PRELIMINARY WORK ON THE DEVELOPMENT OF EXOSUIT FOR DIFFERENTLY ABLED

BY:
ZULHAKIMI ADHILI BIN ZULKIFLI
1. Introduction
2. Problem Statement
3. Objectives
4. Scope of Study
5. Literature Review
6. Methodology
7. Results and Discussion
8. Conclusion
9. Further Recommendation
10. References
Robotics rehabilitation may replace a therapist's physical training effort, allowing for more vigorous repetitive motions and delivering treatment at a reasonable cost. Traditional rehabilitation techniques are very labor-intensive particularly for the recovery of gait, often involving three therapists or more together to physically help the patient's legs and during therapies session. Exosuit is one of the robotics tools that may help disabled people to restore their muscle memory in order to regain mobility.
PROBLEM STATEMENT

• The lack of physical training commitment of a therapist to ensure that the disabled get the rehabilitation treatment.
• The expenses to meet the therapist is quiet high.
• Burden for disabled to meet the therapist often.
OBJECTIVES

To design exosuit for disabled.

To generate the Arduino coding.

To analyse the voltage and current of the stepper motor.
SCOPE OF STUDY

• The project is limited through these scope limitations which are this project will design and developed the exosuit. This project is started by studied the design from the journal and exoskeleton that already exist. The project then developed according to the research.
<table>
<thead>
<tr>
<th>SCOPE OF STUDY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Identify</strong></td>
</tr>
<tr>
<td>Identify the process flow and mechanism of exosuit prototype.</td>
</tr>
<tr>
<td><strong>Design</strong></td>
</tr>
<tr>
<td>Design the working system and develop the Arduino program to control the moving parts of the prototype.</td>
</tr>
<tr>
<td><strong>Select</strong></td>
</tr>
<tr>
<td>Select suitable Arduino devices to be installed in the prototype.</td>
</tr>
<tr>
<td><strong>Program</strong></td>
</tr>
<tr>
<td>Program the Arduino device according to the system requirement.</td>
</tr>
<tr>
<td><strong>Design</strong></td>
</tr>
<tr>
<td>Design electrical circuit for exosuit</td>
</tr>
<tr>
<td>Title and reference</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>Alan T. Asbeck, Kai Schmidt, Conor J. Walsh</td>
</tr>
<tr>
<td>Title and reference</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>Title and reference</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
</tbody>
</table>
• Doesn’t need wire or any other electric conductor to transmit data. | Short range communication between two device. | The exosuit is communicate with the Arduino Bluetooth application using HC-05 Bluetooth module |
METHODOLOGY

System block diagram
HARDWARE

Arduino UNO
- Pins: 14
- Model: ATmega328P
- 6 analog inputs
- 16 MHz quartz crystal
- 1 USB connection
- 1 power jack
- 1 ICSP header
- 1 reset button
MOTOR DRIVER (DM542)

- Suitable for 2-phase and 4-phase motors.
- Over-voltage, over-current protection
- Input voltage 18-50vdc
- Soft-start with no “jump” when powered on
- Anti-resonance provides optimal torque and nulls mid-range instability
- Automatic idle-current reduction
86BYG250B 86 Stepper motor

Step Angle: 1.8 Degree
Phase current: 5Amp
Drive voltage: AC40/80V
Max static torque: 5.0Nm
Resistance/phase: 0.83ohm
Inductance/Phase: 5.5mH
Rotor inertia: 2550 gcm2
Weight: 3000 grams
No-load start rotation speed: 252 rpm
4-CHANNEL RELAY CONTROLLER FOR I2C

- 4 MCP23008 CONTROLLED MECHANICAL RELAYS
- EXPANDABLE TO 8 CONTROLLERS PER I2C PORT
- 1.7 MHZ COMMUNICATION SPEED
- FOUR PROGRAMMABLE DIGITAL I/O
SOFTWARE

- Arduino IDE
  - write and upload programs to Arduino compatible boards, with the help of 3rd party cores.
SOFTWARE

- Arduino Bluetooth controller
  - to connect the exosuit HC-05 Bluetooth module with the android device.
### Prototype Parts Analysis

Refer part number in diagram given below.

