# Smart Assistive Glasses for Alzheimer's Patients

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Mohamed Ait Gacem


Saif Alghlayini
Ajman University


Wessam Shehieb
Ajman University


Mustahsan Mir
Ajman University

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Mohamed Ait Gacem, Saifeddin Alghlayini, Wessam Shehieb, Muaid Saeed, Ahmed Ghazal and Mustahsan Mir

Department of Electrical and Computer Engineering, Ajman University
Ajman, United Arab Emirates

Corresponding author email id: maitgacem@yahoo.com

***Abstract*— Alzheimer's patients require special care and constant monitoring. This paper utilizes smart glasses equipped with Augmented Reality (AR) screen to perform the basic functions of a caregiver and provide the patients with features that increase the independence and reduce caregiving costs. It targets patients during the early and middle stages of the disease who still possess control over their mental and physical behaviours.**

**The core features are detecting the location of misplaced objects and guiding the patient to their last seen location, identifying and displaying the names of friends and relatives on the AR display, monitoring if the patient has lost the way and accordingly displaying the way home on the AR display while simultaneously sending the patient's location to the caregiver as an SMS, detecting if the patient removed the glasses, predicting the cause of removal, then notifying the caregiver with the predicted cause and the patient's location.**

***Keywords*— *Computer vision, Smart Glasses, Alzheimer, Caregiving, Augmented Reality.***

## I. Introduction

Dementia is a syndrome that causes memory deterioration and makes patients unable to perform everyday activities. Around the world there are over 50 million people diagnosed with dementia, and 10 million new cases are added every year. In 2015, this syndrome cost the global economy about US$ 818 billion [1].
Alzheimer's disease is the most common form of Dementia, as it contributes to 60-70 % of the cases [1]. It affects the brain cells and causes gradual mental and physical deterioration through three main stages. The symptoms during the early and middle stages are limited to minor memory loss, forgetting faces and losing directions, while during the last stage patients lose the ability to control their mental and physical behaviour [2].
The target population is early and middle stage Alzheimer's patients. At those stages patients face difficulties doing many everyday activities, but their condition is not severe enough to be admitted in a caring institute, which creates a gap in the caring system. The main approaches to tackle this problem is either by hiring a caregiver which most patients can't afford, or by using technological gadgets like GPS tracking tags, appointment reminding apps and pill boxes [3].
One interesting approach is using Light Emitting Diodes (LED) indicators mounted on the dementia patient's glasses to aid him in the daily navigation using visual indications [4]. Another promising approach is using a wearable Internet of Thing (IoT) device that recognises the faces of known people in real time manner using deep learning [5]. Also there have been attempts to use A.I. based games to help the Alzheimer's patients improve their cognitive performance [6].

Some researchers developed solutions that target the environment where the Dementia patients live rather than offering a wearable solution; like designing a smart kitchen environment that uses surveillance cameras to help the patient keep track of the cooking objects as well as offering audio and graphical assistance and instructions [7].

A Chinese company called Maidu designed the "Know you again" Alzheimer smart glasses. The purpose of those glasses is identifying the faces of friends and family members and their voice biometrics then speak out their names through a speaker. Those glasses were featured as a prototype in March 2017, but still haven't reached the production phase till date [8].

The later glasses are the closest in concept to the glasses presented in this paper where both offer face identification and recognition. And the same thing applies for the wearable IoT face recognition device.

All of the above mentioned solutions provide help to patients to a certain extent but fail to provide a greater level of care. From here arises the need for a gadget that effectively provides constant and comprehensive care for patients without compromising comfort and with the least cost.

## II. Technical Approach

The use of smart glasses with augmented reality (AR) display was found to be the most convenient approach to help the patients. Being a wearable technology ensures that the patients will have direct and continuous access to all of the provided features.

The research methodology followed by this paper is a mixture of qualitative and quantitative approaches. The glasses features presented in this paper rely in its functionality. on multiple existing Computer Vision, Smart Location Services, and Indoor locating Algorithms.
The viability of the developed features was verified by experimental procedures to ensure that the glasses fall within acceptable performance margin.

The VUZIX Blade Augmented reality smart glasses [9], as shown in Fig. 1, were initially chosen to be the main platform used for developing the prototype.

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But it was found that those glasses do not support Google play services; which made it difficult to develop the majority of the features considering that most of them rely on Google maps in their functionality.
Hence, a new prototype smart glasses were designed and an Android based smart phone was used to illustrate some features.

