TOTAL BODY MOVEMENT MONITORING USING A REGULAR SMARTPHONE TO DETECT BICYCLE ACCIDENTS

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AIM: Today's high-end smartphones are typically equipped with both GPS functionality and movement sensors such as accelerometers and gyroscopes. The aim of this study was to explore to what extent inherent smartphone sensors can be used to monitor non-trivial total body movement. A specific aim was to test if a smartphone can be used to automatically detect when a bicyclist fall or is involved in an accident.

METHODS: First an inventory was made to sort out possible smartphone candidates based on sensor dynamics and system characteristics that provide enough amplitude and time resolution of the sensor signals for total body movement evaluation. Next was to use the selected smartphone to record movements during bicycling to create a pool of "normal" data and use this to learn what acceleration and orientation levels typically occur in bicycling. The approach used to detect a possible fall or accident is to detect when the recorded signals deviate significantly from what is found in normal bicycling. The suggested algorithm where verified during regular bicycling and in simulated falls/accidents using a simple custom built crash test dummy placed on a regular bicycle.

RESULTS: A Google Nexus 4 smartphone was chosen for the study. This device is equipped with a combined accelerometer and gyroscope chip (MPU-6050, Invensense) allowing the sensor signals to be recorded with a sampling frequency up to 1 kHz. In order to allow the smartphone to be easily carried, i.e. not fixed to the body and thereby not distinguishing "true" x, y, z –directions, an integrated accelerometer signal measure was created based on the sum of the square of each direction. In normal use this acceleration measure was found to be as high as 4 g. These levels could be from simple handling of the smartphone or e.g. from road bumps during cycling. This prompted that high acceleration measures alone are not appropriate to be used to indicate a fall or accident. Based on the pool of recorded "normal" data and Matlab tests using signals from the simulated fall/accidents an adequate crash detection algorithm could be designed based on a combination of accelerometer and velocity measures and changes in orientation within a time window. The suggested algorithm was evaluated in >20 hours of normal bicycling without any false positive alarms and successfully in 10 simulated accidents using the crash test dummy. Contrary to what was expected, the algorithm did not demand any special arrangement for carrying the smartphone tightly fixed to the body.

CONCLUSION: This study shows that non-trivial total body movements can be monitored and used in real-time evaluation based on the inherent sensors of today's high end smartphones. This opens up for inexpensive and easy access to long term monitoring of total body movements to be used e.g. in rehabilitation to inform or warn about specific activities or activity patterns.

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