REAL-TIME MEASUREMENT USING EMG AND MOTION CAPTURE SYSTEMS

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Real-time feedback to participants of a particular parameter has been a viable tool for learning, training and rehabilitation for many years. The type of feedback that was usually given was in the form of kinematics (e.g. accelerometry) or kinetics (e.g. force). The manner in which the feedback has been given has been altered greatly in recent years by the development of equipment and software that enables the researcher to accomplish the feedback tasks much more easily than previously. In this paper, real-time electromyography (EMG) and real-time kinematics will be presented. The most recent equipment for both real-time EMG and kinematics will be presented along with examples from recent research papers that used such techniques.

KEYWORDS: feedback, electromyography, maximum voluntary contraction, kinematics, functional joint center

INTRODUCTION & OVERVIEW:

For many years, the real-time assessment of movement has been a topic of great interest. Usually real-time feedback was obtained for kinematics using electrogoniometry or accelerometry or for kinetics using force transducers. However, the equipment to easily accomplish real-time assessment for EMG and for motion capture systems has only become readily available quite recently. It should be noted that "real-time" does not necessarily mean at the exact same time as the occurrence of the measurement parameter. Real-time essentially means that there is a very small lag between the occurrence and the presentation of the data. The purpose of this paper is to illustrate the techniques of real-time acquisition and assessement in electromyography (EMG) and kinematics and to present examples of how these techniques can be used in laboratory settings.

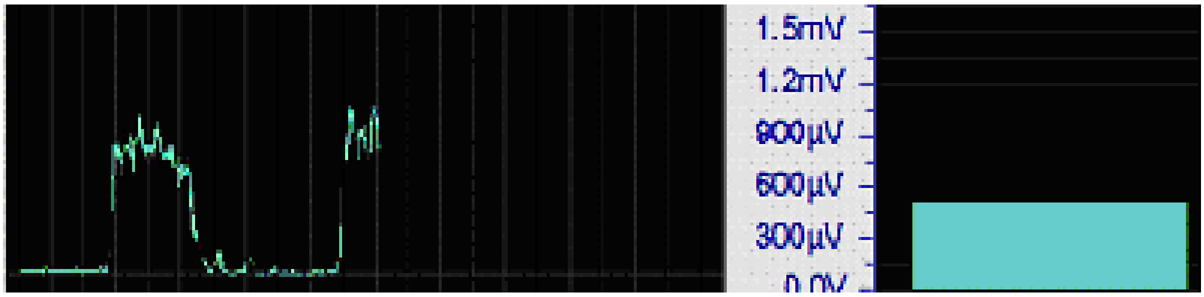
REAL-TIME EMG:

For this paper, the EMG equipment that was used included a Delsys Trigno Wireless EMG system with EMGworks 4.0 software sampling at 4000 Hz. It is assumed in this paper that the placement of EMG electrodes is in compliance with usual standards (Basmajian and DeLuca, 1985). In order to perform real-time EMG recording, it may be necessary to normalize the raw EMG data for comparisons between subjects or to track subject progress over time. Since the amplitude of the EMG signal can depend on sensor placement, skin preparation, and other factors, normalizing the data to a maximum voluntary contraction (MVC) can allow the researcher a quantitative method to compare between subjects or test sessions. This can be easily accomplished using real-time methods. MVC can only be elicited with proper subject training when feedback of the EMG level is observed. Without training, a subject may only contract to 60-80% of their true MVC level. Alternatively, a known voluntary contraction could be used for test subjects that may not be able to perform an MVC. In this case, a sub-maximal activity – such as a toe raise or bicep curl with little weight added – can be used to normalize data (see Figure 1).

PRACTICAL APPLICATIONS OF REAL-TIME EMG:

The type of research that real-time EMG can be used for includes:
1) physical rehabilitation - for physical rehabilitation studies, EMG feedback can be used to monitor the use of certain muscles (Horsley et al., 2010). With appropriate coaching and feedback, a subject can be trained to either activate or avoid activating a certain muscle while performing a task (see Figure 2).

2) fine motor control assessment (tracking) - to assess a participant's fine motor control, tracking a constrained trajectory using biofeedback can be used (Prodoehl and Vaillancourt, 2010).. A number of tracking trajectories can be used for different purposes (see Figure 3).



Subject contracting 1 second pull

Figure 1. Real-time EMG feedback on the left and a bar graph showing the subject their muscle activation level on the right.

