REVIEW OF IOT AND DEVELOPING HAND GESTURE RECOGNITION EASY DEVICE (HGRED) FOR DISABLED PEOPLE

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Abstract: Today, the rapid development of technology allows the widespread use of the Internet of Things (IoT) in everyday life. IoT can make human life easier, convenient, especially important for people with disabilities. This paper focuses on the review of IoT in various domains included for healthcare, smart cities, smart environment etc. IoT technology helps and contributes to disabled people to improve their living, helping them live a more automated and independent life. This study focuses on the problem faced by a regular individual to understand a disabled person's language. To overcome this problem, the glove prototype (Hand Gesture Recognition Easy Device) that can transform a person's nonverbal cues into words that the people around them can easily understand is created. Hand Gesture Recognition Easy Device to help disabled people, especially those who are paralyzed to understand their language and communicate with each other. Specifically, this purpose is to develop a smart glove which can sense the movement and send the signal from the push buttons to translate the language through the text. This can help the assistant know the wishes of the paralyzed person. It is hoped that the use of IoT Hand Gesture Recognition Easy Device can disabled people and improve their quality of life.

Keywords: Internet of Things (IoT), Hand Gesture Recognition Easy Device, RFID, push buttons, paralyzed person

1. INTRODUCTION

In this world, it is estimated that there are around ten billion people with disabilities such as blind, deaf or mute or unable to move their limbs. Among the challenging tasks is how to help them to communicate between disabled people and normal people. The concept of the Internet of Things (IoT) relates to Mark Weiser’s vision of devices interconnected operating under diminishing visibility [1]. However, Kevin Ashton in 1999, first introduced the term IoT through the development of a Radio Frequency Identification (RFID) chip system that can be used to track goods in the supply chain [2]. Next, the use of IoT continues to grow according to the development of technology and continues to grow rapidly until now. For example, after 2010 saw widespread adoption of IoT as the ratio of Internet-connected devices to people increased to 6.25 [3]. Meanwhile, in 2022, the number of IoT devices has reached around 40 billion connected devices, and their numbers are expected to rise to and exceed 70 billion by the end of 2022 [4]. The widespread adoption of IoT has not only contributed to new applications, but also to improvements in communication networks and architectures.

Figure 1 shows some of the IoT domains that have gained increased popularity in recent years. Within homes, the combination of smart connected objects and cloud-based services can enhance home security (through management through smart grid technologies, provide intelligent traffic management to autonomous vehicles and integrate security [5]. IoT can promote improved education and healthcare services. With the growing demand of healthcare needs, IoT devices can address this challenge by supporting a variety of e-health services that provide cost-effective healthcare access and allow remote monitoring of chronic diseases and health conditions within the patient’s home environment [6]. This can improve the quality of life for patients while reducing the costs for healthcare organisations. In the education sector, virtual classrooms and mobile applications can provide enhanced flexibility and allow the design of
solutions tailored to meet the learning abilities and needs of each student and improve their learning experiences. Mobile education models have already shown to promote learning outcomes and lower dropout rates [7]. For companies, sensor data combined with data analytics can improve productivity by refining the quality of decision making and incorporating value-added production techniques.

![Internet of Things (IoT) domains](image)

**Figure 1** Internet of Things (IoT) domains

## 2. RELATED WORKS

In this subsection, related works related to IoT are described. For ease of explanation, it is classified according to the IoT application domain. Among the domains involved are explain below [8-11]

### 2.1 Healthcare

A few years ago, hospitals became the place where patients got a diagnosis if there were any abnormalities in their body. This causes most patients to stay in the hospital for the duration of their treatment. This results in increased health care costs and also puts pressure on rural and remote health care facilities location. Moreover, the current technological development causes the healthcare system to change from hospital-centred to a patient-centred system [12, 13]. For example, some clinical analysis such as measuring blood pressure, blood glucose level, oxygen level and others can be done at home without the help of a healthcare professional.

