# Enhanced Posture Tracking Reveals Common Dimensionality in Crawling and Swimming *C. elegans*

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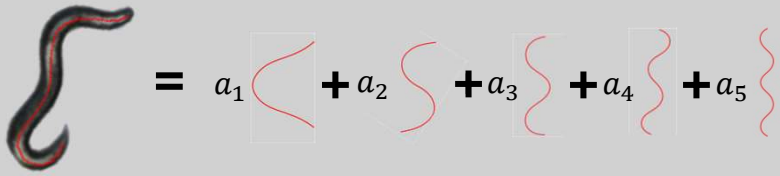
## Background

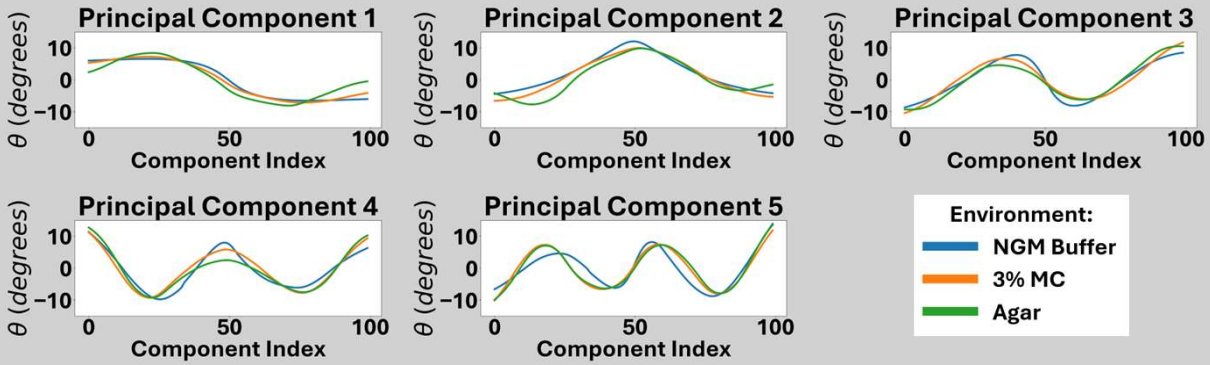
Quantitative posture tracking in *C. elegans* is crucial for understanding behavior. Principal Component Analysis (PCA) reduces complex postures into a few principal components called "eigenworms," which reduce the complexity of detailed behavior analysis [1,2].



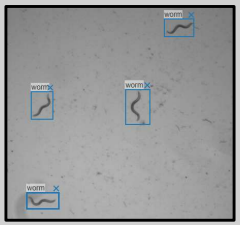

We introduce a robust posture tracking algorithm that overcomes previous limitations in handling self-occluding poses. This advancement allows for accurate posture analysis in various environments, improving understanding of *C. elegans* locomotion and behavior.

## Results

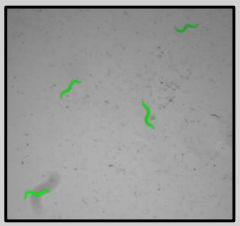
In this study, we analyzed the principal component (PC) shapes of *C. elegans* in three environments with increasing resistance: NGM buffer, 3% methylcellulose, and agar. Ten worms were recorded freely moving in each environment for ten minutes and each worm's principal components were averaged within environments and plotted below. Interestingly, similar eigenworms describe the worm's posture across all environments.



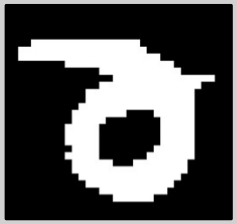

## Posture Tracking Pipeline



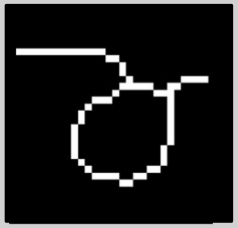
**1.** Annotate Images and Train Bounding Box Detection Network



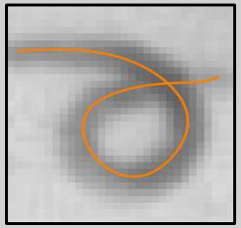
**2.** Automatically generate Rough Masks and Train Mask Detection Network



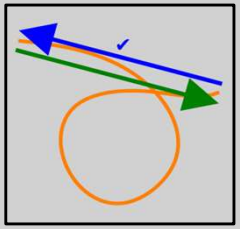
**3.** Detect and Generate Clean Masks on New Dataset



4. Skeletonize and Order Points

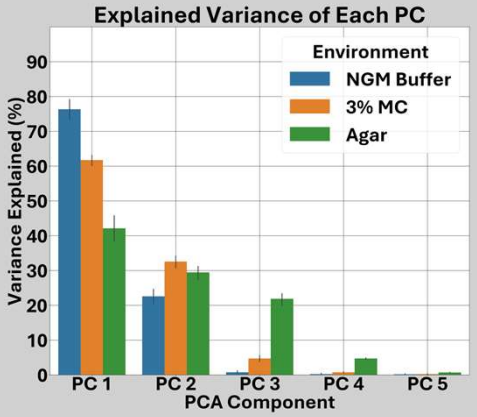


5. Fit Splines

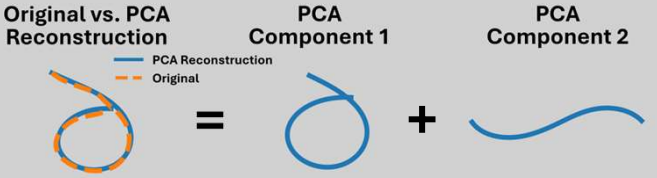


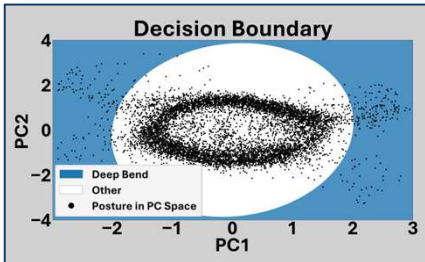
6. Correct Orientation Based on Previous Frame

Though worms in each environment are well represented by similar eigenworms, those in less resistive environments require fewer eigenworms to explain most of their postures.




Only two principal components were needed to explain well over ninety-five percent of body shape variance in NGM buffer




Turning behaviors in NGM buffer are well classified by a decision boundary found by a supervised machine learning algorithm known as a support vector machine

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[1]. Stephens, G. J., Johnson-Kerner, B., Bialek, W., & Ryu, W. S. (2008). Dimensionality and dynamics in the behavior of C. elegans. *PLoS Computational Biology, 4*(4), e1000028.
[2]. Broekmans, O. N., Rodgers, J. B., Ryu, W. S., & Stephens, G. J. (2016). Resolving coiled shapes reveals new reorientation behaviors in C. elegans. *eLife, 5*, e17227