CHAPTER 5

ANALYSIS OF EMG MEASUREMENTS

This chapter presents recorded samples from the EMG Capture (EMGC) program using the developed EMG amplifier device. The samples were recorded in real time from real human hand. The experiment preformed grasping of objects of different sizes and shapes.

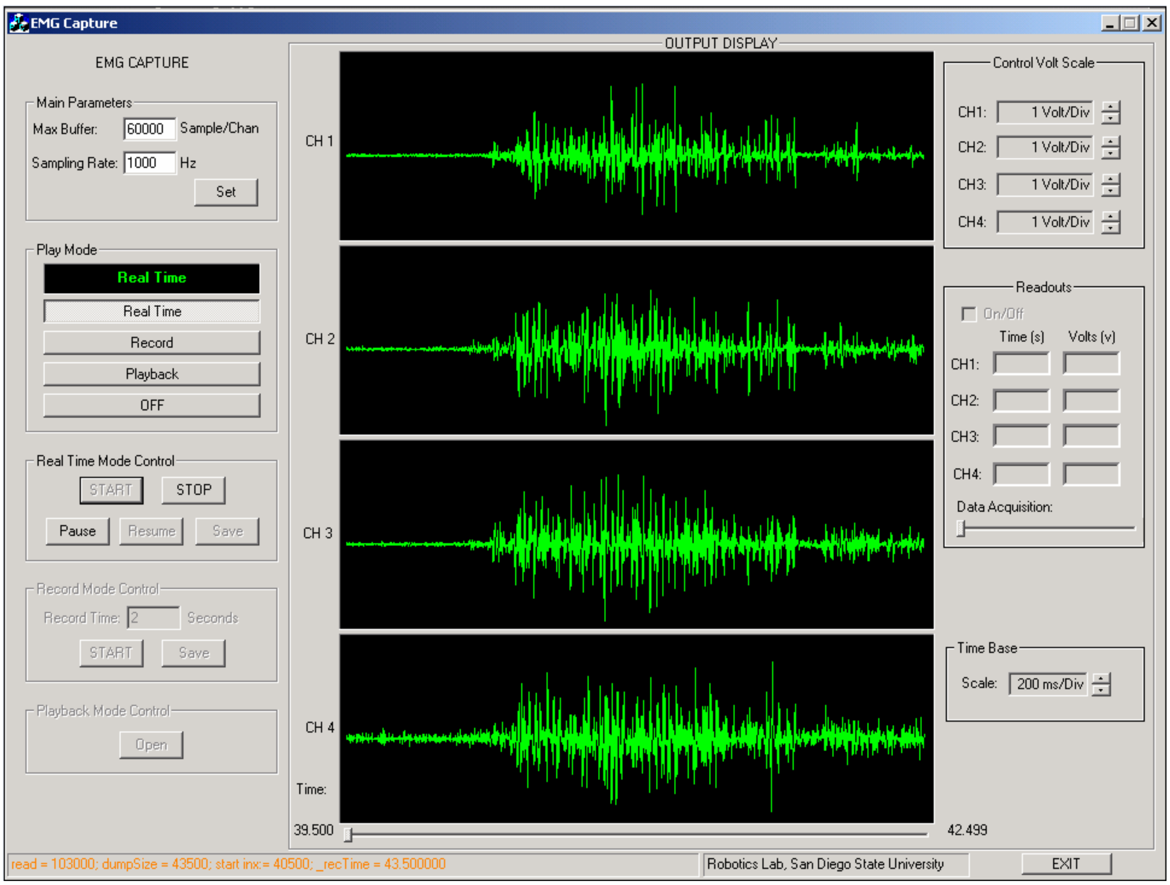

Figure 5.1: Snapshot of EMGC GUI in real time mode.

The snapshot of the EMGC panel in real time mode is shown in Figure 5.1. The experiments began by pressing START button in Real-Time subpanel, then three consecutive grasps were performed. Once all three graphs were completed, the PAUSE button was pressed, followed by pressing SAVE button to save the EMG data to file. The SAVE button opens a dialog as in Figure 5.2. After the saving is completed, the EMGC shows the saving complete message on screen as shown in Figure 5.3.

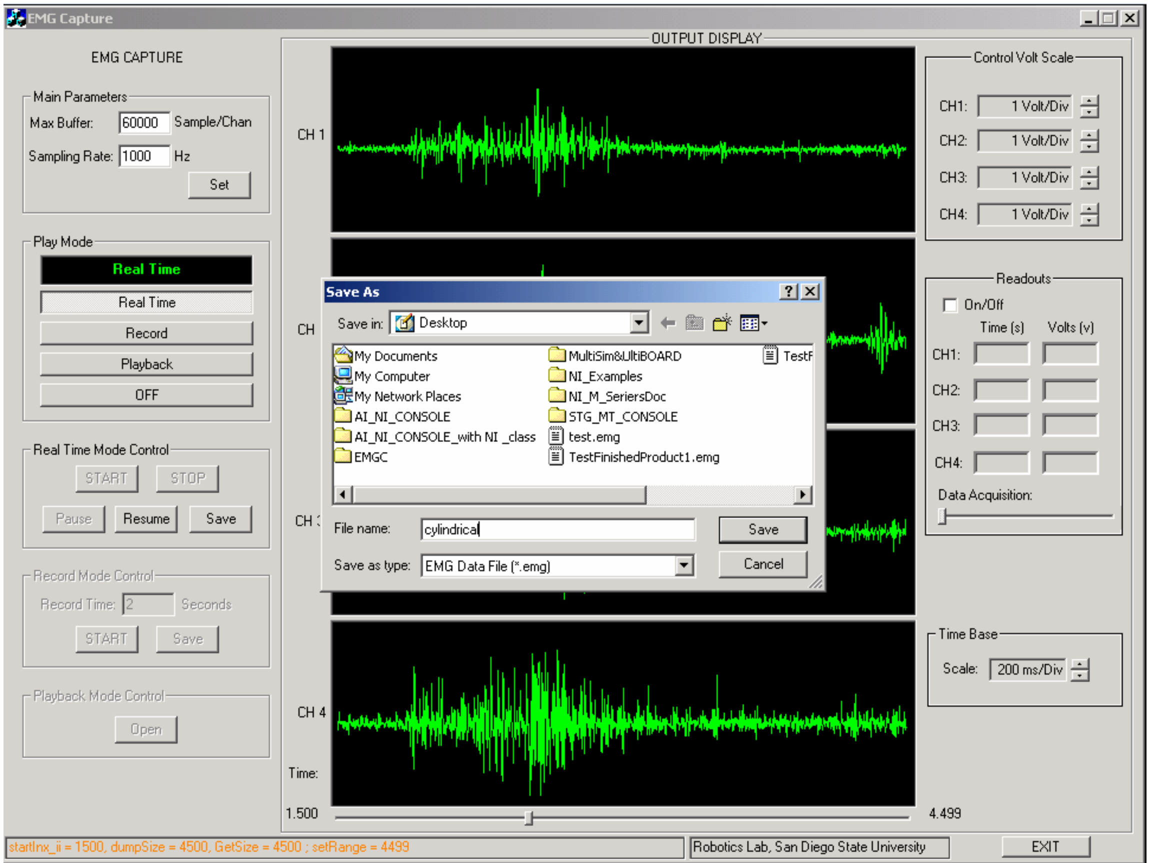

Figure 5.2: Snapshot of EMGC GUI in real time mode with save dialog.

