Automated Calculation of Hummingbird Flight Kinematics

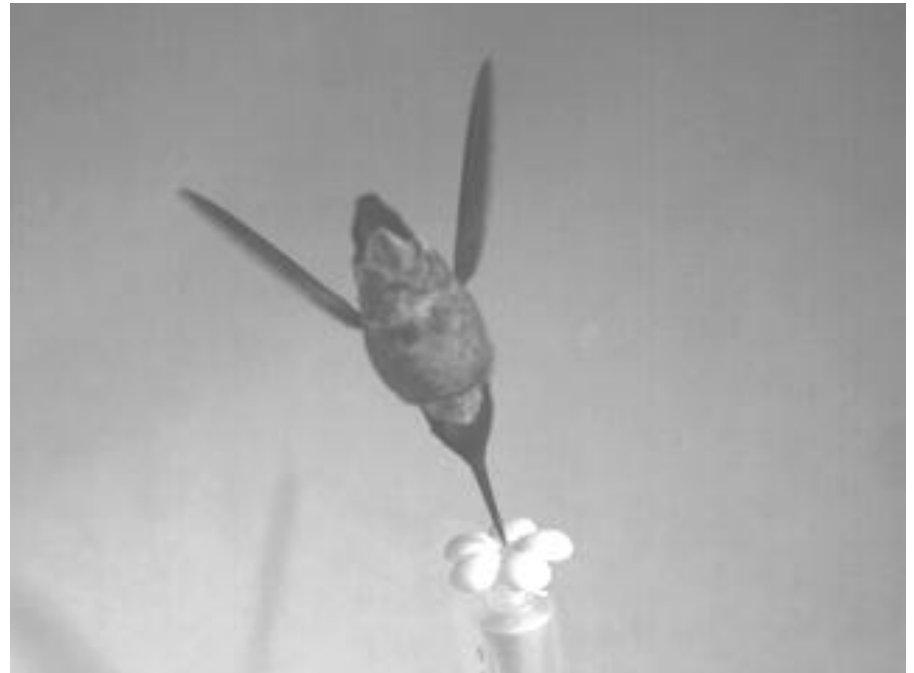Med Imaging Sp2010, Michael McKinley

Inspiration

Hovering Hummingbird in wind tunnel (0m/s airspeed)
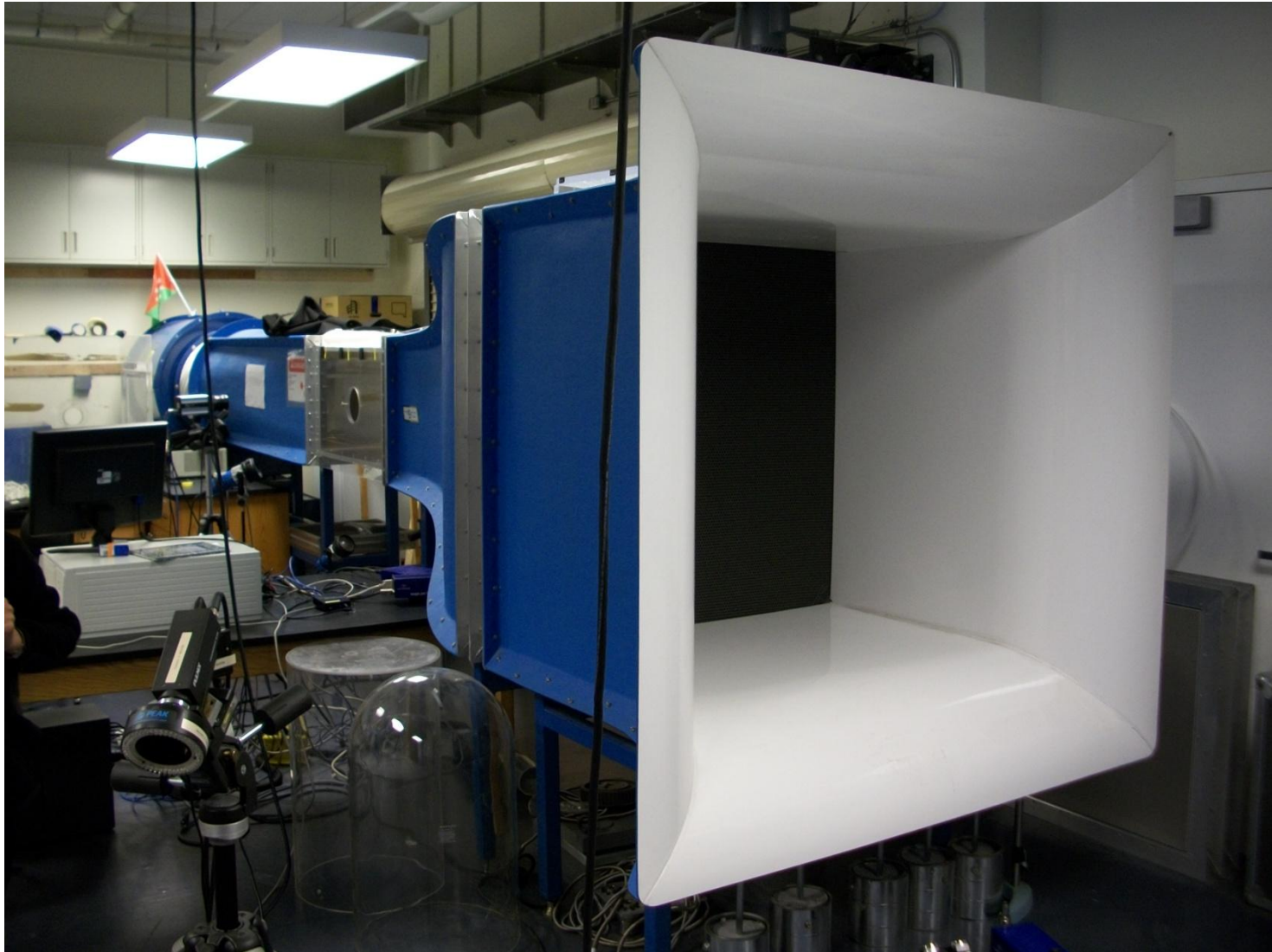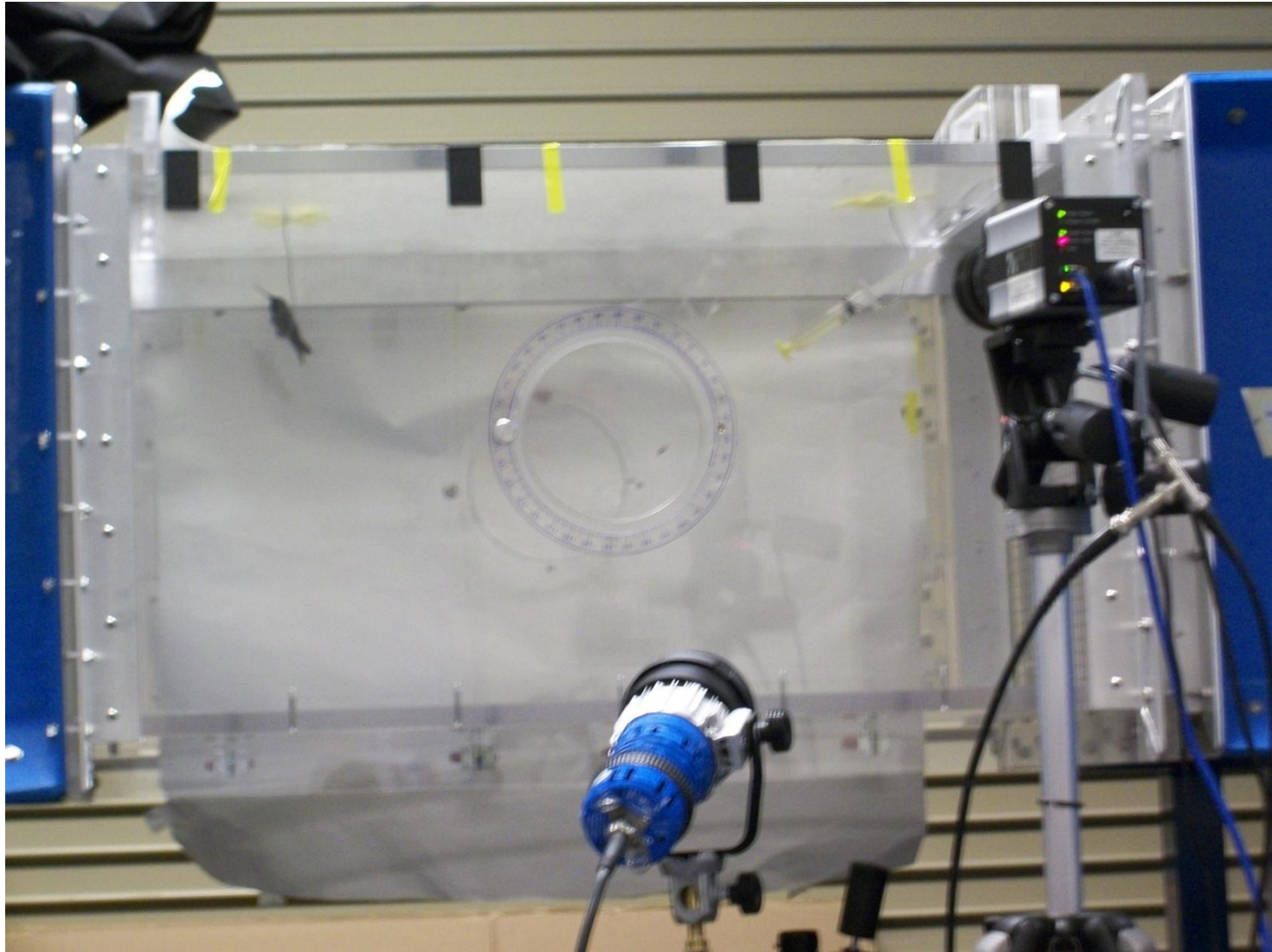Data: High speed video 1280 x 1024 at 500Hz

