Transforming Lives with the Metaverse: Advancing the Lifestyle of Alzheimer's Patients

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Abstract

Background: Alzheimer's disease is a progressive neurological disorder that primarily affects older adults. It is characterised by a loss in cognitive abilities such as memory and concentration, problem-solving, and language skills. It is a devastating condition that affects many people around the world, especially the older generation. One of the most challenging aspects of Alzheimer's is the loss of memories and the ability to recall past experiences. It is a leading cause of dementia, which affects an estimated 50 million people worldwide.

Objective: This paper explores the metaverse's potential to improve the lifestyle quality of Alzheimer's patients by recreating memories using virtual and augmented reality technologies. By harnessing the power of virtual and augmented reality technologies, we aim to recreate precious memories for patients, providing them with a means to relive and reconnect with their past experiences in a virtual environment.

Methods: We discuss the opportunities of using metaverse, augmented reality, virtual reality and other technologies to create personalised experiences that help patients recall important events, places, and people from their past. These technologies have the ability to simulate real-world environments and provide interactive experiences that can trigger memories and emotions.We are capturing real-world events using smart glasses that are provisioned with microphone, cameras, display screen and sensors and which are later modelled into a 3D environment in the metaverse using special software that converts sensor data from the glasses. We have included an AI assistant that can guide the patient in real-world scenarios.

Conclusion: Our goal is to provide a novel and innovative approach to Alzheimer's care, leveraging the limitless possibilities of the metaverse to improve the overall well-being and happiness of those affected by this debilitating condition. Further research and development in this area can pave the way for more effective patient-friendly interventions for cognitive impairment.

Index Terms: Alzheimer's Disease, Augmented Reality, Metaverse, Virtual Reality, Lifelogging, Mirror World, Artificial Intelligence and machine learning, Convolutional Neural Network(CNN)

I. INTRODUCTION

METAVERSE, a combination of the prefix "meta" (implying transcending) with the word "universe", describes a hypothetical synthetic environment linked to the physical world. Metaverse is a virtual environment which merges the physical world and the computer-generated modifications of the physical world which enables users to interact with each other in which the users can perform their activities, more similar to the activities they perform in the physical world. Metaverse is a combination of various concepts like AR (Augmented Reality), VR (Virtual Reality), Mirror World and Lifelogging. Metaverse has helped in the further understanding of various fields of life by providing a real-world practical experience of how things work. One of the real-world problems is Alzheimer's disease, which can be treated more effectively using the metaverse along with the current medical treatments.

We believe that a solution can be provided by using the concept of virtual reality, where the patient's memories are virtualized just as if the patient is reliving his memories, by capturing them when they occur and then converting them into a 3D virtual environment. By using technologies like augmented reality we add computer-generated perceptual information into the patient's field of vision to improve the real-world experience.Using Lifelogging technology we capture patients' daily activities in a prompt manner and log them accurately. With the help of AI, we process the current data and provide smart recommendations to the patient while dealing with real-world situations.AI can also be used to analyze a patient's reactions to real-world interactions and experiences to further understand the current condition and see how it can be improvised.

AI can improve the patient's memory condition by assisting him to recollect specific essential memories, individuals, and solutions to real-life situations. The smart AI assistant employs advanced facial detection algorithms to assist individuals with Alzheimer's in recognizing familiar faces while utilizing previously recorded conversations to provide context and enhance their understanding of

