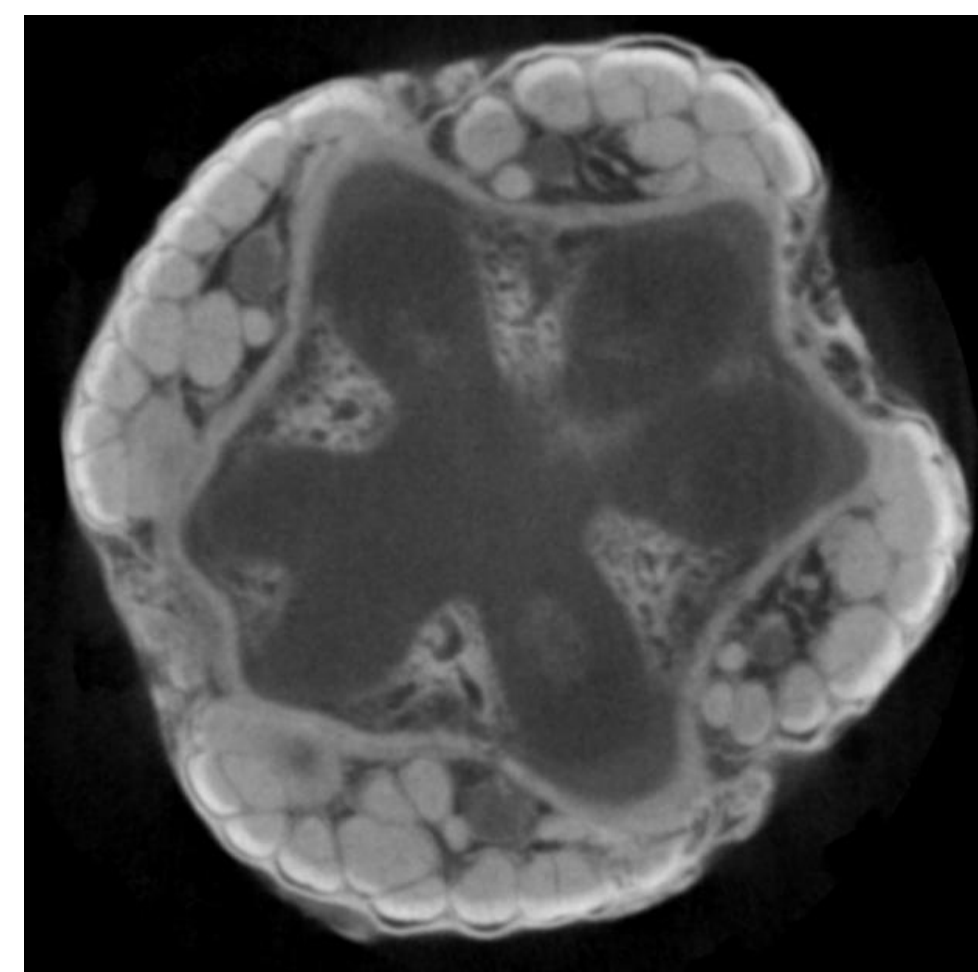


OBJECTIVE

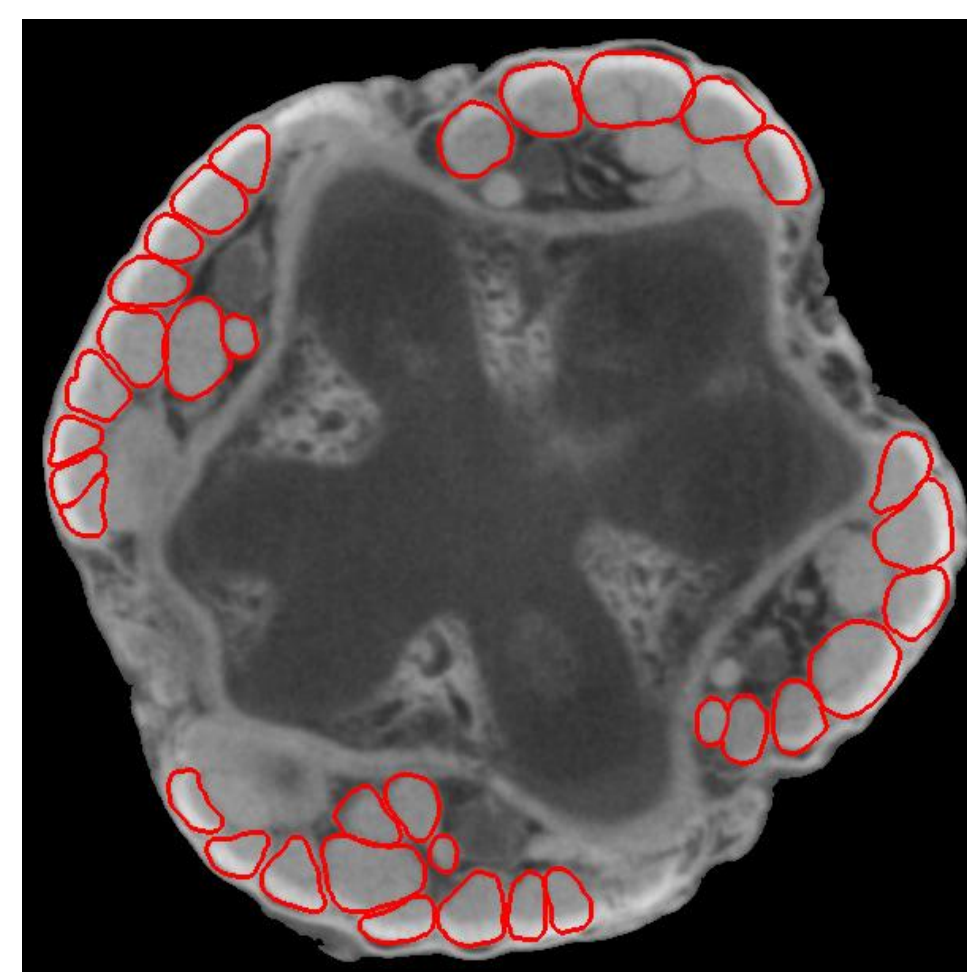
To automate the labor-intensive process of modeling tendon substructures in rat tails by fine-tuning the Segment Anything Model (SAM).

BACKGROUND

Tendons are tissue made up of fibers called fascicles that connect muscle to bone. These fibers are incredibly small, and 3D scanners aren't accurate enough to see them. To preserve detail (at the loss of the original structure), hundreds of cross sections, or slices, are taken of a tail, and scanned one at a time.



Cross-section of a rat tissue sample.



Training image, fascicles indicated in red.

VALUE PROPOSITION

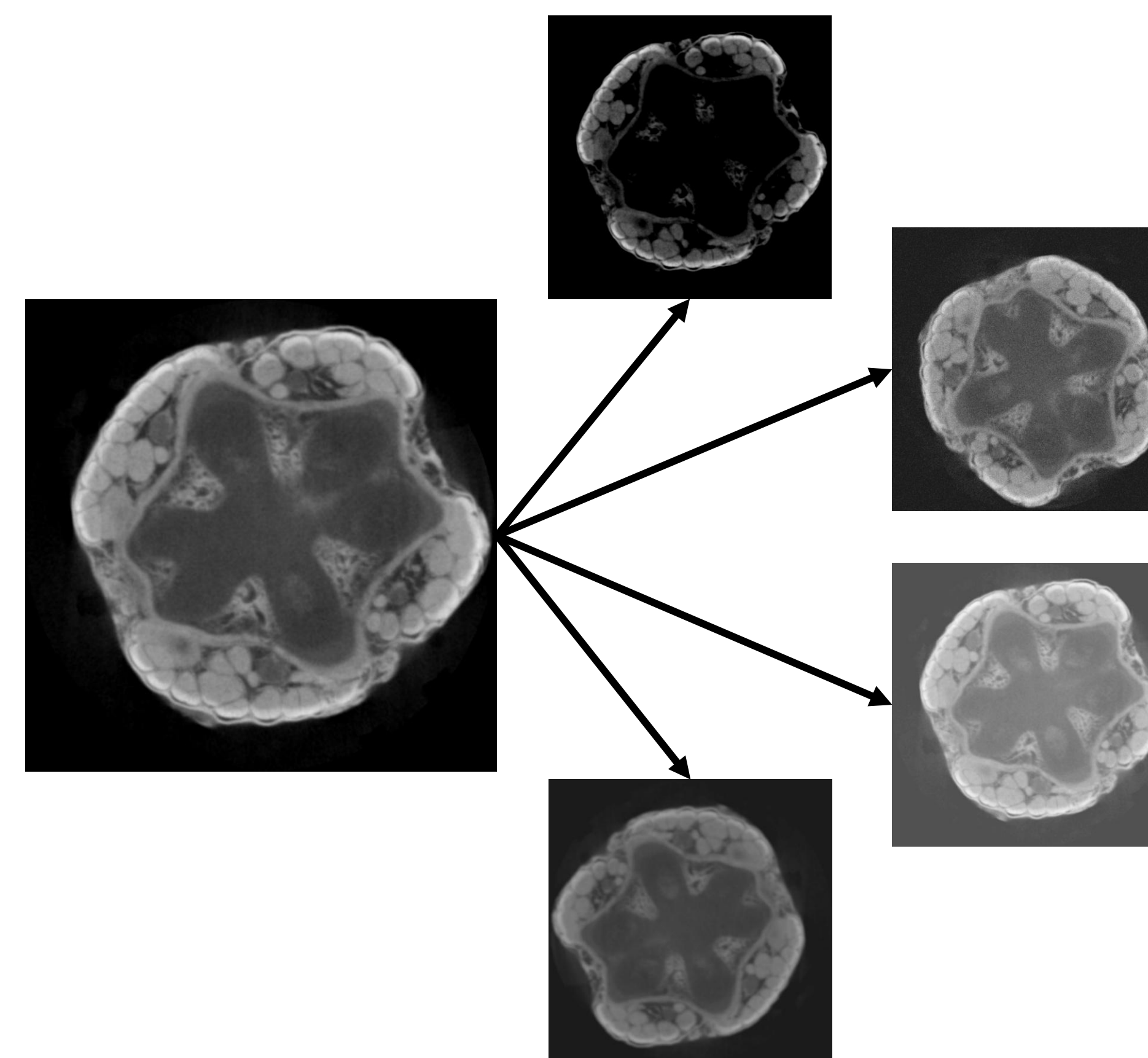
Project R.A.T. addresses the limitations of current methods used to study tendons in rats. Conventional 3D scanners lack the accuracy to effectively detect these tiny fibers and must be done by hand. Traditional methods involve manually scanning and modeling hundreds of cross-sections of a tail to visualize fascicles, a process which is labor and time-intensive. To solve these problems, Project R.A.T. automates the process of identifying and extracting fascicles from micro-CT images by fine-tuning the Segment Anything Model (SAM). By automating this process, R.A.T. improves the efficiency of scanning and modeling tendon structures, reducing the manual labor required and preserving the detailed information contained in the tissue samples.

ACKNOWLEDGEMENTS

Dr. Nathan Schiele, Dr. Boyu Zhang, Dr. Bruce Bolden

CONCEPT DESIGN

Our problem requires us to be able to identify sections of images and pick them out, something that is best solved by segmentation. We experimented with edge detectors, SAM, image processing operations, and more to determine the best method given our resources and time constraint. The bulk of the work done was developing a training dataset. Each cross-section contains between 20 and 40 fascicles, meaning each training image takes several minutes to label by hand. These training images are then augmented using random rotation, noise, blurring, and brightness to create a larger dataset and a more resilient model. The resulting dataset contains around 150 images, and more than 600 after augmentation.