Side View

Bottom View

Wind Tunnel

Wind Tunnel Working Section
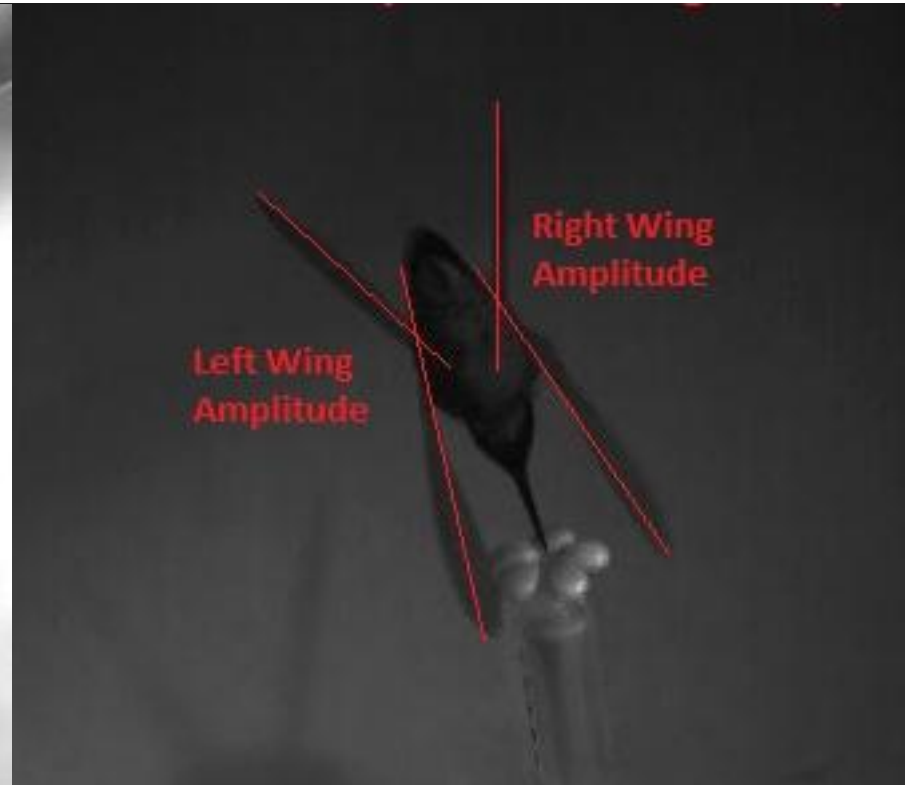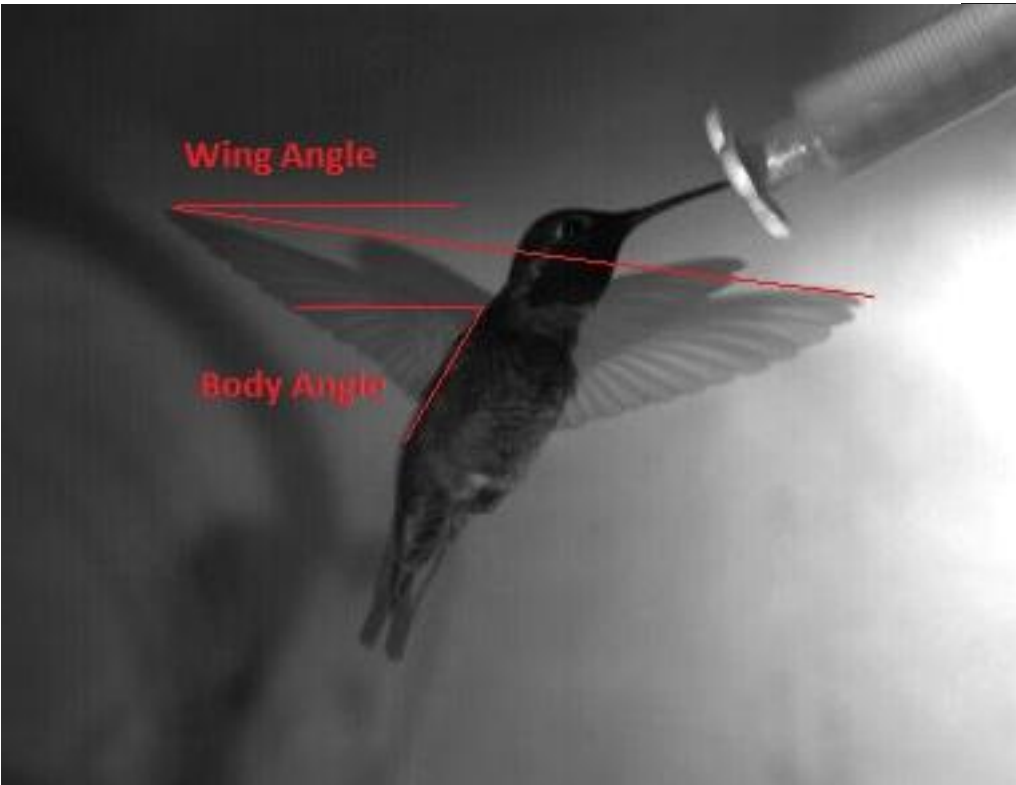
Varying Wind Speed

0 m/s

9 m/s

Change in: Stroke amplitude, frequency, angle of attack, and body orientation

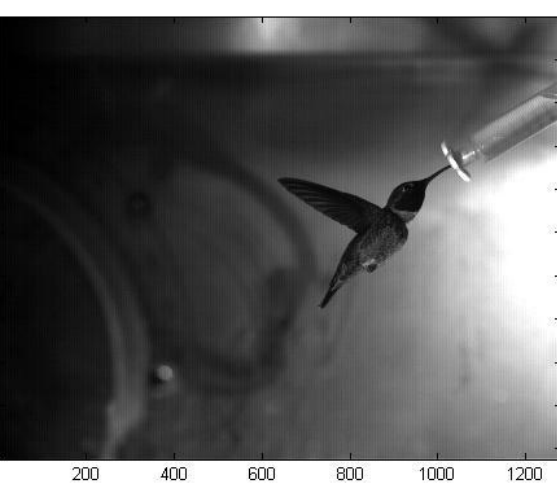# Calculating Kinematic Perameters

Measured Parameters
Beat Frequency
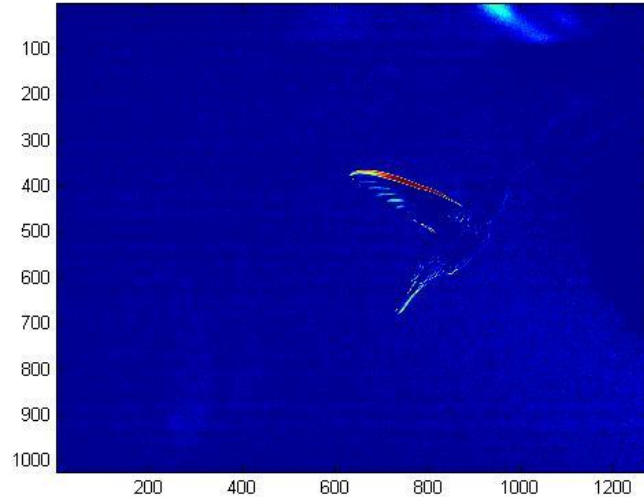Wing Angle
Body Angle
Projected Wing Stroke Amplitude

