Sport and Time Geography: A good match?

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Presented at SIRC 2003 – The 15th Annual Colloquium of the Spatial Information Research Centre
University of Otago, Dunedin, New Zealand
December 1st & 2nd 2003

ABSTRACT

This paper proposes using the rich visual "language" of Hägerstrand's time geography to represent time-space relationships in sport, in particular within the spatial and temporal constraints of a game of rugby. Despite being applied outside of its traditional social context, it is argued that time geography's ability to model movements and relationships at the individual level makes it (and its modelling constructs such as prisms and lifelines) a powerful visualisation tool able to provide valuable insights into goal-oriented team sport. The visual tools of time geography are shown in the context of a video information system, SCRUM (Spatio-Chronological Rugby Union Model).

***Keywords and phrases*:** Spatiotemporal, visualisation, time geography, rugby union, video information system

1.0 INTRODUCTION

There are many spatial phenomena that operate in a limited space, for example the players in the context of team games. In this case the temporal dimension is essential to understanding and visualising spatial patterns (as is generally the case with small-scale events – Batty et al, 2003), as such patterns are subject to constant change.

It is for this scale of the individual that Torsten Hägerstrand's time geography was devised over 30 years ago. The intention of time geography was to reveal and analyse the complex time-space movements and interactions of individuals in a social context (Hägerstrand, 1970). In this paper it is proposed that time geography has the potential to provide valuable insights for competitive team sport, specifically rugby. The application of geography to sport is comparatively recent (Gatrell and Gould, 1979; Wagner, 1981); more recent still is the application of GIS-based spatial and temporal modelling to sport (Whigham, 2000; Moore *et al*, 2001; Pingali *et al* 2002). A video information system called SCRUM (Spatio-Chronological Rugby Union Model) was built as an attempt to provide spatiotemporal analysis and visualisation to sport (Moore *et al*, 2001).

The next section will outline a background of the application of geography to sport, an account of time geography principles, followed by an attempt to translate time geography into a sporting context. The use of video as a data source for sports visualisation and analysis, and video information systems will be briefly outlined in Section 3. Also in this section, the SCRUM video information system will be introduced and time geography elements illustrated in that software environment.

2.0 SPORT, GEOGRAPHY, TIME GEOGRAPHY (AND SPORT)

2.1. Geography in sport

This research is an example of what Gatrell and Gould (1979) term a micro-geography. Their application of multidimensional scaling and notions of pressure systems in the field of play (football and basketball were the two sports exemplified) represents the first treatment of sport in a geographic context. Bale (2000) has defined sports geography through description of some of the spatial attributes and phenomena associated with sport. This research is less a study of sports *places* (and the associated wider geographic connotations), more the representation and analysis of *space* in the context of a game. Team games such as rugby and football are highly constrained spatially, with a precise spatial structure within and rigid, precise boundaries (Bale, 2000) and a constraining temporal structure (Wagner, 1981).

2.2. Time geography

Time geography is a study of humans in space-time with an associated set of visual tools for looking at geographic reality at the individual level. It was developed by Hägerstrand (1970) as a remedy for the perceived tendency to generalize social process, in particular a disregard for the physical structure of the social environment. The "physicalist" approach that time geography acknowledges recognises that at the individual level it takes a certain amount of time to get from A to B (Thrift, 1977), and that while census data, for example, record that individuals live at fixed abodes (implying that they stay at this living space all the time), the reality is that on a day-to-day basis there are many social interactions to capture at a variety of times and at a number of locations (Gatrell and Senior, 1999).

2.2.1. Time geography notation

Time geography offers a set of visual tools with rich semantics. The environment in which space-time interaction is set is a cube, with the two horizontal axes representing the two spatial dimensions of x and y, and the vertical axis representing the time dimension. Hägerstrand (1974) has termed this an 'aquarium', within which are time geography elements such as lifelines, stations, bundles, domains and prisms (Figure 1). These elements are defined in Hägerstrand (1970).