The captured EMG data file can be played back by using EMGC program as shown in Figure 5.4. The data file of interest can be opened by pressing OPEN button in Playback subpanel as shown in Figure 5.5.

After opening the file, EMGC program will draw graph on the output display. After that, user can use time and voltage scale to analyze the EMG data. In addition, user can use the readout feature to read exact voltage values in any specific time instance (see section 4.1.5).

Figure 5.6 shows the excerpt of data file recorded for cylindrical grasp displayed in Figure 5.5. The EMGC program automatically gives the extension '.emg' to the data file. The header of the file provides information about sampling rate, and recorded time period.

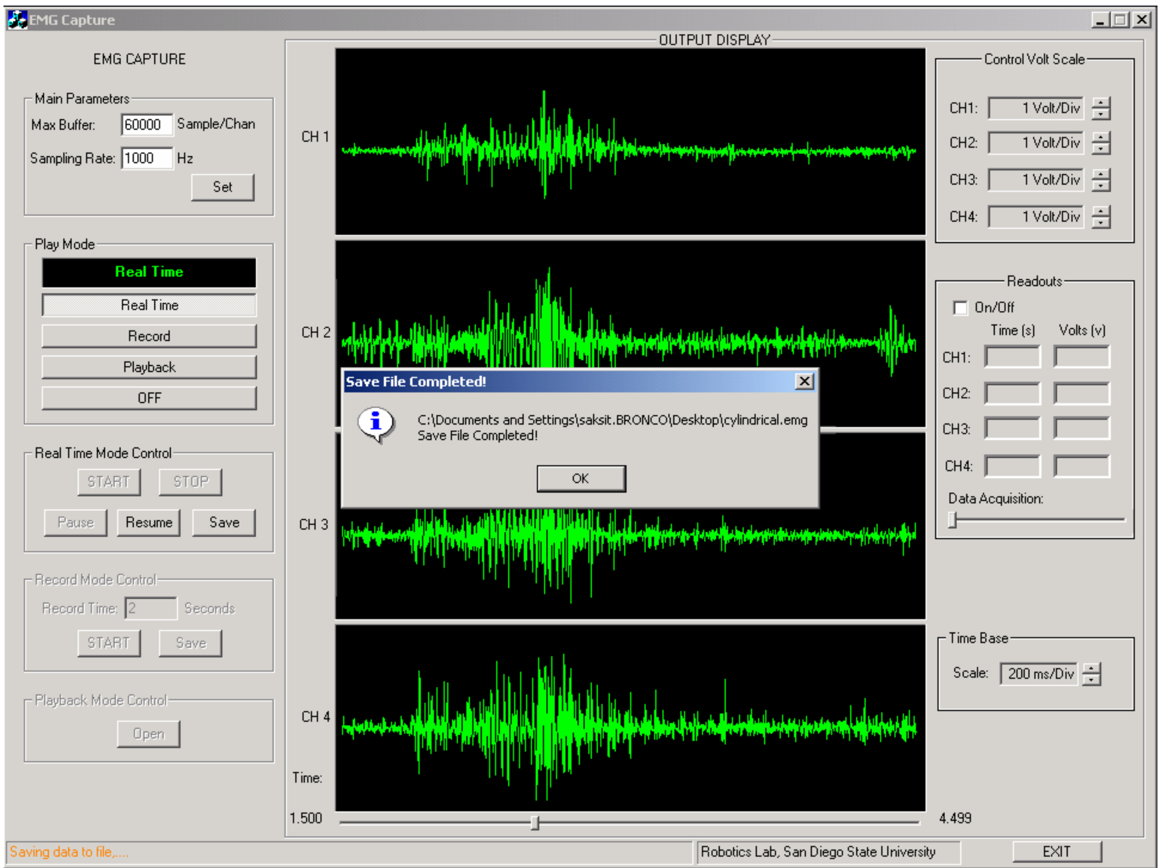

Figure 5.3: Snapshot of EMGC GUI in real time mode with completed saving message.

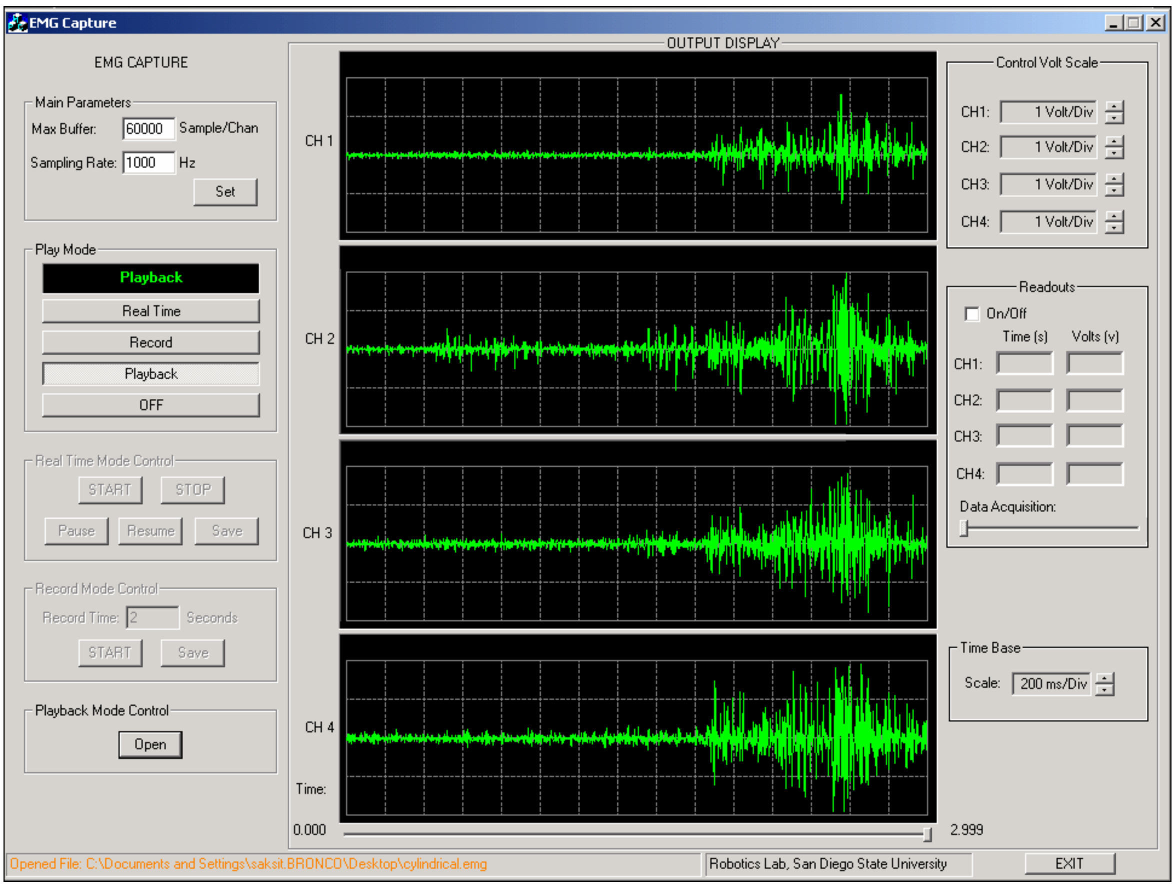

Figure 5.4: Snapshot of EMGC GUI in playback mode.

