A WEARABLE SENSOR SYSTEM FOR SPORTS AND FITNESS APPLICATIONS

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Introduction Wearable sensors are an important tool in sports. They can provide individualised feedback during training sessions, give feedback to athletes, and improve their personal health status. Common to all applications is to measure physiological data or biomechanical motion data. Therefore, we present a wearable, small and lightweight low power sensor system that allows long-term monitoring of physical quantities while maintaining a high sampling rate. It can be integrated into clothing or sports equipment without affecting the athlete's performance and behaviour.

Methods We designed a new sensor system based on available low power components. It contains an inertial measurement unit (IMU) including a 3-dimensional accelerometer, gyroscope and magnetometer. Furthermore, temperature and barometric sensing were added. The core is a powerful ARM Cortex-M3 microcontroller with on-node processing capabilities. Sensor data is stored using a NAND flash memory, while an EEPROM stores permanent configurations. The system is powered by a small lithium-polymer battery which provides long runtime and is monitored by a special fuel gauge. A high precision real time clock enables a constant sampling rate and synchronises multiple sensors by supplying an exact global time. These are important features to allow sophisticated signal processing algorithms to be used on highly dynamic sports motions. All parts are mechanically combined in a plastic enclosure, which has similar dimensions of present wearable monitoring systems. This enables fast and easy sensor integration into clothing and sports equipment.

Results The system was able to successfully record all nine IMU axes plus barometric data at 1 kHz for up to 20 h. Additionally, a maximum sampling rate of up to 8 kHz has been tested. Accelerometer and gyroscope range was adjustable from +/- 2 g to +/- 16 g and from +/- 250 deg/s to +/- 2000 deg/s respectively. Data transmission was realised by USB. Synchronisation of multiple sensors could be achieved with a maximum clock deviation of 8 ms over 1 h. The dimensions are about 40 x 30 x 8 mm.

Discussion Sampling rate and storage capacity should be sufficient for most applications in sports or fitness. It is possible to record data over a long period of time or to measure at higher sampling rates for a shorter time period. The USB connection is more suitable than wireless data transmission regarding energy consumption and the high data volumes caused by long-term measurements. This sensor system allows an easy way to instrument clothes or sports equipment. In the future it will be applied in biomechanical studies and enable a precise analysis of highly dynamic sports movements indoors and outdoors.