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FIRST ATTEMPT TOWARDS THE DEVELOPMENT OF TRANS-TIBIAL PROSTHESIS

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ABSTRACT

This work addresses the field of the artificial devices that replace a missing body limb, particularly the prosthesis used upon a transtibial (TT) amputation, also known as ankle-foot prosthesis. A major challenge in designing an ankle-foot prosthesis lies in synthesizing a mechanism that will functionally mimic the missing part of an anatomical leg and, therefore, restoring the normal gait of the amputee. This way, it will be discussed and presented the requirements for a TT prosthesis, the steps that lead to the primary sketches of the prosthetic model and its main mechanism. This work constitutes a preliminary research in the field of the bionic TT prosthesis.

Keywords: ankle-foot, prosthesis, transtibial, gait.

INTRODUCTION

The human gait, as part of human's locomotion, involves the contribution of the whole body and the coordination of all the members, especially the arms, legs, and trunk. Thus, a trauma (i.e limb amputation) or disease of the musculoskeletal system will affect not only the individual's locomotion but also the physical and psychological health, as well as the individual's social interaction (Winter, 1991).

Most of the existing commercial transtibial prosthesis are energetically passive without actuation, thus unable to provide net power at the joint. To overcome this issue, powered transtibial prosthesis are emerging in the research field as a replacement of power generation (Singh, 2012).

The development of the prosthesis in this work, was built upon the research that facilitated the design of a proof-of-concept prototype. After the analysis of the bionic feet developed in academic environment, it was concluded that most of the TT prosthesis' mechanism mainly focus on the use of motor-screw transmission systems, especially the use of Series Elastic Actuator (SEA) (Bellman, 2008; Cherelle, 2014; Herr, 2012). Inspired by the ankle-foot prosthesis developed by some members of the MIT, within the Biomechatronics Group, the mechanism for our prosthetic model was considered as an elastic actuator, comprising a motor and a screw transmission in series with a leaf spring. The motor, the transmission and the leaf spring were combined to form a rotary SEA. This actuator will be used to modulate the joint stiffness/damping as well to provide the motive power output for active push-off, during the human gait cycle (Herr, 2012).

Thereupon, the mechanism intended for the ankle-foot prosthesis was well studied, which lead to the sketch of its individual components, and the final assembly of the whole prosthesis' mechanism. The outline of the concept was made on a 3D CAD Software.

RESULTS AND CONCLUSIONS

The model comprises mechanical and electronic components, such as a foot part, a leaf spring (in-series) to provide adequate actuator shock tolerance, a ballscrew that converts rotary motion into accurate linear motion, a motor to drive the mechanism accordingly, a belt drive transmission to transmit the movement of the motor to the ballscrew, and the prosthesis' housing.

Subsequently, to obtain the final model, all the prosthesis' components were assembled together, which lead to the main mechanism represented in Fig.1.

This model will serve as a TT prosthesis concept and a continuous work is necessary to improve the design of the device. In the future, it will be considered the physical production of the prosthesis, with a reduction in scale, to be installed on a biped robot, as mechanism proof-of-concept. This work represents one of the biggest and first steps taken towards the right track for the production of a human-like model prototype, in Portugal.

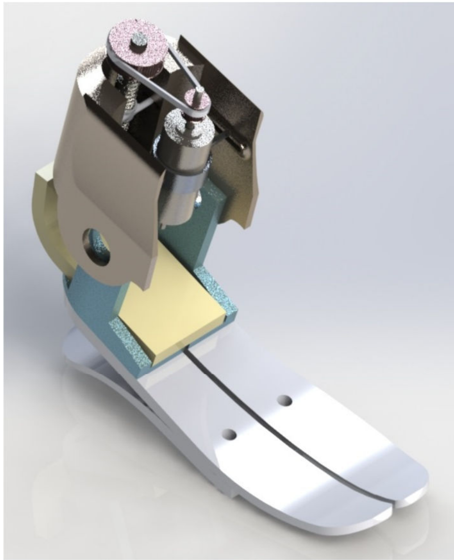

Fig. 1 - Representation of the TT prosthesis' mechanism

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