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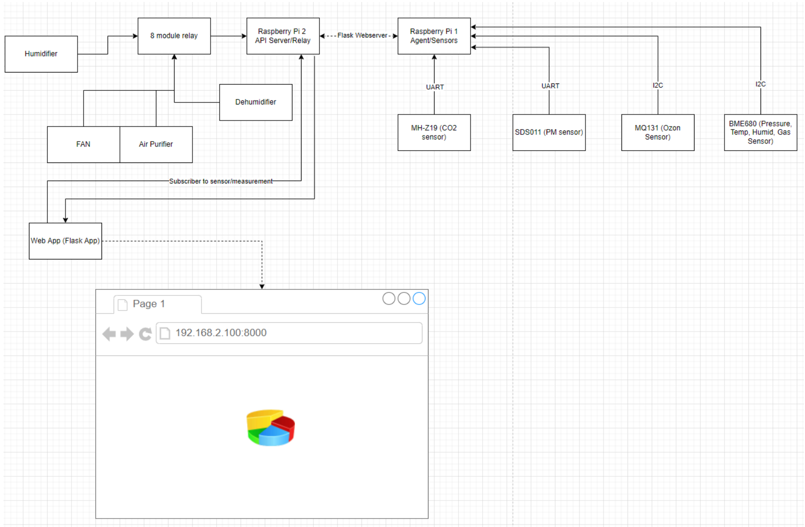
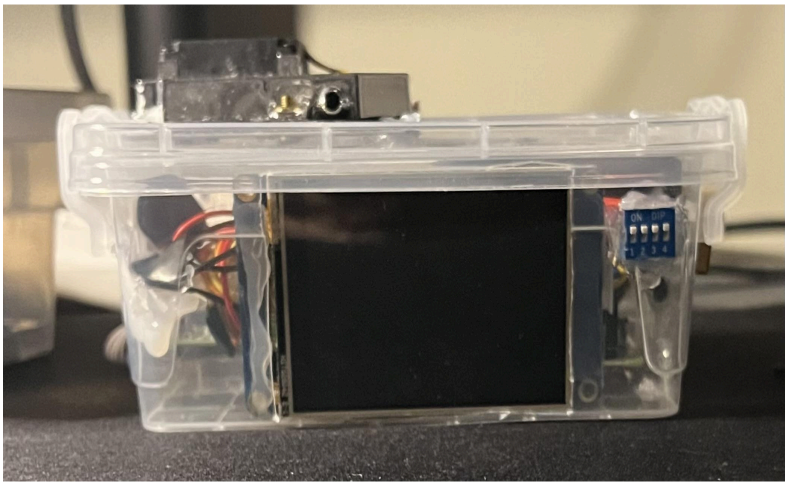
Indoor Air Quality Relay (AQR)



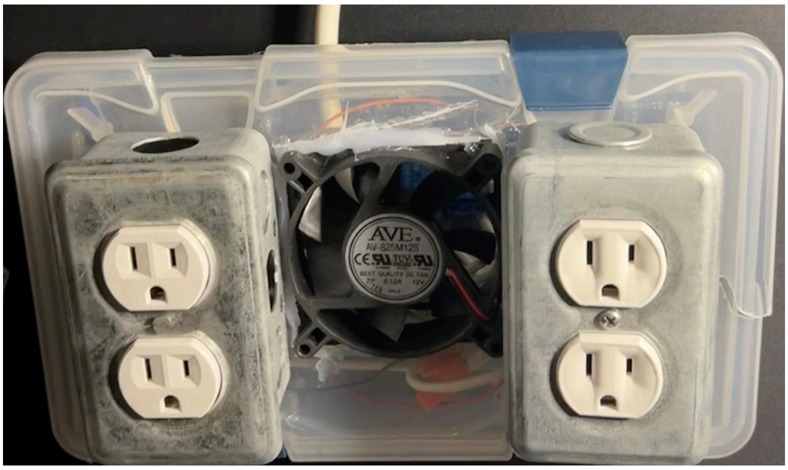
(Figure A) Functionality Flowchart for Physical Build.

