Image Processing - ECE 4367 / ECE 5367
Project 5 – Segmentation of the worm from video(s)
Team Members: Farshad Bolouri, Yildirim Kocoglu

Summary

The given task in this project was to segment the worm itself from the two given videos that has different background scenes however, when writing the algorithm, the assumption was that the camera's view and the scene's conditions (e.g., illumination and resolution) stayed stationary throughout the video.

The provided script "**Bolouri_Kocoglu_P5.m**" that performs the segmentation process asks the user to provide the path of the specific video as input and outputs a video of the segmented worm called "**Bolouri_Kocoglu_Proj5_Video.avi**" in the same folder as the main script. While the script is running, it will also display the segmentation of the worm frame-by-frame (beginning-to-end). **It should also be noted that the output video is not automated to have a different name each time the program is executed, therefore, it is recommended to change the name of the output video manually to avoid overwriting it.**

The script can take approximately 15 minutes to complete running. This process may take longer/shorter depending on the user's computational power however, while the script is running, it will display percentage of the video that has been processed in the command window and it will also display the segmentation results of each frame. The entire process input-to-output involves the general tasks below:

- Calculating the mean frame using all the frames of the input video.
- Processing the video to output/display the segmented worm at each frame of the video.
- Saving the output video "**Bolouri_Kocoglu_Proj5_Video.avi**" which displays the same segmentation results as the main script.

The output video will be similar to the given frame in **Figure-1**. The colors in each frame represent the following:

- **Blue:** Segmented worm
- **Pink:** Skeleton of the worm

- **Green:** Bounding box around the worm
- **Purple:** Bounding box around the head & tail of the worm
- **Red:** Normal vectors to the tangent
- **Yellow:** Equidistant points on the skeleton of the worm

It should also be noted that the normal vectors to the tangent of the equidistant points were calculated using the length of the skeleton of the worm without any interpolation involved.

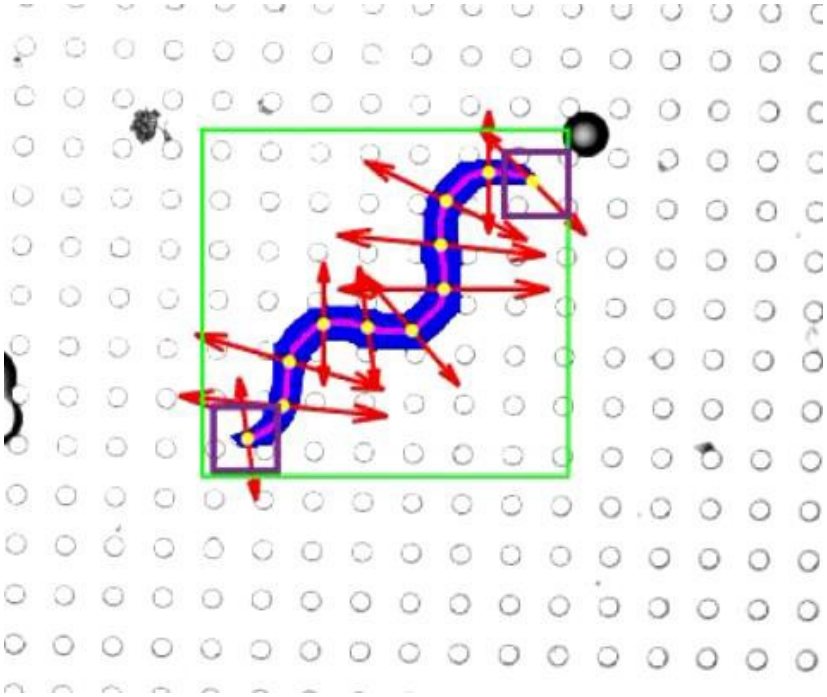


Figure-1: An example frame of the segmented worm (blue) with additional useful information (bounding box around the worm, and head & tail of the worm) and normal vectors to the tangent.

