Often, thinking about crowd models starts with very simple force-based modeling. Forces due to attractors (e.g., the current goal) and constraints (e.g., avoid collisions) are accumulated and each agent’s movements respond to those forces.

To get started thinking about this kind of model, take a look at Craig Reynolds’ boids page: [http://www.red3d.com/cwr/boats/](http://www.red3d.com/cwr/boats/)

Here is an example of a paper that builds on these ideas:


Another early influential point of view was to treat crowds as a continuum, similar to a fluid simulation:


Neither of these models capture the detailed structure of individual behavior in crowds. We spoke about a collection of research based on tracking individuals and developing behavior models informed by data. The following website is a good reference (scroll down to see multiple projects): [http://gamma.cs.unc.edu/REACH/CrowdT/](http://gamma.cs.unc.edu/REACH/CrowdT/)

Here is a representative paper:


Karamouzas, Ioannis, and Mark Overmars. "**Simulating and evaluating the local behavior of small pedestrian groups.**" Visualization and Computer Graphics, IEEE Transactions on 18, no. 3 (2012): 394-406. [https://sites.google.com/site/ikaramouzas/groups](https://sites.google.com/site/ikaramouzas/groups)

The following paper offers a survey on this topic:


We looked at the PowerLaw algorithm, which suggests based on a large quantity of observed data that people act based on the estimated time to collision.


Simulation with the power law was made more stable with implicit integration in this paper:

The following paper begins to get at a concept of how we evaluate and compare crowd simulation algorithms quantitatively.


These authors have also published a short and readable guide to anticipatory collision avoidance with games in mind:


This perception paper discusses how shoulder motion adds to our perception of realism in crowd scenes:

A recent position based dynamics approach includes a frictional contact model, long range collision model, and viscosity for cohesion:


There are a number of models of character personality and emotion that we did not get a chance to cover. The OCEAN, PEN, and OCC models are examples. Here is one example paper that focuses on how individual emotion and the spreading of individual emotions affects group dynamics:

Another important issue is how the crowd behavior is scripted or designed. This recent paper presents an interesting and fine-grained approach:


You can find a recent review paper on crowds here: