

RESEARCH ACTIVITY

The research work was focused on activities related to RIPRENDO@Home project (<http://www.riprenendoathome.it>) at ITIA-CNR and at Valduce Hospital - Villa Beretta Rehabilitation Centre, in particular on the LIGHTArm, an exoskeleton-based device for the neuro-rehabilitation of the upper limb:

- Analysis of the functional requirements of an exoskeleton-based neuro-rehabilitation device: compatibility between human and robot kinematics, Range of Motion (ROM), technical specifications and suitable characteristics of Human-Machine-Interface (HMI) and safety requirements. Achieved through: in-depth study of the state of the art, active exchange of views with medical personnel of the referential clinic, participation in seminars and Biomechanics (MSc) course.
- Design of the exoskeleton: as part of the RIPRENDO@Home project, the first prototype of the LIGHTArm is totally passive because studies demonstrate that technologies that allow patients to perform therapy without robotic actuation are most appropriate for semi-autonomous training at home, in term of cost and safety, than actuated devices, and as effective in improving recovery. The prototype is made of very low cost technologies and components (e.g. 3D printed parts). Special attention was paid to the gravity compensation mechanism that has to guarantee a good limb support for impaired people, facilitating upper-limb spatial movements in rehabilitation therapies and activities of daily living assistance. The gravity balance mechanism is composed by a spring based system acting on the elbow joint and a counterbalance system on the shoulder joint; a four-bar linkage guarantees that the forces generated by the elbow spring and counterbalance system are unaffected by the upper-arm orientation. In order to design this mechanism, it was developed a general model addressed to the optimization of both the shoulder and the elbow joints balancing systems. Multibody simulation results confirmed that the upper limb is slightly affected by its own weight during its necessary movements for rehabilitative tasks, and the reachable ROM resulted increased in respect to the passive devices at the state of the art. On the basis of the mechanical model and the obtained results it was possible to dimension the springs and the counterweights, balancing the LIGHTArm, completing effectively its mechanical dimensioning. MATLAB and Autodesk INVENTOR softwares were used.
- First prototype of LIGHTArm: the production of the first prototype had taken place in the mechanical laboratory of ITIA, from June to September. The original design was partially modified, in order to fulfill the manufacturing needs. The cooperation with the technical staff of the laboratory was a continuous exchange of views, ideas, knowledge and it resulted in the current configuration of the exoskeleton.
- The LIGHTArm was presented at the 1st Clinical Movement Analysis World Conference (29 September - 4 October 2014, Rome) and at the The European Edition of MAKER FAIRE (3-5 October, Rome).