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Research Article

IoT-Based Healthcare Support System for Alzheimer's Patients

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In the last decade, the Internet of Things (IoT) has become a new technology that aims to facilitate life and help people in all aspects of their lives. This technology is used for smart homes, smart grid stations, smart agriculture, health systems, transport services, smart cities, etc. The number of sensors and IoT devices along with applications is used for monitoring the health condition of patients. These devices will monitor the movement of targeted patients at home or out of their homes. Based on their behavior and movement, the treatment will be provided to Alzheimer's patients. The data will be collected from multiple sensors installed at patient's homes and smartwatches for checking their blood pressure level and temperature, which is too important in the current Corona Virus Disease (COVID-19) pandemic for these types of patients. On the other hand, due to the diminishing mobility of people around the world, increasing environmental pollution and stress which is caused by modern machine life and various brain and neurological diseases including Alzheimer's, Parkinson, etc. are widespread among people all over the world. The different types of communication protocols such as Message Queue Telemetry Transport (MQTT) and WebSocket (with authentication and autoclosing of connection) for sensors and the smartwatch have been used. The secure backend admin panel is used for tracing the location of doctors, patients, and ambulance. These protocols are implemented with security to protect the privacy of patients also.

1. Introduction

IoT technology has a huge impact on human life in all aspects like medicine, health, industry, transportation, education, and agriculture from the last decade. This technology uses sensors or actuators to understand the state of the surrounding environment. Most of them connected via these communication technologies such as WiFi and Global System for Mobile (GSM) to communicate with control centers and send data collected from the environment and to help for making decisions at remote control centers. Smart homes [1] are currently being developed with great acceptance by people around the world.

In this paper, the focus is on patients of Alzheimer's disease, which is the most common neurological disorder in the last decade. It is a type of dementia that occurs for most elderly people. In this type of illness, a person becomes oblivious as he/she is not able to perform his/her daily tasks independently and needs to have a person in the family always care for their behaviors and health. Therefore, for families with Alzheimer's patients, the cost of hiring a nurse or continuing care of this patient is high. However, it is expected that we will be able to remotely monitor the behaviors and health status of these patients using the facilities that the Internet of Things can provide, as to decrease the extra expenses and timely response to these patients. The IoT can play a vital role in this current COVID-19 pandemic situation. Different types of smartwatches, sensors, and actuators are installed at the home of these patients. These IoT devices are used to collect the data regarding their temperature, medicine intake timings, and movement. The different types of sensors and actuators have been used for their secure data transfer that the existing protocols have been used. These protocols have been used under the umbrella of Web of Things (WoT) like MQTT, WebSocket, and HTTP. The data collected from these IoT devices have been secured during communication and as it is stored at the cloud servers. Several methods have been performed for monitoring the health conditions of patients. One of them is neural networks and Bayesian [2] for monitoring the skin in real-time with the help of IoT.

The research is organized in five sections. In the second part, we will review the background of researches which is done related to the use of the Internet of Things in the care of neurological patients, especially Alzheimer's patients. Section 3 briefly examines Alzheimer's disease medically and explains the symptoms, the causes of this disease, and the care needed for these patients. In the fourth section, we will introduce the Internet of Things technology and discuss the user of its facilities to help Alzheimer's patients who are living in smart homes. Finally, in Section 5, we will present the conclusions.

2. Related Words

The authors [3] have surveyed different types of sensors based on their potential benefits for the healthcare system. They have listed known sensors for observing physiology, health condition, intellectual, and full of feeling parts of individuals. Alzheimer's disease is named for the first time with the name of a doctor who first described it (Alzheimer) [4]. There are numerous researches which are done on Alzheimer's disease. However, in this part, we will discuss a few of these researches. The authors [5, 6] have primary scientific categorization; to be specific, the scientific classification of related work on the IoT of real-time monitoring health condition in telemedicine applications was introduced and considers the identification with the IoT issues that were examined and talked about in customer and server sides. The security impediment in portraying or understanding the components of real-time health systems observed prompted the examination of an extrascientific categorization layer and improved the security level.

Dieckmann and colleagues [7] investigated the tool that is used for Alzheimer's disease knowledge test (ADKT). The metrics used for these tests ADKT by these researchers showed that five important metrics for measuring the outcomes of caring of Alzheimer's patients have been proposed by different researchers: [8] ADKT, UAB-ADKT for health professionals [9], DQ [10], KAML-C [11, 12], and ADKS.

Karlin and Dalley [13] conducted a study on the relationship between people's concerns about dementia and Alzheimer's disease, the likelihood of doing tests and screenings, and applying methods to detect changes in cognitive status or patient performance, to detect the disease early. They made a descriptive study using data from Porter Novelli's SummerStyles 2013 online survey. They used chi squares with case-level weighting used for analyzing data of the 6,105 people over the age of 18 who were surveyed; 4033 (66% of all of these people who are selected) responded to the surveys.

The results of this study showed that 13% of survey respondents were very concerned about Alzheimer's disease. Women were more concerned about the disease than men. Those who looked after Alzheimer's patients were more concerned about the disease than others. Women were also more welcomed than men by tests to assess their probability of Alzheimer's. The information gained from screening can be useful in developing communication strategies to address public concerns about Alzheimer's disease and increase the likelihood of early detection of the disease.

Brian researched the detection of Alzheimer's disease [14]. The results of this study showed that the biggest challenge in this area is the lack of knowledge needed for the early diagnosis of this disease, not the mistake of diagnosis.

Jagadeeswari and colleagues [15] attempted to provide preliminary evidence for the acceptance, validation of new knowledge of the Alzheimer's Disease Knowledge Scale (ADKS), content updating, and psychometric testing to test knowledge of Alzheimer's disease of doctors and nurses. They used traditional scale development methods to create items and evaluate the psychometric properties of various types of collected samples. Finally, 30 items were selected for use in the diagnosis of the disease, which can be completed in just 5 to 10 minutes by the survey participants, and the results of their analysis can be used to diagnose, evaluate, and understand symptoms, course of the disease, its impact on the patient's life, the care and treatment, and the management of all stages of diagnosis until treatment. Preliminary results show that the ADKS has high reliability (in test phase) and reliability (in content, predictability, etc.). Finally, the ADKS can be designed for use in research and practice and can be used to increase knowledge of Alzheimer's disease and to help patients and their caregivers and physicians.