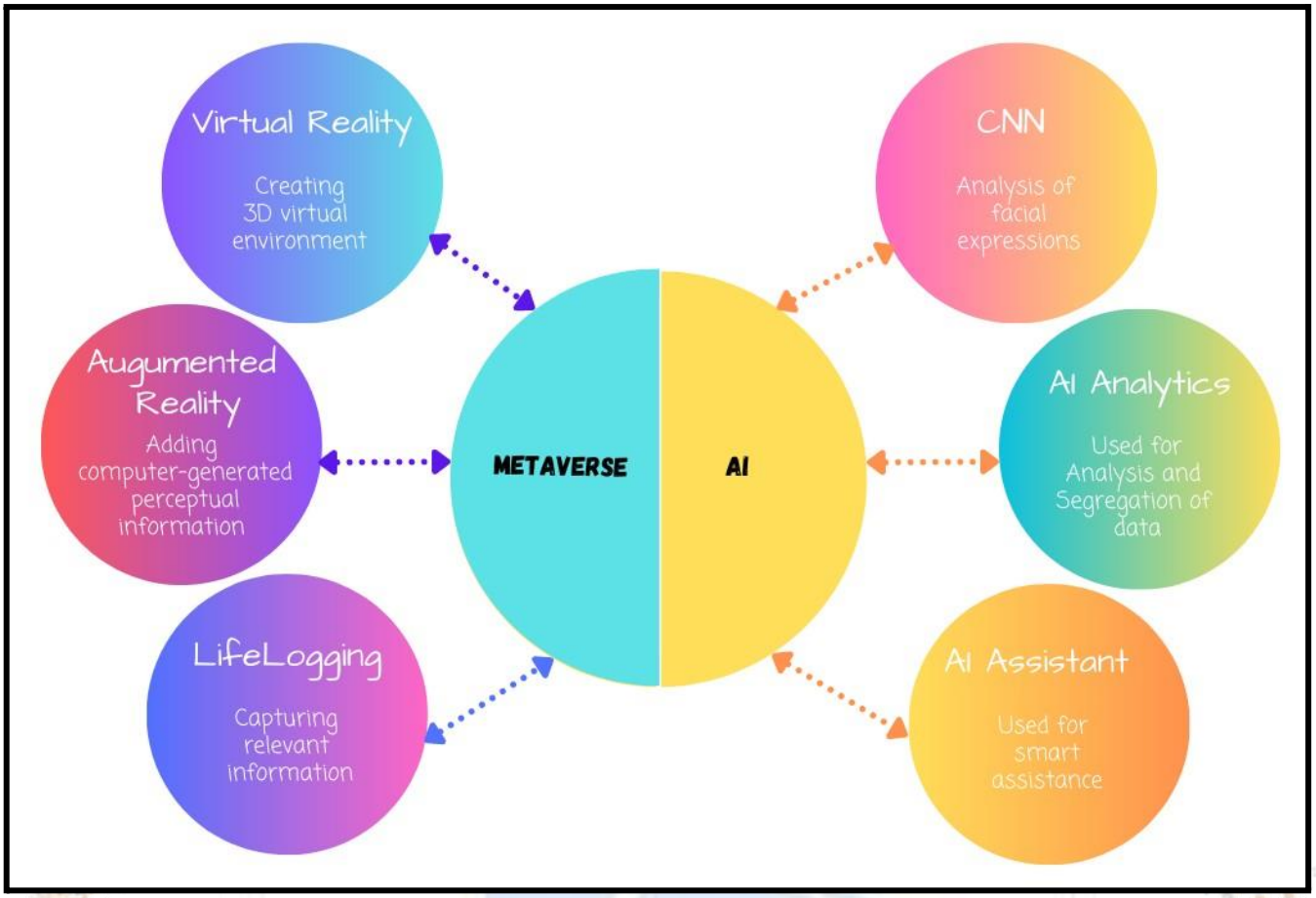

Fig.1 Concept Map

the situation. By analyzing facial features and cross-referencing them with a vast database of recorded conversations, the assistant can quickly identify individuals and provide the patient with relevant information, such as their name, relationship to the patient, and important details about past conversations and shared experiences. This cutting-edge technology offers a personalized and intuitive approach to memory assistance, helping individuals with Alzheimer's to maintain social connections and enhance their overall quality of life. With its sophisticated capabilities, the metaverse has the complete capability to revolutionize the field of Alzheimer's care, providing a novel and effective tool for memory support and cognitive rehabilitation.

II. LITERATURE SURVEY

The paper [1] aims at developing an application which focuses on identifying the summary of the previous conversations between the patient and a person by using a face detection method. The application acts as an assistant to the patients.

