International Cartographic Association
Association Cartographique Internationale

Using Eye-tracking to Evaluate Visual Behaviours on GIS-Enhanced Football Animations

Nianhua Liu [a,*], Joel Salazar [a], Chuan Chen [a], Shengkai Wang [a], Rostislav Netek [b], Stanislav Popelka [b], Liqiu Meng [a]

[a] *Chair of Cartography and Visual Analytics, Technical University of Munich, Germany, nianhua.liu@tum.de, joel.salazar@tum.de, chuan.chen@tum.de, shengkai.wang@tum.de, liqiu.meng@tum.de*
[b] *Dept. of Geoinformatics, Palacký University Olomouc, Czech Republic, rostislav.netek@upol.cz, stanislav.popelka@upol.cz*

* Corresponding author

Keywords: eye-tracking, user study, visual behaviour, football animation

Abstract:

Football play is a dynamic process within a compact spatio-temporal framework. Such a dynamic process is hard to be visualized using static maps. Comparing to the raw video recordings, the animations can track the movement of the players to a bidimensional plane. 2D-plane football pitch map can better present the players' position. Therefore, an increasing number of football analysts are opting for animation method to assist the review of the game course and prepare the tactics for the next game (Fernández & Bornn, 2018). Several papers exploit the idea of generating GIS-enhanced approaches in football analysis and visual analytics. The control area of the player can be modelled using Voronoi diagram, while a larger proportion of the dominant region indicates better chances to win (Kim, 2004 & Fujimura, 2005). Duarte et al. (2013) analysed the performance of football teams based on general statistical indicators of the team's convex hull. Andrienko et al. (2017) designed a novel interactive visual tool to quantify defensive pressure in football. Integrating football animation together with the GIS toolset can result in an advanced and intuitive medium that allows users to quickly perceive and understand the depicted phenomena (Farahani et al., 2020).

Within a compact spatio-temporal framework, football tactics (e.g., Counter-attack, Total Football, Catenaccio) are hard to observe and analyse by raw animations. With GIS-enhanced animation, the understanding threshold of football tactics will be decreased. Although GIS-enhanced animation brings more spatio-temporal information to football analysis, the visual behaviours and its connection to football tactics understanding remains unclear. So far, studying users' visual behaviour and its relation to cognitive processes utilizing eye-tracking methodology has been the interest of many research efforts in spatial cognition over the years (Kiefer et al., 2017, Krassanakis et al., 2021). Recent research on cognitive issues in football was focused on analysing the eye movements of football players in the video recordings (Aksum et al., 2020 & Aksum et al., 2021 & Wirth et al., 2021). Therefore, how GIS-enhanced football animations influence human visual cognition and support the different users' group to understand football players' group behaviour still need to be explored.

Given the above, in this work-in-progress paper, we explore how different user groups observe and interact several GIS-enhanced animations, as well as understand the football tactics. First, the preliminary work has already been completed, as shown in Figure 1 below (Liu, 2022). Several animations (e.g., Voronoi Diagram, Convex Hull) are created in special tactics, based on Bokeh Plots from Python. Second, user study experiments will be performed to clarify the relationship between users' visual behaviours and their understanding. The participant's fixation sequence and area of interest will be measured to compare by gazepoint eye tracker.

Specifically, the participants are selected from two groups – 1) experienced football players and fans, and 2) unexperienced users. Before experiments, participants will fill out a questionnaire before to know about their background and experience in football. And then, participants will observe and interact with the animations. Their eye movement metrics during observing and interacting with the animations will be recorded and compared. The software processor is OGAMA and Gazepoint Analysis software. After experiments, another questionnaire will be filled to test their understanding of football tactics in the animations. The short-term recall of players' movement will also be examined by conducting specific task. Finally, intergroup differences will be summarized and concluded based on the eye-tracking metrics and the results of questionnaires.

This paper aims to evaluate the user's visual behaviour and understanding of several GIS-enhanced football animations. It is hypothesized that experienced group can better capture what's happening on the pitch and understand the game withing a shorter time. Thus, their visual behaviour is worthy to record, compare, and anlayze to improve the visual analysis ability of unexperienced group. The contribution is focused on clarifying the difference of visual behaviours between user groups and exploring how GIS-enhanced animations improve their understanding.

