UNLV

University of Nevada Las Vegas
Department of Electrical and Computer Engineering

EE497 Senior Design
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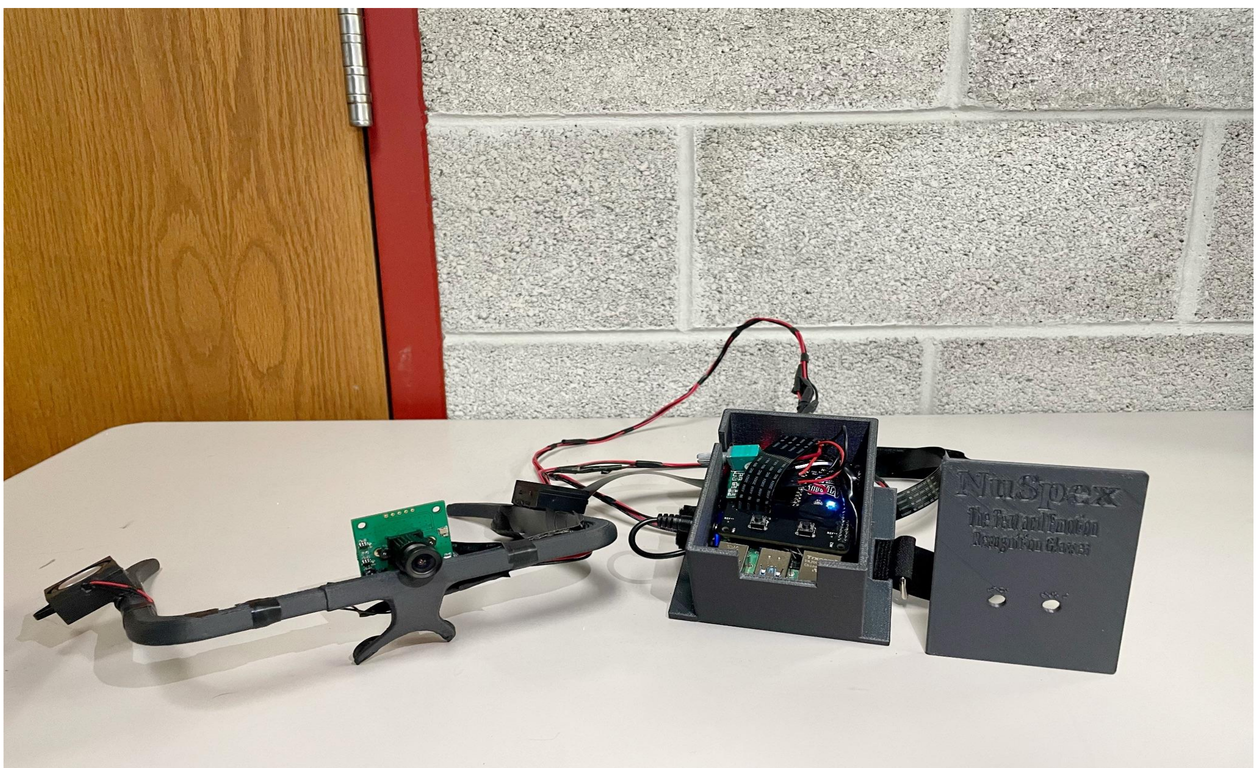
NuSpex: The Text and Emotion Recognition Glasses

Final Project Report



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Abstract

NuSpex: The Text and Emotion Recognition Glasses is intended to make daily life easier for people who are visually impaired or blind. The device can help these individuals become more self-sufficient by allowing them to read common texts such as signs, labels, and instructions. In addition to text recognition, the glasses can also detect emotions on a person's face with the push of a button. The purpose of the device is to provide more accessibility and independence to visually impaired and blind individuals. Using a Raspberry Pi 4B, a small computer, runs software written in the Python programming language to control the hardware, such as a camera module actuation buttons. The text recognition function allows the user to aim the camera at text and have the computer read it aloud. The emotion recognition feature detects the emotions of people near the user, like happiness, sadness, or anger, and provides this information to the user through audio output. The device's ability to detect emotions can also provide valuable information to the user in social situations. Additionally, the device could be sold to organizations and institutions that work with visually impaired or blind individuals, such as schools, rehabilitation centers, and government agencies. The device's ability to recognize emotions could also make it attractive to research institutions and companies in the field of emotional intelligence and human-computer interaction. Overall, the benefits of NuSpex is designed to empower the lives of blind and visually impaired individuals by taking control in their day-to-day lives.

Introduction & background

Text and Emotion Recognition is a growing field of study that has the potential to revolutionize the way we interact with each other and with technology. However, this technology is not always accessible to individuals who are blind or visually impaired. This senior design project report will describe the development of a text and emotion recognition system that is designed to be accessible to individuals who are blind or visually impaired. The project is aimed at helping visually impaired individuals read everyday texts and understand the emotions of the people around them. It uses a combination of software written in the Python programming language and hardware, such as a camera and sensors, to recognize text and emotions. The Raspberry Pi is a small computer that is being used to run the software and control the hardware. The text recognition feature allows the user to point the camera at text, such as a book or a sign, and have the computer read it out loud. The emotion recognition feature detects the emotions of the people around the user, such as whether they are happy, sad, or angry, and provides this information to the user through audio output. This can help the user better understand and navigate social situations.