→

Calculated Parameters
Actual Wing Stroke Amplitude

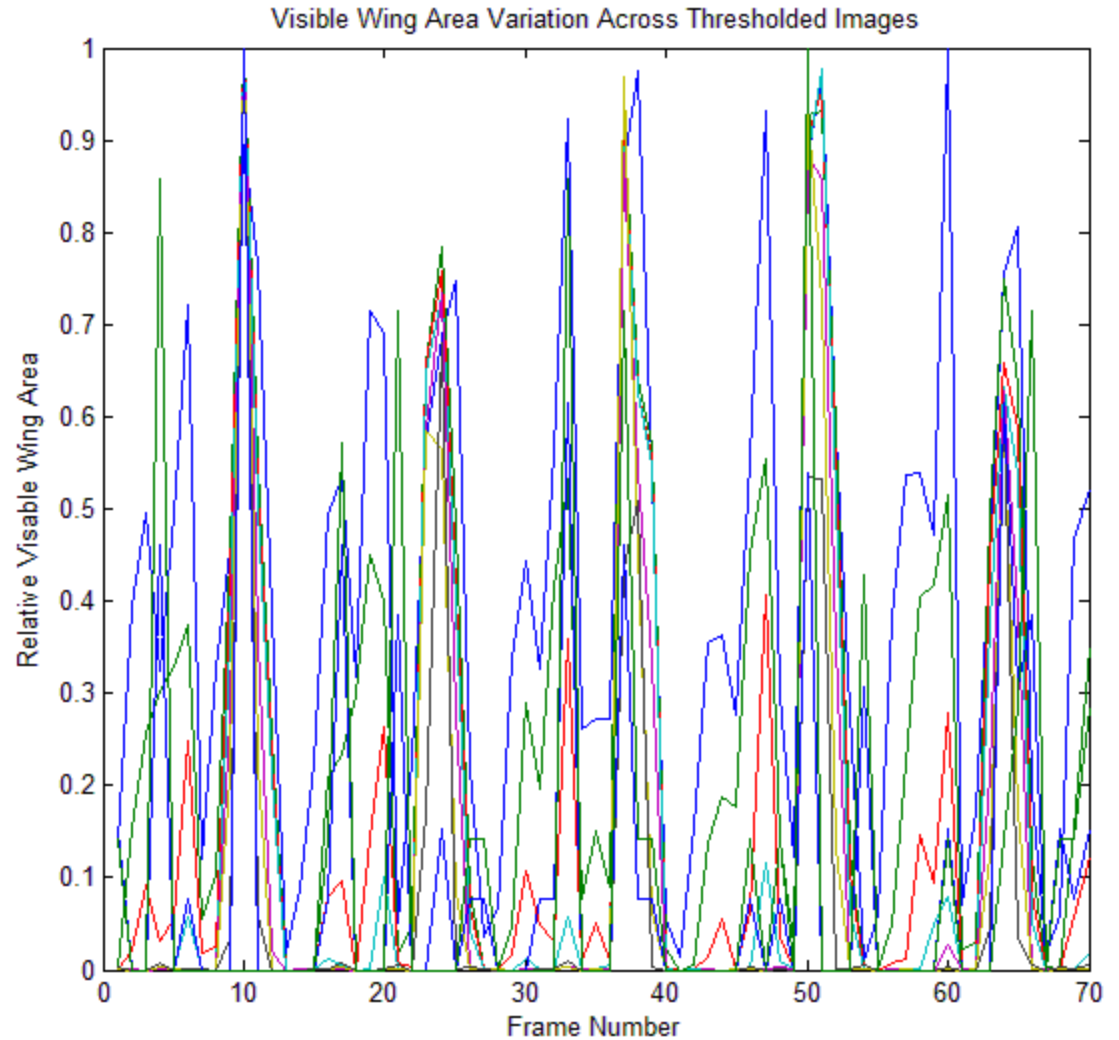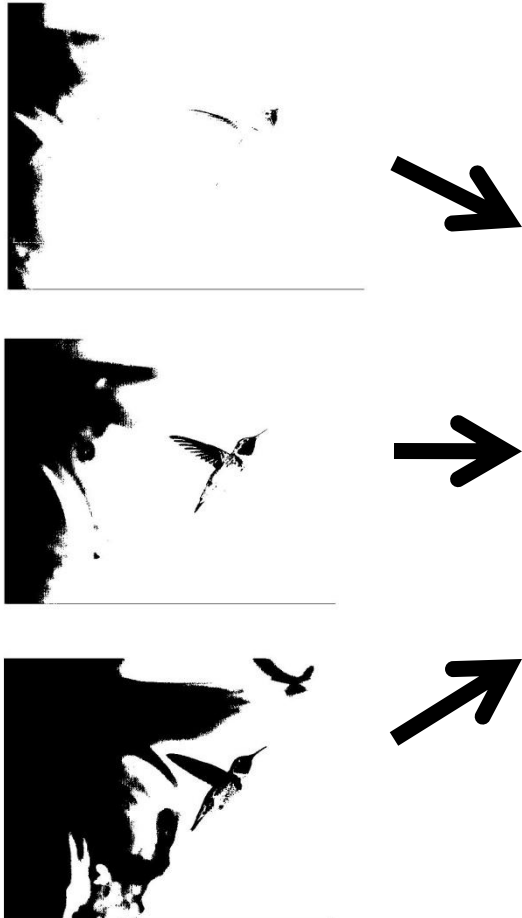# Calculating Beat Frequency

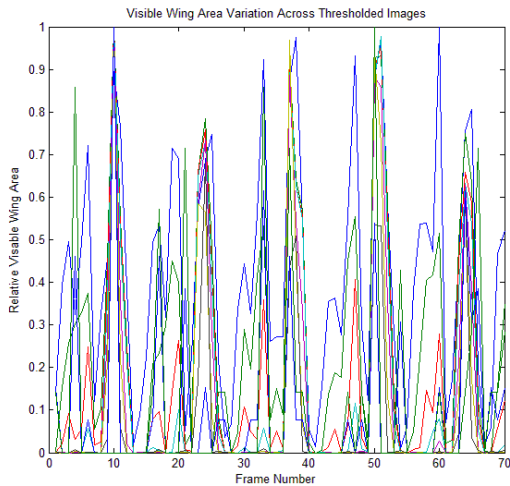Raw Video ➤ Background Subtraction ➤ Threshold Operation

Calculating Beat Frequency

Variable Thresholds

Visible Wing Area Variation Across Thresholded Images
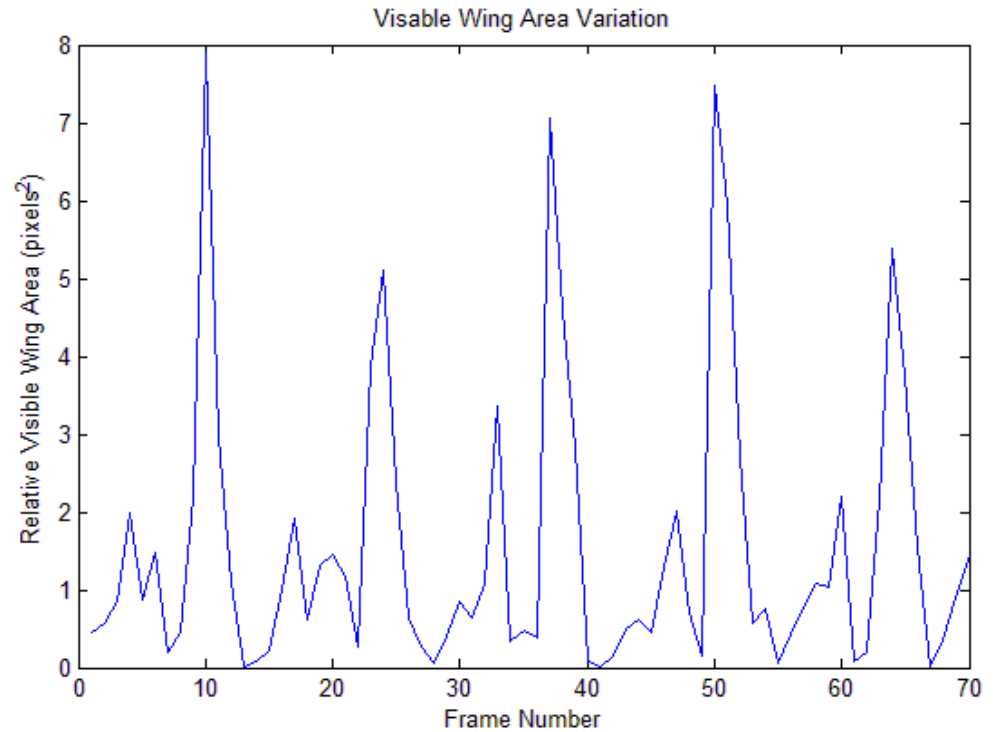
Calculating Beat Frequency

