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IoT Based System for Elders and People with Disabilities

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***Abstract*— The Internet of Things (IoT) has developed rapidly, with a large number of enabling technologies being proposed. This has opened new doors for everyone, particularly for disabled individuals and the elderly, who can greatly benefit from modern technology in their daily lives, ultimately improving their overall quality of life. Various IoT applications have been developed across several domains, tailored to address specific challenges faced by individuals, including health issues, mental health, physical disorders, and sensory impairments such as hearing, smell, and vision impairments, among others. In this paper, we aim to address the challenges faced by older and disabled individuals, identifying their needs and reviewing IoT systems that can assist them in living independently. Finally, we discuss the challenges that need to be considered for the IoT-based systems to make more reliable systems.**

***Index Terms*– IoT-based Applications, Impairments, Challenges, Reliable and Disabled.**

I. INTRODUCTION

THE word “IoT" was introduced by Kevin Ashton in 1999. The Internet of Things (IoT) refers to a network of interconnected devices that engage in communication and data exchange among themselves. IoT devices, such as wearables, are equipped with sensors to measure and collect data in specific fields. This is accomplished by utilizing sensors to measure signals such as electrocardiogram (ECG) readings, respiration rate, skin temperature, electromyogram (EMG) muscle activity, blood pressure, eye conditions, brain waves, among others [1].

The disability model has played a vital role in promoting disability politics, the rights of disabled people, and disability studies [4]. Disability is essentially a limitation in performing normal activities. According to the United Nations 2006 Convention on the Rights of Persons with Disabilities (CRPD), A person is regarded as disabled when they have mental or long-term physical impairments that impede their ability to participate effectively in society. [5]. Based on a World Health Organization report from 2011, [6] Approximately 15% of the world's population has some form of disability. This rise in disabilities is attributed to various factors, including aging and accidents. Older adults make up a fraction of 3-28% of the population in different countries. Most elderly individuals reach a point where they require assistance to live independently in their own homes.

They may struggle to use household appliances. ALS patients who suffer from paralysis [7] cannot move to control a heater or fan, Alzheimer's disease patients who may forget to turn off the gas in the kitchen, or people with hearing disabilities who cannot hear the doorbell. Many new technologies have been developed to improve the living environment of the elderly and individuals with disabilities, enabling them to live independently and perform their regular tasks more easily.

These technologies include unlocking doors, controlling lights, TVs, heaters, air conditioners, etc. The Internet of Things (IoT) has brought a lot of value to elderly and disabled individuals. In recent times, there has been notable progress in IoT-based applications, including smart homes, health care applications, smart farming, environmental monitoring, smart cities, and many others as presented in Fig. 1.

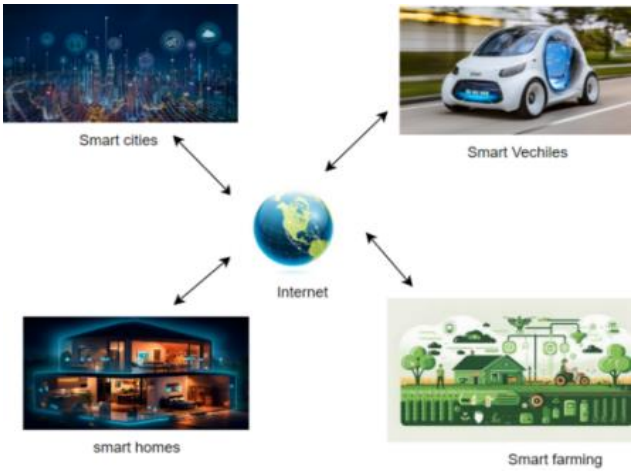

Fig. 1. Applications of IoT

The rest of the paper is structured in the following sections: Section II addresses the challenges faced by elderly and disabled individuals. In Section III, we describe smart living IoT solutions for individuals, while Section IV explores IoT systems. Section V discusses challenges, and Section VI concludes our work.

II. CHALLENGES

In the United States, roughly 29% of elderly individuals live alone and encounter various potential hazards and unique challenges [17]. Living alone comes with many challenges, such as the risk of falling, not having help during emergencies, accidental overdose of medications, injuries, and difficulty in identifying diseases early, among others, as seen in Fig. 2.