The authors of paper [3] have made a survey on the metaverse that uses the concepts of virtual reality, augmented reality, lifelogging, mirror world, extended reality and so on can broaden one’s limitations of the physical world. Mesmerizing games and bilateral virtual environments are known to be precursors of the metaverse. The strong and metamorphic impact of the metaverse has transformed social interactions. In the fields of marketing, sales, education, travel tourism and medical care metaverse has an astounding effect.

The authors of the paper [4] have made a survey reviewing the already existing smart glasses to propose the best design for human-computer interaction and the possibility of multi-modal inputs for the smart glasses. A study on various interaction methods has been found to provide input to the smart glasses but the main focus of the paper is on touch and touchless input.

Structure from Motion (SFM) and Multi-View Stereo (MSV) algorithms, which are based on computer vision, are highlighted in the paper [5] to document 3D model reconstruction to help with the restoration or reconstruction of buildings, especially of the cultural heritage areas, to preserve the building if it is destroyed. The Structure from Motion technique is used to reconstruct the image into a 3D model using two inputs, original images of the building and compressed images. Both the original and compressed photos have improved 3D points. The compressed images are quicker than the original images and go through fewer iterations overall.

The research paper [6] focuses on the static and dynamic features in the image for the facial Action Unit (AU) to be detected automatically. The features of each static image of a video are extracted using nominal hand-crafted and deep learning representations for AU occurrence activation detection and the performance of the pre-trained model is analysed. The features of the dynamic sequence were extracted using supervised and unsupervised methods in temporal variation phases of temporal modelling. A new

approach was developed based on Generative Adversarial Networks (GANs). The Unsupervised DCGAN model was adopted to extract facial features and classify them according to the classes of emotions which improved the generalized results. The DCGAN process was proven to be poorly suited to extracting facial expressions. The paper also discusses the challenges associated with using AI tools for facial expression analysis. The author highlights the importance of addressing these challenges to improve the accuracy and reliability of the results obtained from facial expression analysis using AI tools.

The paper [14] investigated the effects of video game training on cognitive control in older adults with Alzheimer's disease. The study used various cognitive measures and brain imaging studies to investigate the neural mechanism underlying the observed improvements in cognitive control. They discussed the idea that video game training could improve attention control, working memory and the ability to multitask all of which are important components of cognitive control.They also cited previous studies that had found positive effects of video game training on cognitive functioning in both younger and older adults. This makes us believe that the metaverse could be more effective in establishing cognitive control with the help of virtual reality, augmented reality techniques and methodologies that we have proposed in our research paper.

III. PRELIMINARIES

1. An Overview of the Metaverse

The phrase "metaverse" describes a widespread, widely used, shared, three-dimensional virtual environment that converses with the physical world. While they buy, work, play, or just hang out, people can converse in real-time.

A web of 3D virtual worlds that can be experienced concurrently and continuously by an essentially infinite number of users with a sense of personal presence and with data consistency, such as identification, past, privileges, equipment, connections, and payments, is quoted to as the "metaverse" by author Matthew Ball Everything in his book The Metaverse: And How It Will Revolutionise.[11]

2. Types in metaverse

Augmented Reality:
Augmented Reality transforms the real environment into a vibrant, visual one by the use of a camera or video viewer. Augmented reality enhances the user's experience of the real world.

Virtual Reality:
Computer-generated simulation of an alternate world is called Virtual Reality. Virtual Reality creates an immersive simulation of a physical world place or a fictional place which can be accessed through virtual reality headsets [15]

3. Alzheimer's Disease

The most common cause of dementia is Alzheimer's disease.The illness progresses gradually, beginning with modest memory loss and possibly increasing to the loss of communication and environmental awareness. Alzheimer's disease influences the brain regions responsible for cognition, memory, and language. The capability to perform daily duties can be severely hampered.

Along with memory issues, someone with Alzheimer's disease symptoms may also struggle with one or more of the following:

- Memory loss causes problems in life by causing people to ask the same questions repeatedly or to get lost in a familiar place.
- Having trouble paying bills and managing funds.
- A struggle to complete ordinary tasks at work, home, or in leisure.
- Lowered or poor judgements.
- Losing objects and not being able to go back and find them.
- Mood, attitude, or conduct changes.

