UNIVERSITY OF ZIELONA GÓRA

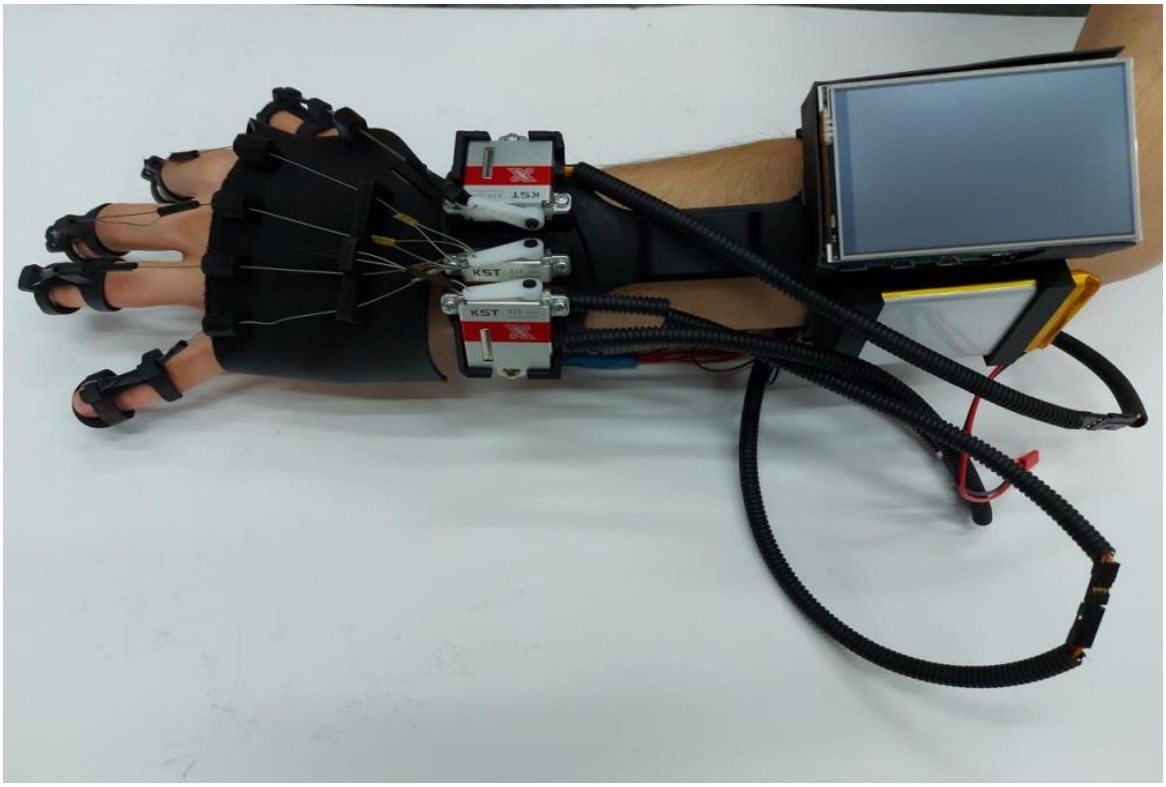
Orthesis for upper limb rehabilitation

Innovative project of a technologically advanced orthosis dedicated to individuals with spasticity, post-stroke conditions, upper limb injuries, and patients requiring intensive hand rehabilitation.

The innovation of this solution is based on the use of electronics, including servomotors and microprocessors, which enable precise assistance and control of hand and finger movements while considering anatomical biomechanics.

Thanks to the applied technology, it is possible to accurately adjust the orthosis parameters to the patient's needs. Using an intuitive touchscreen panel, the user can select:

The orthosis control program on the Raspberry Pi platform is equipped with an intuitive graphical interface that automatically launches when the device is powered on. This interface is designed to allow the user to easily manage the servomotors that assist with wrist, finger, and thumb movements.



User Interface and Touchscreen

Raspberry Pi, equipped with a touchscreen, enables easy operation through dedicated buttons. The screen displays clearly labeled and easy-to-read fields:

- **"Enable" Button for Wrist** – Activates the servomotors controlling wrist movements.
- **"Disable" Button for Wrist** – Deactivates this servomotor.
- **"Enable" Button for Fingers** – Turns on the servomotor controlling all finger movements (excluding the thumb).
- **"Disable" Button for Fingers** – Turns off this function.
- **"Enable" Button for Thumb** – Activates the servomotor responsible for thumb movement.
- **"Disable" Button for Thumb** – Turns off this function.

This solution allows the user to precisely control each part of the orthosis, adjusting its operation to current needs.

Operation Mode and System Management

Besides the touchscreen, the Raspberry Pi can be connected to a monitor, mouse, and keyboard, providing full program management access. Additionally, it is possible to connect to the Raspberry Pi remotely from another computer on the same network. This operation mode is primarily intended for doctors or specialists who may require access to advanced service settings.

Doctor's Service Mode

Access to service settings is password-protected and intended for individuals responsible for adjusting the orthosis parameters to the patient's needs. In service mode, it is possible to modify:

1. **Speed Settings** – Three speed modes regulate how fast the servomotors move the wrist, fingers, and thumb.
    - Finger, thumb, and wrist bending speed, adjustable within a range of **0.8 mm/s to 1.8 mm/s**.
2. **Range of Motion Angles** – Minimum and maximum movement angles of the servomotors to ensure safety and precision.
    - Finger, thumb, and wrist elevation angle, adjustable within three ranges: **0° to 20°**, **20° to 50°**, and **50° to 75°**.
3. **Tension Force** – The system also allows adjustment of the tension force for fingers, thumb, and wrist, regulated within a range of **3 Kg*cm to 5 Kg*cm**, depending on the applied voltage.

