ABSTRACT

Due to severe neuro-muscular damage, people often lose voluntary muscle control of the upper limb and thereby grasping ability. Existing Electro-EncephaloGraphy (EEG) controlled upper limb prosthesis can provide them a solution, however, with only a few degree-of-freedom (DoF) of the hand- Open and Close. Researchers have already deciphered Palmer, Precision and Pinch grasp patterns from motor imagination (MI), but other grasp types are still needed to be explored for precise manipulation. Apart from grasp pattern selection, essential object descriptions are also required for a semi-autonomous prosthesis for precise object manipulation. Object localization along with its shape, size, and orientation, is too challenging task to be decoded from EEG, even after considering immense concentration is achieved by the participant. Hence, natural human manoeuvre should be followed in designing an advanced semi-autonomous upper limb neuro-prosthetic control to perform the 'Reaching to Grasping' tasks.

The thesis presents five distinct phases of grasp control scheme in neuro-prosthetic hand. Firstly, an **EEG classification** technique has been developed for identifying the **various Power and Precision grasp types** from the nonlinear chaos parameter, Correlation Dimension (CD), of human motor imagination using 'One-against-One' Support Vector Machine (SVM). Secondly, a **gaze-controlled vision system** has been designed with a single webcam placed on the cap visor to identify, localize, and estimate the size, shape, and orientation of the intended object to be grasped along with appropriate grasp type detection through simple image processing algorithm. Thirdly, a **Genetic Algorithm (GA) based Inverse Kinematic (IK) solution** was provided to determine the shortest trajectory path for the hand in reaching the object. Fourthly, a simple relationship between the combined interphalangeal angles and object diameter has been established to be used as 'fitness' function in **Particle Swarm Optimization (PSO) for facilitating adaptive grasping** through Shape Adaptation of the hand. Finally, a **Nonlinear AutoRegressive (NAR)** model has been developed to estimate appropriate **fingertip forces** ensuring a stable grasp ensuring slippage avoidance without object deformation as well.

The proposed approach has been conceptualized as a superior alternative by integrating MI and computer vision in association with advanced yet simple algorithmic models as a control scheme for upper limb neuro-prosthetic. This natural control supersedes the requirement of additional training of patients in the future and thereby reducing the overall burden for their use. Moreover, the analysis and overall accuracy of all the sections in the thesis suggests feasibility in real-time implementation.

Keywords: EEG, artificial vision, upper limb neuro-prosthetic, grasping control, Neuro-muscular disorder