Associate Professorship of Sport Equipment and Sport Materials
TUM Departement of Mechanical Engineering
Technical University of Munich

Annual Report 2016

Jahresbericht 2016

Technical University of Munich
Departement of Mechanical Engineering
Associate Professorship of Sport Equipment and Sport Materials

Boltzmannstraße 15
85747 Garching
www.spgm.mw.tum.de

Infrastructure

- Mobile skin- and core-temperature measurement
- Multi-body simulation software SIMPACK®
- Mobile EMG and spirometry
- Video-based motion analysis
- Leg surrogate with loading device
- Instrumented bicycle
- 5-axis fatigue testing device for bicycle frames

Courses

- Basic Skills of Science
- Applied Biomechanics
- Sports Technology
- CAD-Basics (NEW WS16-17)
- Practical Ergonomics
- Digital Human Modeling
- Advanced Biomechanics
- Sports Engineering
- Interdisciplinary Research Project

Management

Prof. Dr.-Ing. Veit Senner, Director

Administrative Staff

Simona Chiritescu-Kretsch

Research Scientists

Aljoscha Hermann, M.Sc.
Dipl.-Sportwiss. Marius Janta, M.Sc.
Bahador Keshvari, M.Sc.
Dipl.-Kfm. techn. Univ. Philipp Kopp
Dipl.-Ing. Daniel Meyer
Dipl.-Phys. Jürgen Mitternacht
Stefanie Passler, M.Sc.
Dipl.-Ing. Kilian Rauner
Daniela Schranner, M.Sc.

Publications 2016

- Adam, C., & Senner, V. (2016). Which Motives are Predictors for Long-term Use of Exergames? Procedia Engineering, 147, 806-811. doi:10.1016/j.proeng.2016.06.310
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Sport Equipment and Materials

R&D in sports technology combining engineering, sports science and computational methods

A holistic approach to understand the interaction between athlete, equipment and environment requires knowledge in material science, biomechanics, physiology and even psychology. For this reason we continued to build up collaborations with different TUM research facilities. Just to mention a few of them, we now work together with our Biopolymer group in Straubing, with the Departement or Prevention, Rehabilitation and Sports Medicine and with the Chair of Psychology at TUM School of Management.

From our 2016 research activities four highlights are worth mentioning:

- Successful termination of our 3-year research project on the heart rate controlled electric bicycle 'QUADRAD'.
- Proof of concept of a new method to non-invasively measure the athletes' core temperature.
- Publication of a patent on energy harvesting by the athletes' motion and patent on emergency release for winter sport equipment licensed by a German/Russian company.
- Design and evaluation of a head cooling system for helmets.

Prof. Dr.-Ing. Veit Senner

Contact

www.spgm.tum.de
senner@tum.de
Phone +49.89.289.15366

Towards Better Performance with Optimized Sport Equipment

Improving the performance in both top level and leisure time sports is one motivation for our work. The focus is on optimizing the energy transfer between athlete and equipment and on reducing the inherent energy loss. On the equipment level we try to achieve this by:

- improved fitting to the individual (i.e. golf shaft),
- better weight to stiffness ratio (i.e. bicycle frame),
- using energy storage and return effects,
- optimized heat- and moisture management of sports garments (i.e. new infills for down jackets).

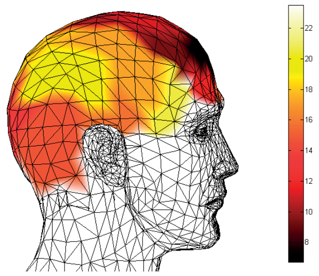
TrakTester measurement of traction loads with various different surfaces and with the foot and lower leg at various different angles (Image: Uli Benz / TUM)

One example of our 2016 research in this field is an investigation on traction behavior of trail running shoes.
Trail running is typically practiced under extreme boundary conditions with the ground being sometimes muddy, sometimes with gravel, sand, grass or even ice and snow. As trail running is often performed in terrain where deep falls are possible, traction is not only a matter of performance but also of safety. To objectively compare the traction behavior of different shoe soles and materials we use a specially designed biomechanical testing device, the so-called TrakTester.

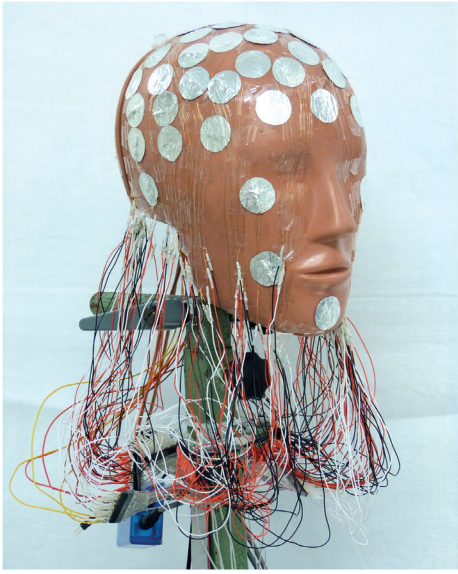
A silicone foot mounted on the testing device simulates the forces which act on both foot and running shoe. The artificial foot can be maneuvered into all positions that are typical of athletic movements and put to the test as part of the experiment. A multi-component measuring cell registers the force and torque delivered to the leg. These laboratory measurements are usually combined with standardized field tests. Professionals and non-professional experienced runners give their subjective ratings on a set of carefully selected items which characterize the functionality of the sport equipment in test.

Understanding the Interaction between Athlete, Equipment and Environment

This important research field in sports engineering continuous to be part of our work in 2016. A good example of this is the heat exchange between the sport helmet and the athlete. A dummy head has been equipped with a temperature controlled heating inside and 61 temperature sensors on the surface. Several concepts of cooling devices (heat relief systems HRS) have been designed for helmet integration. They were then compared under standardized conditions in the climate chamber and their capacity to cool the head's surface was quantified. There is less cooling effect of a vaporative cooling principle compared to a Heat Pipe & Heat Sink System, which seems to be more suited for such kind of application in bicycle helmets.



