Title
Big-Bee: Towards a More Accurate Hair Quantification Pipeline

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Big-Bee: Towards a More Accurate Hair Quantification Pipeline

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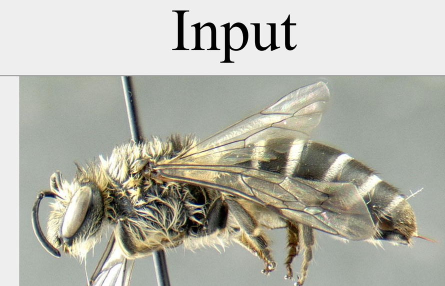
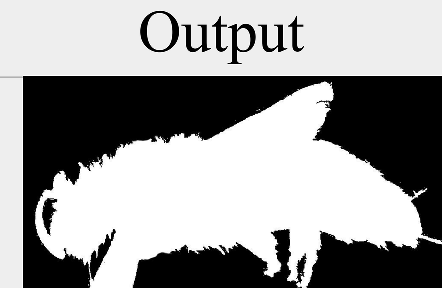
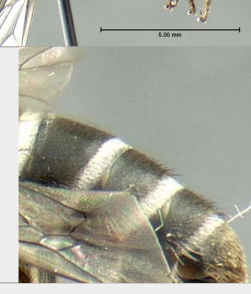
Background

Bees are important pollinators responsible for creating and maintaining the ecosystems that many animals and humans rely on. With many bees declining, the Cheadle Center for Biodiversity and Ecological Restoration is leading the Big-Bee Project Network in an effort to digitize bee traits for further research in bee ecology. Since researchers lack data on anatomical traits that may make bees either vulnerable or resilient to human-induced environmental changes, it is important to find new methods for efficiently collecting these data.

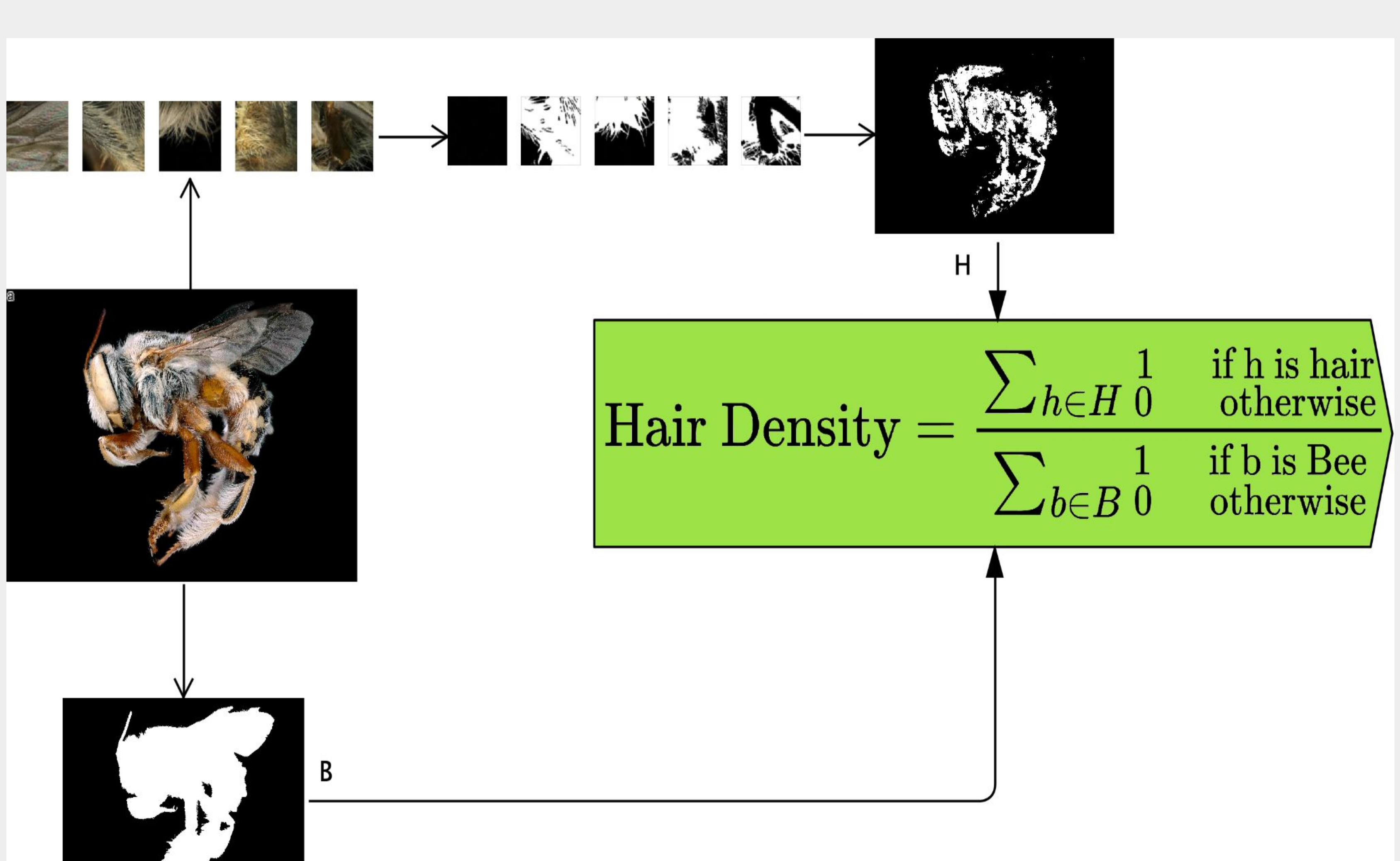
One important bee trait is bee hairiness because they're important for pollination, sensing nearby danger, and staying warm in cooler temperatures. **Through the use of deep learning and computer vision, a new pipeline was created to measure the surface density of hair from bee images.**