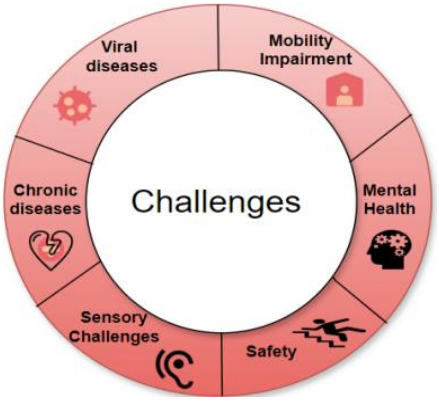

Fig. 2. Challenges for individuals

Elderly individuals often face more health issues compared to younger people due to weaknesses in their bodies. Health problems among adults are a major concern in many countries, with many elders suffering from at least one chronic disease, like diabetes, heart disease, or cancer. These diseases are often caused by poor diet, lack of exercise, smoking, and drinking. Cognitive challenges, such as memory loss, and mental health issues are also common among elderly and disabled individuals. These challenges can arise from chronic health conditions, new diseases, traumatic injuries, or side effects of medication. Mental health can impact physical health, as individuals with mental health issues may partake in unhealthy behaviors. Viral diseases like Ebola, Zika, and COVID-19 can impact the elderly more severely than younger people.

Sensory challenges are problems related to the senses, such as hearing, smell, vision, taste, and touch. People who have difficulty hearing or speaking may struggle to communicate over the phone or in person. Visually impaired individuals may find it challenging to perform tasks like reading labels or prescriptions. Mobility impairment is also a common challenge for many elderly and disabled individuals, often making it difficult for them to do everyday tasks at home. For example, a person with mobility issues may struggle to turn lights on and off, open and close curtains, or lock and unlock doors. Falls are a frequent concern for the elderly and disabled, often resulting in hip fractures and brain injuries.

While aging and disability present numerous challenges, the integration of IoT technology offers promising solutions to enhance the quality of life for elderly and disabled individuals. IoT devices can be deployed in homes to provide real-time monitoring of vital signs, medication adherence, and environmental safety. Smart sensors can detect falls and notify caregivers or emergency services, ensuring quick assistance in case of an accident. Moreover, telemedicine platforms empower elderly individuals to obtain medical care conveniently from their residences, diminishing the necessity for frequent hospital visits. By leveraging innovative tools and resources, we can establish a more inclusive and supportive society where everyone can flourish, irrespective of age or ability.

III. SMART SOLUTIONS

To enhance the lives of elders and disabled individuals, IoT-based devices can be utilized. These devices would be responsible for addressing all the essential needs of elderly and disabled individuals. The utilization of the Internet of Things (IoT) in the realm of health and medicine is considered one of the most significant and crucial applications due to its adaptability in medical contexts. Various sensor technologies are employed in portable devices like wristbands, watches, etc., which are interconnected via the web. The primary concern revolves around how information is exchanged among these portable devices through wireless networks. The reliability of these connections is sometimes impacted by the quality of the networks provided by web services. Third-party monitors oversee the health of the patient by analyzing vital signs transmitted by the sensors to the monitoring entities. These monitors employ various methods to analyze and draw conclusions, which can be beneficial for healthcare professionals [22]. The utilization of IoT in medical care is illustrated in Fig. 3.

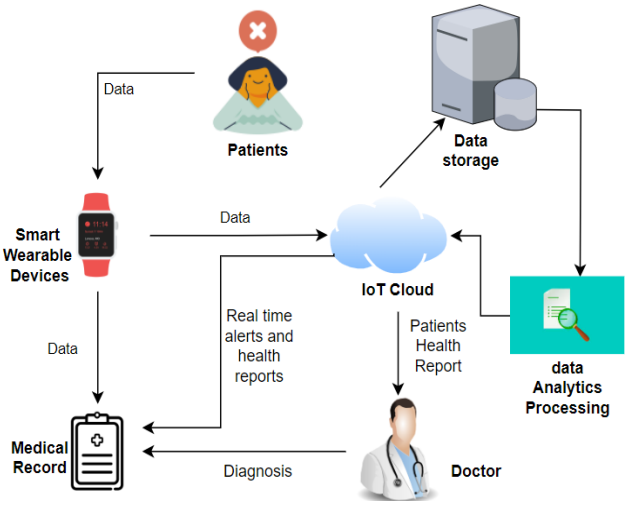

Fig. 3. Use of IoT in healthcare

Smart technologies are now making their way into nearby homes. While these technologies can still be costly, they are increasingly common in many houses today. Smart homes are equipped with special sensors for detecting light, smoke, movement, gas leaks, wind, rain, and heat. They also include surveillance cameras with infrared capabilities. See Fig. 4 for visual reference.

