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AIROW - Artificial Intelligence in Rowing

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A cooperation project of the
Research Network Data Science @ Uni Vienna
Institute of Sports Science, University of Vienna
Austrian Rowing Federation
funded by the **Bundesministerium für Kunst, Kultur, öffentlichen Dienst und Sport**

ÖSTERREICHISCHER RUDERVERBAND

Bundesministerium
Kunst, Kultur,
öffentlicher Dienst und Sport

Research Project AIROW

This project will bring together methodological competence in statistics, machine learning and computer science with current developments in sport sciences as well as technological progress in wearables and medical diagnostics in order to optimize training load of top athletes in endurance sports. We will collect and process „big data“ from training and performance processes of individual athletes and will use state-of-the-art machine learning technology in order to measure effective training load, to predict the effect of training impulses and to optimize training management. It will be carried out as a pilot project in cooperation with the Austrian Rowing Federation and will be tailored to the specific needs and conditions in rowing. In a later stage, the insights gained from the project will be transferred to disciplines with similar training contents and requirements, such as swimming, triathlon, cycling, cross-country skiing and long/mid-distance running.

The project will bring together researchers from statistics, computer science, mathematics, sports science and sports medicine. While being practically highly relevant in order to strengthen the competitiveness of Austrian top-level sports, the project will be scientifically challenging and will produce novel insights and findings. The project is funded by the Bundesministeriums für Kunst, Kultur, öffentlichen Dienst und Sport and will be carried out by the Research Network Data Science and the Institute of Sports Science of the University of Vienna in collaboration with the Austrian Rowing Federation.

Project Description

The process of training is a systematic (and periodized) application of physiological and biomechanical stress. Fitness results from the body's adjustment responses causing an increased resistance against the training stimulus. On the other hand, a downside effect of physiological strain is fatigue. The potential performance of an athlete at a certain point in time is determined by the difference of the current levels of fitness and fatigue. Systematic training load management aims at optimally balancing both effects in order to increase athletes' potential performance in the long run.

The major challenges of training planning and work load management are: (i) both fitness and fatigue are driven by (cumulative) training load but with different impulse responses and different (nonlinear) time delays; (ii) the body's effective (and perceived) response of a training impulse is difficult to quantify. Hence, finding the "optimal" work load is challenging since high training loads without adequate recovery may trigger unwanted adaptations and negative results, while loads with insufficient duration and intensities may not generate necessary adaptations to improve physical performance.

For optimal work load management it is necessary to differentiate between the so-called "external" load, corresponding to the (physically measured) work completed by the athlete, measured independently of his or her internal characteristics. On the other hand, the "internal" load is the individual physiological and psychological response to the external load, combined with non-sport stressors. It triggers the individual training-induced adaptations and is determined by "stress/wellbeing" factors. Since the latter vary over time and across athletes, identical external load can result into different internal load depending on the athlete's status. In fact, there is high inter- and intra-individual variability in the physiological response to training and in the relationship between training adaptations and performance, making the "optimal" workload management a moving target.

One of the major aims of the project is a reliable quantification of athletes' internal load in order to improve training load management on an individual basis. We will systematically record athlete-specific variables, which could serve as potential predictors/indicators of internal load. These are, on the one hand, information on training contents and intensities, athletes' session-specific perceived load (so-called rated perceived exertion; RPE), performance metrics (e.g. speed, time, distance, power, Watt) as well as information from variables (e.g., heart rate characteristics) and and biomarkers in order to track individual strain and stress levels. Based on such athlete- and training-specific „big data", cutting-edge concepts of statistical machine learning will be used in order to (i) quantify internal load, (ii) predict the effect of a certain training stimulus in a given athlete-specific situation, and (iii) gain a better understanding which markers may serve as reliable indicators for athlete-specific states of stress, health and recovery and how modern technology on wearables can be optimally utilized.

