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Structural Analysis and Topological Manipulation of Visual Influence Networks in Walking Crowds

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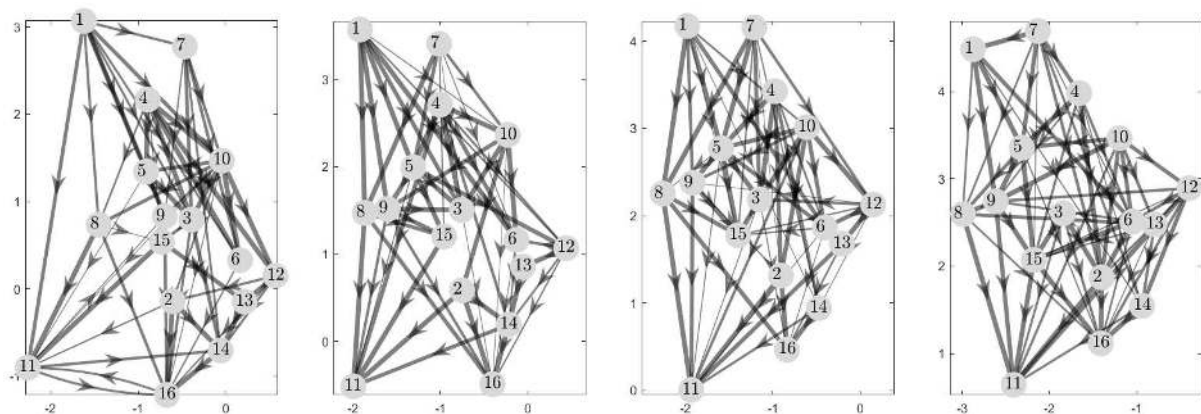


Figure 1: Example snapshots of visual influence networks (N=16). Node positions represent the positions of pedestrians in the crowd (the group mean heading as a vertical axis), and the edge directions and widths represent the leader-to-follower influence and strength, respectively.

Collective motion in human crowds is generated by local visual interactions between neighboring pedestrians. In this self-organizing phenomenon, it has been shown that some individuals play the role of “leaders” who strongly influence the crowd, and scenarios such as emergency evacuation can benefit from strong leadership. However, the underlying mechanism of how one influences others and gains leadership in moving crowds remains to be uncovered.

One way to approach this problem is to reconstruct interaction networks of moving crowds. We employ a spatially-embedded dynamic network representation of interpersonal influence constrained by visual sensory information. We analyzed 15 min of motion-capture data from a human “swarm” experiment (N=10,16,20) in which participants were instructed to walk about the tracking area while staying together as a group. We reconstructed the network every second using Time-Dependent Delayed Correlation (TDDC) (e.g., Fig. 1). Measures of net leadership and accumulated influence (Yoshida & Warren, 2022) produced consistent leadership gradient pattern from the front to the back. We find that leadership strongly depends on spatial position and weakly on personal qualities, with some individuals exhibiting stronger/weaker influence.

Additionally, we introduce an experimental paradigm to alter the network topology in real crowds and study the effects of the manipulation on the macroscopic crowd movements. In this experiment, confederate “leaders” are given instructions about turning direction and timing, and their presence is either unknown or known to the crowd. We investigate whether and how information about heading change initiated by the confederates propagates through a walking crowd, and we assess how uninformed pedestrians adjust their movement. Understanding the network structure and dynamics may help quantitatively explain leader influence.

Bibliography

[1] Yoshida, K., & Warren, W. H. (2022). Visual Interaction Networks and Leadership in Walking Crowds. *Journal of Vision*, 22(14), 3628-3628. <https://doi.org/10.1167/jov.22.14.3628>