

The neighborhood of interaction in human crowds is explained by visual information

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Most models of collective motion are based on the physical positions and velocities of others in a neighborhood of interaction. For example, in our physical model (*PRSB* 2018, *CDPS* 2018) a pedestrian matches the average heading direction and speed of neighbors, weighted by their distance: weights decay gradually to the nearest neighbor, and more rapidly in the crowd. Recently we developed a visual model, in which a pedestrian's heading and speed are controlled by nulling the average angular velocity and optical expansion of neighbors, as sinusoidal functions of eccentricity (*VSS* 2017, 2019). In addition, neighbor influence is proportionally reduced by partial occlusion (*ICPA* 2019). Here we use these models to simulate data from three experiments, with no free parameters. Exp. 1: Participants "walked with" a virtual crowd of 12 neighbors. A subset of neighbors (0, 3, 6, 9, or 12) changed direction ($\pm 10^\circ$) or speed ($\pm 0.3\text{m/s}$) on each trial, and the participant's walking speed and heading were recorded. The RMSE of heading was 1.97° for the visual and 2.08° for the physical model ($\text{BF}_{\text{VB}}=1.90$, anecdotal evidence for visual). The RMSE of speed was 0.063m/s and 0.064m/s , respectively ($\text{BF}_{\text{VB}}=2.43$, anecdotal for visual). Exp. 2: The distance of the virtual crowd was varied (2, 4, or 6m), and one row (near, middle or far) changed direction ($\pm 10^\circ$). The RMSE of heading was 2.5° and 3.6° , respectively ($\text{BF}_{\text{VB}} \gg 100$, decisive for visual). Exp. 3: A human 'swarm' ($N=10, 16, 20$) walked together for 2min trials. Thirty 10s segments were simulated, modeling one participant with input from neighbors. The RMSE of heading was 15° and 29° , respectively ($\text{BF}_{\text{VB}}=6$, substantial for visual). Remarkably, the gradual decay with distance is due to Euclid's law, while the rapid decay is an additional effect of occlusion. The neighborhood of interaction is thus explained by visual information, eliminating explicit distance terms.

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