SmartRolls: Smart wheelchair for the elderly

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# Abstract

Many elders and physically disabled people live in households that will require a guardian to be monitoring them all the time. In this report, we will introduce the Smart Wheelchair for Elders. The Smart Wheelchair aims to make life easier for patients and always help better monitor them. This wheelchair will help the patient maneuver without help, monitor their health and vital signs remotely, and alert the guardian in case of emergencies regarding the patient’s wellbeing. The wheelchair will carry the patient to designated rooms inside the house/apartment. The wheelchair will also monitor the patient’s temperature and heart rate and send those readings to the patient’s guardian via a cloud service.

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# Introduction

## Internet of Things (IoT)

Over the past decade, the Internet of Things (IoT) has become a vital part of our everyday life. From reading calories burned during a walk on our smartwatches to automating the processes of our entire home through built-in sensors that can talk to each other, IoT has proved its limitless potential across all fields, both domestic and industrial.

According to [1], the number of active IoT devices reached more than 10 billion in 2021 and is predicted to surpass 25.4 billion by 2030. Therefore, it is safe to say that IoT will transform as we know it not only through cutting-edge entertainment applications but also through increasing both the efficiency and the safety of industrial manufacturing utilizing automation and the use of collaborative robots.

The Internet of Things can be defined as a system of interconnected smart devices. These smart devices can range from a thermostat to monitor and communicate temperature information to a complex control unit with embedded processors. What gives IoT its true power is the ability of these “things” to communicate with each other in real-time. The exchange of information allows decision-making on a very wide range such as regulating the traffic in an entire city according to current and destination location information of individual cars.

## Literature Review

There have been multiple IoT that also focus on creating a smart wheelchair for not only the elderly but also the disabled or the permanently injured. One of the notable previous works in the field is [2]. The authors designed a smart wheelchair that also uses an ESP module to communicate with the cloud, integrating an imu sensor to detect if the user falls over. Another striking difference is the usage of voice messages to control the chair’s actions.

# Proposed Design

## A picture containing LEGO, toy Description automatically generatedPrototype Overview

## Diagram Description automatically generatedBlock Diagram

## A picture containing diagram Description automatically generatedCircuit Diagram

## Network Protocol

NodeMCU has a built-in WiFi module, namely the ESP8266. The ESP8266 Wi-Fi module is a stand-alone SOC with a built-in TCP / IP protocol stack through the MQTT network protocol. MQTT (MQ Telemetry Transport) is commonly used in IoT applications for being a lightweight open messaging protocol that provides an easy way to distribute telemetry information to resource-constrained network clients in a low-bandwidth environment. MQTT works with publish/subscribe communication model which is traditional to client-server architecture that communicates directly with the endpoint. However, the client (publisher) that sends the message, in the Pub / Sub model, is isolated from one or more clients (or subscribers) that receive the message. Neither publishers nor subscribers are in direct contact, so a central broker manages the connections between them.

Through the cloud-based Adafruit dashboard, we display the patient’s temperature and heartbeat to alert the patients' guardian about any emergency. Adafruit is a cloud service that is meant primarily for storing and retrieving data.

## Limits and precautions

There are some limits and precautions to the use of the Smart Wheelchair that need to be noted:

* It cannot be used outside the house/apartment
* Requires occasional maintenance in case of damage or excessive use
* Requires external help for the user to mount the wheelchair
* Batteries need to be recharged according to use.
* The wheelchair needs to be turned off once not operational (as the user gets up from the wheelchair intentionally).

# Actuation Actions

## Line-following Navigation

As the user is assumed to be an elder who is too weak to move on his/her own, the chair is designed to be automated regarding navigation. There will be a line follower module attached to the bottom front of the chair. The chair will have three possible routes, living room, bedroom, and kitchen, that could be attained by following a black line on the floor. To ensure the feasibility of such an arrangement, the black lines are expected to be contained within an otherwise fully white tile that surrounds the walls of the user’s house. The path is expected to be obstacle-free as it will serve as the main route for the wheelchair. The patient will be provided with three buttons, each for a specific destination.

To overcome a case of intersecting lines, each destination will have a string consisting of multiple letters in order of direction decision at each intersection.

## Monitoring

### Temperature sensor

The temperature sensor will continuously measure the temperature of the user. The data will be sent to the patient’s family and doctor via the cloud and displayed to notify them of the current condition. If it exceeded a certain temperature, the buzzer will be turned on to alert the neighbors or anyone near the patient and an emergency message will be sent on the dashboard.

