Keep your eye on the ball: Local versus global statistics in sport visualisation

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ABSTRACT

This paper describes several simple local space-time statistical measures that can be applied to data that describes ball position over space and time. The main aim is to show that global statistics of rugby union do not describe the most important aspects of team domination, and that other measures may be more meaningful in terms of understanding the overall patterns of play. This paper introduces several measures for describing these local statistics, and shows for one example that they reflect the dominance of one team even though this is not reflected in the half-time score. The main conclusion is that the most important local statistics maintain an explicit spatial representation, and that therefore global measures of behaviour, that have removed the spatial patterns of play, are not appropriate descriptors for rugby union.

Keywords and phrases: visualisation, local statistics, ball movement, spatial patterns

1 Introduction

The use of global statistics for sport is a common method for presenting information, especially to television audiences. For example, at half time in a rugby union game the following statistics are often presented:

- time in possession: the time that each team was in possession. Note that there is some ambiguity associated with this measure, since it is not clear whether this is the time when each team had the ball in hand, or the more coarse measure of the time each team was notionally associated with possession. For example, does the time spent whilst taking a penalty goal or conversion count towards this total? Recently these measures have been extended to include time in each half of the field, and time in the attacking 22, which is an attempt to introduce some spatially localised measure of possession;
- the number of penalties received by each team;
- the number of lineouts won and lost against the throw;
- the number of rucks and mauls and their outcome; and
- a set of other measures that describe the summed account of behaviour during the game.

This paper argues that these statistics do not present the appropriate information to understand the patterns of play that are occurring due to their global assessment both in space and time. Trends towards more local statistical measures may be seen in a variety of sports: association football matches have been analysed in terms of the rate of scoring goals over the course of a match (Dixon 1998); tennis games have been augmented with trajectory information of both players and balls (Pingali, Opalach, Jean & Carlbom 2001); and models for comparing athletic performance over a range of distance competitions to determine athlete characteristics (Grubb 1998). In addition to this, there have been a number of works that discuss the virtues of analysing player movement in team sports using local techniques such as Voronoi diagrams and local statistical measures (Whigham 2000, Fujimura & Sugihara 2005). In addition, professional team sports employ staff using specialised software to digitize individual player location via video for a detailed analysis of each game. Although an automated system for this information

will no doubt eventually be produced, at present this information is too costly to collect in realtime, and therefore has not been used for live broadcasts of team sports such as rugby union.

This paper will consider the forms of visual information that may be presented given the tracking of ball position during the game. Since this can be collected in real time, via a user interface, this paper presents some of the local information that could be presented during a team sport presentation based on ball position alone. The dataset used to create these visualisations is a stream of events, E, each representing a moment in time where some change in state has occurred. Each event is of the form:

$$E(tid, status, x, y, t) \tag{1}$$

where tid indicates which team the behaviour is associated with, status indicates the event (ball in hand, kick, penalty, scrum, etc.) and (x, y, t) represents the spatio-temporal data for this event. A stream, ordered by t, defines the events that occur during the game.

The remainder of this paper is structured as follows:§2 will present the set of visualisations implemented for this study, §3 will present some example statistics for a number of games, and §4 will present some reflections on the work and conclude the paper.

2 Local Visualisations using ball position

There are many possible visualisations based on ball position and the actions that occur resulting in a stoppage of play or a change in possession. This paper will introduce some of these approaches, and mainly focus on those patterns that produce a summary of how behaviour is reflected in the space and time patterns of ball movement. The following patterns will be illustrated to show the potential of using ball position as a measure of space-time usage:

- **TimeMap**: A map showing the time in possession as a grey-scale image over the field;
- **TimeX**: A graph of time in possession aggregated across the width of the field;
- **TimeY**: A graph of time in possession aggregated across the length of the field;
- **Vector**: A graph of the start and end points of ball possession, represented as vectors;
- **FreqTime1**: A frequency distribution graph of time in possession, based on time when the ball was in play;
- **FreqTime2**: A frequency distribution graph of time in possession, between change in possession. This includes time when the play has stopped, but the game clock is still going;
- **FreqMetres**: A frequency distribution graph of metres gained (from when the ball was first in the hand) for each possession when the ball was in play. This only measures the distance that the ball was carried forward while in the hand.

