SOP: Smoothing Coordinate Data in MatLab using a Spline

A. What this SOP covers

If you have digitized a video and have coordinate data in pixels for a point in the video, you can use this SOP to convert pixels to other units, fit a quintic spline to the data, take its derivatives, and calculate instantaneous velocity and acceleration. The output will be a spreadsheet that includes the time associated with each frame, the cumulative displacement of your digitized point in each frame, and the velocity and acceleration for each frame.

B. What you need before you start

- ImageJ and your videos
- MatLab with the Curve Fitting Toolkit
- MatLab scripts: importformat2D.m and derivative.m
- Comma-delimited file with 2D coordinates, as output from DLT

C. Procedure

1. Obtaining calibration numbers
    a. Open ImageJ
    b. File → Open… to open your video
    c. Click 'OK' on the AVI reader dialog box
    d. Manipulate the video window size and use the magnifying glass tool to obtain the best magnification to get the most accurate measurements
    e. Draw a horizontal line across the scale bar/object
    f. Analyze → Set Scale…
    g. Calculate the pixels per meter in your video as (# pixels)/(distance in mm)*1000
    h. Repeat steps 1.d to 1.f with a vertical line if the pixel aspect ratio is suspect
    i. Record vertical & horizontal pixels/m and quit ImageJ

2. Importing your data into MatLab
    a. Open MatLab
    b. File → Import Data… and select you DLT comma-delimited data file
    c. In the Import Wizard click 'Next', then select 'Create vectors…', and click 'Finish'
    d. In the Command Window type:
        calibx=(x) <enter> - x is your horizontal pixels/m
        caliby=(y) <enter> - y is your vertical pixels/m
        rate=(z) <enter> - z is the frame rate of the video
        importformat2D <enter> - This calculates the distance moved from one frame to the next (dist), and the cumulative distance moved in 2D (cDist).

3. Fitting a spline to your data and calculating derivatives (velocity & acceleration)
    a. In the Command Window of MatLab type: **splinetool(time,cDist) <enter>**
    b. Click 'OK' and the splinetool GUI appears
    c. On the left side of the splinetool GUI select the following:
        View → 2nd Derivative
        Approximation Method = Smoothing Spline
        Order = 6

Tolerance = 5e-9

d. Use the Tolerance + & - buttons to adjust the smoothing to remove secondary oscillations and noise from the 2nd derivative (which is the acceleration) in the lower graph. Secondary oscillations are false peaks in acceleration that do not coincide with a stride/push-off by the animal.

e. File → Export Spline, then click 'OK'

4. Saving the spline-smoothed data to a file

a. Switch from the Splinetool GUI to the main MatLab window

b. File → Open, and navigate to the 'derivative.m' file, and open it

c. A window appears with the 'derivative.m' script

d. In line 6 of the script, change the path and file name to where you want to save your data. The script will not overwrite data, but append to the bottom, so you can save results from multiple videos in a single file easily.

e. type: **<ctrl> s** to save the updated script

f. Switch to the MatLab Command Window and type:

id=(a) - a is a numerical identifier of your specimen
trial=(b) - b is a numerical identifier of the trial
derivative

g. Close MatLab

5. Viewing your smoothed displacement, velocity and acceleration data

a. Open Microsoft Excel

b. File → Open, then select 'all file types' in the drop down menu

c. Navigate to the file you identified in step 4.d. and click 'Open'

d. The Text Import Wizard dialog appears; click 'Next', then 'Finish'

e. The lines/rows in the opened spreadsheet are:

ID
Trial
Time - in seconds
Displacement - the smoothed cDist variable, not your raw data
Velocity - this is the 1st derivative in m/s
Acceleration - this is the 2nd derivative in m/s^2

Note that "derivative.m" appends data if a file of the given name already exists. This is useful because you can name the file after a species or a project and have all individuals in one file.