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OVERCOMING BRACHIALIS PLEXUS INJURIES USING A PASSIVE ORTHOSIS

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INTRODUCTION
Brachial plexus injuries typically caused by falls or traffic accidents result in total or partial loss of upper limb function due to permanent lesion of neural pathways, more precisely cervical C5-C8 and thoracic T1 nerves. Thus, the transmission of nervous signals from the spinal cord to the upper limbs is interrupted, resulting in paralysis [1].

Both passive and active arm assistive devices can be found in literature [2]. The concept behind the latter group is to assist the patient with counteracting the external loads (e.g. the gravitational force) using only passive elements and hence does not require actuators or complex control algorithms [3].

The design of a spring-loaded, cable-driven, wearable passive orthosis with four degree-of-freedom is presented here on the basis of simulation of the human body-orthosis interactions through a comprehensive musculoskeletal model.

METHODS
The orthosis is composed of three components (Figure 1): the armor cuff and the elbow upper and lower brackets. Five cables (three for the shoulder joint and two connecting the elbow upper and lower brackets) are linked to individual pre-loaded springs in an array box, which is anchored to the back of the armor part. According to the gravity-balancing principle [3], both springs’ stiffness and pre-load forces can be defined as design parameters for the formulation of an optimization process of the orthosis design [4]. The orthosis model is built in SolidWorks (Dassault Systèmes SolidWorks Corp., Massachusetts, USA).

Given the aim of the orthosis to exploit the residual muscle activity in patients’ arms, the mechanics of the human body-orthosis interactions was formulated and solved with the AnyBody Modeling System (AMS) (AnyBody Technology A/S, Aalborg, Denmark). The orthosis model was imported to AMS and its armor part considered fixed to the trunk of the human model. The attachment of the upper bracket to the upper arm was modelled as a revolute joint. The lower bracket was connected to the lower arm through a translation-spherical joint, allowing the lower bracket to rotate around the pronation axis of the forearm.

By disabling paralyzed muscles, the musculoskeletal model can compute the muscle activations for different nerve lesion conditions. Therefore, a patient-specific brachial plexus injury can be simulated and the design parameters of the orthosis computed from a maximal muscle activation (MMACT) minimization point-of-view [5]. The motion data of picking up a cup was captured using two Kinect™ sensors [6], while a 0.5 kg payload was carried the hand and used as the design case.

REFERENCES