Srimathi et al. [16] conducted studies on cloud computing, fog computing, big data analytics, IoT, and mobile-based applications and emerging technologies in the field of personalized medical care systems. The researchers looked at the challenges of better designing a healthcare system for the early detection of diseases and explored possible solutions for delivering health-related care electronically and safely. This study emphasizes the need for developing high quality and precision electronic healthcare systems.

Smyth and colleagues [17] proposed a new idea to modify the existing access control system to detect medical conditions associated with the brain and receive a timely response from physicians in the time of medical emergencies. The idea is to improve the quality of medical services available to people around the world. In the follow-up to the study, the researchers developed a simple device that could help physicians to find brain abnormalities as quickly as possible in humans. The device can also be highly effective in the care of these patients remotely using IoT technology.

Hoe and colleagues [18] discussed on the physicians' and clinicians' level of knowledge and information about Alzheimer's disease or ADKS of physicians and clinicians across Australia. These researchers asked from 360 doctors and therapists some questions about their level of knowledge of Alzheimer's disease and the history of the practical care that they provided to their Alzheimer's patients, by emailing these questions to them. Results from the responses provided by these 360 individuals indicated that most of them had moderate information on the factors influencing Alzheimer's disease, and only those who specialized in neuroscience or had practically encountered patients and those who attended the relevant workshops had relatively good information about this disease.

Yao and colleagues [19] conducted a study on the prevalence of Alzheimer's disease in the United Kingdom (UK). This study highlights the UK's top priority for tackling Alzheimer's disease, which is expected to become a major challenge for the world in 2020. There are more than 800,000 people in the UK with this disease. Since the disease has a huge impact on the lives of affected people and their families and need costs of £26 billion in a year to care for these patients in the UK and there is no cure for the definitive treatment of the disease, by 2050, nearly two million people in the UK are expected to have Alzheimer's disease. The main goals of this research are to develop and evaluate Maintenance Cognitive Stimulation Therapy (MCST) for Alzheimer's patients. A follow-up plan for the care of these patients Carer Supporter Program (CSP) was then proposed, and the effectiveness of this program was compared with the usual care provided to patients. Finally, a home treatment package (HTP) was developed for Alzheimer's patients, and the trial of this package was practically tested. The results showed that MCST can improve people's quality of life and reduce the cost of caring for sick people. Studies of CST implementation also show that many employees receive CST training over a one-day training period. This training course increases the capacity of medical staff to care for Alzheimer's patients. Management of care for Alzheimer's patients has also shown that it reduces long-term care for these patients and reduces their behavioral problems, creating an easy-to-use home user guide to help caregivers of these patients at home and also prevent hospitalization for dementia patients. Finally, the researchers point out that, due to the huge financial burden, they have not been able to fully put their proposed steps into practice.

Shaikh and colleagues [20] conducted a study to evaluate the knowledge, attitude, and approaches to care of Alzheimer's patients by Chinese medical professionals since China has the largest population in the world. A cross-sectional study was conducted on 450 randomly selected health professionals from Changsha, China. A questionnaire was sent to each of them for asking questions about their knowledge of Alzheimer's disease and their suggested ways to care for Alzheimer's patients and so on. 390 specialized out of a total of 450 selected one responded to this questionnaire, and the results of analyzing their responses showed that 87% of them had very poor knowledge of Alzheimer's disease and their knowledge was directly related to their experience of caring for Alzheimer's patients. Further, most of them were reluctant to provide practical care for Alzheimer's patients. Finally, in this study, the researchers suggested that a multilevel approach, including providing training courses for the community of health professionals and formulating policies and resources to meet the demands related to the delivery of Alzheimer's care services in China, is urgently necessary.

As in an early work, a lot of focus is on privacy and security issues of IoT related to healthcare systems. Instead, the solutions are also provided for the security of IoT devices and sensors from security breaches and privacy issues regarding patient information. To fill this gap in this paper, secure communication between IoT devices, sensors, and IoT apps along with the security of that information is stored. This is implemented with the help of WoT security standards and unique identification number also created for each installed device a client-side.

3. Overview of Alzheimer's Disease

Alzheimer's disease (AD), in 60-70% of cases, leads to dementia. The word dementia refers to a set of symptoms that can include memory loss and difficulty in thinking, forgetting words and stuttering, or delaying speech when speaking.

From a scientific perspective, Alzheimer's is a chronic neurological disorder that usually starts slowly and worsens over time. The most common primary symptom of this disease is difficulty in remembering recent events (so-called short-term memory loss). Alzheimer's is a progressive disease that affects the brain. This means that over time, more parts of the brain are damaged. Currently, it affects about 6% of people who are in 65 years of age and older, and unfortunately, no definitive treatment has been offered so far [21].

In other words, Alzheimer's is a type of memory disorder which occurred by brain cell death. Therefore, dementia patients are unable to continue their normal social lives. The disease can be controlled if it is diagnosed at an early stage. Therefore, early detection of Alzheimer's is essential for the treatment of patients. Usually, people living with the patient can diagnose Alzheimer's due to changes that are happening in the patient's behaviors and cognitive impairment (loss of cognitive abilities). However, it is difficult to diagnose Alzheimer's in the early stages of the elderly people who are living alone [22]. The Journal of the American Medical Association has acknowledged that Alzheimer's is diagnosed only when the patient's memory and cognitive function are severely affected and impair the individual's ability to perform daily tasks.

Alzheimer's patients often do the same task repeatedly, make the same gesture, say the same words, or ask the same question over and over again [23]. Repetition of previous actions and words in Alzheimer's is common due to memory loss and general behavioral changes. One may repeat daily tasks such as shaving or may be tempted to move home appliances [24]. Alzheimer's patients often see changes in their sleep patterns. For example, 20 minutes of sleep per day may increase to several hours in a day [25].