Abstracts of the International Cartographic Association, 6, 144, 2023.
31st International Cartographic Conference (ICC 2023), 13–18 August 2023, Cape Town, South Africa.
https://doi.org/10.5194/ica-abs-6-144-2023

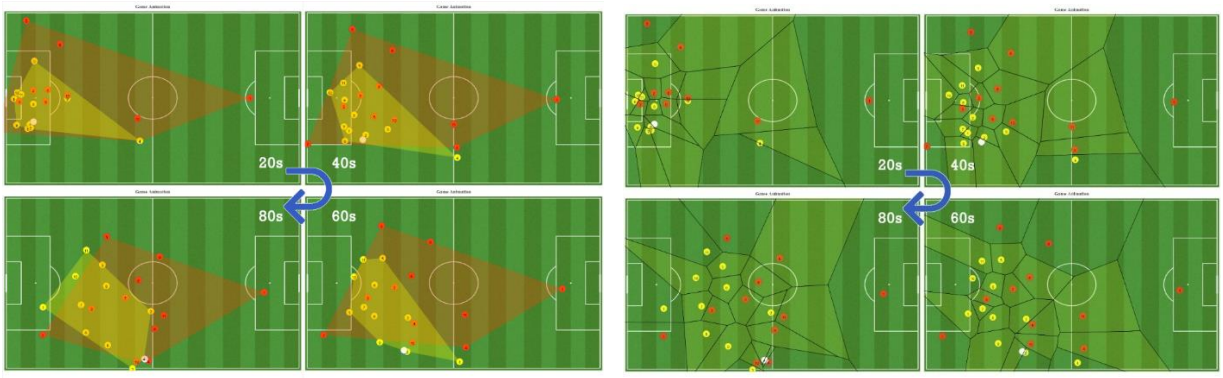

Figure 1. (a) Convex hull animation; (b) Voronoi diagram animation (Liu, 2022)

References

Aksum, K. M., Magnaguagno, L., Bjørndal, C. T., & Jordet, G., 2020. What Do Football Players Look at? An Eye-Tracking Analysis of the Visual Fixations of Players in 11 v 11 Elite Football Match Play. Front Psychol, 11, 562995. https://doi.org/10.3389/fpsyg.2020.562995

Aksum, K. M., Brotangen, L., Bjørndal, C. T., Magnaguagno, L., & Jordet, G., 2021. Scanning activity of elite football players in 11 vs. 11 match play: An eye-tracking analysis on the duration and visual information of scanning. PLOS ONE, 16(8), e0244118. https://doi.org/10.1371/journal.pone.0244118

Andrienko, G., Andrienko, N., Budziak, G., Dykes, J., Fuchs, G., von Landesberger, T., & Weber, H. (2017). Visual analysis of pressure in football. Data Mining and Knowledge Discovery, 31(6), 1793-1839. https://doi.org/10.1007/s10618-017-0513-2

Duarte, R., Araújo, D., Folgado, H., Esteves, P., Marques, P., & Davids, K. (2013). Capturing complex, non-linear team behaviours during competitive football performance. Journal of Systems Science and Complexity, 26(1), 62-72. https://doi.org/10.1007/s11424-013-2290-3

Farahani, J., Soltani, P., Rezlescu, C., & Walsh, V. (2020). Chapter 5 - Assessing decision making using 2D animations in elite academy footballers. In B. L. Parkin (Ed.), Progress in Brain Research (Vol. 253, pp. 71-85). Elsevier. https://doi.org/https://doi.org/10.1016/bs.pbr.2020.06.016

Fernández, J., & Bornn, L., 2018. Wide Open Spaces: A statistical technique for measuring space creation in professional soccer. Paper presented at the MIT Sloan Sports Analytics Conference.

Fujimura, A., & Sugihara, K. (2005). Geometric analysis and quantitative evaluation of sport teamwork. Systems and Computers in Japan, 36(6), 49-58. https://doi.org/https://doi.org/10.1002/scj.20254

Kiefer, P., Giannopoulos, I., Raubal, M., & Duchowski, A., 2017. Eye tracking for spatial research: Cognition, computation, challenges. Spatial Cognition & Computation, 17(1-2), 1-19. https://doi.org/10.1080/13875868.2016.1254634

Kim, S. (2004). Voronoi Analysis of a Soccer Game. Nonlinear Analysis: Modelling and Control, 9(3). https://doi.org/10.15388/NA.2004.9.3.15154

Krassanakis, V., & Cybulski, P., 2021. Eye Tracking Research in Cartography: Looking into the Future. ISPRS International Journal of Geo-Information, 10(6), 411. https://www.mdpi.com/2220-9964/10/6/411

Liu, N., 2022. GeoVisualisation of Football Players Movement. Olomouc. diplomová práce (Mgr.). Univerzita Palackého v Olomouci. Přírodovědecká fakulta

Wirth, M., Kohl, S., Gradl, S., Farlock, R., Roth, D., & Eskofier, B. M., 2021. Assessing Visual Exploratory Activity of Athletes in Virtual Reality Using Head Motion Characteristics. Sensors, 21(11), 3728. https://www.mdpi.com/1424-8220/21/11/3728