SEGMENTING A SONGBIRD'S SYRINX

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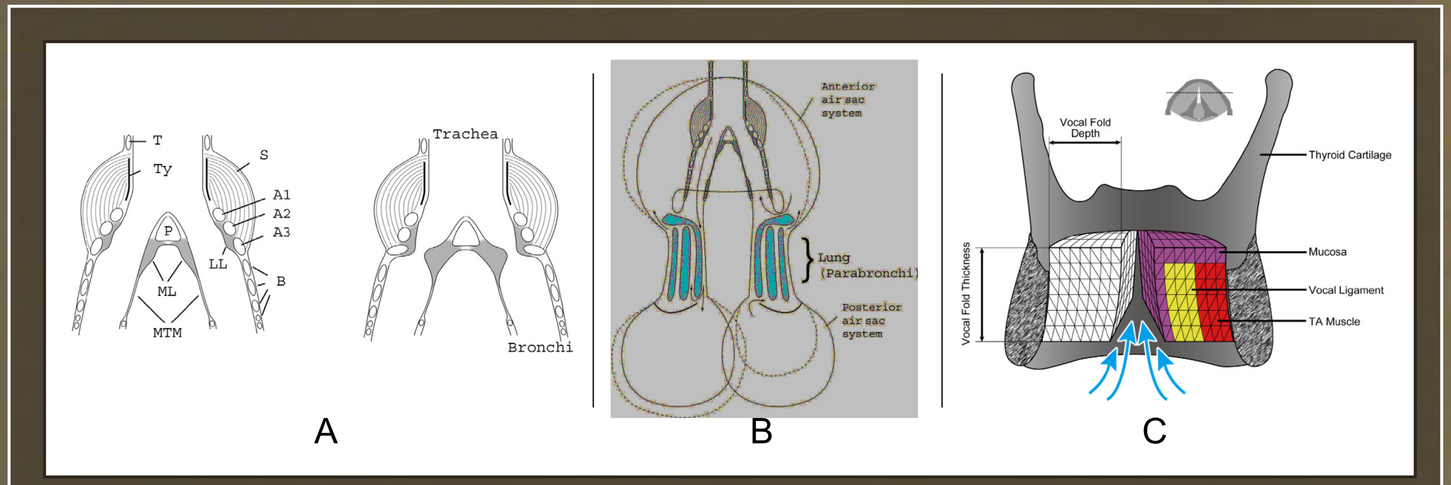
Abstract:
Songbirds have two sound sources that are located within an organ called a syrinx that enables them to produce sound. Our goal is to simulate air flow through a bird's syrinx to better understand how birds make sound. We acquire a series of images via histological slices, and endeavor to create a mesh to be used in the simulation process. To accomplish this, we must first align the images, segment out the relevant tissue, and generate the mesh from those segmentations. By using this technique, we are demonstrating an approach to provide a higher quality solution at a lower cost, compared to a CT- or MRI-based.



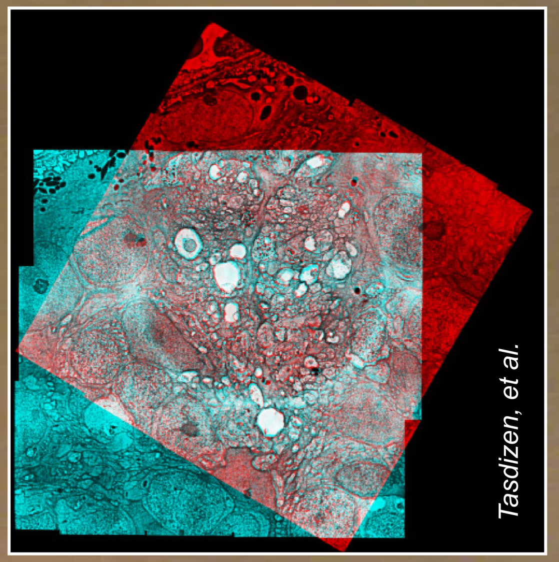
A) Cross section of an avian syrinx. B) The avian respiratory system. C) A complete model of an elk larynx.

Background:
Segmenting is a difficult process that relies on the quality of the segmentation in terms of how much knowledge of the feature one is looking to extract. If the person who was segmenting the data set of the songbird's syrinx was told to segment out the muscle part of the syrinx and they don't know what that is and what it looks like, then it will affect the outcome of what the model of the syrinx should look like in the end significantly.

Segmenting a data set is also hard due to the signal to noise ratio, which affects the contrast of the data set. If there is too much noise shown on the slices, then it will affect what is being segmented resulting in a poor segmentation.

However, this process will help us give a better understanding of how a bird produces sound. This will potentially lead us to understanding how other animals make sound along with how humans make speech and sing based on further studies about the syrinx and its role.