Due to the gradual loss of memory, one of the biggest threats to those suffering from Alzheimer's disease is being confused about what to do. The most common symptoms of Alzheimer's disease include increased daytime sleepiness, nocturnal confusion, confusion, and anxiety. All of these behavioral abnormalities caused by Alzheimer's disease are called "Sunset".

More recently, in 2019, a comprehensive study of Alzheimer's disease has been conducted in the United States for finding the most common cause of dementia [26], with details on how to diagnose the disease, the prevalence of the disease, its mortality rates, and how to present it. Primary care for patients, the cost of maintaining these patients, and how to provide long-term care to patients at home and in the hospital are discussed in this research.

Alzheimer's disease is a type of brain disease. It is also a degenerative disease which means it worsens over time. Alzheimer's disease is thought to become hidden for 20 years or more, and the patient cannot detect minor changes in the patient's behavior. Over the years, people have noticed symptoms such as memory loss and speech problems. The cause of these symptoms is that nerve cells are damaged or destroyed in areas of the brain that are involved in thinking, learning, and memory (cognitive function). In the advanced stages of the disease, one loses the ability to perform daily activities and is said to be suffering from dementia or Alzheimer's disease. The brain of a healthy adult has about 100 billion neurons, each with long and branching branches. These branches enable individual neurons to communicate with other neurons. Such connections are called synapses. The brain has about 100 trillion synapses. They allow signals to move quickly in the neural circuits of the brain, which is related to emotional and emotional messages, memories, thoughts, movements, and skills. Beta-amyloid protein fragment accumulation (also known as beta-amyloid plaque) outside the neurons and accumulation of abnormal tau protein (called tau tangles) in the neurons are two of the changes caused by Alzheimer's disease. Beta-amyloid plaques may interfere with the neuronal communication of neurons in synapses, leading to cell death, while the tau tangles block the transport of nutrients and other essential molecules into the neurons. By increasing the amount of beta-amyloid, we reach a stage where tau is abnormally distributed throughout the brain [27].

3.1. Symptoms of Alzheimer's Disease. The main symptoms of Alzheimer's disease include the following [27]:

(i) Loss of memory that disrupts human daily life

(ii) Occurring problems in planning or solving problems

(iii) Difficulties in doing chores at home and work

(iv) Confusion on choosing a time or place

(v) Difficulties in understanding visual images and spatial relations

(vi) Difficulties in using new words in conversation or writing

(vii) Missing objects and being unable to retrieve those objects

(viii) Decreasing decision-making power in work or social activities

(ix) Changes in the patient's mood and personality

3.2. How to Diagnose Alzheimer's Disease. It is also possible to diagnose Alzheimer's disease by a general practitioner. The steps to identify this disease by a general practitioner (GP) are as follows [27]:

(i) The doctor examines the patient's family and medical history (such as history of psychology and cognitive and behavioral changes)

(ii) In the next step, the physician will obtain information about his or her mood through a close relative of the patient

(iii) Next, the physician will perform cognitive tests, physical exams, or neurological tests

(iv) Then, the physician may request that the person be subjected to magnetic resonance imaging. Magnetic resonance imaging can help identify brain abnormalities such as the presence of a tumor or evidence of a stroke or brain attack

3.3. Important Factors in Alzheimer's Disease. The factors affecting Alzheimer's disease include the following:

(i) Family history: people with one of their parents, brothers, or sisters with Alzheimer's disease are at greater risk of developing the disease in comparison to people with no prior history of relatives [28]. Even people who have more than one member of their first-degree family have been at increased risk of developing the disease [29]. When the disease develops in the family, it can be due to genetic, environmental or lifestyle factors, or a combination of them. Alzheimer's disease may be one of the hereditary causes of the inheritance of the $\varepsilon 4$ Apolipoprotein E (APOE) gene

(ii) APOE $\varepsilon 4$ gene: this gene provides a blueprint for a protein that carries cholesterol into the bloodstream. Each individual inherits a form of the APOE gene—$\varepsilon 2$, $\varepsilon 3$, or $\varepsilon 4$ from each parent. The $\varepsilon 3$ form the most common gene transmitted between individuals of a family [30], which inherits approximately 60% of the US population $\varepsilon 3$ from both parents [31]. The forms of $\varepsilon 2$ and $\varepsilon 4$ are much less common. It is believed that having $\varepsilon 3$ form does not increase or decrease the risk of AD, while having $\varepsilon 2$ may reduce the risk of Alzheimer's disease. However, the $\varepsilon 4$ form increases the risk of AD at a young age. Those who inherit the two $\varepsilon 4$ genes have a much higher risk of developing Alzheimer's disease. Researchers estimate that between 40 and 65 percent of people with AD have one or two copies of the APOE $\varepsilon 4$ gene [32–34]. However, the inheritance of the APOE $\varepsilon 4$ gene does not guarantee that a person will have AD. It is believed that many non-genetic factors are involved in the development of AD

(iii) MCI (Mild Cognitive Impairment): this is a condition in which a person has mild but observable changes in his or her intellectual abilities that are understood by the affected person and their family members and friends, but it does not affect the person's ability to perform daily activities. People with MCI who have memory problems are more likely to develop Alzheimer's disease than those without MCI [35, 36]. However, MCI does not always lead to dementia and may be due to the use of a particular drug and can be resolved after a short time

(iv) Cardiovascular disease risk factors: much evidence suggests that brain health is closely linked to overall cardiovascular health [27]. The brain is nourished by one of the largest networks of blood vessels in the body. A healthy heart helps to get enough blood through the blood vessels to the brain, and healthy blood vessels ensure that the brain receives oxygenated and nutrient-rich blood for its normal function. Many factors (such as smoking [37, 38], obesity (especially in middle age) [39, 40], diabetes [41, 42], high cholesterol in adolescence [42], and hypertension in adolescence [43, 44]) can increase the risk of AD. Also, new evidence suggests that having a proper diet, such as a diet with a vegetable meal and vegetable oil use, may reduce AD and the risk of dementia