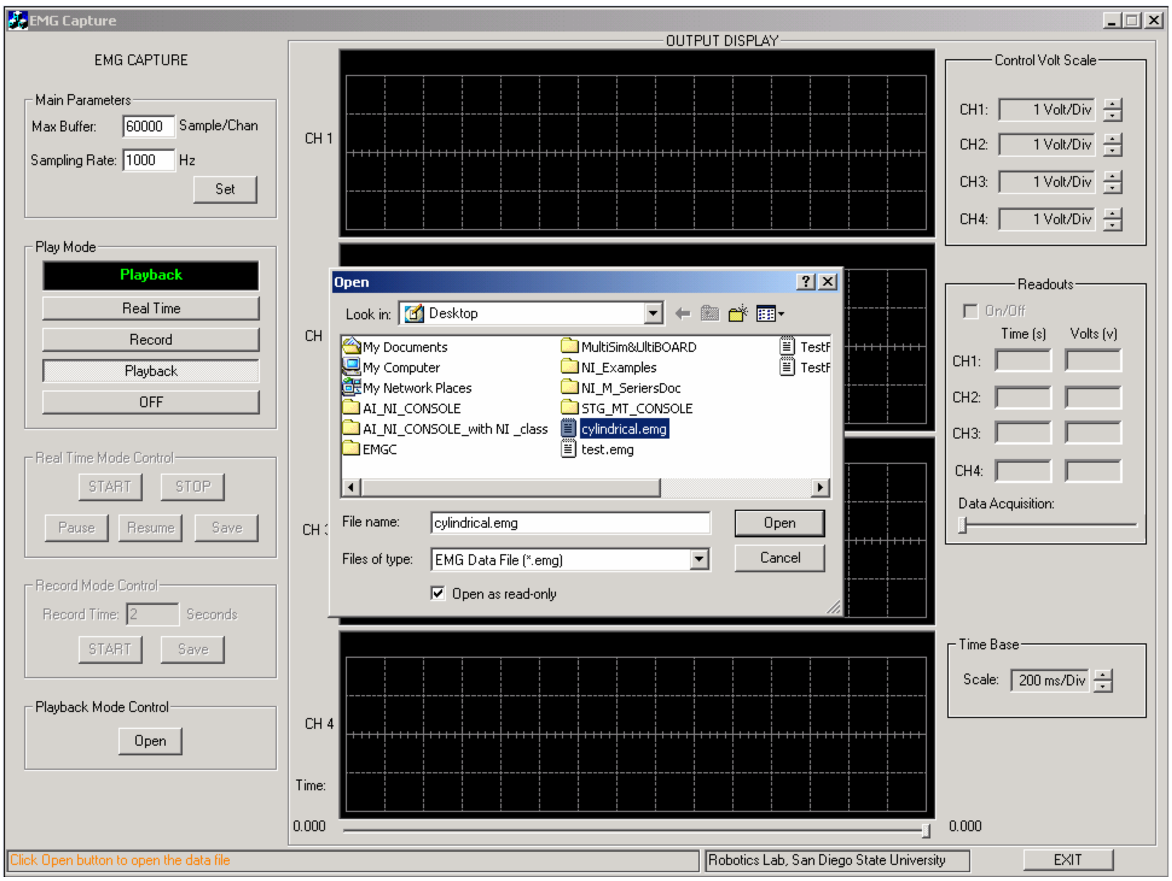

Figure 5.5: Snapshot of EMGC GUI in playback mode with open dialog.

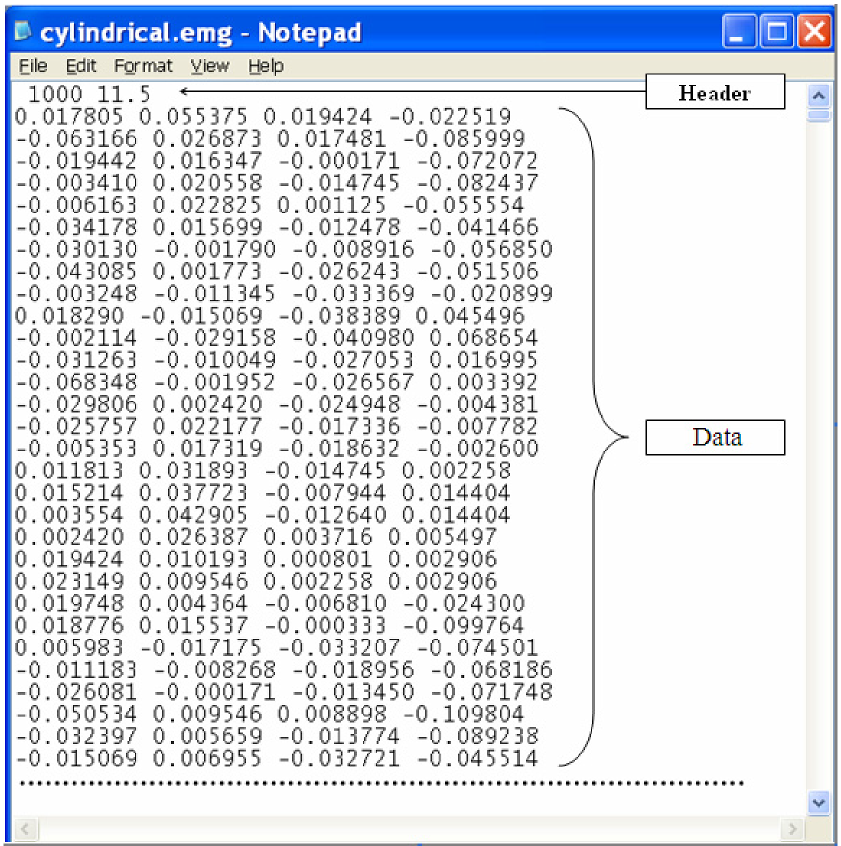

Figure 5.6: Excerpt of data file (cylindrical.emg) recorded for cylindrical grasp.

As shown in Figure 5.6, the file was recorded with a sampling rate of 1000 Hz or 1 kHz for 11.5 seconds. The data portion of the file shows the voltages for channels one through four. The data are space separated.

Figure 5.7 (a)–(d) show the recorded samples of different grasp types: cylindrical grasps, spherical grasps, precision (pinch) grasp, and lateral (key) grasps respectively. The EMG amplifier is calibrated and adjusted to have gain equal to two before doing the experiment. The experiment has preformed three consecutive grasps for each object type. Hand was in initial condition before and after grasping the objects. The grasping was done with a slight touch of the object. In other words, the grasp was done without pressure. The samples were recorded by using sampling rate of one kHz. The graphs in Figure 5.7 (pp. 75-78) were plotted by using MATLAB. The association of finger name with the diagram is not exact. They only indicate the closeness of EMG electrodes to particular finger muscle group. The samples show that the EMG signals have smaller amplitudes when grasping the smaller objects, when the smaller preshape apertures of hand are required.

