A Safe and Comfort Bed for Cerebral Palsy Babies-Bedstead

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Abstract. Cerebral palsy is a disorder that affects the muscle tone, movement and motor skills. Few percent of children affected with cerebral palsy experience problems while sleeping. These include seizure attacks, muscle spasms, pain, respiratory problems, etc. Bedstead is a unique bed designed for the cerebral palsy babies, which automatically massages the baby using vibration motors when some discomfort arises. An EMG placed on the baby senses the muscle spasms, which drives the vibration motors. Additionally, an accelerometer sensor detects seizure attacks by the principle of fall detection. During a seizure attack, a technical buzzer will alarm the caregivers, thereby reducing life-threatening conditions. If left untreated, these complications can result in dangerous situations. Another feature of this set up is that the parameters sensed is uploaded in a cloud, and also sent to caregivers as well. This bed ensures that the babies can have a deep and uninterrupted sleep with little or no intervention from the professional caregivers or family members.

1. Introduction
Cerebral palsy is a neurological disorder occurring due to unusual development of brain that affects muscle control and movement. Any injury occurring before or during childbirth is a major cause of cerebral palsy.\textsuperscript{[1],[2]} As they grow and develop, children with cerebral palsy struggle to regulate their muscles and movement. Through survey it is noted that 3.8% of Indian population is affected by cerebral palsy. Three children out of 1000 in India suffer with this condition. The disorder varies in each individual, from total paralysis to slight movement tremors, requiring little assistance.\textsuperscript{[3],[4]} The condition is incurable and permanent. Cerebral palsy is caused by a variety of factors, including infection during pregnancy, genetic connection, irregular brain growth or lack of oxygen to the brain. These damage the section of the brain that controls posture, movement and coordination. Cerebral palsy is classified into five types depending on which part of the brain is affected which thereby affect a specific movement of the body. They are, Mixed Cerebral Palsy Dyskinetic Cerebral Palsy, Hypotonic Cerebral Palsy, Ataxic Cerebral Palsy and Spastic Cerebral Palsy.\textsuperscript{[5],[6],[7]} Babies and kids affected with CP most of the time experience sleep issues. The usual reasons for trouble sleeping in children with CP are conditions like seizures, muscle spasms, pain, difficulty in breathing, or gastrointestinal upset \textsuperscript{[8],[9]}. Many numbers of studies conducted has shown that as many as half of all children diagnosed with CP suffer from a sleep disorder.\textsuperscript{[10],[11]} Disturbance while sleeping can interfere with learning, mental functioning, emotional functioning, and social functioning. Many of these CP kids need attention of parents and care givers through the night. This further hinders with the day-to-day activities of the parents as well.\textsuperscript{[12],[13]}

We have designed a bed that offers many significant benefits that enhance and improve the lives of the users while reducing long term care and medical benefits. It significantly reduces the risk of developing muscle spasms and seizure attacks that are painful and life-threatening. Paramount importance is given to the safety of the
2. Materials and methods
A. HARDWARE COMPONENTS

Arduino Atmega 328
Atmega328 is an AVR based 8-bit Microcontroller with a 32 Kb built in internal memory operating in the range 3.3V-5 V. This microcontroller is cost efficient, dissipates low power, has a programming lock for security and included with a real timer counter with separate oscillator.

EMG sensor (RKI-2401)
Depending on the amount of activity in the chosen muscle, the EMG sensor measures the filtered and rectified electrical activity of the muscle. Powerful microcontrollers and integrated circuits enhance the sensing of the EMG sensors.[14]

Vibration Motors
The vibrating motor in use is unbalanced, with an off-centered weight attached to the motor's rotational shaft, which generates centrifugal force as it rotates. This unbalanced force causes the motor to vibrate.[15]

L293D Motor Driver Module
L293D is a Motor Driver IC in which the DC motor rotates in both directions. A single L293D IC can control two DC motor simultaneously.

ESP 8266 Wi-Fi Module
The ESP8266 WiFi Module with integrated TCP/IP protocol stack will connect the microcontroller to your WiFi network.

Buzzer
A buzzer or beeper is a 2 pin audio device used in our system to produce an alarm (sound signals) if the acquired bio signals cross over a threshold.