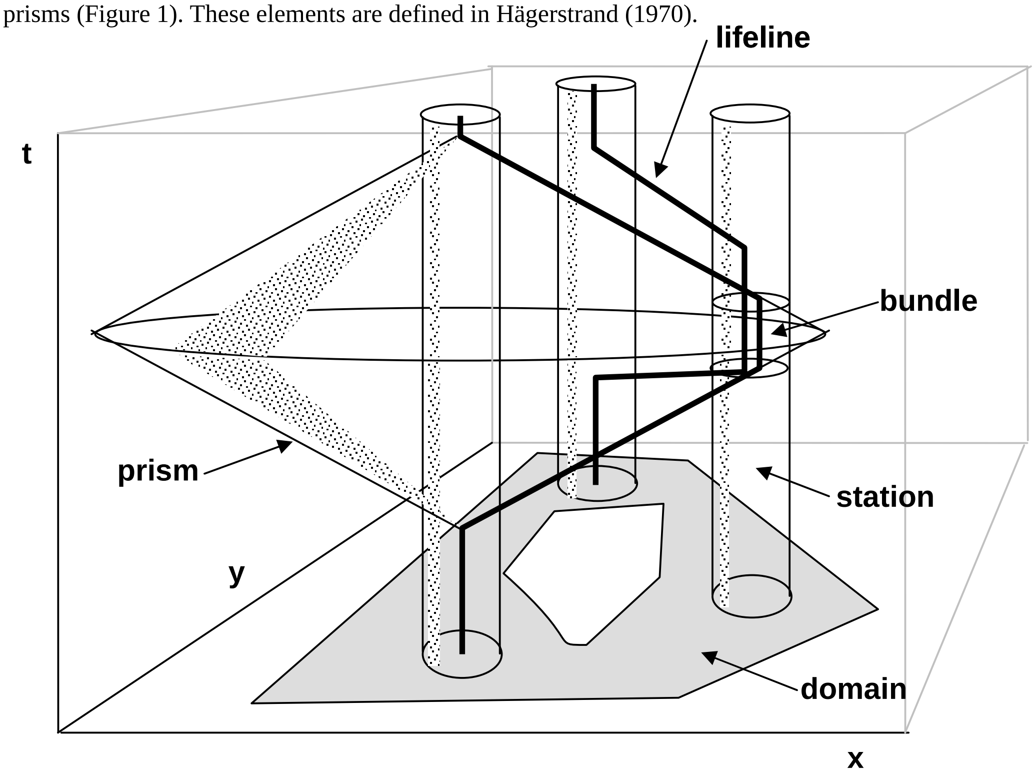

Figure 1: Some time geography elements – see text for explanation

Lifelines represent the path taken by an individual in time-space. An individual will trace a path between stations (e.g. school, work, home – can vary according to size), where they congregate with other individuals to create bundles. Movement in space-time can be constrained by the boundaries of some domain. Finally, a prism represents the total area of space reachable by an individual in the time available (can be projected backwards in time as well as forwards). The shallower the slopes of the prism, the faster the individual is capable of travelling. Together, these time geography elements form a powerful analytical tool – it is hoped that they can provide good insights in a team sport context.

2.2.2. Time geography applications

Fyfe (1992) used time geography for modelling local routine police activities, in particular representing linkages of the individual police officer to the wider community and the law in general. Other contexts of time geography use include the management of time in the work environment (of an IS development team for a large multinational company – Nandhakumar, 2002) and the modelling of the agency of grizzly bears in zoogeomorphology (Baer and Butler, 2000). Building in an awareness of the isotropic geographic environment, Miller (1991) and O'Sullivan *et al* (2000) use space-time prisms and isochrones to model transport accessibility. Forer (1998) also advocates distorting the conventionally uniform space-time prism to reflect barriers and channels in space. Finally, McBride *et al* (2002) put forward a novel treatment of lifelines, storing them using a linear referencing system, to be accessed through dynamic segmentation.

2.3. Translating time geography concepts to sport

The time geography notation maps well to objects, plays and concepts in sport (the following examples are based on rugby). The aquarium representation is apposite, since players do not deviate from the horizontal x, y plane; the pitch is assumed to be flat (this is assumed for most ball games – Wagner, 1981). This lack of movement in the vertical plane means that the z-dimension can be freed up to represent time. This will mean limiting the representation of the ball, since its height is assumed to be on the ground and constant, suppressing any high kick or even high pass information. A possible solution is to make the width of the ball's lifeline proportional to height (see later for the role of the lifeline).

Within the space-time cube, the pitch boundary will form a domain (being a manifestation of the rules of rugby), within or near which all match-related activity will take place. The domain can be limited yet further in a dynamic fashion, changing to reflect the offside zone. The individual has an obvious counterpart on the pitch as the player. This player will have a lifeline for the time that he or she is on the pitch. 'Stations' will have a dynamic nature on the pitch, not being fixed to a particular location. Set pieces such as scrums and line-outs will form the stations at which bundles of players will congregate. In Forer's (1998) description these equate to 'dynamic facilities', "occurrences / facilities whose members vary spatially over time", as opposed to 'discrete facilities', which are fixed.

