SOP for Haptic Feedback for Stroke Rehabilitation in Virtual Environments

Purpose

This SOP provides step-by-step instructions for assembling and operating a haptic feedback system integrated with a Meta Quest2 VR application. The system is designed to aid stroke patients through immersive therapy, enhancing physical rehabilitation by combining VR exercises with precise haptic feedback. This document ensures consistent procedures, maximizes safety, and helps mitigate potential risks associated with handling batteries and haptic motor components.

Context

This procedure is designed to guide stroke patients and their assisting healthcare providers, such as nurses or therapists, in using the VR Haptix system safely and effectively. By following these instructions, patients can engage in immersive therapy that enhances their recovery experience, while healthcare providers can ensure consistent operation and optimal performance of the system.

Definitions

- **Haptic Feedback:** Technology that simulates the sense of touch through vibrations or motions.
- **ERM Motor:** Eccentric Rotating Mass motor, used for generating vibration.
- **DRV2605L:** A haptic driver IC used to control vibration intensity and patterns.
- **TCA9548A:** An I2C mux for connecting multiple drivers and motors.
- **LiPo Battery**: A Lithium Polymer battery used as the primary power source for the system.

Tools and Equipment

- **Hardware Components:**
    - ESP32 Microcontroller
    - Eight Flex PCBs with TCA9548A mux, DRV2605L drivers and 64 ERM motors
    - 3.7V, 450mAh LiPo battery (microcontroller power)
    - 3.7V, 4000mAh LiPo battery (Flex PCB power)
    - Battery level Indicator
    - Meta Quest2 VR headset
    - SPDT swicthes
- **Software Requirements:**
    - VR Haptix application

- Software for TCP, I2C communication setup

How to Assemble and Operate the System

1. Battery Management

1.1 Check the charge level of LiPo batteries using a multimeter. Ensure they are at a safe charge level (between 20% - 80% for storage, fully charged for testing).
1.2 If charging is needed, place batteries in a fireproof bag and connect them to a compatible charger. Do not leave unattended during charging.
1.3 Store batteries in a fireproof bag when not in use.
1.4 Dispose of damaged batteries following proper e-waste guidelines.

2. Hardware Assembly

2.1 Connect the ESP32 microcontroller which is the Power PCB to the Flex PCBs using FPC connectors.
2.2 Power the system:
- Use the 450mAh LiPo battery for the microcontroller.
- Use the 4000mAh LiPo battery for the Flex PCBs.
2.3 Connect the DRV2605L to the microcontroller using I2C. Ensure proper connections (SDA, SCL, VCC, GND).
2.4 Load the appropriate haptic feedback libraries into the Arduino IDE.
2.5 Upload a test sketch to verify communication between the microcontroller and DRV2605L.
2.6 Use predefined vibration profiles to test each driver, ensuring accurate response.

3. Software Setup

3.1 Install the VR Haptix application on the Meta Quest2 headset.
3.2 Establish TCP communication between the headset and the ESP32 microcontroller. Begin by running the controller code to initialize the system. Once the controller is active, launch the Unity application, which will automatically establish a connection to the WiFi network.
3.3 Ensure that the same code has I2C communication setup with mux and drivers as well.

4. Testing

4.1 Start the VR Haptix application and calibrate the intensity levels.
4.2 Test individual motor vibrations for accuracy and ensure simultaneous actuation.
4.3 Validate therapy levels (easy, medium, hard) with corresponding haptic feedback intensity.
4.4 Perform a basic functionality test with a safe, low-intensity vibration pattern to ensure proper behavior.
4.5 Gradually increase intensity and test each functionality (including waveform selection) to validate performance.

5. Operational Guidelines

5.1 Ensure the batteries are fully charged before use. There is a battery indicator used. If it turns red, then the batteries has to charged.
5.2 If an ERM motor overheats, stop testing immediately, allow it to cool down, and inspect for damage.
5.3 Follow safety protocols for handling LiPo batteries to avoid overheating or damage.
5.4 Monitor the system for consistent feedback during therapy sessions.

6. Post-Session Maintenance

6.1 Disconnect all power sources after each session.
6.2 Inspect hardware for wear or damage.
6.3 Update software to the latest version, if available.

7. Documentation

7.1 Record battery usage, including charge cycles, voltage before and after each test, and any abnormalities.
7.2 Maintain logs for vibration intensity tests, including any changes to default parameters.
7.3 Keep track of component wear and tear, especially for ERM motors and battery health.

References

- Meta Quest2 User Guide
- Lipo Battery Safety Warning
- ESP32 Wroom 32 Datasheet
- DRV2605L datasheet
- I2C mux datasheet
- ERM motor Datasheet

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