ESP 32 : SMART SUPPORT EMPOWERING ALZHEIMER'S PATIENTS

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***Abstract*—This paper explores the development of smart glasses equipped with an ESP32-CAM module and a supporting mobile application to enhance memory care for Alzheimer's patients. Alzheimer's patients often face challenges related to memory loss and disorientation, which can lead to confusion and emotional distress. The proposed system addresses these issues by combining wearable technology with visual recognition capabilities. The ESP32-CAM module, mounted on the glasses, captures images of the patient's surroundings and recognizes familiar faces, locations, or objects through coded image recognition algorithms. The mobile application, connected via Wi-Fi or Bluetooth, processes this information and delivers real-time prompts to the patient through audio or visual cues in the glasses. These prompts help patients identify people and contextual information, assisting with recall and orientation and providing a greater sense of familiarity and reassurance. This paper aims to improve the quality of life for Alzheimer's patients by enhancing their independence and reducing moments of confusion, ultimately supporting caregivers and improving patient well-being in memory care settings.**

***Index Terms*—Smart glasses, Alzheimer's care, ESP32-CAM, memory assistance, visual recognition, wearable technology, cognitive support, mobile application, therapeutic interventions, real-time prompts, image processing, patient well-being, independence, caregiver support, coding, Visual Studio, memory prompts, emotional stability, personalized care, health technology.**

I. Introduction

Alzheimer's disease is a progressive neurodegenerative disorder that impacts memory, cognition, and behavior, leading to significant challenges in daily life. One of the most distressing symptoms for patients is the inability to recognize faces and remember names, which often leads to confusion, anxiety, and social withdrawal. As the disease advances, individuals may struggle with basic social interactions, creating an emotional barrier that affects both the patient and their loved ones. This project aims to tackle one of the most difficult aspects of Alzheimer's disease—the loss of social recognition. By using a pair of smart glasses equipped with an embedded camera, the system automatically captures images of the people the patient interacts with throughout the day. These images are then transmitted to a mobile app installed on the patient's smartphone, where the system processes them using face recognition technology. Once the image is processed, the app sends the results as real-time audio feedback through [1] Bluetooth earphones, informing the patient of the person's name or alerting them if the face is unfamiliar.This discreet, non-intrusive feedback helps patients engage with the world around them, reducing anxiety and embarrassment associated with forgetting someone's name. The integration of this technology into everyday life helps foster a sense of normalcy, allowing patients to maintain a level of independence and confidence despite the cognitive challenges of Alzheimer's.

In addition to assisting with social recognition, the system also supports Alzheimer's patients in managing their daily routines, particularly in relation to medication. A common issue for Alzheimer's patients is the difficulty in remembering to take prescribed medications, which can have serious health consequences if neglected. The system allows caregivers to set medication reminders through the mobile app, ensuring that the patient receives timely, gentle reminders via the Bluetooth earphones. This feature helps to alleviate the cognitive burden of remembering medication schedules, reducing the need for constant oversight. The caregiver can manage the system remotely, adjusting medication reminders and updating the list of recognized faces as necessary, providing peace of mind without being overly involved in the day-to-day care. The combination of automatic face recognition, real-time audio feedback, and medication management creates a comprehensive support system that enhances the patient's independence while also easing the caregiver's responsibilities. This system represents a significant step forward in Alzheimer's care, offering a practical solution that improves the quality of life for both patients and their caregivers. It is a promising example of how wearable technology can be used to bridge the gap between cognitive decline and meaningful social interactions, empowering patients to stay connected to their loved ones and maintain control over their health.

II. RELATED WORKS

This paper, "Personal Assistance for Alzheimer's Patients" discusses the development of a mobile application to support Alzheimer's patients in managing their daily lives and assist caregivers in monitoring patient activities. The paper [2] identifies Alzheimer's as a progressive neurodegenerative disease that affects memory and cognitive functions, often leading to confusion, wandering, and difficulties in recognizing familiar faces. These symptoms pose huge difficulties for both the patients and caregivers. The proposed mobile application employs face recognition, wander detection, fall detection, and reminders, which will resolve these problems and enhance the patient's quality of life dealing with Alzheimer's. There is one of the biggest components of the application itself: face recognition technology for helping Alzheimer's patients recall the people they are introduced to on a regular basis. As Alzheimer's advances, patients often forget familiar faces. This can be the faces of close family members and friends. This leads to emotional distress and complicates interactions with others. The paper further describes how the face recognition module uses deep learning algorithms to store and identify faces, reminding the patient about the name and relationship of the person they are interacting with. This feature is highly useful in the middle stages of Alzheimer's when the problem of memory loss becomes more prevalent. By assisting patients to recognize familiar faces, the application helps keep them connected with the people around them and alleviates confusion and isolation.