A further major objective is to predict the athlete- and time-specific potential performance given the individual recovery/health status and the history of (internal) training. We will introduce regular and standardized ergometer test sequences, which allow us to track the individual potential (all-out) performance through time. Via statistical modeling and machine learning we will quantify the (time-varying) relationship between load and potential performance. Combining high-dimensional and heterogeneous athlete-specific training data with data from external devices, wearables and biomarkers as well as data stemming from all-out performance tests is statistically challenging and will be the core of the project. We aim at developing alternative statistical approaches, which will evaluated against each other and may be combined. In this context we employ modern statistical approaches of machine learning, such as artificial neural networks, reinforcement learning, classification techniques, dimension reduction techniques, time series approaches as well as structural sport-scientific approaches.

The project requires expertise from statistics, computer science, mathematics, sports science and sports medicine, and builds on a close collaboration with coaches and approximately 40 top athletes from the Austrian Rowing Federation (ÖRV). The technological front-end will be an app, which (i) allows athletes to enter training data and information on individual states of wellbeing/stress/recovery, (ii) is equipped with interfaces to external devices (e.g., wearables, physical performance measurement), and (iii) provides feedback in terms of indicators, graphs, summary statistics and recommended actions (based on the underlying machine learning procedures) for athletes and coaches.

Operational Aims

The operational aims are as follows:

i. predicting the effect of specific training stimulus on athletes‘ internal load in order to optimize training load management on an individual basis;

ii. analyzing the inter-temporal relationship between training load and athletes’ potential (maximal) performance;

iii. quantifying the risk of overtraining;

iv. identification of relevant sports-medical proxies and indicators of athletes’ internal training load;

v. identifying reliable predictors for athletes’ maximal performance and finding optimal ways to test the latter on a regular and reconcilable way.

Conceptual Components

The conceptual components of the project are as follows:

a) development of an app for recording of training load, individual stress-/health-/recovery level and providing (data-driven) feedback/output to athletes and coaches;

b) incorporation of data from external devices (wearables, biomarkers);

c) incorporation of external measurement devices (ergometer, boat);

d) regular standardized test sequences to measure (all-out) performance;

e) statistical modelling and machine learning based on data from a)-d) in order to predict the effect of training and potential performance on individual basis;

f) translation of statistical predictions into informative and useable indicators for athletes and coaches.

Project Structure

The project will be performed on a modular basis with the following working groups:

Working Group "Data & App"

- Development of an app for manual recording of training data and individual wellbeing/health data;
- Integration of biomarkers;
- Integration of APIs (Application Programming Interfaces) of external devices (e.g. wearables);
- Development of explorative statistics and visualizations of indicators (based on results from working group "Data Science") for feedback to coaches and athletes;
- Setting up IT infrastructure for recording, storage and administration of data, ensuring regulations for data privacy and protection
- Supervision of athletes' compliance

Working Group "Sports Science"

- Adaption and implementation of the „Performance Potential Double Model (PerPot DoMo)" for the current use case
- Using "PerPot DoMo" as a benchmark model for alternative approaches to be developed in the Working Group "Data Science"
- Development of appropriate hard-/software for precise measurement of power in the boat and on the ergometer; adaption of ergometers for regular all-out test sequences
- Development of approaches for the quantification of training load caused by strength training

Working Group "Data Science"

- Development of appropriate statistical approaches of machine learning (e.g. pattern recognition, classification methods, artificial neural networks, filtering, dimension reduction, multivariate time series techniques) in order to
  - quantify internal training load
  - identify relevant variables/markers serving as reliable proxies for internal load (variable selection)
  - predict the effects of certain training stimulus conditionally on athlete-specific states and training load records
  - quantify the relationships between training load, athlete-specific factors and (potential) all-out performance
  - predict potential all-out performance based on (sequences of) sub-tests
- Validation and potential combination of competing statistical approaches
- Combination of machine learning with structural approaches from sport sciences
- Producing suitable indicators and recommended actions as feedback to athletes and coaches (to be visualized through the app)

