Implementation of Recurrence Analysis algorithms in a dashboard for practical application in Football.

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1. INTRODUCTION

Football matches are subject to a temporal sequence of different events that result from a series of upstream chains of interaction between players, positional groupings or teams whose goals either conflict or harmonise. In this context, the prevailing idea is to see football matches as dynamic interaction processes with evolving behaviour (Gréhaigne et al., 1997; Lames & McGarry, 2007; Hughes & Franks, 2008). Complex techniques and methods are necessary to adequately analyse these processes (Lames & McGarry, 2007).

Recurrence analysis represents such a method as it examines approximations of a trajectory in a phase space (Lames & Plück, 2015). The core component of the recurrence analysis is the recurrence plot (RP), which visualises the recurring patterns in a matrix (Eckmann et al., 1987). The method is completed by the recurrence quantification analysis (RQA), which expresses the texture and typology of the recurrence plot in a number by means of statistically calculated key figures (see Marwan et al., 2007).

Applications of the recurrence method in professional football can be found in the work of Lames & Plück (2015), Stöckl et al. (2017) and Lames et al. (2021). The results of these studies are promising, as they demonstrate the representational capacity of RPs in football matches (Lames & Plück, 2015), the unpredictability of the players' behaviour (Stöckl et al., 2017), significant correlations with common performance indicators (Lames et al., 2021) and a correlation of RPs and RQA parameters to open play (ibid.).

It is noticable that in all the studies, the recurrence analysis was carried out without the aid of method-specific analysis tools. Instead, the calculations and plots were executed programmatically and with the help of mathematical programming and visualisation libraries (e.g. Lames et al., 2021). This circumstance is consistent with the authors' knowledge that, at the time of writing, no tool exists for carrying out recurrence analyses in professional football. Furthermore, the method was only used in a scientific context. For practical application, an intuitive and easy-to-use tool is still missing, with the help of which flexible recurrence views are possible within a very short time.

The aim of this study is to present a user-friendly dashboard that can be used to conduct performance analyses in professional soccer including the recurrence method. In pursuit of this goal, it is investigated how the practicability of the recurrence method can be increased and which contents and information are additionally relevant for a comprehensive performance analysis.

2. MODELLING

2.1 RPs

The recurrence plot is a graphical preparation of a square matrix whose coefficients express the approximation of a trajectory at the corresponding time points t=i and t=j. In terms of soccer, the axes correspond to the match time points in seconds. To form a coefficient, the Euclidean distance between the positions at time points i and j is first calculated. The distance is then matched with the recurrence threshold. If the distance equals or falls below the threshold, the recurrence condition is fulfilled for this point. Graphically, the corresponding pixel is coloured black, whereas a non-recurrent point is coded white.

2.2 RQA

We adopted seven recurrence parameters from Marwan et al. (2007). Recurrence Rate (RR) simply counts the recurrence points in the whole RP and provides the rate of these points compared to all points in the RP. Determinism (DET) is the ratio between the recurrence points that lie on a diagonal line of length l with $l \geq l_{min}$ ($l_{min}=3$ in our case) and the total number of recurrence points. Laminarity (LAM) means very much the same as DET, but for vertical lines instead of diagonal ones. Average diagonal line length (LL) is defined as the average of all diagonal lines with $l \geq l_{min}$. Trapping Time (TT) is analogous to LL but is the average vertical line length of all lines with $l \geq l_{min}$. Entropy (ENTR) is the Shannon entropy of the different diagonal line lengths $\geq l_{min}$. ENTR-V is the entropy of the vertical lines.

2.3 Technologies

21 matches of a German Bundesliga team from the 2019/2020 season were used as a sample. The data was preprocessed using the Python programming language and its common data processing libraries. The tool was implemented with the help of Plotly's framework Dash, which enables the development of web-based analysis applications using Python.

3. RESULTS

A recurrence-based dashboard was designed that forms the basis for comprehensive match analyses in practice. Central to the development is the idea of bundling several analysis functions in one tool, so that the RP is contextualised by diagrams, graphics, key figures as well as cross-media content such as match videos. For this reason, the RP is used as an interactive control, whereby the user receives specific information by selecting an area. The dashboard shows extracts of the game video before and after a selected point on the x-axis in the RP and the corresponding part of the game on the y-axis. Practicality has been increased in that sports analysts are able to use the dashboard to quickly search for points of interest in the RP as the relevant video clips are easily accessible. This also makes it easier to find similar clips that might not be easy to find if they were not marked by specific events, e.g. during a set. In addition, a pitch visualisation was integrated, showing the players' positions from a bird's eye view. From this, more detailed interpretations of the positional play at the selected points in time can be derived. Furthermore, filtering by tactical groupings or individual players provides information about commonalities in the behaviour of players in certain positions. In addition to the interactive RP, the analysis tool also contains RQA parameters and performance indicators such as average speed, which allow further aspects of the game to be quantified (Fig. 1).

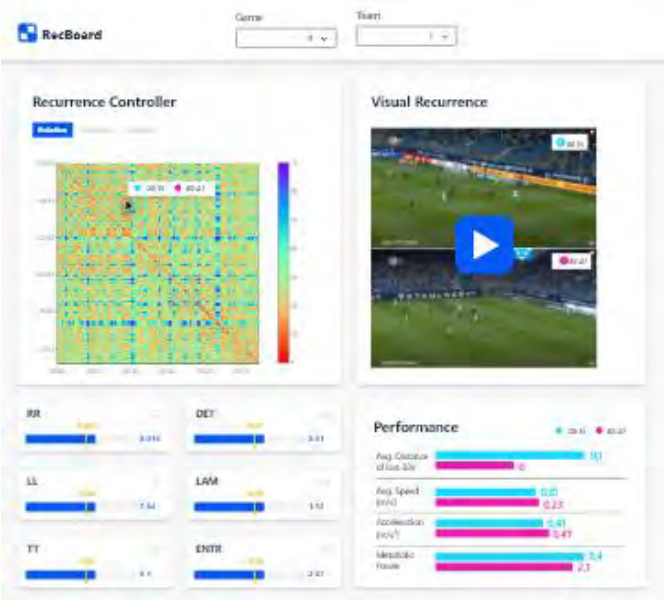

Fig. 1: User interface draft of the RP analysis tool with RP as controller, video display of the selected scenes, local performance indicators as well as recurrence parameters and filtering options.

4. CONCLUSIONS

In this abstract, we presented a dashboard that can be used to perform recurrence analysis in professional soccer games. It shows how recurrence analysis can be integrated into notational performance analysis and what information is useful in this context.

Future work could deal with the further development of the dashboard. On the one hand, new functionalities could improve the practicability and produce innovative insights in performance analysis. At this point, the flexible nature of dashboards should be emphasised, which makes it possible to analyse any key figures and analysis methods simultaneously. On the other hand, the dashboard could be extended to other application scenarios. One possibility would be to include training operations in the match analysis. This could bridge the gap between training and match analysis, for example by examining the implementation of specifically trained tactics in the match. Although this work is aimed overall at football, it is to be expected that other top sports can also benefit from such a recurrence-focused dashboard. Particularly obvious are implementations in those sports for which empirical data already exists in connection with recurrence analysis (e.g. golf, Stöckl et al. 2017).

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