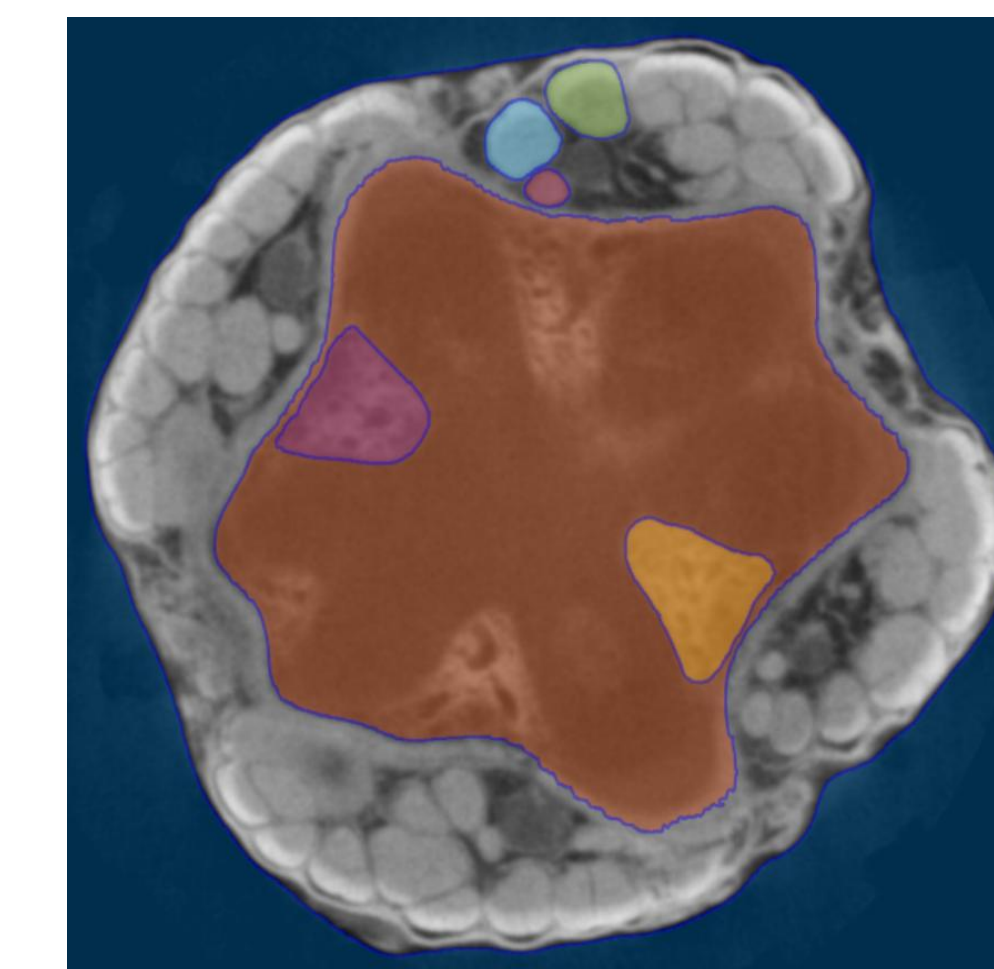
Ex. Image augmentation: random noise, rotation, brightness, and blurring.