Working Group "Sports Medicine"

- Identification and implementation of appropriate bio markers for the quantification of internal load
- Identification of appropriate wearables and corresponding APIs
- Medical supervision
- Integration of aspects from research on sleep quality and nutrition
- Medical input for other working groups

Team

Project Management

Head of Project/Principal Investigator

Univ.-Prof. Dr. Nikolaus Hautsch
Research Network "Data Science", University of Vienna

Head Sports & Athletes

Robert Sens
Head Coach Austrian Rowing Federation

Anna-Maria Götz
Head Coach U19, Austrian Rowing Federation

Management Sport

Norbert Lambing
Director of Sports, Austrian Rowing Federation

Heads of Working Groups

Univ.-Prof. Dr. Arnold Baca
Institute for Sports Science, University of Vienna
Working Group "Sports Science"
arnold.baca@univie.ac.at

Univ.-Prof. Dr. Nikolaus Hautsch
Research Network "Data Science", University of Vienna
Working Group "Data & App" and "Data Science"
nikolaus.hautsch@univie.ac.at

Univ.-Prof. Torsten Möller, PhD
Research Network "Data Science", University of Vienna
Working Groups "Data & App" and "Data Science"
torsten.moeller@univie.ac.at

Univ.-Prof. Dr. Jürgen Scharhag
Institute for Sports Science, University of Vienna
Working Group "Sports Medicine"
juergen.scharhag@univie.ac.at

Head of Software & Data Architecture

Karol Kulma
University of Vienna
karol.kulma@univie.ac.at

Administration

Viktoria Schildhammer
Department of Statistics and Operations Research, University of Vienna
viktoria.schildhammer@univie.ac.at

Petra Schönfelder
Research Network "Data Science", University of Vienna
petra.schoenfelder@univie.ac.at

Scientific Staff

Univ.-Prof. Dr. Arnold Baca
Sports Informatics, Biomechanics
arnold.baca@univie.ac.at

Xandro Bayer
Machine Learning
xandro.bayer@univie.ac.at

Drew Dimmery
Data Science
drew.dimmery@univie.ac.at

Christian Knoll
Scientific Computing
christian.knoll@univie.ac.at

Dr. Philipp Kornfeind
Sports Technology
philipp.kornfeind@univie.ac.at

Univ.-Prof. Dr. Nikolaus Hautsch
Statistics & Machine Learning
nikolaus.hautsch@univie.ac.at

Benedikt Mitter
Training Science
benedikt.mitter@univie.ac.at

Univ.-Prof. Torsten Möller, PhD
Visualization & Data Science
torsten.moeller@univie.ac.at

Dr. Philipp Petersen
Machine Learning
philipp.petersen@univie.ac.at

Univ.-Prof. Dr. Jürgen Scharhag
Sports Science & Sports Medicine
juergen.scharhag@univie.ac.at

Dr. Katerina Schindlerova
Machine Learning & Data Mining
katerina.schindlerova@univie.ac.at

Michael Scherbela
Machine Learning
michael.scherbela@univie.ac.at

Advisory & Cooperative Staff

Dr. Johanna Beyer
Harvard School of Engineering and Applied Sciences
jbeyer@g.harvard.edu

Rob ter Horst, PhD
Research Center for Molecular Medicine
RterHorst@cemm.oeaw.ac.at

Prof. em. Dr. Jürgen Perl
Johannes-Gutenberg-Universität Mainz

Dr. Rafael Reisenhofer
University of Bremen
rafael.reisenhofer@uni-bremen.de

Cheng Ziwei
zhcheng@student.ethz.ch

Student Assistants

David Chmelik

Yu Jin

Aaron Vracar

Elisabeth Wimmer

Contact

AIROW - Artificial Intelligence in Rowing
c/o Data Science @ Uni Vienna
Kolingasse 14-16
A 1090 Vienna
E airow.datascience@univie.ac.at
W airow.univie.ac.at

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