The grasp was done without pressure because the pressure can cause high amplitudes of EMG signals. The pressure grasp or full grasp is called “Isometrics Contraction”. The preshape control of the hand does not require isometric contractions.

Figure 5.7(a) shows three consecutive grasps of a cylindrical object. A coffee cup was used as the grasping object. As seen, three grasps were done in total of 12 seconds. The first was completed in two seconds.

Figure 5.7(b) shows three consecutive grasps of a spherical object. A tennis ball was used as a grasping object. Each grasps was done in two seconds. The EMG activities of thumb and little finger have smaller amplitude compared to the amplitude of index and middle fingers. This is due to the fact that thumb and little finger open less than the index and middle finger in case of a spherical object.

Figure 5.7(c) shows three consecutive grasps of a lateral object. A key mounted on a vertical plane was used as a grasping object. Each grasp was performed in slightly less than two seconds. Comparing to cylindrical grasp (Figure 5.7(a)), and spherical grasp (Figure 5.7(b)), the EMG bursts for lateral grasp have smaller amplitudes. This is again the consequence of smaller hand apertures.

Figure 5.7(d) shows three consecutive precision or pinch grasps. A pill was used for this grasp. The hand was in initial condition, and moved to grasp the pill. Each grasp took about two seconds. The amplitudes of EMG signals are smaller than the amplitudes in cylindrical grasp or spherical grasp since the pill is a small object.

Figure 5.8 shows the detail from Figure 5.7(a) where only the first grasp was displayed. The grasp is done in two seconds. As the figure shows here are two EMG bursts in each grasp. The first burst belongs to the “preshaping” phase. The second burst belongs to ungrasping and retraction. The details of preshaping and ungrasping are shown in Figures 5.9 and 5.10.

Figure 5.9 shows the detail of the preshaping phase of cylindrical grasp from Figure 5.8. The preshaping phase is when hand is opening and preparing to grasp an object. Figure 5.9 shows that the preshaping phase takes about one second.

Figure 5.10 shows the detail of ungrasping and retraction of the cylindrical grasp shown in Figure 5.8. The ungrasping is done when hand is releasing the object. The ungrasping and retraction were completed in one second.

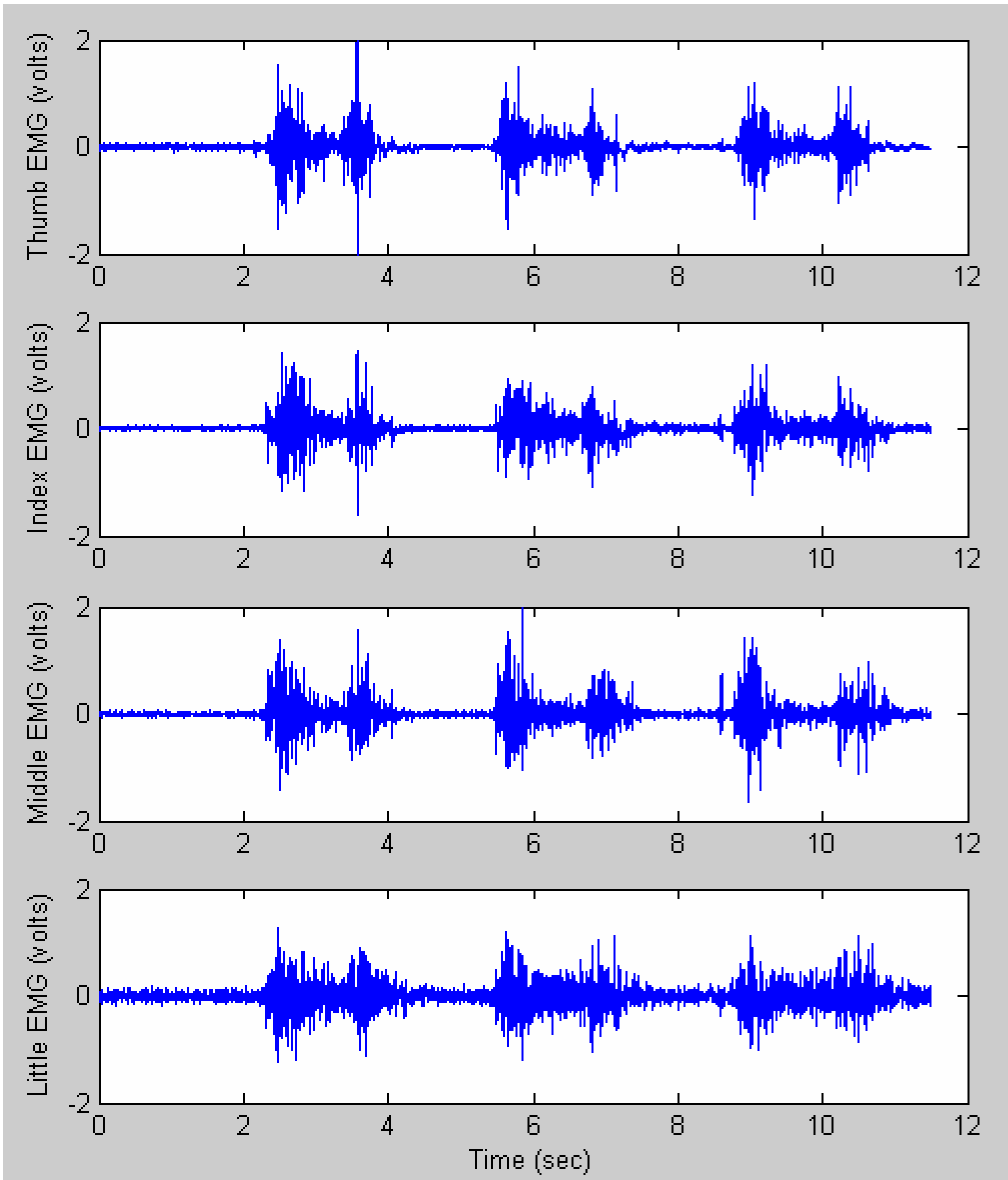

Figure 5.7(a): Three consecutive grasps of cylindrical object.