The previous patterns are only a small portion of other possible measures. For example, the metres gained could include the change in field position from a kick, or the space-time distribution of each event type (scrum, lineout, etc.). Since this paper is a proof of concept it is assumed that the reader can extrapolate to other visualisations without great difficulty. The paper also aims to demonstrate that some of the local statistical measures that are presented give a more insightful interpretation of the game patterns, however this initial study will not consider a large set of different games, and therefore cannot produce statistically meaningful data as proof of the value of these visualisations. A more thorough study of patterns is intended as future work.

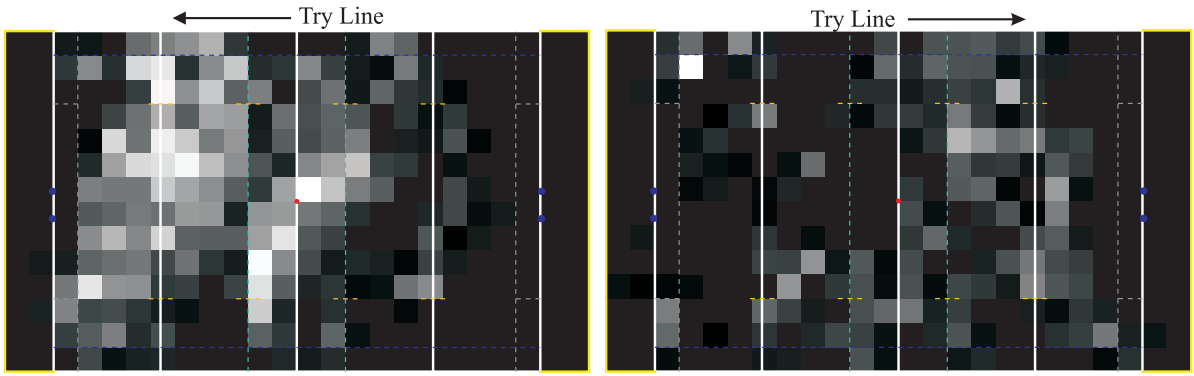
3 An Example: Auckland versus Otago NPC Final

The National Provincal Competition final was held on October 22, 2005, between Auckland and Otago. Although Auckland were the favourites, at half-time they were only leading 10 points to 8. The basic statistics presented by the media at half-time were the total time in possession for each team (which included the time the ball was not in play, but the clock was still running) and the time in each attacking half. These values showed that Auckland was dominating good field position, but the level of domination was understated due to the inclusion of time when no play was actually occurring. Consider Table 1 where the set of statistics for those moments when the ball was in play and in the hands of one of the teams are presented. This table shows that, although the score was very close, Auckland seemed to have the upper hand in field position and possession. Since the times only consider when the ball is actually in hand they more accurately reflect the true possession characteristics of the teams than times that count while the game clock is running, but the ball is dead. However, more easily interpreted statistics can be give by visualising those patterns described in §2.

Figure 2(a) shows the significant difference in possession between Auckland and Otago. Note in particular the amount of time Auckland has the ball in the attacking half compared with Otago, and their domination of the ball

