ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)

Vol 8, Issue 5, May 2021

Comprehensive Monitoring and Remote Control of Therapeutic Exoskeleton for Muscular Dystrophy Physiotherapy

[1] Dr. Abhay. A. Deshpande , [2]GV Keerthi, [3]Ramya N, [4]Suchitra NS , [5]Ramya B
[1] Associate Professor at Dept of ECE, RV College of engineering [2] Student at Dept of ECE, RV College of engineering ,[3] Student at Dept of ECE, RV College of engineering, [4] Student at Dept of ECE, RV College of engineering , [5] Student at Dept of ECE, RV College of engineering

Abstract: This paper mainly focuses on aiding the muscular dystrophy patient to improvise their muscle strength using exoskeleton which is controlled using NEMA 23 and motor driver TB6600 helping in physiotherapy. Considering all the failure cases, solution is also designed. Along with this therapy, the patient's health condition is also monitored using several health sensors and visualized using Thingsboard software with appropriate widgets. Alerts will be given to the physician in case of severity in the health condition of the patient with the help of the data being collected from those sensors.

Index Terms—Exoskeleton, Muscular dystrophy, Physiotherapy, Thingsboard.

I. INTRODUCTION

Muscular dystrophy (MD) is a group of neuromuscular diseases that cause progressive weakness in the body and muscles and reduces muscle mass that leaves the patient bedridden and incapable of mobility. This damage and weakness are due to the lack of a protein called dystrophin, which is necessary for normal muscle function. The absence of this protein can cause problems with walking, swallowing, and even muscle coordination. Muscular dystrophy can occur at any age, but most diagnoses occur in childhood. Children under the age of 12 years old are highly affected by MD along with its other cousins such as arthrogryposis and spinal muscular atrophy. In the current scenario, there is no cure for these diseases, but studies show that with the help of medication and physiotherapy, a significant reduction in symptoms as well as slowing down the course of the disease can be achieved with assurance Physical therapy is an integral part of treatment for advanced stages of muscular dystrophy since the patient is bedridden. Hence reinforcing body movement with the help of an external mechanism through exoskeletons play a vital role

A powered exoskeleton is a wearable mobile machine that is powered by a system of electric motor, hydraulics, levers, or a combination of technologies that allow for limb movement with increased strength and endurance. In the field of an exoskeleton, many researchers have worked significantly in developing prosthetics and aids to enhance human capabilities but there has not been an efficient development for the physiotherapy of MD. We aim at addressing this issue with a proposal of a cost-effective rehabilitative exoskeleton to provide physical exercises to bedridden patients suffering from Muscular Dystrophy from remote or inaccessible locations. Stepper motor and lead-screw-based actuation were adopted for controlled and real-time response. The exoskeleton developed provides flexion from 0◦ to 120◦ for the knee joint. Along aiding them with physiotherapy, patients health is monitored using several sensors, and cautions are given to physicians when there is a fluctuation in the health of a patient

The objective of the paper can be summarized as

1. Integrating motion monitoring sensors and NEMA 23 motor for controlled torque for the lower limb exoskeleton
2. Integrating health sensors viz oximeter, pulse sensor, temperature sensor and other sensors like IR sensors, angle sensor along with push buttons to control manually by the patient
3. To administer and examine the physiotherapy by providing real-time video feed using ESP32 Camera module and TTL Converter

II. COMPONENTS REQUIRED

1. ESP32 Wi-Fi module: ESP32 is a single 2.4 GHz Wi-Fi and Bluetooth combo chip as in Fig 2.1. ESP32 module is interfaced with all the sensors that are used to measures pulse, oxygen level and temperature. Also with the angle and IR sensor. TB6600 Motor driver which in turn is connected to NEMA 23 motor is integrated with ESP32 Wi-Fi module.

Fig 2.1

2. **NEMA 23 Motor**: Stepper motors provide better precision control and repeatability. They provide maximum holding torque which resonant with the human leg torque. This motor has a step angle of 1.8 degree and placed in order to move exoskeleton up and down with the clockwise and counter-clockwise movement of NEMA 23. NEMA 23 and motor driver is shown in Fig 2.2

Fig 2.2

3. TB6600 Motor Driver: It is an easy-to-use professional stepper motor driver, which could control a two-phase stepping motor. The stepper driver supports speed and direction control.

