A Real Time Communication System For Specially A bled

Team ID : PNT2022TMID29473

Industry Mentor(s) Name	**:**	**Divya**
Faculty Mentor(s) Name	**:**	**Shoba G**

Team Members

E.R.SIVAPRIYA	**- 510419104069**
A. SHAMEERA	**- 510419104065**
N. YAMINI	**- 510419104080**
M. YOGESHWARI	**- 510419104082**

Table Of Contents

Real Time Communication System Powered by AI for Specially A bled

1. Introduction

1.1 Project Overview

People with impairments are a part of our society. . The ability to communicate with a deaf-mute person has always been difficult. It is quite challenging for silent persons to communicate with non-mute people because hand sign language is not taught to the general public. It might be quite challenging for them to communicate at times of crisis. In circumstances where other modes of communication, like speech, are not possible, the human hand has remained a common alternative for information transmission. To have proper communication between a normal person and a handicapped person in any language, a voice conversion system with hand gesture recognition and translation will be beneficial.

1.2 Purpose

The project intends to create a system that can translate speech into specified sign language for the deaf and dumb as well as translate sign language into a human hearing voice in the desired language to communicate a message to normal people.

2. Literature Survey

2.1 Existing Problem

In our society, we have people with disabilities. The technology is developing day by day but no significant developments are undertaken for the betterment of these people. Communications between deaf-mute and a normal person has always been a challenging task. It is complicated for mute people to convey their message to normal people. Since normal people are not trained on hand sign language. In emergency times conveying their message is very difficult. The human hand has remained a popular choice to convey information in situations where other forms like speech cannot be used. Voice Conversion System with Hand Gesture Recognition and translation will be handy to have a proper conversation between a normal person and an impaired person in any language.

2.2 References

- http://cs231n.stanford.edu/reports/2016/pdfs/214_Report.pdf
- http://www.iosrjen.org/Papers/vol3_issue2%20(part-2)/H03224551.pdf

Other References:

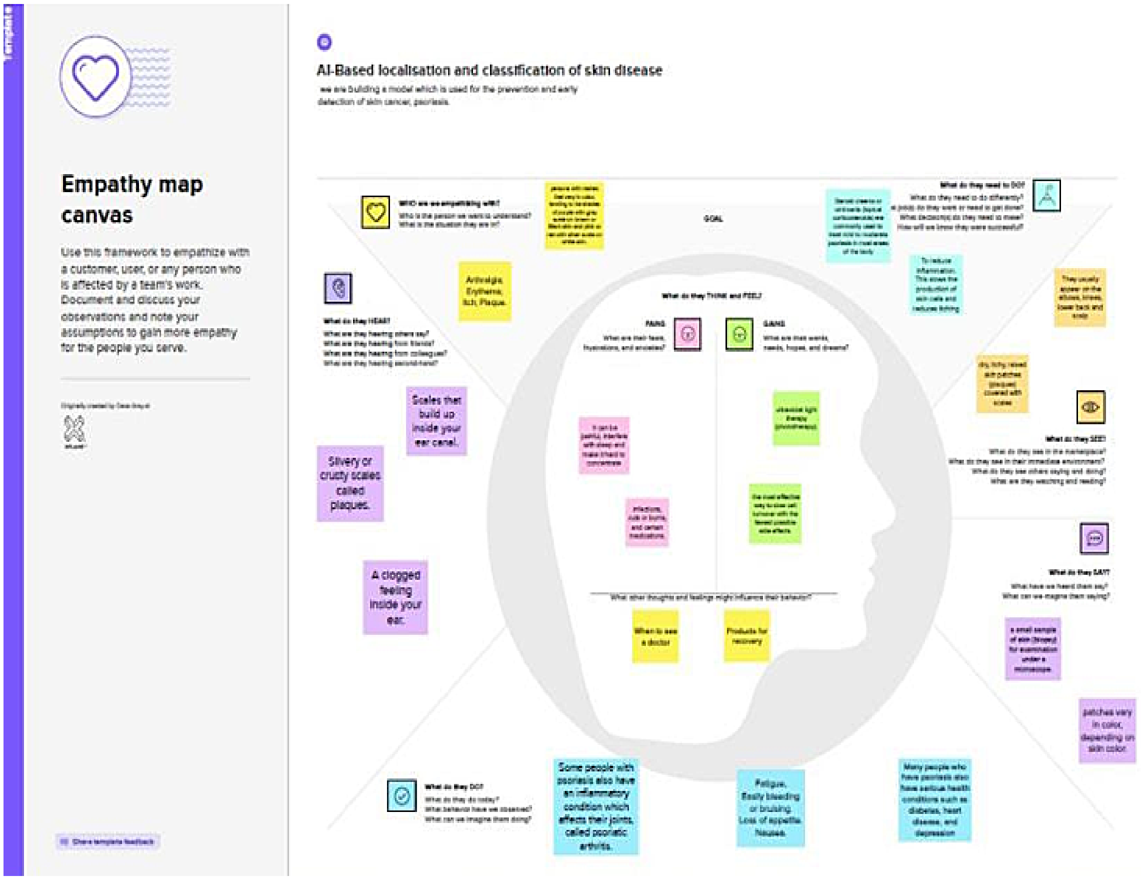
- http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.734.8389&rep=rep1&type=pdf
- http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.734.8389&rep=rep1&type=pdf
- https://ieeexplore.ieee.org/document/7507939
- https://ieeexplore.ieee.org/document/7916786
- https://www.sciencedirect.com/science/article/pii/S1877050917320720

2.3 Problem Definition Statement

People with disabilities are a part of our society. Even though technology is constantly evolving, little is being done to improve the lives of these people. Communication with a deaf-mute person has always been difficult. Because hand sign language is not taught to the public, it can be difficult for silent people to communicate with non-mute people. In times of crisis, they may find it difficult to communicate. When other modes of communication, such as speech, are unavailable, the human hand has remained a popular method of information transmission. A voice conversion system with hand gesture recognition and translation will be beneficial in establishing proper communication between a normal person and a handicapped person in any language.

