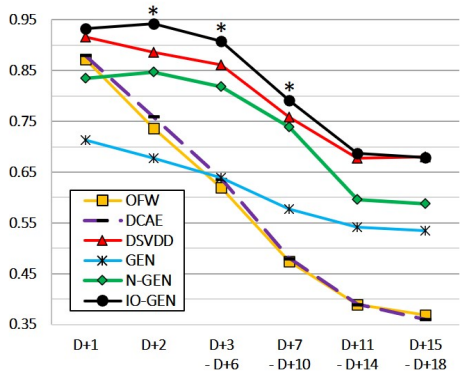

Figure 5: Average AUC changes for predictions within different temporal windows. Asterisks (*) mark statistically significant improvement over DSVDD ($p < .05$).

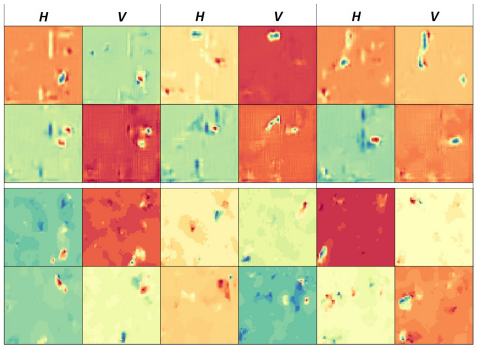

Figure 6: Optical flow examples: (top two rows) Six synthesized pairs from IO-GEN; (bottom two rows) Six real examples. Each (H-V) pair show horizontal and vertical motions, respectively, for which pixels are normalized in each image.

highly ambiguous time period between D+2 and D+10, in which the proportion of stable observations dramatically increased. As expected from Fig. 4, OFW and DCAE highly depend on the timing of application because their scores are close to that of DSVDD early while lower even than 0.5 after D+6. If the initial social transition is less conspicuous, possibly due to a smaller population, these models may perform poorly because of less intense competition caused. Moreover, the results from GEN and N-GEN reemphasize the insufficiency of solely relying on realism or spatial characteristics of produced features when training generative models. In particular, as illustrated in Fig. 2, GEN produces fake samples that closely resemble the ones of stable state, and so the biased classifier leads to the worst performance in the early stages (∼D+2) when colonial instability was highest.

Model Properties

Figure 6 compares synthetic optical flows from IO-GEN to real optical flows; the generated optical flows are visually similar to real flows. Furthermore, Fig. 7a illustrates that the lowest distance distribution to $\vec{c}$ is measured with IO-GEN, as designed, whereas GEN behaves similarly to the stable

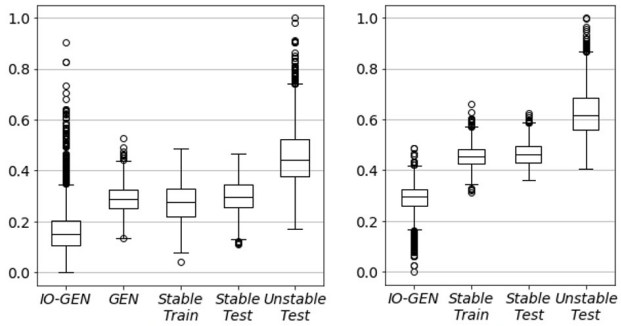

Figure 7: For different types of data: On left, normalized Euclidean distances to $\vec{c}$ in feature description $\mathscr{F}$ of DSVDD. On right, predicted likelihoods from Classifier.

dataset. Figure 7b finally shows the predictive outcomes of Classifier, which are likelihoods of unstable state. With the *label switch*, the confidence becomes positively correlated with the distance to $\vec{c}$ viewing inner outliers as samples from the most stable colony. Clear differences between classes imply that learned knowledge to discriminate stable and more-stable states in DSVDD can be transferred for classification of another pair as stable or unstable.

Conclusion

We have introduced a novel generative model IO-GEN that can utilize a pre-trained DSVDD and a separate classifier to successfully solve the OC problem. Our framework has been applied to 20-day video data from an entire society of 59 *H. saltator* ants to identify a colony's stable or unstable state only from a 1-second motional sequence. Experiments have shown that the classifier trained with the synthetic data from IO-GEN outperforms other state-of-the-art baselines at any temporal phase during social stabilization. Our future directions include a graphical user interface for this method that acts as a tool for biologists that can propose frames or individuals (regions of interest) implicated as being crucial in the evolution of social state. To implement this, an additional module can be built to monitor and visualize the levels of gradient passing from spatio-temporal behavioral features to the final decision output (**?**).

Acknowledgments

Support provided by NSF PHY-1505048 and SES-1735579. Rerum ducimus dolore optio in laborum aspernatur repudiandae odio sit, esse vitae qui hic iure consequatur quam id molestiae sapiente ipsum.Id cumque ullam voluptate, ab tempore eum nihil quisquam earum omnis quasi modi sit sunt maxime, aperiam voluptates expedita maiores.Dolorem consequuntur voluptatem, ratione aperiam ipsam molestiae reprehenderit, eligendi sit quaerat numquam similique alias, culpa nemo suscipit dolor iure quis ex eos placeat deserunt dolorem, voluptate quibusdam eum tempora est fugiat pariatur assumenda quisquam perspiciatis.Minus nam suscipit doloremque repellendus, doloribus sequi autem eveniet, expedita praesentium porro pariatur quod corporis

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