4. **Pulse sensor**: Pulse Sensor HBT-V2 is a well-designed plug-and-play heart-rate sensor shown in fig 2.3. The sensor clips onto a fingertip or earlobe and plugs right into ESP32.

Fig 2.3

5. **MAX30100 Pulse Oximeter Sensor**: Pulse Oximetry is a test used to measure the oxygen saturation level of the blood shown in fig 2.4. The MAX30100 is an integrated pulse oximetry and heartrate monitor sensor solution.

Fig 2.4

6. **Temperature sensor:** The DHT22 is a basic, low-cost digital temperature and humidity sensor shown in fig 2.5. Heat discharge by component will be monitored with the help of this sensor

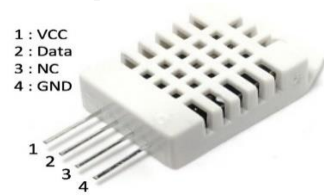

Fig 2.5

7. **IR sensor**: An infrared sensor is used for position sensing during normal cycle of operation shown in fig 2.6. It is used to map the data from the angle sensor during the calibration cycle. Presence of this avoids sudden backing of exoskeleton during failed cases.

Fig 2.6

8. **Angle sensor**: An angle sensor or rotary sensor establishes the position of an object in relation to a reference point shown in fig 2.7. Exoskeleton's movement is restricted to some angle, and to monitor the movement, angle sensor is used which helps in resetting the motor during the failed case

Fig 2.7

9. **Push button**: The push button is interfaced with ESP32 either through pull up resistor or pull-down resistor shown in fig 2.8. Wherein the patient undergoing the physiotherapy with this exoskeleton can use this push button in order to notify the care taker or the physician indicating his problem or may be out of tiredness or uneasy.

Fig 2.8

10. **ESP32 camera module**: The ESP32-CAM is a small size, low power consumption camera module based on ESP32 microcontroller shown in fig 2.9. It is used to provide the real time video feed of patient under exoskeleton physiotherapy.

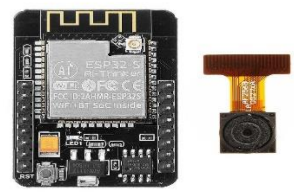

Fig 2.9

11. **TTL convertor:** The ESP32 camera module helps us achieve this virtual proximity with the at most concern of the patient safety. This module is connected to TTL module to interface with the computer for live video feed. TTL converter is shown in fig 2.10

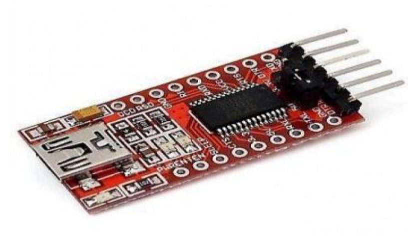

Fig 2.10

III. METHODOLGY

The exoskeleton frame is actuated using the lead screw linear slide actuation mechanism. The exoskeleton frame is as shown in fig 3.1. NEMA 23 and TB6600 Motor driver is powered by a DC source. ESP32 runs the control algorithm to operate the device appropriately using Arduino IDE. The Motor is controlled using ThingsBoard software. Along with motor control, Thingsboard software is used to monitor the health condition of the patient and will be supervised when required by the physician. Certain health monitoring sensors are connected to ESP32 and will be connected to Thingsboard.

IR sensor and Angle sensor have connected the exoskeleton to get real-time feedback from the exoskeleton's movement. To administer and examine the physiotherapy, a real-time video feed is used with the help of the ESP32 Camera module and TTL Converter. The design framework is as shown in the block diagram as in fig 3.2.