3. Ideation and Proposed Solution

3.1 Empathy Map



Empathy map canvas

Use this framework to empathize with a customer, user, or any person who is affected by a team's work. Document and discuss your observations and note your assumptions to gain more empathy for the people you serve.

Originally created by Dave Gray at XPLANE

AI-Based localisation and classification of skin disease

we are building a model which is used for the prevention and early detection of skin cancer, psoriasis.

WHO are we empathizing with?
Who is the person we want to understand?
What is the situation they are in?

[illegible]

GOAL

What do they need to DO?
What do they need to do differently?
What job(s) do they want or need to get done?
What decision(s) do they need to make?
How will we know they were successful?

Steroid creams or ointments (topical corticosteroids) are commonly used to treat mild to moderate psoriasis in most areas of the body

To reduce inflammation. This slows the production of skin cells and reduces itching

They usually appear on the elbows, knees, lower back and scalp

Arthralgia, Erythema, Itch, Plaque.

What do they HEAR?
What are they hearing others say?
What are they hearing from friends?
What are they hearing from colleagues?
What are they hearing second-hand?

Scales that build up inside your ear canal.

Silvery or crusty scales called plaques.

A clogged feeling inside your ear.

What do they THINK and FEEL?

PAINS
What are their fears, frustrations, and anxieties?

It can be painful, interfere with sleep and make it hard to concentrate

infections, cuts or burns, and certain medications

GAINS
What are their wants, needs, hopes, and dreams?

ultraviolet light therapy (phototherapy)

the most effective way to slow cell turnover with the fewest possible side effects

What other thoughts and feelings might influence their behavior?

When to see a doctor

Products for recovery

dry, itchy, raised skin patches (plaques) covered with scales

What do they SEE?
What do they see in the marketplace?
What do they see in their immediate environment?
What do they see others saying and doing?
What are they watching and reading?

What do they SAY?
What have we heard them say?
What can we imagine them saying?

a small sample of skin (biopsy) for examination under a microscope

patches vary in color, depending on skin color

What do they DO?
What do they do today?
What behavior have we observed?
What can we imagine them doing?

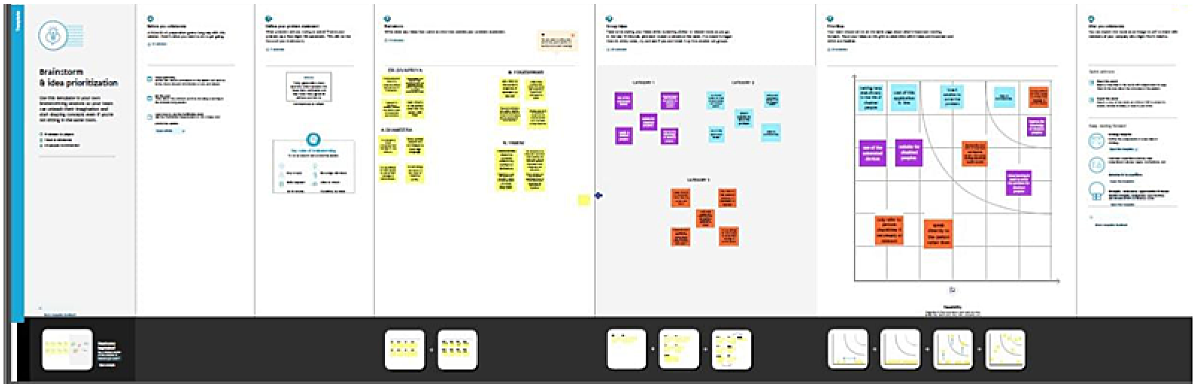
Some people with psoriasis also have an inflammatory condition which effects their joints, called psoriatic arthritis.

Fatigue, Easily bleeding or bruising. Loss of appetite. Nausea.

Many people who have psoriasis also have serious health conditions such as diabetes, heart disease, and depression