This device can be used by the visually impaired at any time, as it is a wearable device that allows them to read texts and understand emotions while interacting with others. The device can be particularly useful in social situations, where the ability to read facial expressions and understand the emotions of others can be critical for successful communication. A couple of devices that perform similar functions are: Microsoft HoloLens with the Seeing AI app, OrCam MyEye 2, Google Glass with the KNFB Reader app, Aira Explorer, XploreEye, and Optelec ClearReader+. This solution is different from other solutions for the visually impaired because it uses advanced technology to provide more comprehensive and accurate feedback to the user. This allows the user to not only read text, but also understand the emotional context of the conversation, providing a more holistic and intuitive experience.

Additionally, the use of the Raspberry Pi and Python allows for a more portable and lightweight solution compared to other devices that may require more complex hardware.The device is perfect for the visually impaired who want to live a more independent and connected lifestyle. The compact and lightweight design of the glasses makes them easy to wear and use on a daily basis. The Python code, Raspberry Pi, and sensors ensure a smooth and reliable operation, while the speakers provide clear and audible audio feedback. In short, the project is a cutting-edge biomedical device that provides text and emotion recognition capabilities to the visually impaired. It offers a convenient and intuitive solution for the visually impaired to read texts and understand emotions in real-time, making their everyday lives easier and more enjoyable.

Current Market Solutions

	Vendor	Consumer	Popularity	Form Factor	Text Detection	Price	Comment
OrCam MyEye	OrCam	Blind and Visually impaired	Small market,too expensive for the common consumer	Small device that attaches to any pair of glasses	Uses gestures to detect which text to read	$3,500	User needs to know what they are pointing at in order to start reading (i.e reading a sign, how would the user know a sign is there for them to point)
NuEyes Pro	NuEyes	Visually Impaired	Small market, product is too expensive	Glasses is entire system	Uses an operator to tell user the text	$3,845	These glasses require an operator to tell the user it is in front of them (Text/Object)
NuSpex.	NuSpex	Blind and Visually Impaired	Wider market since its more affordable	Two components: The glasses housing and Raspberry Pi housing	Glasses takes a picture once in range	$238.20	Less expensive product, however, it is more of a prototype which is less sleek from the others.

Table 1. Comparison of available devices

	Text Recognition	Battery life	Price	Strengths	Weaknesses
OrCam	- Fast text recognition - Real time	Short	Expensive	▪ Voice Controlled ▪ Able to detect not just text but object ▪ Gestured controlled	▪ Not water resistant ▪ Too expensive ▪ Uses a speaker which is not suitable for all environments
NuEyes Pro	Operator Required	Medium	Expensive	▪ High quality camera ▪ AR	▪ Requires an operator ▪ Expensive
NuSpex	-Snap shots which starts the TR process - Fast TR	Medium	Affordable	▪ Clear picture since its a snapshot ▪ Detects emotion of other person	▪ Bulky

Table 2. Strengths and weaknesses of available devices

Research results

The Arducam is a better camera for this device because it has a high resolution and a wide field of view, which allows it to capture detailed images and a larger area. This is important for blind and visually impaired individuals, as they rely on visual information to navigate their surroundings. The Arducam also has a built-in image processor, which allows it to quickly and accurately recognize text and emotions in the images it captures.

Specification of the project

Functionality & conceptual design:

Here is a possible scenario of a blind person using text and emotion recognition glasses to recognize someone's facial emotions:

Sarah is a 35-year-old woman who has been blind since birth. She has always relied on Braille and audiobooks to access written information, and she has relied on touch and sound to navigate the world and understand the emotions of the people around her.

One day, Sarah's friend tells her about a new product called the OrCam MyEye, which is a pair of glasses that uses text recognition and emotion recognition technology to read print text out loud to the wearer and detect and interpret the facial emotions of the people the wearer is looking at. Sarah is excited by the idea and decides to try it out.

She goes to a local store that sells NuSpex glasses and tries on a pair. The glasses are lightweight and comfortable to wear, and they have a small camera mounted on the frame that points towards the text and faces that the wearer is looking at.

Sarah is amazed by the technology. She points the glasses at a book and listens as the glasses read the text out loud to her in a clear, natural-sounding voice. She is able to follow along with the text as it is being read, and she can even pause, rewind, and skip ahead just like she would with an audio book.

Then, Sarah points the glasses at her friend and listens as the glasses describe her friend's facial expression as "happy" and "smiling". She is then able to understand her friend's emotional state without needing to see her face.

Sarah is thrilled with the NuSpex: Text and Emotion Recognition Glasses and decides to buy a pair. She now has a new way to access written information and understand the emotions of the people around her, and she is excited to explore the world in a way that was not previously possible for her.

Architecture:

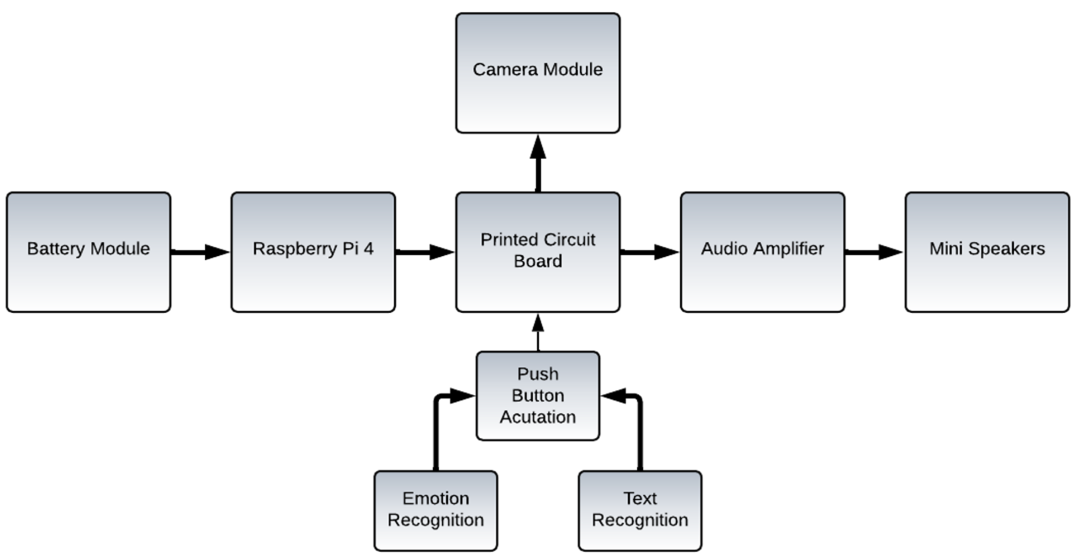

Figure 1: Device Diagram

Design

To create our product, we followed several steps, one after the other. We started by writing the main code and tested it on our laptops. This was a crucial stage where we ensured everything was functioning as expected. After we were confident about the code, we ordered the needed parts, which included a Raspberry Pi 4B, a camera, speakers, and other necessary components.

Before testing the code on the Raspberry Pi, we created a circuit schematic to map out the connections between the components. This schematic helped us ensure proper wiring and identify any potential issues before implementing the code on the hardware.

Once we had all the parts, we tested our code specifically on the Raspberry Pi 4B. We needed to ensure that our code was compatible with this model and could effectively communicate with all the other components. After the code was working well on the Raspberry Pi 4B, we moved on to creating a housing for the Raspberry Pi and the PCB. We used a 3D printer to make a case that would fit within a glasses frame, custom-designed for our device.

We then focused on the design of the PCB, an essential part of our device. After finalizing the design, we ordered the PCB.

The code, which you'll see in the following images, facilitates the device's capacity to interact with its environment, recognize text, and interpret human emotions.

```python
# Import necessary libraries
from time import sleep
from tensorflow.keras.preprocessing.image import img_to_array
import cv2
from tflite_runtime.interpreter import Interpreter
import numpy as np
import time
import threading
import pytesseract
import picamera
import subprocess
import RPi.GPIO as GPIO
import pyttsx3
import io

# Print starting message
print("Starting program")

# Load the pre-trained face classifier model
face_classifier=cv2.CascadeClassifier('data/haarcascades/haarcascade_frontalface_default.xml')

# Load the TFLite emotion detection model and allocate tensors
emotion_interpreter = Interpreter(model_path="emotion_detection_model_100epochs_no_opt.tflite")
emotion_interpreter.allocate_tensors()

# Get input and output tensors for emotion detection model
emotion_input_details = emotion_interpreter.get_input_details()
emotion_output_details = emotion_interpreter.get_output_details()

# Define input shape for the emotion detection model
emotion_input_shape = emotion_input_details[0]['shape']

# Define emotion class labels
class_labels=['Angry','Disgust', 'Fear', 'Happy','Neutral','Sad','Surprise']

# Initialize the pyttsx3 text-to-speech engine
engine = pyttsx3.init(driverName='espeak')
```

```python

# Configure the engine's voice and speech rate
voices = engine.getProperty('voices')
engine.setProperty('voice', voices[12].id)
engine.setProperty('rate', 160)

# Set up the GPIO mode for Raspberry Pi
GPIO.setmode(GPIO.BCM)

# Define button pin numbers and state variables
button_pin1 = 6
button_pin2 = 16
button1_pressed = False
button2_pressed = False

# Define a debounce function to prevent false button press detections
def debounce(channel):
    time.sleep(0.5)
    if GPIO.input(channel) == GPIO.LOW:
        return True
    else:
        return False

# Define a function to capture an image using PiCamera
def capture_image():
    #... (code for capturing image)

# Define a function for text recognition and text-to-speech conversion
def text_recognition():
    #... (code for text recognition)

# Define a function to capture an image, detect faces, and recognize emotions
def capture_and_detect_emotion():
    #... (code for emotion recognition)

# Set up GPIO pins for button inputs with pull-up resistors
GPIO.setup(button_pin1, GPIO.IN, pull_up_down=GPIO.PUD_UP)
GPIO.setup(button_pin2, GPIO.IN, pull_up_down=GPIO.PUD_UP)

# Initialize text recognition and emotion recognition threads
text_recognition_thread = threading.Thread(target=text_recognition)
emotion_recognition_thread = threading.Thread(target=capture_and_detect_emotion)

# Start the threads
text_recognition_thread.start()
emotion_recognition_thread.start()

# Main loop
try:
    while True:
        # Do other stuff in the main loop if needed
        time.sleep(0.1)

# Handle KeyboardInterrupt to stop the program
except KeyboardInterrupt:
    print("Program stopped by user")

# Clean up GPIO pins before ending the program
finally:
    GPIO.cleanup()

# Print ending message
print("Ending program")

```

Figure 2: Text and Emotion Recognition Code

In the following section, we present the Printed Circuit Board (PCB). This component serves as the primary hub for the system's operations. It enables data processing and supports audio output.