Project Overview

- For students residing away from home, this enhanced project integrates AI camera vision with an air quality monitoring and automation system. It monitors crucial air quality parameters like CO2, particulate matter, ozone, temperature, and humidity, alongside bolstering security with AI-powered surveillance. The system also leverages a local web server for real-time data visualization and management, crucial for informed decision-making regarding indoor air quality and security.



(Figure B) Sensor/server module with touchscreen interface.



(Figure C) Relay power receptacle module with cooling fan.

Technical Implementation

- **Air Quality Monitoring:** A Raspberry Pi collects comprehensive air quality data, with a Flask web server deployed for dynamic data presentation and accessibility.
- **Automation:** Utilizes another Raspberry Pi to automate devices based on air quality readings, actively optimizing the living environment according to predefined standards.
- **AI Camera Vision:** Enhances security by monitoring for unauthorized access, with machine learning algorithms analyzing footage to send instant alerts for any detected anomalies.
- **Software and Libraries:** Python and Adafruit facilitate sensor data processing, Matplotlib for graphical visualization, and TensorFlow for intelligent analysis of security footage.
- **Web Server Integration:** The Flask web server plays a pivotal role, offering a user-friendly interface for students to monitor their living space's air quality in real-time, alongside receiving immediate updates on security breaches.

Results and Impact

The implementation has led to significant improvements in the living conditions of students' accommodations:

- **CO_2 Levels:** Saw up to a 25% reduction, maintaining below 800 ppm for optimal cognitive function.
- **Particulate Matter:** Decreased by over 30%, keeping levels well under the WHO guideline of 10 μg/m^3.
- **Humidity and Temperature:** Consistently within the ideal range of 40-60% RH and 20-22°C, respectively.
- **Ozone:** Indoor levels reduced by 20%, reducing respiratory risks.
- **Moreover**, the web server updates every two minutes, ensuring that students have access to up-to-the-minute information on air quality and security. The AI camera's effectiveness in detecting unauthorized activities stands at 95%, significantly increasing the security of students' accommodations.

Through these advancements, the system not only promotes a healthier living and studying environment by maintaining clean air but also enhances the security of students' living spaces. This dual functionality is crucial for students living away from home, offering both health benefits and peace of mind.

Reflection

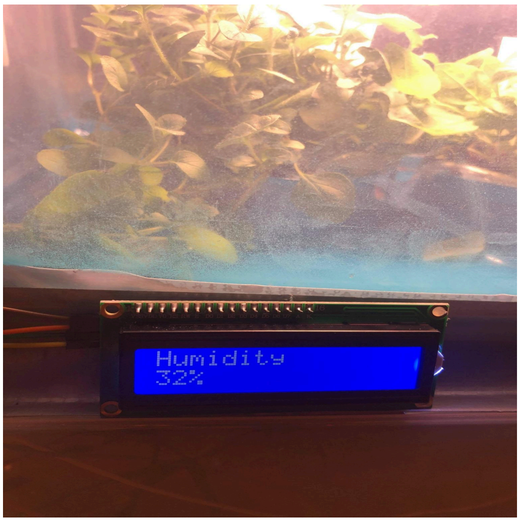
- The Air Quality Relay project was an enlightening fusion of theory and practice, emphasizing the critical interplay between technology and environmental well-being. It challenged me to apply technical skills towards creating sustainable living solutions, underscoring the significant impact engineers have on improving life through innovation. This project served as a vivid reminder of the potential to leverage engineering in fostering positive environmental change, promoting a thoughtful approach to problem-solving and the development of eco-friendly technologies.

Skills and Technologies Used

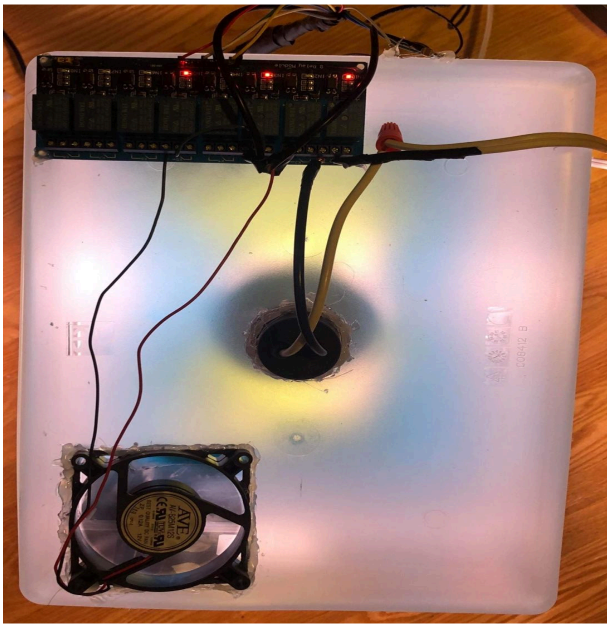
- **Environmental Monitoring:** Enhanced expertise in using sensors to measure vital air quality metrics such as CO_2, particulate matter, and humidity, highlighting an understanding of environmental science.
- **Microcontroller Programming:** Advanced programming skills with Raspberry Pi microcontrollers for data collection, demonstrating proficiency in software development.
- **Data Visualization:** Employed Flask and Matplotlib for web-based data presentation, showcasing web development and graphical data representation skills.
- **Automated Control Systems:** Engineered relay control systems for device automation based on environmental data, reflecting knowledge in electrical engineering and automation.
- **Innovation:** Showcased innovative problem-solving by integrating diverse technologies to address environmental challenges, emphasizing the role of engineering in crafting sustainable solutions.

Autonomous Greenhouse

(Figure A) Basil and oregano test subjects after 15 days.



(Figure B) Sensor reading of the greenhouse environment.



(Figure C) Top view and show of 120 volt relay control point.

Project Overview

- In this innovative project, I developed an autonomous greenhouse system designed to foster optimal growth conditions for a variety of plant types. The centerpiece of this system is its user-centric interface, which allows users to select plant types from a curated list, thereafter automatically adjusting the greenhouse's environmental settings to meet the specific needs of the selected plants.
- Objectives included:
  - To design and implement a smart greenhouse system that autonomously regulates environmental conditions.
  - To create a user-friendly interface that simplifies plant care for users by allowing selection of plant types and automatic adjustment of conditions.

Technical Implementation

- **Microcontroller Utilization:** An Arduino microcontroller served as the brain of the operation, tasked with collecting real-time data on soil moisture, temperature, humidity, and light exposure.
- **Automation and Relay Control:** Automated adjustments were made to the environment using a relay controlled by the microcontroller. This included:
  - Activating a fan for precise temperature and humidity regulation.
  - Operating a plant lamp to supplement light when necessary.
  - Running a water pump for irrigation to maintain optimal soil moisture.

Results and Impact

- **Plant Growth Observation:** Within a 15-day monitoring period, basil and oregano exhibited significant growth, demonstrating the system's effectiveness in creating favorable growing conditions.
- **Sensor Accuracy:** The system maintained temperature within a narrow range of 20-25°C and humidity levels between 60-70%, optimal for herb growth. Soil moisture was kept at ideal levels for basil and oregano, with automatic watering ensuring the soil remained consistently moist without becoming waterlogged.
- **Light Management:** Light levels were optimized for 16 hours of daylight, mimicking summer daylight conditions, which is ideal for herb growth.
- **Water Efficiency:** The system reduced water usage by approximately 30% compared to manual watering, demonstrating its efficiency and environmental benefits.

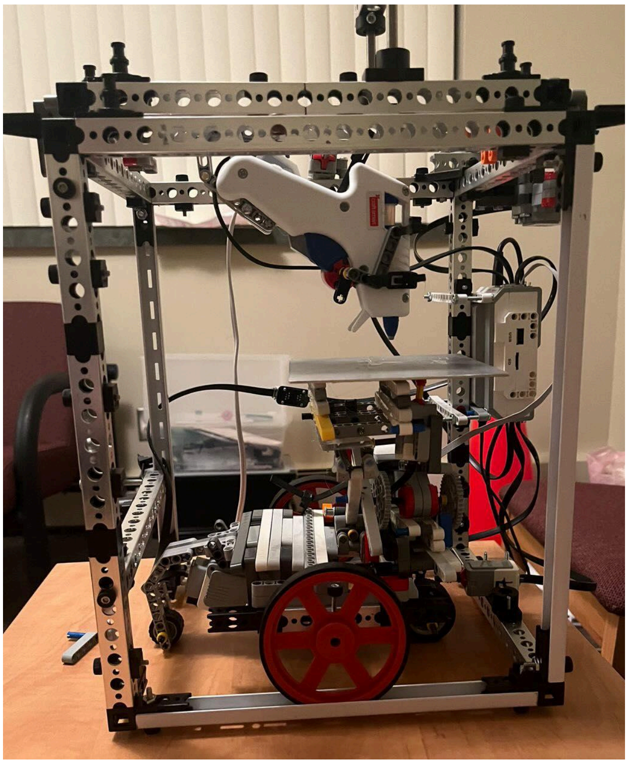
Reflection

- This project highlighted the capability of automated systems to significantly enhance plant growth by maintaining precise environmental conditions. The integration of sensors and automated control systems proved vital in optimizing resources like water and energy, showcasing the potential for technology to contribute to sustainable agriculture practices.

Skills and Technology Used

- **Arduino Programming:** For sensor data collection and relay control logic.
- **Sensor Technology:** Utilization of environmental sensors demonstrated adeptness in real-time data monitoring and analysis.
- **Automated Control Systems:** Design and implementation of relay controls for environmental management illustrated mechanical control acumen.
- **Interface Design:** Development of a user interface showcased skills in creating accessible technology solutions.

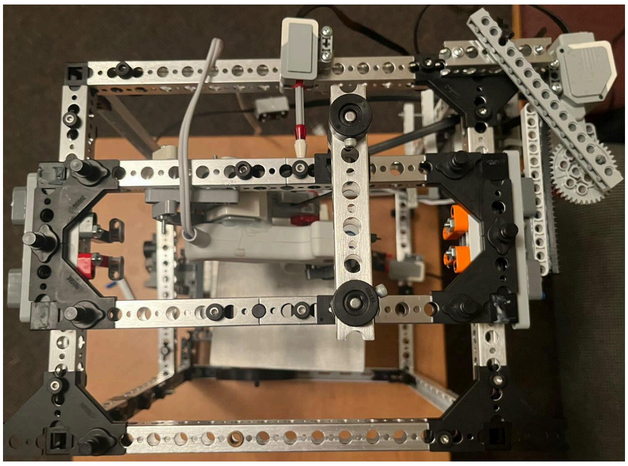
Lego 3D Printer



(Figure A) Side view of completed build and y-axis mechanism.

Project Overview

- This project aimed to construct a functional 3D printer from a unique combination of Tetrix parts and LEGO elements, incorporating a hot glue gun for material extrusion. Controlled by an EV3 kit, the printer was capable of precise movements along the x, y, and z axes, demonstrating the versatility and potential of educational building sets for complex engineering applications.
- Objectives included:
  - To build a cost-effective 3D printer using readily available Tetrix and LEGO components.
  - Implement control systems for precise movement and extrusion, enabling the creation of 3D objects.



(Figure B) Top view showing the x-axis rack and pinion mechanism.

Technical Implementation

- **Movement Control:** Utilized three large motors for movement along the x, y, and z axes, ensuring comprehensive coverage and the ability to print in three dimensions.
- **Extrusion Mechanism:** A separate motor was dedicated to operating the hot glue gun trigger, allowing for controlled extrusion of the printing material.
- **Mechanical Design:** Incorporated mechanisms such as rack and pinion for linear motion, wheel and track for stable movement, and a scissor lift for vertical expansion, facilitating accurate and coordinated movements.
- **Precision Enhancement:** The PI (Proportional-Integral) control function was applied to refine motor control, significantly reducing overshoot and enhancing the precision of movements.