(v) Education: uneducated or illiterate people are at a higher risk of developing Alzheimer's and dementia compared to those with higher education [45–47]. Some researchers believe that when a person is educated for many years, a cognitive reserve is created in his/her brain that enables him/her to largely neutralize the changes that lead to Alzheimer's disease [48–50]. According to cognitive storage, having years of training enhances the communication between neurons in the brain and enables the brain to compensate very early brain changes that are happening due to Alzheimer's by using alternate pathways to complete a cognitive task

(vi) Social and cognitive engagement: many studies have shown that having social interactions can reduce Alzheimer's disease [51, 52]. Being socially and cognitively active may help to create a cognitive reserve, but the precise mechanism of this fact is unknown. Fewer studies have been conducted on the relationship between social and cognitive interactions and the likelihood of AD and dementia, and more research currently is necessary to be done to fully understand how social and cognitive interactions with biological processes reduce the risk of Alzheimer's disease

(vii) Traumatic brain injury (TBI): moderate or severe brain injury can increase the risk of Alzheimer's disease [53]. TBI is a disorder of the normal functioning of the brain caused by blows on head or skull injuries. Not all blows to the head cause impaired brain function. TBI is caused by a brain injury that results in loss of consciousness or forgetfulness for more than 30 minutes. If the loss of consciousness or posttraumatic forgetfulness lasts more than 24 hours, severe injury is considered. Half of all moderate or severe TBIs are caused by motor vehicle accidents [54]. Moderate TBI, on average, doubles the risk of AD, but if TBI is severe it can increase the risk of AD by 4.5 times [55]. Groups that suffer from repeated injuries, such as boxers, soccer players, and warriors, are at a higher risk of developing dementia, cognitive impairment, and neurological illnesses than others [56, 57]

3.4. Nursing Care for Alzheimer's Patients. In general, the care of Alzheimer's patients is classified into two types.

3.4.1. Pharmacological Treatment. Pharmacological treatments are treatments that prescribe medications to stop the disease or treat its symptoms. There is currently no drug that can stop the death and neuronal defects in the brain which are caused by Alzheimer's disease. Several drugs have been introduced to reduce or stop brain cell death, but only 5 of them have been approved by the US Food and Drug Administration. These drugs improve the symptoms of Alzheimer's by increasing the number of chemicals called neurotransmitters in the brain [58].

3.4.2. Nonpharmacological Treatment. Nonpharmacological therapies are methods in which some methods such as cognitive training and behavioral interventions are used to treat patients. The nonpharmacological treatment cannot reduce the amount of neuronal death and defect in the brain which is caused by Alzheimer's disease. In general, the goals of nontherapeutic approaches include the following:

(i) The goal of some of them is to compensate for abnormalities to maintain cognitive function or help the brain

(ii) The goal of some nonpharmacological approaches is to improve the quality of life of patients

(iii) Other goals of nontherapeutic approaches include reducing behavioral symptoms such as depression, anorexia, wandering, sleep disorders, anxiety, and aggression

Previous studies have shown that few nonpharmacological therapy methods may improve or stabilize cognitive function, daily activities, behavior, mood, and quality of life of Alzheimer's patients [59].

4. IoT Technology

The Internet of Things (IoT) provides how intelligent objects can be interconnected in computing environments everywhere [60]. Internet infrastructure as a global platform plays an important role in the formation of the Internet of Things and enabling it to communicate between physical objects. Innovations in the IoT are accomplished by incorporating sensors into the objects that make them intelligent and allowing physical infrastructures to be integrated around the world and able to connect using communication technologies.

The overall architecture of the Internet of Things is illustrated in Figure 1.

The term "Internet of Things" refers to an Internet-based architecture that facilitates the exchange of services, information, and data between billions of predominantly intelligent objects. The idea of the Internet of Things was first proposed by Kevin Ashton in 1998 and has been the focus of many universities and industries in the short term [61].

In some literature and research, the Internet of Things by the name of the Internet which has been mentioned everywhere and at all times provides a link between all of these objects to facilitate and make life easier for people in all situations.

From Figure 1, we can see that hardware and software solutions work together to create an Internet of Things object. The Internet of Things must be able to communicate between billions or trillions of nonhomogenous devices over the Internet, so there is a critical need to create a layered architecture for flexible Internet of Things.

The IoT domain covers a wide range of standard or nonstandard technologies, software platforms, and applications. Therefore, a reference architecture alone cannot be used as a blueprint for all possible implementations. In Figure 1, we define the architecture of the Internet of Things as a framework in which objects, people, and cloud services interact to facilitate the delivery of functional tasks. Therefore, Figure 1 can be considered as a reference model for IoT [60].

According to the Institute of Electrical and Electronics Engineers (IEEE) definitions and standards, an IoT system is a network of networks that typically connect a large number of objects/sensors/devices through information communications and infrastructures to process value-added services and services through processing. Smart to provide data and various application managements.

IoT is a computational concept that envisions a future in which physical objects will be connected to the Internet and able to identify themselves to other devices. It was first introduced with RFID technology as a communication method, and subsequently, sensor technologies and other wireless technologies were added to ICT.

According to the Internet of Things European Research Cluster (IERC) definition, the Internet of Things is a dynamic global network infrastructure with capabilities for self-regulation based on collaboration standards and communication protocols, as physical and virtual objects and physical properties and virtual characters can be identified and utilized intelligent interfaces and integrated seamlessly into information networks [62].

IoT technology has been developed in the last decade. By using different sensors, we can understand the environment and communicate with different objects in remote environments with the help of one of the communication technologies (such as WiFi and GSM). In the case of Alzheimer's patients, by installing sensors in various locations of the smart home, we can fully monitor the movements and activities of these patients indoors. We can also monitor the movement of these patients anywhere outside the home by installing sensors on the clothing or body of patients.

By analyzing the data collected by these sensors, which are sent to embedded control centers through one of the communication technologies (such as WiFi), we will be able to extract useful information and this information can be used by physicians and health professional to be effective in making appropriate decisions in the care or treatment of these patients [63].

4.1. Application of Internet of Things in Medicine. Some of the applications of IoT technology in the field of healthcare include tracking objects, staff, and patients; identifying and authenticating individuals; and collecting data of patients' physical health automatically [64].

