centerlineBezier

In some cases, because of a lack of contrast in an image, it is very challenging to extract the centerline of a fish automatically. In those cases, one may consider a manual method involving selecting random points along the body of the fish to obtain a crude centerline. Then, smoothing and interpolation are generally performed. Unfortunately, this leads to noise in the data and can generate unwanted artifacts. I developed this new approach to save time when extracting data and also to ensure that data could be safely extracted without requiring any smoothing or intertpolation.

This method requires manual placement of two points and handles, but it produces very smooth Bezier curves with virtually no noise. One of the advantages is that the script is interactive and the curve can be reshaped in real time to fit the shape of the fish. It is also more intuitive to trace the centerline and gauge the distance between the edges of the fish profile from the centerline. One additional advantage is that there is no smoothing required since a Bezier curve is the smoothest and most natural shape to approximate body bending in undulatory swimmers.

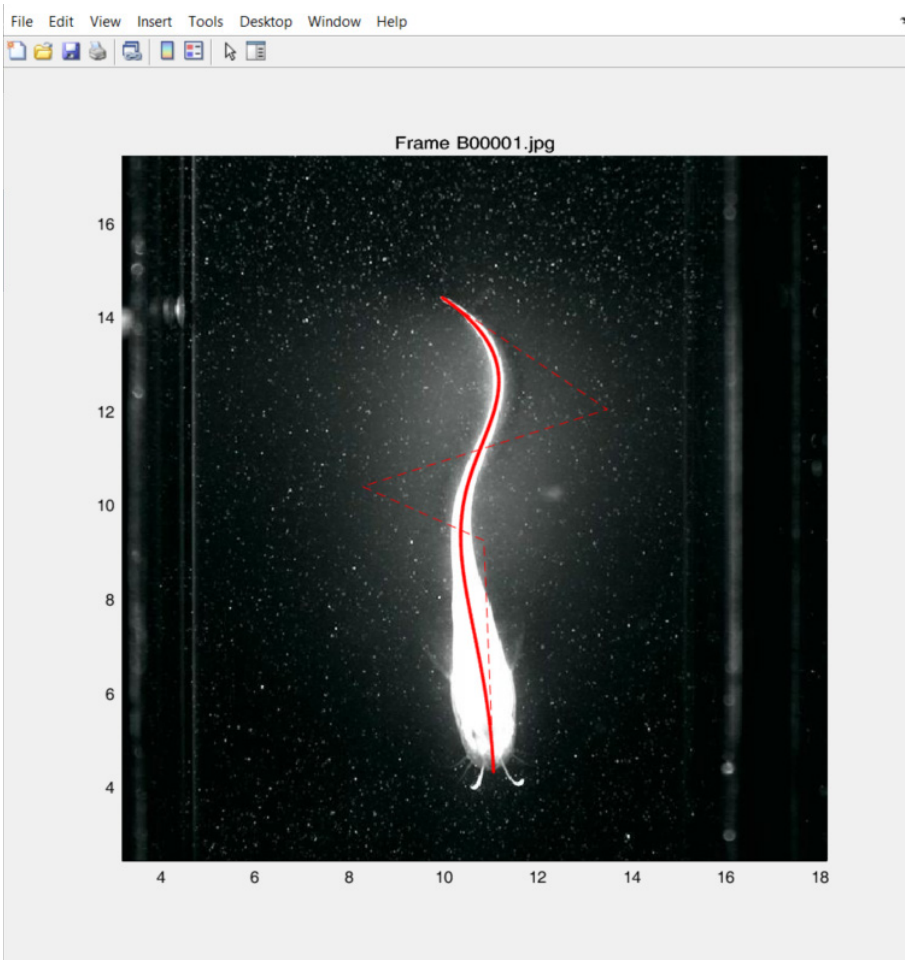

Figure 1. Bezier curve and handles used to trace the midline of the fish. This method reduces noise traditionally caused by the manual selection of points along the body. Here two points (snout and tip of tail) are created, and the shape of the curve is dictated by 3 handles.

