Data Analysis in Sport Climbing with an Instrumented Belay Device

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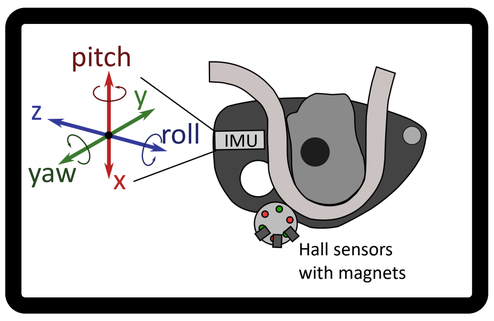
Introduction

Sport climbing has become increasingly popular over the last decades. In combination with the growing interest of data analyzation in sports, we investigated the possibilities of an instrumented belay device. Therefore, we combined the **sensor technology** to track kinematic information about the device. In combination with methods from **data analytics** and **artificial intelligence** we were able to extract meaningful parameter for analyzing typical sport climbing activities. This enables us to **increase the knowledge** about the sport itself. Our system can be **utilized in a training environment** to improve the awareness and skills of a belayer in critical situations or as a monitoring device for sport climber to keep track of their progress.

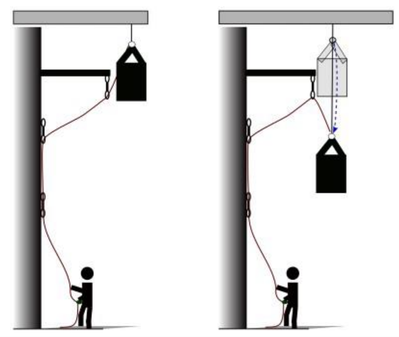
Data Analysis Methods

Climbing Ascent

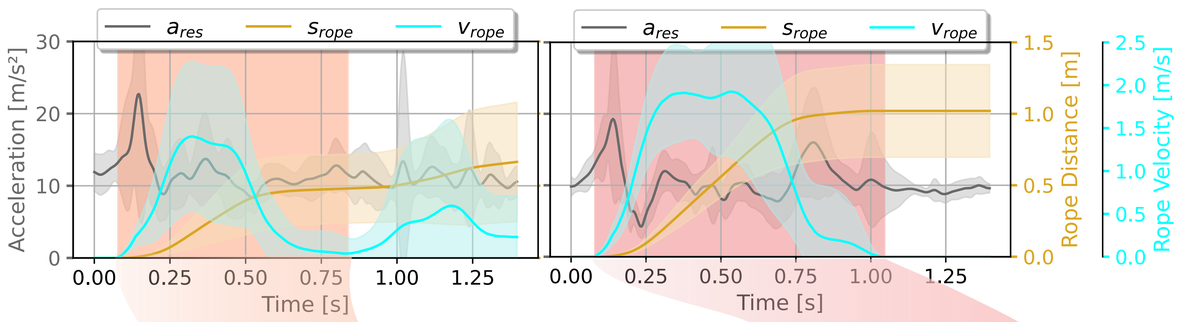
The instrumented sensor system consists of an Inertial Measurement Unit (IMU) measuring the accelerations and angular velocities of the belay device and Hall sensors for estimating the amount of rope running through the device.



