PROBLEM STATEMENT

Amputee rehabilitation is challenging and lacks personalization.

- Amputees have to deal with the physical pain of losing a limb along with the overwhelming emotional toll of losing dignity and control. For 57 million people worldwide as of 2017, this is their daily reality.
- Rehabilitation for amputees is a challenging and painful journey. Amputees experience ‘phantom limb pain’, which happens after an amputation; nerves which are severed continue to fire looking for something that no longer exists and this manifests as pain for the amputee.
- To counteract this pain, prosthetic limbs are used but they not easily accessible to many amputees due to high costs, adding to their emotional distress. Even those which are accessible are not personalised to an amputee’s needs.

SOLUTION

Mirror therapy, which uses the reflection of an existing limb to trick the brain into perceiving movement in a phantom limb, is highly effective for phantom limb pain. Our solution builds on this by integrating mirror therapy principles with VR, using sensors to simulate limb movement and recreate the sensation of a moving limb in a virtual environment.

Our solution has 3 primary goals:

- To give disabled people the ability to control a virtual limb
- Pairing the above with a virtual assistant and an immersive experience, we allow amputees to rediscover the joy and wonder of touch to ease their emotional burden and physical pain at a lower cost than a prosthetic limb, offering a cost-effective alternative to prosthetics, especially with AR technology for everyday tasks in day-to-day life.
- For a broader impact, our solution can be used to collect muscle data and feedback from its users to help with the future customization and development of prosthetic limbs

What Makes Us Unique?

- Combines mirror therapy with VR , making it cheaper and more accessible than prosthetics
- Integrates both EMG and haptic devices, a rarity in virtual limb technology
- Leverages latest research in machine learning and EMG signal processing, making it superior

SOLUTION

STEP 1: Machine Learning Classification

Database	Signal Processing	Feature Extraction	Dimensionality Reduction	Machine Learning Classification
Taking a pre-existing dataset, specifically GRABMyo dataset containing EMG signals for wrist and forearm muscle movements for simple hand gestures.	* Convert the dataset to a MATLAB file *Apply Average Referencing to improve the accuracy of the recorded EMG signals. *Use three common filters for EMG signal filtering using Band-Pass Filter, Notch Filter High-Pass Filter *Utilize Biorthogonal 3.3 Discrete Wavelet Transform (DWT) to analyze the signals and separate them into discrete frequency bands.	Use feature extraction techniques to achieve high accuracy from EMG signals: - Mean Absolute Value (MAV) - Waveform Length (WL) - Zero Crossing (ZC) - Slope Sign Change (SSC) - Root Mean Square (RMS) - Energy of Wavelet Coefficients (EWC) - Enhanced Mean Absolute Value (EMAV)	Use Linear Discriminant Analysis (LDA) to: - Reduce dimensionality - Simplify computational tasks - Aid in understanding complex data structures - Improve overall model performance	We will use a Support Vector Machine (SVM) as our machine learning model for this dataset. This will map the signals to relevant virtual hand positions.

This procedure has been chosen as per latest research provided by this research paper.

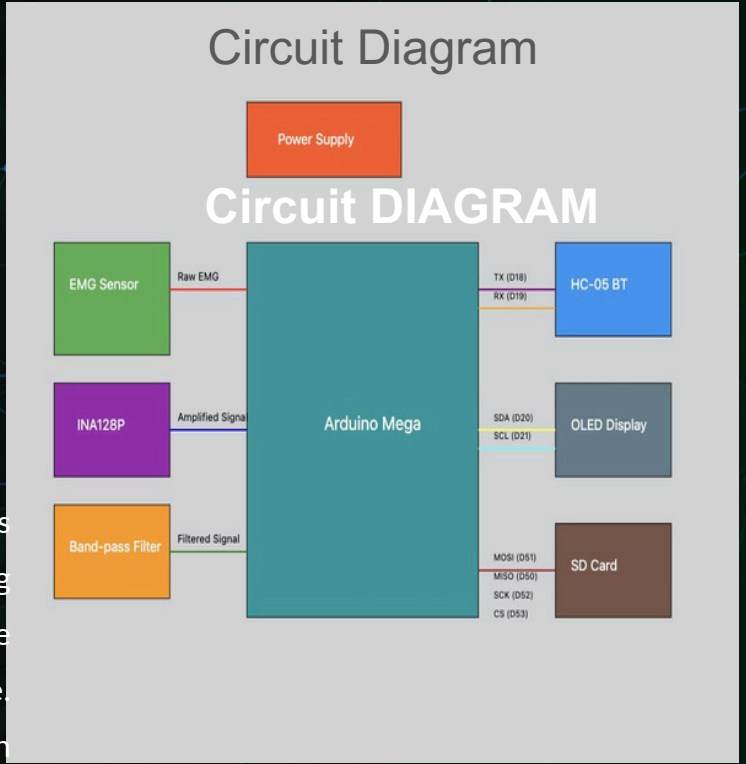
SOLUTION

STEP 2: Setting Up VR Environment & ASSISTANT

- Using Blender and SketchFab we will create and rig 3D model of a hand which will be able to perform basic hand gestures as given in the dataset.
- Set up a world environment using Unity and add the hand. The environment will be interactive, re-creating various rehabilitation exercises in use for amputees in a virtual world.