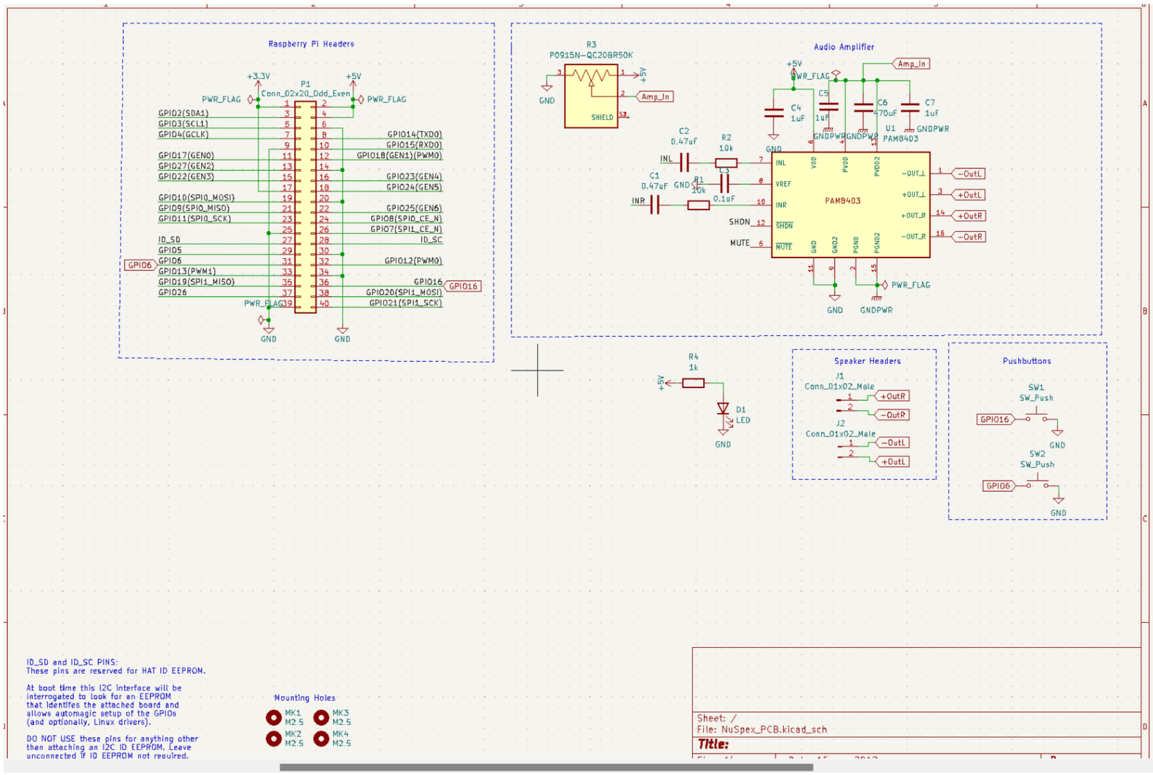

Figure 3: PCB Schematic Design

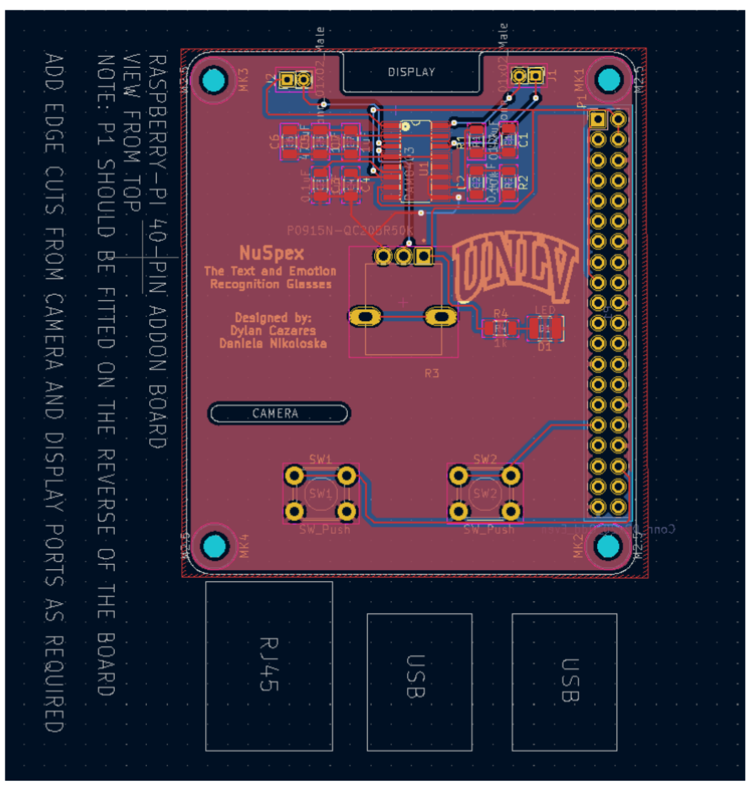

Figure 4: PCB View

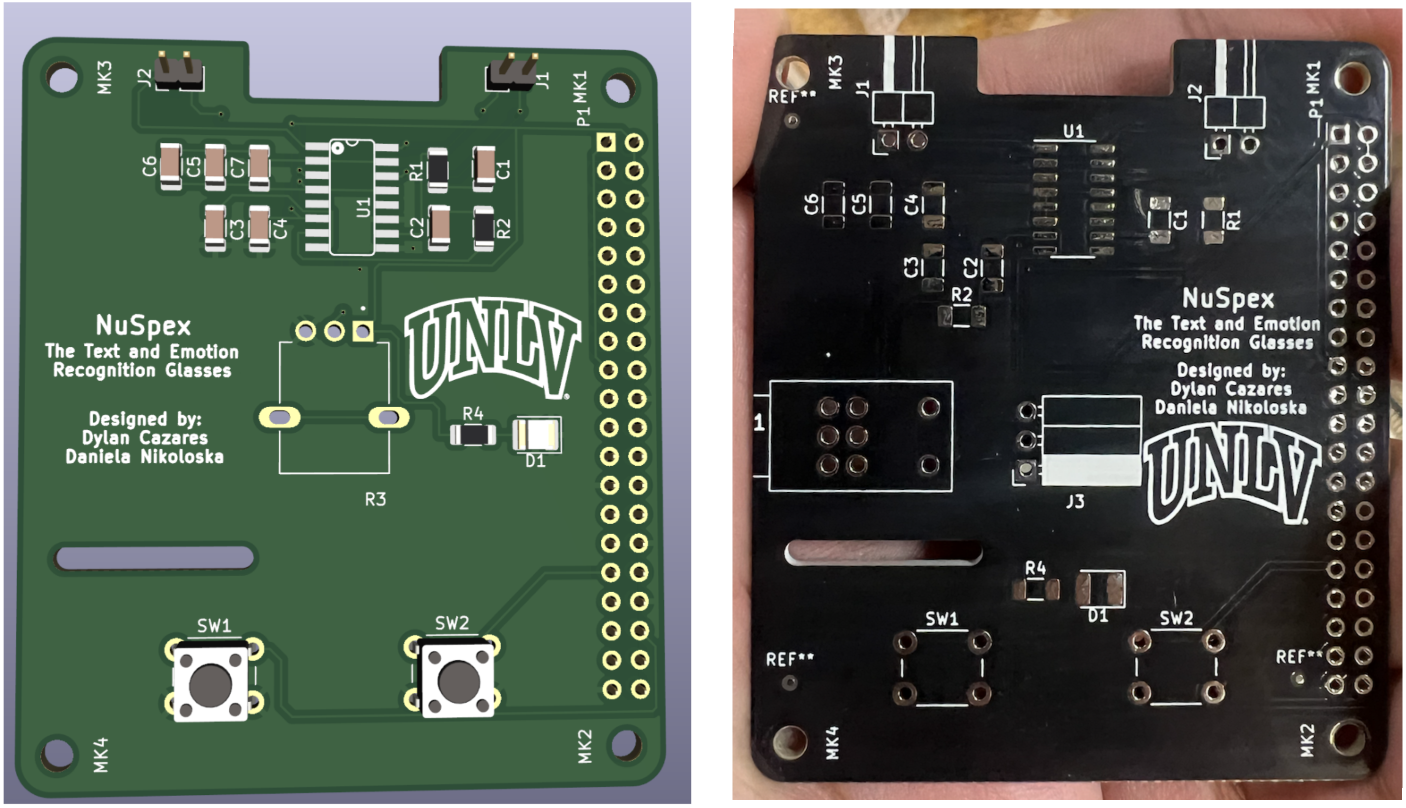

Figure 5: 3D View of PCB and Final PCB

We used 3D printing to make parts for our glasses. This included a special case for the Raspberry Pi 4B and the PCB, and also the frame of the glasses. We made sure that everything was designed to fit together well. In the next images, you'll see the parts we made with the 3D printer.