Remote patient status monitoring systems are used by physicians and medical staff to control blood pressure, temperature, heart rate, respiratory rate, etc. It has been the focus of many medical centers in recent years. Other uses of the Internet of Things in the health and medical world include identification and authentication including unique patient identification to reduce sudden and harmful events for that patient, comprehensive electronic medical record-keeping, identification of neonatal vital signs, and identifying them in hospitals to prevent them from coordinating their delivery to their parents.

Automated data collection and transfer are mainly used to reduce form processing time, automation, automated care, rapid audit, and inventory management in medical centers. The sensors are capable of focusing on patients, in particular detecting the condition of the patient, providing real-time information to the patient and their companions to improve patients' health indicators. Other applications include telemedicine, monitoring compliance of patients' prescriptions with their current conditions, and alerting patients when critical health status and vital signs are present.

It is noteworthy that the Internet of Things (IoT) uses communication technologies (such as RFID, NFC, WSN, Wi-Fi, and Bluetooth) to communicate between different objects in the medical world. To continuously monitor patients' vital functions (such as body temperature, blood pressure, heart rate, cholesterol levels, and blood sugar), sensors send data to doctors or physicians from long distance.

The dependence on using IoT to provide health and medical care to patients is increasing day by day. This is due to the low cost of patient care and the high quality of services that are provided by IoT [64]. Based on the unique biological, behavioral, social, and cultural characteristics of each patient, the integrated function of providing comfort and well-being healthcare and protecting each patient from a critical situation is defined as personal healthcare. Such care allows physicians and nurses to follow the principle of primary care, "delivering the right care for the right person at the right time," resulting in better outcomes and higher satisfaction for patients and their families. In other words, in this way, the provision of health and medical care at a much lower cost is provided and the primary pathological diagnosis is made by providing preventive services to worsen the patient's condition.

An appropriate service refers to the prevention, early detection of disease and primary pathology, and home care

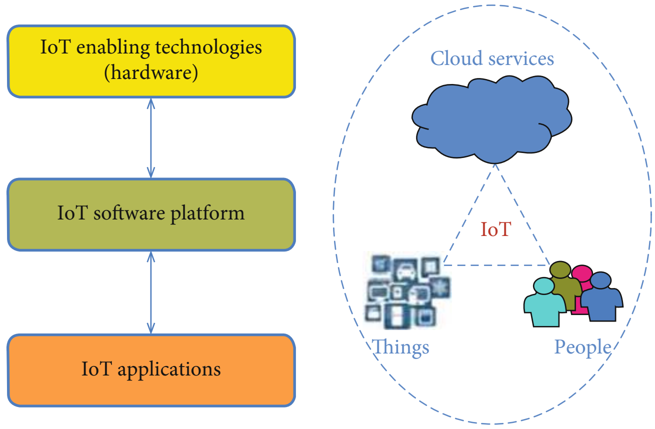

Figure 1: Architecture of the Internet of Things architecture [60].

rather than hospitalization and very expensive care in the clinic by checking patients' status to ensure their total health status. It is expected that using the Internet of Things (IoT) will be able to manage personalized care services and create a digital ID for each person. Various tools are used in health centers, they can communicate with each other and provide system-to-system communication services in any location, and it will have a significant impact on early identification and easier treatment of patients. The classification of IoT-based personalized healthcare systems is summarized in two categories including clinical care and remote monitoring, which are briefly described below [65].

4.2. Clinical Care. IoT-based surveillance systems are used for hospitalized patients whose physiological status requires ongoing attention. These surveillance systems use sensors to collect patients' physiological information, which is analyzed using gateways and applications in cloud computing, and ultimately, the results are stored on the cloud server. This information is then transmitted wirelessly to professionals for analysis on a digital basis. It is unnecessary to control the vital signs of patients at regular intervals by a health professional using the Internet of Things. In other words, the Internet of Things creates an automatic, continuous flow of health information and vital signs for patients. Thus, the quality of medical care is enhanced through continuous attention, which reduces the cost of care and eliminates the need to permanently monitor the patient [64].

4.3. Remote Monitoring. Lack of easy access to effective health surveillance systems can lead to many risks to patients' health or some illnesses remain unknown for long periods which causes disease progression, which is currently one of the problems in the health field all around the world. Some small but powerful wireless devices that interconnect via IoT and monitor patients' health status are currently being developed as a viable solution to this problem. An example of a patient remote control system using the Internet of Things is shown in Figure 2.

As can be seen in Figure 2, patients' health data can be safely collected using these solutions. Various types of sophisticated sensors and algorithms are used to analyze data and then to share data and results through wireless communications. Medical professionals can remotely provide patients the necessary recommendations to maintain their health.

4.4. Health and Treatment Networks in the Internet of Things. The IoT Health Network or the IoT Network for Health and treatment (abbreviated as IoThNet) is one of the essential elements of the IoT Health Internet. This network provides access to the IoT backbone and provides access to healthcare-related communications.

4.5. Application of Internet of Things to Improve the Quality of Life of Alzheimer's Patients. Three conditions can be attributed to Alzheimer's disease: wandering, dementia, and severe memory loss. Several types of research have been done by various researchers about IoT application in improving the life of Alzheimer's patients. In this section, we discuss some of these researches.

Ashfaq and colleagues [4] proposed a mobile-based system for Alzheimer's patients. They used the smartphone app to guide Alzheimer's patients and assist them in their daily activities. IoT technology can play a major role in helping Alzheimer's patients. This researcher developed a special Android application to help relatives and guide Alzheimer's patients. The program has various games and competitions to enhance the patient's brain functions and display progress reports. It also provides tips on where to place different objects and daily reminders of the food and medicine to Alzheimer's patients. It also utilizes GPS location capabilities to provide location care for Alzheimer's patients. IoT technology is used to measure patient status using wireless communication technology. The main purpose of the system is to create an environment for patient care at home and reduce the costs of patient healthcare.

