Lehrstuhl für Bewegungswissenschaft
Fakultät für Sport- und Gesundheitswissenschaften
Technische Universität München

Bachelor/Master Thesis

Kinematic analyses in bouldering

Kinematic analyses are broadly used, with topics ranging from hand kinematics during everyday life in persons with neurological disease to performance analysis in top athletes. While the gold standard of motion capturing is video-based, field assessments can make use of inertial measurement units (IMUs), for instance, the acceleration sensors of a smartwatch. So far, kinematic analyses have been shown to be able to sensitively quantify behavior. A kinematic analysis is commonly a time series analysis, where specific features are extracted (Fig. 1).

In climbing and bouldering, especially in halls, levels of difficulty are estimated on a subjective level in a semi-constrained environment (routes are fixed). Further, the estimated level of difficulty can be expected to be biased by the rater's abilities ("strengths" and "weaknesses"). In this sense, the question arises: *What is difficulty and is it really one-dimensional?*

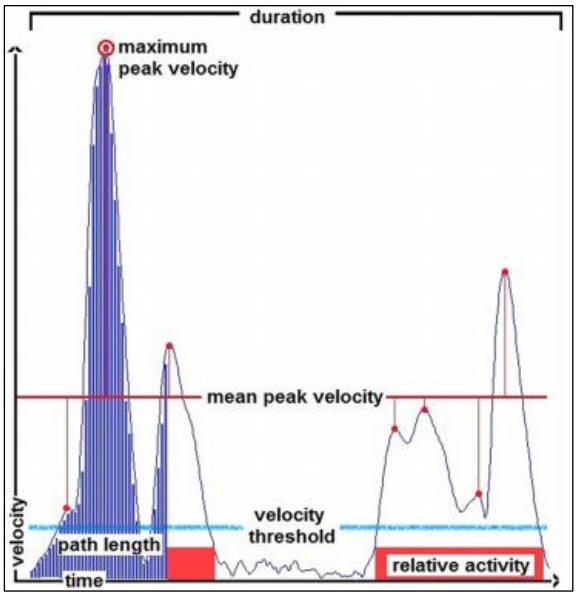

Fig. 1: *Illustration of some of the most common velocity-based kinematic parameters. The velocity profile is derived from the dominant hand of a healthy participant during an activity of daily living.*

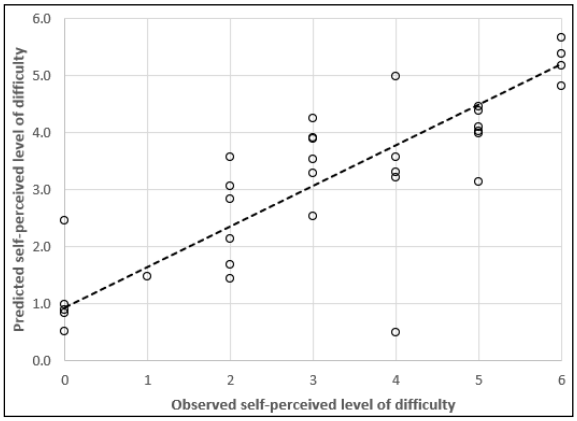

Fig. 2: *Observed and predicted (MLR) self-perceived level of difficulty from a pilot examination. Based on the kinematic performance of the dominant hand of one subject.*

Research question (BSc): What kinematic parameters are correlated with the official (Spearman) and the self-perceived (Pearson) levels of difficulty of different boulder routes? What factors can explain the self-perceived level of difficulty (MLR; Fig. 2)?

Research question (MSc): What is the relation (z-score based PCA) of different kinematic parameters and official as well as self-perceived levels of difficulty of different boulder routes? Can different behavioral types of boulderers be extracted (cluster analysis), for instance, power climbers?

Procedure: IMU-derived hand kinematics during mixed-level of difficulty bouldering are assessed by a wrist-worn sensor system. Advanced to expert boulderers should be recruited.

Material: Huawei gt2 smartwatches with custom software, RStudio.

Prerequisites: Experience in climbing / bouldering.

Literature: All manuscripts can be requested via email.

Scripts:

Gulde P & Schmidle S. *Time series analysis of human movement data – from scratch to bite.*

Gulde P, Schwienbacher A, & Moebus L. *RStudio for sport scientists: Quick, dirty, but helpful.*

Kinematic analysis in clinical populations:

Gulde P, Hughes CML, & Hermsdörfer J (2017). *Effects of stroke on ipsilesional end-effector kinematics in a multi-step activity of daily living.* Frontiers in Human Neuroscience.

Gulde P, Schmidle S, Aumüller A, & Hermsdörfer J (2019). *The effects of speed of execution on upper-limb kinematics in activities of daily living with respect to age*. Experimental Brain Research.

Schmidle S, Gulde P, Herdegen S, Böhme G-E, & Hermsdörfer J (2022*). Kinematic analysis of activities of daily living performance in frail elderly.* BMC Geriatrics.

PCA & cluster analyses of kinematic/actigraphic data:

Gulde P & Rieckmann P (2022). *The association between actigraphy-derived behavioral clusters and self-reported fatigue in persons with multiple sclerosis: Cross-sectional study*. JMIR Rehabilitation and Assistive Technologies.

Gulde P, Vojta H, Schmidle S, Rieckmann P, & Hermsdörfer J (*in preparation*). *Going beyond PA: Assessing sensorimotor capacity by wearables in multiple sclerosis – a cross-sectional study.*

Schmidle S, Gulder P, Koster R, Soaz C, & Hermsdörfer J (*in preparation*). *The relationship between self-reported physical frailty and sensor-based physical activity measures in older adults.*

Methodological papers:

Gulde P & Hermsdörfer J (2018). *Smoothness metrics in complex movement tasks*. Frontiers in Neurology.

Gulde P & Hermsdörfer J (2018*). A comparison of smoothing and filtering approaches using simulated kinematic data of human movements*. Advances in Intelligent Systems and Computing.

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