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Exploring Pressure in Football

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1 Abstract

From a set of trajectories of the players and the ball in a football (soccer) game, we computationally estimate, for each time frame, the pressure of the defending players upon the ball and the opponents. The extracted pressure relationships are visualized in detailed and summarized forms. Interactive filtering enables exploration of the pressure relationships in selected game episodes or in game situations satisfying specific query conditions.

2 Introduction

Current tracking technologies enable acquisition of high quality data describing the movements of the players and the ball in football (a.k.a. soccer) games. Analysis of so obtained trajectories is a hot topic in sports sciences and data mining (e.g., [1][2][5]). Football data have also attracted attention of researchers in visualization and visual analytics (e.g., [3][4]). However, no approaches have been proposed yet for analyzing the phenomenon of *pressing*, which is an important trend in modern football tactics. Pressing may be applied by the defending team against the team that possesses the ball. The aim is to win the ball or at least prevent the opponents from developing an attack. The term *counter-pressing* denotes a special case of pressing: attempting to re-gain the ball as soon as it has been lost.

A pressing behavior of a defending team at each time moment can be seen as a combination of multiple instances of pressure relationships. In one instance, the pressure is exerted by one defending player (henceforth called *presser*) on one *pressure target*, which is either the ball or one of the opponent players. A presser or a target can be involved in several pressure instances.

Our research team, which is composed of visual analytics researchers and football experts, have developed an approach to computational detection of pressure instances emerging in a football game and devised a numeric measure of the pressure strength [6]. Detected pressure instances can be visualized in detailed and summarized ways, and interactive filtering tools enable exploration of the pressure relationships and teams' defense tactics in different game episodes and classes of situations.

3 Approach

The aim of a presser is to prevent the ball from approaching the defended goal or to prevent an opponent player from sending or receiving a pass. Let us call the direction from the pressure target towards the goal or a teammate "threat direction". The movement in this direction can most effectively be prevented or obstructed by the presser when he is positioned on the movement vector in front of the target. When the presser is positioned aside of the movement vector or behind the pressure target, the movement can still be obstructed if the distance to the target is small enough. Hence, the maximal distance from which a presser can obstruct the movement in the threat direction depends on the angle θ between the threat direction and the ray from the pressure target to the presser. When θ = 0, pressure can be exerted from a longer distance. As the angle increases (in the absolute value), the maximal distance for pressure decreases and reaches a minimum when θ = ±180°, i.e., when the defender is behind the pressure target. This dependency can be geometrically represented by an egg-shaped curve (Fig. 1) where the pressure target is located at the narrow side whereas the wide side is oriented towards the threat direction. The exterior space around this shape can be considered as unsuitable for pressure on the target, i.e., we assume the pressure from any location beyond the egg shape to be zero. The interior of the shape can be called "pressure zone". The distance limit for exerting pressure depending on the angle θ is

$$L = D_{back} + \frac{(D_{front} - D_{back})(z^3 + 0.3z)}{1.3}; \qquad z = (1 - \cos\theta)\,/\,2 \qquad (1)$$

where D_{front} is the maximal distance for exerting pressure when the pressure is in front of the target and D_{back} is the distance limit in the case when the defender is behind the pressure target. Specific values for D_{front} and D_{back} (9 and 3 meters, respectively) were recommended by the football experts.

The maximal theoretically possible pressure, taken as 100%, is when the presser is positioned exactly in the location of the pressure target. For any point within the pressure zone, the strength of the pressure that can be exerted from this position is estimated as

$$p = (1 - d/L)^q \cdot 100\% \qquad (2)$$

where d is the distance of the point to the pressure target, L is the distance limit determined by the formula (1), and the exponent q regulates the speed of the distance decay, i.e., how fast the pressure decreases with the distance. The value for q (1.75) was empirically chosen by the experts with the help of the interactive tool shown in Fig. 1.

We implemented a tool that computes for each time frame of a game and each pair (p_d, p_b), where p_d is a player of the defending team and p_b is a player of the team possessing the ball, the pressure from p_d onto p_b, and for each pair (p_d, b), where b is the ball, the pressure from p_d onto b. The derived data can be

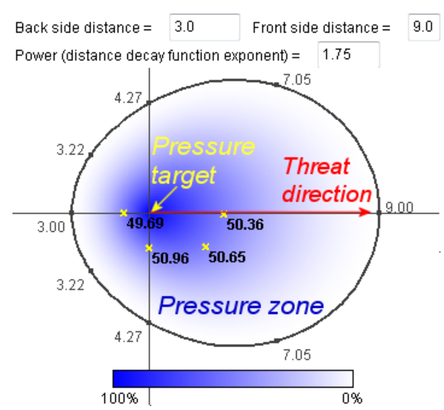

Fig. 1. Estimation of the pressure strength depending on the presser's position w.r.t. the target and the threat direction.

