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Literature Review #2: Player Movement Analysis

Since the Premier League (the top-level soccer league in England) is approaching its final weeks of the season, I have decided to do my second literature review on papers that analyze player movement. Vinicius Machado, Roger Leite, Felipe Moura, Sergio Cunha, Filip Sadlo & João L.D. Comba wrote my *primary paper* "Visual soccer match analysis using spatiotemporal positions of players"; it's found in the November 2017 issue of the "Computers & Graphics" Journal. Lin Shao, Dominik Sacha, Benjamin Neldner, Manuel Stein & Tobias Schreck wrote my *secondary paper* "Visual-Interactive Search for Soccer Trajectories to Identify Interesting Game Situations"; it's found in the 2016 issue of the "Visualization and Data Analysis" Journal. Both papers show similar approaches at tracking player movement on the pitch, but use different visualization methods.

Let's start with the secondary paper... The approach Shao and his team use is inspired by board sketches (you know those sketches coaches use to show their team a play). The plan is for the user to sketch out a path (on a tablet) and the best-matched

trajectories will be displayed on the right portion of the interface as thumbnails, along with additional information (e.g. player name, number, match time, trajectory type). Clicking on a thumbnail will highlight said thumbnail and display a larger image of the matched trajectory on the left portion of the screen. Filters can be applied to narrow down specific scenarios, such as specifying a player, player position, time interval, and ball possession.

The algorithm that is used to find these similar trajectories is a complicated one, but it is easy to explain. The users sketched out path is placed on a grid, keeping the direction of the path in mind. The algorithm then searches for trajectories that fall on that grid that are most similar to the sketched path created by the user. The algorithm *only* considers trajectories that fall on that grid. To help visualize this, picture a soccer field. Now draw a path on the field to be analyzed by the application and box in that path. The algorithm will search for trajectories created by players movement that fall on any coordinate in that box (provided that most of the path is in the box), and pick the closest matching ones given the specific filters if there are any.

The algorithm keeps track of the position of the ball at all times. So for any similar trajectory found by the system, the ball trajectory can also be mapped onto the pitch (using the ball possession filter). This is great for showing players reactions to where the ball is on the pitch. Using the data of the balls location can also help show players passing the ball between each other, mapping out an attack on goal fairly well.

The algorithm can determine specific situations that happen in the match: corner kicks, goal kicks, kickoff, etc. This is done by searching for patterns of all twenty-two players at the same time. If the collective player movements fit certain parameters for any specific game event, the algorithm will take note of it. For instance, if all players are set up in front of the goal and one player is at a corner on the same side of the pitch, with the ball, the algorithm will spot that a corner kick is happening at that given time of the match.

Like specific situations, the algorithm can determine when a similar situation is happening. These situations occur throughout the match, but using other data from the match, we can answer questions like: Which player had more touches on the ball? How often did a player slide tackle in a given area of the pitch? How often did the left defender make a clearance of the ball?

The methods this paper uses, can, and *are* used in professional sports today. In the Premier League, players after a match will receive a score from zero to ten, based on their play on the pitch. Moreover, the NFL just recently started using player trajectories to better show a players route before a play when showing highlights of a game.

Both papers give ways to track a player's movement quite well. Machado and his team agree with Shao, that a player's movement on a pitch play an important role in

analysis. Machado takes what Shao did and implements alternate ways to view the player trajectories.

Machado implemented different visual designs to analyze the position of players: two types of heatmaps, and one, barrowed from the design Shao and his team implemented, pathline trajectories.

The first of the two heatmaps implemented is called a player attribute heatmap. This kind of heatmap encodes the speed and positon of a player, and turns the color of the pitch in that area (position) a color in respect to the players speed. This is done by taking two mappings of the player. The first takes the speed of the player and maps it into a 1D color table. The second takes the coordinates of the player's position and maps it to a 2D color table. The purpose of this design is to show the evolution of the position of layers throughout a match. A darker color on the map shows the player prefers playing in that area of the pitch.

In most cases, a player attribute heatmap is fine. In the few cases, it isn't fine, a more abstract map is needed. A tactical scheme heatmap analyzes a team's formation over time. During a soccer match players are divided up into formations (e.g. 4-3-3: four defensive players, three midfielders, and three attackers) given by their coach. Using this type of heatmap will allow the visualization of number of players playing as

defenders, midfielders, and attackers on the pitch at one time. The purpose for this style of heatmap is to observe changes in a team's formation over time.

The final visual design implemented, borrowed from Shaos implementation, is pathline trajectories; these are the trajectories of players on the pitch. These trajectories are essential to investigate the complex movements of players during a match. Similarly, to the way the secondary paper implemented trajectories, filtering can be used to show players movement on different time intervals.

In conclusion, both papers show similar approaches at tracking player movement on the pitch, both have their pros and cons. The Machado's approach had better visualizations of player movement. Whereas, Shao's approach had better analyzation of determining unusual movements of players that can be found automatically by the system; situations including, goal kicks, corner kicks, kickoffs, clearances, slide tackles, the list goes on. Machado brought up this fact, and he plans to implement a similar algorithm in the future to do the same thing.