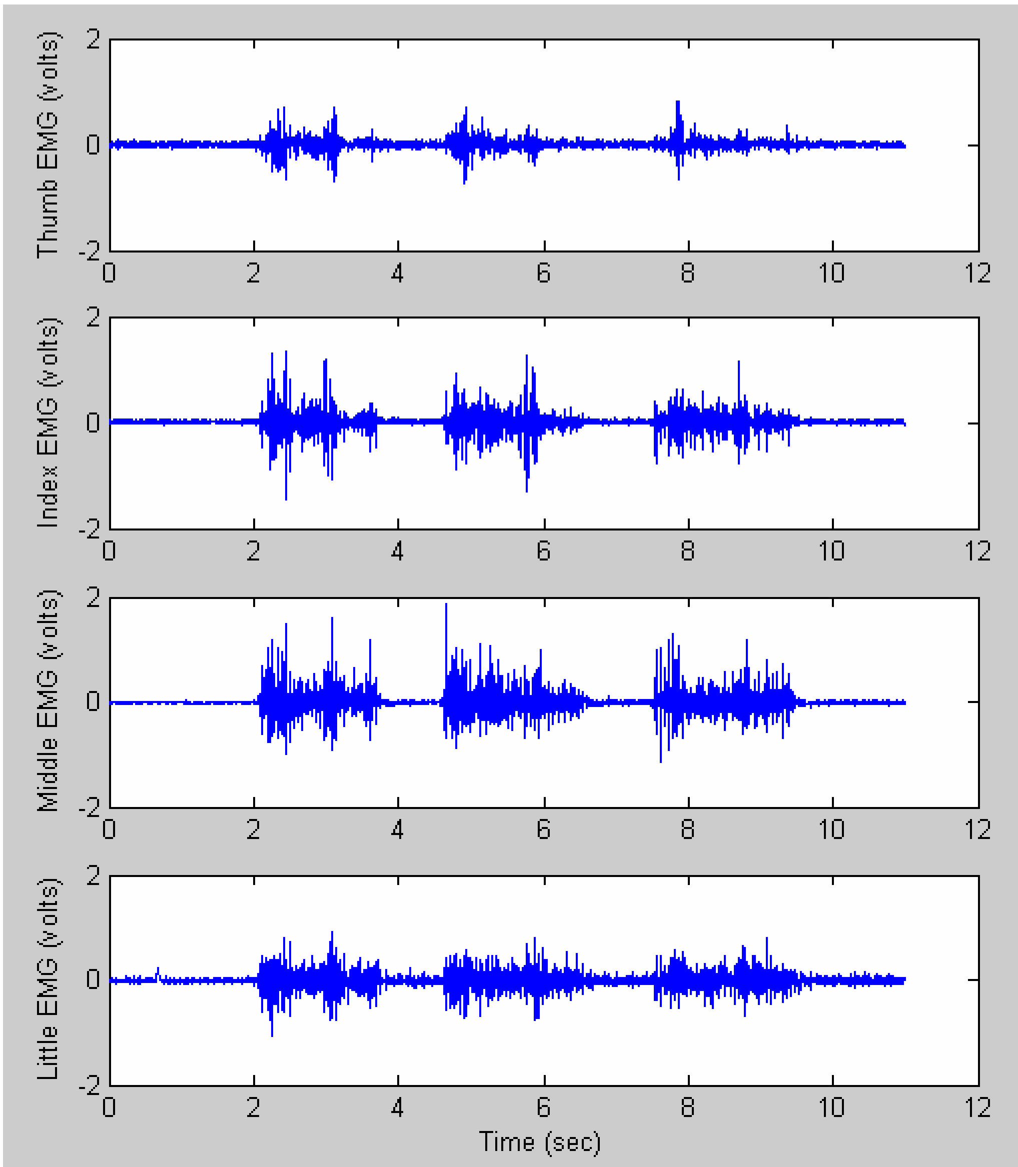

Figure 5.7(b): Three consecutive grasps of spherical object.

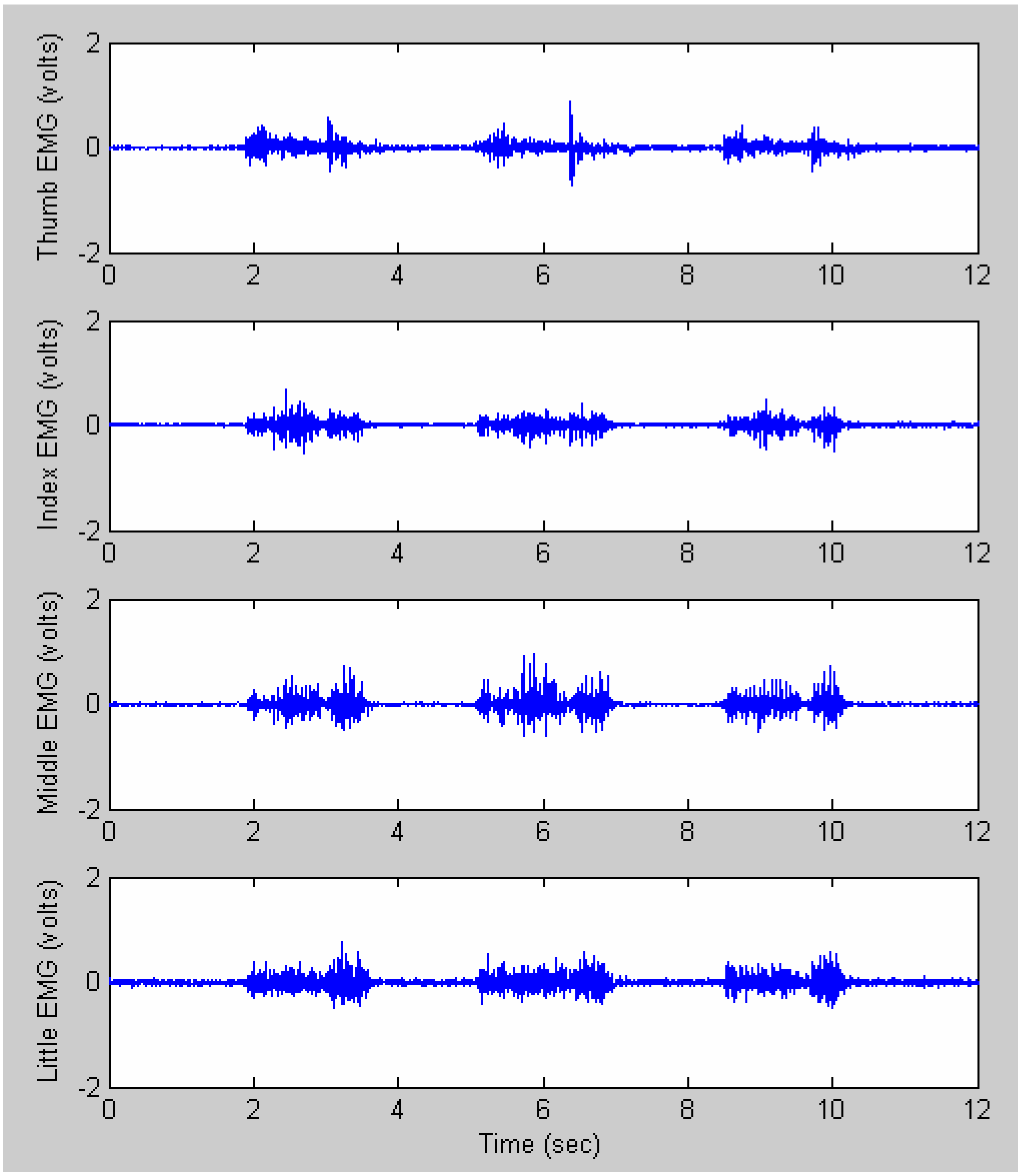

Figure 5.7(c): Three consecutive grasps of lateral (key) object.