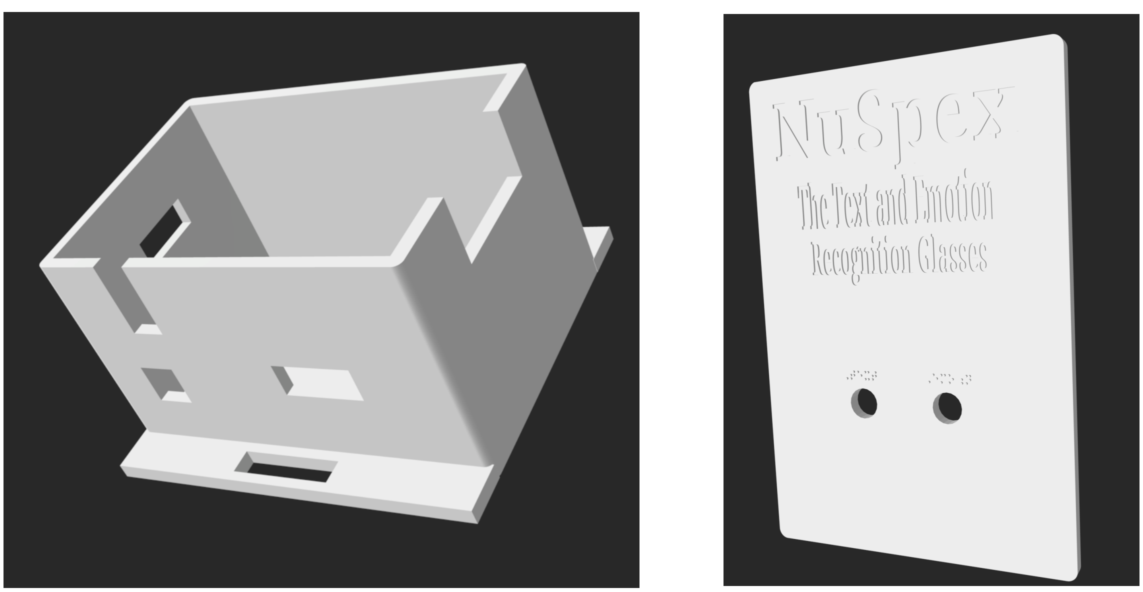

Figure 6: 3D Model of Case and Lid

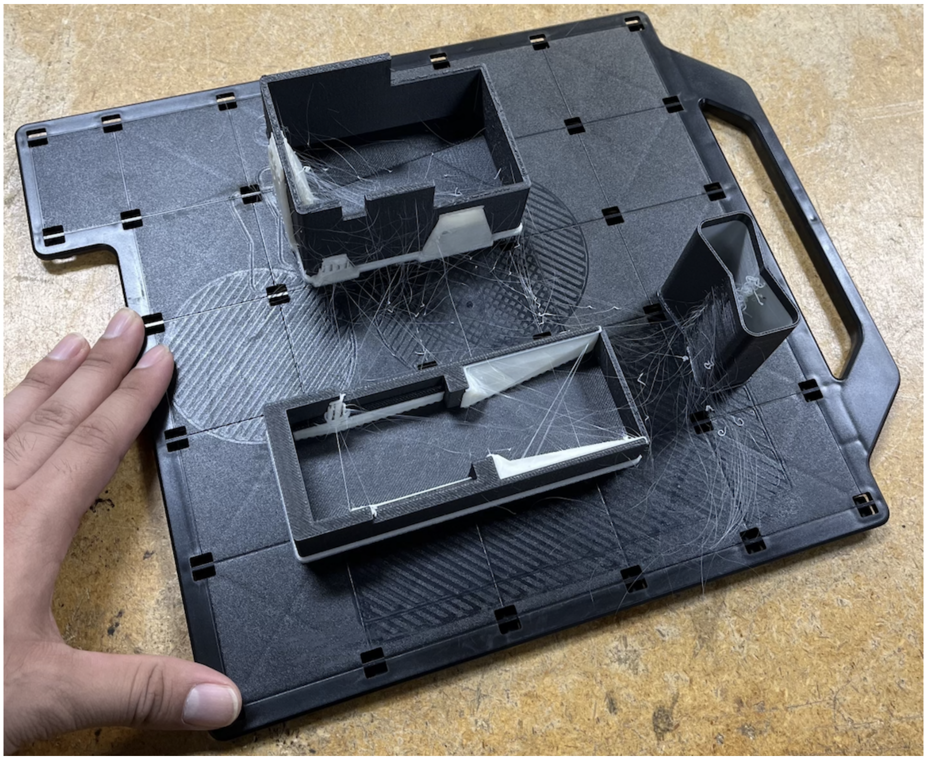

Figure 7: Process of 3D Printing the Case and Lid

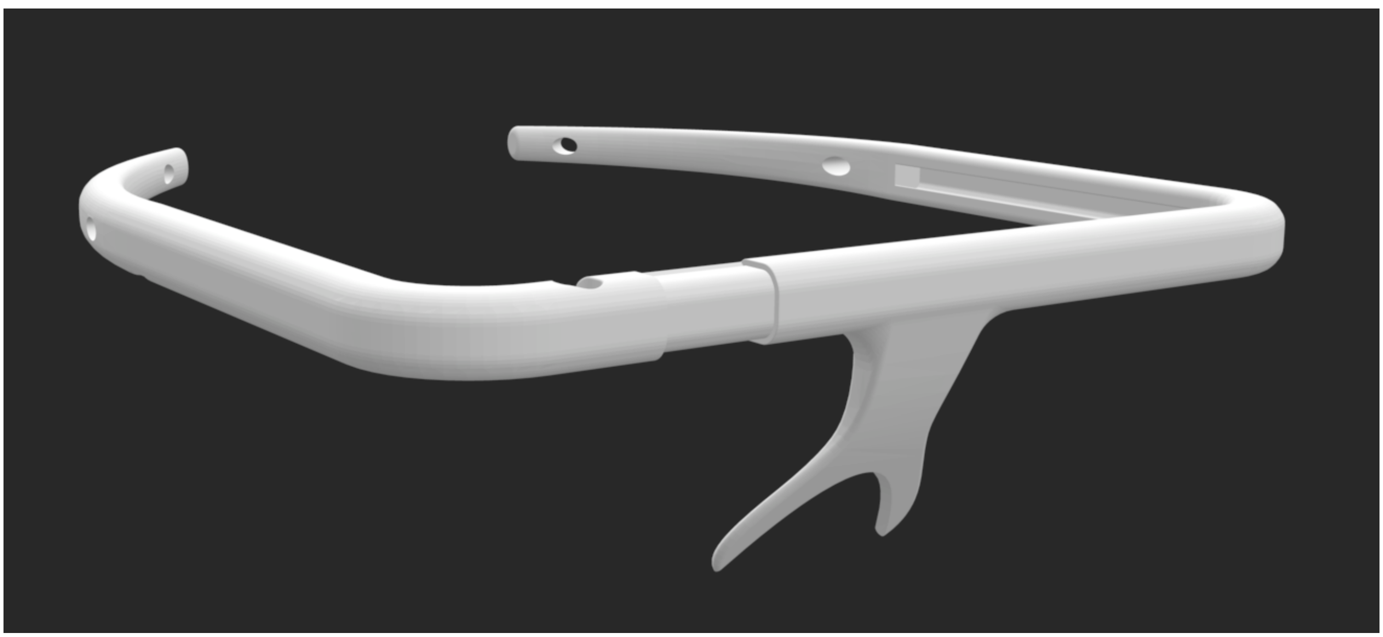

Figure 8: 3D Model of Frame

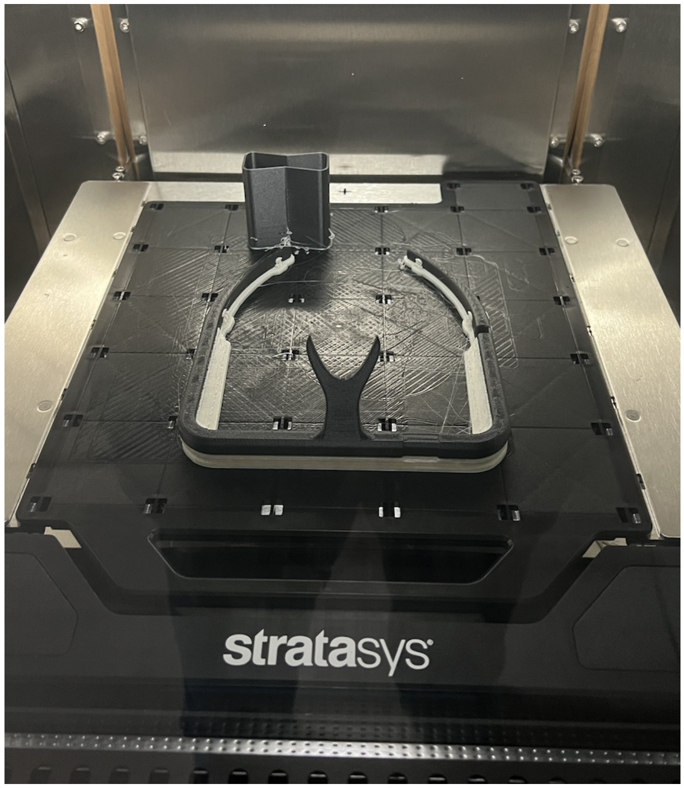

Figure 9: 3D Printing of the Frame

The final step was assembling all the components together. We made sure everything was properly fitted within the glasses frame and that all parts were working together smoothly. This careful process enabled us to successfully create our device.

Simulation

The circuit schematic for our device enabled seamless communication between the Raspberry Pi, camera, and speakers. It served as a simplified guide for implementing our device.

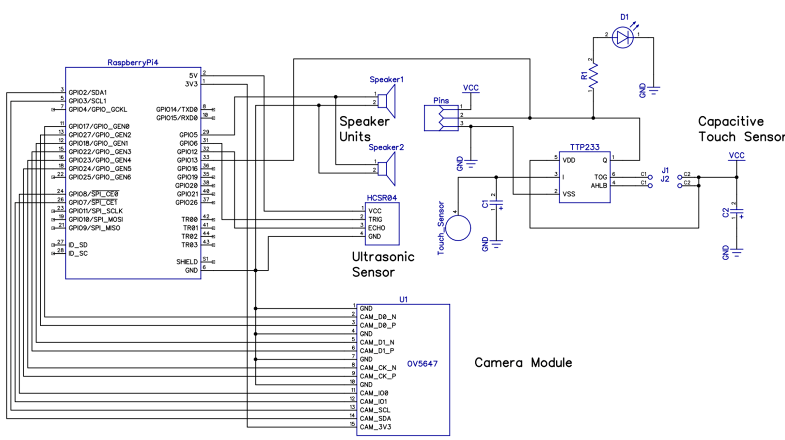

Figure 10: Circuit Schematic

Test plan

	Inputs / actions to the device	Expected output	Comment
Test case #1	To read text from a distance away	Relay the data back to the user through the speakers	
Test case #2	To read human emotion accurately	Relay the data back to the user through the speakers	

Table 3. Test plan

Current form of the project