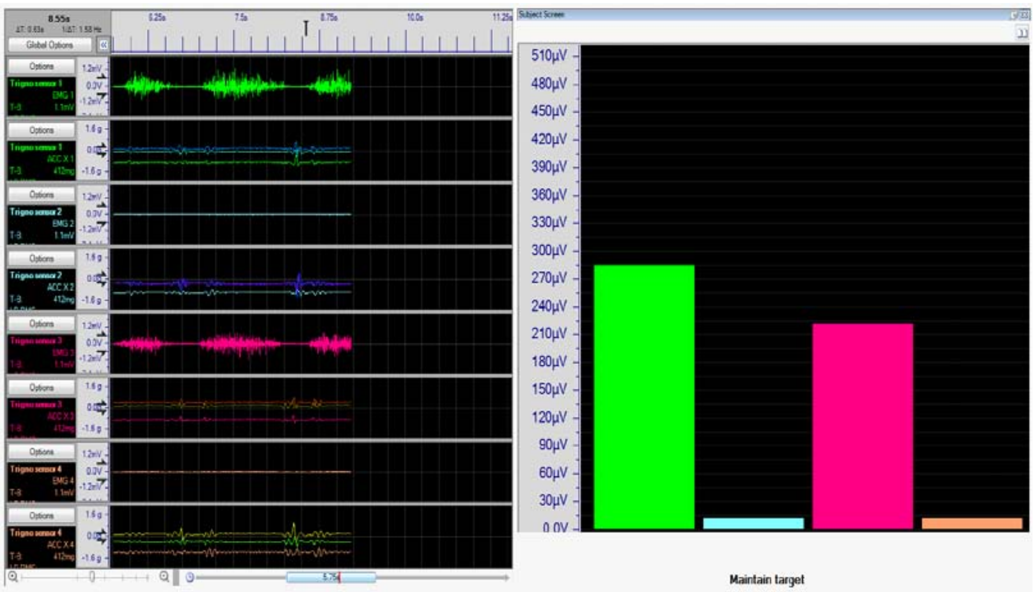


Figure 2. On the right, color-coded bars show the real-time EMG activity to the subject in an easily interpretable fashion—a taller bar means more activity. The subject can use this information to modify their behavior in order to selectively activate or not activate a muscle.

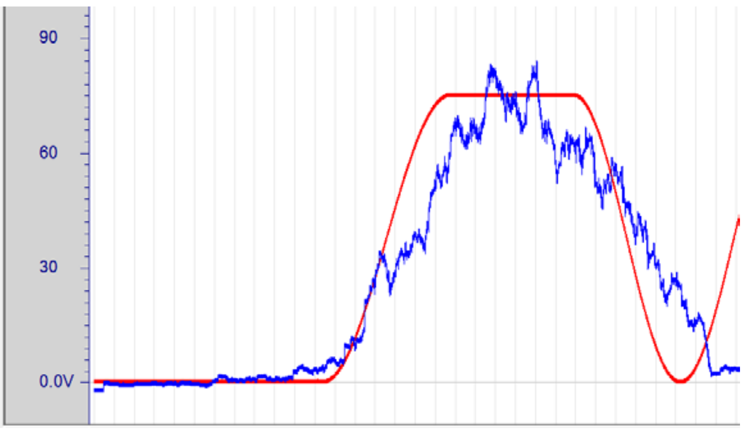


Figure 3. In real-time, the participant is required to activate the muscle is a manner that tracks the target.

REAL-TIME KINEMATICS:

The equipment that was used to present real-time kinematics was an eight camera Qualysis Oquus motion capture system sampling at 250 Hz. The software used for real-time capture is Visual3D (C-motion, Rockville, MD, USA) which can be used in conjunction with all of the major motion capture systems. There are two uses that real-time data capture can serve in a kinematic study. The first of these involves the determination of functional joint centers that will be later used in the analysis. In order to compute a functional joint center, a model must be determined with all of the relevant markers identified. In addition, all of the functional joints must be defined. With the subject standing in the field of view, the markers that define the joint are identified while the participant moves the joint through a range of motion that is functional for that joint. Based on these movements, the instantaneous joint center is defined. There are particular advantages in using a functional determination of the joint center rather than the usual static determination. Most important is that the joints that are determined are functionally relevant and anatomically meaningful. This provides an advantage to further calculations that may be considered more accurate.