Next, a concept of Ambient Assisted Living (ALL) which is a branch of artificial intelligence (AI) has been integrated with IoT. It aims to help elderly people to live independently at home with convenience and safety [14]. The use of ALL allows this real-time monitoring of patients and ensures that they will accept humans’ assistance such as services in the event of a medical emergency. ALL is possible to engage with the advanced concepts of AI such as machine learning, deep learning, big data analysis, gesture recognition and their application in healthcare industries.

The author in [15] proposed a framework that dispenses healthcare solutions to elderly people and this framework is designed as a modular architecture for automation, security, and communication for the AAL. The device employs a closed-loop communication service to connect the patient with the healthcare providers and this architecture was later used as a basis for the development and design of advanced IoT-based AAL systems. Based on Sandeepa, this author developed an emergency detector for elderly people
that assists in monitoring chronic conditions and other potential health-related emergencies, in case of an emergency, this system alerts the caregivers to take action properly [16]. Many studies have been done to study the effectiveness of the use of IoT in AAL [17–20]. In addition, IoT-based healthcare systems can now track indoor air quality with the help of assistive robots. Air quality in the patient's environment stay will be checked and if the air quality is below the standard value, the system will trigger an alert to the caregivers [21,22].

2.2 Retail and Logistics

Another other area that can use IoT retail and logistics. The implementation of IoT in logistics provides quick and effective results. This is because it can track the status of assets, packages and people in real time along the entire value chain using this technology. Apart from logistics, retail is also an opportunity to automate business processes, eliminating manual labour, improving quality and predictability, and reducing operating costs. In addition, the Internet of Things allows to optimize the work together of people and devices connected to a computer network, as well as providing monitoring and transferring incoming processes the right direction [23].

For example, in logistics (transportation) such as a taxi or Grab car. In order to remain in the market, industry representatives should include advanced technology in the services provided. IoT connects all of these processes (scheduling, communication, fast service and payment) in a centralized cloud network real time. Scheduling guarantees customers pick up on time, regularly updates driver information, estimated arrival time, set price, driver rating and trip management. All these factors create a positive effect and thereby improve the business climate. The solutions implemented have greatly influenced the transport ecosystem for taxis or Grab in the market [23]. Based on [24–27] reporting IoT can work to improve logistics and infrastructure for retail businesses and more effective store management.

2.3 Smart Living/Home

IoT also provides DIY solutions for Home Automation. Control is done remotely according to specific needs. Proper utility monitoring metre, energy and water supply will help save resources and detect unexpected overloads, water leaks etc. There will be a proper intrusion detection system that will prevent theft. The authors in [28] proposed IoT architecture implementation for smart homes using GSM technology. This proposed framework authorizes the users to manage and control the smart objects using an internet connection. The architecture is done by the web by providing such as SMS messages that are transformed from user input and finally commands are sent to the GSM network implemented by electronic gadgets. Authorized users can send commands to web devices connected to the network and user data remains in a condensed database through an application programming interface.

Designed a very low-cost smart home system functioned by Android application and the user from the home or anywhere in the world can access it wirelessly using the GSM system is proposed by Rahman et al. [29]. In this system, it is linked with a smart electrical monitoring system where users can operate wirelessly their light, refrigerant, fan, TV, etc outside or inside the house or inside the house. For security, this system can be used as a Smart Security System that allows security alerts to be sent to users no matter where they are. Based on authors in [30], this research emphases on the engineering and design of wireless, elastic and low-cost smart platforms for home automation. A smart system developed to be able to send real-time video information and GSM-based of a fire, motion detection and break-in, moisture and temperature monitoring system by utilizing board Mega 2560 Arduino. Smart home system pledges us safe living space, improved security, less power consumption and is environmentally friendly which is impossible to think about in the last few decades [31].

2.4 Smart Environment

Environment monitoring (EM) consists of proper planning and management of disasters, controlling different pollution and effectively addressing the challenges that arise due to unhealthy external conditions. EM deals with water pollution, air pollution, hazardous radiation, weather changes, earthquake events, etc. The sources of pollution are contributed by several factors, some of which are man-made and others due to natural causes, and the role of EM is precisely to address the challenges so that the environment is protected for a healthy society and world [32]. The latest technological developments especially AI, deep learning and machine learning cause EM to become intelligent environmental monitoring (SEM). In [33] the authors use IoT, AI and wireless sensors networks in their SEM systems. Internet of things (IoT) devices
are employed in WSNs for effective waste management, vehicle marking, temperature control, and pollution control.

