Development of an Intelligent Body Weight Support System for Climbing

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Introduction

Climbing has become a popular sport in recent years. Apart from being considered as a sport activity, climbing can be used in the context of physio- and ergotherapy. Not only does it build strength, endurance and flexibility, but it also teaches how to stay focused in challenging situations [1]. Although this form of therapy is recognised and funded by basic health insurances, access remains limited. The strength and endurance required for climbing is a major hurdle for patients. The eClimber is a novel device that is mounted at the top of the climbing wall (see Fig. 1). It performs two main functions: i) it assists by actively pulling the person up using the rope; ii) it belays the person using the same rope without the need for an additional person. The aim of the thesis is the mechatronic development of the eClimber.

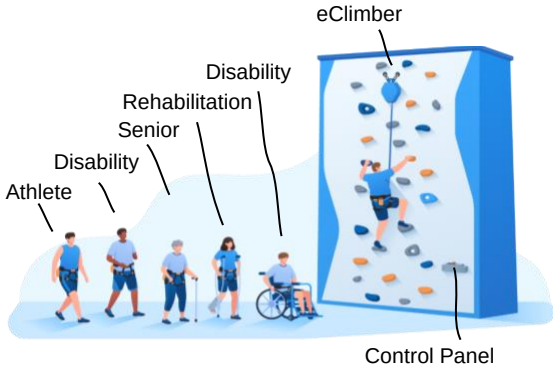

Fig. 1 Use case of the eClimber [2]

Materials and Methods

The thesis covers all phases of the development process, from the selection of the components to programming, assembly and testing. This includes both the eClimber itself and the control panel (see Fig. 2). Care was taken to ensure conformity with the EN341 standard. The MiniMACS6 motion controller from Maxon is used to control the eClimber. The control panel is based on a single-board computer and the user interface on web technologies. Communication between the eClimber and the control panel takes place via the CAN bus. Risk assessment and risk reduction measures were carried out in parallel with the development to ensure safety and reliability. The developed prototype was tested on a climbing wall with a height of around 4 m.

Results

The eClimber was successfully put into operation. It has a self-developed force sensor and amplifier, which allows the force in the rope to be precisely measured. A control loop was implemented that controls the drive so that the measured rope force is as close as possible to the target force. The desired support, which corresponds to the target force, can be selected via the control panel. The eClimber can currently support a person with up to 600 N when climbing. On average, the root mean square error (RMSE) between the target and actual force during climbing was 17 N over the support range. Tests with experienced climbers have shown that the type of support is perceived as pleasant. The eClimber is operated entirely via the control panel. Exploratory tests demonstrated its user-friendliness and self-explanatory character.

Fig. 2 eClimber (left) and control panel (right) [2]

Discussion

The thesis has demonstrated that a functional, safe and standard-compliant eClimber is feasible. The development has led to innovative solutions, which are supported by a registered patent. Certification is in progress to enable the eClimber to be used outside the laboratory.

References

[1] L. Gassner et al., “The Therapeutic Effects of Climbing: A Systematic Review and Meta-Analysis,” PM&R, Aug. 2022, doi: https://doi.org/10.1002/pmrj.12891
[2] www.eclimber.ch

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