Wearable Assistive Communication Device

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1. What is AAC?

14 Million
People in the UK experience communication difficulty [1]

10%
Of children in the UK have long-term communication needs [1]

1 in 400
Babies in the UK are born with cerebral palsy [2]

Communication is vital, yet not all individuals are able to do so freely.
Those who struggle with communication due to a range of conditions can benefit from assistive technologies known as augmentative and alternative communication (AAC) devices. The effectiveness of most AAC devices depends on the severity of the speech impediment, and for those with more severe impairments, current AAC devices can prove unhelpful and frustrating due to their **unreliability, dependence on bulky mountings, and high price** [3].

Our aim
Is to design a **novel, wearable AAC device** which can replace current expensive, wheelchair-mounted models. This project, undertaken in collaboration with the Pace Centre in Aylesbury, England, focuses primarily **on enabling children and young people with cerebral palsy** to communicate an audio output using physical input devices.

2. Requirements

- Safe [4]
- Reliable [4]
- Light-weight [4]
- Intuitive [4]
- Compatible with Existing Applications [4]
- Affordable [4]

3. Our Idea

The device consists of **a headset and an armband**, which incorporate a **diverse set of inputs** for easy navigation of a chosen AAC application (example: The Pace Centre My Way App – Figure 1 [5]).

The headset incorporates an **augmented reality visual display** which allows users to view their AAC application without the need for wheelchair-mounted screens. To select the desired output within the display, users have the option of utilizing an **eye-tracking program** incorporated in the headset, or a **motion sensor** in the armband. Once a selection is made within the application, the corresponding audio output will be played from a speaker.

By combining multimodal inputs with a wearable visual interface, this design allows users with a wide range of physical abilities to live their lives without fear of losing their ability to communicate with **ease, comfort, and dignity**.

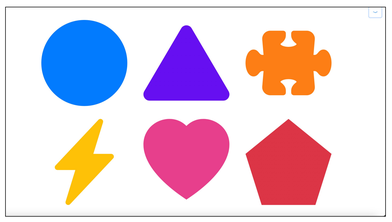

Figure 1: My Way application user interface [left], My Way logo [right]

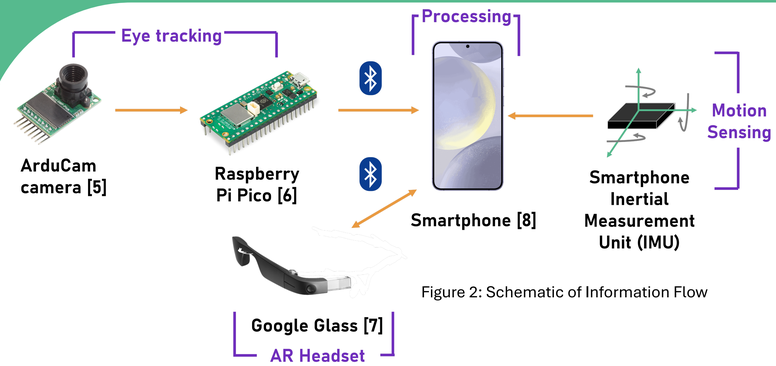

Figure 2: Schematic of Information Flow

Input Integration and Processing
- An **Android application,** written for the Google Glass, opens and runs the AAC application from within the headset, allowing the user to see the visual display.
- When the user navigates the interface, data encoding the cursor location is sent via Bluetooth to the Google Glass (from the IMU or eye tracking program respectively).
- When the selection is made within the interface, this information is sent via Bluetooth back to the smartphone and the associated audio is played off the **smartphone speaker.**

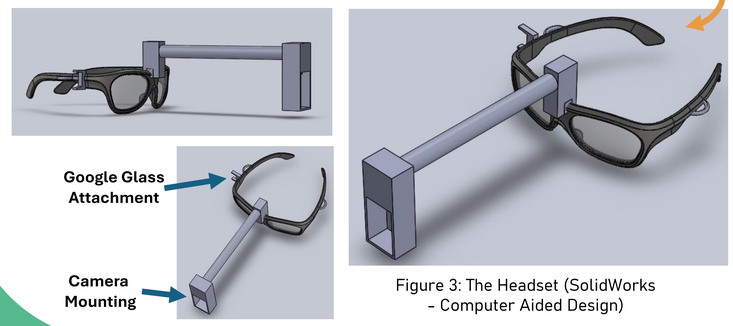

Figure 3: The Headset (SolidWorks - Computer Aided Design)