Fig. 4. Smart homes

Light sensors are connected to smart lighting switches, while smoke sensors are linked to fire sprinklers and a server connected to the internet. In the event of an alarm from any sensor, a notification is sent to the fire department. These technologies have proven effective in preventing danger and alerting users, ultimately saving lives and property. This principle has been extended to meet the needs of two important segments of society: disables and elders. This is especially crucial during disease outbreaks like the COVID-19 pandemic [24], which highlighted challenges in mobility and posed significant risks to vulnerable populations.

Recent studies in this area have focused on using medical gadgets to assess the body's vital functions, particularly using wearable and portable devices like smartwatches capable of measuring blood pressure and pulse rate. Additionally, there are more precise devices like ECG machines that provide more effective and accurate signals, as well as devices that track the patient's location and movement.

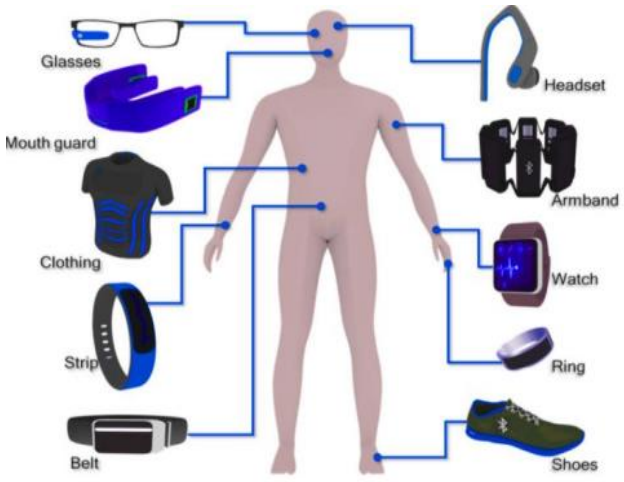

Fig. 5. Smart wearable devices [22]

In the early 21st century, wearable devices began offering personalized healthcare services. Later, these devices became available with advanced handheld sensors and detectors. These devices can be categorized into watches, glasses, wristbands, straps, hats, trousers, and jackets [23], as shown in Fig. 5. As wearable technology sizes have decreased, monitoring solutions integrated into our daily lives have improved, thanks to advancements in biosensing microelectronics and cellular networking technology [24].

IV. IoT SYSTEMS

As the population ages, older individuals often experience illness, which can limit both their health and their independence. They encounter various challenges in their daily lives. The utilization of IoT (Internet of Things) services can offer more affordable and scalable approaches for elders and people with disabilities. Table 1 summarizes the available IoT-based systems designed to support the elderly and those with impairments.

Hosseinzade and Ahmed introduced an IoT-enabled health monitoring system aimed at examining vital signs and identifying biological and behavioral changes in individuals. This system helps medical teams continuously monitor the activities and biological parameters of elderly and disabled people. In this method, essential data is gathered through IoT monitoring devices, followed by data analysis employing various machine learning algorithms like Naive Bayes, Decision Tree, Multi-Layer Perceptron, and Sequential Minimal Optimization to identify potential risks associated with behavioral and physiological changes in the elderly. Experimental findings reveal that J48 exhibits the best performance in predicting health status, achieving 99% precision and accuracy, 100% recall, and a 97% F-score in their context. [15].

Zulfiqur and Latif developed and presented a general architecture for a smart wheelchair. Biophysical sensors were integrated to collect patients' vital signs in real-world scenarios within ten seconds and wirelessly upload them to the cloud every forty minutes. A user interface was introduced to record, visualize, and analyze patient data for caretakers and doctors. The smart wheelchair will help patients drive autonomously within predefined area. Vital signs from patients can be collected and analyzed remotely. For further improvements, different biophysical sensors, including those for monitoring falls and postures, and further improvements of algorithms to allow better management of patients' chronic diseases are suggested [16].

Panda and Warma focused on a completely integrated system where the doctor can remotely connect with the patients, and the physician can access the patients. The system helps the physician attend to the patients remotely and administer lifesaving drugs during emergencies. The doctor can see the patient's ongoing vital parameters (ECG, Blood pressure), communicate with patients and their close relatives, observe body parts such as the eyes, throat, and so forth, and plan medication through the proposed drug delivery framework, which is designed to provide timely therapy and quickly assist patients in emergencies. This

device provides two-way communication through video calling and real-time chat. The specialist and patient can communicate with each other [14].