After the functional joint centers have been determined, these joint centers are used in the calculation of 3-D joint angles. In the streaming data mode, with the participant performing a particular movement, the markers are automatically identified, the angles calculated and a particular angle may be presented to the participant. The participant may see the angle as a time history or as a bar graph. By viewing this feed-back, the participant may alter or sustain a particular level of joint motion (see Figure 2).

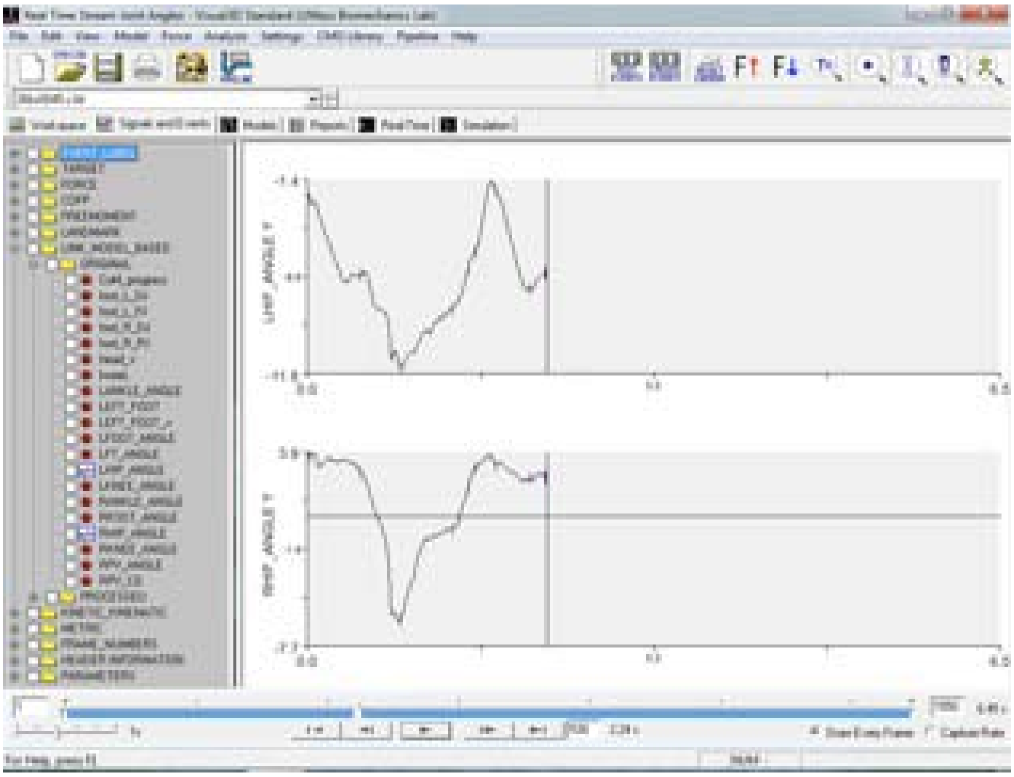


Figure 2. Real-time feedback in Visual3D showing joint angles. The horizontal line indicates the time at which the sample was taken.

PRACTICAL APPLICATIONS OF REAL-TIME KINEMATICS:

Real-time kinematics have been used for several types of feedback studies. In a recent study, Hanlon and Anderson (2005) used real-time bandwidth kinematic feedback in learning a novel cyclical lower extremity movement skill. The task used in this study involved accurately replicating a 4-s movement of the right limb followed by non-feedback trials. These

authors reported that steady performance improvements were made with relatively simple feedback.
In a study that incorporated real-time feedback, Page and Hawkins (2003) developed a system in which rowers were trained on an ergometer that gave biomechanical information as feedback. The rowers were presented with a stick-figure representation while they performed on the ergometer. In addition, they were given information on handle position. Re-training movement after an injury has been a key feature of rehabilitation treatment in physical therapy. Willson and Davis (2005) used real-time feedback from a motion capture system on injured runners. These researchers determined a target range of motion for a particular lower extremity joint for each participant. When presented with a real-time bar graph of the target area, the runner attempted to alter their movement pattern within the target range.

CONCLUSIONS:

Real-time data acquisition is not new and the applications of this type of data acquisition have been used previously. However, much easier real-time data acquisition for EMG and kinematics has been made possible by advances in both technology and software. While the research questions have not really changed, these developments have made real-time studies more accessable to researchers and much easier to accomplish.

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