Using Electromyography to Predict Head Motion for Virtual Reality Applications

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The objective of this research is to use neck and shoulder electroymograms (EMG) to predict head movements in immersive virtual environments in order to minimize time lags in updating the visual scene that can cause disorientation and simulation sickness. Visual update delays are a critical technical obstacle for implementation of head-mounted displays in a wide variety of applications from training simulations and mission rehearsal to teleoperation and telemedicine. These applications require a perceptually veridical mapping between actual head position and virtual spatial position in the synthetic environment. Figure 1 shows an example of a subject attempting to superimpose virtual and real objects where the virtual visual environment appears to “swim” around when head movements are translated slowly into visual updates. These latencies are mostly due to delays in sensing head motion with inertial sensors (accelerometers and rate gyros). EMG signals from muscles precede force exertion and, therefore, limb or head accelerations by about 30 milliseconds. We expect to gain a comparable reduction in head position update time by using EMG in the VE stabilization loop instead of or in addition to inertial sensors. We evaluated the pattern of EMG activities in the roughly 30 muscles involved in head motion with a set of up to 32 electrodes placed around the neck as shown in Figure 2 rather than attempting to isolate the effect of each muscle separately.

A solution of this many-to-six (32 EMG signals to 6 inertial linear and angular accelerations) real-time pattern-recognition problem could reduce or eliminate the latencies encountered in current VE applications, making this technology more viable, especially for see-through applications.. In support of this goal, we established an EMG laboratory where data from both EMG and inertial sensors were collected to predict head movements in virtual environments and to minimize update delays. Data from five human subjects have been collected thus far. Data analysis supported the prediction that EMG signals precede inertial measurements by 20 to 30 milliseconds. As an initial step, we have developed a neural network pattern recognition algorithm that accepts current inertial data and predicts future angular velocity for a single angular velocity component.

Research Area: Aerospace Human Factors and Human-Centered Systems Engineering.