Another critical feature discussed in the paper is wander detection. The common behavior among Alzheimer's patients is wandering. People get up and leave their homes, not knowing their way back. This paper describes how a mobile application uses GPS tracking technology to keep track of the patient's location in real time. If the system determines that the patient has wandered from the path set for him or her, it alerts the caregiver about the location of the patient. This feature makes sure that caregivers can intervene immediately, preventing the patient from getting lost or entering dangerous areas. Wander detection not only increases the safety of Alzheimer's patients but also gives peace of mind to caregivers as they are able to track and help the patient remotely when necessary.

This paper, titled "A Mobile Application for Alzheimer's Caregivers," presents the development of a mobile application specifically designed to assist caregivers in managing the care of Alzheimer's patients. Alzheimer's disease is a progressive condition that severely impacts memory and cognitive functions, creating [3] significant challenges for caregivers who are responsible for the daily care of these patients. The paper emphasizes the growing need for technological interventions that not only improve patient care but also provide crucial support for caregivers. The proposed mobile application aims to reduce the emotional and physical burden on caregivers while ensuring the safety and well-being of patients through features like real-time tracking, fall detection, face recognition, and task reminders.

One of the key focuses of this paper is the role of caregivers in managing Alzheimer's patients. Caregivers are often family members who lack professional medical training but are responsible for overseeing the daily needs of patients, such as ensuring they take medications, monitoring their safety, and handling behavioral changes associated with the disease. The paper points out that while caregiving is essential for Alzheimer's patients, it can lead to burnout and emotional distress for caregivers. Thus, the mobile application is designed to alleviate these pressures by offering tools that help caregivers monitor patient behavior remotely and intervene in critical situations, such as wandering or falls. This real-time assistance allows caregivers to provide better care with less stress, thereby improving the overall caregiving experience.

The main application of this paper has a feature of tracking in real-time through GPS, which helps the caregiver know where the Alzheimer's patients are located. Among the symptoms that show Alzheimer's is that of wandering, which makes [4] the condition deadly; Alzheimer's patients wander and become either disoriented or lost after leaving their homes. The application uses GPS tracking to continuously monitor the patient's movements, sending alerts to caregivers if the patient leaves a predefined safe zone or appears to be wandering aimlessly. This feature significantly enhances patient safety and provides peace of mind to caregivers, knowing they can quickly locate their loved ones in case of an emergency. Moreover, the [5] tracking system is integrated with Google Maps, allowing caregivers to follow the patient's movements in real-time and intervene when necessary.

The paper addresses a critical need for innovative solutions in the care of individuals affected by Alzheimer's disease, a progressive neurodegenerative disorder that primarily impacts memory, cognition, and overall quality of life. As Alzheimer's disease progresses, patients develop severe cognitive impairments to the point where they cannot really navigate their daily activities anymore, remember important information at times, and maintain their independence. This paper introduces a smart wearable memory band system designed specifically for Alzheimer's patients, with the aim to support memory recall, independence, and providing caregivers with essential tools for monitoring and assistance. Millions of people worldwide are suffering from Alzheimer's disease, and this is creating a significant amount of emotional and physical burdens not only for the diagnosed but also for their families and caregivers. The symptoms of Alzheimer's include memory loss, confusion, and difficulty in recognizing familiar faces and places. These challenges can lead to feelings of frustration, anxiety, and social isolation for both patients and caregivers. As cognitive skills are reduced, the caregiver will face increased stress and concern with the individual leaving the home and his or her safety.

