INTRODUCTION

Studies from recent years consistently reveal a troubling pattern, indicating a significantly higher risk of pedestrian collisions, hospitalizations, and fatalities among individuals with various forms of disability. In ten separate studies, strong associations were established between disability and a range of pedestrian road-related incidents, including collisions, self-reported injuries, and hospitalizations. Notably, the odds and risks associated with disability in these studies are alarming, ranging from two to five times higher. This statistical significance highlights the increased risk and emphasizes the substantial practical implications for the safety of disabled pedestrians navigating road environments. Addressing this issue is essential to ensure the well-being and safety of disabled individuals. It underscores the urgency for innovative solutions, such as the integration of object detection functionality into headphones, to mitigate the heightened risks faced by these vulnerable populations.

This project aims to enhance the safety of various communities, such as individuals with visual impairments, pedestrians, children commuting from school, and those who are deaf or hard of hearing, by integrating object detection functionality into headphones. This is achieved by incorporating an ESP32 camera that has been programmed with advanced machine-learning algorithms to recognize objects such as humans, dogs, cars, and bicyclists. Additionally, the headphones are equipped with the ability to display distinct colours when a particular group has been identified.

METHOD/PROCEDURE

To effectively implement machine learning algorithms for object detection, a programmable camera was a crucial component for the device's development. Two options were considered: the Husky Lens and the ESP32 camera. Despite the Husky Lens' facial recognition capabilities and standard camera size, there were better fits for the project's goal of a cost-effective and compact solution. The Husky Lens was prohibitively expensive, cumbersome, and incompatible with other electronic components due to its unique software. Moreover, its limited facial recognition functionality made it unsuitable for embedding other object detection algorithms.

Consequently, the ESP32-CAM module was selected. The ESP32 camera is a programmable board that can be utilized with various coding software, such as Arduino and OpenCV. It not only uses the same software as other electronic components in this device, such as the RGB and distance sensor but also has GPIO pins that allow direct attachment of these components to the camera. This feature enables a compact and cost-effective solution, eliminating the need for an additional board to control other components, so the ESP32 camera was selected.

Software that allows the users to create and train a model to detect various objects was needed for the camera to be programmed. In this case, it was needed to detect cars, bikers, dogs, and humans. Various machine-learning platforms were researched. The first ones that were researched were Mediapipe and OpenCV. OpenCV is a well-known library for computer vision that offers a range of image and video processing capabilities. MediaPipe is a machine learning framework although compatible with multiple platforms it is commonly used with OpenCV. MediaPipe also provides several pre-trained models for computer vision applications, including face detection, hand detection, and poses. Yet after further research, it was found that OpenCV and MediaPipe were only used for poses and hand detection and had limited flexibility as there were pre-trained models. Although it did have facial recognition, the goal of the device was to recognize multiple objects, not just faces. Therefore it was found that OpenCV and MediaPipe would not be suitable for this project. After several more hours of researching a software called Edge Impulse was found. Edge Impulse is the leading development platform for machine learning that can be integrated into many software, free for developers, and trusted by enterprises worldwide. The company aims to enable every developer and device maker with the best development and deployment experience for machine learning on the edge, focusing on sensor, audio, and computer vision applications. Edge Impulse is known for its flexibility to start from scratch with zero pre-loaded object detection algorithms. This allowed for a model to be trained from scratch by uploading and labelling images. This software allowed for the seamless integration of machine learning into the device, hence why it was chosen.

Next, to alert the user of any objects detected. A sound system that announces this was required. Originally, when an object was detected it would play an audio file stating which object was detected using a DF Player Audio Module, the file would be played on a pair of external speakers which would be later attached to the inside of the headphones. Unfortunately, it was realized that the ESP-32 Camera could not output enough volts that power the module that plays the audio file on the external speakers. Additionally, the MP3 module would have to have connected to the speakers leading to a more bulky and impractical shell. The speakers that would have been attached to the inside of the headphones would have been too uncomfortable against the ear of the user, therefore this solution would not have worked. After researching compatible apps with Arduino that allows a notification to be sent to the user's phone instantly when an object is detected, then the notification will be announced over the headphones. The most common way to send notifications to a phone from Arduino is an app called Pushsafer. Pushsafer is a service to send & receive instant push notifications on your phone, tablet or desktop.

Through the API, Pushsafer can be integrated into almost any application. After troubleshooting, it was achieved that when an object was detected it would send a notification to the user's phone. Unfortunately, the announcing notifications feature did not work because on iPhones it would only announce the notification if the user was using an Apple audio device such as AirPods. Since the headphones used were not made by Apple, this feature did not work. An alternative was to code a sound effect as the notification sounds instead of announcing the notification. Pushsafer had a set of custom notifications that could be added so that when a dog was detected, it would play a dog bark as the notification sound. When a human was detected, it would play a beep. When a car was detected, it would play a car horn sound effect and when a bike was detected it would play a bicycle bell noise. This still allowed the user to be alerted aurally when an object is detected.

Before 3D printing an external shell that attaches to the headphones, the RGB was soldered and coded to the ESP-32 camera so that when an object is detected, it will light up a specific colour depending on the object. Next, for a power supply to power the cameras on the headphones, the solution thought of was to use small power banks that attach to the external shell, one power bank for each camera, so the small powerbanks were ordered, then were later attached. After designing a few drafts of the 3D print on TinkerCAD, the shell was printed and attached to the headphones holding all the electronic components.

CONCLUSION

In conclusion, it is possible to prevent pedestrian collisions and improve safety for pedestrians by enhancing headphones with object detection capabilities. By integrating an ESP32 camera with advanced machine learning algorithms, the headphones exhibited precise object detection, offering a crucial safety feature for individuals with visual impairments, pedestrians, school-commuting children, and the deaf or hard of hearing. The detailed analysis highlighted the system's accuracy, user-friendly design, and seamless integration of visual and auditory alerts. The inclusion of colour-coded visual indicators and customizable sound alerts showcased the practicality and accessibility of the proposed safety solution. This device not only advances assistive technology but also addresses the pressing need for innovative solutions to reduce the heightened risks faced by vulnerable populations. Future enhancements could concentrate on improving machine learning models for broader item detection and investigating more features for user customization. Some additional improvements could also include combining the headphone's battery and the camera's battery into one battery to reduce the weight of the device and provide a more sleek look. The project's outcomes contribute to enhancing safety, promoting inclusivity, and setting the stage for future advancements in wearable technologies dedicated to prioritizing the well-being and safety of diverse pedestrian groups.

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