IV. PROPOSED METHODOLOGY

(1) Wearable Smart glasses with a camera and lidar sensor to capture surroundings

There are glasses and other wearable gadgets that can record the surrounding environment and create a 3D model. These glasses typically use various sensors such as cameras, microphones, and depth sensors to capture visual and audio information from the surrounding environment. The wearable glass is an augmented reality headset that uses cameras, microphones and LIDAR(Light detection and ranging) sensors to capture the surrounding environment and create a 3D model. The camera and microphone can capture visual and audio information respectively, from the surrounding environment. The glasses are equipped with a small screen along with the lens to display information to the wearer. [4]

Cameras: capture visual information in the form of images or video. They may be located on the front of the device, facing outward, or on the back of the device, facing inward toward the user. In addition, it can contain multiple cameras positioned at different angles to capture a more comprehensive view of the environment.

Microphones: capture acoustic data from the surrounding environment. They may be used to record ambient sounds, conversations, or other audio cues that can provide additional context to the visual information being captured.

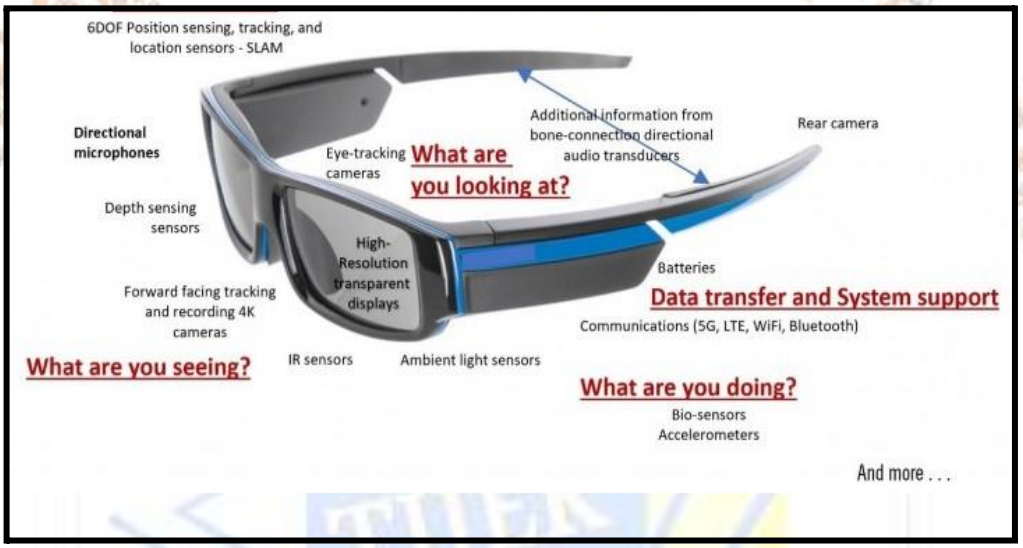

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Fig.2 Smart Glasses

Depth Sensors: Sensors like Lidar (Light Detection and Ranging) which is a laser light-powered sensing technology that uses laser light to measure distances and create 3D maps of the surrounding environment. A lidar sensor emits a laser beam and measures the return time of the laser light that bounces back after hitting an object. By calculating the time-of-flight of the laser pulse, the lidar sensor can calculate the distance to the object. Lidar sensors typically use a rotating mirror or a scanning mechanism to direct the laser beam in different directions and cover a larger field of view. Using this data, a 3D map of the environment is produced, which may then be utilised to produce a completely virtualized version of the environment in the metaverse.

The glasses also include an accelerometer, gyroscope, and ambient light sensor. These sensors help the device understand the user's movements and surroundings. The glasses have small screens that display the view in the metaverse. The display is a high-resolution, full-colour display that shows the metaverse view. The glasses can also overlay virtual objects in the metaverse with the real world.