The prototype smart glasses shown in Fig. 2 offer four main features: Detect everyday used objects then guiding the patient to their last seen location when asked for, identifying the faces of people who are already in the database or adding new ones, tracking the patient's location, and detecting if the patient removed the smart glasses and predicting the cause of removal.
Each feature is explained in detail with the results obtained in the following parts of the paper.


Fig. 1: VUZIX Blade AR smart glasses main components.

Fig. 2: The designed smart glasses prototype.

## III. DESIGN AND IMPLEMENTATION

The smart glasses prototype provides a variety of features to the patient by utilizing a selection of hardware and software. The feature development underwent three main phases:

1. Phase 1: Developing the features on an Android based smart phone.
2. Phase 2: Developing a smart glasses prototype that interfaces with the Android application developed in phase 1.
3. Phase 3: Shifting the developed features to the VUZIX Blade AR Smart Glasses.

The smart glasses prototype has two main compartments; the left compartment shown in Fig. 3, is equipped with a sensitive switch, raspberry pi V2.1 camera and an Accelerometer and Gyroscope sensor.

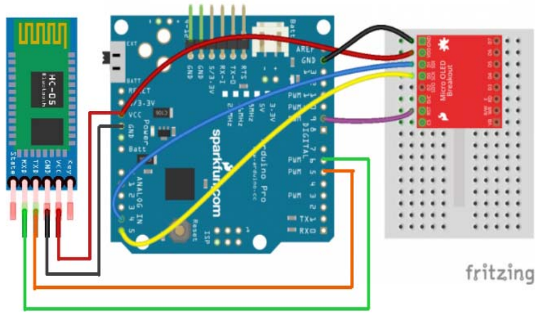



Fig. 3: The circuit connection of the right compartment components created using fritzing.

The right compartment shown in Fig. 4, is equipped with a micro OLED display, Arduino Nano and a 10,000 mAh LiPo battery. The glasses are expected to operate for roughly 75 hours. However, the power consumption depends on how often the patient uses the features. The operating time was estimated using the current consumption of the components provided by their datasheet.
Both compartments interface with the developed Android application using an HC-05 Bluetooth module.

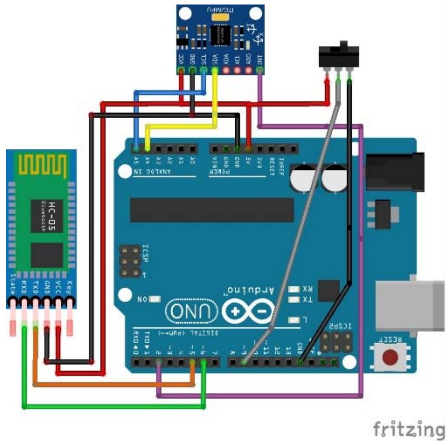



Fig. 4: The circuit connection of the left compartment components created using fritzing.

## IV. KEY RESULTS

The prototype smart glasses offers four main features designed to tackle the main problems faced by Alzheimer's patients.

### *4.1 Detecting the location of everyday used objects*

The glasses capture a live streaming video through the built-in camera, then it uses TensorFlow object detection API [10] to classify the seen objects as shown in Fig. 5 (right). Once the designated object appears in the frame, the software tracks it, then records the last seen location of that object in an internal map.
The internal map is created using the IndoorAtlas API [11] which uses data collected from the internal accelerometer, gyroscope and campus sensors of the device and the Wi-Fi signal to form the map. The collected data is analyzed using machine learning algorithms in the cloud. The generated map is shown in Fig. 5 (left). When asked for, the glasses direct

the patient to the object's stored location through audio commands and AR illustrations.

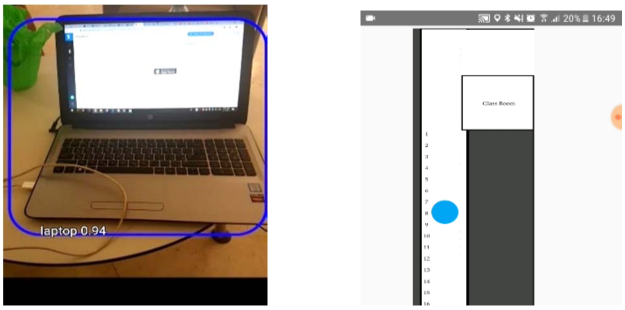



Fig. 5: Tensorflow Object detection API (left). IndoorAtlas indoor mapping API (right).