The final form for NuSpex: The Text and Emotion Recognition Glasses, is a wearable and user-friendly solution designed to assist individuals who are blind or visually impaired. It consists of a compact set of glasses equipped with a Raspberry Pi 4B, camera, and speakers The device runs software written in Python, enabling it to recognize and read text aloud when the user points the camera at signs, labels, or instructions. Additionally, with the push of a button, the glasses can detect the emotions of people nearby and provide this information through audio output. This device empowers visually impaired individuals by offering accessibility to everyday texts and enhancing their understanding of emotional cues in social interactions. Its portability, lightweight design, and reliable operation make it a valuable tool for achieving greater independence and connectedness in daily life.

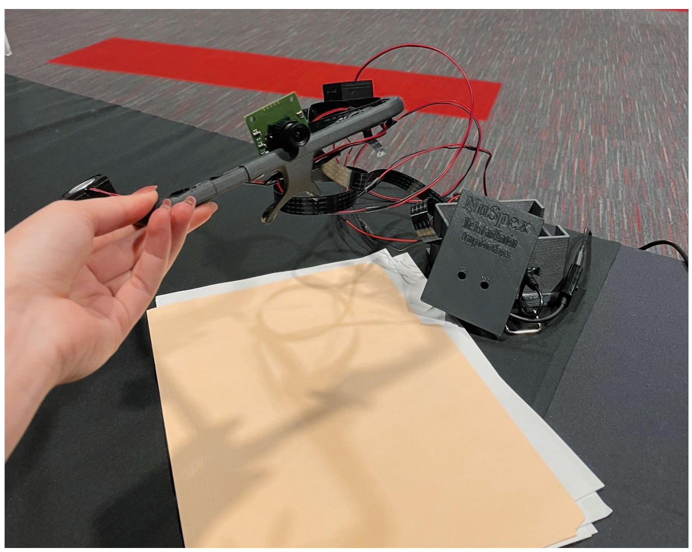

Figure 11: Final Device

Roles & skills in the project

	Objects involved	Required skills
Role 1	Emotion Recognition	● Knowledge in OpenCV and TensorFlow
Role 2	Text Recognition	● Knowledge in OpenCV
Microcontroller programmer	▪ Camera image analyzer	▪ Knowledge of Raspberry Pi 4 Microprocessor ▪ Python programming ▪ VS Code Experience
Image processing specialist	▪ Camera image analyzer	▪ Knowledge of image processing algorithms ▪ Knowledge of computer vision and deep learning
CAD designer	▪ Device case	▪ CAD skills sufficient to design the device case and body of the glasses

