SPORTS TECH Projects: Master Thesis

1. Head acceleration sensors (skiing, snowboarding, bicycle, extreme sports etc.)

Using small sensor chips it is needed to design something measuring and recording the head motion one can wear under the helmet. Sensors should detect motion of the head (linear/angular accelerations) and record to the laptop computer (or dedicated small logger).

This is a typical 'design with users in mind' type project, needing some pre-studies of existing examples, discussing with potential users and thinking of the future manufacturing, doing small prototype and performing initial tests (ideally including the tests in the field).

Some knowledge of electronics will be a bonus, but help with the sensors and recording equipment will be provided.

The Project is suitable for one or two students.

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2. Temperature/humidity monitoring underwear

In many cases, especially with the amputee athletes, there is a loss of body sensitivity to low temperatures. During training and especially competitions athletes can (and some time do) damage their health through not knowing that in some parts the body temperature dropped below dangerous limit. Cases of dangerous body temperature drops are known not only for the winter sports but also for the swimming, but we are thinking about winter sports and outdoors first of all.

The task is to design an underwear garment that can incorporate small temperature (temperature + humidity) sensors in different positions. It should be comfortable to wear, and there should be a possibility to remove sensors so user can easily wash the garment.

This is a typical 'design with users in mind' type project, needing some pre-studies of existing examples (if available), discussing with potential users and thinking of the future manufacturing.

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4. Measuring snow properties & designing new materials for indoor testing

Also- system for the field measurements (Density, acoustics, impact, RH, T, Friction, water content using resistance)

Today many of the skiing events happen at near-melting temperatures. Ski gliding at such temperatures is rather poor, and preparing the skis for near-melting temperatures is a real challenge. One of the largest problems is that snow properties (and thus- gliding conditions) are changing dramatically when the temperature changes from near melting (above zero- to about -3 ^{o}C) to cold conditions (below -5 ^{o}C). This is also complicated by the fact that ski tracks are often coming through the terrain with changing profile (higher to lower ground and back), so the temperature along the track near Ski Stadium in Östersund can be varying for more than 5-7 degrees.

Portable equipment is very much needed to forecast snow properties and to forecast the gliding conditions. Corresponding sensors that can be used to measure snow density, temperature, humidity are easily available, but there is a lack of the knowledge how one can use what is measured (e.g. how to link it to the snow conditions and gliding).

The task is to design small device that can be driven into the snow with the sensors in it. And to perform some field experiments comparing gliding times for the same skier and same pair of the skis at different weather conditions (ideal time is spring, when the temperature at night falls below zero and during the day time rises up considerably), recording the data from this new 'composite sensor' thing and snow surface temperature (for example using IR thermometer or camera). Finally you should look at the correlation between the measured parameters and the gliding times.
Some knowledge of electronics will be a bonus, but help with the sensors and recording equipment will be provided.
This is a project for those who are interested in additive manufacturing, research and skiing-related applications.
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5. Dedicated force plates for skis (5a: alpine ski; 5b: cross-country ski)

Measuring forces in tree directions between the ski binding and the ski is widely used in research and training. There are no commercial systems available at the moment, and only home-made ones are used today. Majority of the systems are using commercial load cells and thus the dimension of the overall plate system is defined by these cells. Thus such systems are not as thin as we would like them to be.

Majority of the load cells are monitoring the deformations of their metal sections produced by external loads. And actual sensor elements in the call are strain gauges, extremely thin and having rather small footprints on the surface. There is an alternative: using additive manufacturing in metal (Ti64) it is possible to design a dedicating plate with integrated strain gauges, that will be thinner and lighter than other constructions.