FINAL DESIGN

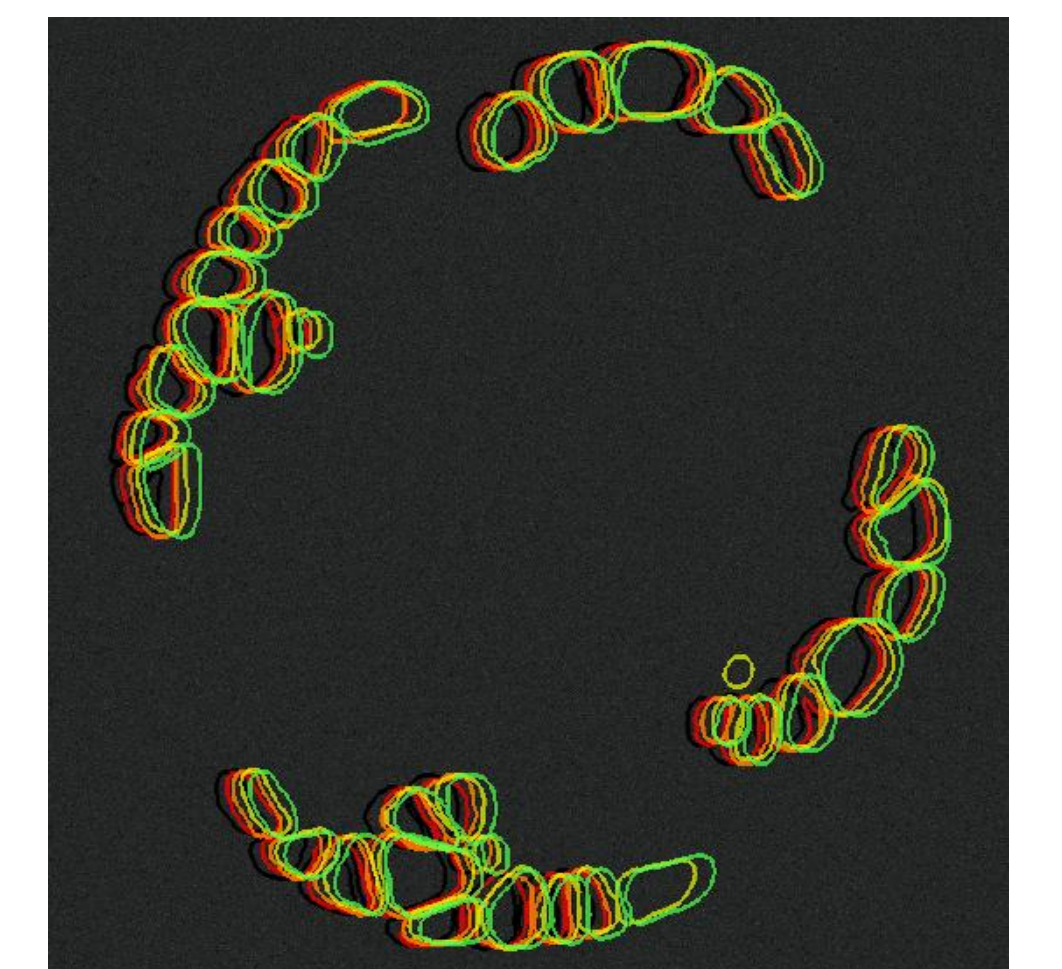
The final design consists of a fine-tuned SAM model for automated fascicle segmentation, and programs for training data conversion and preparation.

RESULTS

The fine-tuned SAM approach has proven effective in extracting fascicles. Preliminary testing on a small dataset of approximately 30 images demonstrated accuracy exceeding 85%, greatly surpassing initial expectations. Further SAM testing showed accuracy nearing 90%. We anticipate that continued training could push the model closer to the target of 95%. Furthermore, SAM annotates each image in under one second, a task that takes approximately 3 minutes when done manually. This represents an approximately 200-fold speedup.



Untrained SAM results.



Resulting masks labeled in order by color.

SUMMARY

The application of SAM has proven effective in automating fascicle extraction from micro-CT images, significantly reducing the time and labor required for tendon analysis. Moreover, the process of extracting features or portions of an image is widely applicable in both medicine and machine learning. Due to physical limitations, important details are lost when scanning tissues, hindering our understanding of their structure and purpose. Machine learning is a promising technique that will continue to provide us with valuable insight going forward.