	Restore user settings	System restores previous settings		
8.	Resume operations	System returns to functional state		

Post-Conditions:

1. Data recovered
2. Session restored
3. System stable

Test Case #: 9 **Test Case Name:** Auto-Save Functionality

System: Sign Language to Audio and Text Translation **Subsystem:** Data Preservation

Designed by: Jiya **Design Date:** 12/11/2024

Executed by: **Execution Date:**

Short Description: Test automatic data saving mechanisms

Pre-Conditions:

1. User is logged in
2. Active session exists
3. Unsaved work may be present
4. System is in stable state

Step	Action	Expected System Response	Pass/Fail	Comment
1.	Start new translation session	System initiates auto-save timer		
2.	Wait for auto-save interval	System performs automatic save		
3.	Modify translation data	System flags changes for next save		
4.	Check auto-save frequency	System follows save schedule		
5.	Verify save locations	System uses correct storage paths		
6.	Test low storage scenario	System shows storage warning		
7.	Check backup creation	System maintains backup copies		
8.	Verify data versions	System manages version history		

Post-Conditions:

1. Auto-save working
2. Backups created
3. Storage managed

Test Case #: 10 **Test Case Name:** Network Disconnection

System: Sign Language to Audio and Text Translation **Subsystem:** Connectivity Management

Designed by: Jiya **Design Date:** 12/11/2024

Executed by: **Execution Date:**

Short Description: Test system behaviour during networks

Pre-Conditions:

1. User is logged in
2. Active session exists
3. Unsaved work may be present
4. System is in stable state

Step	Action	Expected System Response	Pass/Fail	Comment
1.	Disconnect network	System detects connection loss		
2.	Continue operations	System switches to offline mode		
3.	Save offline data	System stores data locally		
4.	Attempt sync	System queues sync operations		
5.	Restore connections	System detects network return		
6.	Sync pending data	System synchronizes offline data		
7.	Verify data sync	System confirms synchronization		
8.	Resume online mode	System returns to normal operation		

Post-Conditions:

1. Offline data preserved
2. Sync completed
3. Normal Operation resumed

Test Case #: 11 **Test Case Name:** Basic Word Formation

System: Sign Language to Audio and Text Translation **Subsystem:** Core recognition

Designed by: Jiya **Design Date:** 12/11/2024

Executed by: **Execution Date:**

Short Description: Test the basic sign language to text/speech conversion functionality

Pre-Conditions:

1. The system camera is operational and properly calibrated
2. The user is positioned within the camera's optimal detection range (1-2 meters)
3. The lighting conditions are adequate (300-700 lux)
4. The system is in "Recognition Mode"

Step	Action	Expected System Response	Pass/Fail	Comment
1.	User performs ASL sign for "H"	System recognizes and displays "H" on screen		
2.	User performs ASL sign for "E"	System recognizes and displays "HE" on screen		
3.	User performs ASL sign for "L"	System recognizes and displays "HEL" on screen		
4.	User performs ASL sign for "L"	System recognizes and displays "HELL" on screen		
5.	User performs ASL sign for "O"	System recognizes and displays "HELLO" on screen		
6.	User removes hand from gesture detecting box	System adds space after the word		
7.	Check text-to-speech output	System pronounces "HELLO" through speakers		
8.	Verify data sync	System confirms synchronization		

Post-Conditions:

1. The word "HELLO" is saved in the session history
2. The speech output is logged in the system
3. Recognition accuracy metrics are updated

Test Case #: 12 **Test Case Name:** Sentence Structure

System: Sign Language to Audio and Text Translation **Subsystem:** Sentence Formation

Designed by: Kushagr Sharma **Design Date:** 12/11/2024

Executed by: **Execution Date:**

Short Description: Test the basic sign language to text/speech conversion functionality

Pre-Conditions:

1. System is in "Sentence Mode"
2. Previous text cleared
3. Speech output enabled

Step	Action	Expected System Response	Pass/Fail	Comment
1.	Sign "I"	System recognizes and displays "I"		
2.	User performs space gesture	System adds space after "I"		
3.	User performs ASL sign for "A""M"	System recognizes and displays " I AM" on screen		
4.	User performs space gesture	System adds space		
5.	User performs ASL sign for "H" "A" "P" "P" "Y"	System recognizes and displays "I AM HAPPY" on screen		
6.	User removes hand from gesture detecting box	System finalizes the sentence		
7.	Perform speak gesture	System reads full sentence		
8.	Verify data sync	System confirms synchronization		

Post-Conditions:

1. Complete sentence saved
2. Proper spacing verified
3. Speech synthesis successful

Test Case #: 13 **Test Case Name:** Display Formatting

System: Sign Language to Audio and Text Translation **Subsystem:** Text Display Output

Designed by: Kushagr Sharma **Design Date:** 12/11/2024

Executed by: **Execution Date:**

Short Description: Test text display formatting and screen output features

Pre-Conditions:

1. Display screen is active and calibrated
2. Font size set to default (16pt)
3. Display area is clear
4. System in "Standard Output Mode"

Step	Action	Expected System Response	Pass/Fail	Comment
1.	Sign "HELLO"	Text appears in main display area at 16pt		
2.	Click zoom up	Font size increases to 24pt		
3.	Click zoom down	Font size returns to 16pt		
4.	Sign multiple words quickly	Text appears with proper word spacing		
5.	Fill display with long sentence	Text auto-wraps to next line		
6.	Start scrolling	Display scrolls to show older text		
7.	Test real-time display	Letters appear with <100ms delay		
8.	Click “Clear Screen” button	All text cleared from display		

Post-Conditions:

1. Display settings remain consistent
2. Text formatting preserved
3. Screen refresh rate normal

Test Case #: 14 **Test Case Name:** Voice Synthesis Quality

System: Sign Language to Audio and Text Translation **Subsystem:** Speech Output

Designed by: Kushagr Sharma **Design Date:** 12/11/2024

Executed by: **Execution Date:**

Short Description: Test audio output features

Pre-Conditions:

1. Speech system initialized
2. Volume at 70%
3. Default voice selected
4. Speaker system connected

Step	Action	Expected System Response	Pass/Fail	Comment
1.	Sign "HELLO"	System pronounces "HELLO" clearly		
2.	Sign longer word "IMMEDIATE"	System pronounces all syllables correctly		
3.	Increase volume	Speech volume increases by 10%		
4.	Decrease volume	Speech volume decreases by 10%		
5.	Fill display with long sentence	System waits for sentence completion before speaking		
6.	Click “pause” button	System stops but maintains natural speech rhythm		
7.	Click “Speed up” button	Speech pace increases by 20%		
8.	Click “Speed down” button	Speech pace returns to normal		

Post-Conditions:

1. Speech settings saved
2. Volume levels maintained
3. Speech clarity verified

Test Case #: 15 **Test Case Name:** Synchronised Output Testing

System: Sign Language to Audio and Text Translation **Subsystem:** Multi-Output Mode

Designed by: Kushagr Sharma **Design Date:** 12/11/2024

Executed by: **Execution Date:**

Short Description: Test audio and text output synchronisation features

Pre-Conditions:

1. Both display and speech systems active
2. Secondary display connected (if applicable)
3. Output synchronization enabled

Step	Action	Expected System Response	Pass/Fail	Comment
1.	Sign "HELLO"	Text appears and speech plays simultaneously		
2.	Make highlight gesture	Current word highlighted while being spoken		
3.	Test word-by-word mode	Each word highlighted as it's spoken		
4.	Enable caption mode	Caption appear below main text		
5.	Click “pause” button	Both text and speech stop		
6.	Click “resume” button	Output continues from pause point		
7.	Test emergency stop	All output systems stop immediately		

Post-Conditions:

1. All outputs properly synchronized
2. No lag between text and speech
3. System resources properly managed

Test Case #: 16 **Test Case Name:** System Accessibility

System: Sign Language to Audio and Text Translation **Subsystem:** User Interface

Designed by: Kushagr Sharma **Design Date:** 12/11/2024

Executed by: **Execution Date:**

Short Description: Test system accessibility features

Pre-Conditions:

1. Both display and speech systems active
2. Secondary display connected (if applicable)
3. Output synchronization enabled

Step	Action	Expected System Response	Pass/Fail	Comment
1.	Test screen reader compatibility	System works with screen readers		
2.	Check keyboard navigation	System supports full keyboard control		
3.	Test color contrast	System meets WCAG guidelines		
4.	Verify text scaling	System handles text size changes		
5.	Test alternative text	System provides image descriptions		
6.	Check focus indicators	System shows clear focus states		
7.	Test error messages	System provides clear error feedback		
8.	Verify form labels	System has proper form accessibility		

Post-Conditions:

1. Accessibility standards met
2. Navigation functional
3. Screen reader compatible

Test Case #: 17 **Test Case Name:** Cross-Platform Testing

System: Sign Language to Audio and Text Translation **Subsystem:** Platform Compatibility

Designed by: Kushagr Sharma **Design Date:** 12/11/2024

Executed by: **Execution Date:**

Short Description: Test system functionality across different platforms

Pre-Conditions:

1. System is in stable state
2. Error logging is enabled
3. Recovery procedures are configured
4. Test environment is isolated

Step	Action	Expected System Response	Pass/Fail	Comment
1.	Test on Chrome browser	System functions correctly		
2.	Test on Firefox browser	System maintains functionality		
3.	Test on Safari browser	System maintains functionality		
4.	Test on mobile devices	System adapts to mobile view		
5.	Test on tablets	System supports tablet interfaces		
6.	Check responsive design	System adjusts to screen size		
7.	Test offline functionality	System handles offline state		
8.	Verify data sync	System syncs across platforms		

Post-Conditions:

1. Cross-platform compatibility verified
2. Responsive design working
3. Data consistency maintained

5.3 Test Reports

Test Suite ID	**TS002**
Test Case ID	TC002
Summary	Verify user login
Preconditions	Valid username and password exist.
Test Data	Username: "admin," Password: "password123."
Expected Result	Successful login with redirection to the home page
Actual Result	Successful login with redirection to the home page
Status	Pass
Remarks	Login working successfully
Date of Creation	25/11/2024
Test Environment	Chrome Browser

Test Suite ID	**TS015**
Test Case ID	TC015
Summary	Verify gesture recognition accuracy
Preconditions	System has access to a calibrated camera and gesture library.
Test Data	Gesture: "Hello."
Expected Result	Recognized as "Hello" with text and speech output.
Actual Result	Recognized as "Hello" with text and speech output.
Status	Pass
Remarks	Core gesture recognition successful
Date of Creation	25/11/2024
Test Environment	Chrome Browser