Share template feedback

3.2 Ideation and Brainstorming



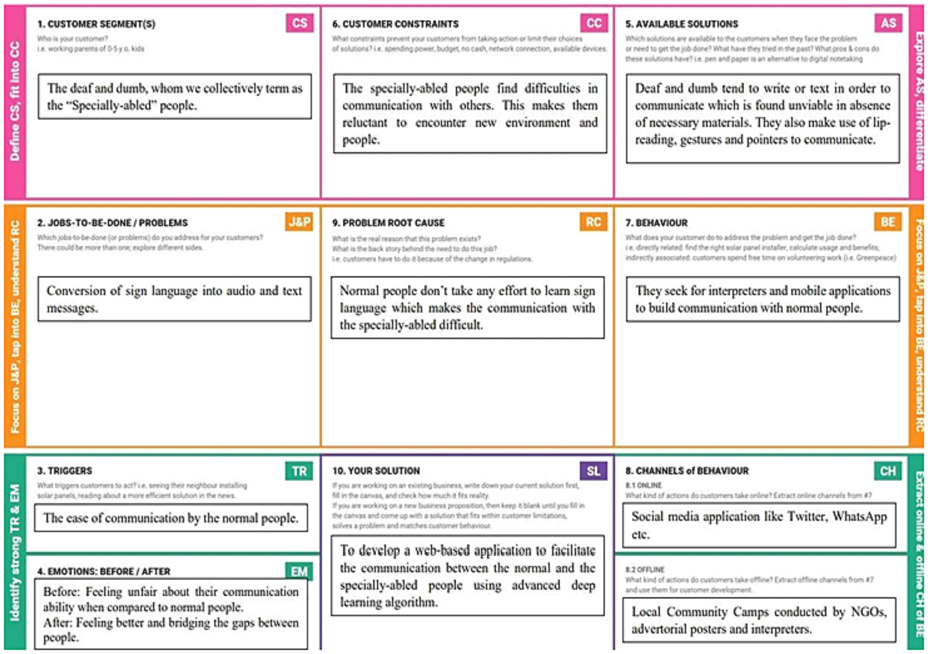
3.3.Proposed Solution

S No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	In our society, we have people with disabilities. The technology is developing day by day but no significant developments are undertaken for the betterment of these people. Communications between deaf-mute and a normal person has always been a challenging task. It is challenging for mute people to convey their message to normal people. Since normal people are not trained on hand sign language. In emergency times conveying their message is very difficult.

2.	Idea / Solution description	The project aims to develop a system that converts the sign language into a human hearing voice. In the desired language to convey a message to normal people, as well as convert speech into understandable sign language for the deaf and dumb. We are use of a convolution neural network to create a model that is trained on different hand gestures. An app is built which uses this model. This app enables deaf and dumb people to convey their information using signs which get converted to human-understandable language and speech is given as output.
3.	Novelty / Uniqueness	1. Facial Emotion Detection • Language customization • User-friendly interface. 2. Greater accuracy.
4.	Social Impact / Customer Satisfaction	The proposed solution is keen on providing a friendly user interface and user experience. User Interface (UI) is aimed to be developed in such a that way that it can be very handy and easy to learn. The system is also aimed to be light weight which would make the system provide faster and accurate results and hence it provides a better User Experience (UX).
5.	Business Model (Revenue Model)	The proposed solutions help to ease the communication between deaf and dumb people and normal people. The customization and emotion detection feature can make it lot more reliable. Hence, the solution has wide usability and requirement.

6.	Scalability of the Solution	This proposed solution is extensible in terms of the features that is been offered by the system. It can be seen as a improvised and light weight model when compared to the existing systems. The system can further be scaled in such a way that enables tasks being assigned and completed in system through gestures.

3.4 Proposed Solution Fit


Define CS, fit into CC
Explore AS, differentiate
Focus on J&P, tap into BE, understand RC
Focus on J&P, tap into BE, understand RC
Identify strong TR & EM
Extract online & offline CH of BE

1. CUSTOMER SEGMENT(S) CS

Who is your customer?
i.e. working parents of 0-5 y.o. kids

The deaf and dumb, whom we collectively term as the "Specially-abled" people.

6. CUSTOMER CONSTRAINTS CC

What constraints prevent your customers from taking action or limit their choices of solutions? i.e. spending power, budget, no cash, network connection, available devices.

The specially-abled people find difficulties in communication with others. This makes them reluctant to encounter new environment and people.

5. AVAILABLE SOLUTIONS AS

Which solutions are available to the customers when they face the problem or need to get the job done? What have they tried in the past? What pros & cons do these solutions have? i.e. pen and paper is an alternative to digital notetaking

Deaf and dumb tend to write or text in order to communicate which is found unviable in absence of necessary materials. They also make use of lip-reading, gestures and pointers to communicate.

2. JOBS-TO-BE-DONE / PROBLEMS J&P

Which jobs-to-be-done (or problems) do you address for your customers? There could be more than one; explore different sides.

Conversion of sign language into audio and text messages.

9. PROBLEM ROOT CAUSE RC

What is the real reason that this problem exists?
What is the back story behind the need to do this job?
i.e. customers have to do it because of the change in regulations.

Normal people don't take any effort to learn sign language which makes the communication with the specially-abled difficult.

7. BEHAVIOUR BE

What does your customer do to address the problem and get the job done?
i.e. directly related: find the right solar panel installer, calculate usage and benefits; indirectly associated: customers spend free time on volunteering work (i.e. Greenpeace)

They seek for interpreters and mobile applications to build communication with normal people.

3. TRIGGERS TR

What triggers customers to act? i.e. seeing their neighbour installing solar panels, reading about a more efficient solution in the news.

The ease of communication by the normal people.

4. EMOTIONS: BEFORE / AFTER EM

Before: Feeling unfair about their communication ability when compared to normal people.
After: Feeling better and bridging the gaps between people.

10. YOUR SOLUTION SL

If you are working on an existing business, write down your current solution first, fill in the canvas, and check how much it fits reality.
If you are working on a new business proposition, then keep it blank until you fill in the canvas and come up with a solution that fits within customer limitations, solves a problem and matches customer behaviour.

To develop a web-based application to facilitate the communication between the normal and the specially-abled people using advanced deep learning algorithm.

8. CHANNELS of BEHAVIOUR CH

8.1 ONLINE
What kind of actions do customers take online? Extract online channels from #7

Social media application like Twitter, WhatsApp etc.

8.2 OFFLINE
What kind of actions do customers take offline? Extract offline channels from #7 and use them for customer development.

Local Community Camps conducted by NGOs, advertorial posters and interpreters.