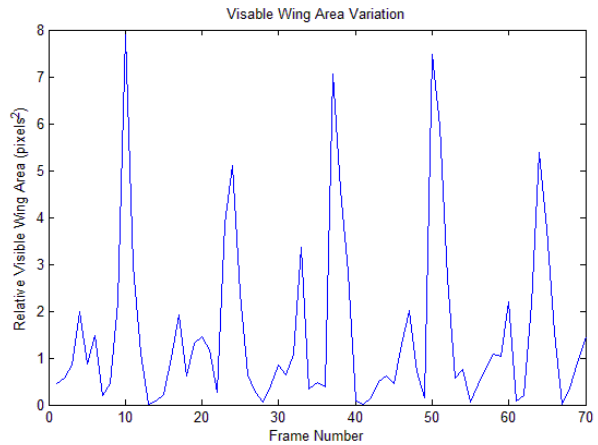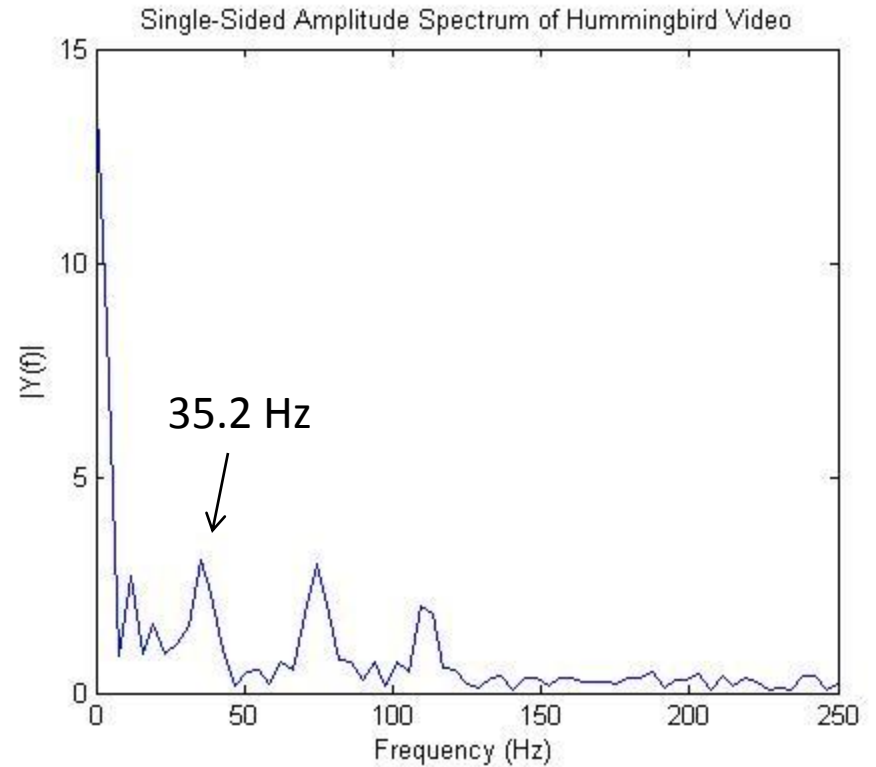Sum Thresholded Data →
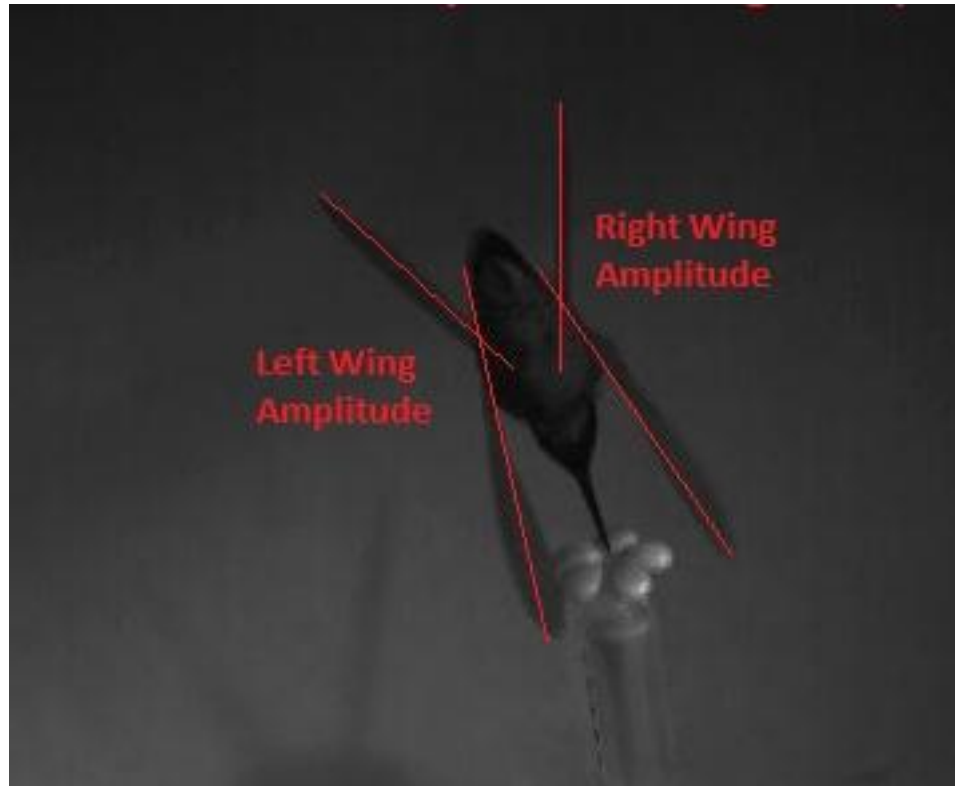
Superior signal to noise ratio

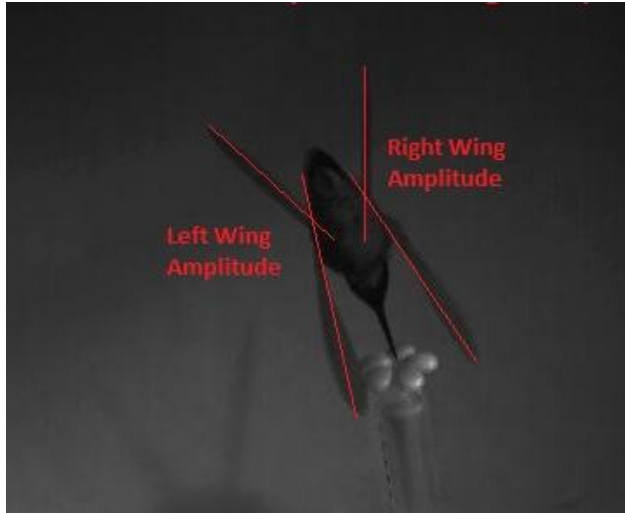# Calculating Beat Frequency

FFT

Projected Wing Stroke Amplitude

Overlay of Extreme Wing Positions

Projected Wing Stroke Amplitude

Thresholded Image after Background Subtraction

(Threshold chosen from first optimization)
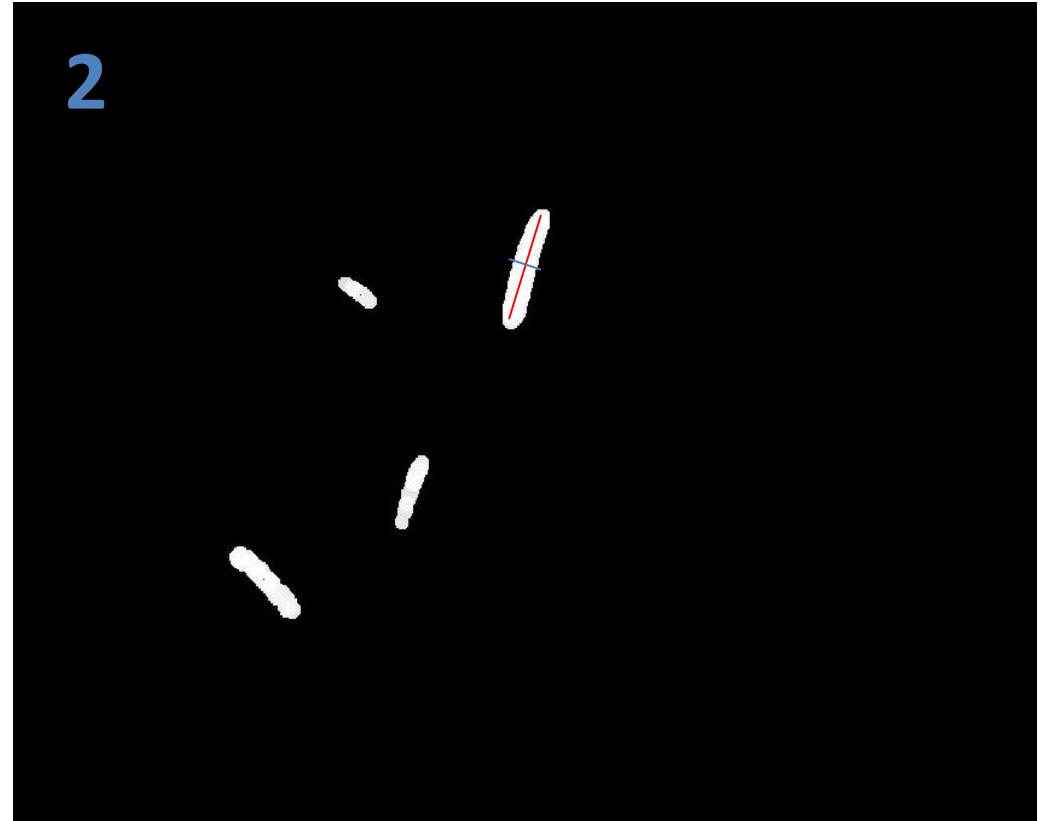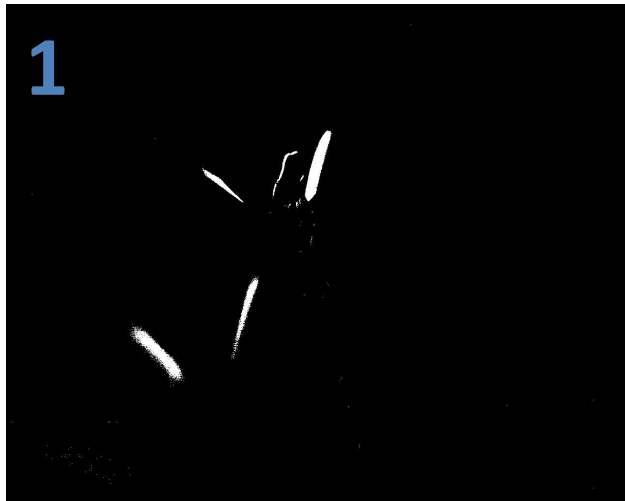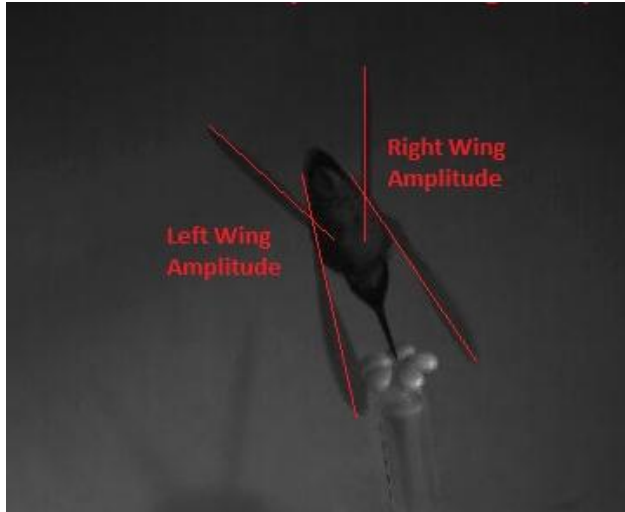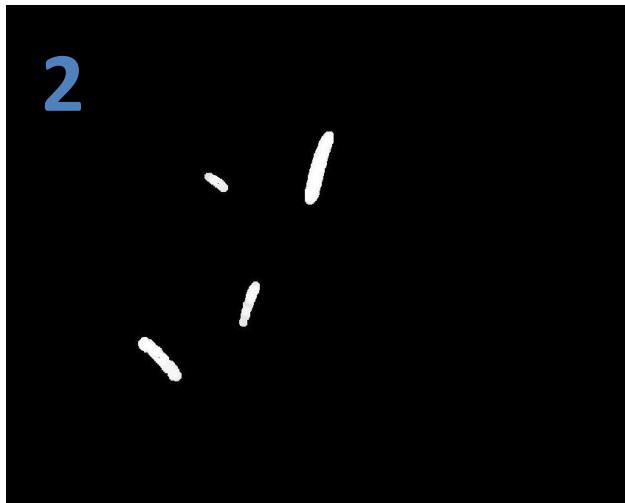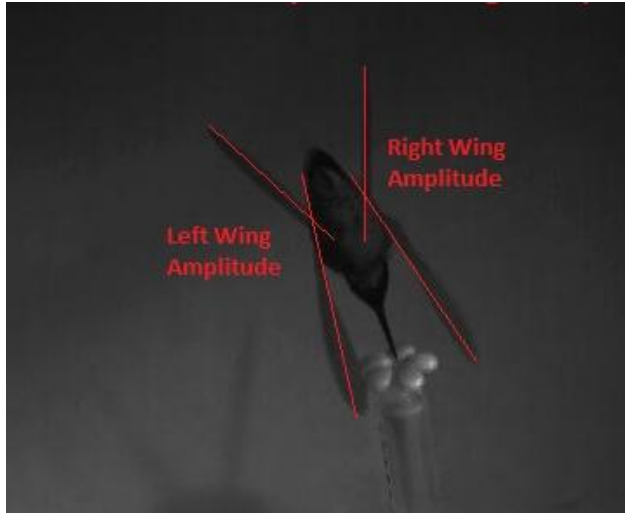
Projected Wing Stroke Amplitude

