3. Transcutaneous Magnet Localizer for a Self- Contained Myokinetic Prosthetic Hand.

Methodology: The methodology consisted of designing and validating a novel transcutaneous magnetic tracking system, where small biocompatible permanent magnets were implanted into the residual muscles of an amputated limb, and their movements were tracked externally using an array of 3D magnetic sensors. The system captured variations in the magnetic field caused by muscle contractions, allowing for real-time position tracking to control a prosthetic hand in multiple degrees of freedom.

Results: The results demonstrated that the system could localize single magnets with sub-millimeter accuracy and manage the simultaneous tracking of up to three magnets with minimal interference, validating its performance both in static and dynamic tests under simulated clinical conditions.

Challenges: Challenges encountered included managing the complex interactions and cross-talk between multiple magnetic fields when more than one magnet was implanted, ensuring reliable signal acquisition despite changes in limb orientation, and minimizing the effects of external magnetic noise.

Future Improvements: Future improvements are expected to focus on increasing the resolution and sampling rate of the sensor array, improving the computational algorithms for magnet localization and signal separation, and reducing the hardware size for easier integration into wearable prosthetic systems.

Goals: The overarching goal of this research was to provide an intuitive, precise, and self-contained method for controlling myokinetic prosthetic hands, enabling amputees to perform natural and independent hand movements through direct muscle activation.

4. Neural Network-Based Lower Limb Prostheses Control Using Super Twisting Sliding Mode Control

Methodology: The methodology involved designing a hybrid control approach for lower limb prostheses by combining Super-Twisting Sliding Mode Control (ST-SMC) with an Artificial Neural Network (ANN) to address the nonlinear dynamics and external disturbances affecting the prosthetic knee joint during gait. A three-layer feedforward ANN was used to estimate unknown disturbances and uncertainties in real-time, and the ST-SMC component ensured robust control performance by reducing tracking errors and chattering effects.

Results: The results from simulations conducted in MATLAB/Simulink demonstrated that the proposed controller effectively maintained stable and accurate knee joint motion, even in the presence of dynamic uncertainties and noise, showing significantly improved performance over conventional sliding mode controllers, particularly in minimizing chattering and achieving smoother joint trajectories.

Challenges: The main challenges included accurately modeling the highly nonlinear behavior of the human-prosthesis interaction, ensuring the neural network's capacity to learn and adapt to real-time changes, and maintaining computational efficiency for real-time control applications.

Future Improvements: Future improvements are expected to focus on implementing the controller in physical hardware for experimental validation, improving the ANN with more advanced learning techniques or architectures for better adaptation and faster convergence, and extending the control system to manage multi-joint prosthetic limbs for more natural and complete leg movements.

Goals: The overarching goals of the research were to develop a reliable, adaptive, and robust control system for powered lower limb prostheses that ensures stable gait, enhances user safety and comfort, and ultimately improves mobility and quality of life for amputees.