Title
Group Path Formation

Journal
Proceedings of the Annual Meeting of the Cognitive Science Society, 26(26)

ISSN
1069-7977

Authors
Goldstone, Robert L.
Jones, Andy
Roberts, Michael E.

Publication Date
2004

Peer reviewed

Group Path Formation

Robert L. Goldstone (rgoldsto@indiana.edu)
Andy Jones
Michael E. Roberts
Cognitive Science Program, Indiana University
Bloomington, IN. 47405

Communal Path Construction

When people make choices within a group, they are frequently influenced by the choices made by others. One reason for this is that the actions of other people changes the environment in which a person makes their choices. In many domains, initial pioneers reduce the costs for followers who subsequently pursue the same path.

Our concrete instantiation of this situation is group path formation where people travel between destinations with the travel cost for moving onto a location inversely related to the frequency with which the location has been visited by others. In this situation, people may detour from straight paths connecting destinations to take advantage of frequently visited, hence inexpensive, paths. At a group level, the mathematics of "Minimal Steiner Trees" describes optimal path systems for connecting a set of destinations. A Minimal Steiner Tree (MST) is the set of paths that fully connects a set of destinations using the minimal amount of total path length. Finding minimal MSTs is a notorious NP-complete problem, with all known, provably optimal algorithms requiring an exponential increase in computation as the number of destination points increases linearly (Garey, Graham, & Johnson, 1977). However, analog devices such as soap films over wire frames have been shown to spontaneously create MSTs. Do groups of people create path systems that approximate MSTs as well?

Path Formation Experiment

59 Indiana University undergraduates were divided into 8 groups. The participants in each group were given the task of traveling between randomly sampled cities from a set of 3-4 cities. Participants were told to try to maximize their total number of points. Points were earned by successfully reaching destination cities, and were deducted for travel costs associated with each visited square on the map. The travel cost for a square was inversely related to the number of times all individuals previously visited the square, with recent visits reducing travel costs more than older visits.

As participants moved between cities, they saw their own locations as red triangles, other participants' locations as yellow circles, and the moment-by-moment cost of each map square color-coded with brightness representing ease of travel. Cities were arranged in triangular or rectangular configurations.

Results and Modeling

There were systematic deviations from beeline pathways in the direction of MSTs for all of the configurations of cities, however the participants' paths never converged upon MSTs. Greater deviations of beeline paths (see the solid lines in Fig. 1) toward MSTs (dashed lines) were found for the isosceles than the equilateral triangle arrangement of cities. In Fig. 1, the more often a square is visited, the brighter it appears. Furthermore, greater pro-MST deviations were found for a small rectangle than a large rectangle possessing the same proportions. Finally, asymmetric pro-MST deviations were observed, with greater deviations for participants traveling from City A to City B than traveling from City B to City A.

All three of these deviations from beeline pathways can be explained by Helbing, Keltsch, and Molnár's (1997) "Active Walker" model of pedestrian motion. This agent-based model includes equations for environmental changes produced by walking on paths that make the paths more accessible for subsequent walkers. At every time step, each walker in a group moves in a direction that compromises between moving toward the destination and moving toward heavily trafficked locations. This model and our experimental groups both establish path systems that lie between beeline and MSTs, with the deviation from beeline paths influenced by the topology of the destinations, the duration of travel, and the absolute scale of the world.

Acknowledgments

This research was funded by NIH grant MH56871 and NSF grant 0125287.

References

Garey, M. R., Graham, R. L, & Johnson, D. S. (1977). The complexity of computing Steiner Minimal Trees. *SIAM Journal on Applied Mathematics*, *32*, 835-859.

Helbing, D., Keltsch, J., & Molnár, P. (1997). Modeling the evolution of human trail systems. *Nature*, *388,* 47-50.

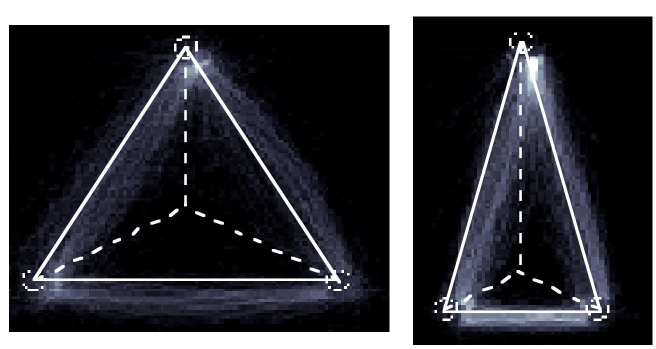

Figure 1: Group pathways for equilateral and isosceles triangles