Modular Arm Orthosis with Weight Support: Mechanical Concept

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W.Reichenfelser, J.Karner, M.Gföhler

Vienna University of Technology, Austria

Introduction

Passive arm orthoses like the JAECO WREX [1] or the ARMON device [2] support patients with motor impairments in the upper limb when performing activities of daily living.
The presented concept of a modular arm orthosis is part of the European MUNDUS (MUltimodal Neuroprosthesis for Daily Upper limb Support) project that aims to assist patients with degenerative neuronal diseases or high level Spinal Cord Injuries (SCI). When clinically applied, it will be combined with Neuromuscular Electrical Stimulation (NMES) to enable the desired arm movements.

Methods

The analysis of different motions associated with daily living allowed an estimation of the range of motion. The required joint angles were calculated using inverse kinematics [3] and a dynamic simulation was performed to assess the torque characteristics and time history. The resulting mechanical 3D design was done in Catia V5R19, focusing on modularity, simplicity and low weight.

Results

The outcome of the preliminary investigations is an orthotic design with two degrees of freedom (DoF) at the shoulder, one at the elbow joint and one for pro- and supination (see coloured arrows in Fig.1). These DoF can be locked with electromagnetic brakes to support the control of the NMES induced arm movement.

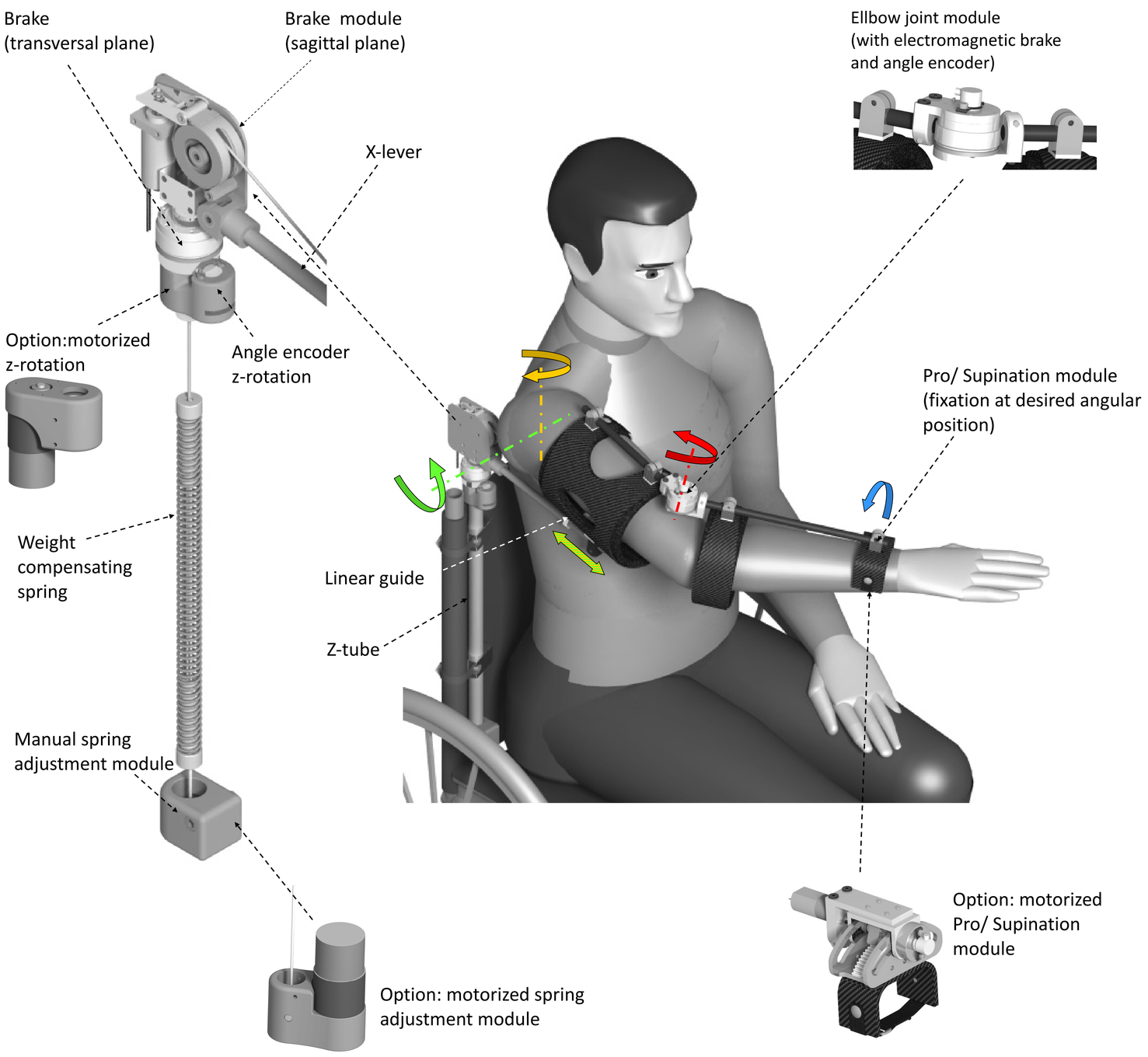

Figure 1: Digital mock-up of the orthosis worn by a manikin and mounted on a wheel chair. The colored arrows depict the mechanical DoF. The main mechanical components and optional modules are illustrated by detailed 3-D graphics.