4. Requirement Analysis

4.1 Functional Requirement

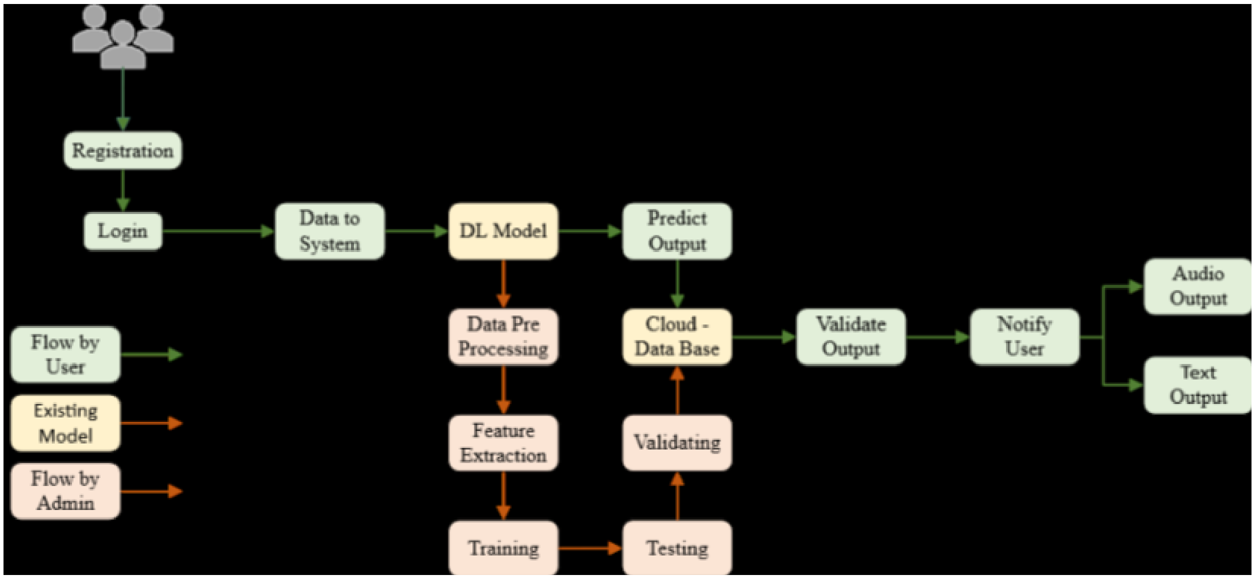
FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	**Language customization**	The user performs language customization.
FR-2	**User Options**	The user either chooses to convert speech to sign language and sign language to speech.
FR-3	**Test Inputs**	The real time video and audio data is collected and fed into the machine learning model.
FR-4 x	**Result**	The conversion will take place simultaneously and will be displayed on the screen.

4.2 Non-Functional Requirement

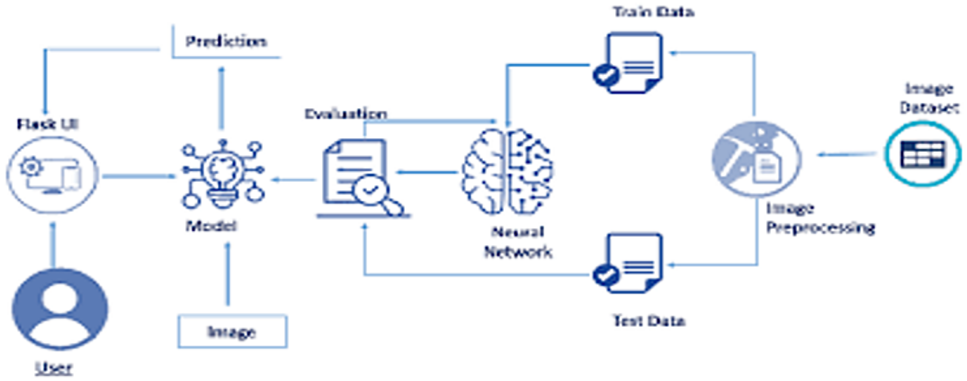
FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	The user will have access to all the resources present in that website.
NFR-2	**Security**	User information is protected.
NFR-3	**Reliability**	It offers accurate results.
NFR-4	**Performance**	The web application makes use of light weight model hence the result will be accurate and fast.
NFR-5	**Availability**	The web application can be accessed 24/7 from anywhere when connected to the internet.
NFR-6	**Scalability**	The trained ML model can provide accurate results whenever the size of the dataset and the number of users is extended.

5. Project Design

5.1 Data-flow Diagram



5.2 Solution and Technical Architecture



5.3 User Story

User	Functional Requirement t (Epic)	User Story Number	User story/Task	Acceptance criteria	Priority	Release
Customer r	Uploading the real time data.	USN-1	The user will be presented with two options. Speech to sign language conversion. 2. Sign language to speech conversion.	They can access the portal	High	Sprint-1
		USN-2	Language selection	They can access the portal	Low	Sprint-1
		USN-3	The deaf-mute person will choose the speech to sign language conversion which would take them into a portal that collects the real time data (sign language recognition) and converts it into speech simultaneously.	Video processing	High	Sprint-2

6. Project Planning and Scheduling

6.1 Sprint Planning and Estimation

Product Backlog, Sprint Schedule, and Estimation

Sprint	**Functional Requirement (Epic)**	**User Story Number**	**User Story / Task**	**Story Point**	**Priority**	**Team Members**
Sprint 1	Choose Available Options	USN-1	The user will be presented with two options. 1. Speech to sign language conversion. 2. Sign language to speech conversion	1	Low	**ER. SIVAPRIYA** **A.SHAMEERA** **N.YAMINI** **M.YOGESHWARI**
Sprint 2	Language selection	USN-2	The user can select any one of the available options according to their requirement	**2**	**MEDIUM**	**ER. SIVAPRIYA** **A.SHAMEERA** **N.YAMINI** **M.YOGESHWARI**
Sprint 3	Convert from one language to another	USN-4	The deaf-mute person will choose the speech to sign language conversion which would take them into a portal that collects the real time data	**2**	**HIGH**	**ER. SIVAPRIYA** **A.SHAMEERA** **N.YAMINI** **M.YOGESHWARI**