Image after Erosion and Dilation

Blob detection:
Centroids calculated
Position Defined
Orientation Calculated

Projected Wing Stroke Amplitude
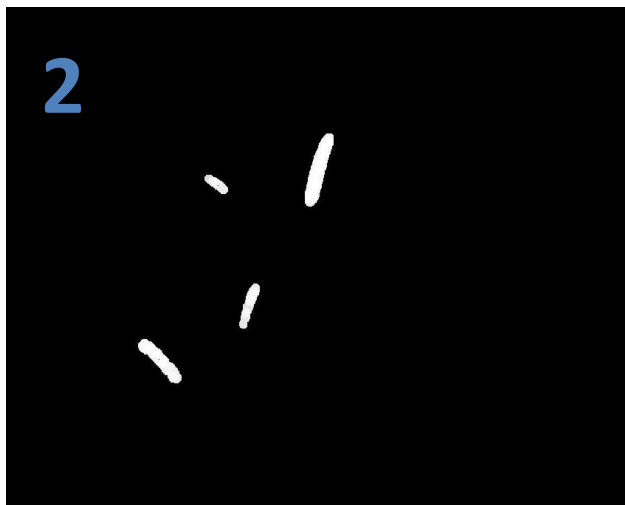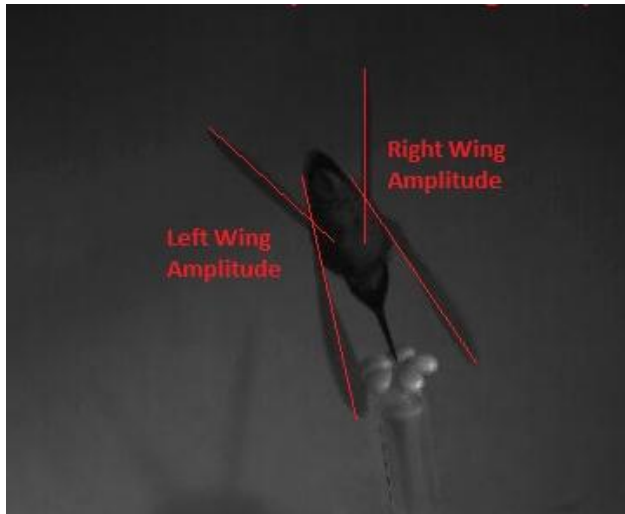

Right Wing Amplitude

Left Wing Amplitude
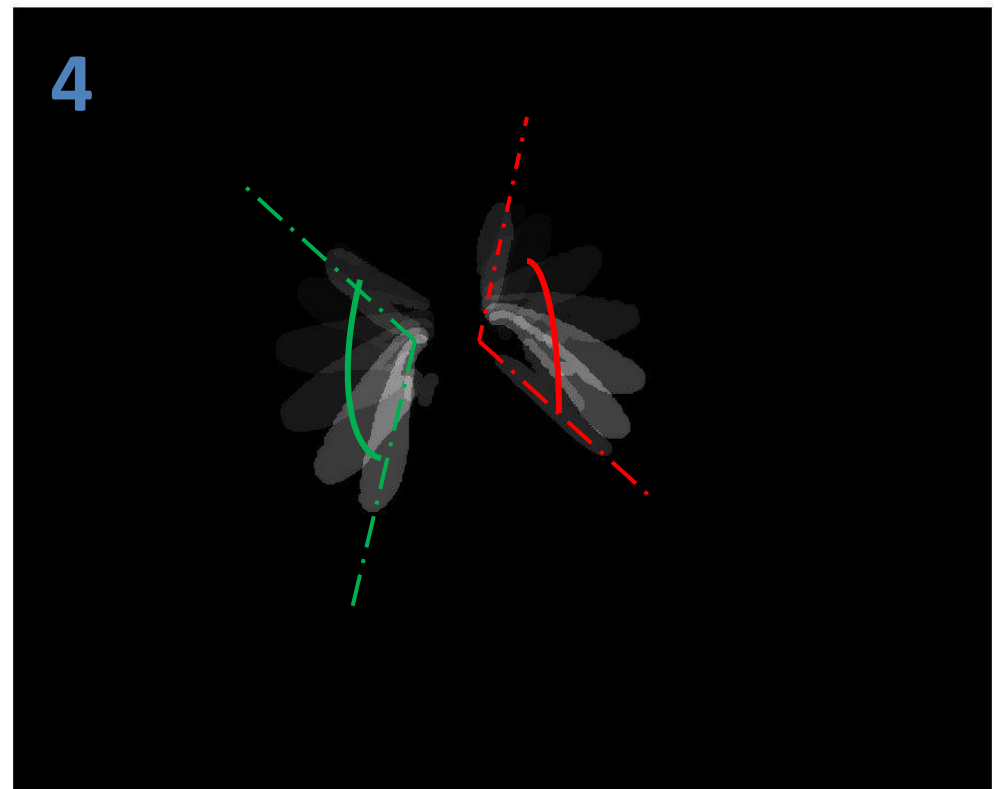
3

2

Prewitt Edge Detection
(chosen for speed)
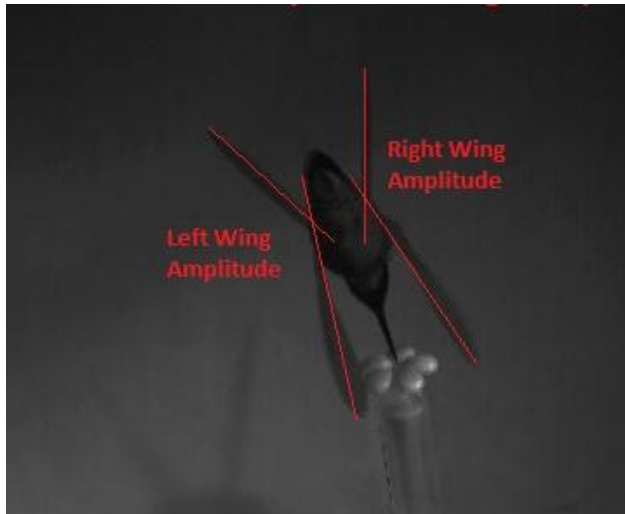
Projected Wing Stroke Amplitude