(Figure C) View of rack and pinion mechanism controlling scissor lift.

Results and Impact

- **Printing Capability:** The printer successfully produced objects with a maximum volume of 125 cm^3 and a resolution of 0.5 cm, showcasing its ability to create relatively detailed small-scale models.
- **Accuracy Improvement:** The implementation of the PI function played a crucial role in preventing motor overshoot, leading to a high level of precision in the printing process that exceeded expectations for a prototype built from educational components.
- **Innovative Use of Materials:** By utilizing Tetrix and LEGO for the construction of a 3D printer, the project demonstrated the potential of modular building systems in creating complex machinery, providing a cost-effective alternative to traditional manufacturing methods.

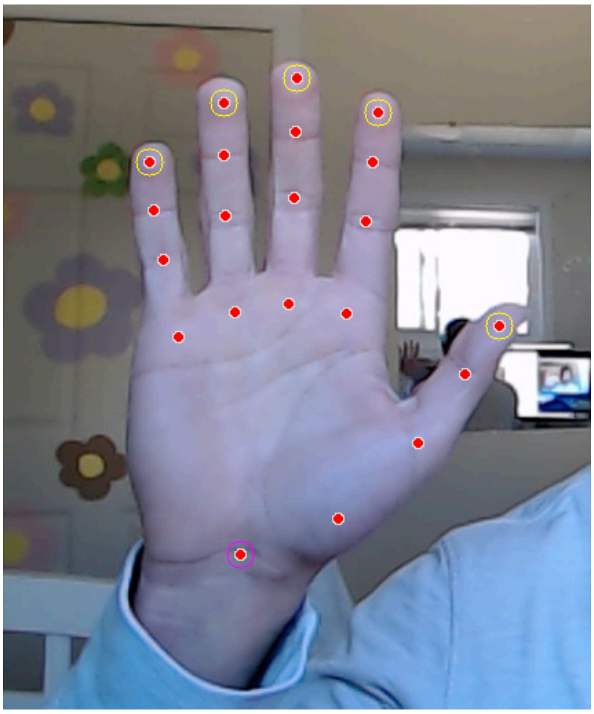
Reflection

- The completion of this project not only showcased the creative use of unconventional materials to build a functioning 3D printer but also highlighted the importance of precise control systems in additive manufacturing. It stands as a testament to the ingenuity in engineering, proving that with innovative thinking and technical skills, limitations in resources can be overcome.

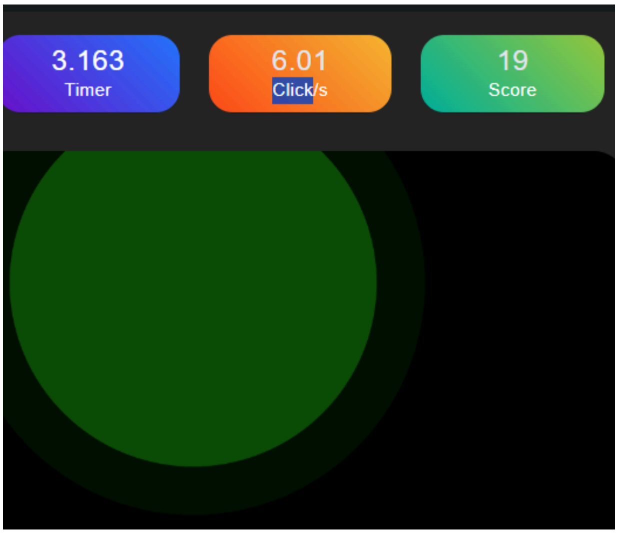
Skills and Technology Used

- **Mechanical Engineering:** Demonstrated through the design and implementation of movement and extrusion mechanisms.
- **Control Systems:** Application of the PI function for improved precision in motor movements.
- **Creative Problem Solving:** Illustrated by the adaptation of Tetrix and LEGO components for complex engineering purposes.