The task is to design such plate, manufacture it from Ti64 in the ARCAM 3d-printer, integrate the strain gauges into it, perform laboratory tests (design corresponding rigs and test under different loading conditions with INSTRON), and- ideally- perform preliminary field tests.
Some knowledge of electronics will be a bonus, but help with the sensors and recording equipment will be provided.
Differences: cross-country skis, alpine skis, snowboard
For the snowboard/alpine skis the plate should be some thicker and larger- easier to construct as there is larger space. For the cross country ski- thinner and smaller size plate, certain optimisatoin of the construction will be needed.
This is a project for those who are interested in additive manufacturing, research and skiing-related applications.
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6. Ski pole force sensors

Measuring forces in the cross-country or alpine skiing is widely used in research and training. There are no commercial systems available at the moment, and only home-made ones are used today. Majority of the systems are using commercial load cells or thin film sensors . Though such systems are successfully used, but they are not free from the drawbacks. Moving parts in the systems with thin film pressure sensors can get stuck, commercial load cells (even smallest of them) are larger than what would be ideal.

Majority of the load cells are monitoring the deformations of their metal sections produced by external loads. And actual sensor elements in the call are strain gauges, extremely thin and having rather small footprints on the surface. There is an alternative: using additive manufacturing in metal (Ti64) it is possible to design a dedicating plate with integrated strain gauges, that will be thinner and lighter than other constructions.

The task is to design metallic (Ti64) insert that can be integrated into the ski pole top (handle) working as the three-directional force sensor and to manufacture it in the ARCAM 3d-printer, integrate the strain gauges into it, perform laboratory tests (design corresponding rigs and test under different loading conditions), and- ideally- perform preliminary field tests.
Some knowledge of electronics will be a bonus, but help with the sensors and recording equipment will be provided.
This is a project for those who are interested in additive manufacturing, research and skiing-related applications.
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7a, b. Comfort in the cold: "Artificial hand (a) /foot (b)"

Measuring heat transfer properties of the gloves, socks and footwear in the controlled laboratory conditions will improve the reliability of the acquired data. There exist full body mannequins of different degree of complexity allowing for such or similar tests. But full body mannequin systems are extremely complex and expensive. Thus making artificial hand/foot for such studies could be advantageous.

<u>Project @level complexity 1</u>

The task is to design and manufacture using 3d-printing a thin shell following the 3d outlines of the hand (foot). This shell should be filled with liquid (water or water-based solution) and have a heater inside. Multiple small (chip) temperature sensors should be placed at a number of positions on the outer (and inner) surfaces of the shell. The system should be tested with the gloves (socks, footwear) over it when placed inside the freezer to assess the dynamics of the heat loss at different conditions. Comparison of few different brands of the winter gloves (socks, footwear) should be carried out in the laboratory and the field tests.

<u>Project @level complexity 2</u>

The task is to design and manufacture using 3d-printing a thin shell following the 3d outlines of the hand (foot). This shell should be filled with the material mimicking the human tissue and have a set of integrated (thin-film?) heaters. Multiple small (chip) temperature sensors should be placed at a number of positions on the outer (and inner) surfaces of the shell. Control electronics allowing for the differentiated heat deposition in different sections of the model should be designed and constructed. The system should be tested with the gloves (socks, footwear) over it when placed inside the freezer to assess the dynamics of the heat loss at different conditions.
Some knowledge of electronics will be a bonus for project @ complexity level 1 and essential for project @ complexity level 2, but help with the sensors and recording equipment will be provided.
This is a project for those who are interested in additive manufacturing, research and comfort-related applications.
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8. Biathlon recoil mimicking device and indoor training technology

Dry shooting (without ammunition) is not replicating real one as there is no gun recoil. Present project involves testing new device mimicking gun recoil that can be added to any biathlon rifle allowing better fidelity of training. It will be complemented by other measurements characterising the balance of athlete when shooting in staying position. Main aim is to develop technology of indoor training (no ammunition involved) for the biathletes improving better stability of the rifle and faster recovery of the rifle position after distortions ("shooting", wind etc.)

This is a project for those who are interested in training, biathlon and related issues and are not afraid of many experimental trails with real small caliber weapons.
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