Sprint-4	Emotion detection	USN-4	By processing the video it detects the emotion of the user	**2**	**HIGH**	**ER. SIVAPRIYA** **A.SHAMEERA** **N.YAMINI** **M.YOGESHWARI**

6.2 Sprint Delivery Schedule

Project Tracker, Velocity & Burndown Chart:

Sprint	**Total Story Points**	**Duration**	**Sprint Start Date**	**Sprint End Date (Planned)**	**Story Points Completed (as on Planned End Date)**	**Sprint Release Date (Actual)**
Sprint 1	20	6 Days	24 Oct 2022	29 Oct 2022	20	29 Oct 2022
Sprint 2	20	6 Days	31 Oct 2022	5 Nov 2022	20	5 Nov 2022
Sprint 3	20	6 Days	7 Nov 2022	12 Nov 2022	20	12 Nov 2022
Sprint 4	20	6 Days	14 Nov 2022	19 Nov 2022	20	19 Nov 2022

Velocity:

Imagine we have a 10-day sprint duration, and the velocity of the team is 20 (points per sprint). Let’s calculate the team’s average velocity (AV) per iteration unit (story points per day)

Burndown Chart:

A burndown chart is a graphical representation of work left to do versus time. It is often used in agile software development methodologies such as Scrum. However, burn down charts can be applied to any project containing measurable progress over time.

7.Coding and Solutioning

7.1 Feature 1

Real time sign to speech

Sign language is generally used by the people who are unable to speak, for communication. Most people will not be able to understand the Universal Sign Language (unless they have learnt it) and due to this lack of knowledge about the language, it is complicated for them to communicate with mute people. A device that helps to bridge a gap between mute persons and other people forms the crux of this project. Our system makes use of a model build using CNN that that is capable of detection sign languages real time.

7.2 Feature 2

Real time speech to sign

With the Web Speech API, we can recognize speech using JavaScript. It is super easy to recognize speech in a browser using JavaScript and then getting the text from the speech to use as user input. We use the **SpeechRecognition** object to convert the speech into text and then display the text on the screen. Our system is capable of doing this over real time. It is capable of recognizing any languages in which the user is trying to communicate. But the support for this API is limited to the **Chrome browser only**. So if you are viewing this example in some other browser, the live example below might not work.

8. Testing

8.1 Test Cases

1. Verify if user can see the options when user clicks the URL
2. Verify if the UI elements are getting displayed properly
3. Verify if the user can choose any languages
4. Verify if the user is getting redirected to the sign to speech page
5. Verify if the application can convert the sign to speech
6. Verify if the user can exit the sign to speech page
7. Verify if the user is getting redirected to the speech to sign page
8. Verify if the UI elements are being displayed
9. Verify if the application can convert speech to text on clicking voice to text button.
10. Verify if the user can exit the speech to sign page.

8.2 User Acceptance Testing

Defect Analysis

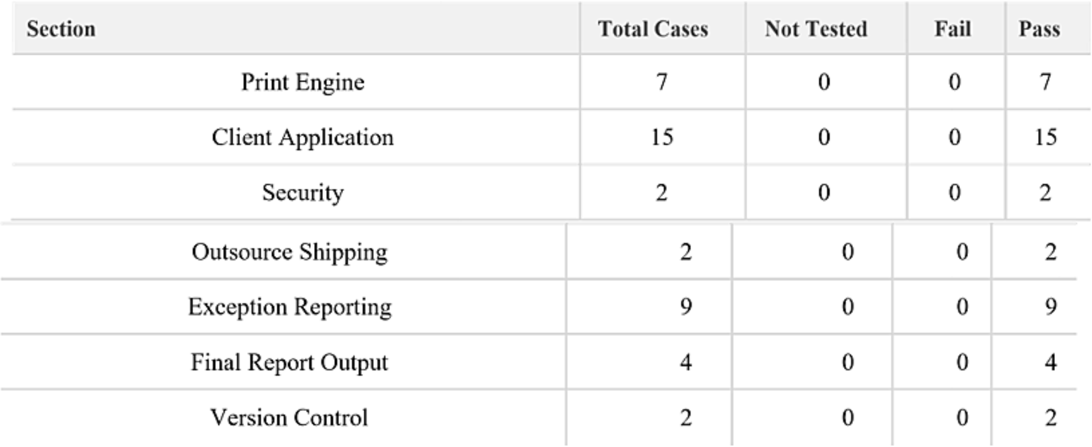
This report shows the number of resolved or closed bugs at each and how they were resolved

Resolution	Severity 1	Severity 2	Severity 3	Severity 4	Subtotal
By Design	11	7	4	2	24
Duplicate	1	0	2	0	3
External	2	3	2	1	8
Fixed	10	5	3	14	32
Not Reproduced	0	0	1	0	1
Skipped	0	0	1	1	2

Won't Fix	1	0	0	0	1
Totals	25	16	13	18	71

2. Test Case Analysis

This report shows the number of test cases that have passed, failed and tested .

