Probabilistic Analysis of Pedestrian Dynamics

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Introduction

In the study of jamming phenomena, one specific subject of interest is the application of traffic patterns to pedestrians. Pedestrians complicate common jamming setups, since simple physical forces are not enough to capture the entirety of the scene. We must also include psychological forces such as follow factors and collision avoidance routines.

Using Easy Java Simulations, we created a bi-dispersed flow using two groups of pedestrians, with the groups starting at opposite ends of the corridor. In the middle of the corridor, there is a narrow opening, allowing particles to get through, and particles are reinitialized to their respective origin if they make it to the other end. To extract new data and further analyze the simulation to generate new results, we created an analysis routine to run over the simulations.

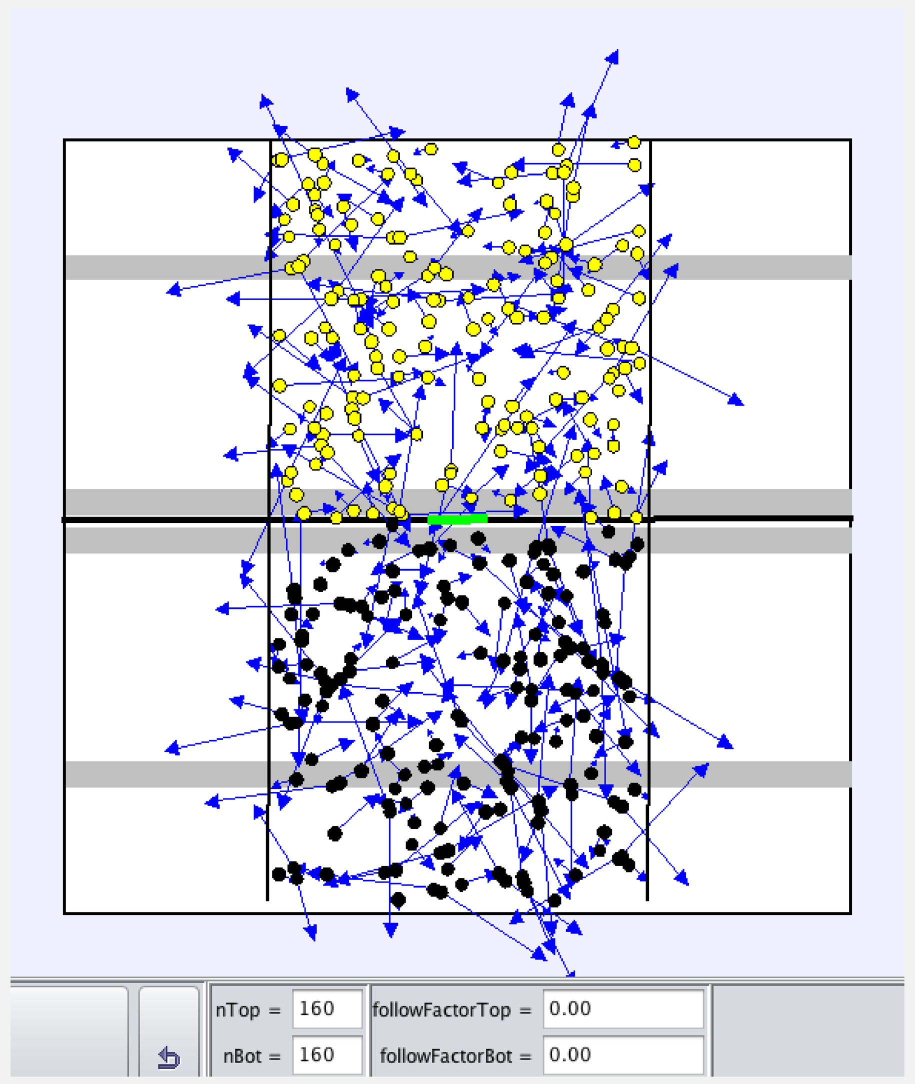

Figure: Sample simulation of pedestrians

Steady State Time and PDFs

Before we could perform any analysis, we needed to find the starting time at which the statistical anomalies are significantly reduced. We decided to use mean values for the entropy and current over a fixed size of time to figure out the stable starting time. The routine then produces some plotted outputs, such as the number of particles transited against time, entropy as a histogram, and current plotted against time.