B. SOFTWARE COMPONENTS

Embedded C Program
Microcontrollers are mostly programmed using Embedded C language. The written C code is more dependable, flexible, compact, and understandable. External devices can be monitored and regulated with the aid of these programmes. [16][17] They can also directly function and use the microcontroller's internal architecture, such as timers, serial communication, and interrupt management.

C. BLOCK DIAGRAM DESCRIPTION
The bed in is made up of a material named dephron. The material is cheap and safe. The bed promotes better health and an improved lifestyle for bed users and their care-givers. Another unique feature of the bed is that it can detect fall during a seizure attack. The Bedstead is fitted with on board sensors such as EMG sensor, Accelerometer which reads out the value of muscle spasms and seizure attacks or any falls. The bed’s managing system closely mimics the massage as done by humans and re-establishes the blood flow, thus promoting sleep and thereby reducing the complications during a seizure attack. (Figure 1)
Figure 1: Block diagram of the system

The EMG Sensor and accelerometer are respectively used to detect the electrical activity of the muscle and detect any fall by the baby. If the baby experiences a muscle spasm, the electrical activity of the muscle will vary in turn triggering the buzzer alarms. Simultaneously the vibration motor starts to vibrate with the help of the L293D motor driver.[18] In case of a seizure attack, the accelerometer sensor detects the fall rate and produces an alarm alerting the parent or caregiver. The EMG values and the angle of fall are also displayed on an LCD display. [19] The ESP8266 Wifi Module transfers the data to the caregivers or doctors immediately. All these data are also stored within an app with the help of IoT. Arduino microcontroller is used to store the sensed values and used for actuation [20] (buzzer and vibration motors). The flow in which the entire process is given in Figure 2.

Figure 2: Flow chart of the working of Bedstead.

3. Results and discussion

Our results cast a new light on the ways to promote sleep in Cerebral Palsy children by massaging the babies using L293D which runs the vibration motors during muscle spasms. The respiration rate and seizure attacks are also monitored and the values displayed on LCD display. Additionally, the data is sent to Thingspeak
account using ESP8266 Wifi module. (Figure 3)

**Figure 3:** Prototype model of Bedstead with sensors

The EMG electrodes placed on the subject reads the EMG values and the normal values and peak values are displayed on the LCD display. The values of the accelerometer sensor are displayed on the LCD display. As soon as a fall is detected during a seizure attack, a buzzer will alarm the caregivers. (Figure 4)

**Figure 4:** Detection of fall on LCD

Once the peak value(threshold) is set, whenever the value crosses the peak value, the vibration motors are turned ON using the L293D motor driver module. Also, the obtained values are recorded in the form of line graph using internet of things by utilizing the ESP8266 Wi-fi module.
After monitoring it is for 12 seconds, the data is uploaded in the internet. In the above graph (Figure:5) data is mentioned in the x-axis and EMG values are mentioned in the y-axis. From the graph, we can infer that on a specific day, the EMG value was 904, which indicates a muscle spasm thereby turning on the vibration motors and on another day the value dropped to 50 approximately, later rising up to 1000. Therefore, whenever the EMG value is high the vibration motor is turned ON, thereby massaging the baby. (Figure 6)

The greatest advantage of our proposed cerebral palsy bed is that it automatically massages the baby using vibration motors, during muscle spasms and to notify the parents using a buzzer during a seizure attack. Additionally, it also records the data using “Internet of Things” so that the doctors can study the fault and prescribe the right medications thus reducing the life-threatening conditions.

4. Conclusion

We have achieved our goal to develop a prototype for cerebral palsy babies suffering from sleeping discomforts. The bed designed by us consists of vibration motors which give a massaging effect to the baby during the onset of muscle spasms, thus improving the blood flow, which ultimately promotes sleep without the aid of caregivers. Therefore, even the caregivers get a proper sleep, without any disturbance so that they can carry out their day-to-day activities in a smooth manner.
Precisely fall detection is done by the accelerometer sensor and a buzzer will alarm the parents, if the baby has a seizure attack so that they can give first aid and give the right medication at the right time which will save the baby’s life. The bed designed by us is supposed to increase the baby’s safety by detecting seizure attacks using an accelerometer sensor, thus decreasing the life-threatening conditions. Safety, configurability, robustness, and cost were the most important specifications of the bed.

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