CHALMERS

TRACKS -Digitalization in Sports and health

Aims

The aim of this course is to introduce the students to digital technologies applied in sports and health promoting applications. The scope covers on the one hand side hardware sensors for measurements and data acquisition and on the other hand side the process of data analysis including machine learning and artificial intelligence. The two categories meet in the area of user interface and interaction design where the feeback loop will be closed and hopefully result in benefits for the practioneer.

In the course, the students will face several examples of sensors and measurement data collected in the sport and health sectors. In a problem-based learning environment we will get the chance to acquire new knowledge but also to apply previously acquired knowledge, e.g., in mechanics, electronics, physics, mathematics, and data science.

Sensor technologies covered include common commercial sensors, e.g., inertial measurement units (IMUs), photo-sensors, gps, and barometers available in modern consumer electronics such as smart phones, watches and other devices. Customized sensors integrated in equipment for sports or health care, e.g., strain-gauge sensors and load cells for registration of forces or various bioelectrical sensors are also covered.

The part on data analysis covers firstly fundamental methods based on fundamental mechanics and first principle calculus but also more modern data driven methods and machine learning. The students will be introduced to methods for error-propagation with a clear focus on understanding the link between measured property and studied variable.

Finally the students will be introduced to recent methods for user feedback and interaction design. Modern tools for virtual and augmented reality applications will be covered.

Learning objectives

After completed course all students are expected to have fulfilled the general learning objectives of TRA100 or TRA105, depending on whether they follow the advanced track or the basic track. Specifically, all students are expected to

1. be familiar with main concepts describing the society's digital transformation and able to discuss its implication for humans
2. be familiar with the main digital tools and techniques used for motion tracking in preventive health care and sport applications
3. understand basic principles behind widely used sensor technologies.
4. be familiar with the principles of error propagation and assessment of measurement uncertainties
5. be familiar with some of the main concepts from artificial intelligence (AI), e.g., data-driven methods and machine learning

6. be familiar with some of the modern tools and sensors for interaction design such as virtual reality/augmented reality
7. Be able to synthesize and apply knowledge, as specified in points 2-5 above, to tackle or master problems with open solution spaces

Organization

The course is scheduled to be running during one semester (study period 1 and 2). The bulk of the course is the project carried out in groups by the students under supervision and guidance of course teachers.

In addition to the project, ten two-hour lecture/tutorial will be arranged. The lectures can be physical or on-line.

Literature

Lecture slides and recommended scientific papers, beside what is identified by the students during the course of the project work.

Examination

The course will be examined based on

- Project outcome, summarized in a written report as well as relevant demonstrator material in terms of hardware prototypes or software developed, 60%
- Learnings from lectures, examined in four quizzes, 30%
- Students presentation skills assessed by the examiner and teachers in the course, 10%

Prerequisites

The course is open to Bachelor students and Master students from all programs at Chalmers. In the application, students are expected to declare which project they are interested in primarily. Depending on program and the students previous courses, some fields may be more suitable.

Miscellaneous

1. The course may handle up to 5 projects with 3-6 participants. In selection of students, the course responsible will consider the students course background and declared interest to balance competence and engagement.
2. It may be possible to work on challenges presented by external stakeholders, e.g., commercial actors, professional athletes or sport federations, or the public health care sector, a list of proposed projects are given in Appendix A

Course duration:

September 2022– January 2023.

Enrollment:

Apply for the course no later than June 15 by sending an e-mail including a motivation letter to: danku@chalmers.se. Please attach your CV and course transcripts.

We aim at 20 students (minimum 5) in balanced project groups with a mix of competences and backgrounds (master and bachelor). If the interest is high, there will be a selection of students based on their competence, interests and motivation. Interviews may be called upon.

Examiner: Dan Kuylenstierna
Lecturers: Dan Kuylenstierna, Moa Johansson, and guest lecturers

Appendix A: Project descriptions

Cross-country skiing propulsion modelling

Propulsion in cross country skiing is a complex biomechanical process involving full-body motion. The propulsive force may be injected either through the poles or through the feet. Depending on speed and terrain, a skier uses different *gaits* where legs and arms move in specific patterns to maximize propulsion efficiency and/or peak-power output.

It takes years of training for an athlete to reach a good technique and it is at least equally difficult for a coach to identify and understand the small details that may be changed to make a good athlete even better. Furthermore, even when the coach identifies the details, the communication and feedback to the athlete is a limitation if there are no quantifiable key performance indicators closely related to the performance.

It is difficult to improve what you cannot measure, only when you can measure it and put a number on it you know something about it and will be able to systematically improve it

-inspired by Sir William Thompson (Lord Kelvin).

