Wireless Acquisition of Joint Loading in Industrial Tasks using Inertial Motion Sensors

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Introduction

Acquiring continuous data collection from field-based industrial work tasks that adequately portrays joint loading has been a goal of researchers for many years. Several video and camera based methods have been used to acquire kinematic data but these systems make it difficult to acquire motion in numerous planes of motion. They are also criticized for being invasive to the worker and leading to altered motion characteristics. Until now, the ability to acquire highly accurate kinematic data in the field has been unattainable. A newly developed portable data acquisition system using inertial motion sensors means that continuous, non-invasive data from an industrial work task can now be accessed and analyzed. It will now be possible to understand how ongoing daily work tasks affect cumulative loading patterns in all joints of the body.

Method

Advances in technology have made it possible to acquire three-dimensional orientation estimates using small inertial motion sensors and the use of Bluetooth™ technology enables wireless transmission of the signal to a portable computer. Luinge and Veltink (2005) designed a Kalman filter capable of correcting integrated gyroscope data by referencing accelerometer data and continuously calculating a gyroscope offset value to yield orientation values accurate to within 3º root-mean-square (RMS) error. In order to correct drift around the vertical axis, a magnetometer reading was fused with the gyroscope and accelerometer data (Bachmann, 2003; Zhu and Zhou, 2004).

The kinematic orientation data acquired with these sensors have been mapped to an anthropometric model to yield relative positional data for each segment. Using only orientation estimates (3 degrees of freedom), the model predicts positional coordinates for each link endpoint to yield full 6 DOF kinematic data input. To acquire kinetic information, an estimate of hand load is incorporated into a hands-down inverse dynamic model in order to predict joint forces and torques for each linked joint from the wrist to lumbar spine. Ongoing work is quantifying how individual sensor orientation errors propagate along the linked segments within a human model to influence the positional estimates of the relative joint center. The software interface allows graphical plotting of the human moving in real-time and off-line estimates of cumulative joint loading at the elbow, shoulder and L5/S1 joint can be made.

Conclusion

Ongoing work is being done to establish that inertial motion sensors (IMS) have sufficient accuracy to be used as a kinematic data collector for incorporation into an inverse dynamic model. The IMS based system has the potential to measure cumulative loading in the field more efficiently and effectively than existing tools that rely on video or pen and paper data collection.

References:

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