The Paper Titled "Memory Aid Device for Alzheimer's Patient" is a research paper introduces a wearable device tailored for individuals with Alzheimer's disease, focusing on their specific needs for recognizing loved ones and navigating their environment safely. The device integrates a face recognition model with a Raspberry Pi and Pi-camera to identify people from a pre-stored dataset of known faces. This allows users to hear the name and relationship of the person in front of them through a text-to-speech function

III. PROPOSED SYSTEM

The proposed system for the "ESP 32 SMART SUPPORT" project integrates a smart wearable device in the form of glasses, combined with a Flutter-based mobile application.

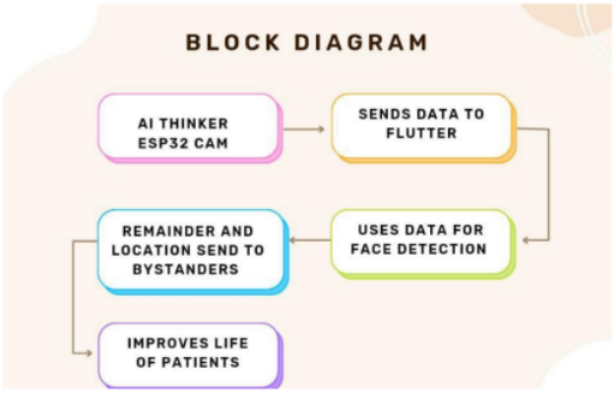

Fig. 1. BLOCK DIAGRAM

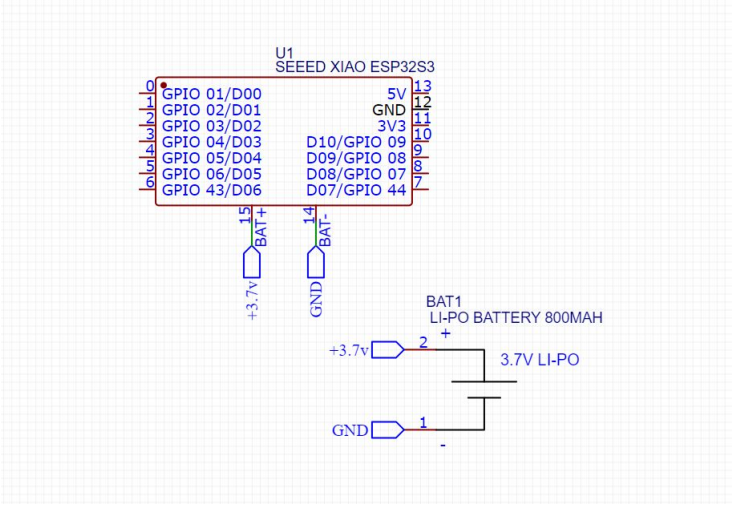

Fig. 2. CIRCUIT DIAGRAM

1) Smart Glasses: Capturing Faces Automatically: The smart glasses in this system are designed [6] to make it easy for Alzheimer's patients to recognize people around them without requiring any active effort on their part. The glasses are equipped with a camera that automatically detects and captures images of individuals the patient interacts with. This camera is discreetly embedded within the frame, ensuring that the patient feels comfortable wearing it, and the process is entirely seamless. When the patient meets someone, the camera is triggered by face detection algorithms, which constantly monitor for recognizable facial features within the frame's field of view. Once a face is detected, the camera captures the image automatically, ensuring that the patient's experience is intuitive and unobtrusive.

These captured images are then wirelessly transmitted to Firebase via a secure Wi-Fi connection. This transmission occurs without the need for any manual intervention from the patient, making the system completely hands-off. Firebase securely receives the images, and the data is encrypted during transmission to protect patient privacy. This automatic capture and transfer of images help the patient focus on interacting with others rather than worrying about taking pictures or remembering faces.

2) The App: Handling the Photos and Preparing the Data: Once the images are transferred to the mobile app, the real work of face recognition and data management begins. The mobile application, built using Flutter, acts as a central interface between the smart glasses, the cloud, and the caregiver. When an image is received, the app processes the photo and uploads it to Firebase, where more advanced analysis takes place. The app ensures that these background tasks do not

overburden the patient's phone by offloading the heavy lifting to the cloud, where processing power is virtually unlimited. This helps keep the system efficient and responsive.