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Part Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Motor and Disk</td>
<td>Motor is loaded onto the motor casing and disk acts as the medium of angular force distribution. Two 85 kg-cm stepper motors are used in this model.</td>
</tr>
<tr>
<td>02</td>
<td>Motor Casing</td>
<td>Holds the motor, motor driver and accompanying microprocessors.</td>
</tr>
<tr>
<td>03</td>
<td>Motor-knee shaft</td>
<td>Acts as the link connecting motor disk and knee joint. The absence of this shaft would cause the knee joint to be free of any mechanical support and would sag to either side.</td>
</tr>
<tr>
<td>04</td>
<td>Shaft-knee coupling</td>
<td>Connects the motor-knee shaft to the knee joint. Without this part the knee would not be pushed forward with each stride as it acts as a force direction shifter.</td>
</tr>
<tr>
<td>05</td>
<td>Calf Support</td>
<td>This piece connects the knee joint to foot plate and supports the calf during the stride. Straps and clamps would be fixed onto this piece to hold the user's leg in place with the exoskeleton.</td>
</tr>
<tr>
<td>06</td>
<td>Angle Joint</td>
<td>The angle joint is fixed and does not move around the pivot. This is to avoid foot drag or toe drag situations.</td>
</tr>
<tr>
<td>07</td>
<td>Foot plate</td>
<td>The foot plates support the feet while the limb is in stride and protects the feet from roughness in the walking plane.</td>
</tr>
<tr>
<td>08</td>
<td>Foot support bar</td>
<td>These pieces acts as a support beam from the knee to the foot plate to hold the foot plate in the right angle and distribute the weight of the leg evenly to the ground.</td>
</tr>
<tr>
<td>09</td>
<td>Knee Joint</td>
<td>The knee joint is the pivot around which the calf and knee rotate with respect to each other. The foot support bar and the motor-knee shaft is coupled here. It forms an integral part of the walking stride.</td>
</tr>
<tr>
<td>10</td>
<td>Hip Joints</td>
<td>Both limbs of the exoskeleton are connected to the side bars to form the joint at the hip. These joints form a major pivot around which the whole stride of the leg is dependent upon.</td>
</tr>
<tr>
<td>11</td>
<td>Thigh Support</td>
<td>This piece connects the knee joint to the hip and supports the thigh during the stride. Straps and clamps would be fixed onto this piece to hold the user's leg in place with the exoskeleton.</td>
</tr>
<tr>
<td>12</td>
<td>Belt slot</td>
<td>This slot is provided on both side bars to connect belts and harnesses that would help to mount the device onto the user.</td>
</tr>
<tr>
<td>13</td>
<td>Hip side-bars</td>
<td>These form the structure around the hip and joins the limbs to the hip part.</td>
</tr>
<tr>
<td>14</td>
<td>Motor-hip shaft</td>
<td>These shafts transfer motive force to the top of the thigh support bar so that the limb pivots around the hip joint in a 10 and from motion.</td>
</tr>
</tbody>
</table>

*All parts in the above list except the motor casing consists of two parts – left and right for each leg. The letters L and R would be suffixed to the part number from here on to refer to a part from one side in specific. For example, part 01L would refer to the motor and disk on the left leg side.*
Assembly of the prototype.
ARDUINO CODING

```cpp
#include <Stepper.h>

const int stepsPerRevolution = 13110; // change this to fit the
// for your motor
int relay=2;
// initialize the stepper library on pins 8 through 11:
Stepper myStepper(stepsPerRevolution, 8, 9, 10, 11);
int i;
void setup() {
  // set the speed at 20 rpm:
  myStepper.setSpeed(20);
  pinMode(relay, OUTPUT);
  // initialize the serial port:
  Serial.begin(9600);
}
void loop() {
  while(i>=0)
  {
    //
    if(i--==0)
    {
      //
    }
  }
}
```

Sketch uses 3154 bytes (9%) of program storage space. Maximum is 3.
Global variables use 230 bytes (11%) of dynamic memory, leaving 18...
// Establish the serial port
Serial.begin(9600);

void loop() {
  while(i>=0)
  {
    if(i%2==0)
    {
      digitalWrite(1, HIGH);
      Serial.println("Motor1");
      myStepper.step(stepsPerRevolution);
      i++;
    }
    else
    {
      digitalWrite(2, LOW);
      Serial.println("Motor2");
      myStepper.step(stepsPerRevolution);
      i++;
    }
  }
}
RESULTS AND DISCUSSION

The coding of Arduino is according to the system protocol.

The exosuit help the disabled to walk during the recovery period.

The man power to help the disabled move no longer needed.
<table>
<thead>
<tr>
<th>Condition of motor</th>
<th>Voltage (V)</th>
<th>Current (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static</td>
<td>23.7</td>
<td>5</td>
</tr>
<tr>
<td>Running</td>
<td>24</td>
<td>5.2</td>
</tr>
</tbody>
</table>
Chart voltage and current of the stepper motor
• Solidword drawing of the exosuit
ELECTRICAL SCHEMATIC DIAGRAM FOR EXOSUIT PROTOTYPE
CONCLUSION

This lower limb exoskeleton prototype is to help disabled with walking disabilities in their therapies.

The system contains two main parts which are the mobile phone and the exosuit.
FURTHER RECOMMENDATION

- Enhancement of the exosuit design to be more compact and lightweight
- Employ other wireless technology for wider coverage to allow the collectivity of movement data which may aid the learning of the patient’s progress in walking recovery for health system
REFERENCES


• Anisha Cotta, Naik Trupti, Varda Kalidas. Wireless communication using HC-05 Bluetooth module interfaced with arduino. 2016;5:4