STEP 3: Integrating VR and Hardware

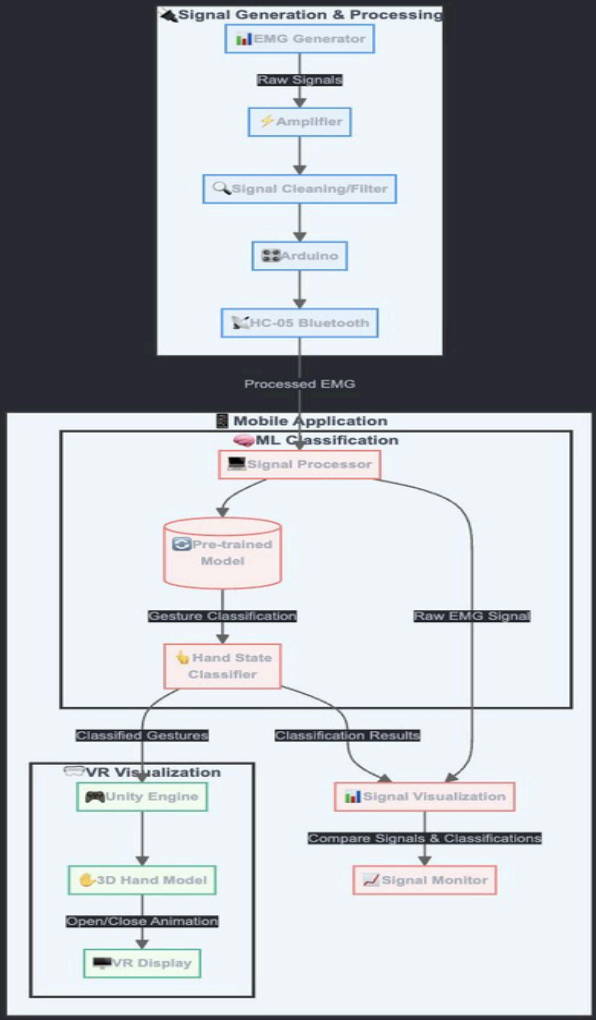
- The EMG and haptic devices will be connected to Arduino. EMG sensors will be placed in appropriate locations on the forearm to track incoming EMG signals from the associated muscles. This setup will be done inside a glove/wearable accessory and Arduino will be attached to the same.
- The microcontroller will be connected to the VR headset via Bluetooth Module. VR headset will display environment set up in Unity.



SOLUTION

WORKING PRINCIPLE:

- Amputees can still control muscles in the amputated limb despite the limb not being present.
- When a gesture is made, the EMG sensor detects muscle vibrations.
- Pre-trained ML model will classify these signals into specific hand movements.
- The classified gesture is then replicated in a VR environment, tricking the brain into perceiving actual hand movement, reducing phantom limb pain.
- Haptic devices provide basic sensations (e.g., wind), enhancing the experience.



TECH STACK

- FRONTEND: Unity, HTML, CSS, JavaScript
- BACKEND: TensorFlow, C#, SciKit- learn, Blender, Python (Flask), PyTorch, MATLAB, SketchFab, Arduino IDE
- DATABASE: N/A
- API's/SERVICES: Flask, Dotnet
- HARDWARE: EMG Sensors, Arduino(Mega/Nano), Wires, Haptic Devices, VR Headset, EMG Signal Generator Module, HC-05(Bluetooth Module), Batteries, OLED Display, INA128P (signal amplifier), SD Card (Optional) ,Band-pass filter

Domains Covered: Machine Learning, VR/AR, IoT

BUSINESS SCOPE

Value to Organizations

- **HEALTHCARE CENTERS**: Offers interactive rehab to help amputees manage phantom limb pain and speed up recovery. Integrating with AI technology, we can create a doctor-assisted virtual assistant for personalised recovery to allow rehabilitation from the comfort of home.
  PROSTHETICS COMPANIES: Provides muscle data to improve prosthetic designs.
- **RESEARCH INSTITUTIONS**: Supports studies in neurorehabilitation, biomechanics, and phantom limb pain.
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Revenue Potential

- **DATA PARTNERSHIPS:** Revenue from sharing anonymized data.
- **CUSTOM SOLUTIONS**: Tailored premium features.
- **GRANTS AND SPONSORSHIPS**: Funding through health and rehabilitation grants.