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Modeling, design and construction of prototype finger exoskeleton

Mobility limitations of hand and in particular of fingers are common problems that we encounter in everyday life. The standard rehabilitation method is based on exercising hand and fingers aiming on their recovery, by restoring mobility and dynamics values close to the typical for a healthy body. Usually rehabilitation is carried out by qualified physiotherapists, but there also can be designed suitable exoskeleton that would be able to recreate the required motion trajectories and forces suitable for therapy.

This dissertation concerns the design and construction of a finger exoskeleton prototype on the basis of a theoretical model of the system, numerical calculations carried out in MATLAB/Simulink and the three-dimensional model made in Autodesk Inventor. Its thesis is formulated as follows:

The mathematical model of the exoskeleton supporting finger movement metacarpophalangeal, proximal and distal phalangeal joint and experimental stand will contribute to the study of finger exoskeletons designed for the rehabilitation of injuried fingers.

The proposed design is an innovative solution based on the links moving only in rotational manner in respect to the bearing points. The main advantage of the proposed design solution is relieving the finger joint from external forces during activity, allowing rehabilitation of damaged joints. The exoskeleton is being driven by electromechanical linear actuators which control was carried out using a prototype electronic circuit connected to the measurement card made by National Instruments and controlled by provided by the same company software installed on a PC. The last step was the construction of the research stand basing on the technical documentation prepared in Autodesk Inventor and AutoCAD.

The following conclusions were formulated:

1. The proposed design solution supports finger movement in metacarpophalangeal, proximal and distal phalangeal joint.
2. During the operation the device does not cause additional load on patient finger joints.
3. Numerical simulations illustrate the changes in displacements, velocities and accelerations of the characteristic points. Simulation was carried out also for the forces acting on the bearings during operation.
4. A three-dimensional model has allowed the creation of technical documentation of the experimental stand.
5. The LabVIEW based control program allows free modification of the control algorithms depending on the selected method of rehabilitation.

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