General process & flowchart

In order to segment the worm, each frame of the video and the mean of all the frames were binarized in advance. In general, the main script involves the following processes to segment the worm:

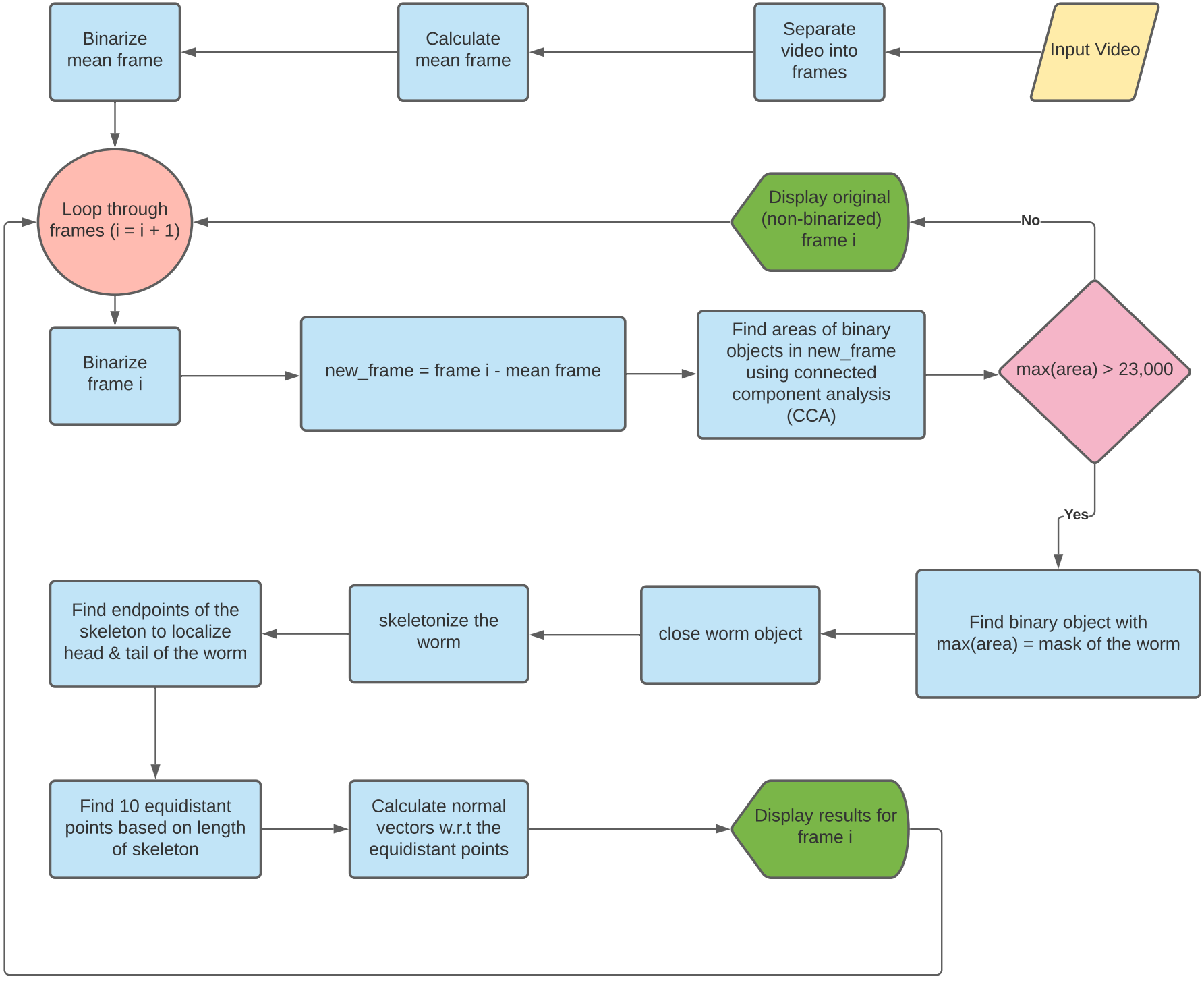
- Calculating the mean frame using all the frames of the video and then subtracting the mean frame from each frame to remove the background.

- Using 8-connected component analysis and morphological operations to remove remaining noise and fill holes to segment the worm as best as possible.

The rest of the script involves:

- Drawing a bounding box around the worm using the previously segmented worm.
- Finding the skeleton of the worm to localize the head & tail of the worm and calculate the equidistant points along the skeleton of the worm.
- Using the equidistant points along the skeleton of the worm to calculate the normal vectors to the tangent.

A more detailed flow chart of the entire process can be seen below. The threshold value of 23,000 given in the flow chart was chosen empirically based on careful observation throughout the frames.


Input Video
Separate video into frames
Calculate mean frame
Binarize mean frame
Loop through frames (i = i + 1)
Display original (non-binarized) frame i
No
Binarize frame i
new_frame = frame i - mean frame
Find areas of binary objects in new_frame using connected component analysis (CCA)
max(area) > 23,000
Yes
Find binary object with max(area) = mask of the worm
close worm object
skeletonize the worm
Find endpoints of the skeleton to localize head & tail of the worm
Find 10 equidistant points based on length of skeleton
Calculate normal vectors w.r.t the equidistant points
Display results for frame i