

# Automated Gender Detection of C. Elegans Samples

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## Introduction

- *Caenorhabditis elegans* is a nematode extensively researched for its neurological properties. Since its entire nervous system has been mapped, It is an ideal candidate to study how neurology influences behavior.
- Additionally, due to the worm's short lifespan and prolific breeding, it can be quickly bred and monitored to generate an astonishing amount of data. Worms can be simultaneously bred in separate petri dishes, allowing parallel experimentation.
- Given both the ease of growing worms and the potential amount of data collected, it is imperative to automate various tasks like worm-picking and categorization.
- Accurate identification of a C. elegans' gender allows for routine actions such as picking worms based on gender to be automated. In turn, this leads to a higher throughput of C. elegans data and a better understanding on how to continue scripting otherwise manual processes.



C. elegans male



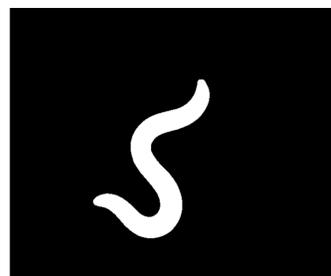
C. elegans hermaphrodite

## Objective

- The primary objective is to determine the gender of a C. Elegans given a picture of a C. Elegans.
- This goal is accomplished by identifying and outlining the worm, finding the edges of the worm, and then calculating the score based off the edges. Next, the scores are fed into an equation that will determine the final gender.

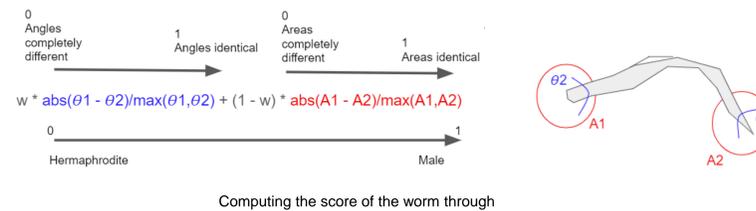


First step: from worm to proper outline



## Methodology

- 20 male and 20 hermaphrodite images were created for testing purposes.
- The primary observation used to determine a worm's gender is the differences of the worms ends. A male worm has a tail fan that makes the tail have a similar shape to the head, while the hermaphrodite lacks the tail and thus has a tail that is narrower than the head.
- The algorithm consists of two parts: first one is calculating score of the worm. The process is displayed by the diagram below.

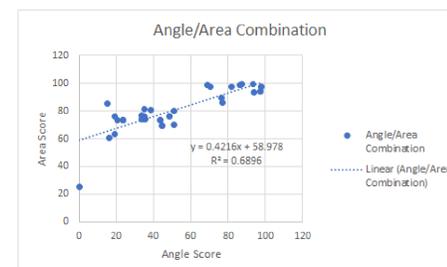
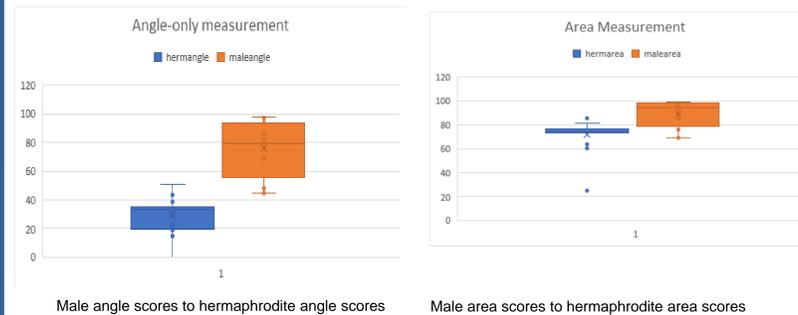


- The blue part represents the angle of the lowest degree on the ends of the worm. The red part represents the total area the ends of the worm occupy when surrounded by a circle of set size.
- After calculating the area score and the angle score based off the method above, next step is to plug it into this expression:

$$-0.27213838 * \text{angle} + 0.43917897 * \text{space} - 5.13413322$$

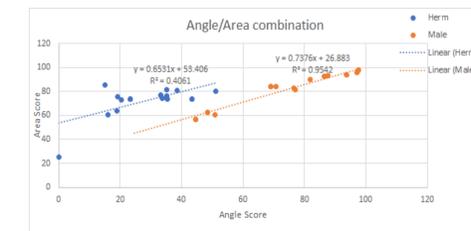
- This expression was obtained by categorizing the scores using a support vector machine.
- Finally if the result is positive, the worm is a hermaphrodite, and if the result is negative, the worm is a male.

## Results



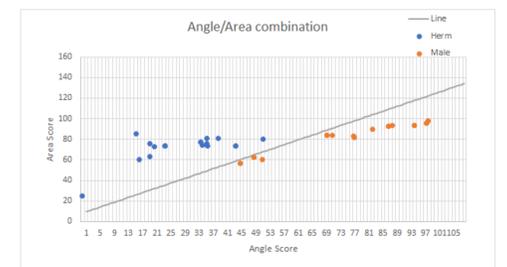
Are angle and area scores correlated? 68% of variation in area scores are determined by angle scores

## Additional Results



Angle and area correlations with male and hermaphrodite labeled separately

The dividing line drawn by the support vector machine.



## Discussion

- Overall the algorithm is successful, with 100% accuracy reached on the training images and generally correct when identifying single worms in videos.
- The algorithm demonstrated that the visual differences between the male and hermaphrodites can be detected and processed.
- There is some positive correlation with the area score and the angle score, however it is not significant enough to warrant letting one variable substitute the other one.
- More generally, the method of identifying and quantitatively describing differences can be applied to distinguish other characteristics of worms, like their age.

## Further Directions

- Adapting this decision process to the worm-picking script in order to pick specific worms.
- Allow detection of gender in low magnification images: the current process applies to high magnification images.

## Acknowledgements

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