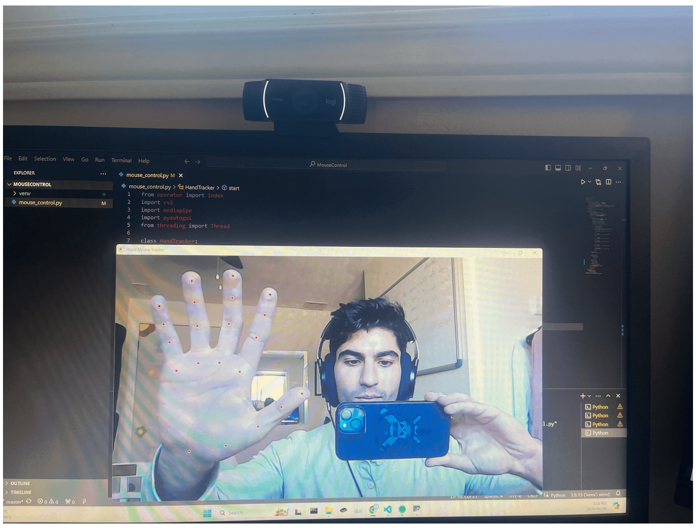
Hand Gesture Controlled Mouse Application



(Figure A) A hand with red and yellow tracking points for gesture recognition.



(Figure B) Application UI showing a timer, click rate, and score.



(Figure C) Developer testing gesture control with the camera and application's interface visible on the monitor.

Project Overview

- This project focused on developing an innovative hand gesture controlled mouse application, designed to track hand movements in real-time to perform mouse actions without the need for traditional input devices. Utilizing Python, OpenCV for gesture recognition, and PyAutoGUI for executing mouse commands, this application offers a groundbreaking approach to computer interaction, especially for users with physical disabilities or limited mobility.
- Objectives included:
  - Create a user-friendly, hand gesture-based mouse control system.
  - Leverage computer vision techniques for accurate hand tracking and gesture recognition.
  - Implement an efficient, real-time response system to user gestures for controlling mouse actions.

Technical Implementation

- **Gesture Recognition:** Employed OpenCV, a leading computer vision library, to accurately track hand movements and recognize predefined gestures.
- **Application Integration:** Utilized PyAutoGUI for translating recognized gestures into mouse actions, such as cursor movement and clicks.
- **Performance Optimization:** Implemented threading to ensure smooth performance, preventing lag between gesture recognition and action execution.
- **User Interface Design:** Developed a straightforward and intuitive interface that easily allows users to control their computer's mouse through hand gestures.

Results and Impact

Functionality: Successfully created a fully operational hand gesture controlled mouse, capable of understanding various commands like single-click, double-click, and cursor movement through hand gestures.
Accessibility: Provided an alternative method of interaction for individuals with physical disabilities or those who experience discomfort using traditional input devices, significantly enhancing accessibility and inclusivity.
Technical Proficiency: Demonstrated advanced knowledge in computer vision, human-computer interaction, and application development, showcasing the potential of gesture-based interfaces to revolutionize user experience.

Reflection

- This project exemplifies the practical application of computer vision and human-computer interaction principles to create a more accessible and intuitive user interface. It highlights the importance of innovation in technology to address real-world challenges, such as improving computer accessibility for individuals with limited mobility.

Skills and Technology Used

- **Computer Vision:** Advanced proficiency with OpenCV for real-time hand tracking and gesture recognition.
- **Programming:** Developed using Python, demonstrating strong coding skills and the ability to integrate various libraries.
- **Human-Computer Interaction:** Implemented principles of human-computer interaction to design an application that is both effective and user-friendly.
- **Multi-threading:** Utilized threading to enhance application performance, ensuring a seamless user experience.

Smart HUD Glasses

(Figure A) First concept drawing of glasses.

(Figure B) Second concept drawing of glasses.