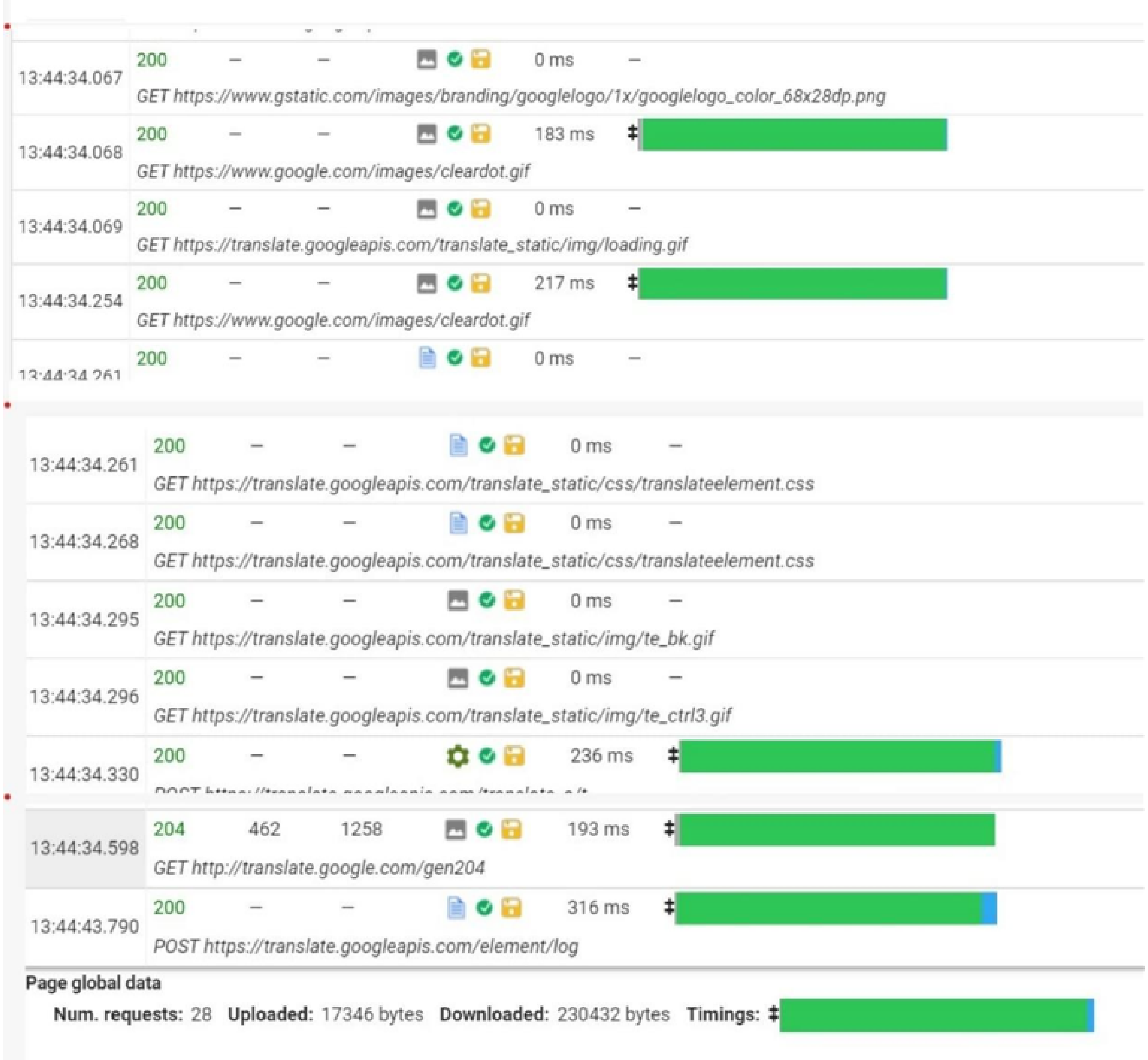


Section	Total Cases	Not Tested	Fail	Pass
Print Engine	7	0	0	7
Client Application	15	0	0	15
Security	2	0	0	2
Outsource Shipping	2	0	0	2
Exception Reporting	9	0	0	9
Final Report Output	4	0	0	4
Version Control	2	0	0	2

9. Results

Performance Metrics

The following images can be studied to understand the performance metrics of our system .



```
13:44:34.067  200  –     –     0 ms    –
              GET https://www.gstatic.com/images/branding/googlelogo/1x/googlelogo_color_68x28dp.png
13:44:34.068  200  –     –     183 ms  ‡
              GET https://www.google.com/images/cleardot.gif
13:44:34.069  200  –     –     0 ms    –
              GET https://translate.googleapis.com/translate_static/img/loading.gif
13:44:34.254  200  –     –     217 ms  ‡
              GET https://www.google.com/images/cleardot.gif
13:44:34.261  200  –     –     0 ms    –

13:44:34.261  200  –     –     0 ms    –
              GET https://translate.googleapis.com/translate_static/css/translateelement.css
13:44:34.268  200  –     –     0 ms    –
              GET https://translate.googleapis.com/translate_static/css/translateelement.css
13:44:34.295  200  –     –     0 ms    –
              GET https://translate.googleapis.com/translate_static/img/te_bk.gif
13:44:34.296  200  –     –     0 ms    –
              GET https://translate.googleapis.com/translate_static/img/te_ctrl3.gif
13:44:34.330  200  –     –     236 ms  ‡
              POST https://translate.googleapis.com/translate_a/t
13:44:34.598  204  462   1258  193 ms  ‡
              GET http://translate.google.com/gen204
13:44:43.790  200  –     –     316 ms  ‡
              POST https://translate.googleapis.com/element/log
Page global data
   Num. requests: 28   Uploaded: 17346 bytes   Downloaded: 230432 bytes   Timings: ‡
```

10. Advantages and Disadvantages

Advantages:

1. Real time sign to speech detection.
2. Model provides good accuracy.
3. Real time facial emotion detection.
4. Language Customization.
5. Real time speech to text conversion.
6. Data privacy

Disadvantages:

1. At times the website may lag.
2. Model is not tested on a wide set of data set, having all the signs.
3. Sign language customization feature is not available.
4. User cannot take notes while using the app.
5. User cannot make calls using the app.Speech recognition works only on google chrome.

