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Cloud AIoT based Smart Wheelchair using Module for Social Distancing, Temperature Monitoring, and Oximeter Module

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ABSTRACT

The prospective Smart WheelChair and its three modules — Social Distancing Module, Temperature Sensor Module, and Oximeter Module — are analyzed. The paper proposes the ways in which these modules are combined into the smart wheelchair. The Smart Wheel Chair (SWC) is meant to provide resources and assistance to paraplegics, particularly during pandemics such as COVID-19. Humans with a higher degree of impairment, such as quadriplegics, may benefit greatly from the intended chair. Quadriplegics are men and women who, due to age or infection, are unable to move any of the body's organs save the head. The paper also discusses the oximeter module that will facilitate the monitoring of blood oxygen levels in the disabled. The technology used is the Internet of Things, in which sensors measure heart rate and blood oxygen levels, which are then processed by embedded systems and relayed to the cloud, which triggers an alarm if anything goes wrong. The entire system is supported by Artificial IoT (Internet of Things) that transmits the entire data into the cloud for further processing and storage. Other objectives of this paper also include elucidating the use of the Smart Wheel Chair (SWC) to protect disabled people from catastrophic pandemics like COVID-19 or to assist them in their treatment of any pandemic-causing sickness. The current project's purpose is to expand an automatic sensing wheelchair by including sensors into its components. Such features in chairs increase a challenged individual's independence while also allowing them to be monitored by their loved ones.

Keywords — Artificial IoT (Internet of Things), Oximeter, Thermometer, Social Distancing Module, Cloud.

I. INTRODUCTION

The basic aim of this paper is to make life easier for those of us who have lost the capacity to use their legs due to a substantial amount of paralysis, an accident, or old age. The disability might also be a result of any genetic or pre-birth condition. Many differently abled persons rely on others in their daily lives, particularly when travelling from one location to another. Wheelchair users require constant assistance in getting their wheelchair rolling. Their lives are complicated by the lack of an intuitive control system for their wheelchairs that allows them to monitor their health. Using a smart wheelchair provides a great deal of independence to those with physical disabilities who can't walk or operate a mechanical wheelchair on their own because it takes a lot of work and the assistance of others, especially during the pandemics. COVID-19 is the most recent example of such a pandemic. The issue is that some disabilities cause people to lose their capacity to use their hands; consequently, in this scenario, controlling a motorized wheelchair can be done using spoken instructions for patients who are unable to use their hands, resulting in an intriguing and promising conclusion. However, due to expensive costs and inconvenient operations, the availability of smart wheelchair solutions is generally limited. The proposed approach, outlined in this work, would present a low-cost, simple, and user-friendly solution that is both economical and user-friendly. Another motivation is to keep the entire system's power consumption low while maintaining mobility. By eliminating collisions with walls, mounted objects, articles of furniture, and people, the device may improve safety for users of standard joystick-controlled high-powered wheelchairs[1]. Additionally, an oximeter surmounted on the wheelchair to monitor the heartbeat and the oxygen levels of the blood, and store it in the cloud. An oximeter either separately on the chair detects blood oxygen level by inserting a finger into the oximeter or is integrated into the heartbeat monitor, which is further elucidated later, in the paper. The concept of a change in the amount of red light absorbed by blood as a function of blood oxygenation is applied here. The changes in light intensity level are measured using a photodiode, and the noise content is removed using filters. The heartbeat waveform is the filter's output. The data gathered is stored on the cloud for further processing, so that any risk of low oxygen levels or heart-related risks can be predicted[2].