In this project you will quantify good skiing technique based on measurements of temporal variations in force and angle of poles and limbs that are active in the propulsion. You will be working in the new TRACKS biomechanical laboratory with a wide treadmill allowing studies of classical as well as freestyle skiing under controlled conditions. Specifically, you will collect data using high-speed cameras, axial pole force sensors, and IMUs.

Under supervision of course teachers and coaches connected to the national federation and/or professional ski-teams, you will build a behavioural model describing cross country skiing propulsion based on axial pole force and angle data.

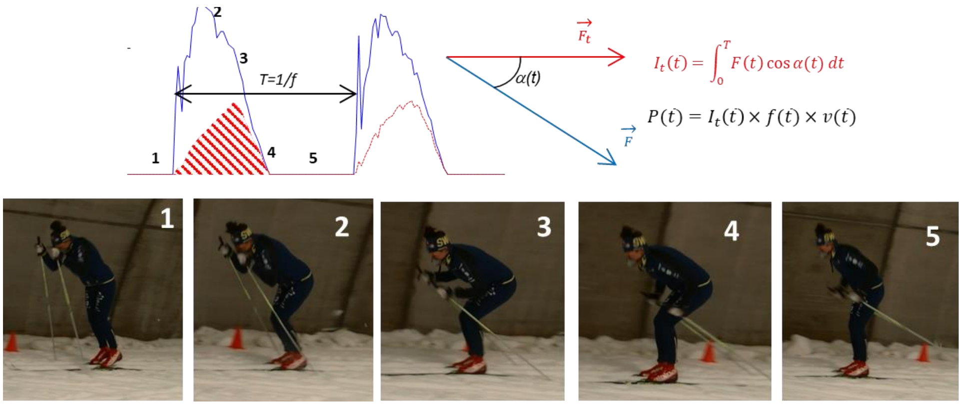

Illustration how cross-country skiing propulsion in double poling technique may be broken down into axial pole force and pole-ground angle temporal variations and further analysed by propulsive impulse and poling frequency

Core competencies needed: *Mathematical modelling, Mechanics, Programming, Experimental planning*
Miscellaneous competencies: *Artificial intelligence and machine learning*

Cross-country ski friction measurements

In cross country skiing, the athlete constantly fights to overcome the refraining forces from nature. At moderate speed, the most dominant force is due to glide friction between the snow and the ski. Prior to every race the waxing teams behind professional skiers spend considerable time to reduce glide friction without really measuring it, -and recall: *"you cannot improve what you cannot measure"*.

Instead of measuring absolute glide friction, the waxing teams rely on relative benchmarks, i.e., comparing pairs or groups of skis before they select the pair that is best compared to the other. A methodology based on relative benchmarks has flaws. It is resource inefficient and cannot assess how close one is to the optimum glide. Even for waxing teams with large resources, it is likely to end up in a local optimum about some preliminary assumptions. If we could instead measure the absolute friction coefficient, we could record it over time for every training and race and build a data base with skiing friction coefficient for different waxing methods in different skiing conditions.

Courtesy: http://www.157training.com

In this project, you will develop a method to measure ski glide friction based on data from axial pole force sensors and IMUs for angle detection. The principle is based on measuring the propulsive force while double poling in controlled slope and wind conditions. The glide friction can then be calculated from the propulsive force. The method will first be developed using roller skis with predetermined friction on treadmill in the new biomechanics lab in the TRACKS learning environment where ski-pole angle can be measured with high-speed IR cameras

Core competencies needed: *Mathematical modelling, Mechanics, Experimental planning and measurement methodology*
Miscellaneous competencies: *Artificial intelligence and Machine learning*

Digitalization in Biathlon

Biathlon is a combination of cross-country skiing and Rifle shooting. In recent years the sport has attracted increased media interest not only in Sweden, but also in Europe and specifically in Germany, Italy, and France.

A reason making the sport very popular may be the shooting element that is less predictable than pure cross-country skiing. Even if shooting at the end is a skill, there are mental as well as random factors such as external conditions that may change the game plan so that it is not always the same winner, which often is the case if only physical capacity would determine the game.

© Copy: Biathlon Östersund, Worldcup in Biathlon 2023

Chalmers has a research collaboration agreement with the Swedish Biathlon association and also close connection to one of the most competitive clubs in Southern Sweden, OK Landehof that recently earned 9 medals in the Junior/Youth National Championships.

In this project, you work on research challenges defined in collaboration between Chalmers researchers and coaches in the Biathlon association.

Two specific challenges are:

1. Modeling of Air rifle ballistic motion, 2-4 students,
   suitable background courses (Mechanics, Mathematical modelling, Machine learning, Experimental Physics)
2. Development of a fair ranking system based on past race results, 2-4 students
   Mathematical modelling, Programming, Machine learning