Once the visual, audio, and depth information has been captured, it is processed and analysed using specialised software. The software may use computer vision algorithms to identify objects and surfaces in the environment. The glasses are connected to a smartphone and integrated with the cloud for storage. The data from the sensors, cameras and microphone is processed and uploaded to the cloud. The captured data is processed again using Artificial intelligence and machine learning algorithms to classify the memories. These memories are later used to create metaverse models.

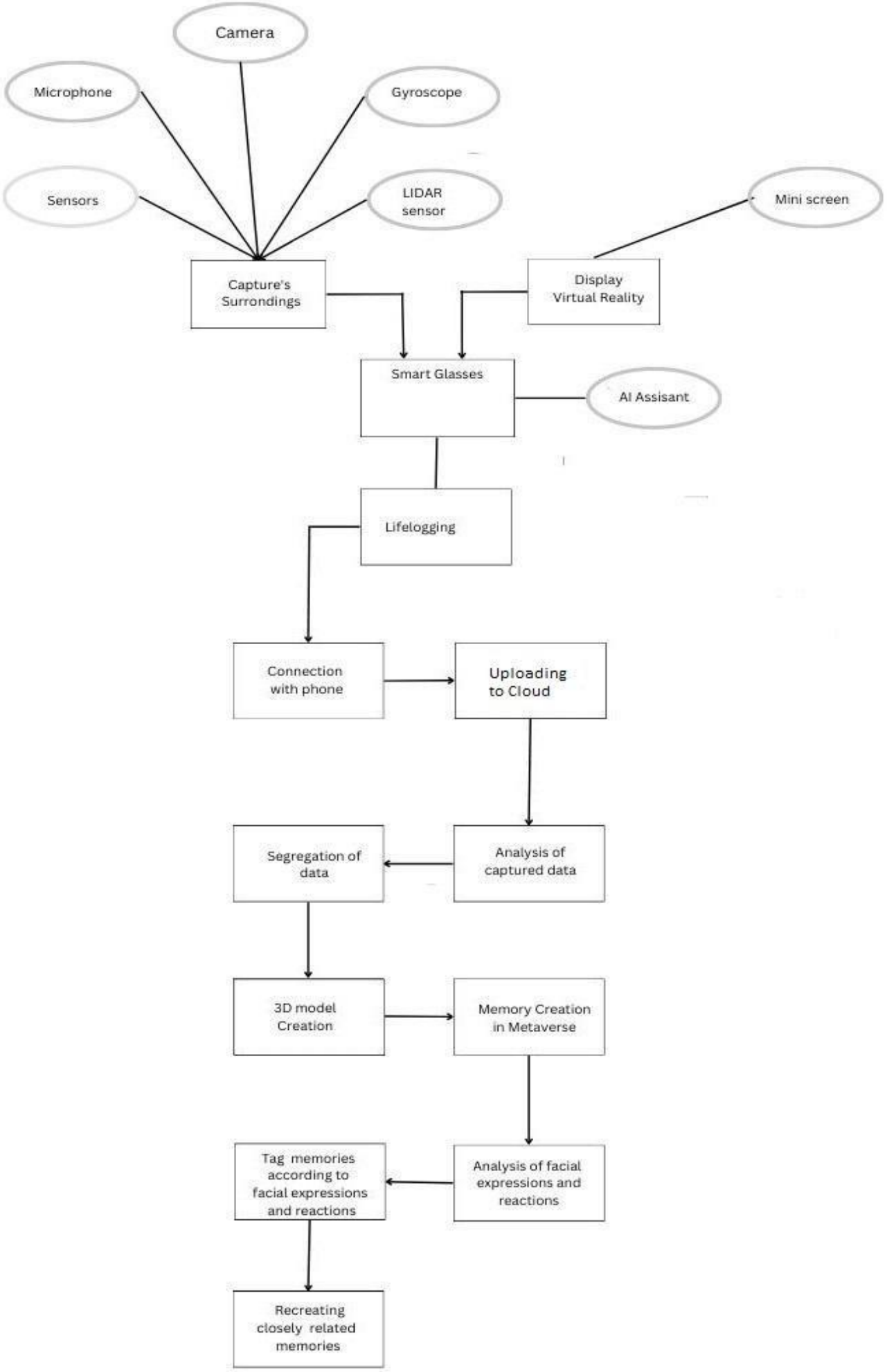

Fig.2 Flow Chart

(2) Lifelogging and capturing

The daily activities and surroundings are logged from the patient's point of view. Lifelogging using smart glasses continuously captures and records a user's daily experiences and activities. The objective of lifelogging is to create a comprehensive digital record of a person's life, which is further used for memory enhancement and behavioural analysis.