II. RELATED WORKS

The goal of this paper is to discuss the potential replacement of the current motorised wheelchair control system with a voice command system that is both inexpensive and easy to use. Differently abled persons, particularly those with severe disabilities who are unable to move like regular people, will be able to move independently using these qualities. Several smart wheelchair prototypes have been developed using advanced technology to assist the differently-abled. A system can be devised by modifying or converting a manual wheelchair, or attaching a seat to a mobile robot are all possible ways to build a smart wheelchair platform. When electronics are added to an Electric Powered Wheelchair (EPW) to create a smart wheelchair, the smart features are connected to the Electric Powered Wheelchair (EPW) controller to access the embedded drive train[3-6]. Using merely a single laptop computer, on the other hand, can severely limit a smart wheelchair's real-time processing capabilities. Cloud computing could be used as an alternative to offloading real-time data processing from smart wheelchair hardware[5]. Most smart wheelchairs currently present in the market are not cost efficient, and are very expensive and are not much accessible to common people, and that has caused a lack of facilitation to most of the needed differently abled individuals. Andrej Kraba et al. demonstrated a speech-controlled cloud-based wheelchair platform in 2014. The platform's control is implemented in the cloud utilising the low-cost speech WebKit. Apart from voice control, a graphical user interface (GUI) is implemented, which works in a web browser as well as on mobile devices and provides a live video stream[7]. Sobia, M. Carmel, and colleagues suggested a wheelchair command interface in 2014 that did not involve the use of the other's hands and consists of three major modules. Face detection, facial expression recognition, and command generation are the three methods. Digital image processing for face detection, principal component analysis for facial expression recognition, and producing command signals for wheelchair interfacing are all included in the software [8]. Vertical movement capability of smart wheelchairs has been discussed by Weijun Tao, Junyi Xu, Tao Liu for enabling stair climbing in smart wheelchairs[26].

TABLE I
SUMMARY OF A FEW RECENT PROPOSED MODULES ON SMART WHEELCHAIR DURING THE PAST DECADE:

S. No	Authors	Modules related to SWC that are proposed/experimented/implemented	Year
1	M. C. Sobia, V. Brindha and A. Abudhahir	Facial Expression Recognition using PCA	2014
2	A. Škraba, A. Koložvari, D. Kofjač and R. Stojanović,	Speech-controlled cloud-based platform integrated into the wheelchair	2014
3	Minhas, Manpreet Singh & Jeevanchavan, & Singh, Ujwal	Patient-Monitoring	2015
4	Weijun Tao, Junyi Xu, Tao Liu[26]	Stair-climbing ability	2017
5	Olivier Rabreau, Sylvain Chevallier, Luc Chassagne & Eric Monacelli[27]	SenseJoy is a pluggable system for evaluating user behaviour while driving a powered wheelchair.	2019
6	Amiel Hartman, Vidya K. Nandikolla[16],[17]	Integration of sensor technology and computing for next-generation wheelchairs.	2019
7	Mohammed Mecifi, Abdelmadjid[32] Boumediene, Djamila Boubekeur[28]	An electric propelled wheelchair's trajectory tracking is controlled by a fuzzy sliding mode control.	2021

Some other notable works have been summarised in Table I. Each work done on the wheelchair has brought a significant contribution to ongoing research in developing the wheelchair. In conclusion, SWC entails the inclusion of three other modules that will be surmounted on the existing developed Automated Wheel Chair (AWC). AWC was our completed project sanctioned by the Department of Scientific and Industrial Research , Govt of India.

III. MODULES IN SMART WHEELCHAIR

Medical and health care is one of the most intriguing IoT application areas. The Internet of Things could enable a variety of medical applications, including remote health monitoring, fitness programmes, chronic illness management, and senior care.[9] Compliance with therapy and medication at home and by healthcare providers is another key potential application. By providing a continuum of care and precise prognosis, sharing effective health strategies between various regions, checking patients' compliance with treatment, offering effective and customised treatment planning, and gaining insight from the collected data, the Internet of Things contributes to effective and efficient treatment[9][10][11]. The Artificial Internet of Things (AIoT) is a concept that includes everyone, everywhere, at any time, utilising any service, on any network. The Internet of Things (AIoT) is a mega trend in next-generation technologies that has the potential to have a broad impact across industries. The existing modules in the market that are facilitating the Electronic Wheel chair Modules are shown in Figure 1.

Fig. 1 A basic smart wheelchair system without proposed modules[16-17]

The three modules that are of significant importance to the addition of the wheelchair are Social distancing module, temperature sensor and Oximeter sensor modules.

