Sonifying Players' Positional Relation in Football

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Abstract. This paper presents a prototype system that visually and aurally represents information on the positions and movements of players in a football game, with the aim of facilitating understanding of football. Understanding the positional relationship of players is important in analyzing the situation of a game. Although visualization has been used for this purpose, there are no examples of audible representation. In this paper, we use Delaunay triangulation to find the pass courses between the players, and then sonify the pass courses with sound. By extending this trial, we expect to be able to understand the match situation more effectively than with visualization alone.

Keywords: Football Sonification visualization

1 Introduction

In football, eleven players work together and yet move differently to move the ball to the goal. In order to understand the matchup, it is necessary to understand the movements of the players who do not have the ball. However, it is not easy to keep track of the standing positions and movements of all eleven players at the same time.

There have already been studies on tracking the positional relationship of football players [1][2]. On the other hand, sonification is used in other fields to facilitate to understand complex scenes [3], but there have not been attempts for analyzing footnote scenes.

In this paper, we attempt to visualize and sonify the positional relationships of players in a football game. In football, it is necessary to pass the ball in order to carry the ball to the goal. Therefore, our system analyzes available pass courses from the player holding the ball by making triangles among the players and tell them through sonification as well as visualization.

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2 Proposed System

2.1 System overview

Our system visualizes the positional relationships between players and then represents these relationships as sound to promote understanding of football. The visualization and sonification shown below are performed only when one team (called *team A* here) is attacking.

2.2 Data

We use positional tracking data provided by Data Stadium Corporation, which records frame numbers, players, and the ball's position at every 1/25 second. The players' data are recorded for a total of 22 players (11 players $\times$ 2 teams) on the field (Table 1).

Table 1: Tracking Data

Data	Description
Game ID	ID that uniquely identifies a match
Frame	Tracking system frame number
HA	Flags for home and away identification. 1：Home 2：Away 0：Ball
NO	Player's back number . 0 for ball
X	-5250∼5220 Pitch size 105m x 68m, 105m side
Y	-3400∼3400 Pitch size 105m x 68m, 68m side
Speed	Indicates the speed of the ball and the players in km/h

2.3 Visualization

First, every 1/25 second, the coordinates of the players and the ball for both teams are represented by a circle. Each team is distinguished by a different color, and the ball is represented by black.

Next, the system connects the points $P_1, \cdots, P_{11}$ representing each player of team A by an edge so that the following conditions are satisfied.

- Every point P_i has an edge.
- Every edge P_iP_j does not intersect any other edge P_kP_l.

This edge are drawn by using the Delaunay triangulation algorithm [4]. Suppose now that the player represented by vertex P_i is in possession of the ball (i.e., the coordinates of P_i and P_0 overlap). When vertex P_i has edges $P_iP_{j_1}, P_iP_{j_2}, \cdots, P_iP_{j_N}$, we can consider these as pass courses from P_i.

An example of the visualization is shown in Figure 1.

2.4 Sonification

The position of the ball and the pass courses obtained above are represented as sounds because these are highly related to the chances of scoring goals. These data are converted to MIDI note numbers and MIDI Note On messages are sent out. In the current implementation, an acoustic piano tone is used.

Sonification of ball position Every 2/5 second, the coordinates of the point P_0 representing the ball are converted to a MIDI note number. The note number is determined according to Figure

Sonification of pass courses When a player holds the ball, the pass courses' feature obtained above is made audible. Let P_i be the vertices of the player holding the ball and P_i be the edges of $P_iP_{j_1}, P_iP_{j_2}, \cdots, P_iP_{j_N}$. The vertices $P_{j_1}, P_{j_2}, \cdots, P_{j_N}$ can be interpreted to represent players to whom the ball can be passed from P_i. The coordinates of these vertices are then converted to note numbers according to Figure 2 and sounded. When N is large (when there are many passable players), chords with many tones are formed. When the edge $P_iP_{j_n}$ $(n = 1, 2, \cdots, N)$ is long or the coordinates of P_{j_n} are far from each other, chords with open voicings are formed. In this way, the user can know the occurrence and characteristics of the pass courses from the chords. This sonification process occurs only when the player holding the ball changes, unlike the sonification of the ball position.

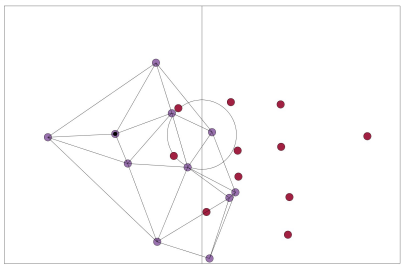

Fig. 1: Visualization Results

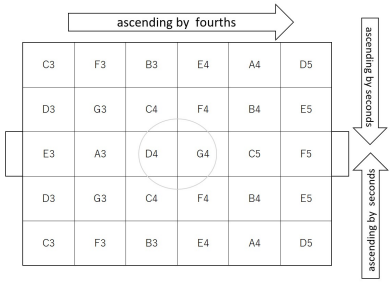

Fig. 2: How to determine note numbers

3 Preliminary Results

Using this system, the position of the ball and the pass courses were sonified using the positional data described in Section 2.1. Figure 3 is a spectrogram obtained by sonifying a scene in which team A connects a pass from a position close to its own goal to a player in the center of the rival team and carries the ball. As a result of the sonification, the following can be read.

– From around 0 to 4 seconds, only the sound of the ball was heard; there was no movement of the ball between blocks.
– From around 4 to 12 seconds, the sound (chord) consisting of multiple tones was heard as multiple pass courses were found
– From 12 to 18 seconds, only the ball is sounded, but the ball is moving between the blocks, so the pitch of the sound ascends
– From 18 seconds onwards, the pass courses were audible, while the ball was closer to the rival's goal, so the pitch of the sound was higher than in the 4–12 second period.

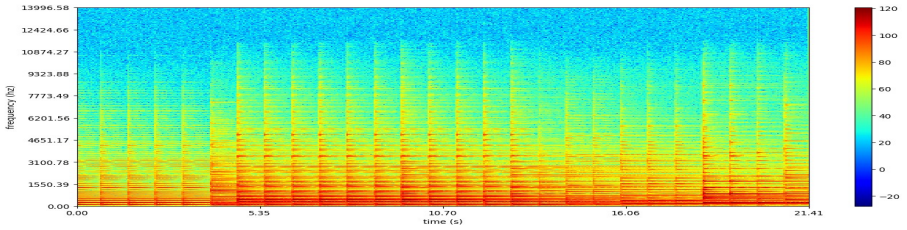

Fig. 3: Spectrogram of the sound generated by our sonification method

4 Conclusion

This paper described a prototype system that visually and aurally represented information on the positions and movements of players in a football game. The system faciliatedthe feature of pass courses in the football game by sonifying them as well as visualization.

For more precise analysis of game scenes, we have to solve many issues. If a player in the defending team is near from pass courses found through our system, this pass course cannot be considered available. If this is the case, this pass course must be excluded, but this has not yet been implemented. It is also necessary to consider how to sonify players other than those forming pass courses. Through such development, we would like to establish a technique that helps understand football games.

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