Sports, Time Geography, and Mobility Data

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Abstract

This research investigates the usefulness of concepts from time geography for studying in-game movements of athletes. Mobility data, collected using sport-specific GPS devices is used to highlight this approach. A simple training-ground drill is conducted on members of the University of Victoria Ultimate Frisbee Club (*UVictim*) to investigate differences in players' ability to cover space. Results are discussed with respect to defensive tactics in team sports. Future directions for mobility data applications in sports are presented.

Background and Relevance

Hagerstrand's (1970) time geography develops conceptual limits on spatial bounds of objects moving in a space-time continuum. Time geography uses volumes, such as the space-time cone and space-time prism (Miller 2005), to delineate these limits. The reach of time geography volumes into space is controlled by an object's movement capability, for example it's maximum velocity. In general, time geography has been applied to problems concerned with broad spatial and temporal extents (e.g., the daily activities of humans, Kwan 1998), but also in the context of agent-based systems (Boman & Holm 2005).

Time geography presents a unique angle for investigating player movement in team sports (Moore et al. 2003), relating to a player's ability to cover space. Traditionally, time geography volumes are symmetrical, however with fine-grained athletic movement, an athlete's current direction of motion will influence the shape of these volumes. Consider in football, when attempting a pass the quarterback subconsciously performs intersections of the space-time cones of the receivers and defenders on the field. A defender that moves in the wrong direction, or shifts their momentum, becomes out-of-position, opening up an opportunity for the offensive team.

New developments in GPS and video-analysis now facilitate generation of extremely detailed records of athlete movement (Randers et al. 2010). The study of player movement in team sports represents an ideal arena for investigating novel methods in mobility data analysis because of explicit spatial and temporal bounds placed on movement (Moore et al. 2001) and the fine temporal scale of processes. Moreover, given the competitive nature of sports, analysis methods that can be related to in-game tactics have increased value. Here, I present necessary modifications to Hagerstrand's time geography for use with fine-grain movement, such as that performed by an athlete in a team sport. Specifically, I calculate space-time *isochrones* (O'Sullivan et al. 2000) for athletes, that incorporate player momentum. Space-time isochrones can be used to delineate

the area that a player is able cover. The size and shape of athlete isochones depends not only on physical abilities, but on their current direction of movement.

Methods and Data

Impacts of object momentum on time geography volumes, specifically space-time isochrones, are demonstrated using a micro-study on the types of movements common in thrower-receiver sports (e.g., football and ultimate Frisbee). Athletes participating in this study are drawn from the 2010-2011 University of Victoria Ultimate Frisbee Club (*UVictim*). Athletes will first be measured for physical attributes (i.e., height, weight, resting heart rate), and a timed 40-yard dash trial to derive a relative measure of speed. Athletes will be affixed with a 5 Hz sport specific GPS device (GPSports – Fyshwick, Australia, http://www.gpsports.com). The athletes will navigate an agility drill, specifically designed for deriving estimates of the space-time isochrones for each athlete. The GPS mobility data for each athlete will than be analyzed in a geographic information system (GIS) to investigate the geometric properties (e.g., size, shape, symmetry) of each individual isochrone.

Results and Conclusions

Results are discussed in relation to the concept of defensive coverage in team sports. Players with larger isochone areas at given intervals (e.g., 2 sec.) are therefore capable of covering more space. As well, the positional and mental aspects of defensive coverage (such as not responding to fake movements) will be discussed. Results will be related to tactical options available to coaches, and how such analysis could improve team management. Further discussion will identify future opportunities for mobility data and sports analysis.

References

Boman, M., and E. Holm. 2005. Multi-agent systems, time geography, and microsimulations. Pages 95-118 in M.-O. Olsson, and G. Sjostedt, editors. Systems Approaches and Their Application: Examples from Sweden. Kluwer Academic Publishers, New York.

Hagerstrand, T. 1970. What about people in regional science? Papers of the Regional Science Association **24**:7-21.

Kwan, M. P. 1998. Space-time and integral measures of individual accessibility: A comparative analysis using a point-based framework. Geographical Analysis **30**:191-216.

Miller, H. J. 2005. A measurement theory for time geography. Geographical Analysis **37**:17-45.

Moore, A. B., P. Whigham, C. Aldridge, A. Holt, and K. Hodge. 2001. Rugby: (a) union of space and time. Pages 12. SIRC 2001 - The 13th Annual Colloquim of the Spatial Information Research Centre, University of Otago, Dunedin, New Zealand.

Moore, A. B., P. Whigham, A. Holt, C. Aldridge, and K. Hodge. 2003. Sport and time geography: A good match? SIRC 2003 - The 15th Annual Colloquim of the Spatial Information Research Centre, University of Otago, Dunedin, New Zealand. 7p.

O'Sullivan, D., A. Morrison, and J. Shearer. 2000. Using desktop GIS for the investigation of accessibility by public transport: an isochrone approach. International Journal of Geographical Information Science **14**:85-104.

Randers, M. B., I. Mujika, A. Hewitt, J. Santisteban, R. Bischoff, R. Solano, Z. A., E. Peltola, P. Krustrup, and M. Mohr. 2010. Application of four different football match analysis systems: A comparative study. Journal of Sports Sciences **28**:171-182.