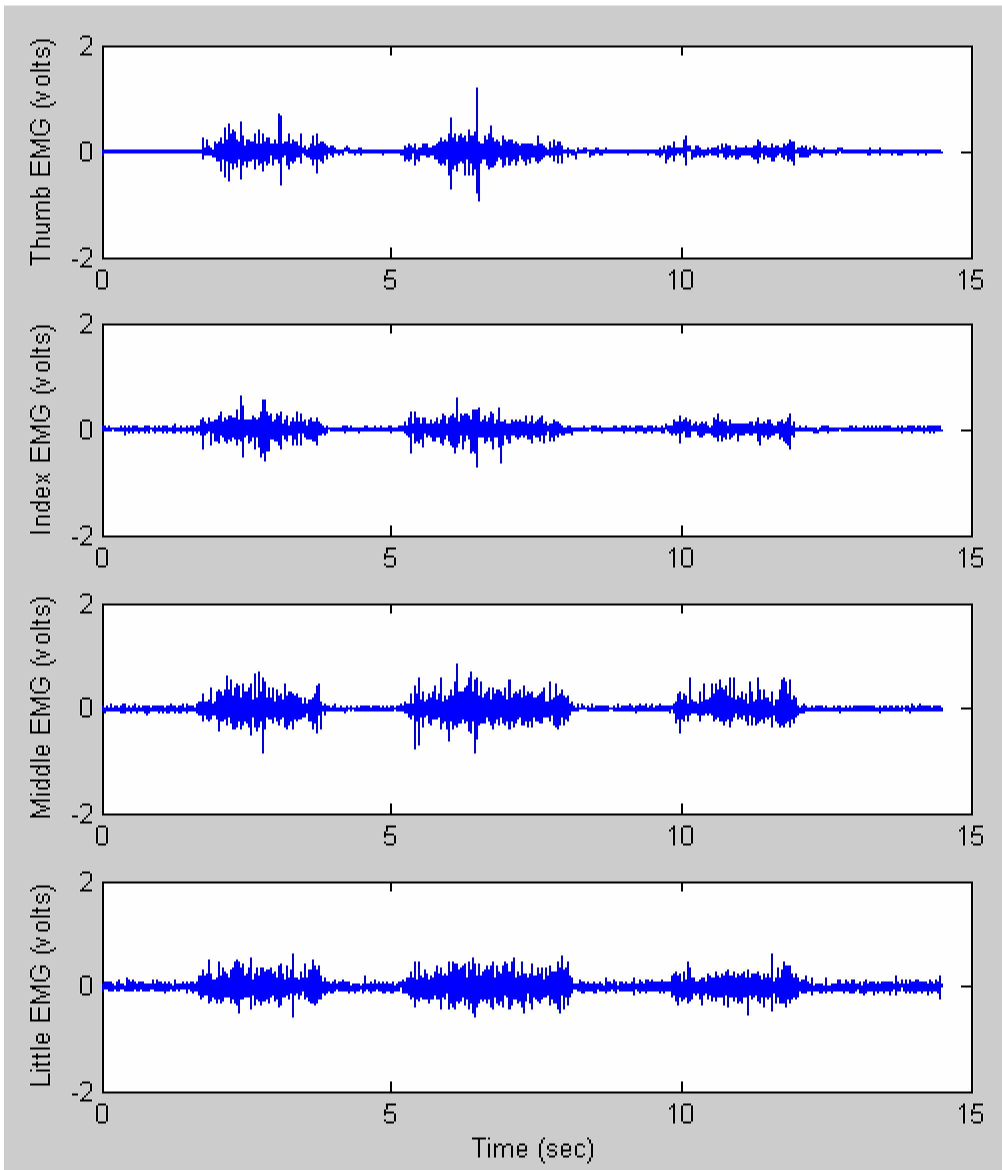

Figure 5.7(d): Three consecutive grasps of precision (pinch) grasp.

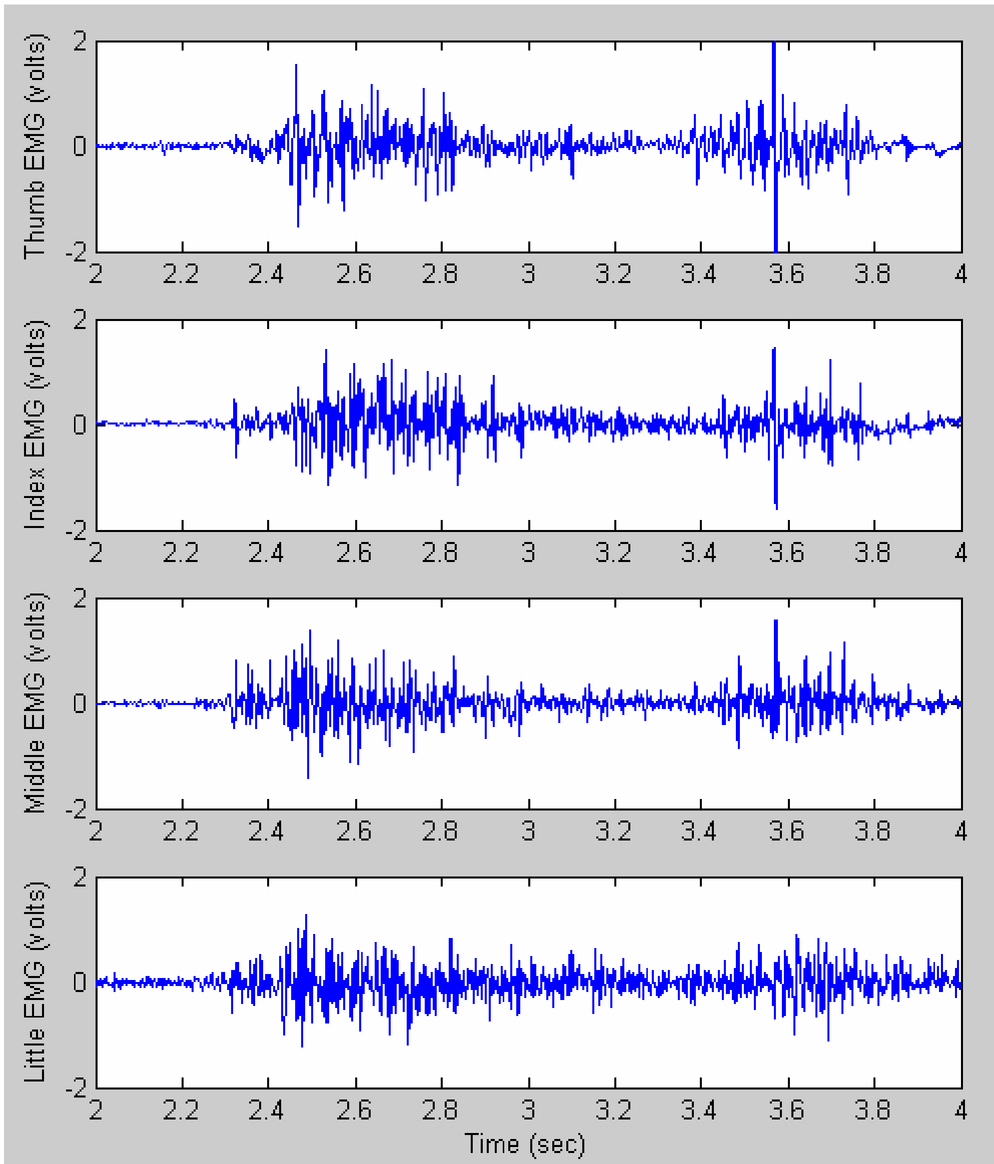

Figure 5.8: Detail from Figure 5.7(a) for first grasp.