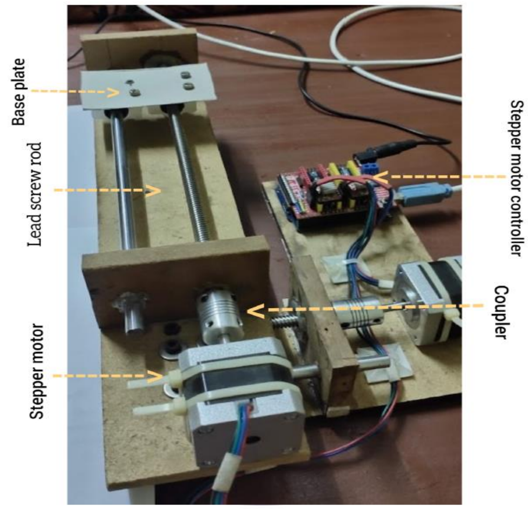

Fig 3.1

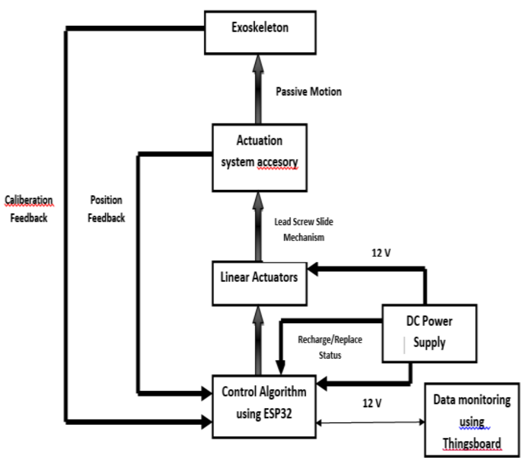

Fig 3.2

IV. SYSTEM FLOWCHART

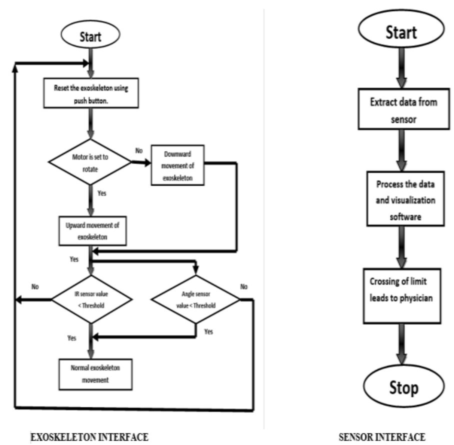

Fig 4.1

There are two interfaces in the work as shown in fig4.1. The first one is the exoskeleton interface, other is the sensor interfaces. The patient is recommended to do several exercises to strengthen their muscle. Those sets of an exercise are repeated for few times and will be decided by the physician according to the condition of the patient. Moving up and down of the leg by the muscular dystrophy patient is impossible, so to address this, exoskeleton aid them in doing the exercise. NEMA 23 and TB6600 motor driver is placed at position 4 as in figure 4.4. The clockwise movement of the motor makes the exoskeleton move upward and the counter-clockwise movement of the motor makes the exoskeleton move downward. An exoskeleton is made to move to a certain angle according to the patient's condition recommended by the physician.

ISSN (Online) 2394-2320

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)

Vol 8, Issue 5, May 2021

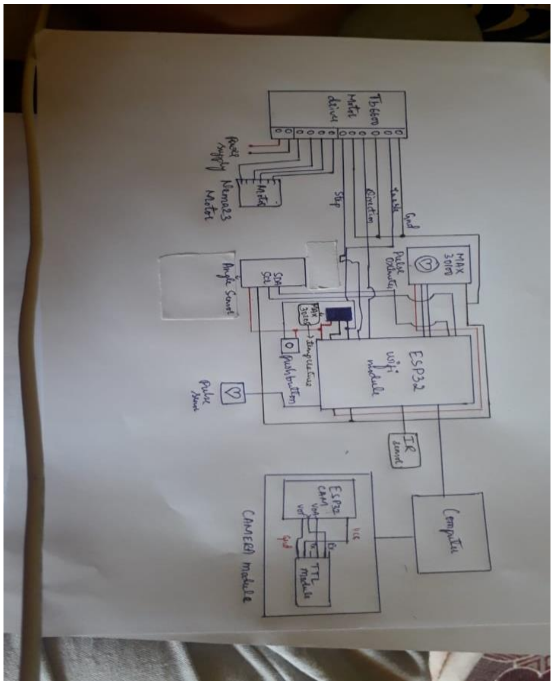

FIG 4.2

If in a case due to the fault in the motor, the exoskeleton crosses the angle threshold then ESP32 is programmed to reset the NEMA 23 which makes the exoskeleton to be in the rest position. IR sensor is placed to detect the position of the exoskeleton, in case the exoskeleton move beyond a threshold it will be detected by IR sensor and again NEMA 23 motor is made to come to the rest position. The patient will have a manually controllable push button within a reachable region which he can control whenever he feels uneasy or tired during exercise.