### Limit switch

The switch function is to detect if the patient is safely on the chair or not in the case of falling over. If the patient fell over, the switch will be turned off and accordingly the buzzer will be turned on to alert the neighbors or any nearby person and an emergency message will be sent to the patient’s family and doctor via the cloud dashboard. If the patient would like to leave the chair with external support for any reason, the system has to be shut off to not launch the buzzer and the emergency notification.

# List of Components

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Name | Function | Reason | Technical specs | Price |
| NodeMCU LUA WiFi IoT ESP8266 | Node MCU is an open-source microcontroller based on the ESP8266 that allows devices to be connected and data to be transferred using the Wi-Fi protocol. | The NodeMCU has a built-in WIFI module, ESP8266, which would be suitable for IoT applications as it decreases both complexity and price. | Operating Voltage: 3.3V  Input Voltage: 7-12V  Flash Memory: 4 MB | 150 EGP |
| L298N dual H-bridge Motor Driver | An H-Bridge circuit contains four switches. The arrangement of closed switches controls the motor direction. To decrease the number of pins, we connect each side (2 motors) to each input. | Because of the high current input, connecting the motors directly to the Arduino will burn it. Specifically, L298 has a PWM enables which allows controlling the speed of the motors. | * Logical voltage: 5V * Drive voltage: 5V-35V * Drive current: 2A * Storage temperature: -20 to +135 * Max power: 25W | 2 x 55 EGP |
| 4wd Chassis | The wooden chassis is laser-cut and equipped with 4 dc motors and wheels. It is also equipped with 2 plates and spacers for mounting. | We use 4 wheels to enhance the stability and balance of the system. The differential drive model is used for steering. | * Supply voltage: 3 - 12V * Operating current: 60mA 180mA * Max Torque: 800g/cm | 350 EGP |
| IR contactless temperature sensor: MLX90614 | To measure the object's temperature, the sensor receives the reflected IR beam and converts the energy into an electrical signal that can be shown in temperature units. | An IR-based sensor allows the measurement of temperature without direct contact instead of the traditional ambient temperature sensors | * Op. Voltage: 3.3V * Object Temperature Range: -70°: 382.2°C * Ambient Temperature Range: -40° C to 125°C * Accuracy: 0.02°C | 400 EGP |
| 3-channel line tracking follower sensor with TCRT5000  Line Follower Tracking Module 3 Channels - Micro Ohm Electronics | Attached to the chassis, the line tracking sensor detects reflected light from its infrared LED and can identify transitions from light to dark lines or even objects directly in front of it by measuring the amount of reflected infrared light. | A 3-channel line follower module to detect center, right, or left lines. | * Detect distance: 1 to 25mm * Focal distance: 2.5 mm * Voltage: 3.5 - 5V | 65 EGP |
| Heartbeat rate sensor IR KY39  Heartbeat Sensor Module KY039 | Makers Electronics | Transmits IR through the user’s finger and measures the portion of received light. At each heartbeat, the veins in the finger dilate blocking more IR from reaching the receiver. | * More affordable and widespread * More stable on the user’s finger | * Operating voltage: 3.3 – 5 v * Frequency 50/60Hz * Working voltage 3.3-5v | 25 EGP |
| Long limit switch | An electromechanical device is activated when an object exerts a physical force on it. We use the limit switch if the user is exerting a force on the switch by sitting. | Using a limit switch to verify the user is secured on the chair is more efficient and affordable than a traditional weight sensor as it’s more compact and outputs a digital, instead of analog value. | 3 pins:   * Input voltage * Ground * Output | 10 EGP |
| Buzzer | The buzzer will make a sound if the elder reaches an abnormal temperature or if he fell over from the chair. | Affordable and easily sourced | * Voltage: 5V * Frequency range: 2300Hz * Min sound output: 10cm – 85dB | 5 EGP |
| Breadboard and jumpers | To connect 2 different points on the breadboard to each other or on the Arduino and the breadboard | Affordable and easily sourced | * Male-Male * Male-Female * Female-Female | 2 x (22 + 28) EGP |
| Batteries | To provide power for the motors and electronic components | A 9-volt battery would be within the allowed voltage of both the MCU and the driver | * 9 v non-rechargeable | 2 x 10 EGP |

Prototype total estimated cost = 1235 EGP

# References

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