Communication with Arduino

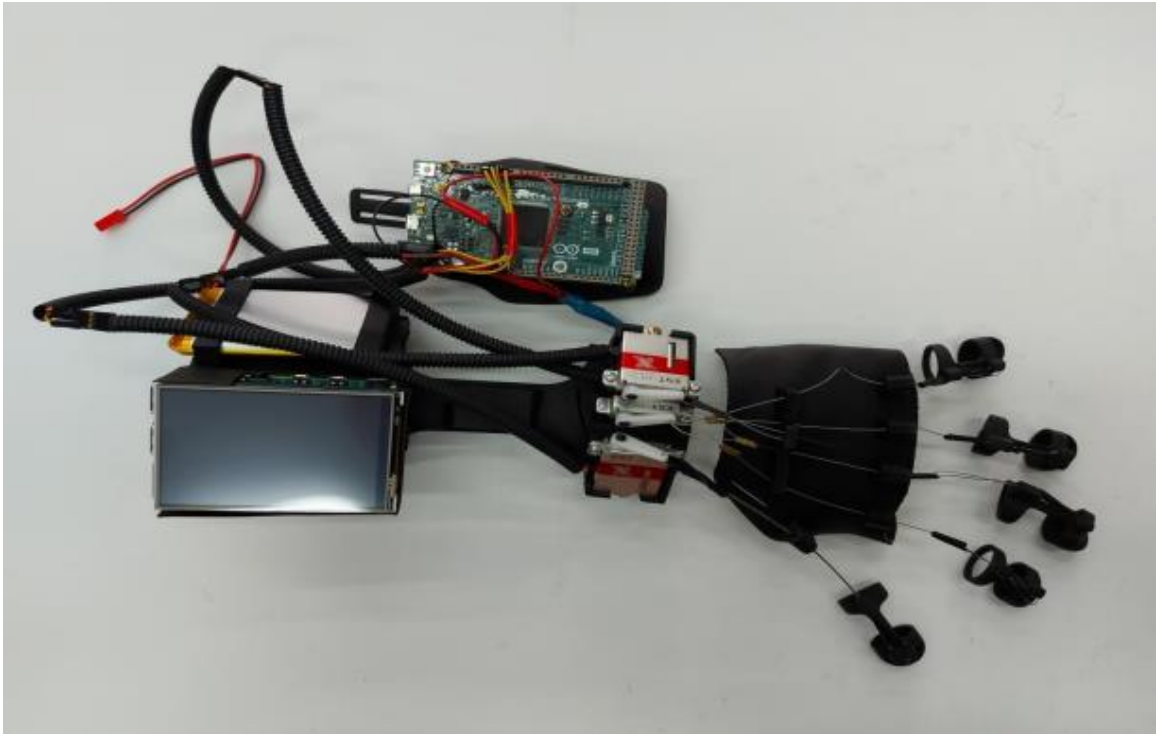
All commands and settings are transmitted from the Raspberry Pi to the Arduino microcontroller, which executes the operations controlling the servomotors. This system ensures reliability and smooth movements, supporting the user in daily activities and the rehabilitation process.

Summary

Thanks to a clear interface with distinctly labeled "Enable" and "Disable" buttons for each function (wrist, fingers, thumb), the program is easy to use and tailored to user needs. Additionally, advanced

management settings accessible to doctors ensure appropriate parameter customization, supporting rehabilitation and orthosis functionality.

The innovative orthosis design allows precise replication of interphalangeal, metacarpophalangeal, and wrist joint movements, optimizing the rehabilitation process for spasticity, stroke recovery, and supporting daily manual functions in patients.



Main Components of the Orthosis:

1. **Finger Covers** – Each finger is equipped with a cover to which cables driven by servomotors are attached. These cables, integrated with the dynamic control system, regulate flexion and extension in the proximal and distal interphalangeal joints, enabling precise movements such as grasping and releasing objects.
2. **Guiding Plate** – Positioned in the upper part of the metacarpus, this plate ensures proper positioning and guidance of the cables. Its structure stabilizes finger movements, allowing natural and controlled motion aligned with metacarpophalangeal joint biomechanics.
3. **Metacarpal Support Pad** – Located in the palmar section of the metacarpus, this pad plays a key role in hand stabilization, preventing excessive bending and supporting optimal anatomical positioning of the hand during orthosis operation.
4. **Upper and Lower Forearm Orthosis Plates** – The upper orthosis plate, positioned on the dorsal forearm, houses the servomotors and user interface in the form of a touchscreen. This allows for customization of settings such as motion range, assistance force, and rehabilitation modes. The lower plate, located on the ventral side of the forearm, provides additional stabilization and structural support.
5. **Stabilizing Handles and Support Bracket** – To ensure maximum stability and safety, the orthosis is equipped with stabilizing handles on the arm and forearm, as well as a shoulder support. These elements minimize the risk of uncontrolled movements and enhance comfort and efficiency of use, contributing to improved shoulder joint mobility.

Our goal was to create an innovative and functional yet comfortable orthosis suitable for daily use. Thanks to advanced electronics, the orthosis not only supports the rehabilitation process but also facilitates everyday activities such as grasping objects, writing, and performing precise manual tasks.

The use of modern technologies enables patients with upper limb movement limitations to achieve significant hand function improvement, leading to a better quality of life and increased independence in daily activities.

The project has been granted a patent by the Patent Office of the Republic of Poland: [WIPO ST 10/C PL450617]

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