Sachdev and Tiwari presented a glove-based home automation system that understands gestures to control devices. Household devices can be controlled simply by gestures while wearing the gloves. A mobile application is also developed for the family to track the status and usage of devices. This system provides comfort to everyone, especially to disabled and elderly individuals. It also informs the caretaker about activities. This system fulfills the aim of helping individuals control household appliances and monitor their activities remotely. The proposed system accurately identifies and performs the tasks [21].

According to Prabakaran, smart devices can play a crucial role in assisting disabled and elderly individuals by ensuring adequate access. They introduced a smart door lock system controlled via a smartphone app, offering the owner real-time monitoring of door movements. Upon doorbell activation, the owner receives a notification on their phone, enabling them to use live video streaming to identify visitors and grant access via the smart lock app. This solution effectively addresses accessibility challenges faced by disabled and elderly individuals unable to physically reach the door. Additionally, they proposed integrating fire detection modules and other sensors to enhance security measures. In the event of a break-in attempt, the system activates buzzers to alert the owner. Moreover, a password-based system facilitates external door access. This project is cost-effective, easy to implement, and user-friendly, making it highly practical and beneficial. [12].

A smart IoT-based system tailored for elderly individuals and those with partial memory loss, such as dementia patients and MCI patients, to enhance their safety and provide early warnings for associated challenges. Data collection is facilitated through various ambient sensors, enabling the detection of activities, monitoring patient behavior, and supplying essential data to family members or caregivers. Activities are categorized into normal and abnormal, with normal activities remaining unrecorded. Evaluation of abnormal activities prompts various responses: non-life-threatening abnormalities trigger reminder messages for the patient, while dangerous situations prompt alerts to family members or caregivers. This communication is facilitated through the cloud-based PusingBox IoT application. Additionally, an emergency wristwatch is included to address hazardous scenarios like leaving water or gas open in the house or experiencing unexpected falls. The developed system stands as a cost-effective solution, boasting low energy consumption and easy implementation, thereby enhancing its practicality and versatility [2].

Godinho and António stated that as a society, we should provide support to elderly and disabled individuals. We must strive to make their lives comfortable and safe, as small things can sometimes create critical problems for them. For instance, a malfunctioning heating system can pose life-threatening risks, while undetected gas leaks can have fatal consequences if not promptly addressed. Their objective was to explore solutions aimed at averting accidents within these vulnerable populations. To this end, they introduced a safety device equipped with sensors designed to continuously monitor the living environments of elderly and disabled individuals. In case of any irregularities, the system promptly alerts caregivers, relatives, and relevant security authorities, ensuring swift responses to emergency situations. The primary goal of this system is to enhance safety and provide peace of mind to individuals. Through the implementation of such security measures, the safety of elderly and disabled individuals can be effectively ensured [9].

A smart home (SH) system has been specifically developed and deployed to cater to the needs of elderly and disabled individuals. This system integrates Radio Frequency Identification (RFID) tags, gas and moisture sensors, a motion detection Node MCU micro-controller with ESP8266 Wi-Fi module, and various actuators. Remote management and voice commands are facilitated through Google Assistant, If This Then That (IFTTT), and Blynk, accessible via a user-friendly Android-based mobile application. The versatility in controlling home components through different methods contributes to the comprehensiveness of this study. Additionally, the innovative design of barrier-free stairs enhances accessibility for disabled individuals. By addressing security, accessibility, and comfort requirements, this system significantly improves the quality of life for its users, enabling them to live independently [19].

Sankar and SM Udhaya explored the creation of a home automation system aimed at simplifying various operations. Their system is designed to streamline the lives of elderly and disabled individuals by offering control over household devices. Relays play a crucial role in the system's architecture, physically linking home appliances to the output port of the embedded controller board. To enable more natural interaction, the system employs digital assistants like MPU6050, allowing disabled individuals to command actions such as turning lights on and off with hand gestures. By connecting the digital assistant to electrical household appliances via a power strip or smart Arduino, users can control them effortlessly. Merely adjusting the position of the MPU6050 allows users to activate or deactivate appliances with hand movements. For future enhancements, the addition of a timer feature could further expand the system's functionality, enabling remote, automated, and manual management options. The application underwent evaluation with the participation of individuals with physical and vision impairments. [10].