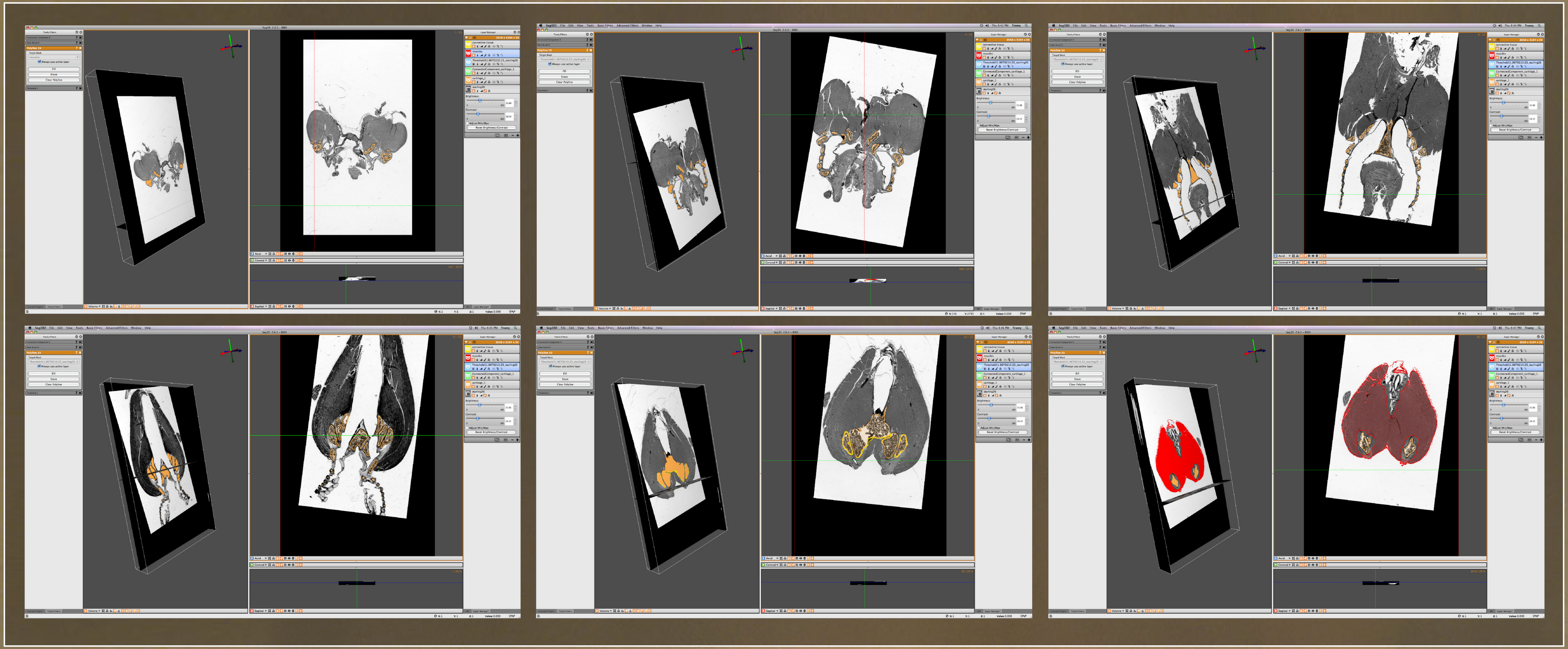
Process:
In order to segment data of the syrinx, histological slices were acquired. These images must be aligned into the same space. Then the relevant tissue must be segmented to provide input for a mesh algorithm, which triangulates the segmented region appropriately.



Alignment of the slices is critical to creating an accurate 3D model. This image shows alignment of confocal microscopy data.

Align:
In order to align these slices, the images are rigidly transformed based on an energy function which is high during misalignment and low when the alignment is good. By solving the resulting energy minimization problem, we derive an alignment for the given image stack. The following formula is used for the energy minimization equation.

Segmentation:
After the data is aligned, segmentation takes place. Segmentation is a classification process which identifies data types in a mixed data set. These data sets are comprised of voxels that represents parts of the bird's syrinx. Through each histological slices taken, different parts of the slices are painted to highlight multiple tissue types, classifying the different parts of the slice. These 2D slices are compiled up, creating a 3D structure of the images that were originally given with a difference of segmenting the object we want to visualize while excluding the rest, which was not segmented/painted.



Mesh:
Following a certain algorithm that locates boundaries of the segmentation, these data sets are then put through a meshing pipeline that creates triangles over these surfaces and gives us a 3D representation of the syrinx we have segmented once it is done.

Conclusion:
The bird's syrinx is cut and taken into many thin slices that are then transformed through the process of aligning, segmenting, and meshing the data that was acquired. While the alignment is completed and the segmentation of the data is still in progress, future work of meshing these datas has yet to be completed.

Acknowledgements: