

Video Analysis and Filtering

Name _____

Partner (s) _____

Grade _____/10

Introduction

The goal of this lab is to obtain a position-time dataset from video analysis and create a Butterworth filter with appropriate smoothing to obtain useful velocity and acceleration graphs.

Objectives

- Understand the basics of video digitization;
- Obtain useful 2D data from a video clip;
- Understand how digital filtering can increase the quality of results.

Equipment Provided

- Computer with appropriate software.

References

- Video digitization and digital filtering textbooks and web sites.

Procedure

- 1) On the class website under the heading of Lab #7, you will find a video file showing a side view of a human vertical jump with markers indicating various joint centers, including at the hip. Download the .mp4 video file and save it to your lab computer.
- 2) Download and install the LoggerPro software from the course web site. Save it on the Desktop, then double-click to install. Open the video file from within LoggerPro by using the **insert** function.
- 3) The video sampling frequency is 60 Hz. Before digitizing the hip marker positions, make sure the video is on the first image and then locate the origin at this beginning hip position. Also, in the image you'll see a meter stick with two markers which are 90 cm apart which can be used as the scaling factor in the analysis.
- 4) Digitize the hip marker position in LoggerPro for the entire jump. Each time you center the crosshairs on the hip marker and click, the frame will advance automatically and the x,y coordinates will be placed in the columns on the left.
- 5) Download the Excel spreadsheet (**butterworth vertical jump template.xlsx**) from the website. Copy the position-time data (time and vertical coordinate Y) from LoggerPro and paste into the Excel worksheet.

- 6) Read the instructions embedded in the spreadsheet first. Then, process the vertical data in Excel by calculating velocity and acceleration using first central difference formulas found on the last page of this handout. Update the stat sets of the embedded graphs of position, velocity, and acceleration vs. time.
- 7) Calculate velocity and acceleration of the smoothed data, and graph these along with the corresponding results from the raw data. Experiment by varying cutoff frequencies in the Butterworth filter to obtain an optimal amount of smoothing for the velocity and acceleration curves.
- 8) Take your raw position-time data to Matlab and process these using Fourier methods to obtain a frequency distribution for the data set. Compare this frequency distribution graph to your decision about an optimal cutoff frequency for filtering of the data.

To Turn In

- 1) Graphs for the raw and filtered position, velocity and acceleration data.
- 2) Write a short summary (one-page double spaced maximum) with a description of your methods, results and observations about this lab. Staple your graphs and summary sheet to this page and turn them in.

Formulas

First Central Difference formulas:

$$\text{Velocity: } V_i = \frac{X_{i+1} - X_{i-1}}{t_{i+1} - t_{i-1}}$$

$$\text{Acceleration: } a_i = \frac{X_{i+1} - 2X_i + X_{i-1}}{(t_{i+1} - t_{i-1})^2}$$

Butterworth filtering:

$$X'_i = a_0 X_i + a_1 X_{i-1} + a_2 X_{i-2} + b_1 X'_{i-1} + b_2 X'_{i-2}$$

X = raw data points

X' = previously filtered data points (recursion)

$$\omega_c = \tan \left(\frac{\pi f_c}{f_s} \right)$$

$K_1 = \sqrt{2}\omega_c$ for a Butterworth filter,
or, $2\omega_c$ for a critically damped filter

$$K_2 = \omega_c^2, \quad a_0 = \frac{K_2}{(1 + K_1 + K_2)} \quad a_1 = 2a_0, \quad a_2 = a_0$$

$$K_3 = \frac{2a_0}{K_2}, \quad b_1 = -2a_0 + K_3$$

$$b_2 = 1 - 2a_0 - K_3, \quad \text{or,} \quad b_2 = 1 - a_0 - a_1 - a_2 - b_1$$