4. The Technology

Eye tracking
1) Visual inputs are taken from the ArduCam Camera
2) The libraries **OpenCV, dlib, Pyautogui, MediaPipe, and NumPy** are employed to allow for video processing, machine-learning enabled facial and pupil detection, real-time synchronization, and automated control of mouse position.
3) The program is run off the Raspberry Pi Pico.

Motion Sensing
1) Motion inputs are taken from the **inertial measurement unit** (IMU) built into an Android smartphone.
2) The data from the IMU is collected and processed using the **Pyautogui** Python library

The smartphone is held to the user's arm by a runner's band for comfort and to ensure **ease of cleaning and maintenance**.

Headset
Comfortable mounting for the following components [10]:
- **Google Glass**: provides an augmented reality visual display of the AAC application
- **ArduCam Camera:** picks up live pupil movements for eye tracking

Nylon-12 (PA 2200) was selected for the frame due to its **biocompatibility, strength, chemical resistance,** and ability to be printed using **selective laser sintering (SLS)** [11]. The headset is 3D printed for **easy customization** to each user.

Hip Belt
A **Raspberry Pi Pico** and connected **power bank** sit in a belt on the hip to **prevent discomfort** on the head from potential overheating. The Raspberry Pi processes live camera inputs taken via a wire connecting to the ArduCam and sends information **via Bluetooth** to the Google Glass.

Scan the QR code to see some examples of our eye tracking and motion tracking programs!

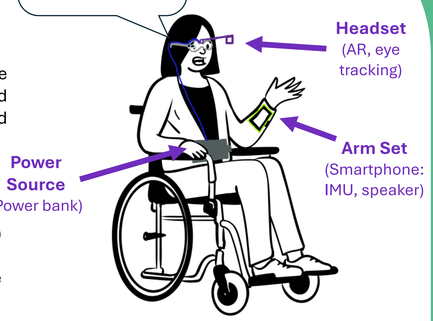

Figure 4: Device Positioning

Figure 5: The armband

Safety & Security Considerations
- Safe materials
- Smooth finish; no sharp edges on all worn parts
- Power source comes from a reliable manufacturer & meets electrical safety requirements
- No parts pose a choking hazard
- Safety-focused data processing

5. Results

- Safe
- Lightweight: Headset < 0.5 kg; Arm set < 0.2 kg
- Affordable: < £2500

Further testing and user feedback needed to assess **reliability & ease of use.**

Prototype is **not yet compatible with other AAC applications or alternative inputs** and requires further development to make **navigation of the settings** more intuitive.

6. Conclusion

The device does not yet meet the full requirements, but it remains our aim to **increase its compatibility** with different AAC applications, provide **additional modes of input** and **perform further testing** to assess and improve its reliability. Ultimately, we endeavour to improve this technology to respond to the needs of a **wide range of users** with unique sets of **preferences and physical abilities**.

7. Making a Difference

Due to its adaptability and multimodal input, this technology **can help a wide range of people who struggle with verbal communication** including, but not limited to, people with **cerebral palsy**.

It could additionally be used with non-AAC applications and advertised to a wider user base including gamers, tech-enthusiasts, and the general public. This potential for broader marketability has the potential to make the device **more affordable** for everyone, including AAC users.

8. What the Future Holds

- **Short Term:** More Compact Design; Improved Settings Navigation
- **Long Term:** Infrared Eye Tracking; Speech Generation; Compatibility with More Applications; Diversified Inputs

Acknowledgements
This project would not have been possible without the help of:
- **Dr. Ian Radcliffe**
- **Dr. Christopher Rowlands**
- **Mr. Luke Thompson**
- **Mr. Paschal Egan**
- **Mr. Martin Holloway**
- **The Pace Centre families and staff**
- **The Department of Bioengineering at Imperial College London**

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