Microsoft Azure computer vision was used to create a training model that recognizes and classifies a selection of everyday used objects using machine learning. The model was then exported to a TensorFlow compatible format after performing optimization to the training process which enhanced the accuracy. The training accuracy is shown in Fig. 6.

| Tag | Precision | Recall | A.P. | Image count |
|---|---|---|---|---|
| Saif | 100.0% | 100.0% | 100.0% | 137 |
| keys | 100.0% | 94.7% | 100.0% | 94 |
| Watch | 94.1% | 100.0% | 100.0% | 78 |

Fig. 6: Object detection and face recognition computer vision model training accuracy.

The location accuracy of the object detected by the TensorFlow Object detection API depends on how fast the application can detect and recognize the object appearing in the frame as well as the distance between the camera and the object when a positive detection occurs.

Recognizing objects from a long distance would mean saving a location that doesn't reflect the real location inside the indoor map, hence the app should ideally recognize objects only from a short range.

Also, if the patient moves too fast, the application may not be able to recognize the seen objects which could lead to inaccurate results. The test results are shown in Fig. 7.

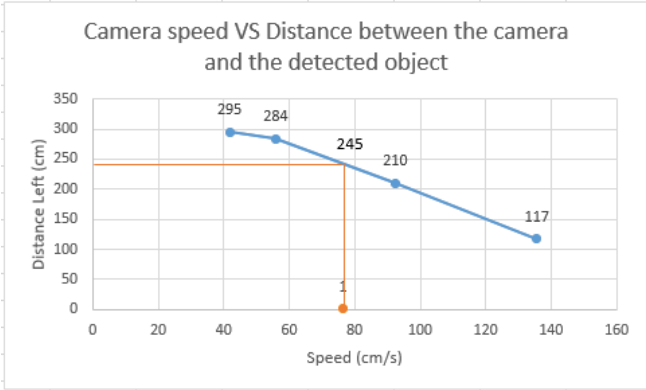



Fig. 7: A graph showing the correlation between the distance between the camera and the detected object when a positive detection occurs, with the speed of which the camera moves.

The average speed of movement within an indoor environment was measured to be 76.45 cm/s. At that speed the distance between the camera and the detected object is roughly 245 cm (2.45 m) as shown in Fig.7.

Since the error margin of the indoor location given by the Indoor Atlas indoor mapping SDK is 1-3 meters, and the average distance for detection within indoor environment is 2.45 m; it was concluded that the trained object detection model is suitable for the desired application.

### *4.2 Detecting the faces of friends and relatives*

The glasses detect the faces of designated people in the captured video using LUXAND SDK [12], then display their names on the AR display as shown in Fig. 8.

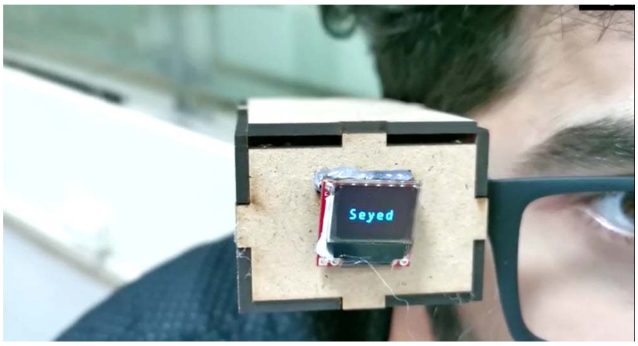
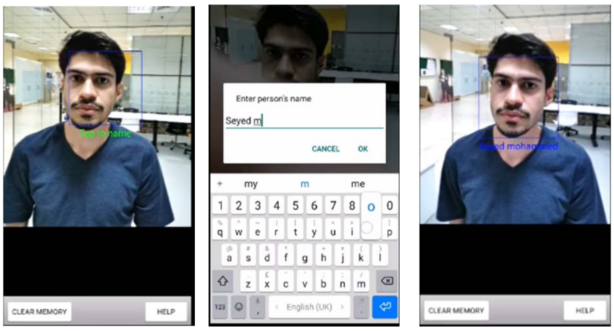



Fig. 8: The Augmented Reality display showing the name of the detected person.

The patient can add new people to the database as well as activate and deactivate the feature through voice commands. The process of adding new people to the database through an Android application is shown in Fig. 9.