Next many researchers in their SEM system such as Cicala et al. [34] are used to assessment of burned areas using multispectral data captured through satellite imaging and remote sensing, meanwhile in [35], the authors used mobile health monitoring systems and IoT based environment systems. The following authors in [36] apply for smart marine environment systems using multimodal sensing networks. Next, SEM are used for environment monitoring methods are implemented for various applications, aiming to serve certain purposes, which may include weather forecasting are discussed in [37,38], the authors research in [39-41] is related to air pollution control, meanwhile in [42,43,44] based on water quality control and monitoring, and crop damage assessment is used by [43,45]. Today, many everyday appliances and machines are already networked, with sensing and other capabilities that make them considered smart devices. This equipment with a variety of functions is automatically increasing rapidly day by day.

2.5 Smart Agriculture and Water Management

The world's primary source of food is agriculture. According to UN predictions, the global human population will reach 8.0 billion in mid-November 2022. the population could reach 9.7 billion in 2050 [46]. As a result, there will be a continual rise in the need for food and water around the world. Correspondingly, IoT applications can provide farmers with the appropriate tools to support them in their decision making and automation of all areas of agriculture by offering products, services and knowledge for making the entire process more productive and efficient[47].

IoT is considered as an element of the internet of the future and is expected to include billions of intelligent communication "things". It features intelligent Internet of Things (IoT) monitoring systems that help maintain ideal conditions to ensure higher agricultural product quality. For example, the Crop Monitoring system will monitor crop growth and production performance throughout the stages of development. In an intelligent agricultural monitoring system, it can provide structural components of the monitoring system by building on IoT communication technologies and WSN features in cooperation with energy-saving protocols [48]. The project is illustrated by a practical application for monitoring saffron agriculture in Kozani, Greece. Augmented Reality Internet of Things (AR-IoT) is an application of augmented reality (AR) in crop monitoring, which supports IoT data visualisation by using a colour scale to represent the crop parameters [49]. It enables agricultural data acquisition, with IoT-based multi-cameras, to provide 3D visual serving in the physical world. Results showed that AR-IoT could be applied to monitor crops simply and effectively.

Agriculture consumes more than 50% of the world's annual water consumption [50]. It is used to support a wide range of activities such as irrigation, watering, and cleaning of livestock and aquaculture. IoT can be used to improve water resource management and achieve efficient and optimal results. The wise use of water resources in agriculture is essential to increase crop yields and reduce costs, while at the same time being a necessary step towards sustainability. In a Smart Irrigation system, it uses data-intensive methods to increase agricultural productivity while reducing its environmental impact [47]. An efficient irrigation system must provide water to the entire field in a uniform manner to ensure the quality of crop and reduce wastage [51].

2.6 Smart Cities

Smart cities are complex socio-technical infrastructures composed of human actors and digital devices that are exploited in many domains, such as transportation, environment, energy, healthcare, governance, industry 4.0 etc.[52]. The main goal of implementing and integrating IoT solutions is to enable smart cities to grow further by offering new capabilities and features while dramatically lowering human intervention[53].

A specific domain such as smart governance, used to incorporate ICT into municipal governance practises in order to enhance decision-making and expedite bureaucratic and administrative processes through a more intelligent collaboration between various stakeholders and social actors, such as public administrations, municipal employees, private businesses, and citizens [54]. Accordingly, the architecture of the IoT system is built such that the smart city will be able to function in a more efficient manner by means of network transmission, information processing and intelligent perceptions.

The adoption of IoT in smart cities brings numerous benefits, transforming urban areas into more efficient, sustainable, and liveable environments. The smart cities will improve Infrastructure Management: IoT enables real-time monitoring and management of critical infrastructure components such as
transportation systems, utilities (electricity, water, gas), waste management, and public facilities [55]. Sensors and connected devices provide data on usage patterns, maintenance needs, and potential issues, allowing proactive maintenance and efficient resource allocation.

