Application Note RACCT9021

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Cicada Analysis by X-ray CT

About the sample: Cicada

Cicadas are known for the exceptionally loud song produced by males during courtship. The 'song' is made by using the tymbals and tymbal muscles. Specifically, the tymbal muscles buckle and unbuckle tymbals. Because the male abdomen is mostly hollow, it acts as a soundbox and amplifies the song. These experiments show the use of X-ray CT (computed tomography) to examine the sound-producing structures in a male cicada. To ensure ideal contrast, the insect was first iodine-stained and dried prior to X-ray CT data collection.

Analysis procedure

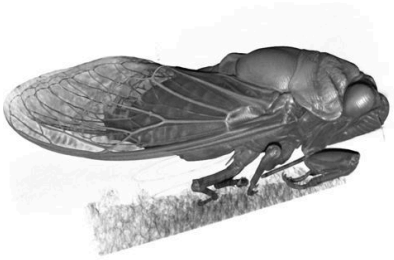
1. In this example, a cicada was scanned using a micro-CT scanner, CT Lab HX.
2. The CT image was segmented to isolate the cicada using deep learning segmentation.
3. The CT image was further segmented and analyzed with regard to the song-producing structures within the cicada.

1. CT scan

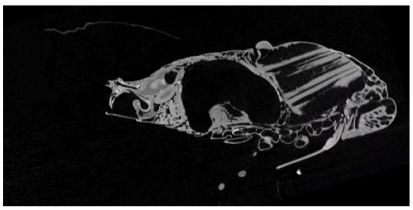
An iodine-stained male cicada was scanned to produce a 3D grayscale CT image.

The 3D volume and 2D cross-section show good contrast for the cicada. Internal muscles and other structures are clearly visible due to iodine-staining.

3D volume



2D cross-section



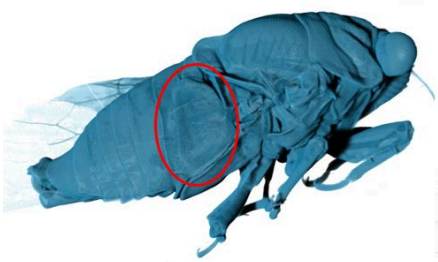
2. Image segmentation

Segmentation for this sample was done using deep learning segmentation to separate the CT image into three phases: cicada (blue), foam holding the sample (hidden), and air (hidden). The wings were manually isolated and subtracted to allow for a full side view in 3D to locate the tymbal membrane.

3. Cicada sound structures

The tymbal is circled in a 3D volume rendering (left), and a 3D rendering of the underside of the cicada (right) shows the tymbal covers as indicated with the red lines.

Tymbal

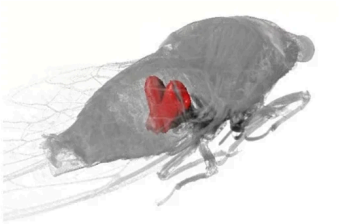


Tymbal covers

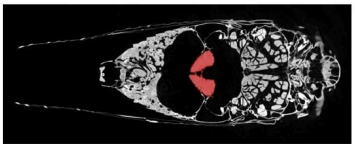
The tymbal muscles were further isolated and are illustrated in 3D volume and 2D cross-sections. These muscles connect to the tymbal, a corrugated exoskeletal structure, to produce the characteristic cicada song. The tymbal muscles account for only 2.91% of the entire cicada (solid parts, such as chitin shell, muscles, wings, and legs), however, they are very good at making big sounds.

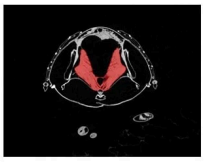
Cicada’s tymbal muscles

3D volume



2D cross-sections





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