Right Wing Amplitude

Left Wing Amplitude

2

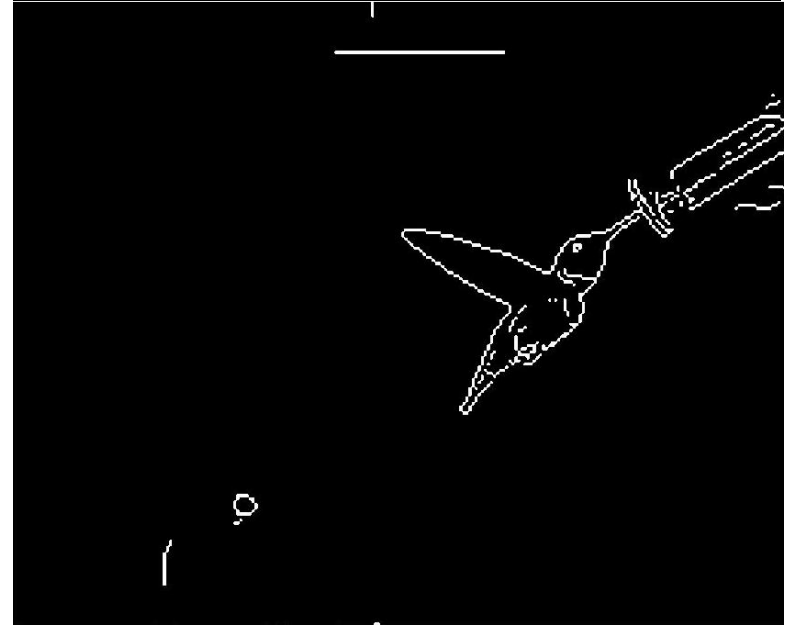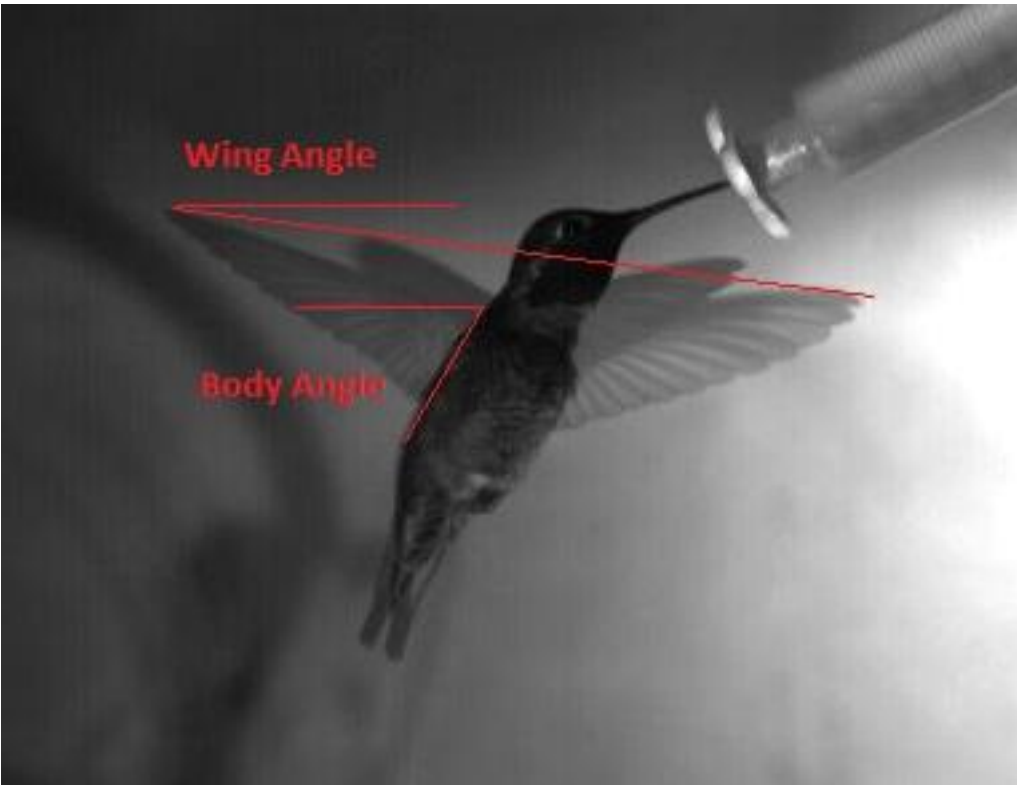2+3

Prewitt Edge Detection
(chosen for speed)

Blobs chosen based on correlation with body edges
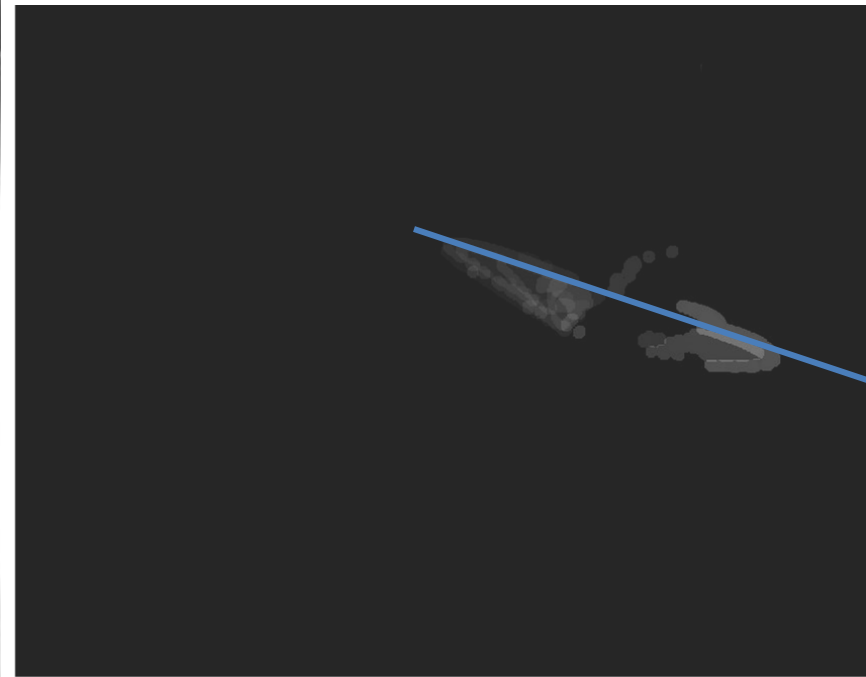
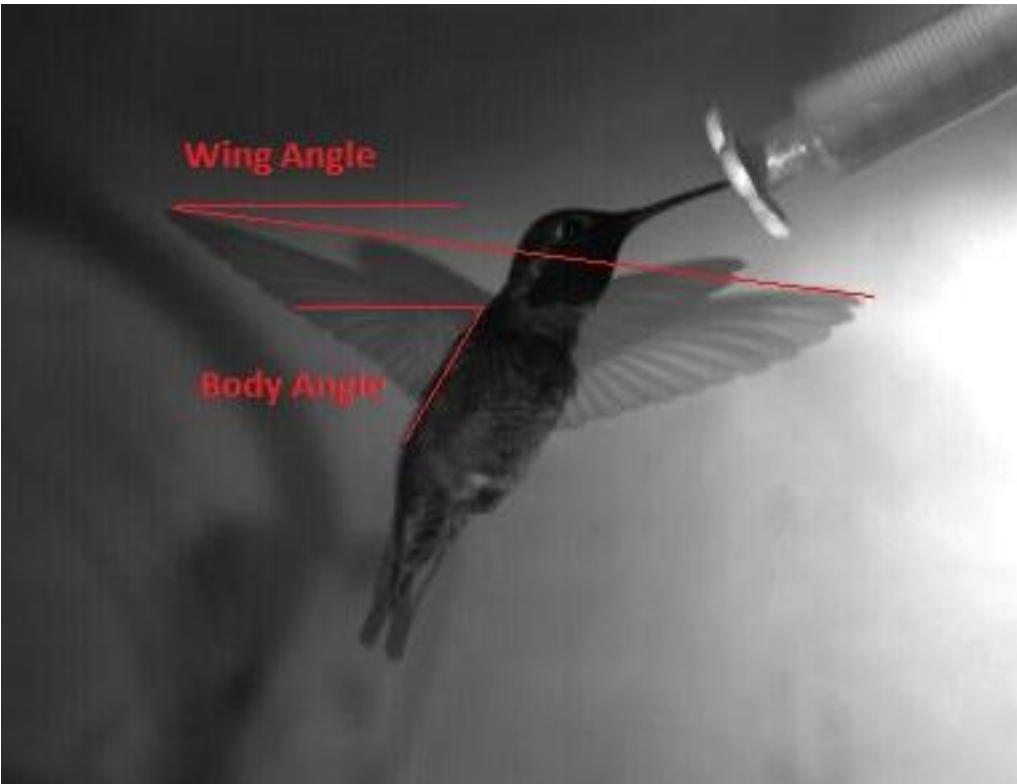# Projected Wing Stroke Amplitude

- Track Centroids
- Determine Projected stroke amplitude based on extreme blob orientations
- Average over multiple cycles