To make sense of the large amounts of data captured by smart glasses, machine learning algorithms can be utilized to extract relevant features and insights from the data. For instance, algorithms of computer vision can be applied to detect and recognize objects, people, and activities in the images and videos captured by the glasses.

Lifelogging can assist Alzheimer's patients as it records their day-to-day activities. Using the data collected by lifelogging the lifestyle of a patient can be improved massively. Data collected using lifelogging is completely reliable.

The captured data is usually stored in the cloud through a smartphone. Machine learning algorithms can be implemented for analyzing the data and extracting useful insights, such as identifying patterns in the user's behaviour, detecting changes in health or mood, and predicting future behaviour or outcomes.

(3) 3d modelling using computer vision algorithms and Recreating the model of the patient's memory in the Metaverse

The video captured using the glasses is converted to a 3-dimensional model with the help of various software. This 3-dimensional model is used to recreate a metaverse model, made using the patient's memory.

Computer vision algorithms could be used to create 3D models from video by analysing the motion and shape of the objects in the scene. One common approach is to use a technique called structure from motion (SFM), which involves estimating the camera parameters and 3D point locations from the 2D image data.

Here is a brief overview of how SFM(Structure from Motion) works:

Feature detection: The initial step is to detect features in the video frames that can be matched across different frames. These features could be points, corners, edges, or other distinctive visual patterns.

Feature matching: Once the features have been detected, the upcoming step is to match them across different frames using techniques such as feature descriptors and nearest neighbour matching.

Camera calibration: With the matched features, the camera parameters can be estimated for each frame, such as the position, orientation, and focal length.

3D reconstruction: Once the camera parameters are known, the 3D point locations can be estimated from the feature correspondences and camera projections which can be done using techniques such as triangulation or multiview stereo. LIDAR sensor data is also used to create a 3D point cloud representation of the environment.

Model refinement: Finally, the 3D model can be refined and optimised using techniques such as mesh smoothing, texture mapping, and error minimization.[5]

There are multiple software tools that can be used to convert video footage into a 3D model, some of them are Agisoft Metashape, RealityCapture, COLMAP,3DF Zephyr etc.

(4) Using AI to analyse facial reactions and expressions to existing memory and then recreate related memories.

Once the patient's memories are recreated in the metaverse we analyse the reaction of the patient corresponding to the memory being displayed. We use Artificial intelligence to analyse facial expressions, pupil dilation and surrounding sounds to understand the type of memory being shown in the metaverse.

AI can be used to recognize facial expressions by training machine learning models on large datasets of labelled facial expression images. There are several different approaches that can be used, but one popular method is to use deep learning models such as convolutional neural networks (CNNs) or recurrent neural networks (RNNs).[6]

To train a Convoluted Neural Network for facial expression recognition, the initial step is to gather a large dataset of facial expression images with labelled emotions. This could be done by collecting images from several sources or by using datasets such as CK+ or FER2013 that are available to the public.

Next, the images are preprocessed and fed into the CNN(Computer Neural Network) for training. The CNN will learn to recognize patterns in the images that correspond to different facial expressions. CNN will also learn to generalise these patterns to new, unseen images.

Once the CNN is trained, it is then used to recognize facial expressions in real-time. This is typically done by capturing a video feed from a camera and processing each frame to detect and classify facial expressions. The CNN will output a probability distribution over the different emotions, and the highly obvious emotion can be selected as the recognized facial expression.

Later, the memory is segregated based on the facial expressions and reactions that a patient has to a particular memory. Facial expressions to important memories will be deeply analysed, stored and highlighted.