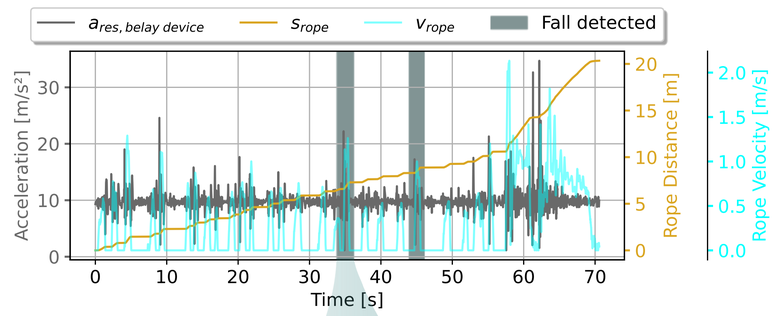
A Climbers' Fall



Sequences of Handing out Rope

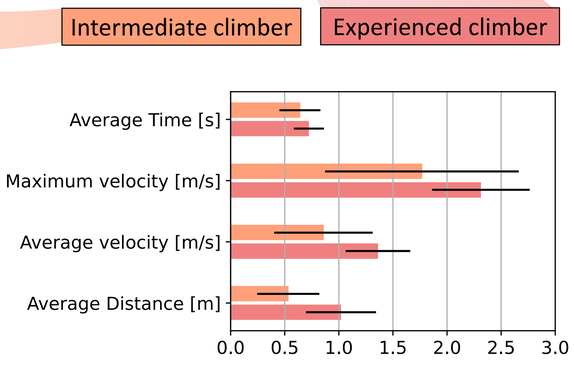


Sequence of a Climbing Ascent



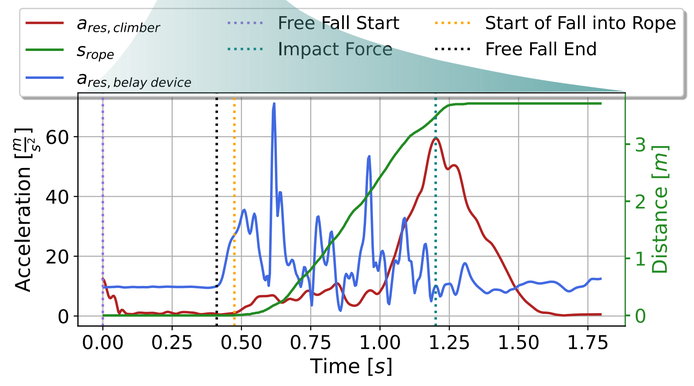
Information Extraction (Climb)

The kinematic sensor information can be extracted and pre-processed to analyse and compare climb specific situations, like the way of handing out rope or lowering the climber.



Information Extraction (Fall)

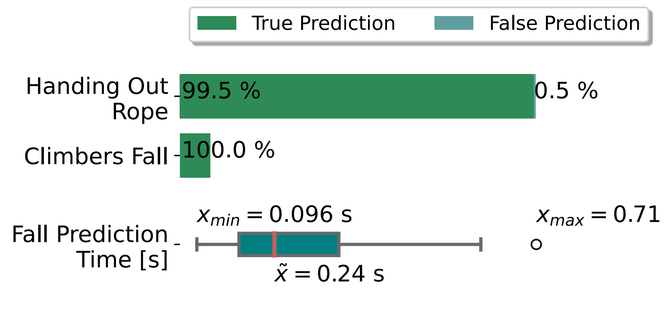
- Duration of the free fall
- Impact Force
- Falling distance into the rope
- Velocity whilst falling into the rope



Application and Possibilities of Artificial Intelligence in Sport Climbing

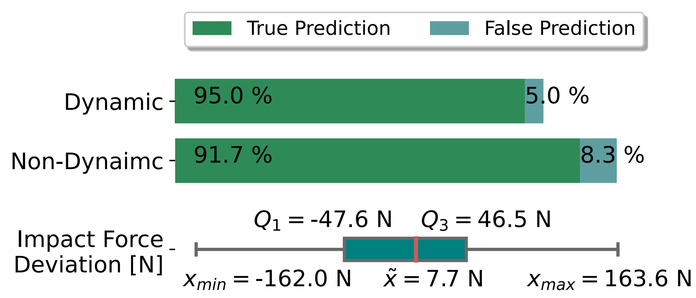
Fall Identification

The fall of a climber into the rope allowed us to extract information about the skillset of the belayer as well as the severity of the fall itself. We were able to identify a fall with a 100 % certainty within our test set containing 165 trials, based on the information from the belay device alone. Though, 9 out of 1924 sequences of handing out rope were falsely classified this way. Additionally, the device can be utilized in a real environment for teaching purposes by signaling the belayer in case of misusing the device or wrong timing whilst dynamically belaying. Therefore, our algorithm was also developed to be fast in time predicting a fall.



Type of Belaying in a Fall Situation

By analyzing the fall sequences further, we were able to identify the behavior of the belayer whilst catching the fall of a climber. We could identify whether the belaying was active or passive. Even further, we estimated the impact force acting on the climber solely from the information recorded with the sensors attached to the belay device. The true impact forces ranged from 700 N to 1300 N, whereas the average deviation from the estimation was $59.7\ \mathrm{N} \pm 42.9\ \mathrm{N}$



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