A. PIR Sensor Module for Social Distancing

The in-built module is really important for pandemics since social distancing is one of the key factors in keeping an individual safe during the pandemic. According to the World Health Organization, social distancing is the recommended strategy for minimising physical contact with potential COVID-19 carriers by keeping a set distance between one person and another[12]. The transmission of common respiratory viruses is comparable to that of SARS-CoV-2 and influenza virus. Distancing oneself from others is thought to have some effect on the spread of common respiratory infections. Even without the use of antiviral medications or vaccines, the results of this study clearly illustrate how significant social distance helps prevent the spread of numerous respiratory viruses. As a result, widespread social isolation could be one of the most efficient ways to combat a pandemic of related respiratory viruses[13]. PIR (Pyroelectric Infrared Sensors) are specifically designed for measure motion detection and have applications in a wide range of domains. Security is one of the key areas where one would easily find the PIR system. PIRs detect the presence of humans and animals based on their body heat radiation. This might be used to initiate actions such as opening doors, recording video, and so on. Because of their low power consumption, PIRs are widely employed.

1. ***PIR Working:*** Above the temperature of absolute zero, all objects and living beings emit infrared rays. Although infrared rays are not visible to the naked eye, they can be detected using electronic instruments intended for this purpose. Because they do not produce any energy to detect the presence of objects, PIR sensors are referred to as passive devices.

Fig. 2 An OCTIOT PIR sensor[15]

Most of the PIRs are used to check the presence of human/animal etc. and generates results in binary - Yes/No method as illustrated in Figure 3. Essentially, we can leverage the use of PIR to detect the presence of any human around the wheelchair, and also to measure the distance of individuals, if any, that are present around the vicinity of the wheelchair. The PIR that is proposed in this paper is OCTIOT PIR sensor which is highly efficient, easy to use and supports remote control[14].

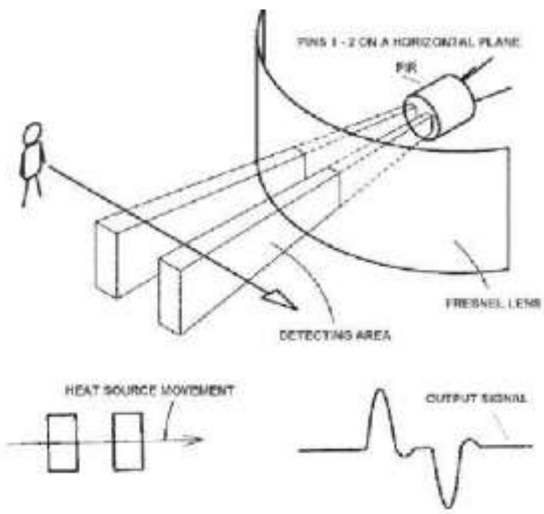

Fig 3: PIR motion working principle[15]

Figure 2 depicts a typical OCTIOT PIT sensor. OCTIOT sensor systems employ OCTi-Sense Technology, which delivers accurate motion detection around the installation area while also being energy efficient[14]. Features of OCTIOT sensors' that are approving of using this technology for the proposed wheelchair are: Light and robust: The OCTIOT sensor is made of high-quality materials, demonstrating its safety and long-term dedication to our product service and value. This gives the device more toughness in terms of hard use and handling[14]. Easy to Install: The feature of easy installation of OCTIOT sensors comes in very handy owing to the fact that it is lightweight and small in size as shown in Fig 1. This asserts the fact that the wheelchair maintains its mobility, and smooth movement[14]. Range: Another robust feature of this OCTIOT PIR (Poly-Infrared Sensor) is it's range. A typical IoT sensor has a range that varies from 5-8 metres[14]. This is considerably sufficient for maintaining the social distance whilst being in the crowd. Power consumption: The power consumption of OCTIOT sensor is normally set at around 0.4

- 0.7 W. This keeps the efficiency of the entire system when the sensor is mounted onto the wheelchair[14].