Table 4. Roles & skills

List all the roles mentioned in Table 3 and assign names of team member to each role:

	Assignment
Role 1	Daniela Nikoloska
Role 2	Dylan Cazares
Microcontroller programmer	Daniela and Dylan
Image processing specialist	Daniela and Dylan
CAD designer	Daniela and Dylan

Table 5. Roles assignment

ITEM	Name
Research regarding project	Daniela Nikoloska and Dylan Cazares
EE497 slides presentation	Daniela Nikoloska and Dylan Cazares
EE497 final report	Daniela Nikoloska and Dylan Cazares
Amplifier design	Dylan Cazares
PCB design	Dylan Cazares
PCB soldering	Dylan Cazares
EE 498 Final Report	Daniela Nikoloska
EE 498 Final Video	Dylan Cazares

Table 6. Items done

Parts list

	Parameters	Picture	Att. id
Raspberry Pi	Main Processing Unit		Link
Camera Module	Live Video Feedback		Link
Mini Speaker	3W, 8 ohm, Audio Feedback		Link

Table 7. List of required parts

Engineering standards used in the project

The following engineering standards have been used for the project:

Number (reference)	Symbol	Description	Justification why this standard has been used
1	NIST 800-30	Guidance for carrying out steps in the risk assessment procedure such as framing risk, assessing risk, responding to risk, and monitoring risk.	This standard satisfies the requirements of our project, while maintaining the simplicity. Also there are many universal modules available on the market.
2	IEEE 610.13-1993	This glossary defines terms concerning computer languages. Including types of computer languages, page description languages, and names of computer languages	This standard instructs what computer language terms should be used.
3	IEEE 1625-2004	This standard establishes criteria for design analysis for qualification, quality, and reliability of rechargeable battery systems for portable computing	This standard provides guidance in providing portable battery systems which our device requires the use of a battery pack to provide power.

Table 8. List of engineering standards

Engineering constraints for the project

The following engineering constraints have been used for the project:

#	Name	Description	Specification of the constraint
1	Camera Module	Maximum power drawn by the device	100W
2	Raspberry Pi Power Consumption	Maximum power drawn from device	3.8W-4.0W
3	Raspberry Pi Output Voltage/Amperage	Maximum power that Microprocessor can supply	3.3V, 50mA (8mA per pin)

Table 9. List of engineering constraints

User's manual

Dear valued customer,

Thank you for choosing NuSpex: The Text and Emotion Recognition Glasses. This device uses text recognition and emotion recognition software to improve the lives of blind and visually impaired individuals. We are committed to providing the best possible experience for our users, and we hope that this device will enhance your daily life.

To get started, please follow the steps below:

1. Begin by unboxing the biomedical device and ensuring that all necessary components are included. This should include the device itself, a power cord, and a user manual.
2. Ensure that your device is charged or has fresh batteries installed.
3. Turn on the device by pressing the power button located on the front of the unit. The device should automatically boot up and be ready to use.
4. Point the device towards the text you wish to recognize. The device will use its built-in camera and advanced software to analyze the image and provide a verbal response.
5. For text recognition, the device will read the text aloud in a clear, easy-to-understand voice. To use the text recognition feature, simply point the device towards the text that you want to read. The device will read the text aloud using a high-quality text-to-speech engine.

6. For emotion recognition, the device will analyze the facial expressions and body language of the person in front of the camera and provide a verbal response indicating the detected emotion.
7. If desired, you can adjust the volume and voice settings of the device by using the buttons on the side of the unit.
8. To connect the device to a smartphone or other device, simply turn on Bluetooth on both devices and pair them using the instructions provided in your device's user manual.
9. Once connected, you can use the device as a wireless text and emotion recognition tool, allowing you to access and interpret information from a wider range of sources.
10. Always ensure that your device is stored and transported safely, and remember to turn it off when not in use to conserve battery power.
11. With regular use and proper care, your biomedical device will provide you with enhanced access to the world around you, helping you to live a more independent and fulfilling life.

To ensure the longevity and functionality of the device, please follow the care instructions below:

- Avoid exposing the device to water or other liquids.
- Do not drop or subject the device to excessive force.
- Clean the device using a soft, dry cloth.
- Keep the device in a dry, cool location when not in use.
- Keep the device charged to ensure optimal performance.

If you have any questions or concerns, please contact our customer support team for assistance. We are dedicated to providing the best possible experience for our users, and we look forward to hearing your feedback.

Best regards,

DnD Connection

Final remarks

Thank you to our instructor Dr. Grzegorz Chmaj and faculty advisor Dr. Brendan Morris for your guidance throughout our project. We greatly appreciate the feedback and mentorship you have given us. Your contributions have been invaluable, and we are grateful for your support.