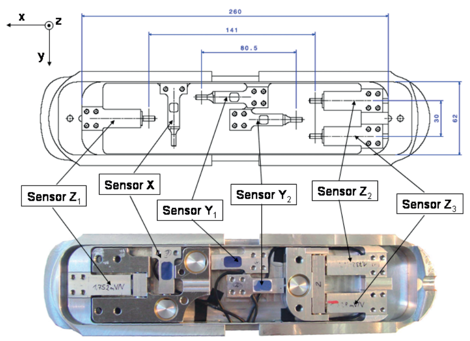
Measuring the head temperature distribution using helmets with different prototype cooling devices (Illustration: Stefanie Passler, TUM)



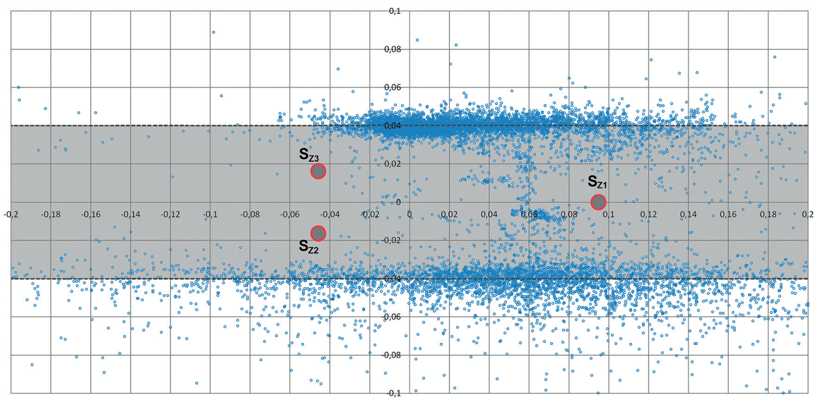
Instrumented dummy head with temperature sensors on the surface (Photo: Stefanie Passler, TUM)

More Safety with Improved Protection Gear

In alpine skiing knee injuries remain the major challenge for improved protection equipment. Systematic analysis of injury situations and human anatomy suggest that mechatronic ski bindings may provide the solution. In order to develop the release algorithms of such mechatronic ski bindings, it is necessary to determine the point of force application (PFA) during the turn. Using a specially designed six-component measurement binding, we collect on-slope data and determine the PFA for different skiing maneuvers. Knowing the PFA and the values of the external load components, we can combine these with the measured joint kinematics. Both together allow us to perform inverse dynamics to calculate the loadings to the critical knee ligaments.



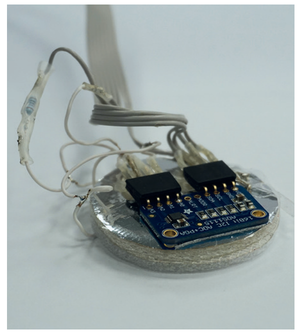
Inside view of TUM six component ski binding dynamometer



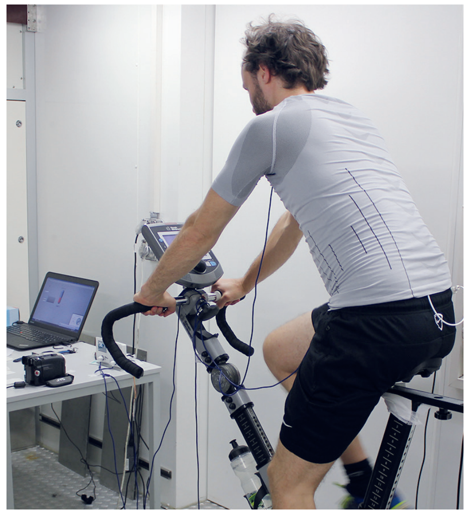
Location of the point of force application during a set of turns.

Health, Wellness and More Fun Through Technical Support

Sport and physical activity are considered as the preventive medicine not taken. Making physical activity part of daily or weekly routine thus is a strong predictor of long term self-management of health. In the last few years, a multitude of wearable smart phone accessories, such as activity trackers, smart watches or inertia sensors have come onto the market. They assist as a virtual coach, monitor vital parameters or even serve as a feedback system, if gait or posture differ from the normal. The future of wearables with sensors close, on or even in the body seems to be bright.



Our prototype of a zero-heat-flex sensor



Ergometer test in the climate chamber to validate a new type of on skin sensor to measure core temperature and dehydration state.

Sports engineering not only takes care of developing those systems or improving their accuracy and usability. It is also in charge to validate them against gold standards.
One example of our work in this field is the development of a Biofeedback System for Thermal Strain (BIOSS). The goal is the establishment of a non-invasive measuring method to determine heat stress and a possible over- or dehydration state. Relevant parameters are measured, such as skin and core temperature, sweat rate, heart frequency, serum sodium via blood sampling venipuncture or local sweat sodium concentration using ion selective electrodes. The integration of multiple factors shall lead to more reliable predictions of thermal strain and feedback on reasonable counteractions in physically active situations.

Research Focus

- Improved performance of sport equipment
- Safety and protection gear to avoid overloads
- Thermo-physiology in sport garment design
- Footwear – sport surface interaction
- Electric and muscle-powered lightweight vehicles

Competence

- Muscular-skeletal models and simulation
- 3D-motion analysis (optical, inertia, DGPS)
- Electromyography (EMG) and spirometry
- Measurement of external loads and plantar pressure
- Development of physical models (foot and ankle, knee, lower leg)