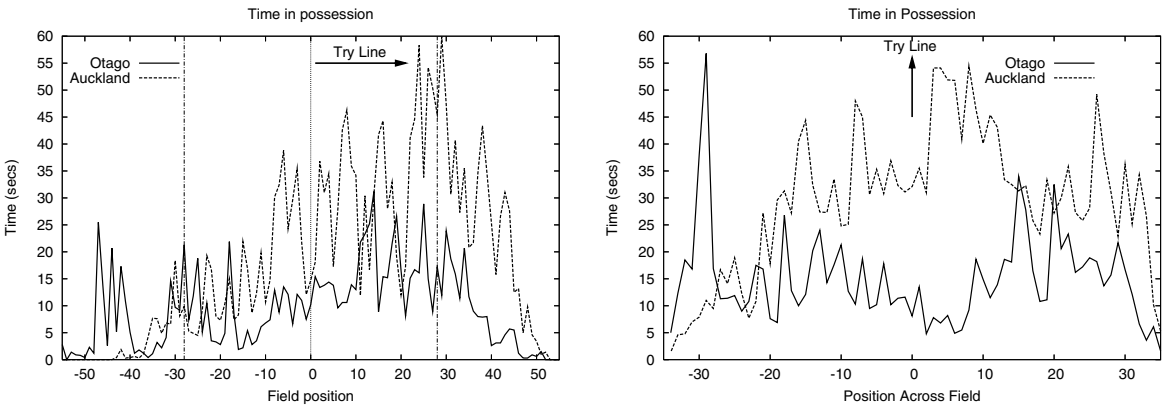
Description	Auckland	Otago
Time in possession	59%	41%
Total Time in Possession	9:37	6:29
Time in own half	2:30	3:10
Time in attacking half	7:06	3:19
Last time in attacking half	39:57	41:16
Last time in attacking 22	38:15	23:39
Time in own 22	0:16	1:30
Time in attacking 22	3:00	0:59

Table 1: Summary statistics of ball in hand possession.



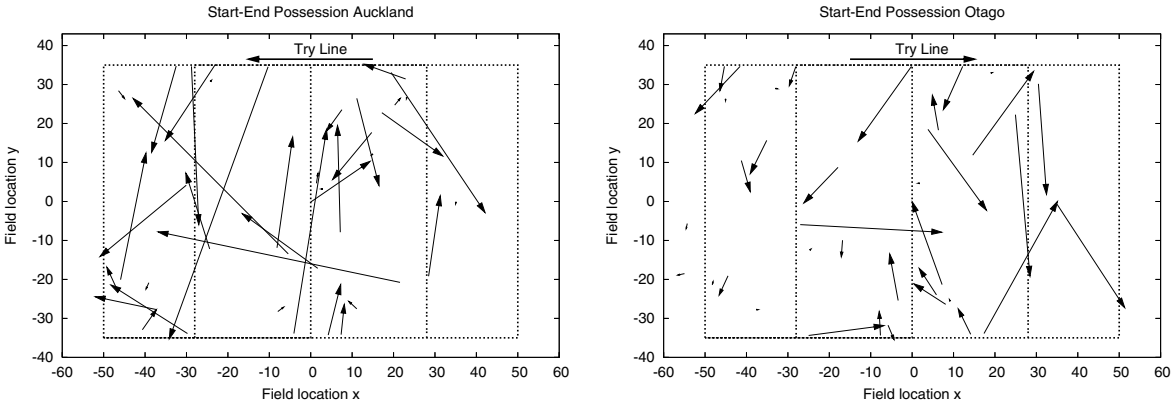
(a) Auckland (b) Otago

Figure 1: Normalised **Timemap** for the first half - most time (white) to least (black)