Fig 7 A LM35 temperature LCD display[20]

2. ***Temperature Sensor :*** Temperature sensor module is another important component of an AIoT based smart wheelchair system. The module helps in monitoring the temperature and thermal vitals of the disabled individual using the chair. There are a plethora of wearable health monitoring technologies on the market [1]. These systems have the benefit of continuous real-time health monitoring over a lengthy period of time. However, a number of hurdles must be overcome for a reliable application, including total system cost, signal accuracy, low power consumption, connectivity method, and unobtrusive design [2]. As of now, a literature search reveals just a few initiatives devoted to the creation of smart wheelchairs, such as Intel® Technology's Connected Wheelchair project [18], and another multiple sensor-integrated wheelchair presented during 17th World Textile Conference AUTEX 2017- Textiles - Shaping the Future[19].

Fig. 6: A typical LM35 Temperature sensor by Texas Instruments [30]

As a result, another goal of the paper is to discuss a smart wheelchair based on a regular one by integrating thermometer sensors into its structure, and taking discrete measurements at regular intervals and storing it on a cloud for future reference. The thermometer sensor that we are incorporating is LM35 series' sensors as displayed in Figure 3 which has previously been tried onto many devices to capture the body temperature readings. The LM- 35 is a compact and inexpensive integrated circuit that may be used to measure temperature in the range of -55°C to 150°C. It may be readily connected to any microcontroller having an ADC function, as well as any development platform such as Arduino. Applying a regulated voltage to the input pin, such as +5V (VS), and connecting the ground pin to the circuit's ground will power the IC. You may now measure temperature in terms of voltage[21]. The LM35 series are precise temperature circuits with output voltage that is proportional to the temperature in degrees Celsius. The LM35 has an advantage over Kelvin's linear temperature sensors in that actual centigrade scaling prevents the consumer from removing the enormous constant voltage from the display.

The discrepancy in reading due to error is also quite less than compared to other standard models. An error threshold of LM35 (<1%) shown in table below makes it very efficient to take readings of the individuals using the wheelchair[20-21].

TABLE II

SUMMARY OF THE ACTUAL AND OBSERVED DATA WITH ERROR RATE FOR HEARTBEAT, BODY TEMPERATURE, AND ROOM TEMPERATURE SENSORS:

S.No	Subjects	Actual Data (°F)	Observed Data (°F)	Error (%)
1	S_1	97.3	97.8	0.51
2	S_2	98.4	97.7	0.71
3	S_3	98.1	98.6	0.50
4	S_4	96.9	97.5	0.62
5	S_5	97.5	97.1	0.41
6	S_5	98.2	97.0	0.81

The temperature recordings can be transmitted to any cloud services for storage and further prediction at any later stage. There are certain adhesive temperature sensors that can also be implemented, but the error threshold can prove to be a problem because of lack of proper positioning on the wheelchair in accordance with the organs from where the temperature is recorded on the human body, since it becomes difficult to record temperature. Mobility is a non-negotiable component of a successful wheelchair, and hence cannot be compromised.

3. ***Oximeter Reading:*** During the recent COVID-19, it has been evident that monitoring blood oxygen is one of the key attributes in understanding if the person is suffering from moderate or severe COVID. During the ongoing coronavirus illness (COVID-19) pandemic, reports on social media and in the lay press indicate that a subset of patients are presenting with severe hypoxia without dyspnea, a condition dubbed "silent hypoxemia" by some. One proposed option to reduce the risk of problems in such individuals is to have those diagnosed with COVID-19 but not unwell enough to require admission monitor their arterial oxygenation at home using pulse oximetry and present for care if they show signs of Hypoxemia[22],[23].

