

JAABA: An interactive machine learning system for automatic annotation of animal behavior

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We present the Janelia Automatic Animal Behavior Annotator (JAABA), a new machine learning-based system to enable researchers to automatically compute highly descriptive, interpretable, quantitative statistics of the behavior of animals [1]. Through our system, the user encodes their intuition about the structure of behavior in their experiment by labeling the behavior of the animal, e.g. walking, grooming, or following, in a small set of video frames. Our system uses machine learning techniques to convert these manual labels into behavior detectors that can then be used to automatically classify the behaviors of the animals in a large data set with high throughput. We combine an intuitive graphical user interface, a fast and powerful machine learning algorithm, and visualizations of the classifier into an interactive, usable system for creating automatic behavior detectors.

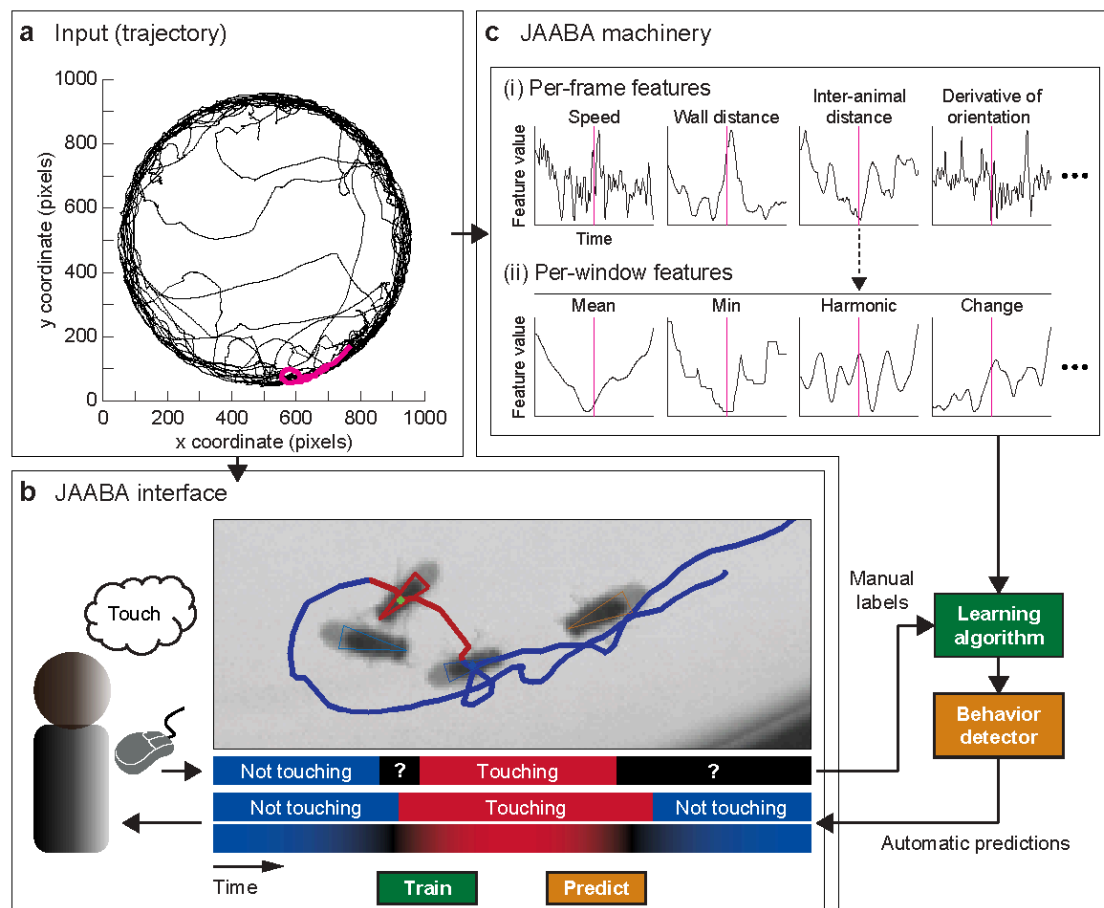


Figure 1. JAABA overview. (a) Input trajectory (x,y position over 1000s). (b) JAABA interface. The top time line shows the user's manual labels, and the bottom two time lines show the classifier's predictions and confidence. (c) JAABA machinery. (i) Example “per-frame” feature time series. (ii) Example “window” feature time series.

JAABA operates on the animals' trajectories computed from automatic tracking methods (Figure 1a). From these, we compute simple “per-frame” features such as instantaneous speed or distance to the closest animal (Figure 1c(i)). Next, we compute “window features” that describe the distribution of per-frame features around the current frame (Figure 1c(ii)). We compute the mean, standard deviation, minimum, etc. for multiple window sizes and temporal offsets. All window features can be computed efficiently using convolution or image morphology. We compute between 5,000 and 10,000 window features to represent each frame for each animal. We use an instantiation of Boosting (GentleBoost), modified for speed, to train classifiers. Training takes 15-45 seconds, depending on the data set.

We demonstrate that our system can be used by scientists without expertise in machine learning to independently train accurate behavior detectors. We show that it is sufficiently powerful and general-purpose to train a large, diverse set of single-animal and social behavior classifiers for flies (15 behaviors), mice (2 behaviors), and *Drosophila* larvae (3 behaviors), achieving an average per-frame error rate of 2.7% and a maximum error rate of 6% over all behaviors, compared to human annotations. We show that JAABA is usable by non-computer scientists: we gave 12 volunteers a 15-minute presentation on how to install and use JAABA, then asked them to each train a “chase” classifier for flies. The error rates achieved were 2% on average and 5% maximum over users. Finally, we show that JAABA can be used to create behavior classifiers robust enough to successfully be applied to a large, phenotypically diverse data set consisting of thousands of transgenic lines of *Drosophila melanogaster* collected in our thermogenetic screen of the Janelia GAL4 collection. Statistics of the automatic behavior classifications such as the fraction of time spent performing a given behavior are powerful descriptions, and we show that these statistics can be used to map neuronal anatomy to behavior in this neural activation screen.

Our system is complementary to video-based tracking methods, and we envision that it will facilitate extraction of detailed, scientifically meaningful measurements of the behavioral effects in large experiments.

Reference

- [1] Kabra, M., Robie, A.A., Rivera-Alba, M., Branson, S., Branson, K. (2013). JAABA: Interactive machine learning for automatic annotation of animal behavior. *Nature Methods*, **10**, 64-67.