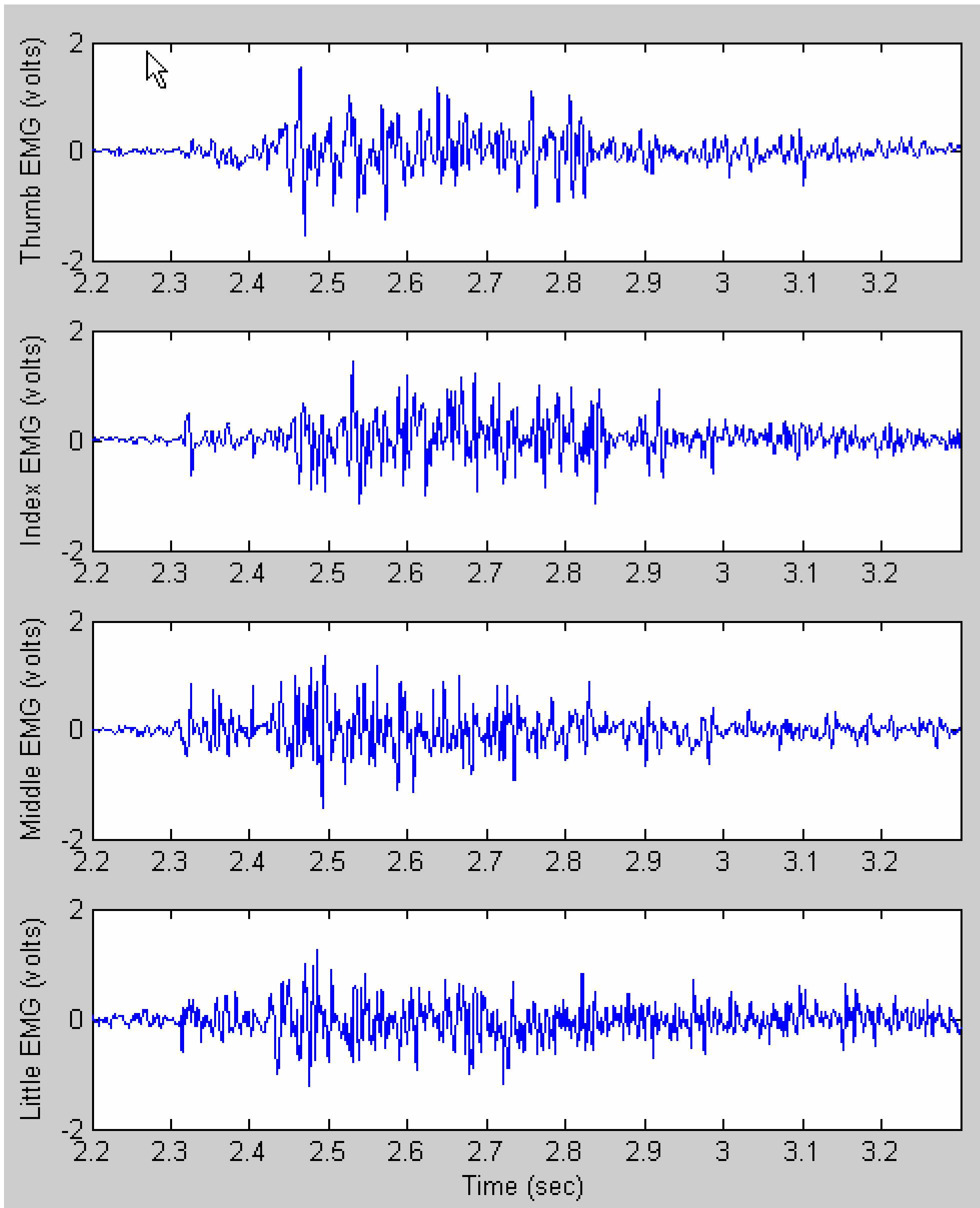

Figure 5.9: Detail from Figure 5.7(a) (preshaping phase).