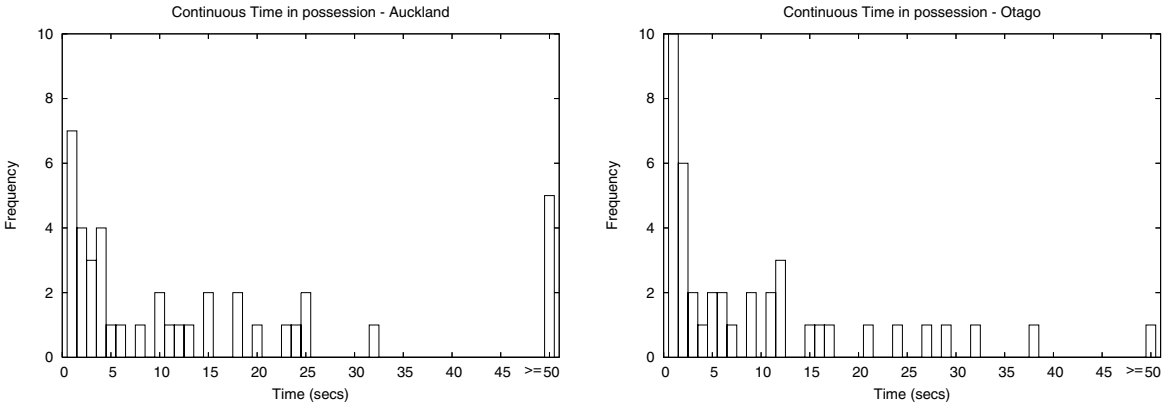
(a) **Time X** (b) **Time Y**

Figure 2: Spatially aggregated time in possession for the first half.



(a) Auckland (b) Otago

Figure 3: **Vector** movement of single possession behaviours.



(a) Auckland (b) Otago

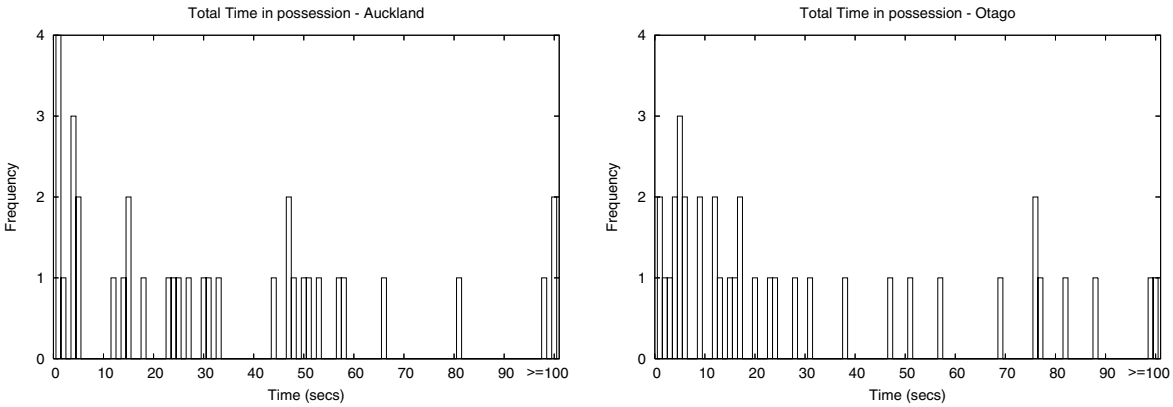
Figure 4: **FreqTime1**: Time in possession - ball in hand.

just outside their attacking 22. Otago also spends a much longer time with the ball near their own line, reflecting the fact that they spent a large amount of time defending in their own 22. Figure 2(b) also shows a characteristic of Auckland's domination of good field position. Since a team that can control the centre of the field has many more options for attacking, the greater amount of time with the ball near the centre (0) the more likely the team is to be able to create opportunities for attack. These two figures probably more than any other statistic show that Auckland has control over the game and that the score is not a true reflection of their dominance.

Figure 3 shows the difference in overall ball movement for each possession between Auckland and Otago. In particular, Figure 3(a) shows that Auckland is using the entire extent of the field, and controlling the mid-field. Note that the backward movements generally occur where they are completed by a kick, which you might generally expect to happen from near the teams own 22. However, in Figure 3(b) there are a number of backward vectors (i.e. away from their try line) in the centre of the field, showing that Otago are struggling to break the Auckland defensive line.

Figures 4-5 do not show quite the domination of behaviour reflected in the previous figures. There is a larger number of times that Auckland has held the ball continuously for approx. one minute or more, however there does not appear to be any great differences between the plots. Clearly, for this example, the removal of the spatial component has severly restricted the interpretation of behaviour.

