We present a physically motivated approach to modeling the structure as well as dynamic movements of the nematode *C. elegans* as observed in time-lapse microscopy image sequences. The model provides a flexible description of a broad range of worm shapes and movements, and provides strong constraints on feasible deformation patterns to image-based segmentation, morphometry, and tracking algorithms. Specifically, we model the predictable patterns of deformations of the spatial axes of the nematodes.

Model-based algorithms are presented for segmentation and simultaneous tracking of an entire imaging field containing multiple worms, some of which may be interacting in complex ways. Central to our method is the observation that the spatial axes undergo deformations obeying a pattern that can be modeled thus reducing the complexity of the measurement process from one frame to the next. Tracking is performed using a recursive Bayesian filter that performs well in the presence of clutter. Interaction between worms leads to unpredictable behaviors that are resolved using a variant of multiple-hypothesis tracking. The net result is an integrated method to understand and quantify worm interactions.

Experimental results indicate that the proposed algorithms are demonstrably robust to the presence of imaging artifacts and clutter, such as old worm tracks, in the field. An ad-hoc-based validation strategy was used to quantify the algorithm performance. Overall, the method provides the basis for high-throughput automated observation, morphometry, and locomotory analysis of multiple worms in a wide field, and a new range of quantification metrics for nematode social behaviors.

**Main ideas**

- Exploiting known worm locomotory concept to model movement and deformation in a correlated manner.
- Modeling interaction and overlap.
- Probabilistic approach to measurement and prediction.
- Resolving entanglement problem by a combination of Multiple hypothesis tracking and overlap modeling.

**Conclusion**

The proposed methods enable large scale automated analysis of entire worm populations, providing quantitative data on the morphology and locomotion of each worm. Our model can accept additional constraints on the tracking process to further improve ability and performance. Overall, our experiments indicate that our tracking algorithms are practically useful. They advance the state of the art in terms of modeling methodology, tracking performance, and analysis of multiple interacting worms. This work opens up opportunities for high-throughput locomotory analysis of worm populations, and a new range of quantification metrics for nematode social behaviors.

**References**