Fig. 5 A oximeter in use[29]

A little clamp-like device is put on a finger, earlobe, or toe during a pulse oximetry reading. The amount of oxygen in the finger is measured by little beams of light passing through the blood. It accomplishes so by detecting variations in light absorption in oxygenated and deoxygenated blood. This is a simple procedure. A standard oximeter can be one way to incorporate the module into the smart wheelchair. It can be placed on either side of the chair on the armrest. Since oximeters usually run on batteries, and are smaller in size, installation is very easy, and like other modules, mobility is maintained. In the proposed smart wheelchair, oximeters can be employed in two ways: Readings from oximeters can be stored on the cloud, and can be displayed on the phone or any other device. Also, storing the data over a longer period of time can be used for future reference to predict any condition of incoming Hypoxia. Oximeter mounted on a smart wheelchair can also be integrated with an mini-oxygen cylinder or oxygen concentrator that can be surmounted on the smart wheelchair within a frame or by other means as can be seen in figure 6, so that oxygen can be provided to a disabled individual via mask or nasal cannula (NC) suffering from COVID-19 in case of Hypoxia.

Fig 6 An oxygen cylinder on a wheelchair[24].

IV. CONCLUSIONS

The final wheelchair, as conceived and implemented, is a cost-effective solution to society's demand for modern smart assistive technology in unique instances such as pandemics, as well as in general. During the pandemic emergency, infrared sensors were employed to implement obstacle avoidance and asocial distance mechanisms. The wheelchair user's body temperature and heart rate are monitored, and if the values surpass a predetermined normal level, a warning message is delivered to the individuals chosen by the user. AIoT makes these features possible with the least latency. Smart wheelchair technology is now available for usage in modified interior areas that prohibit access to drop-offs. The first commercially successful smart wheelchair is expected to be marketed as a gadget that can be operated independently indoors but requires the assistance of an attendant outdoors or in unmodified interior surroundings. The environments in which smart wheelchairs can safely function will continue to expand as sensor technology advances. Hence, it is wise to ruminate upon the cost efficiency, mobility, and ease of the user as the key components for further advancements in the field of smart wheelchair. Using AIoT has decreased a lot of hassles, and further inventions in AIoT are expected to bolster the modifications in the smart wheelchair technology to facilitate the disabled individuals in adverse conditions like pandemics.

V. FUTURE WORKS

The proposed modules to the chair are very significant in value, and are expected to facilitate the disabled during the pandemics and other circumstances. There are certain extrapolations that can be pursued in the proposed system to increase certain features and the overall efficiency of the smart wheelchair.

1. The smart wheelchair can be integrated with Amazon - Alexa or google home devices to increase its accessibility and responsiveness resulting in the wheelchair being a component of the smart home rather than a discrete system. Certain programs can be programmed within Alexa using their Alexa Skills kit, or using Dialog Flow for Google Echo and Dot devices. Controlling AC temperature, digital locks around the house, switching the lights on/off around the house among others are the most promising of the future scopes.

2. Carbon-Fibre frames are highly durable and do help in decreasing the overall weight, and correspondingly increasing the mobility, but it is highly expensive[25]. Thus, future scope calls for finding an alternative to the conventional heavy plastic, or iron-based frame. Aluminium can prove to be a good supplant, but substantial experiments are to be conducted before corroborating on this solution.

3. Another future work is to find an effective solution of modifying the wheelchair and making it fire-proof. Disabled individuals are more prone to fire-related incidents in case of a fire because of their lack of mobility. Oxygen cylinder being mounted on the wheelchair increases the risks of an explosion since liquid Oxygen is a highly combustible fluid/gas. Thus, making chairs fire-resistant or fire-proof is highly called for, and demands an urgency.

4. Vertical Movement/Stair climbing capability: The wheelchair's functionality can be enhanced by including a feature that allows the user to climb up the steps while keeping in mind the weight of the wheelchair and the patient's condition.

5. Hardware and Software Diagnosis — Troubleshooting system: The modules on the smart wheelchair must be incorporated with a troubleshooting feature to diagnose the error in case there is any malfunction in any of the modules. For instance, If a wheel cannot move owing to physical constraints, the controller must be informed; If cylinders run out of oxygen, the caretaker or relative is sent an automatic message et al. A feedback system can provide information to the controller about the status of the wheel.

6. Solar Panel inclusion: With advancements in technology, light-weight solar panels can be mounted on the wheelchair to charge the various batteries that are utilised on the wheelchair. Thus, another aspect is to find a way to incorporate solar panels into the chair to make it more energy efficient and sustainable without compromising the cost effectiveness.

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