Abstract Submitted
for the MAR17 Meeting of
The American Physical Society

The Density Functional Theory of Flies: Predicting distributions of interacting active organisms[1] YUNUS KINKHABWALA, Cornell University, JUAN VALDERRAMA, Universidad de los Andes, ITAI COHEN, TOMAS ARIAS, Cornell University — On October 2nd, 2016, 52 people were crushed in a stampede when a crowd panicked at a religious gathering in Ethiopia. The ability to predict the state of a crowd and whether it is susceptible to such transitions could help prevent such catastrophes. While current techniques such as agent based models can predict transitions in emergent behaviors of crowds, the assumptions used to describe the agents are often ad hoc and the simulations are computationally expensive making their application to real-time crowd prediction challenging. Here, we pursue an orthogonal approach and ask whether a reduced set of variables, such as the local densities, are sufficient to describe the state of a crowd. Inspired by the theoretical framework of Density Functional Theory, we have developed a system that uses only measurements of local densities to extract two independent crowd behavior functions: (1) preferences for locations and (2) interactions between individuals. With these two functions, we have accurately predicted how a model system of walking *Drosophila melanogaster* distributes itself in an arbitrary 2D environment. In addition, this density-based approach measures properties of the crowd from only observations of the crowd itself without any knowledge of the detailed interactions and thus it can make predictions about the resulting distributions of these flies in arbitrary environments, in real-time.

[1]This research was supported in part by ARO W911NF-16-1-0433

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Date submitted: 11 Nov 2016 Electronic form version 1.4