11. Conclusion

- Communication is crucial for self-expression. Additionally, it meets one's necessities. Effective communication is necessary for career advancement. Effective communication skills can make your life easier and improve your interactions with others by facilitating mutual understanding.

A system that translates speech into acceptable sign language for the deaf and dumb has been developed as part of our project. It also translates sign language into a human hearing voice to communicate with average people.

- A convolution neural network has been used to build a model that is trained on various hand motions. Utilizing this concept, an app is created. Through the use of signs that are translated into speech and human-understandable English, this software aids deaf and dumb individuals to communicate easily.

12. Future Scope

The following are the features that can be added in our application:

1. A communication app can be built with the same set of features. The user can choose the appropriate mode (speech to sign or sign to speech) and accordingly the real time detection would take place on both the end users' application.
2. The accuracy of the model shall be increased.
3. Customization of languages shall be added.
4. Users shall be allowed to write notes while on call.
5. Customization of signs can also be added as a feature.

13. Appendix Source Code

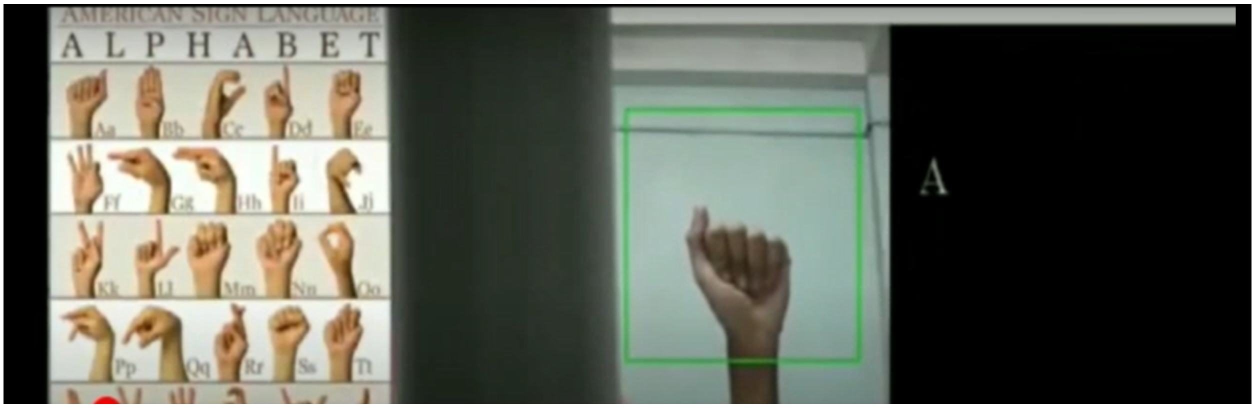
```
import cv2, pickle
import lumpy as p
import tensor-flow as if
from cnn_tf import cnn_model_fn
import is
import sqlite3
from keras.models import load_model

os.environ['TF_CPP_MIN_LOG_LEVEL'] = '3'
tf.logging.set_verbosity(tf.logging.ERROR)
classifier = tf.estimator.Estimator(model_dir="tmp/cnn_model2",
model_fn=cnn_model_fn)
prediction = None
model = load_model('cnn_model_keras2.h5')

def get_image_size():
        I mg = cv2.imread('gestures/0/100.jpg', 0)
        return img.shape

image_x, image_y = get_image_size()
```