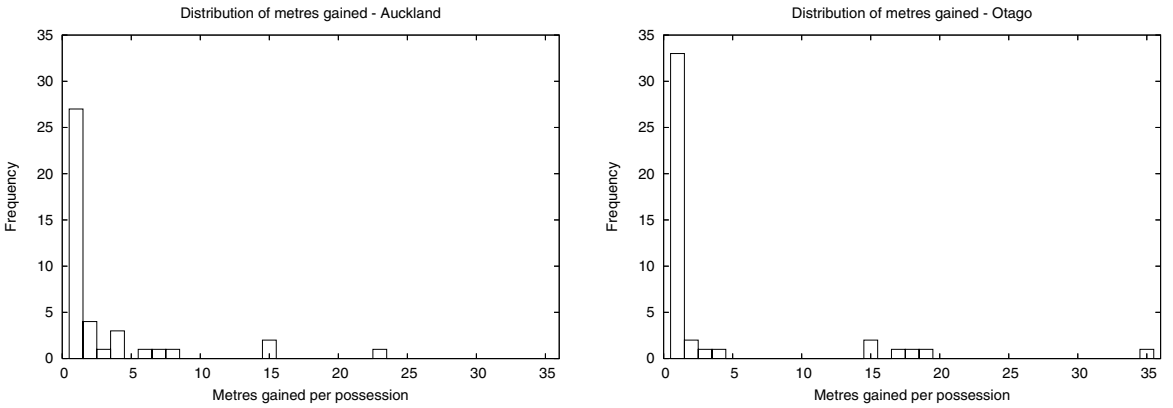
Figure 6 shows the distribution of metres gained per possession. Here once again, the aggregated measure does not help to greatly distinguish between the team behaviours. For example, the largest metres gained event occurs



(a) Auckland

(b) Otago

Figure 5: **FreqTime2**: Total Time in possession.



(a) Auckland

(b) Otago

Figure 6: **FreqMetres**: Count of metres gained while in possession of the ball.

in Figure 6(b), where Otago gained 35 metres in one possession. This once again shows that aggregating the spatial component of behaviour loses the significance of which team is dominating the overall play in the game.

4 Discussion and Conclusion

An examination of the ball patterns from §3 implies that Auckland is in a far stronger position than Otago. This was reflected in the final result of the game with Auckland winning 39 to 11. From an analysis of the half-time behaviour this does not seem surprising, but of course we have only shown one game as an example of some of the simple statistics that can be derived from ball and event tracking.

A large number of more local statistics could also be derived from the basic data. For example, a plot of penalties, scrums, lineouts, etc. over the field, or as a graph based on distance to the try line may well show some characteristics of good field position and dominance in attack. Another possible description that may be useful is to consider where kicks have occurred, and their result in terms of field position. Of course, having the position of the ball as an indicator of movement would also allow the path of the ball to be analysed, perhaps as a fractal, with one possible result being that different fractal (line) dimensions may characterise a team that is struggling against a good defense, or one where rucks and mauls are having a major impact on possession. One final approach that could be considered is to describe the behaviour of each team in terms of a set of finite states, and the movement between these states of behaviour. For example, does a try typically occur after a scrum, followed by a kick, or a penalty followed by a lineout? Of course this would require a large number of games to produce a statistically meaningful measure of these patterns, but now that a procedure has been developed to produce this data the possibilities seem endless.

This paper has demonstrated that collecting ball position over time as a set of events allows a variety of local measures in space and time to be developed. There are a number of steps that need to be taken before this work can begin to develop significant statements about ball movement and the interpretation of game behaviour:

- the data collection process must be evaluated in terms of accuracy, precision and repeatability. This will allow the tool to be used with some confidence intervals and therefore produce more valid statements from the pattern analysis;
- a large number of games need to be digitised so that generalised statements on game behaviour can be developed; and
- further space-time approaches to visualisation need to be considered to extend the simple approaches described here.

The results from this simple example have shown that the spatial component of events generally produces the most meaningful interpretation of team behaviour. This is perhaps not surprising, since in a game such as rugby union often the key to playing well is to maintain good field position. How this is best characterised and presented opens up an interesting area of research - as any coach will state, to play well the first key step is to *keep your eye on the ball*.

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