The weight supporting spring is integrated in a tube that is attached to a harness for mobile use or mountable to a wheelchair. The compensating force of the spring is transferred via a rope to the upper arm shell. The orthosis is also prepared to carry a hand module that can activate the fingers. Depending on the severity or progression of the disease motors can be added to the DoF that can not be actuated by NMES sufficiently. Figure 1 shows the main components of the orthosis and gives an overview of possible additional modules.

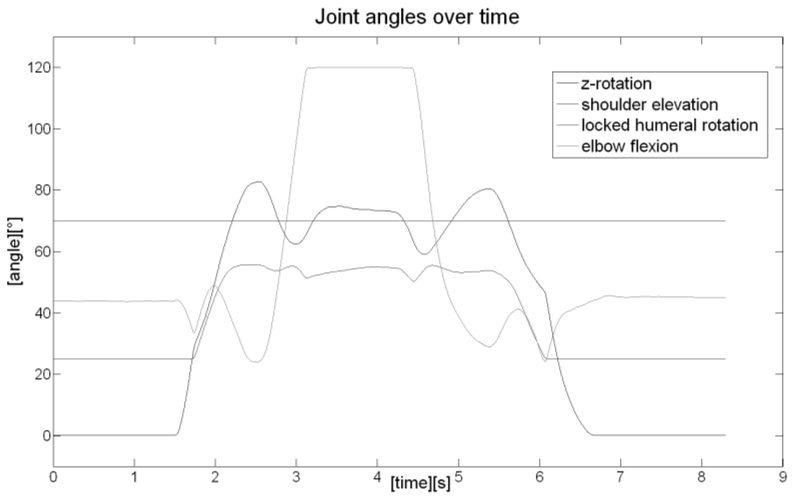

Figure 2: Time history of estimated joint angles of each DoF during the task “Drinking”.

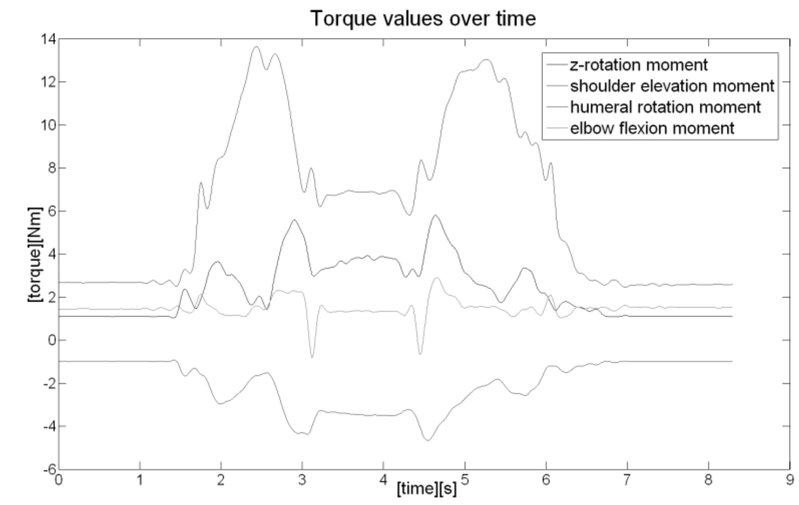

Figure 3: Torque values on each DoF after a dynamic analysis of the “Drinking” task. The additional force of a bottle was considered with 5N (500ml).

Figure 2 and Figure 3 show the results of the simulation with a biomechanical model of the upper extremity [4] after motion analysis with a healthy adult.

Discussion and Conclusion

The mechanical concept offers a lightweight orthosis with weight support for the arm and four lockable DoF. Due to its modularity it can be adapted to the specific needs of the user. A prototype is being built to evaluate its functionality with patients at the rehabilitation centre.

Acknowledgements

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References

[1] http://jaecoorthopedic.com; cited April 28, 2011.
[2] Herder J, et al. JRRD 43, 5, 591-604, 2006.
[3] Delp SL., et al. IEEE Transactions on Biomechanical Engineering 54,11, 1940-50, 2007.
[4] Holzbauer KRS., et al. Annals of Biomechanical Engineering 33, 6, 829-840, 2005.

TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology