19th International Conference on Advanced Computational Engineering and Experimenting
29 JUNE – 3 JULY 2026 | RHODES, GREECE

ABSTRACT:

Design of a VR-Based Training System for Control of Body-Powered Transhumeral Prostheses using an Instrumented Harness and Prosthesis Simulator

A. Martínez-Hernández[1], A.D. De León-Hernández[1], C.O. López-López[1], M.F. Cabrera-Padilla[1], B. Mondragon-Herrada[1]

[1]Institute of Applied Research and Technology – Universidad Iberoamericana, Mexico City, Mexico.

Prostheses are devices used to replace the absence of a segment of the upper or lower limbs. The most commonly recommended prosthesis for individuals with upper-limb amputation at the humeral level is a mechanical, or body-powered, prosthesis, due to its affordability. These prostheses are operated through a system of cables and attachment points connected to a harness, enabling flexion and extension of the prosthetic elbow joint as well as opening and closing of the terminal device (hook) through movements of the residual limb and the contralateral arm. However, due to the complexity associated with the adaptation and use of these devices, prosthesis abandonment rates exceeding 80% have been reported.

Several studies have demonstrated that the use of virtual reality (VR) in rehabilitation is an effective and patient-friendly strategy for performing activities focused on functional recovery, as it promotes active participation and progressive learning of motor skills.

This work presents the development of a training system for new users of transhumeral prostheses, comprising a virtual environment that enables them to learn and practice the control movements required to operate the prosthesis. To visualize prosthetic motion within the virtual environment, an instrumented harness equipped with inertial sensors was developed to detect the user's activation movements: scapular protraction/retraction and scapular elevation.

To establish the correlation between the control movement performed by the user and the resulting prosthetic motion (elbow flexion/extension and hook opening/closing) in the virtual environment, a transhumeral prosthesis simulator adaptable to the instrumented harness was designed. The simulator incorporates all the components of a real prosthesis: socket, prosthetic elbow joint, control elements (cables and attachment points), and terminal device, and allows its use by individuals without limb loss. Previous studies have reported that implementing this type of simulator increases the number of participants in such studies, thereby contributing to the development of more robust systems.

Currently, the system is in the experimental testing phase, using the simulator to determine the ranges of motion the patient should perform to activate their future prosthesis. These measurements will be used to calibrate the virtual environment so that the virtual prosthesis's movement closely resembles

real prosthetic behavior. Through this training system, we aim to reduce the abandonment rate of these assistive technologies. Although users will still need to undergo an adaptation phase when receiving their prosthesis, prior familiarity with the activation movements is expected to reduce the overall learning curve.