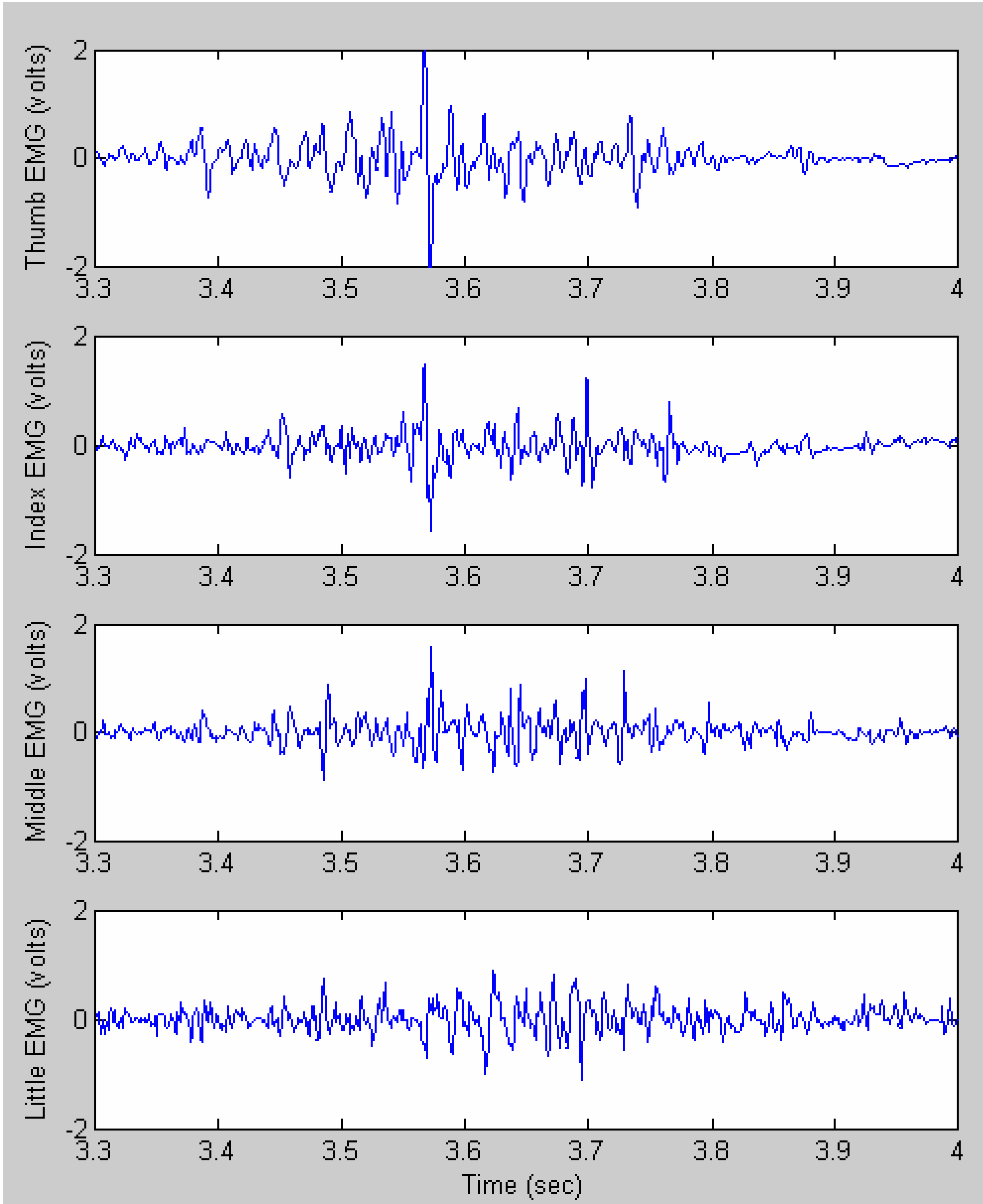

Figure 5.10: Detail from Figure 5.7(a) (ungrasping and retraction).

In order to verify the quality of the hardware, we are showing similar EMG signals recorded by Muscle Tester ME3000 manufactured by Maga Electronics Ltd., Finland [33]. This product is known as one of the most successful products of that sort on market. The EMG data were recorded for a cylindrical grasp similar to Figure 5.8. The EMG data are displayed by using the VIEW program, an in-house software package for viewing and classification of prehensile EMG patterns [26] (see Figure 5.11).

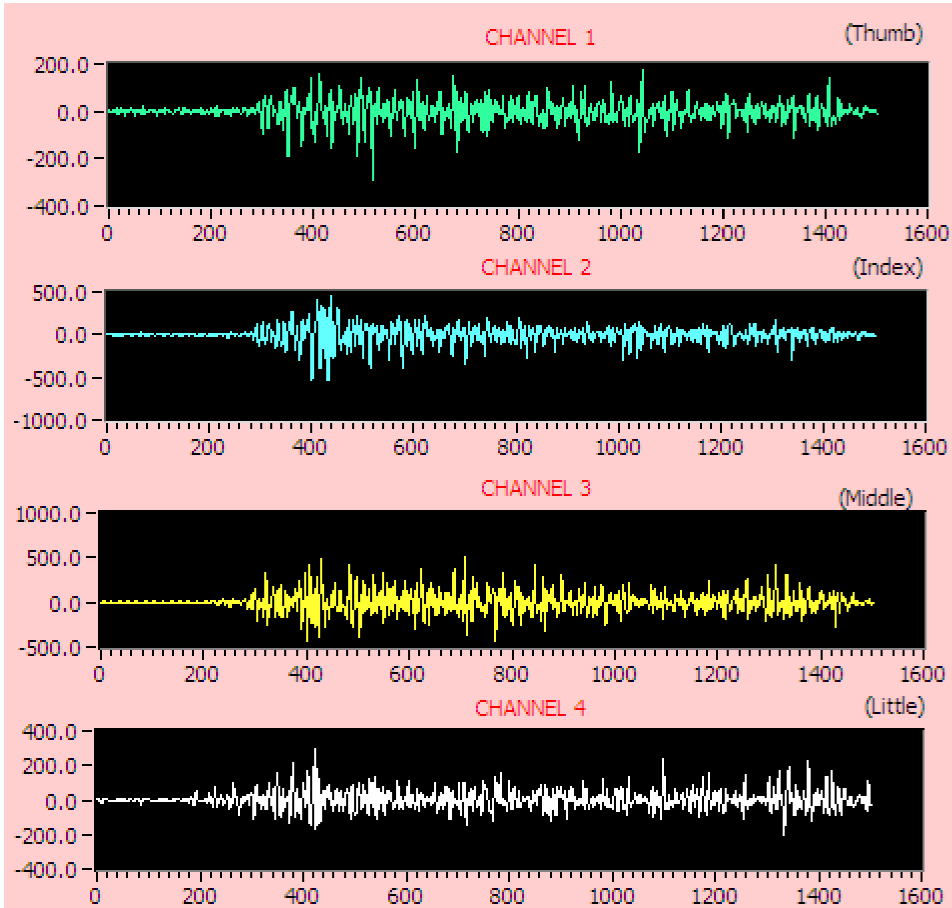

Figure 5.11: Snapshot of a cylindrical grasps displayed from Program VIEW, version 2.

Figure 5.12 shows the detial of Figure 5.11 plotted with MATLAB. By comparing the Figure 5.12 with the Figure 5.9, we can see that the level of signal-to-noise ratio obtained with our EMG amplifier is similar to the one obtained with Muscle Tester (ME3000).

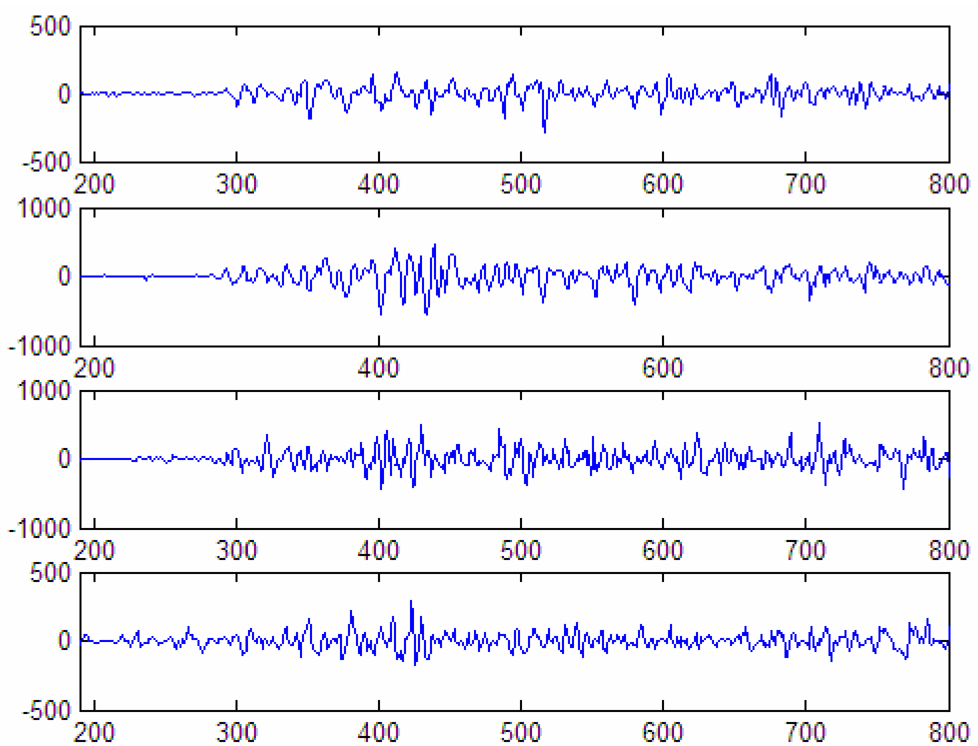

Figure 5.12: Detail from Figure 5.11 (preshaping phase).