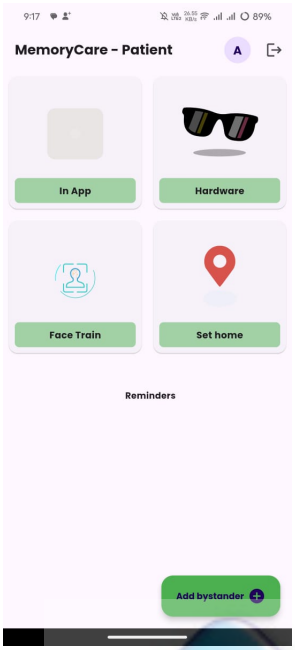

Fig. 3. APP DISPLAY

The mobile app also provides an intuitive user interface for the caregiver. It allows caregivers to monitor all of the captured images, update the database with new faces, and manage past interactions. By integrating a database within the app, caregivers can ensure that the database of recognized individuals stays up to date and accurate. This makes it easier to maintain the system's recognition capabilities over time, as caregivers can add names and update details about the individuals the patient interacts with. The app also gives caregivers the ability to track the patient's social interactions, ensuring that they have full control over the patient's experience with the system.

The app essentially acts like a digital assistant. While the patient doesn't have to interact directly with the technology, Dart makes sure the image gets where it needs to go, handling everything in the background.

3) Cloud-Based Face Recognition: Identifying Faces: 3. Cloud-Based Face Recognition: [7] Identifying Faces When an image is uploaded to Firebase, the system begins the process of face recognition. This is handled using Regula SDK and machine learning algorithms, which are capable of identifying faces by analyzing specific features. The process starts with feature extraction, where the system uses a method called Principal Component Analysis (PCA) to reduce the dimensionality of the image while retaining essential facial features. By converting the image into a set of features, the system can compare the new face to a collection of previously stored faces in the database.

Once the face features are extracted, the system performs a face matching procedure. Using Cosine Similarity, the system compares the extracted features with those in the database to find the best match. If the system detects a high similarity score, it confirms the individual's identity and retrieves their name from the database. This match helps the system provide the patient with immediate, accurate identification. If no match is found, the system informs the patient that the person is unknown and prompts the caregiver to add their details to the database for future recognition. The cloud-based processing ensures that the system is scalable and accurate, as it can handle complex recognition tasks without placing strain on the patient's mobile device.

In this step, after an image is uploaded to Firebase, Regula SDK and machine learning algorithms are used to analyze the image and identify faces. First, feature extraction occurs using Principal Component Analysis (PCA). PCA is used to reduce the dimensionality of the image while retaining key facial features for matching.

The formula for PCA is:

$$Y = W^T(X - \mu)$$

X = Original image vector
μ = Mean face
W = Transformation matrix (obtained from PCA)
Y = Reduced feature representation

After feature extraction, the system compares the features of the detected face with stored face features in the database using a Cosine Similarity metric. The formula for cosine similarity is:

$$\text{Similarity} = \frac{A \cdot B}{\|A\|\|B\|}$$

A = Feature vector of the captured face
B = Feature vector of the stored face in the database
The result is a value between 0 and 1; values close to 1 indicate a high likelihood of a match.

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4) Optical Character Recognition (OCR) for Name Extraction: OCR is used when face recognition fails or when text-based identifiers are present. To extract meaningful text, the system applies Otsu's Thresholding technique for binarization. The threshold is determined by maximizing the between-class variance to distinguish text from the background.

The threshold is calculated by:

$$T = \arg\max_t \sigma_B^2(t)$$

T = Optimal threshold
σ_B^2 = Between-class variance, which is maximized for clear text extraction.

After binarization, the system uses a deep learning-based OCR model to detect and recognize characters from the image.

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5) Audio Feedback: A Personal Assistant in Your Ear: The speech synthesis system uses a simple harmonic oscillation model to generate sound. The formula for the speech waveform is:

$$S(t) = A\sin(2\pi ft + \phi)$$

$S(t)$ = Speech waveform at time t
A = Amplitude of the sound wave (determines the volume)
f = Frequency of the sound wave (determines the pitch)
t = Time
ϕ = Phase shift, which affects the starting point of the oscillation

This formula generates the audio signal that plays through Bluetooth headphones, providing feedback to the patient.

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6) Medication Reminders: Helping Stay on Track: Along with face recognition, the system also provides a crucial service for Alzheimer's patients—medication reminders. Forgetting to take medications is a common issue for Alzheimer's patients, which can lead to health problems. This system helps the patient remember to take their medicine by sending them audio reminders directly to their Bluetooth earphones.

The caregiver can set up these medication reminders through the app, so the system knows exactly when to send the alert. When it's time for the patient to take their medication, they'll hear a gentle reminder like, "It's time to take your medication." The reminder comes through the earphones, ensuring that the patient stays on schedule without needing to rely on their own memory.

The caregiver doesn't have to worry about reminding the patient constantly. The system automatically keeps track of the medication schedule, making sure that the patient gets the reminders when they need them. This provides a sense of peace and reassurance for both the patient and the caregiver.

7) Empowering the Caregiver: The system isn't just designed for the Alzheimer's patient; it also provides a great deal of support for the caregiver. Managing the day-to-day care of someone with Alzheimer's can be overwhelming, and this system helps by automating some of the tasks that would otherwise require constant attention.

The caregiver can easily add new faces to the database, so the system will recognize people the patient interacts with. They can also set up and adjust medication reminders to suit the patient's needs. This means the caregiver doesn't need to worry about managing these tasks manually or remembering every detail. The system does it for them, providing valuable support.

Additionally, because the system learns over time, it becomes more intuitive and personalized. As the patient meets more people, the system gets better at recognizing them, which makes social interactions smoother. Over time, this reduces the number of "unknown faces" the patient encounters, allowing them to feel more confident and less confused.

8) Continuous Learning: Becoming Smarter Over Time: One of the unique [8]features of this system is that it learns and adapts over time. As the patient meets new people, the caregiver can add their names and faces to the system's database. This makes the system more accurate as it collects more data, allowing it to recognize people more quickly and efficiently.

The longer the system is used, the better it gets at identifying faces. The patient will start to notice that the system recognizes more and more of their social circle. This not only helps with social interactions but also [9] contributes to a sense of continuity and familiarity, which is important for patients with Alzheimer's.

In addition to face recognition, the smart glasses are equipped with a GPS module that tracks the patient's location. The ESP32 collects location data and transmits it to the Flutter app via Firebase. This feature is particularly useful for caregivers, as they can set geofencing parameters within the app. If the patient moves outside of a predefined safe zone, an automatic alert is sent to the caregiver's smartphone, allowing them to take swift action. The location tracking feature not only enhances the safety of the patients but also provides caregivers with peace of mind, knowing they can monitor their loved ones' whereabouts at any time.

The integration of 3D printing technology is crucial in the design and production of the glasses' housing. The 3D-printed frames allow for customization to fit the specific needs of each patient, such as adjusting the size or adding ergonomic features for comfort. This also makes it easy to replace parts or update the design as needed, providing flexibility in the development and maintenance of the device. The 3D-printed structure ensures that the glasses remain lightweight while securely holding the ESP32, camera module, GPS, and speaker, making them suitable for daily wear by elderly patients.

The Flutter app also supports additional functionalities such as setting reminders for the patient's daily activities like taking medication, drinking water, or going for a walk. Caregivers can schedule these reminders through the app, and the glasses play audio prompts when it's time for the patient to perform the scheduled activity. This feature helps maintain the patient's routine and promotes a sense of independence, as they receive gentle guidance throughout the day without the need for constant caregiver intervention. The ability to customize reminders through the app ensures that the care provided is tailored to the individual needs of each patient

IV. RESULTS AND DISCUSSIONS

The Smart Glasses for Alzheimer's Patients [10] project is a fusion of high technology and user-centric design, which has the power to improve the lives of people living with memory impairments. This system is built around the ESP32 microcontroller, offering Bluetooth connectivity. The glasses can then be paired with a companion mobile app built with Flutter, making it easier for caregivers to manage user profiles and settings.

Equipped with a compact camera, the glasses capture real-time images of the user's surroundings. Using machine learning algorithms powered by TensorFlow Lite adopted from Google Colab and using DART Software, the device can recognize familiar faces and give immediate feedback, helping users recall names and relationships. This Memory Recall Assistant feature not only aids in recognition but also alleviates anxiety by reinforcing social connections. Additionally, a digital microphone facilitates voice interaction, allowing users to issue commands or ask questions, further enhancing usability. Audio notifications and prompts are delivered through Bluetooth earphones, ensuring that users receive relevant information discreetly.