(Figure C) Third concept drawing of glasses.

Project Overview

- The HUD Glasses project is a significant advancement in wearable technology, integrating AI capabilities with user-friendly design principles to enhance everyday interactions. Powered by a Raspberry Pi Zero 2 and equipped with a Pi Camera, these glasses utilize sophisticated hardware components to enable features such as facial recognition and real-time language translation. The software, leveraging tools like OpenCV and Deep Translator, ensures seamless performance and intuitive user experiences. With a focus on practicality and functionality, the HUD Glasses aim to provide users with a convenient and accessible way to engage with their surroundings.

Technical Implementation

- **Facial Recognition with OpenCV:** Leveraged OpenCV's advanced facial recognition capabilities to enable the glasses to identify individuals in real-time. Implemented robust algorithms to detect and analyze facial features, ensuring accurate and reliable recognition performance. Optimized the software to run efficiently on the Raspberry Pi Zero 2, balancing computational complexity with real-time processing requirements.
- **Real-time Language Translation:** Implemented Deep Translator for real-time language translation, seamlessly integrating it with the HUD display and bone conduction headphones, facilitating effortless cross-language communication.
- **Speech Recognition & Audio Output:** Utilized SpeechRecognition for converting spoken language to text, enabling user interaction. Integrated gTTS to generate clear audio from translated text, ensuring natural-sounding output.
- **3D Printed Frame Design:** Utilized SolidWorks for frame design, ensuring precise dimensions and ergonomic fit, and PrusaSlicer for prototype printing, enabling rapid iteration and customization.

Results and Impact

- **Seamless Communication and Enhanced Understanding:**
    - Enabled users to communicate effectively across language barriers, fostering greater understanding and collaboration in diverse environments.
    - Empowered individuals with hearing impairments to participate in conversations by providing real-time text and audio translations.
- **Intuitive Interaction and Accessibility Features:**
    - Designed an intuitive user interface with minimal learning curve, allowing users to quickly adapt to the functionality of the glasses.
    - Incorporated accessibility features such as customizable font sizes and color schemes to accommodate users with varying visual preferences and needs.
- **Pioneering the Future of Wearable Technology:**
    - Positioned the HUD Glasses as a trailblazer in the field of wearable AI technology, setting a new standard for innovation and usability.
    - Sparked interest and excitement among users and industry professionals alike, paving the way for further advancements in the wearable technology landscape.

Reflection

- The HUD Glasses project represents a culmination of collaborative effort, technical expertise, and a shared vision for leveraging technology to improve lives. As we reflect on our journey, we are proud of the strides we have made in pushing the boundaries of what is possible with wearable devices. Moving forward, we remain committed to refining and expanding upon our innovations, with a steadfast dedication to enhancing user experiences and fostering inclusivity through technology.

Skills and Technologies Used

- **Python programming:** Leveraged Python for rapid prototyping and development of the AI-driven functionalities of the HUD Glasses.
- **OpenCV:** Employed OpenCV for facial recognition and image processing tasks, ensuring accurate and reliable performance in real-world scenarios.
- **Deep Translator:** Integrated Deep Translator to provide seamless language translation capabilities, enabling cross-lingual communication in real-time.
- **SpeechRecognition:** Utilized SpeechRecognition for converting spoken language into text, facilitating natural and intuitive user interactions.
- **gTTS:** Integrated gTTS for generating spoken audio from translated text, delivering clear and natural-sounding output to the user.
- **Raspberry Pi Zero 2:** Utilized the Raspberry Pi Zero 2 as the hardware platform for running the AI software and driving the functionality of the HUD Glasses.
- **Pi Camera:** Integrated a Pi Camera for capturing images and video, enhancing the facial recognition capabilities of the glasses.
- **3D Printed Frame:** Designed and printed a custom 3D frame to house the hardware components, ensuring a comfortable and ergonomic fit for the user.
- **Debian OS:** Deployed the Debian operating system to provide a stable and reliable platform for running the software stack of the HUD Glasses.