

## Development of a Sensor System for Muscle and Limb Motion

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*The Eurostars Sensmotion project aims at providing a solution to assess the muscle performance of professional athletes. The system could also be used to measure the progress of athletes in re-education after an injury. The industrial partner of the project is already using a larger and cumbersome system to address the performance evaluation of professional sportsmen. Sensmotion aims at providing a more powerful, multi-dimensional and easy to use version of such a system.*

Measuring the forces exerted by a muscle is a difficult process without relying upon invasive measurement methods and procedures. Traditional indirect measurements, like measuring the electrical activity by putting electrodes on the surface of the muscle or needles into the muscle, the so-called electromyography (EMG), do not produce reliable image of the physical forces produced by the muscle.

An achievement of the industrial partner of the Eurostars SensMotion project, the Slovenian company TMG-BMC Ltd, is the development of a sensor which measures the physical displacement of the muscle. The sensor is taped on the limb and is able to estimate the strength exerted by the muscle. The principle of this sensor is already used commercially by TMG-BMC, but their current measurement system is not miniaturized and therefore not wearable which makes some type of measurements impossible.

The goal of the sensor system development is to provide a set of devices capable of measuring:

- the signal provided by the special muscle sensor;
- the electrical muscle activity (EMG);
- the acceleration of the limb at the place of the sensor;
- the articulation angle between two limbs.

The articulation angle is a physical parameter which is not available with the current system used by TMG-BMC. However, the muscle sensor output is related to that articulation angle, which makes it an interesting parameter regarding the measurement of muscle power.

The key requirements for the success of the sensor system, as envisioned by TMG-BMC, are:

- it should be easy to use, to wear and to setup;
- it should be capable of monitoring a running athlete;
- the sensor should be kept small and very light-weight, in order not to alter the measured parameters;
- it should be able to provide a feedback to the user.

A corollary of the ease to use and to wear is that the project partner would like to avoid as much as possible the employment of wires to interconnect each entity of the sensor system. Ideally, the system entities should send wirelessly the measured parameters to a central unit located on the body or near the user, which should also provide a biofeedback to the user. The biofeedback may be an acoustic signal, warning the user within an appropriate delay that he is making a wrong movement. The shorter the feedback delay is the better the system efficacy will be. The sensor transmission should thus provide a means to communicate without a large latency. The commonly used Bluetooth™ technology cannot be used both

for communication latency and module size reasons. Some other common technologies, like Wireless LAN, cannot be used either due to the size of the available modules and the power consumption. Finally, the sensor system will rely upon traditional radio transceivers, but used in a proprietary transmission mode. Figure 1 shows the muscle sensor electronics first PCB and sensor.

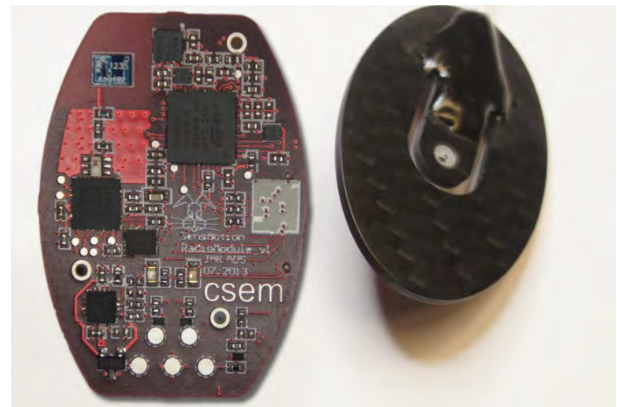


Figure 1: Muscle sensor electronics first PCB and sensor.

The measurement of the limb angle is quite difficult, especially with the emphasis on user friendliness, setup, and comfort. In fact, the system should not hinder the movements of the athlete wearing it.

A study performed within the framework of the project listed most technologies available to measure the limb angle, but none of them fulfills user requirements. Direct physical measurement performed by a mechanical goniometer are difficult to install and cumbersome. Optical sensors are either too difficult to setup or cannot work reliably in outside conditions under direct sunlight. Inertial measurements, commonly performed with accelerometers and gyroscopes, are commercially available and are covered by an important patent portfolio. Moreover, these sensors are quite difficult to calibrate if installed on the body by final users. Technologies relying on the measurement of propagation time of either a sound or radio wave are not accurate enough to provide either resolution of a few degrees or the update rate required for fast running movements.

The measurement principle used in this project, will be based upon inductive coupling between two coils, one on each limb of the articulation being measured. By giving a slight angle to the coils, the accuracy of measurement should be improved at the extreme position of the joint. This measurement principle is also compatible with limited power consumption, and hence can be powered from a small battery.

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