Wing Angle

- Background subtraction
- Threshold
- Erode / Diliate
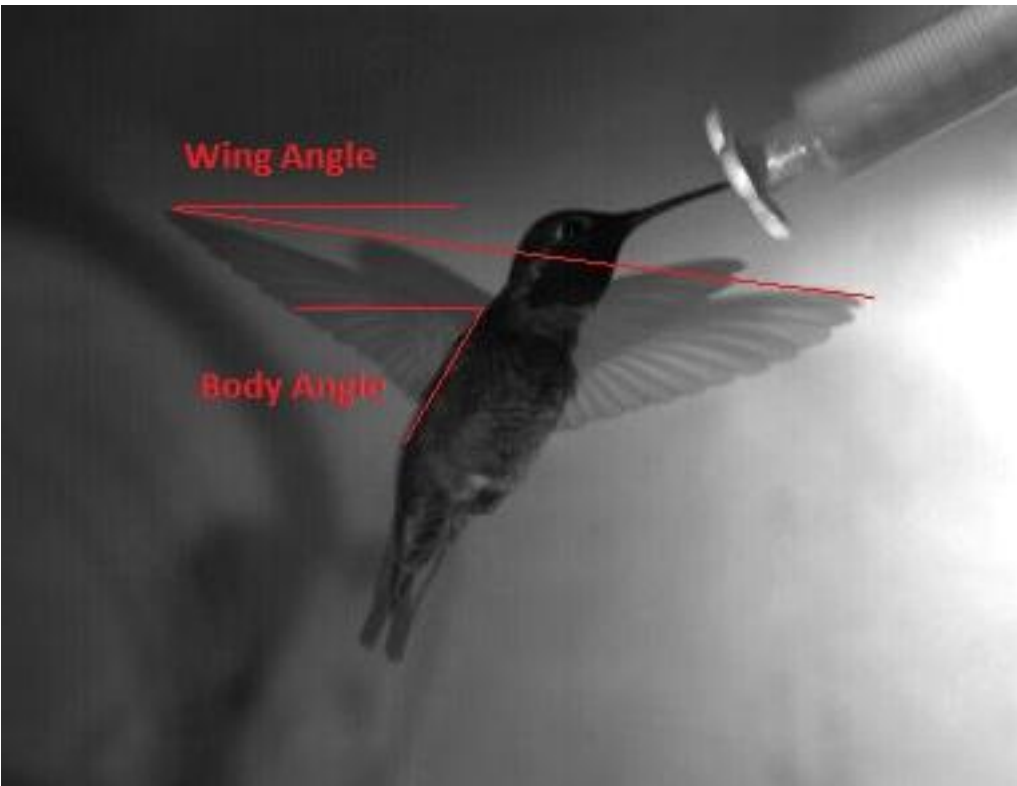- Edge Find
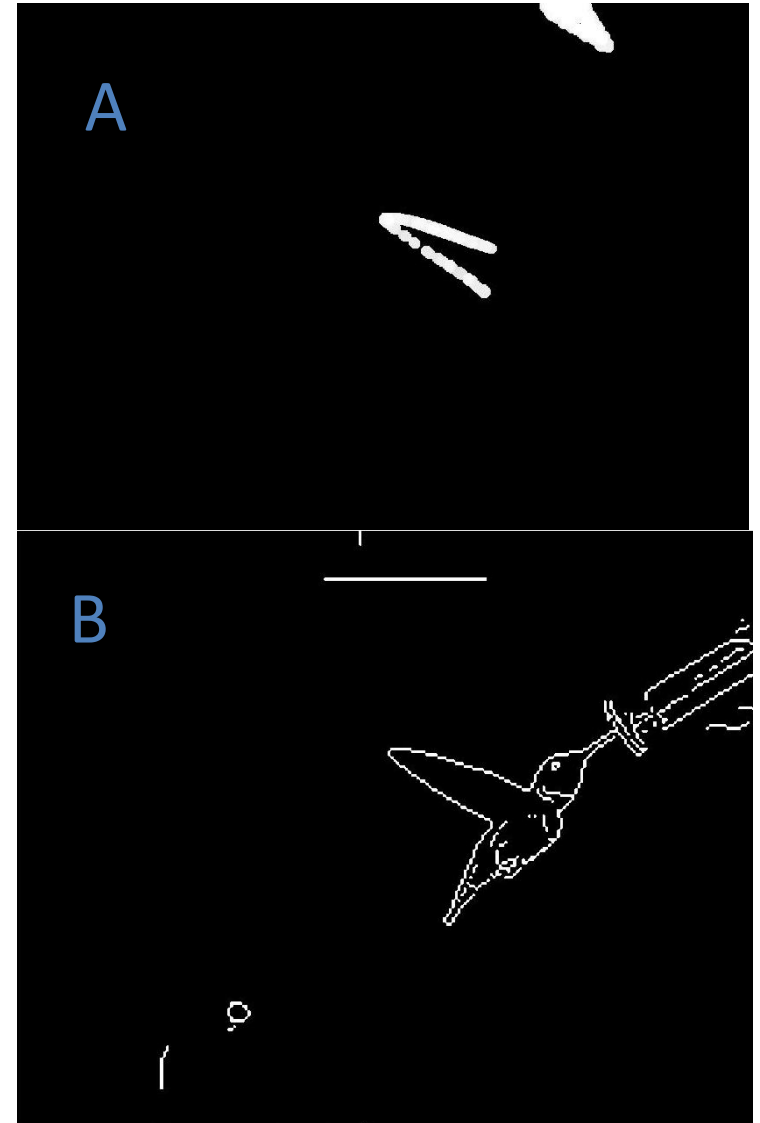- Eliminate extra blobs

Wing Angle

- Fit line to centroids of wing blobs to determine wing angle
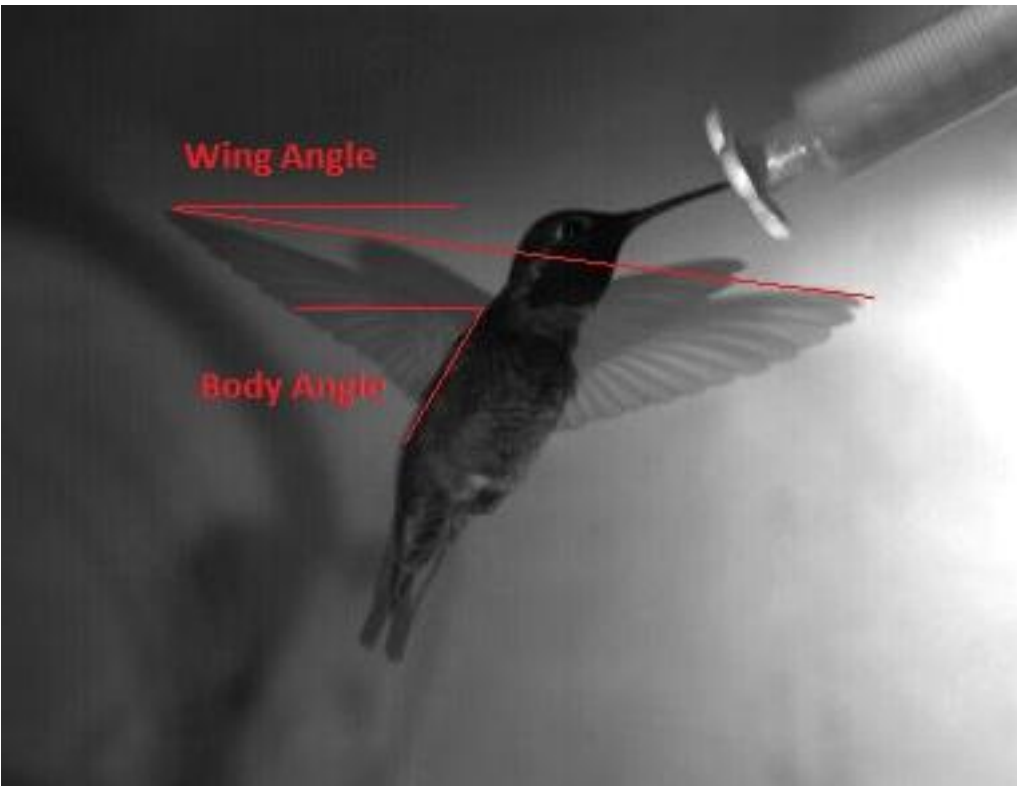- Average over multiple cycles
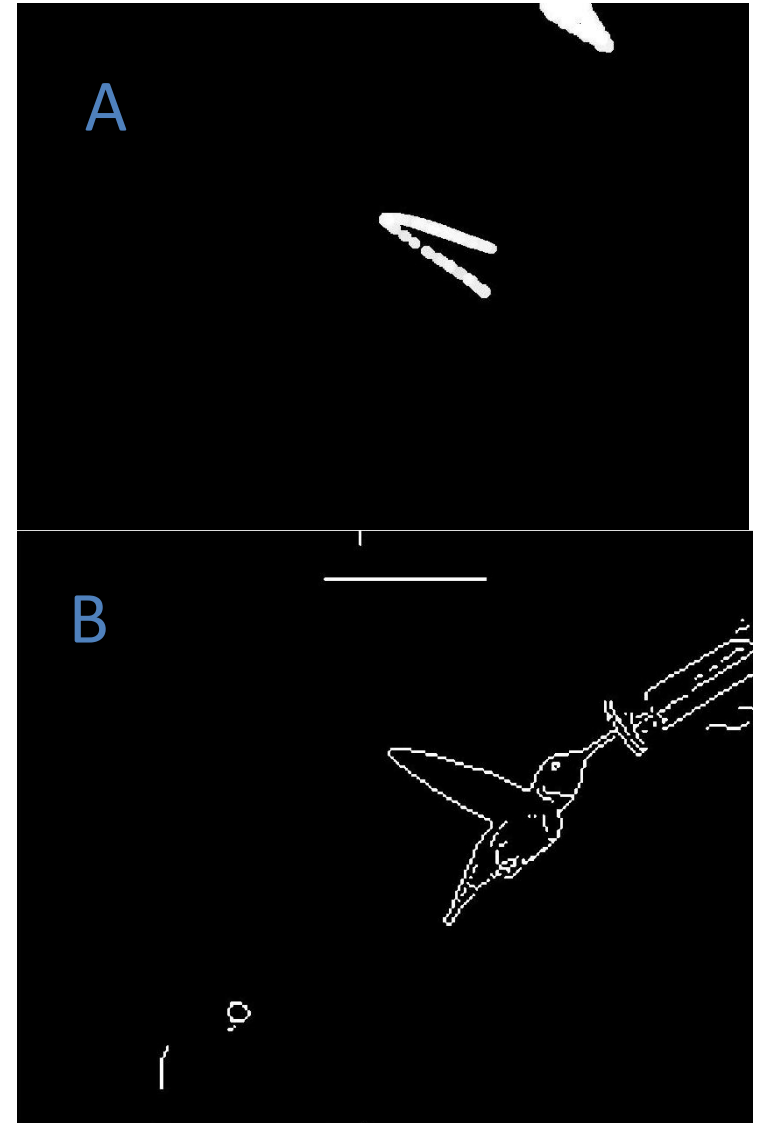
Body Angle
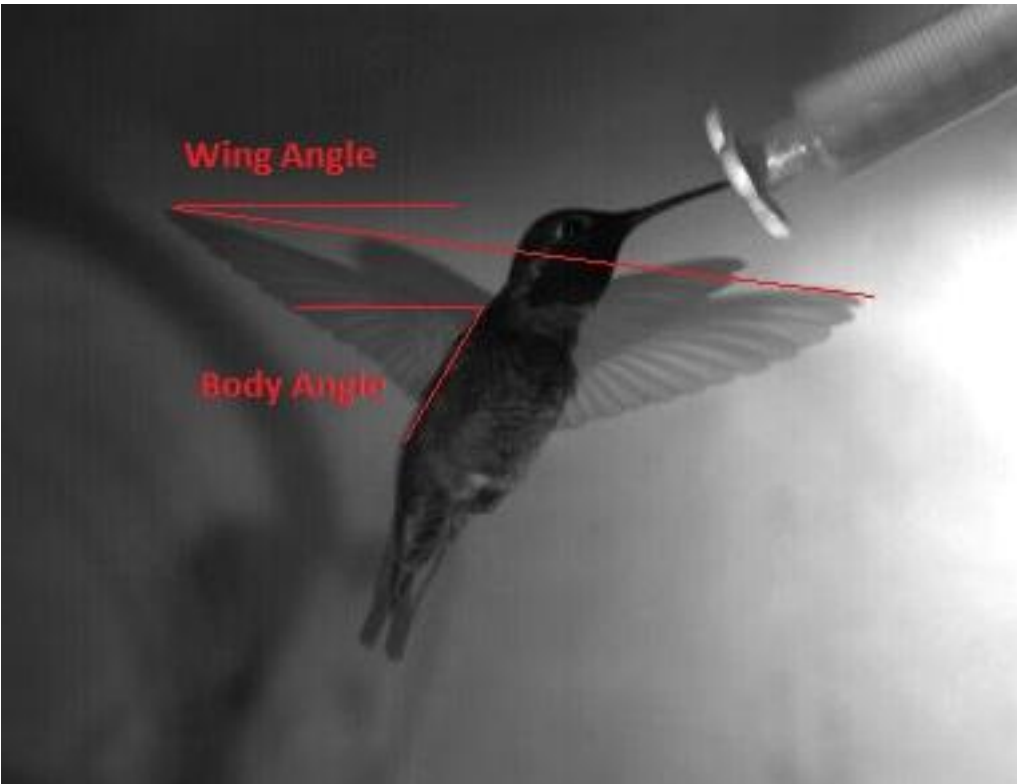

