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Smart Home Design for Disabled People

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Abstract- **Currently, over a billion people including children (or about 15% of the world's population) are estimated to be living with disability. The lack of support services can make disabled people overly dependent on their families, which prevents them from being economically active and socially included. The Internet of Things can offer people with disabilities the assistance and support they need to achieve a good quality of life and allows them to participate in the social and economic life. In this paper, an overview of the Internet of Things for people with disabilities is provided. For this purpose, the proposed architecture of the Internet of Things is introduced. Different application scenarios are considered in order to illustrate the interaction of the components of the Internet of Things. Smart home technology can include environmental adaptations that allow remote control of home appliances, electronic communication, safety monitoring and automated task cueing.**

Index terms- Smart home, Artificial Intelligence, Feed-Forward Neural Network, Recurrent Neural Network, Automatic Adaptation

1 INTRODUCTION

In the last few decades, the life expectancy in most countries in the world has increased dramatically. This improvement is achieved primarily due to significant advancements in medical science and diagnostic technology, as well as the rising awareness about personal and environmental hygiene, health, nutrition, and education [1–4]. However, increased life expectancy coupled with falling birthrates is expected to result in a large aging population in the near future. In fact, according to the World Health Organization (WHO), the elderly population over 65 years of age would outnumber the children under the age of 14 by 2050 [3]. In addition, about 15% of the world's population suffers from various disabilities, with 110–190 million adults having significant functional difficulties [5]. People with disabilities, due to their limited mobility and independence, are often deprived of their regular healthcare needs. Furthermore, chronic diseases and conditions such as heart disease, stroke, cancer, and diabetes are among the most common health problems in adults. Out of 10 leading causes of death, chronic diseases account for ~65–70% of total mortality [6]. In particular, heart disease and cancer together are the leading causes of death, accounting for 48% of all deaths [7]. In addition, unregulated blood sugar i.e., diabetes, if not managed properly, may lead to long-term complications such as kidney failure, limb amputations, and blindness. Therefore, it is no wonder that the demand for healthcare services increases with the increasing average life expectancy of the population. However, the cost associated with present-day healthcare services continues to rise due to the ever-rising prices of prescription drugs, diagnostic tools and in-clinic care. For example, investments in healthcare sectors increased by a massive $11.5 billion in the 2017 budget of Ontario, Canada [8]. Therefore, existing healthcare services are likely to impose a significant burden on the socio-economic structures of most countries, particularly the developing and least developed ones [9–13]. In addition, a large number of elderly people require regular assistance for their daily living and healthcare, which are mostly supported by the family, friends or volunteers [14]. Formal paid care services offered by caregivers, or elderly care centers are expensive and thus are still out of reach for a large section of the elderly population living under constrained or fixed budget conditions [15,16]. Therefore, there has been a growing awareness to develop and implement efficient and cost-effective strategies and systems in order to provide affordable yet superior healthcare and monitoring services for the people having limited access to healthcare facilities, particularly the aging population. The elderly may require frequent, immediate medical intervention, which may otherwise result into fatal consequences. Such emergency situations can be avoided by monitoring the physiological parameters and activities of the elderly in a continuous fashion [16–18]. In most emergency cases, the elderly seek in-patient care, which is very expensive and can be a serious financial burden on the patient if the hospital stay is prolonged. Remote health monitoring in a smart home platform, on the other hand, allows people to remain in their comfortable home environment rather than in expensive and limited nursing homes or hospitals, ensuring maximum independence to the occupants [19]. Such smart homes are outfitted with unobtrusive and non-invasive environmental and physiological sensors and actuators that can facilitate remote monitoring of the home environment (such as temperature, humidity, and smoke in the home) as well as important physiological signs (such as heart rate, body temperature, blood pressure and blood oxygen level), and activities of the occupants. It can also communicate with the remote healthcare facilities and caregivers, thus allowing the healthcare personnel to keep track of the overall physiological condition of the occupants and respond, if necessary, from a distant facility [16,20]. blood pressure and blood oxygen level), and activities of the occupants. It can also communicate with the remote healthcare facilities and caregivers, thus allowing the healthcare personnel to keep track of the overall physiological condition of the occupants and respond, if necessary, from a distant facility 16,20].

2. SYSTEM DESIGN

As a general overview, the system design consists of two internal network Backbones. The first one serves as

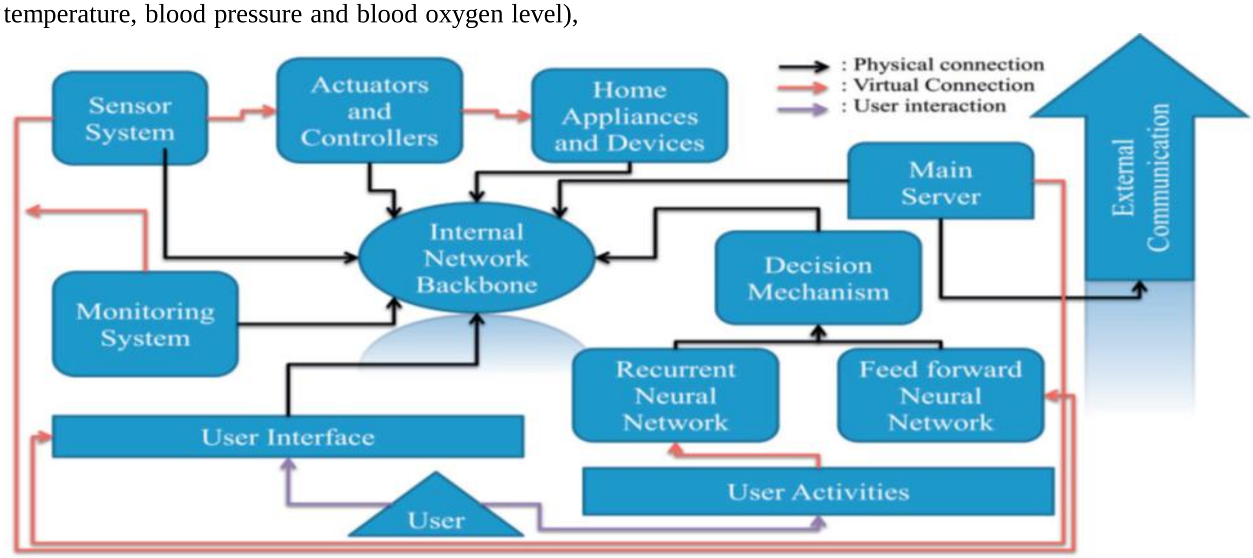

Fig.1 System Design Diagram

the main network and the second one as a backup of the main network, (Fig. 1). The purpose of these networks is to connect the different elements of the whole system[31,32]. Similar to the internal networks is the two external networks which enable the communication between the house and the responsible authorities, and for other administrative and remote access purposes. For adaptive learning two artificial neural networks are available. They are responsible for predicting the likelihood of an event so the environment may be adapted to the user's needs and anticipate his next move. The neural networks will use collected data from sensors and cameras to complete their learning process. A regular feature in a Smart Home is automation, which allows controlling and monitoring of all devices in the house. Another feature is security which is possible using access code on main doors and windows, motion sensors, smart cameras with face recognition to identify movement around the house, smart fire alarm and a reliable connection with the police department. Health care and safety of the users inside the house are also essential features; these tasks are for example accomplished using a fall detection mechanism, humidity sensors, oxygen sensors, and constant monitoring of vital signs and monitoring the user's daily activities for abnormal events such as lack of eating or slow movements. In addition, the system will monitor his medical problems and set a schedule for his medicine and alerting him when it is time to take it or when he is nearly out of medicine. On top of all that a reliable connection with the emergency personnel and the medical team is established. The activity of one feature could sometimes depend on another feature, which is why the smart house system is fully connected through a backbone network so features can interact and exchange information for better decisions and cooperation.

3. EXPERIMENTS AND DISCUSSIONS

3.1. Software Prototype

The software prototype we developed is mainly based on a Microsoft visual studio program written using C# programming language[32]. It is an easy to use web application with six web forms. The main page provides a clear picture of the purpose of the software and contains a list of all smart devices available for control and monitoring. The users can easily pick any device and switch it ON/OFF. The program uses an UDP (User Datagram Protocol) connection to send the right code to the system network that is then passed through to the correct control unit of the targeted device. From the main page the timer page can be accessed. In this page, the users can set alarms for each device and program it to be switched ON/OFF at a specific time and date. Immediately when a device is switched ON, the control and monitoring unit responsible for this device will calculate the device's power consumption and send it along with an acknowledgement using the same UDP connection back to the server. So the program will display the power consumption of each device. The switching process, alarm setting, and power consumption need to be logged for future use. It is for this purpose that the third page was made. Connected to an SQL server database, the program uses relational tables to save all the data to be searched by the users according to different parameters. In order to give the users an easy control and visualization mechanism, the fourth page was developed. Using this page the users can see what devices are turned ON and since when they were turned in addition to the power consumption beneath each device. The fifth page is intended to be used to monitor all alarms, sensors and cameras in the house. Using this page, users may check if everything is safe and secure. This page is connected directly to our feed-forward neural network which determines the outcome of each alarm, such example is the fire alarm that we discussed earlier. The sixth page is not viewable by the user; it is for administrative purposes only.

3.2. Control and Monitoring Unit

The control and monitoring unit is responsible for switching ON/OFF the devices and calculating their power consumption. This unit will open an UDP connection with the main server through the system backbone network. Each unit can control up to five devices[32]. The unit is a 10cm by 10cm box so it can fit easily on the wall or any other place without taking much space.

3.3. Neural Networks

In our experiments we designed a smart fire alarm detection system. It uses a perceptron based feed-forward neural network developed using an input layer with 5 parameters and an output layer with a single output. The predefined criteria and events are studied for a period of time. These arrays of data have known outputs. Studies suggested five main parameters to be monitored in order to conclude if there will be a fire or not. So here we have a Boolean output: either there will be a fire or not. These five events are carbon monoxide level with a normal level of 35ppm and a threshold of 100ppm, oxygen concentration with a normal level of 21% and a minimum threshold of 13%, smoke detection, heat level, and flame detection using image processing software. In our experiment, we used sensors to collect data from the environment to obtain a large set of records[32]. This set is then divided into two subsets, with the first 75% are for learning and the second 25% are for testing. When the learning process is finished each event will be given a specific weight according to its importance then the testing process will start. Now, the network will be fed with combinations from the second subset. After the output in ready it will be compared with real output and error evaluation is done. According to the Delta Rule the weight will be changed to increase the efficiency of the network, this process will be repeated until the error is close to zero. The network is connected to the Smart Home prototype system.

4. CONCLUSION

We have presented in this paper a theoretical design of a Smart Home environment for disabled people. A Prototype was developed and simulations were run to show the effectiveness of this system. It is noteworthy that the design used for one user may differ from that of another user depending on their situation and disabilities. Thus, it is not required to have the whole system set in the same manner for all the users. Throughout this paper we have seen the significant importance of a Smart Home to help disabled people in their everyday life. In addition to the aspects that form such a space, including the importance of artificial intelligence through the benefits and progress it can make in such a domain. In the near future, we are planning to further develop the prototype and make it much closer to the theoretical system we designed. Then, it will be validated by performing more extensive and real life experiments.

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