Methods

A pre-trained U-Net model(TernausNet) was extended into two new learning tasks(one for masking bees and one for masking hair). To train and evaluate the models, a dataset of 315 bee masks and 199 hair masks were created via Adobe Photoshop. The hair masks are 300x300 random crops of the original images to help the model generalize better. Consequently, the final pipeline for measuring a density index will slice an inputted image into 300x300 pieces, feed each part into the hair masking model, and restitch each slice into the final image. Both datasets were split at a 60/20/20 ratio for use as the models' train/validation/test sets.

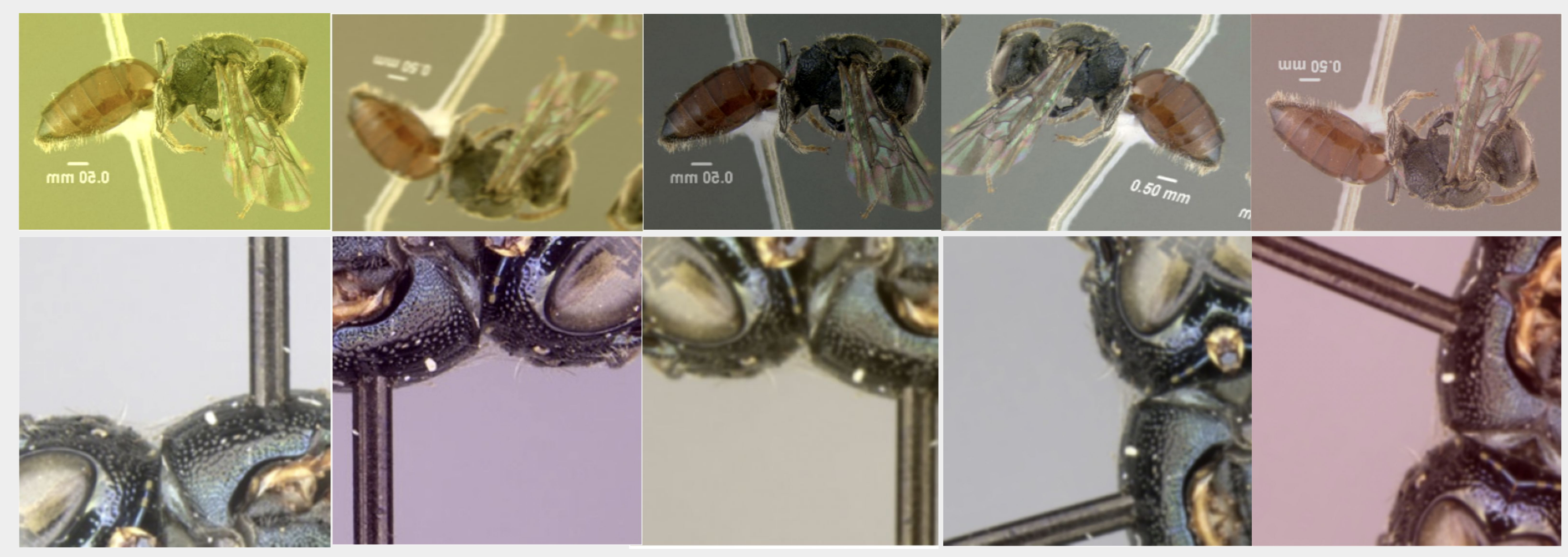
Model	Input	Output
Bee Masking		
Hair Masking		

Data augmentation was used to create a larger training dataset. Methods include random combinations of blurring, horizontal/vertical flipping, random rotation, and RGB shifting. This in effect creates a new image/mask during each round of training.



Results

Random Augmentations (many more possibilities not shown)



Model	Best Iteration	Train Loss	Validation Loss
Bee	303	0.047418	0.047709
Hair	219	0.223569	0.229942

Model	Train F1	Test F1	Train Acc	Test Acc
Bee	0.98	0.972	0.985	0.98
Hair	0.73	0.65	0.932	0.897

By calculating hair model's mean F1 for images where F1 >= 0.1, we get:

Model	Train F1	Test F1	Train Acc	Test Acc
Hair	0.82	0.71	0.92	0.88

This removes 6/41 of the testing images which scored an F1 score around the magnitude 10^-19. These scores are a result of having false positives for an image that holds mostly true negatives. Thus, the adjusted F1 score should be considered during evaluation. Many of these outliers come from images of eyes/wings.

Conclusion/Future Research

- Current hair masking pipeline needs significantly more training data in order to improve.
- Training a model to mask out all irrelevant noise(including eyes and wings) of a bee image and using the resulting image for predicting hair density may help improve performance scores(dataset under construction).
- A new dataset will also allows for tuning and evaluating traditional edge detection algorithms.

References & Acknowledgements

Vladimir Iglovikov, Alexey Shvets. 2018. TernausNet: U-Net with VGG11 Encoder Pre-Trained on ImageNet for Image Segmentation. arXiv:1801.05746 https://doi.org/10.48550/arXiv.1801.05746

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