The custom 3D-printed frame is designed to be both comfortable and practical, making it possible to wear the glasses all day without discomfort. Such ergonomic design is important because prolonged use is necessary to realize the full benefits of the memory recall features. In addition, the system is powered by a lightweight 1250 mAh LiPo battery that has enough battery life to sustain daily activities while remaining portable in form factor.

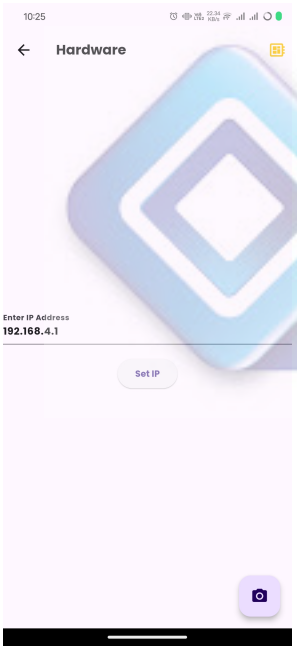

Fig. 4. IP Address Screenshot

In essence, this project makes significant progress in the aspect of assistive technology for it fulfills critical needs in patients with Alzheimer's disease as well as their caregivers. Users are enabled to recognize and remember essential people in their lives by enhancing independence and the quality of social interaction for people afflicted with memory impairments. This innovative solution has the potential to positively influence many aspects of the health and personal assistance sphere, proving that technology indeed is capable of making a difference.

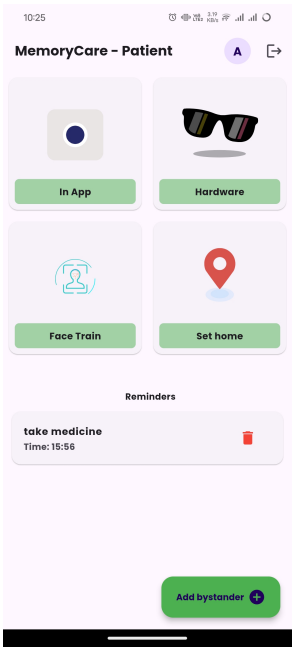

Fig. 5. Home Page Screenshot

Fig. 6. SMART GLASS (ESP32 MODULE)

Fig. 7. SMART GLASS (TOP)

Fig. 8. SMART GLASS (FRONT)

V. CONCLUSIONS AND FUTURE SCOPE

In conclusion, the Smart Glasses for Alzheimer's Patients project is a transformative approach to assistive technology, greatly supporting people with memory impairments. Advanced features include real-time facial recognition, voice interaction, and seamless connectivity with a mobile app, empowering the user to navigate their social environment more confidently and easily. The system is designed to continuously adapt to the user's needs by integrating machine learning algorithms, hence making it more effective over time. The comfort and usability-centric design of the custom 3D-printed frame allows for prolonged wear and makes the glasses a practical solution for everyday use. This innovative tool supports memory recall but also encourages independence and social engagement, thus alleviating feelings of isolation and anxiety that often accompany Alzheimer's disease. As such, this project not only improves quality of life for patients but also provides valuable support to caregivers, creating a holistic approach to managing the challenges of memory loss. After all, the Smart Glasses are a promising form of assistive technology, capable of bringing modern innovations in combination to make meaningful differences for the healthcare sector and to alleviate the lives of people whose lives are affected by Alzheimer's disease. The future potential of this project is vast, with numerous opportunities for enhancement and expansion. As technology advances, the integration of AI-driven personalization could enable the system to recognize not only faces but also emotional cues—such as detecting when a patient feels anxious or stressed during a social interaction and providing appropriate support or calming interventions. The system may further evolve to track health metrics, such as heart rate or activity levels, through wearable sensors, thus providing a much more holistic caregiving solution. Improvements in data privacy could further extend this technology to other aspects of dementia care, such as reminding patients about appointments or even offering daily cognitive exercises tailored to their needs. This will expand the interactivity of the system further to include voice recognition and natural language processing, so the patient would require fewer caregivers for the management of the system. As the database of recognized faces expands, so will the system become smarter, thus bringing deeper social connections and improving quality of life. The project could also be expanded to assist other memory-related conditions, creating a broader impact in eldercare and improving the lives of those with cognitive impairments.

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