How to use the script

1) Place all the frames of interest in a folder called ‘images’.
2) Set the paths and directories accordingly.
   - In this section of the script, also make sure to set the temporal and spatial scales.
3) To extract the profiles, set the ID number of the first frame that you want to start with (if different from frame 1) and select an increment between frames if need. When filming at high speed, it may not be necessary to trace the profiles for all the frames.
   - Upon starting this section of the script, the first image is plotted in a figure. Press ’a’ on the keyboard to enter the processing loop (this applies to each frame). A cursor will appear that you can move throughout the frame. This will allow you to temporarily zoom on the image if needed. Upon clicking (say on the fish), the field of view is narrowed. Depending on the image resolution and individual size, you may want to change the setting called ‘fov’ (line 68). You can also disable this function completely using opts.resetAxis if no re-scaling of the image is needed (set the option to 0).
   - Once the image is temporarily re-scaled, select the snout of the fish, however many points you need to define the handles (usually 2-3), and lastly the tail. Make sure to move from the snout to the tail if you want the data of the output centerlines to be sorted as such. Once you are done, a smooth solid red line and a dashed red line will plot on the figure. The solid line is the Bezier curve that defines the centerline. The dashed lines are the handles. Everything can be moved straight onto the figure using the mouse. The snout and the tail points can be repositioned if necessary, and the handles can be moved to shape the solid line as you want. When satisfied, hit ‘return’ on the keyboard. This will export the x and y coordinates in .csv format for the centerline into a folder called ‘Kinematics’.
   - The following frame appears with the previous centerline overlaid in yellow. Same as before, hit ‘a’ to start the Bezier curve extraction.
   - If you need to stop the loop, hit ‘s’. Make sure to hit ‘s’ only after you exported the last profile of interest. Otherwise, this will interrupt the centerline extraction for the current frame and will not export it.

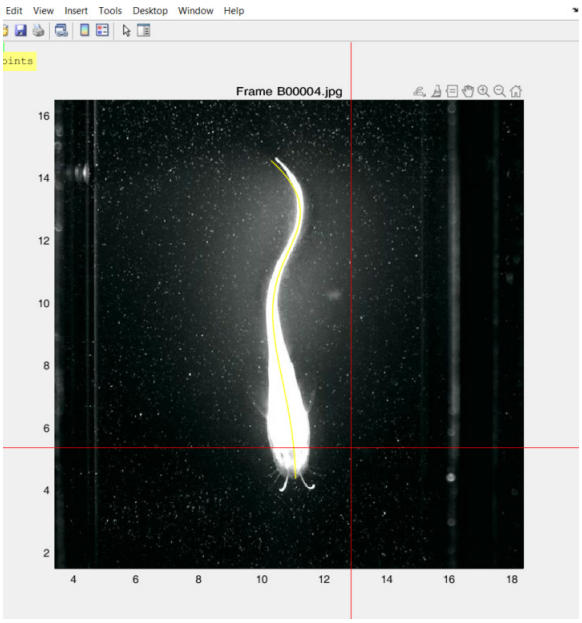

Figure 2. Following frame displaying the previous centerline (yellow line) for quick visual comparison.

One important thing to remember!

You may have to change the number of handles needed to draw the centerlines. Elongated fish like coral catfish tend to display a little more than 1 full body wave, so 3 handles may be required to control the three body-wave peaks. However, carangiform fishes require only 2 handles (makes centerline extraction easier). Once you know what works best for you, you must change the parameter called **'n'** accordingly. 'n' is the total number of points that you will be selecting on the image. For example, if you need 2 handles, then you will need 'n' to be set to 4 (2 points for beginning and end of profile, and two points for handles). The 'n' parameter needs to be changed in two spots; in the while loop and in the core function that automatically updates the curve based on inputs from the mouse. The corresponding lines to change are **line 76 and 188**. Both values for 'n' must be the same otherwise the curve cannot update.