On the other hand, IoT deployments in smart cities create opportunities for economic growth and innovation. They attract businesses and entrepreneurs who can develop new applications and services based on IoT technologies. It provides e-business and e-commerce services to increase productivity and delivery [56]. IoT-driven data analytics can generate insights that help optimize city operations, leading to cost savings and increased efficiency. Smart city initiatives can also attract investments and support the growth of technology sectors.

3. DEVELOPING PROTOTYPE HGRED

This section describes the details of developing prototype HGRED. This prototype can be further developed by adding more functions and the latest equipment to help people with disabilities live a better life.

![Flowchart of HGRED](image)

Figure 2 The flowchart of the HGRED
3.1 Agile Methodology
The Agile method has several key characteristics that make it a good fit for the development of IoT hand gesture recognition devices. Agile methodology is an iterative and flexible approach to project management and software development. It emphasizes collaboration, adaptability, and continuous improvement throughout the development process [57]. Agile methodologies promote frequent feedback, regular team meetings (such as daily stand-ups), and the use of visual tools like task boards or burndown charts to track progress. The iterative nature of agile allows for continuous learning and improvement, enabling teams to deliver value to customers more efficiently [58,59].

3.2 Flowchart
The flowchart of the prototype of HGRED shown as Figure 2.

3.3 Framework
Framework of this prototype is as in Figure 3. The glove will be worn by the disabled person and is embedded with node MCU ESP8266 and buttons. Each button has their own command to transmit the data to firebase. When the disabled person makes any finger movement after wearing the glove, the sensor will be triggered and send the data to the Firebase in real-time via Arduino and the node. Once the data has been received to firebase successfully, it will be sent to the App that has been invented via Flutter SDK. A notification will be received in push notification at Flutter app same as the commands that have been declared to buttons. The helper will be notified via the Flutter app. so the helper can assist the user easily and properly.

![Figure 3 The framework of HGRED](image)

4. RESULT AND DISCUSSION OF HAND GESTURE RECOGNITION EASY DEVICE (HGRED)
All the procedures of implementation include getting the system to run properly with precise interfaces. Each interface of the project is described in detail. Several different programming languages have been used during the development of the HGRED. With Firebase as cloud database may be set up and utilized. The code is written in Visual Studio Code. Hence, The Arduino IDE is the software that features a code editor, a message board, a text terminal, a toolbar with frequently used buttons, and a selection of menus. It communicates with NodeMCU ESP8266 hardware so that code may be uploaded and run. Meanwhile, Dart is a programming tool for wiring together between hardware and device and acts as a platform to transform the data from NodeMCU ESP8266 to the Firebase database. This system employs exactly like an Android Studio project validation procedure. The validation is essential to stop the user from inputting inappropriate data and ensure the input is accurate.

4.1 Device Development of Hand Gesture Recognition Easy Device (HGRED)
Device installation is shown in Figure 4(a). Based on this figure, NodeMCU ESP8266 was inserted at glove, and the installation of five push buttons which is send input data to firebase and mobile apps once has been triggered. Each press will trigger data transmission to Firebase, a powerful cloud-based platform. This allows for real-time data storage and analysis, opening up possibilities for remote monitoring, analytics, and integration with other applications. Figure 4(a,b,c,d) are examples of microcontroller functions.
4.2 Application Development of HGRED

This section describes how the system was built to meet the requirements or the goal of the system.

4.2.1 User Login Interface

For this page, users can view the push button status on the interface display to ensure the functionality of the HGRED in facilitating their affairs. In addition, users can be notified via through the push buttons status change. Figure 5 depicts the login account interface to access the dashboard application to insert the data.
4.2.2 **User Registration Interface**
When users open the app, they will see a login or registration form. Existing users can log into the system by entering their credentials, such as a username and password. If they are new users, they can finish the signup process by giving their name, email address, password, category, age, mobile number and gender that they choose. This process of signing up makes sure that only people who are allowed to can use the management functions. Figure 6 illustrates the interface of the registration page.