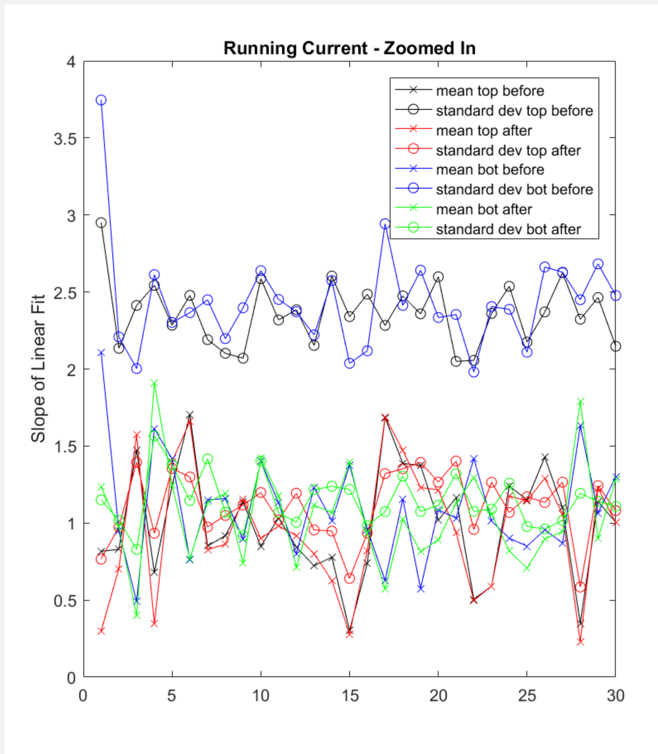

Figure: Plot of entropy for time intervals

The analysis routine also generated probability distribution functions for the cluster sizes. We defined a cluster to be the number of particles that successively crossed an opening. To find the true lag, during which no particles cross, we used polynomial fits for various lag sizes.

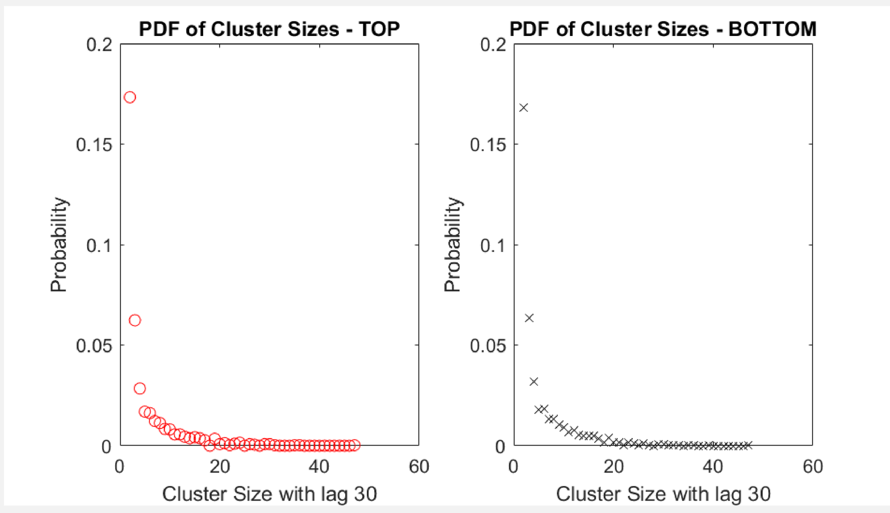

Figure: Probability distribution functions

cCDFs and Power-Law Fits

The analysis routine also produces a complimentary cumulative distribution function to give the probability that a lag will be a certain duration.