The sensor interfaces contain ESP32 interfaced with a pulse sensor, pulse oximeter sensor, temperature sensor, angle sensor, IR sensor as shown in the figure. The camera module is connected to the TTL converter to have a live feed of exoskeleton movement. The entire interface with the sensors is as shown in fig 4.2

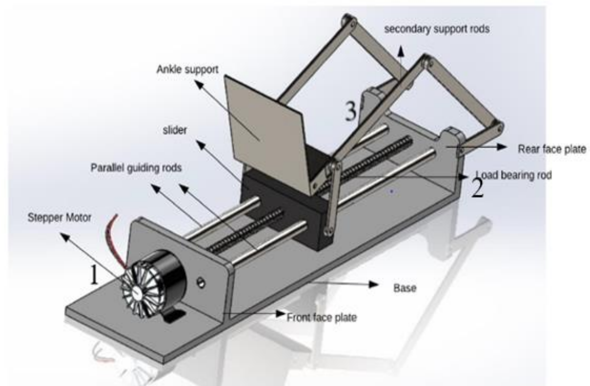

Fig 4.3

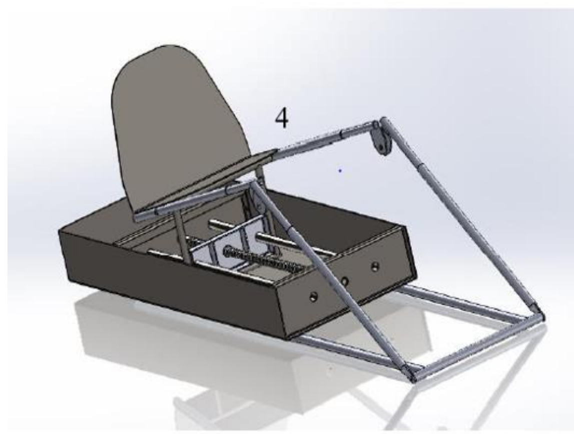

Fig 4.4

V. RESULTS

The target of the proposed work is to aid muscular dystrophy patients in strengthening their muscles with physiotherapy. The wearable exoskeleton is worn by the patient. Certain exercises are prescribed by the physician to strengthen their muscle. NEMA 23 connected at the bottom helps in moving the leg up and down with the motor's clockwise and counter-clockwise rotation. In the failed condition of the exoskeleton, the IR sensor and angle sensor are placed in positions 2 and 3 respectively as shown in fig 4.3, to detect the sudden reversing of the exoskeleton in failed conditions.

Health sensors are placed outside the exoskeleton to monitor the health status of the patient. A pulse rate sensor is used to know the heart pulse status, the oximeter is used to check the oxygen saturation level in the patient's body. If there is any heat dissipation from the motor which affects the patient's skin will be detected by the DTH22 temperature and humidity sensor. All the sensor values will be displayed on the monitor using an appropriate widget to visualize the data from the sensors easily

VI. CONCLUSION

Muscular dystrophy is one of the inherited diseases, which over time reduces muscle strength which trouble walking, loss of reflexes, difficulty in standing up, will have a poor posture, Will have frequent falls. Physiotherapy can help them with this. To aid physiotherapy, an exoskeleton is built with an actuator and will be controlled by the physician. In the IoT world, making use of technology health sensors are used to have a clear vision of patient health status. Alerts will be given to physician in case of the severe condition by setting the thresholds

REFERENCES

1. An adaptive controller for human lower extremity exoskeleton robot- Microsystem Technologies, 2021
2. Robotics in Lower-Limb Rehabilitation after Stroke, Neural Engineering for Rehabilitation, Behavioural Neurology,Hindawi 2017
3. Pleated pneumatic artificial muscle-based actuator system as a torque source for compliant lower limb exoskeletons, IEEE/ASME Transactions on Mechatronics, 2014
4. Data security of android applications, 12th International Conference on Natural Computation, Fuzzy Systems and Knowledge Discovery (ICNC-FSKD), IEEE, Aug. 2016
5. A Review of Lower Extremity Assistive Robotic Exoskeletons in Rehabilitation Therapy, Critical Reviews in Biomedical Engineering, vol. 41, no. 4-5, pp. 343-363, 2013