Sindhu and colleagues [66] provided information to family members conducting Alzheimer's care in homes that are equipped with smart home automation. They were offered a solution to take care of their patients full-time. People who care for Alzheimer's patients in nursing homes can also use this system. The results of the proposed solutions by the

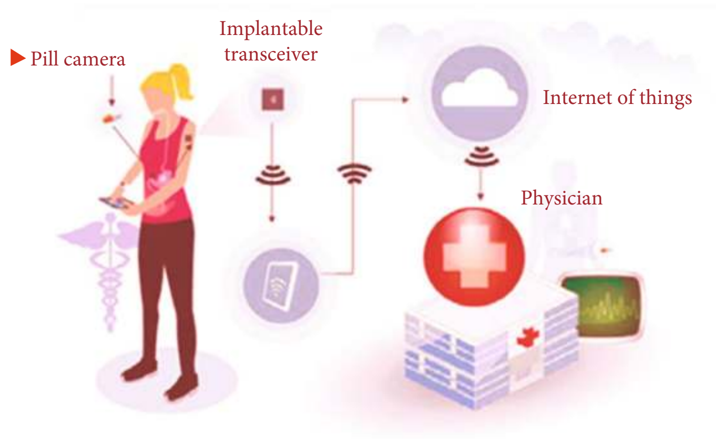

FIGURE 2: Telecommunications of patient care system using IoT [64].

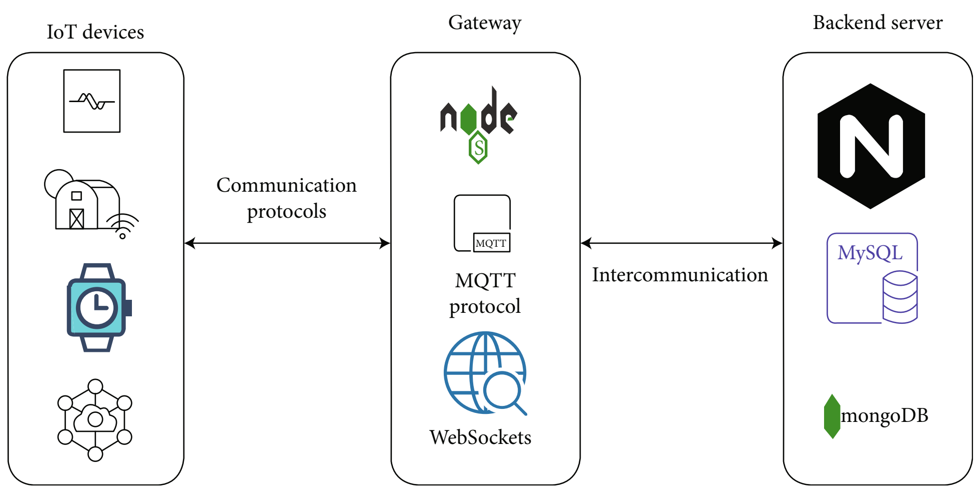

FIGURE 3: Proposed system diagram for improving Alzheimer patients.

researchers showed that, by applying the proposed solutions, the patients' quality of life has been improved.

Haruka and colleagues [67] proposed a low-cost GPS tracking system for Alzheimer's patients that could track and locate these patients in real-time. The main focus of this study is one of the uses of health monitoring technology by caregivers of Alzheimer's patients. According to reports released by this research group, some dementia symptoms are unfortunately often seen by doctors and patients' families as signs of aging, so care does not start on time. It is also reported that the number of Alzheimer's patients in India in 2010 was approximately 3.7 million, which is expected to increase to 6 million by 2040. Therefore, it is necessary to adopt methods for accurate identification of these patients in the early stages of the disease.

Haruka and colleagues [68] have introduced a system using the machine-to-machine (M2M)/IoT platform to help Alzheimer's patients who are living alone. For this purpose, the researchers installed sensors in the patients' homes that can detect early signs of behavior change and mental disorder and dementia. Data from these sensors are also used to analyze the behaviors of Alzheimer's patients. Also, a questionnaire was developed and distributed among these patients. The results of these questionnaires were used as data for their characteristics. Then, analyzing this data and comparing it with the data collected by the sensors can determine the presence or absence of dementia.

Enshaeifar and colleagues [69] developed a localized product for controlling the activities of Alzheimer's patients using real-time image processing that is capable of monitoring patient activities and managing emergencies. The purpose of this product is to help patients to maintain their independence while reducing the demand for the physical presence of physicians and health professionals to check their health status. In this study, a safety assistant was called the Path Tracking and Fall Detection System (PTFaD) wandering tracking system, a smartphone-based system that can monitor patients in and out of the home and make alert notifications in emergency time to medical services. To effectively detect Alzheimer's patients, PTFaD uses a smartphone camera to take pictures of the patient while s/he is moving. The photos will be delivered to the cloud computing system along with the time they were taken and the GPS location information. If needed, doctors or carers can use that data to quickly

```
let server = net.createServer(function (connection) {
  console.log('Client connected');
  connection.on('data', function (data) {
    cdata = data.toString();
    parts = cdata.split(";");
    imei_number = parts[1];
    dbConnecct();
    if (!empty(imei_number)) {
      if (checkDeviceRegistered(imei_number)) { // Checking the device already registered in DB
      // True
      //Do something if device already registered
      logDeviceConnection(imei_number); // Save the request in the file
    } else {
      // False
      //If device is not registerd this code will execite
      registerDevice(imei_number); // Registering/storing device information in System/DB
      logNewDevice(imei_number); // Save the new device connection is file
      notifySystemAdmin(imei_number); // Notifying sytem admin about device connection
    }
      connection.write("Device connection establised");
    } else {
      connection.write("Device did not recognised");
    }
  });
    connection.on('end', function () {
      console.log('Client disconnected');
    });
});
server.timeout =0;
server.listen(port, function () {
  console.log('Server is now listening on ' + port);
});
server.on('error', function (err) { console.log(err);
});
function dbConnecct() {
  con.connect(function (err) {
    if (err) throw err;
  });
}
function checkDeviceRegistered(imei_number) {
  con.query("SELECT * FROM devices WHERE imei=" + imei_number, function (err, result, fields) {
    if (err) throw err;
    if (result) {
      return true;
    } else
      return false;
  });
}
function logDeviceConnection() {
}
function registerDevice() { // Registering/storing device information in System/DB
}
function logNewDevice() { // Save the new device connection is file
}
```

Algorithm 1: The WebSocket connection function

find a way to help the patient. The study also suggested a method for detecting the time when a patient falls; in that case, a message would be sent to the caregiver or physician, and if the response was not received within the specified timeframe from this caregiver or physician, then a message would be sent to the emergency departments in the city of the emergency health center of a hospital.