(5) AI assistant

AI assistants can be useful to Alzheimer's patients with VR glasses and AR by providing them with personalised and interactive experiences that can help improve their cognitive and emotional well-being. VR glasses can be used to create immersive and engaging environments that stimulate the senses and promote memory recall, while AR (Augmented Reality) can overlay digital information and graphics onto the real world to enhance the user's perception and understanding of their surroundings.

For example, an AI assistant could use VR to recreate a patient's childhood home or a familiar location and help them recall it by providing visual cues and allowing them to explore it in a safe and controlled environment. The AI could use sensors and cameras to monitor the patient's movements and reactions and adjust the experience accordingly to provide a more personalised and engaging experience.

Utilizing advanced facial detection algorithms, the intelligent AI assistant aids individuals with Alzheimer's in recognizing familiar faces. Additionally, the assistant leverages previously recorded conversations to provide context and enhance the patient's comprehension of the situation. By examining facial characteristics and cross-checking them against an extensive database of recorded conversations, the assistant can quickly identify individuals and provide the patient with pertinent information, such as their name, relation to the patient, and essential details about prior conversations and shared experiences.

Similarly, AR can be used to provide visual cues and reminders to help patients with daily tasks such as taking medication or completing routines. The AI assistant could use natural language processing to understand the patient's needs and provide relevant information or assistance in real time.

Overall, AI assistants combined with VR and AR have the potential to significantly enhance the lifestyle of Alzheimer's patients by providing them with personalised and engaging experiences that promote memory recollection, enhance cognitive function, and increase social engagement. However, it is important to note that these technologies are still in development and their effectiveness and potential are not yet fully understood. It is crucial to carefully consider the ethical implications and potential that come with their use.

V. FUTURE SCOPE

As wearable glasses are always in use, they must be ergonomically designed. The glasses must be engineered in a manner that provides comfort while performing everyday tasks. It should also support different focal areas of the patient's vision without having them use their primary pair of spectacles. Ergonomically designed wearable glasses should help in reducing eye strain and enhancing the vision of the patients to enjoy and relive their memories in a stress-free environment.

The glasses can be customized based on the needs of the patients and their caretakers to give a more personalised feel and better user experience. The features being added to satisfy the different requirements are kept optional to reduce the bulkiness of the glasses. The following are examples of the additional features. The GPS tracking system can be implemented to immediately track the patient’s location in a lost situation. An alert message is sent to the emergency contacts if the patient leaves a specified boundary location. The gas detection system alerts emergency contacts immediately when a gas leak is detected in the house.

Data is fed into a machine-learning model to improve its accuracy. With a larger dataset, the model makes better predictions to analyse facial expressions, pupil dilation and surrounding sounds thereby responding to the patient's needs and providing relevant information or assistance at a much faster and more accurate rate.

Lastly, one out of fourteen people are affected with Alzheimer's disease at an age above sixty years. With the advancement in healthcare and increase in life expectancy, the need for such AR and VR products will create a larger demand in the near future. To make the products accessible to people of all financial brackets, the product must be made in the most economic manner possible. More research is needed to provide the best experience at a very affordable price.

VI. CONCLUSION

Alzheimer's disease is a complex and terrible disease that affects the person and their loved ones. Even with medical advancements, a cure has not been found till date. VR provides an escape from the enclosed controlled environment provided by the special hospitals and care centres for Alzheimer's patients. Researchers at the University of Cambridge have also proposed that VR is being used to detect Alzheimer's disease in the starting stages using a VR navigation test. The patient has to successfully complete tasks in a simulated environment. This tests the patient's internal navigation system [12]. Another research shows that VR further reduces pain, depression and puts the patients at ease for a temporary period of time and they relive their memories to increase their social interactions [13]. Thus, VR is used for better mental health in aged care. The patient's heart rate, blood pressure levels, their walk, talking style, sleep pattern, breath, etc can be monitored and analysed using AI. Why stop here? Lets implement AR and VR forming a metaverse for the benefit of Alzheimer's patients. To help them regain memory, at least temporarily. The use of technology might help them live in a world they feel afraid or alone with their memory slowly fading in a slightly more comfortable manner.

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