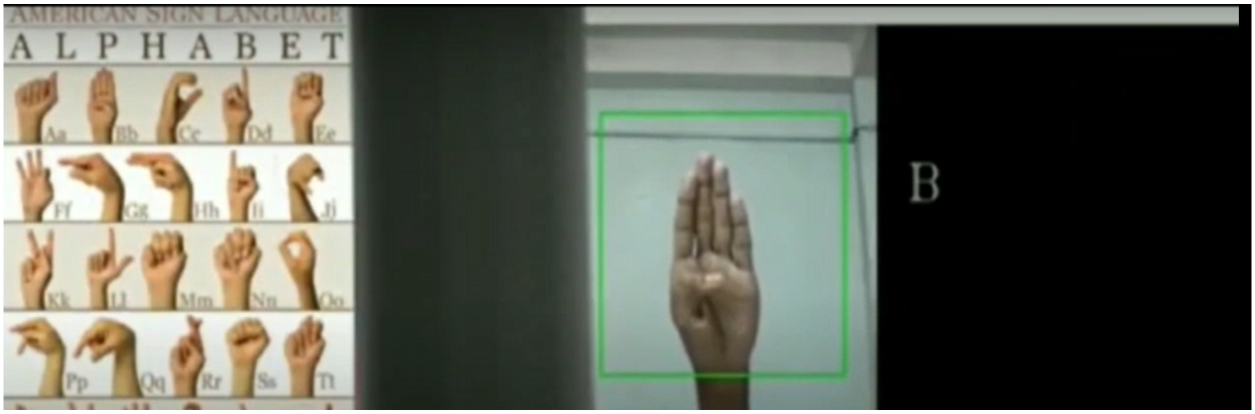
```
def tf_process_image(img):
        i mg = cv2.resize(img, (image_x, image_y))
        i mg = np.array(img, d type=np.float32)
        np_array = np.array(img)
        return np_array

def tf_predict(classifier, image):
        '''
        need help with prediction using tensor flow
        '''
        global prediction
        processed_array = tf_process_image(image)
        pred_input_fn =
tf.estimator.inputs.numpy_input_fn(x={"x":processed_array}, shuffle=False)
        pre = classifier.predict(input_fn=pred_input_fn)
        prediction = next(pred)
        print(prediction)

def keras_process_image(img):
        i mg = cv2.resize(img, (image_x, image_y))
        i mg = np.array(img, d type=np.float32)
        i mg = np.reshape(img, (1, image_x, image_y, 1))
        return i mg

def keras_predict(model, image):
        processed = keras_process_image(image)
        pred_probab = model.predict(processed)[0]
        pred_class = list(pred_probab).index(max(pred_probab))
        return max(pred_probab), pred_class

def get_pred_text_from_db(pred_class):
        con = sqlite3.connect("gesture_db.db")
        c md = "SELECT g_name FROM gesture WHERE
g_id="+str(pred_class)
```

```
    cursor = conn.execute(cmd)
    for row in cursor:
        return row[0]

def split_sentence(text, num_of_words):
    '''
    Splits a text into group of num_of_words
    '''
    list_words = text.split(" ")
    length = len(list_words)
    splitted_sentence = []
    b_index = 0
    e_index = num_of_words
    while length > 0:
        part = ""
        for word in list_words[b_index:e_index]:
            part = part + " " + word
        splitted_sentence.append(part)
        b_index += num_of_words
        e_index += num_of_words
        length -= num_of_words
    return splitted_sentence

def put_splitted_text_in_blackboard(blackboard, splitted_text):
    y = 200
    for text in splitted_text:
        cv2.putText(blackboard, text, (4, y),
cv2.FONT_HERSHEY_TRIPLEX, 2, (255, 255, 255))
        y += 50

def get_hand_hist():
    with open("hist", "r") as f:
        hist = pickle.load(f)
    return hist
```

```
def recognize():
    global prediction
    cam = cv2.VideoCapture(1)
    if cam.read()[0] == False:
        cam = cv2.VideoCapture(0)
    hist = get_hand_hist()
    x, y, w, h = 300, 100, 300, 300
    while True:
        text = ""
        i mg = cam.read()[1]
        i mg = cv2.flip(img, 1)
        i mg = cv2.resize(img, (640, 480))
        imgCrop = img[y:y+h, x:x+w]
        imgHSV = cv2.cvtColor(img, cv2.COLOR_BGR2HSV)
        st = cv2.calcBackProject([imgHSV], [0, 1], hist, [0, 180, 0, 256], 1)
        disc = cv2.getStructuringElement(cv2.MORPH_ELLIPSE,(10,10))
        cv2.filter2D(dst,-1,disc,st)
        blur = cv2.GaussianBlur(dst, (11,11), 0)
        blur = cv2.medianBlur(blur, 15)
        thresh =
cv2.threshold(blur,0,255,cv2.THRESH_BINARY+cv2.THRESH_OTSU)[1]
        thresh = cv2.merge((thresh,thresh,thresh))
        thresh = cv2.cvtColor(thresh, cv2.COLOR_BGR2GRAY)
        thresh = thresh[y:y+h, x:x+w]
        (openCV_ver,_,__) = cv2.__version__.split(".")
        if openCV_ver=='3':
            contours = cv2.findContours(thresh.copy(),
cv2.RETR_TREE, cv2.CHAIN_APPROX_NONE)[1]
        el if openCV_ver=='4':
            contours = cv2.findContours(thresh.copy(),
cv2.RETR_TREE, cv2.CHAIN_APPROX_NONE)[0]
        if len(contours) > 0:
            contour = max(contours, key = cv2.contourArea)
            #print(cv2.contourArea(contour))
            if cv2.contourArea(contour) > 10000:
                x1, y1, w1, h1 = cv2.boundingRect(contour)
                save_img = thresh[y1:y1+h1, x1:x1+w1]

                if w1 > h1:
                    save_img = cv2.copyMakeBorder(save_img,
int((w1-h1)/2) , int((w1-h1)/2) , 0, 0, cv2.BORDER_CONSTANT, (0, 0, 0))
                el if h1 > w1:
                    save_img = cv2.copyMakeBorder(save_img, 0,
0, int((h1-w1)/2) , int((h1-w1)/2) , cv2.BORDER_CONSTANT, (0, 0, 0))

                pred_probab, pred_class = keras_predict(model,
save_img)

                if pred_probab*100 > 80:
                    text = get_pred_text_from_db(pred_class)
                    print(text)
        blackboard = np.zeros((480, 640, 3), d type=np.uint8)
        splitted_text = split_sentence(text, 2)
        put_splitted_text_in_blackboard(blackboard, splitted_text)
        #cv2.putText(blackboard, text, (30, 200),
cv2.FONT_HERSHEY_TRIPLEX, 1.3, (255, 255, 255))
        cv2.rectangle(img, (x,y), (x+w, y+h), (0,255,0), 2)
        res = np.hstack((img, blackboard))
        cv2.imshow("Recognizing gesture", res)
        cv2.imshow("thresh", thresh)
        if cv2.waitKey(1) == ord('q'):
            break

keras_predict(model, np.zeros((50, 50), d type=np.uint8))
recognize()
```

Output





13.2 Github and Demo Link:

https://github.com/IBM-EPBL/IBM-Project-52606-1661013150.

Demo Link:
https://drive.google.com/file/d/1CYPOp86nEYWJ3FPBRNKwq19WSmr3Ee3t/view?usp=drive_open