MatchVis: A generalized visual multi-scale analysis framework for competitive sports

Wentao Wang*
School of Computer Software, Tianjin University, China

Jiawan Zhang†
School of Computer Software, Tianjin University, China

Tianshi Liu
Electronic and Information Engineering, Beihang University, China

Abstract

Sports are highly competitive, fast-paced, and teamwork-based. In this article, we introduce a novel approach in analyzing competitive sports based on music metaphor. Our proposed framework *MatchVis* extracts match information from raw webcast dataset about NBA and incorporates historical models into the investigation, providing a more compact and understandable visual representation of the details and patterns of match, which can consequently aid analysts in performing specific tasks and decision-making.

Keywords: competitive team sports, multi-scale analysis, multi-dimensional scaling, visualization framework

1 Introduction

Multi-players generally participate in competitive team sports. In particular, athletes cooperate with teammates and resist opponents under constraints of rules, with the goal of attaining a higher score and beating the rival team at a rapid pace. Teamwork, confrontation, and fast-paced tempo characterize competitive team sports, which are likewise reflected in some other competitive affairs. Meanwhile, sports analysis has a broad market prospect in areas of entertainment, commerce, and scientific research.

However, performing intensive study on competitive sports is relatively difficult. The major challenges are as follows. First, sports match data are multi-dimensional and difficult to understand. Second, match evolution is time-varying, and athlete correlations are complex and various. Thirdly, comprehensive sports analysis requires multi-scale research from different angles that completely reveal match patterns. Finally, essential patterns may potentially exist behind the massive and inconspicuous historical statistical data, but effectively determining these patterns may be difficult.

Although Brian J. Reich [1] and Sho Takahashi [2] visualized the shot chart and pass region of an athlete, full-scale presentation of player multi-dimensional statistics has yet to be achieved.

2 Music Metaphor

As we all know, musical notation is a widely used system in visually representing aurally perceived music by means of written symbols. In a way, music is a visual representation of temporal information with a time-oriented feature and an adequate system of symbols(see Fig.1).

We obtained our design inspiration from musical notation for some common features in tempo and cooperation. The time-varying tempo of a match is comparable to the speed of a musical tune. Relations existing among players form a round of teamwork, similar to a chord (an aggregate of simultaneous musical pitches) in a musical notation.

*e-mail: wentaowang1990@hotmail.com
†e-mail: jwzhang@tju.edu.cn

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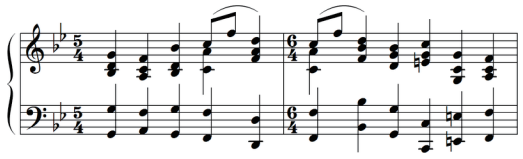

Figure 1: A simple musical staff (image courtesy of Wikipedia).

3 Visual Design

3.1 Personal Action Glyph-based Visualization

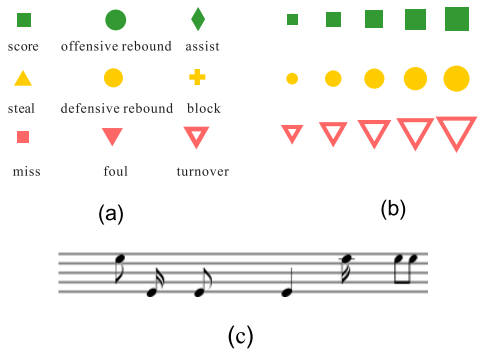

Figure 2: Player Action Glyph-based Visualization(a,b)our symbol system.(c)music note mapping, just display parts for explanation.

We choose different glyphs or symbols, such as squares and triangles, to represent the various actions of athletes. And different colors represent different types of action, such as green for favorable actions in offence and yellow for favorable actions in defence. For example, a defensive rebound is represented as a yellow circle (see Fig.2.a). In an actual sports match, a player may sometimes constantly score, rebound, or turnover. Thus, we increase the glyph size to represent a player's continuous behaviors(see Fig.2.b).

These ordinary action symbols are similar to notes on a musical staff (see Fig.2.c). Adverse actions(such as foul, turnover, etc) are represented by a note with a lower pitch, whereas favorable actions(such as score, rebound, etc) are represented with a higher pitch, and the last two conjoint notes in Fig.2.c can be used to demonstrate the continuous behaviors in Fig.2.b.

3.2 Time-varing Curve Visualization on Match

In our design, we employed a curve (see Fig.3.a) to link all individual actions together, with the favorable actions shown up and adverse actions down, so the player line can reflect the rise and fall of an athletes status. Meanwhile, the player line can indicate the athlete's playing time as well. The line starts when the player enters the court and ends when he gets off field.

Similar with player line, we set favorable rounds at the top of the team area, whereas adverse rounds are placed at the bottom. Consequently, team performance can be presented by a round-linked fluctuant curve (see the top part of Fig.3.b), round is like the chord in a movement (see bottom part in Fig.3.b), and each round is separated by a vertical line like the the bar in staff. In the match, the ball control power is frequently exchanged between two teams, therefore, we used a rising and falling curve in Fig.3.c to represent the change of ball control power, which can be understood as the slur (a symbol in musical notation indicating the notes it embraces are to be played continuously) in the music staff (see Fig.3.c).