The prism offers the greatest potential analytical capability for goal-oriented sport. The prisms formed will be very short term, as the interrupted nature of the game will mean that stations as players encounter them will never be far apart from each other (a notable exception is the breakaway try). This implies that prisms, when used in a team game situation, may need a high temporal resolution to even exist. Running at fastest speed, a player could reach any boundary of the pitch within several seconds, meaning that visualisation and analysis at this scale has to be facilitated in the system. Modifications of prisms can reflect the anisotropy of the rugby field, creating what Forer (1998) terms diffuse prisms to reflect capability constraints (players favouring going forwards rather than backwards) and barriers to movement (the opposing team).

Forer (1998) notes a number of shortcomings in time geography that have come to light since its inception. Out of these, two are of note here:

- "limited progress in making the theoretical translation from simple, convincing case studies of specific processes and small groups to general operational models"
- getting practical cost-effective working models for use in theory development / empirical investigation, due to problems of generating space-time prisms for individuals.

Although devoid of a true real world social setting, the team game scenario offers something beyond a 'case study' and the chance to create a model of a tightly-constrained, self-contained system. Furthermore, due to ready access to video and the tendency for in-depth statistical analysis at the professional level, there is no shortage of potential data from which to build the necessary space-time constructs. While this may provide little insight on social geography, the benefits for sport analysis are potentially numerous.

3.0 SPORT, VIDEO, VIDEO INFORMATION SYSTEMS (AND SCRUM)

3.1. Using video for sport visualization and analysis

Video is the most common raw data source used with software for sports analysis, for example Dennis and Carron, 1999; Chang and Lee (1997). A Video Information System, as defined by Chang and Lee (1997), "manages the video input, video processing, video query, video storage and video indexing to provide a collection of video data for easy access by a large number of users".

As an example of a video information system, Pingali *et al* (2002) have developed LucentVision, sports software able to capture video data from multiple sensors, and convert them in real time to a multimedia database, and produce output in the form of 3D virtual replays, visualization of player strategy or performance, and customized video clips of highlights.

3.1.1. The spatiotemporal elements of sport videos

A video in its original raw form contains no explicit spatiotemporal data, yet it is there to be mined (Moore *et al*, 2001). One of the earliest sports information systems that was able to process videos could also record spatiotemporal information (Franks and Nagelkerke, 1988). A system for field hockey was described, which allowed recorded footage of player behaviour and the recall of selected video instances. Input was through a keypad, with 72 spatial zones representing a scaled hockey pitch on a touch sensitive digitising tablet. There were also keys representing each of the players, set pieces and other elements of the hockey game.

Use of the software reaped benefits for both coach and player, according to subjective evaluation reports. The coach thought that the system lent structure to any subjective impressions of the game; the player reckoned that the coach's demands had become more objective and realistic since using the system.

Pingali *et al*'s LucentVision (2002) explicitly uses spatiotemporal data, in the form of motion trajectories, stored in a relational database. However, this database does not support spatiotemporal queries, so a separate spatiotemporal analysis structure was built for that purpose.

3.2. The SCRUM system

These time geography principles are being built into SCRUM (Spatio-Chronological Rugby Union Model – Moore *et al*, 2001), a video information system that facilitates the recording of spatiotemporal data from digital video. The internal elements of SCRUM are shown diagrammatically in figure 2. A screen shot is shown in figure 3.

