Using Network Analysis to Visualize Dominant Pass Lines in Football

Umut Evren [1]

[1]*Applied Data Science MSc.*

Universiteit Utrecht

FORWARD FOOTBALL

Introduction

The foundational principle of applying network analysis to team sports lies in conceptualizing the team members as nodes within a network, with the interactions between them — specifically the passes exchanged — represented as weighted edges. The frequency of passes between any two players dictates the weight of these edges [1].

Modeling the team's passing dynamics in this way facilitates the straightforward identification of pivotal players, characterized by their extensive connectivity and the higher weights of their associated vertices [2]. By examining the structure of passing networks, one can discern patterns of repeated pass sequences that are indicative of a team's distinctive playing style [3].

Methodology

- **PageRank**
  - *Explanation*: Operates on the premise that more important nodes are likely to receive more links from other nodes. It assigns a numerical weighting to each node, signifying its relative importance within the network.
  - *Formula*:

$$P(u) = \frac{1-d}{N} + d \sum_{v \in M(u)} \frac{P(v)}{L(v)}$$

- **Degree Centrality**
  - *Explanation*: Measures the importance of a node based on the number of connections it has. The more connections a node has, the higher its degree centrality, indicating it is an important node within the network.
  - *Formula*:

$$C_D(u) = \deg(u)$$

- **Betweenness Centrality**
  - *Explanation*: Identifies nodes that act as bridges within the network. It measures the number of times a node lies on the shortest path between other nodes. Nodes with high betweenness centrality are crucial for the flow of information in the network.
  - *Formula*:

$$C_B(u) = \sum_{s \neq u \neq t} \frac{\sigma_{st}(u)}{\sigma_{st}}$$

Objectives

- **Visualizing** dominant pass pairs and combinations through the weights created by centrality indicators
- **Detecting** key players who might potentially affect the connection between others players

Visualization of Objectives

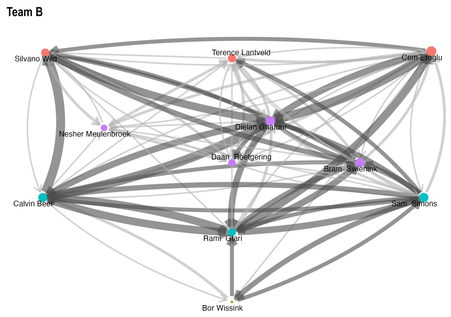
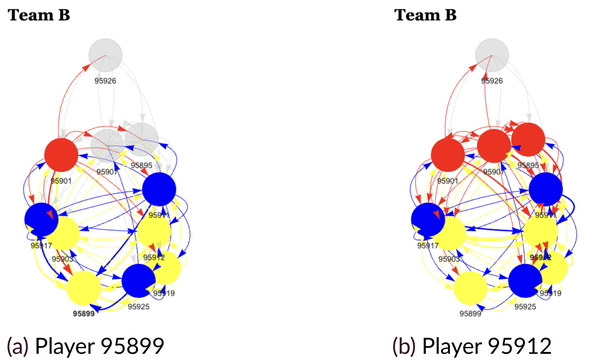


Figure 1. Degree centrality on the team's formation



(a) Player 95899 (b) Player 95912

Figure 2. Pass pairs comparison of two players

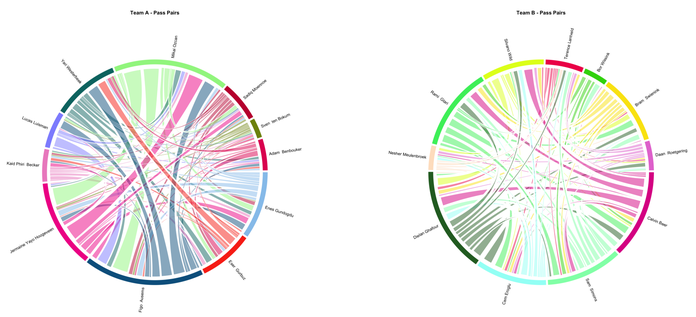


Figure 3. Comparison of each team's passing pairs

Results

Figure 4 presents the PageRank centrality scores for each player within their respective teams. As shown in Figure 2, there is a significant difference in the metrics related to being pass hubs between player IDs 95899 and 95912, further highlighting the disparity in their roles and influence on the field.

Team A (PR)

Node	PageRank
95890	0.15599392
95921	0.14179249
95915	0.11449622
95924	0.11203056
95913	0.10668841
95896	0.10145158
95920	0.06442495
95891	0.06113434
95892	0.05521228
95945	0.04825527
95893	0.03851999

Team B (PR)

Node	PageRank
95912	0.16494595
95911	0.12396670
95925	0.11089680
95903	0.10501199
95907	0.09803606
95895	0.09472388
95901	0.08409635
95917	0.07907170
95899	0.05614033
95919	0.05560319
95926	0.02750705

Figure 4. PageRank centrality order for both team

The implementation of PageRank centrality to measure pass connections allows for the evaluation of players' efficiency other than the selected player himself. For example, Figure 2(b) demonstrates that when Player 912 is either the passer or receiver, Players 917 and 985 play a more significant role in passing. This is evident from the number of arrows associated with them.

References

[1] Pedro Passos, Keith Davids, Duarte Araujo, N Paz, J Minguéns, and José Fernando Mendes. Network as a novel tool for studying team ball sports as complex social system. *Journal of science and medicine in sport / Sports Medicine Australia*, 14:170–6, 12 2010.

[2] José Gama, Pedro Passos, Keith Davids, Hugo Relvas, João Ribeiro, Vasco Vaz, and Gonçalo Dias. Network analysis and intra-team activity in attacking phases of professional football. *International Journal of Performance Analysis in Sport*, 14, 12 2014.

[3] Laszlo Gyarmati and Xavier Anguera. Automatic extraction of the passing strategies of soccer teams. *arXiv preprint arXiv:1508.02171*, 2015.