Abstract of doctoral dissertation

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Doctoral dissertation title: The selection of an optimal kinematic chain and drive units of an upper limb exoskeleton.

The doctoral dissertation is related to the subject of robotic rehabilitation of the upper limb. The research, carried out as a part of the doctoral dissertation, contributed to the implementation of the upper limb exoskeleton project, and is also intended to be the basis for the development of future projects on other rehabilitation devices that will be carried out in the Łukasiewicz Research Network – Krakow Institute of Technology.

Understanding the structure and biomechanics of the upper limb and determining its anthropometric values and ranges of motion in individual joints was the base of the research. The review of existing solutions for robots and devices for upper limb rehabilitation enabled defining the current state of the art in the considered field of bioengineering. In the first stage of the work, the actual angular displacements in individual joints of the upper limb were analysed and the actual trajectories of therapeutic, simple and complex movements were determined. On this basis, the optimal trajectories of selected points of the upper limbs in the spatio-temporal configuration for specific neurophysiological disabilities were developed and analysed.

In the next stage of the doctoral thesis, various models of the kinematic chain were developed and drives for kinematic pairs were selected to ensure the implementation of the developed trajectories. The resulting concepts were analysed to achieve the widest possible mobility of the device and minimum torque values in the driven kinematic pairs. Appropriate precautions related to the need to eliminate threats resulting from the use of actuators have been developed. Digital research models of the developed device concepts allowed for conducting numerical analyses, the aim of which was to select the material characteristics of the device and to ensure the safety and reliability of the mechanical structure. The research consisted in determining the state of displacements and reduced stresses in the structure, taking into account different configurations of the exoskeleton settings.

The last stage of work included experimental verification of the prototype and final refinement of the mechanical design so that it fully meets the assumptions set for it. The effect of the work is the development of a device that can be implemented into production and will be an innovative and complementary alternative to similar devices available on the market.