In an ordinary basketball match, a player may generate dozens of actions and a team may participate in approximately 100 rounds. We use overview+detail technique to conduct interactive analysis in our system, users select the match zone of interest using an extensible focus brush, detailed information on the focused region will populate at the bottom of the detail panel.

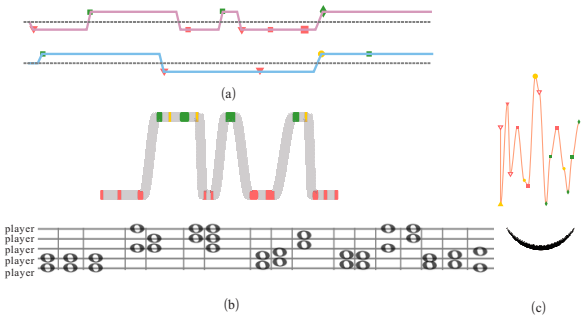

Figure 3: (a) Playing time line, status line, initial base line of two players.(b)Team performance curve and similar chord symbol.(c)Ball control power move path and slur between continuous notes.

3.3 Player Cooperation and Confrontation Visual Analysis

Actions of team cooperation, such as assists in a player's own side, indicate teamwork. We can connect player actions with the ball movement path to demonstrate team cooperation. We added dashed lines with different gradations to represent the potential assist directions in history based on MDS(multi-dimensional scaling)algorithm. We define δ_i as player i in the objective team, $\delta_{i,j}$ as distance between player i and player j, assuming that the player's distance is inversely proportional to mutual cooperation between two players, subsequently determined the m vectors(indicate m different players) $X_1, X_2, \ldots, X_m \in \mathbb{R}^2$ as a minimizer of the objective optimization function, given by Equation.1

$$\min \sum_{i<j} (||X_i - X_j|| - \delta_{i,j})^2 \qquad (1)$$

and the assist probability is represented by player distance. The greater the probability of assists between players, the deeper the color gradation of the dashed assist line (see Fig.4.a).

One-to-one defense is the most basic form of defense in a basketball game. Confrontations may occur simultaneously, and therefore bilateral rounds including such actions emerge face to face in the situation of confrontation (see Fig.4.b).

4 Player Performance and Correlation Visual Analysis

In Fig.5.a, James' playing time was divided into four parts. Most of the time, James acted as a small forward in his regular position. At times, he acted as a power forward (in Fig.5.a James' bitmap rise beyond the other three lines). In all his 33 actions, 22 actions were

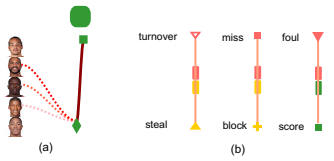

Figure 4: (a)Player actual assist direction in the match(solid line), and potential assist direction in history(dashed line).(b)Player confrontation face-to-face design.

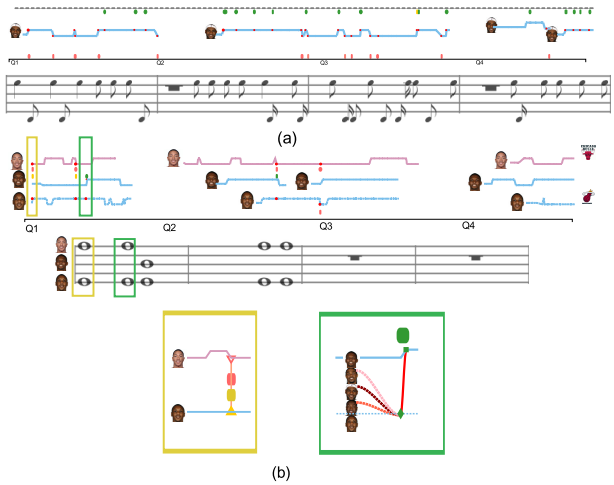

Figure 5: (a)James' player line, and the expanding staff of his. (b)Overview of three players cooperation and confrontation and aggregation chord staff of theirs, details are in green and yellow panel.

favorable and the other 11 were adverse actions. Thus, in general, James performed remarkably during his playing time.

We can select Chalmers (Heat), Bosh (Heat), and Rose (Bulls) to study cooperation and confrontation, providing technical support for tactical decisions. Fig.5.b shows Chalmers in a dashed blue line, and Chalmers and Bosh (solid blue line) were in the same Heat area. Rose was in a solid red line. And Rose and Chalmers had 4 confrontations, and Bosh only cooperated with Chalmers once.

First, when we can concentrate only in the cooperation round for details (the area in the green pane), 4 lines can be found, and the solid line is the actual cooperation line (Chalmers assisted Bosh to score). The 3 dashed lines demonstrate the potential cooperation patterns based on MDS analysis about cooperation tendency.

Second, comparative analysis between Chalmers and Rose (see Fig.5.b) shows that Chalmers took advantage over Rose in 4 confrontations. We can further explore the details, for example in the below yellow panel, we can see Chalmers stole the ball from Rose. In general, Chalmers is a good defender for Rose in this match.

5 Conclusion

We combined single match information with historical statistics data in the attempt to find potential pattern and solve several typical problems in actual sports game analysis.

References

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