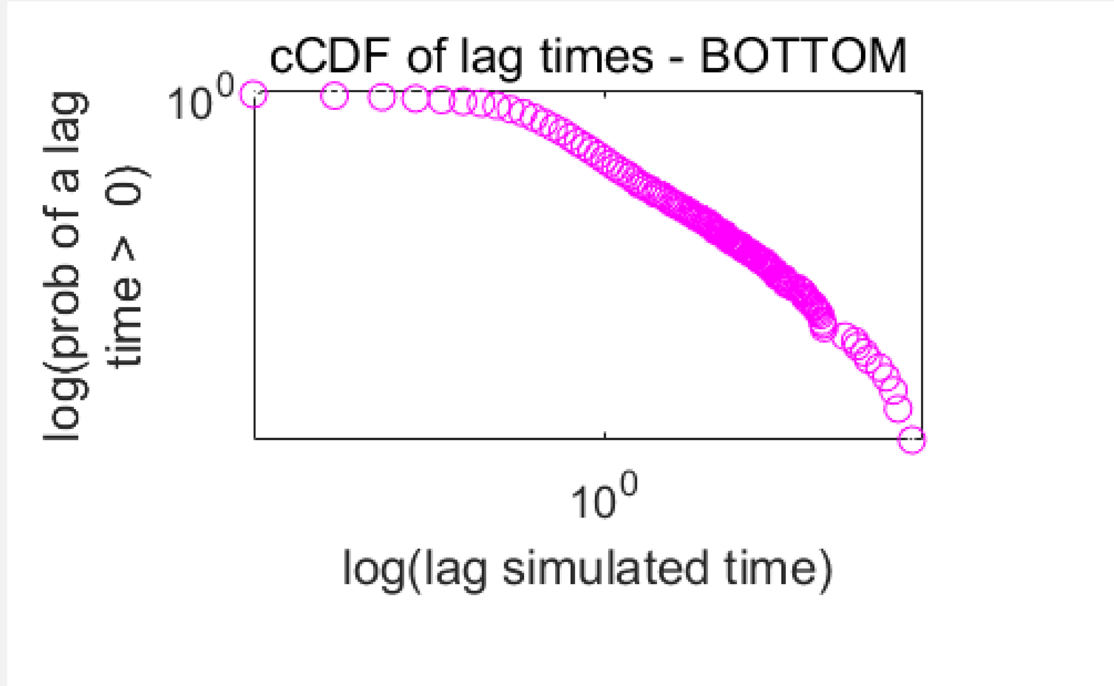

Figure: Cumulative distribution function

Furthermore, a fit can be performed for this CCDF since it is a power-law distribution. Through a method proposed by Clauset et al., the routine can first determine if the empirical data set presented indeed follows a power law distribution, and if it does fit the criteria, then we can perform a fit for the distribution past some x_{min}, so that the linear fit for the log log plot is applicable. An empirical distribution obeys a power-law if

$$p(x) \propto x^{-\alpha}$$

We can estimate the scaling parameter with

$$\hat{\alpha} = 1 + n\left[\sum_{i=1}^{n} \ln \frac{x_i}{x_{min}}\right]^{-1}$$

and since we only want to the linear part, we want to estimate x_{min} that minimizes the value of D, where

$$D = \max_{x \geq x_{min}} |S(x) - P(x)|$$

Conclusion

Through this new analysis routine, we have a created a streamlined process for analyzing the simulations, and made results easier to produce. Instant results can now be produced for variances in simulation paramaters such as door width and follow factor. Future work for this project will include adaptation to support mono-disperse flow, so that one group can be simulated and a richer implementation of the power-law fitting algorithm.

Acknowledgments

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References

[1] Clauset, Aaron, Cosma Rohilla Shalizi, and Mark EJ Newman, *Power-law distributions in empirical data*, SIAM review 51.4 (2009), 661-703

[2] Kretz, Tobias, et al, *Experimental study of pedestrian counterflow in a corridor*, Journal of Statistical Mechanics: Theory and Experiment 2006.10 (2006), P10001