![Figure 6 User Registration](image)

4.2.3 **User Main Activity Interface**
The interface simplifies the process receiving input data from push buttons and monitor their status change through the data provided as required. Therefore, Figure 7 illustrates the main interface and allow users to view the notification of data through this page.

![Figure 7 User Main Dashboard](image)

4.2.4 **User Info Interface**
The interface of the user's information is displayed in Figure 8. On this page, the information about the user that was registered during the user's sign-up process will be displayed.
4.2.5 Logout Interface
Figure 9 depicts the user logout interface in its entirety. This page will log the user out of the homepage and redirect them to the login page.

5. CHALLENGES IN USING IOT FOR ELDERLY AND DISABLED (HEALTHCARE)

In recent times, the healthcare industry has witnessed tremendous technological development and its application in solving healthcare related issues. This has improved with healthcare services available at the fingertips. With the application of smart sensors, cloud computing and communication technology, IoT has successfully revolutionised the healthcare industry. Despite this, IoT also has some challenges and potential issues to be considered for future research. Among the issues are:

5.1 Cost of Maintenance and services
Rapid technological advances cause the need for upgrading IoT devices from time to time. IoT systems involve a large number of connections to medical devices and sensors. This involves a high cost of maintenance, possible service upgrades impacting not only the company's finances but also the end user. Therefore, the inclusion of operable sensors with lower maintenance costs is required.

5.2 Importance of Standardization
Various types of products are produced for the healthcare industry. Most of the vendors who manufacture this product claim to follow the standard rules and protocols in the design process and the validity of this is less valid. This problem can be solved when various organisations and standardisation bodies such as
Information Technology and Innovation Foundation (IETF), the European Telecommunications Standards Institute (ETSI), the Internet Protocol for Smart Objects (IPSO), and so on can collaborate with the researchers to form working groups for the standardisation of the devices.

5.3 Continuous Monitoring Requirements
Many health care situations require long-term monitoring of the patient during the treatment process. Such monitoring is mainly in case of chronic diseases, heart diseases, etc. In this situation IoT devices must be efficient and can perform real-time monitoring.

5.4 Allows Self Configuration
IoT devices must give more power to the user by including features such as manual configuration. This allows the user to change the system parameters according to the application request and also with changing environmental conditions.

5.5 Data Security and Privacy
Cloud integration computing has changed the idea of real-time monitoring. This usage has made healthcare networks more vulnerable to cyber-attacks, especially important patient information. Identity authentication, secure booting, fault tolerance, authorization management, whitelisting, password encryption, and secure pairing protocols to avoid an attack must be included or integrated into medical and sensing devices of IoT and network.

5.6 Scalability
Ability a healthcare device that can adapt to changing environments is known as scalability. IoT with higher scalability works smoothly without any delay and uses what is available efficiently. Therefore, it is important to design devices with higher scalability and make the system more efficient for present and future use.

5.7 Impact of the Environment
Development of IoT systems requires the integration of various biomedical sensors with semiconductor-rich devices. Manufacturing and fabrication mostly use earth metals and other toxic chemicals and this in turn has a negative impact on the environment. Therefore, a proper regulatory body must be established to control and regulate manufacturing sensors. Further, more research must be devoted to making sensors using recyclable materials.

6. CONCLUSION
With the continuous development of emerging IoT technologies, the concept of the Internet of Things will soon grow on a very large scale. The emergence of the network paradigm will affect every part of our lives from home automation to smart healthcare and environmental monitoring by embedding intelligence such as AI, machine learning and Deep Learning into the objects around us. This research paper reviews IoT-related scientific research that has been done by researchers in various fields. It also builds an IoT prototype known as HGRED which aims to overcome the problems faced by normal individuals to understand the language of disabled people. With greater funding, research on the HGRED prototype can increase its effectiveness and efficiency. Finally, challenges and related issues with design, manufacture, and use IoT systems are also discussed.

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