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### Virtual & inertial sensors to detect illegal cricket bowling

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Cricket bowlers suspected of an illegal arm action under the laws of cricket undergo testing in an approved biomechanics laboratory. They are assessed using a variety of analysis systems such as retro-reflective motion analysis systems (e.g. VICON). In general these systems allow for detailed and sophisticated analysis of human movement but are limited to the contrived laboratory environment and have suspect ecological validity. In-situ studies into bowling actions have typically relied upon frame by frame high speed match video analysis which, aside from the time involved, also has limitations in discriminating between sources of elbow movement such as flexion, extension, hyperextension, abduction & adduction. In-situ Micro Electro Mechanical Systems (MEMS) inertial sensors have the potential to discriminate between legal & illegal bowling actions in real time.

**Methodology and Results:** Using previously developed wearable technology it is possible to measure arm action at a number of points on the bowling arm. The technology is based on inertial sensors and measures the arms changes in motion hundreds of times a second. These sensors respond to minute changes in inertia in linear and radial directions. These are known as accelerometers and rate gyroscopes, respectively. Case study results from a sub elite bowler show clear differences between throwing and bowling action. Processing of existing *elite bowler* laboratory motion capture data, to convert the 3D global frame of reference data into arm mounted 'virtual' inertial sensors has provided confirmation of information collected from sub-elite bowlers. These virtual sensors also provide information on the range of rotation rates and accelerations that occur during the bowling arm-action as well as identifying signatures that frame the bowling action.

**Conclusions:** The sensors have been shown to be able to detect a number of arm actions. The virtual sensors have confirmed that these signals exist in the actions of elite bowlers. The virtual sensors have also identified signals that frame the bowling action allowing it to be identified in real time. The next step in this research is the development of sensors that can respond to the range of high rotation rates and accelerations, the laboratory verification of these sensors, and the testing of the sensors in competition.

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**Keywords:** Rate Gyroscope; Accelerometers; Virtual Sensors; Cricket; Illegal Bowling Action.