Murugadhas and Al-Aamri developed the automation system for elders and handicapped people with a web-based application. The aim was to overcome the challenges faced by elderly and disabled individuals. System allows users to command devices without having to move to the nearest control point. Many household devices are automated. In their research, they focused on IoT, which connects home electrical gadgets [20].

Ahmad and Nawaf stated that eye tracking is crucial in many sectors as it facilitates daily activities, especially for disabled individuals where simple tasks like turning on and off a light require effort. To address this issue, they proposed a model that utilizes video oculography through Tobii

technology, with an added voice interface using Azure cloud to assist in controlling home appliances. Eye tracking helps users control home appliances [8].

Sankar and Udhaya presented a system that uses smart camera, smart plugs, smart power strips and a digital assistant such as Siri, Alexa, Cortana to capture a voice command of disabled peoples, to control appliances, to activate and deactivate them, with minimum interaction [10].

V. DISSCUSSION

In this segment, we delve into several prevailing challenges and concerns that necessitate resolution to unlock the complete potential of IoT services for the elderly and individuals with disabilities.

User Adoption: One of the primary issues is assure that end-users (elders and disabled peoples) are ready to use the present IoT technologies and systems. This is a complex task because mostly they do not have technical background and sometimes their mental and physical health is a hurdle. That's why it is necessary to developed use friendly system that does not require regular user input (Automate user tasks to the fullest extent possible). Describing the benefits of these technologies can greatly enhance their quality of life.

Data Protection: It is crucial to assure identification, authorization and control of data transfer between users/systems and IoT middleware. In IoT systems data integrity and confidentiality may be at risk. So, we need to make sure the data stays secure and hasn't been changed while it's being sent. Moreover, person privacy is a major concern because personal information of people like location, medical information and habits can be obtained without their knowledge and permission. It's really important to make sure that users feel okay about giving out sensitive data, while also making sure their privacy is protected.

Interoperability: The main aim of IoT services is to help elderly and people with disabilities in their daily tasks, keep them informed about their surroundings, and overall make their lives better. Nevertheless, this expertise typically remains confined to a singular application and within a single system. Integrating data across various IoT platforms, services, and domains poses significant challenges. For instance, if we could combine data from different apps, we could find connections between data and users (user related data), predict future events. Analyzing this data could help in planning city infrastructure or improve the lives of elderly and people with disabilities with positive impacts on their health. But right now, this is hard to achieve, due to the lack of interoperability between IoT services. One way to fix this problem is to standardize the description of resources and acquired data.

Cooperation between individuals and medical personnel: To maximize the benefits of IoT technologies, it would be beneficial to connect elderly and disabled individuals with medical personnel, social workers, and therapists through a developed IoT system. IoT services have the ability to build deeper connections between patients and caregivers, enabling patients to receive accurate treatment on time.

Live data management: Applications or systems for elders and people with disabilities need to be fast and always have the latest information to help users, it's important to make sure there's not much delay in processing data. Usually, applications demand continuous sensing and real-time analysis of data, and the distribution of information to end users. Filtering techniques deployed near the end-user can effectively minimize the volume of data transmitted over the network, resulting in shorter data propagation durations. However, it's not a good idea to do heavy data processing on mobile devices because they don't have enough power. Instead, it's better to do that kind of processing on servers or in the cloud, so the important information can be delivered quickly.

Service Facilitator: It is essential for IoT service facilitators to offer prompt assistance for elderly and disabled users of their applications, as these individuals frequently need continuous monitoring and immediate feedback. Statistical Analysis: Gaining a deeper understanding of the collected data can significantly enhance the quality of service provided to elders and disabled people. To do this, we can use data analysis functions to group together past data or do complex processing tasks, like looking at patterns or connections between different types of data.

VI. CONCLUSION

According to the WHO, billions of people have some sort of disability. Due to dependencies, they have been excluded from society. They financially and physically depend on others. The United Nations indicates that the world population of individuals aged over 80 was 125 million in 2015 and will grow to 202 million by 2030. Most of the elderly and disabled live alone and face many unique challenges. The evolution of technology, especially the Internet of Things (IoT), can help them overcome these challenges. The Internet of Things (IoT) is an idea that links devices together in a big network using the internet. This allows for the creation or development of smart environments that can change and adapt to different situations. These environments offer advanced services that suit the needs of users. IoT technology offers more independent living. In this paper, we discussed various IoT-based health care and smart home applications and systems that have been proposed to support elderly and disabled individuals. We also underscore the challenges that require consideration during the development of IoT systems for their use.

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