Utilize stencils (A,B) from previous step
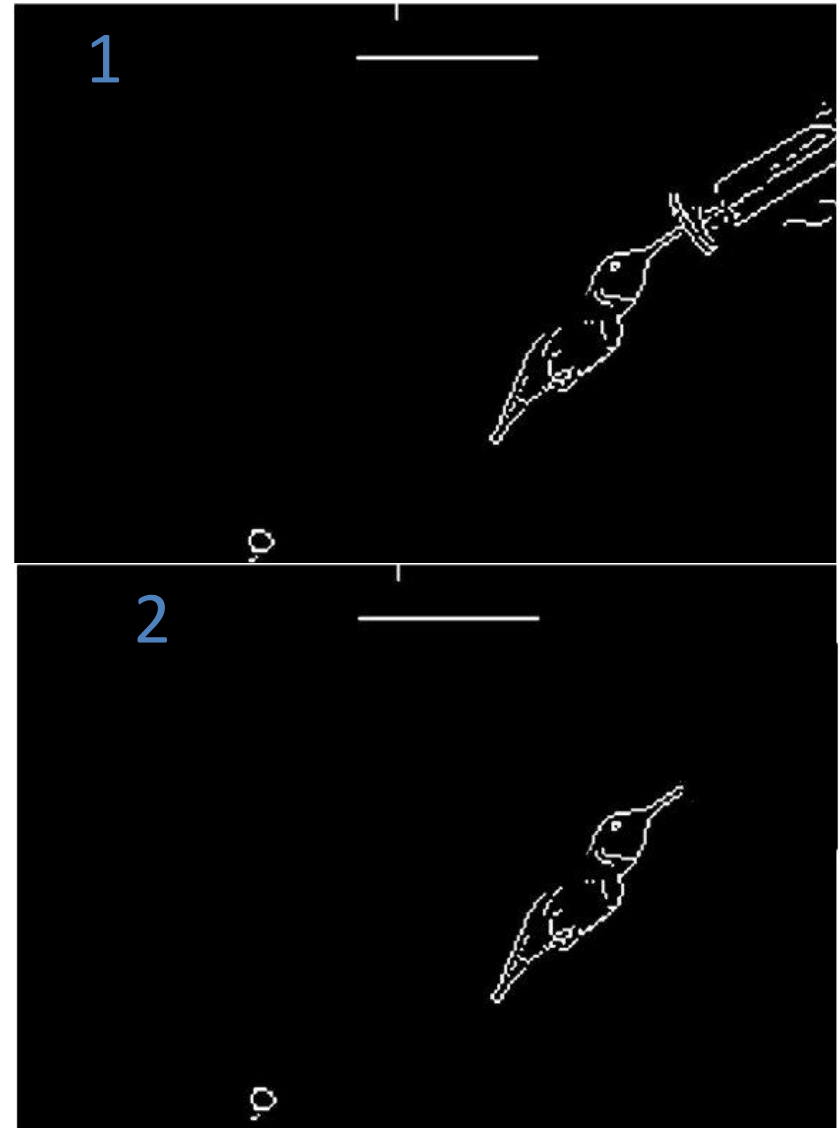
Body Angle

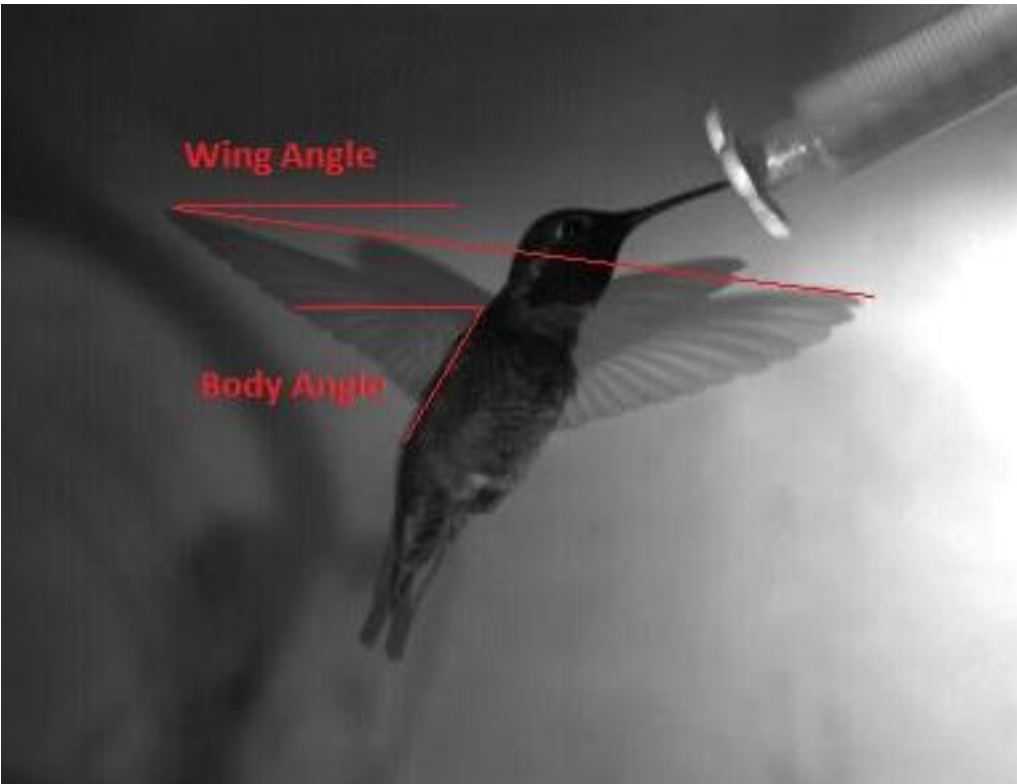Utilize stencils (A,B) from previous step

Body Angle

- Subtract Wings
- Subtract Feeder

Body Angle

- Turn body into blob (Erode, Diliate, fill)
- Calculate orientation of bounding ellipse
- Average over multiple frames

Results

- Previously 30min of hand picking points

- Now 45sec of automation

- Larger datasets can be quickly analyzed

- Easily add error calculation