Enshaeifar and colleagues [69] investigated a technical design called Integrated Health Management Technology (TIHM). TIHM generates notifications about patients' health

```
<?php
$data = json_decode(file_get_contents("php://input"));
if (isset($data) && !empty($data)){
   deviceConnection($data);
}
echo json_encode(array('success' =>1, 'response' => 'Device connection establised'));
function deviceConnection($data)
{
   $imei = isset($data['imei']) ? $data['imei'] : "; // Getting the imei number from request
   if (!empty($imei)) {
      if ($this->checkDeviceRegistered($imei)) { // Checking the device already registered in DB
         // True
         //Do something if device already registered
         $this->logDeviceConnection($imei); // Save the request in the file
      } else { // False
         //If device is not registerd this code will execite
         $this->registerDevice($imei); // Registering/storing device information in System/DB
         $this->logNewDevice($imei); // Save the new device connection is file
         $this->notifySystemAdmin($imei); // Notifying sytem admin about device connection
         }
         echo json_encode(array('success' =>1, 'response' => 'Device connection establised'));
   } else {
      echo json_encode(array('status' =>0, 'response' => 'Device did not recognised'));
   }
}
function checkDeviceRegistered($imei)
{
   $res = $this->db->from('devices')->where(array('imei' => $imei))->get()->row(); // Checking/Fetching in DB
   if (!empty($res))
      return false;
   else
      return true;
}
function registerDevice($imei)
{
   $this->db->insert('devices', array('imei' => $imei)); // Adding/Inserting new entery to DB
}
```

Algorithm 2: HTTP RestAPI for device connection

using the Internet of Things, IoT devices and solutions and interoperable standards, a set of machine learning algorithms, and data analysis. This information is monitored continually by a team of physicians at the healthcare center who make appropriate decisions about how best to care for Alzheimer's patients, based on the data collected and the warnings generated. This research discusses the technical design of TIHM and explains why the combination of patient-centered design and human experience should be an integral part of technology design.

5. Proposed Research Methodology

The IoT instead of existing security challenges and privacy issues has played a vital role in a different area of daily life, such as transportation, smart homes, smart agriculture, smart grid stations, and healthcare systems. In this research paper, the proposed solution is for mentally ill persons. This system as shown in Figure 3 will help to monitor activities of these persons, health conditions, and movements and will be responded as quickly as possible in case of emergency by concerned hospitals.

In the above system, different types of devices are used like sensors, smart stickers on cloths of those peoples, smartwatches, smart cameras, and smartphone apps. As the heterogeneous devices are being used so that all have different ways of communication, some of them are using Message Queuing Telemetry Transport (MQTT), HyperText Transfer Protocol (HTTP), or WebSockets for fetching the required information. All the methods are developed in NodeJS for communication between these IoT devices. The smartwatches are used for the fetching of heartbeat blood pressure, temperature level, and diabetes level information into the proposed system. Based on the defined thrash hold for each mentioned disease, the alert will be generated to concerned persons against the patient's identification number and name.

The Nginx web server is used as a reverse proxy for the NodeJS program which communicates locally at the Ubuntu server for the security and protection of user privacy information. This web server is used for the public face domain

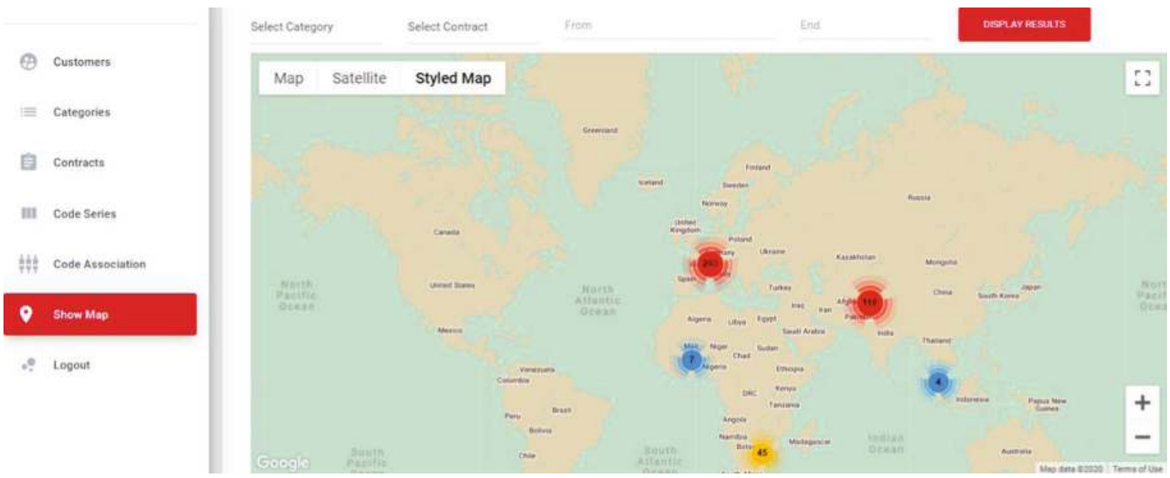

Figure 4: Live locations of Alzheimer patients.

also for the management dashboard and showing publically viewable information. The MySQL database server is used for storing the information of users for the data analysis regarding mental issues and disease records for future use. For real-time data storage, mongoDB has been used and this server is hosted at a cloud.

5.1. Method for IoT Device Communication Protocols. As the various devices are in use for tracking and monitoring the healthcare of Alzheimer patients at the same time, these are supporting different types of communication protocols. To fulfill those requirements, the communication method for devices has been developed in NodeJS for the MQTT, HTTPS, and WebSockets protocols, as it is depicted in Algorithm 1.