**(a)** **(b)** **(c)**

Fig. 9: Detecting a new face that hasn't been stored in the database (a). Inputting the name of that person (b). The application detects the face of the newly added person (c).

The AR display shown in Fig. 8, is designed using a Micro OLED display which displays text that get reflected on a transparent surface.

### *4.3 Detecting if the patient is lost*

The glasses will track the patient's GPS location to determine if he/she went to an unusual path or outside a geofence as shown in Fig. 10. The glasses will then display the way home on the AR display, while simultaneously sending the patient's GPS location to the caregiver. The care giver can track the live location of the patient using the developed application shown in Fig. 11.

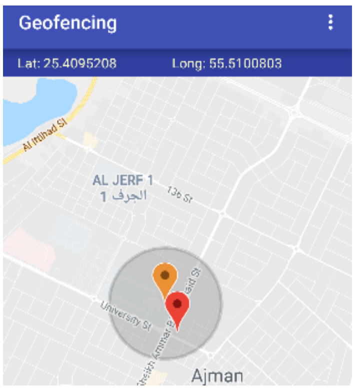



Fig. 10: Geofence centre symbolized by the orange arrow and current location symbolized by the red arrow (right).

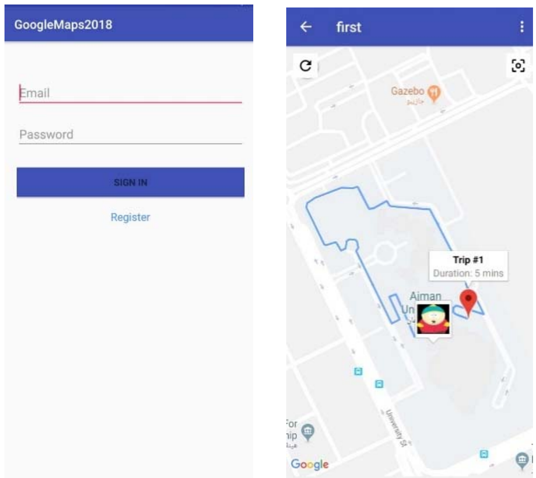



Fig. 11: Live tracking application login page (left). Showing the shortest route between the caregiver and the patient (right).

### *4.4 Detecting if the patient removed the glasses and predicting the cause of removal*

A sensitive switch placed in the contact area between the patient's head and the glasses converts the pressure at that point to a voltage signal. That signal passes through a signal conditioning circuit to be in a form recognized by the glasses. A major change in the voltage indicates that the patient removed the glasses. The glasses removal detection system simulation is shown in Fig. 12.

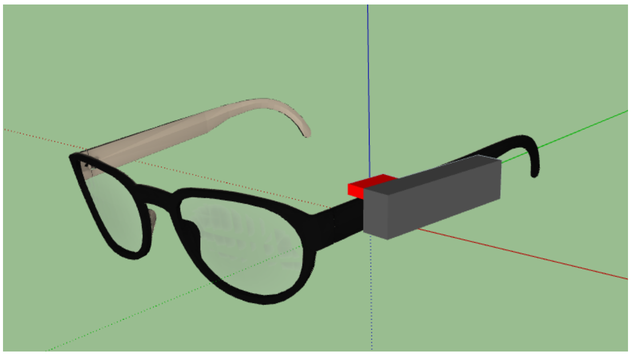


Fig.12: The glasses removal detection system simulated using Sketch-Up [13]. The sensitive switch is placed in the red area.

The glasses uses the built-in accelerometer sensor to detect the acceleration of which the glasses were removed. Taking the glasses voluntarily will have a smaller acceleration compared to the one caused by falling down. Then a message is sent to the caregiver with the expected cause of removing the glasses and the patient's GPS location. The glasses removal cause prediction system is shown in Fig. 13.

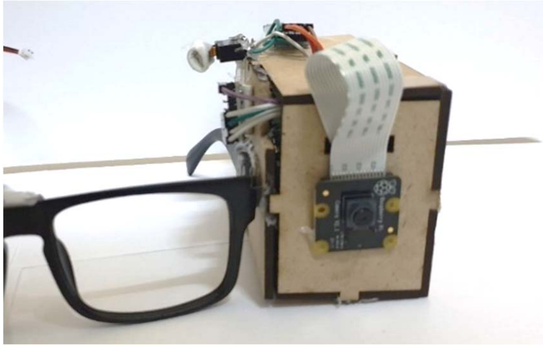


Fig.13: An Accelerometer and Gyroscope sensor detects any changing pattern in the glasses acceleration.