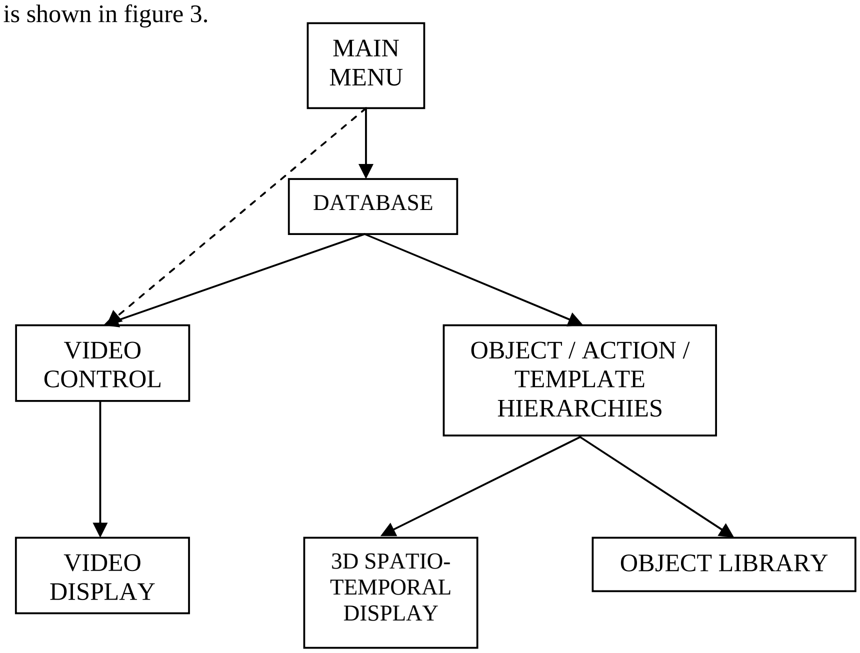

Figure 2: The components of SCRUM

The core of the system is the database, storing instantiations of the objects, actions and combinations of both (called 'events') during a game, with associated coordinates (relative to the centre of the field) and timestamps. The database also stores links to specific videos which themselves are linked to "atomic events", and associated metadata (for SCRUM, the video of a rugby match is divided into atomic events, defined as a segment of the game that is temporally bounded by when the referee blows the whistle). Finally, for semantic linkage, the database also stores object, action and template hierarchies in BLOB format. Any element of one of these hierarchies represents a discernable and discrete element in the game of rugby. These are loaded into the 'hierarchies' component when the database is opened, ready for editing.

Figure 3: A screenshot of SCRUM, showing database, hierarchies, video and 3D display (bottom left) components

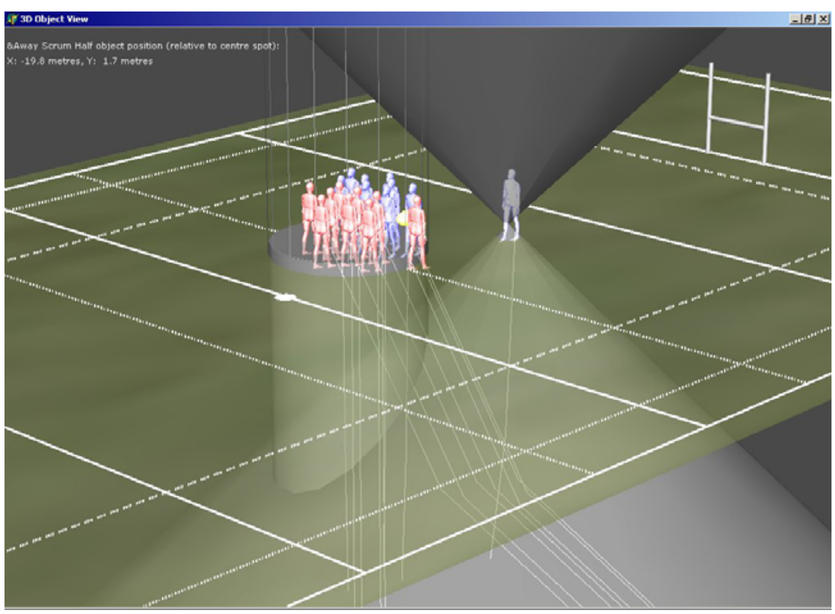

Figure 4: Time geography elements for a game of rugby. Opposing players have congregated in scrum formation, forming a bundle (solid cylinder). The potential for a station at the same location is also shown (cylindrical skeleton). Each player's lifeline is shown 'below' the pitch (i.e. in the past). Finally, the past and future prisms are shown for the opposing scrum half, indicating potential scope of movement across the pitch.

The recording mechanism for the data capture is via a 3D representation of the rugby field, with objects superimposed (these objects are capable of a subset of actions) and moved as the game unfolds on digital video (the display and control of which forms another part of the system), their spatiotemporal coordinates being stored periodically in the database. It is in this component that the visual elements associated with time geography, such as prisms and lifelines can be displayed, making for effective visualisation and facilitating analysis. Figure 4 shows what this may look like in SCRUM.

4.0 CONCLUSION

There is much to recommend the use of time geography in the context of a rugby match, providing a rich visual environment with which to explore spatiotemporal relationships, potentially providing novel insights. In addition, there is the potential to animate the space-time environment as changes. Although lacking a wider social context, contrary to what you would expect with time geography applications, professional goal-oriented team sport has several practical advantages over the real-world social environment, when regarding the potential for use of time geography elements. These are:

- a time-space that is manageable and tightly bounded in both the spatial and the temporal dimensions
- intensive data capture in the form of videos (small wearable devices could adopt the same role in the future), providing an ample resource from which to visualise and analyse relationships in space-time at the individual level.
- In a wider societal context, data from surveillance cameras found in city centres could provide a similar magnitude of resource (Hägerstrand [1970] looks forward to a time when technology provides instruments that “help…judge the impacts on social organization and thereby the impact on the ordinary day of the ordinary person”), though there are likely to be serious ethical issues involved with this.

ACKNOWLEDGEMENTS

This research is supported by a University of Otago research grant. We would like to thank Jarrod Carroll for digitising games from the 1999 Rugby World Cup and compiling the associated metadata.

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