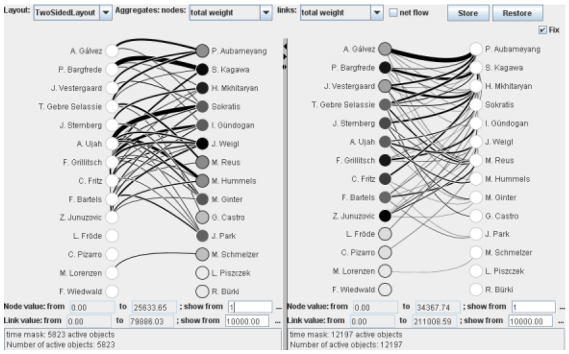

Fig. 2. Pressure graphs show the amounts of pressure exerted by the defending team players on the ball (node darkness) and on the opponents (edge thickness) during ball possession by Bremen (left) and Dortmund (right).

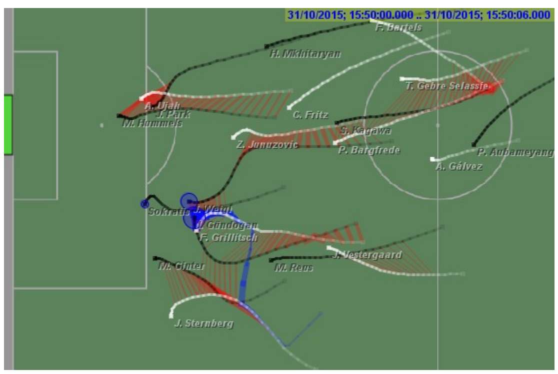

Fig. 3. A map fragment shows a game episode. The white and black lines represent the players' trajectories, and the blue line is the trajectory of the ball. The red lines show the pressure forces from the players of the defending team (black) on the opponents, the blue circles represent the pressure of the defenders on the ball, and the blue line width is proportional to the total pressure on the ball.

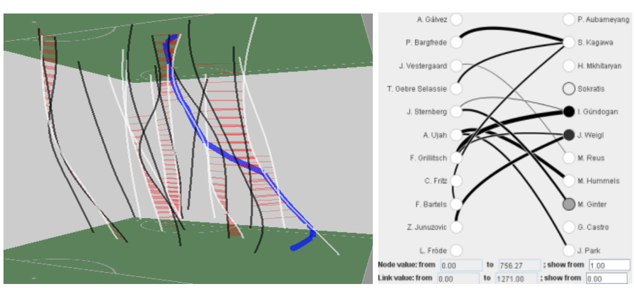

Fig. 4. The same game episode as in Fig. 3 is shown in a space-time cube (left), and the pressure graph on the right shows the corresponding amounts of pressure.

interactively explored using a combination of visual displays and interactive tools. Some examples are shown in Figs. 2 – 5. The data used as an input were captured during a game of the German national championship between the clubs SV Werder Bremen and Borussia Dortmund (1:3) that took place on October 31, 2015.

The graphs in Fig. 2 show the total amounts of pressure exerted by individual players (represented by graph nodes) on the ball and the opponents. The node darkness encodes the pressure on the ball, and the edge width represents the player-to-player pressure. The time series of the pressure values are shown in an interactive display together with information on the ball status (in or out of play), ball possession (Bremen or Dortmund), and other attributes.

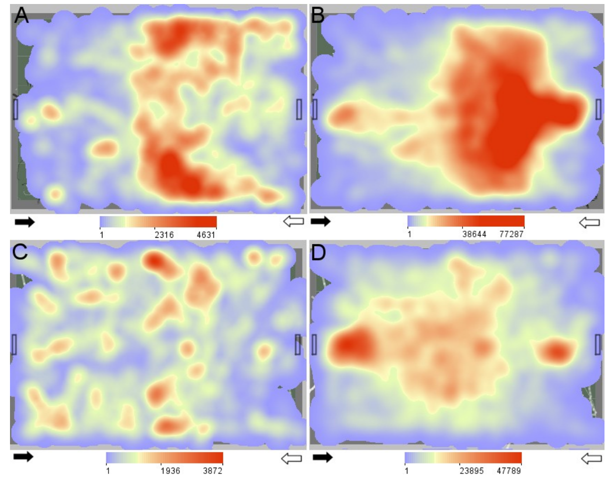

Fig. 5. Spatial summaries (pressure-weighted density maps) of the pressure on the ball (A, C) and on the opponents (B, D) generated by Bremen (A, B) and Dortmund (C, D).

Time intervals of interest can be selected by mouse dragging in this display, and the corresponding game episodes can be viewed in a map (as a static image or in animation) and in a space-time cube (STC). Thus, Figs. 3 and 4 show a selected a game episode in which the ball is possessed by Bremen, and Dortmund puts much pressure on the ball and the attackers. In the map and the STC, the pressure forces between the players are represented by red lines connecting trajectory positions; the line thickness is proportional to the pressure strength. The blue circles encode the pressure on the ball, and the width of the blue line representing the ball trajectory is proportional to the total pressure on the ball. The time interval selection is also applied to the pressure graph (Fig. 4, right), which shows the amounts of pressure generated during the selected episode.

Summary displays of the pressure for the whole game, selected time intervals, or selected classes of situations support the exploration of the teams' defense tactics. Thus, the pressure density maps in Fig. 5 show a striking difference between the tactics of Bremen (top) and Dortmund (bottom). Selection of classes of situations (e.g., the first 5 seconds after losing the ball, to investigate counter-pressing) is enabled by an interactive time mask filter, which can select a subset of disjoint time moments and intervals satisfying interactively specified query conditions.

4 References

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