This method will first look into the communication method or request type from devices. In that condition, the communication protocol will be selected from this method, which can be MQTT, HTTP, or WebSocket protocol for gathering the information from Alzheimer monitoring IoT devices that are connected with this network via WiFi or data network from respective country cellular network company. As in the above function, we have developed a method for the WebSocket connection with sensors or with other IoT devices. This method has been created for database connection and store required information into it. For the security of patient's information and to avoid fake devices, this method will look into the database also for the registration of these devices. It is providing the functionality of data analysis and activities of patients to the system administrators or concerned authorities for the development of more facilities for them. The same type of method is also developed for the MQTT protocol-supported device for communication.

In Algorithm 2, the RestAPI method is developed for the communication over HTTP-supported devices and smartphone apps. This function also creates a database connection and looks for registered devices and apps. This function mainly proposes it to provide the service of transportation to Alzheimer patients as they need it. And it will be used for the delivery of medical facilities to them at the doorstep, and they can be registered via this app with simple steps. These two methods are described here just for the proof of concept to our improved solution for these patients, and some information has not been shared here due to the privacy of users.

6. Results and Discussions

In this paper, the different types of sensors, smartwatches, actuators, and IoT applications are used for the monitoring movement of Alzheimer patients. The various types of IoT devices are used for the health monitoring of these patients for the accuracy of information regarding their health. Due to the COVID-19 pandemic, it is very hard to take care of Alzheimer patients because there is a need for social distance. The communication between these devices has been made secure by implementing existing IoT protocols under the umbrella of WoT. To overcome the unavailability of authentication in WebSocket, it is managed via programming for each device authentication token that has been stored in the database at a cloud. This is implemented for the security of a patient's privacy and data collected from these IoT devices. By following, these authors [70] recommended a method against device forging at the physical layer and security of data at transit or rest. Due to this system, it will be easy for the health department of any country to locate these patients or any other patients with different diseases. The better service can be provided via ambulant or doctor advise remotely. As already mentioned, security or privacy issues in their survey by authors [4] have been fixed in this research paper.

6.1. Tracking and Management Dashboard. The critical part of any application or Alzheimer patients is monitoring, as the activities are monitoring and stored in the database that can be used for analysis and develop a good treatment solution for these patients. At the same time, these improved services can be utilized for the old people at the doorstep with the help of IoT. By this, any government body for health services or any private company can get information regarding those patient's area which is affected by this disease, so that medical facilities can be provided in that location and more transportation in that area. The tracking of vehicles and

Figure 5: List of events processed.

Figure 6: Alert rules defined.

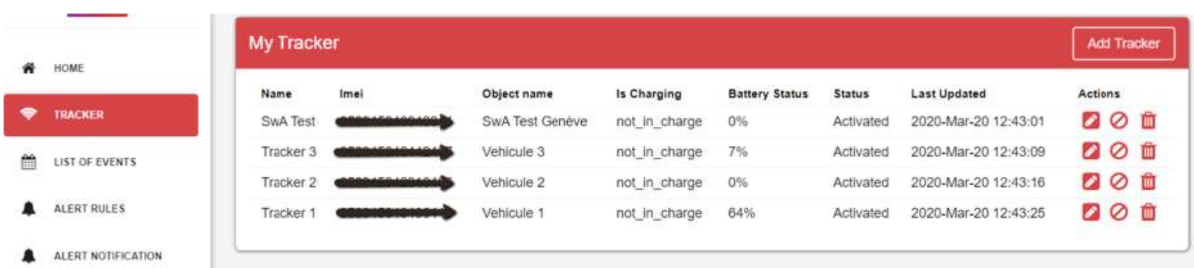

Figure 7: Status devices at patient's area.

locations of these patients is shown in Figure 4. These locations are dummy currently as per our testing of the developed application with the help of NodeJS and other tools.

The test of different events has been done on real Alzheimer patients as depicted in Figure 5. These events are related to the ambulance services to them in an emergency and also in normal routine for their medical checkup. These events are processed on the bases of alerts generated by those sensors or smartwatches. But we have not displayed those events here due to the privacy protection of patients suffering from this disease. The resulting ratio of this improved solution is 95% accurate in the shape of alerts generated by installed sensors, stickers on cloths, or smartwatches.

The list of alert rules has been designed which can be defined by the administrator. These rules are based on real issues faced by Alzheimer patients and categorized on that condition. Few rules are shown in Figure 6. These are categorized with added trackers as per respective area and medical service providers.

Another main section of this solution is the status of devices installed at the client-side. We have tried our best to get useful information as much as possible for the betterment of these patients and easiness for them. In this status section, the device name, IMEI number, charging status, battery status, and active or not are as shown in Figure 7.

7. Conclusions

One of the greatest human problems is the development of a variety of diseases, including Alzheimer's, in the old age of people all around the world. In the last decade, for unknown reasons, the number of people with this disease has been rising worldwide. Numerous studies have been conducted by researchers around the world, but the real reasons which cause the disease are still unknown. On the other hand, despite the pharmacological and nonpharmacological treatments which are suggested by physicians and researchers to help these patients, virtually none of those treatments can completely prevent the disease from progressing. Since caring for these patients is needed at all times (24 hours per day), it takes a lot of patience for the family and ultimately is economically costly. On the other hand, the Internet of Things (IoT) has rapidly received popularity throughout the world in the last decade. This technology can continuously monitor Alzheimer's patient's behaviors at home and abroad and inform the geographical location and occurrence of the accident and critical conditions to family members and healthcare personnel. In this paper, we have proposed a novel solution for tracking activities and monitoring the health condition of patients with the help of IoT devices. This devices' communication has been secured with the recommended standards for the MQTT, WebSocket, and HTTP for the IoT application. The data has been collected from different types of devices and sensors to get accurate information regarding the patient's health condition. To keep in view the security and privacy issues of data, it is secured during transit and at rest. With this solution, transportation and medical facilities can be provided to them. The state-of-the-art administration dashboard has been developed for monitoring, device status alert generation rules, and live tracking of patients and vehicles for them with the help of Google maps. Our proposed system has a 95% accuracy ratio for the emergency alerts and condition of patients regarding their blood pressure, heartbeat, or sugar level. This will help health departments of any country to provide health facilities rapidly and perfectly to their patients.

Data Availability

All are simulation.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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