### *4.4 Smart glasses prototype limitations*

The smart glasses prototype size (W=10 cm, L=25 cm, H=6.5 cm) is not convenient for actual use due to the size of the circuits. The end product will eventually offer similar functionality with a more compact design by using Printed Circuit Boards (PCB) and that would eliminate the need for separate modules which also contribute to the oversize. The current module's dimensions are shown in Fig.

The second limitation is the augmented reality display. Although it offers an insight on how the end user will perceive the features, the display is limited to text output and it can be unclear under certain lighting conditions. This can be improved by using a better display with more resolutions and by proposing a way to uniform the performance regardless of the environment.

The glasses dependency on a smart phone application to operate may cause inconvenience and it would be ideal if all the processes are embedded within the glasses as it was initially planned.

## V. CONCLUSION

The smart assistive glasses prototype was developed to help Alzheimer's patients during the early stages of the disease become more independent and reduce the caregiving costs.

The main prototyping platform was initially the VUZIX Blade Augmented Reality Smart Glasses, but due to some software limitations in those glasses a new smart glasses prototype was developed to illustrate the project features.

The smart glasses prototype was successful in detecting the location of everyday used objects and navigating the patient to their last seen location, detecting and recognizing the faces of friends and relatives and display their names on the Augmented reality display, automatically detecting if the patient was lost and notifying the caregiver with the patient's location and informing the care giver when the patient removes the glasses as well as predicting the cause or removal.

The main features of this paper's prototype were demonstrated to two medical doctors and both appreciated the contribution of this project towards developing a practical solution that would make a significant difference in the lives of Alzheimer's patients, especially those in the early stages of the disease.

## REFERENCES


[1] World Health Organization. (2018). Dementia. [online] Available at: http://www.who.int/news-room/fact-sheets/detail/dementia.

[2] Alzheimer's Disease and Dementia. (2018). Stages of Alzheimer's. [online] Available at: https://www.alz.org/alzheimers-dementia/stages.

[3] Sauer, A. and Sauer, A. (2018). 7 Technological Innovations for those Living with Dementia. [online] Alzheimers.net. Available at: https://www.alzheimers.net/9-22-14-technology-for-dementia/ .

[4] Firouzian, A., Asghar, Z., Tervonen, J., Pulli, P. and Yamamoto, G. (2015). Conceptual design and implementation of Indicator-based Smart Glasses: A navigational device for remote assistance of senior citizens suffering from memory loss. 2015 9th International Symposium on Medical Information and Communication Technology (ISMICT).

[5] Roopaei, M., Rad, P. and Prevost, J. (2018). A Wearable IoT with Complex Artificial Perception Embedding for Alzheimer Patients. 2018 World Automation Congress (WAC).

[6] Imbeault, F., Bouchard, B. and Bouzouane, A. (2011). Serious games in cognitive training for Alzheimer's patients. 2011 IEEE 1st International Conference on Serious Games and Applications for Health (SeGAH).

[7] Li, Y., Asghar, M. and Pulii, P. (2013). Visually-aided smart kitchen environment for senior citizens suffering from dementia. 2013 International Joint Conference on Awareness Science and Technology & Ubi-Media Computing (iCAST 2013 & UMEDIA 2013).

[8] Welovead.com. (2018). Baidu | F5 | Know You Again | WE LOVE AD. [online] Available at: http://www.welovead.com/en/works/details/17dwgnsBi [Accessed 8 Nov. 2018].

[9] Vuzix.com. (2019). *Vuzix | Vuzix is a Leading Developer of Smart and Augmented Reality Glasses*. [online] Available at: https://www.vuzix.com/ .

[10] TensorFlow. (2019). *TensorFlow*. [online] Available at: https://www.tensorflow.org/ .

[11] Indooratlas.com. (2019). *IndoorAtlas*. [online] Available at: https://www.indooratlas.com/ .

[12] Luxand.com. (2019). Detect and Recognize Faces and Facial Features with Luxand FaceSDK. [online] Available at: https://www.luxand.com/facesdk/

[13] Help.sketchup.com. (2019). *Homepage | SketchUp Help*. [online] Available at: https://help.sketchup.com/en.