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Using Distinctive Colour Signatures to Capture Team Behaviour During Matches

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Abstract

To capture team behaviour, kinematic variables, such as the surface area and the geometrical centre of the team, have been used. Although these variables have shown interesting results in capturing team behaviour, they reduce individual differences to a unique measure, losing the contribution of each player to the team. Using infrared (IR) dyes, it is possible for each player to have a distinctive colour signature to capture their behaviour online. The first stage of this study consisted in the selection of appropriate IR dyes with peak absorbance at different wavelengths (800nm, 910nm, 949nm and 1031nm) that were dissolved in solutions and diluted two times with a 1/5 ratio. To assess the contrast between the solutions, they were applied in a 6x4 chessboard. A unique colour signature was made composing an image from three different charge-coupled devices (CCDs) (one in the visible spectral region and two in the near IR) that were used like the RGB colour system. The IR markers absorbing at shorter wavelengths (800nm and 910nm) have a darker tone in the range 750-900nm and appear white between 900-1900nm. The markers with longer absorption wavelengths have a dark tone in both regions. We calibrated the images from the three CCDs and composed an image in which we give a different colour signature to each square. It is possible to create distinctive colour signatures using the coordinates from three different images.

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Keywords: infrared; colour signature; tracking system

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1. Introduction

Sport teams can be seen as complex open systems, where components are coupled by information, and whose interactions originate collective patterns (Passos et al., 2009). The interaction of individual, environment and task is responsible for a continuous emergence of patterns of intra- and inter-team interaction (Fonseca et al., 2013). The analysis of these complex social interactions has been developed using 2D positional data (Yue et al., 2008). In order to study the collective behaviours of sports teams, these analysis methods require the use of compound variables to functionally synthesize the high dimensional information emerging from the multiple interactions between constraints (McGarry, 2009; Schöllhorn, 2003). Some compound variables have already been used to capture complex group behaviors that express the collective patterns of performance in team sports. These variables include the surface area (see Frencken et al., 2011), the geometrical centre of teams (see Duarte et al., 2013; Frencken and Lemmink, 2008), the stretch index of teams (see Bourbousson et al., 2010), and the team length and width (see Folgado et al., 2012). These compound variables have revealed different trends in performance variation, attesting their complementarity for capturing the behaviours of sports teams as complex, dynamical systems during a game (Duarte et al., 2013). However, compound variables currently used to describe spatial behaviour, as they are calculated for each team, ignore the spatial distribution of the opponent team, the dimension of the field (Fonseca et al., 2013) and the contribution of each player to the team. Fonseca et al. (2013) defend that since the spatial organization of one team is influenced by the spatial organization of its opponent, the position of all players in the field must be considered, as well as its dimension, to define variables that describe teams' spatial arrangement. Thus, some authors have suggested measures of spatial organization based on a geometric partition of space like Voronoi diagrams, obtained from manual digitization of players' coordinates (Fonseca et al., 2013).

Different methods have been used for sports performance analyses, with emphasis on full- and semi-automatic position tracking systems. An investigation carried out by Barros et al. (2007) used an automatic tracking system (DVideo, Campinas, Brazil) to measure distances covered by association football players. In each game, four digital cameras were fixed, each covering approximately a quarter of the field, with overlapping regions. After measuring the players' positions, the 2D coordinates of the players were reconstructed using Direct Linear Transformation algorithms (2D-DLT). The percentage of automatic tracking was around 95% for each player and situations where players were not tracked automatically were corrected manually. However, the investigators claimed that it took approximately 16 hours to get the results (Barros et al., 2007).

Prozone (West Yorkshire, England) is a video-based multi-player tracking system, designed for the analysis of football performance that requires multi-camera systems that is custom-fitted at sports stadia (Barris and Button, 2008). Di Salvo et al. (2006) analysed players' displacements and speed on a football field. This system uses complex trigonometry, proper mathematical algorithms, image-object transformation methods such as DLT to calculate the positions of the players (Carling et al., 2008). Technology is facilitated by supportive information such as shirt color, optical character recognition of shirt numbers and prediction of running patterns to help maintain accurate player identification and tracking (Carling et al., 2008). However, in this system, operators are required to continuously and manually verify if the players are being correctly tracked (Barris and Button, 2008) and do not provide a real-time analysis. Results are generally available within 24-36 hours of the final whistle.

Other methods such as global positioning systems (GPS) or the LPM Soccer 3D developed by INMOTIO have the disadvantage that in association football, electronic devices are restricted to measure players' performance only during practice sessions or friendly matches, because they require a receiver to be worn by each athlete, which is currently forbidden by FIFA International Board (Carling et al. 2008).

The aim of the present study is to contribute to the development a non-intrusive and automatic tracking system that is able to distinguish every player on the field, calculate compound variables and thus, give information about the influence ("weight") that each player has on the collective behaviour of the team. This method is based on infrared markers (that absorb the infrared light) to create distinctive colour signatures similar to the RGB code system.

2. Method

2.1 Materials