Network theory and analysis of football strategies

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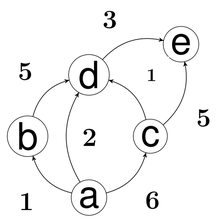
Summary

In this work we showcase the use of some tools from network theory in order to describe the strategy of football teams.
Each team gets associated a directed network where nodes correspond to players and arrows to passes providing a direct visual inspection of the team strategy.
The network allows to visualize a team's strategy, identify play pattern, determine hot-spots on the play and localize potential weaknesses.
Different centrality measures are used to determine the relative importance of each player in the game, the "popularity" of a player, and how affected would the team be if each player was removed from the game.

Networks



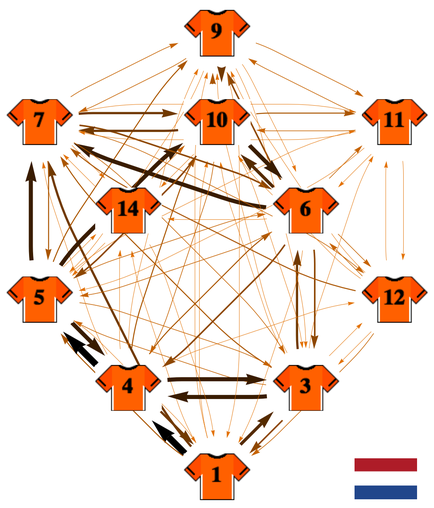
A ***network*** consists of:
- A collection of ***nodes***
- Some ***arrows*** connecting the nodes
- Some ***weights*** associated to the arrows

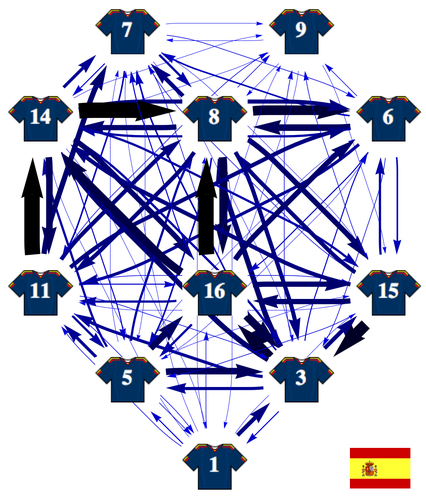
The network of a football team

- **Nodes** represent the **team players**
- **Arrows** represent **passes**
- **Weights** are the **number of passes**
- **Adjacency matrix of the network**:

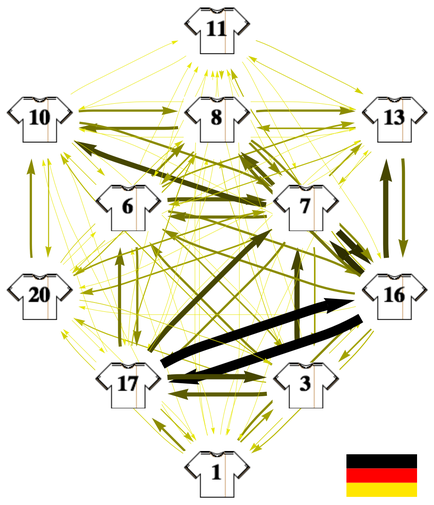
$$A_{ij} = \text{number of passes from } i \text{ to } j$$

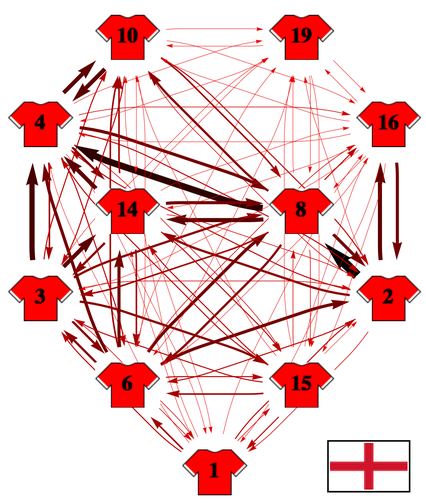
Netherlands vs Spain





Germany vs England





The fundamental theorem of football

"*Good football teams have a recognizable style*"

Our network helps to visualize that style!

Who is the most relevant player?

- ***Centrality measures*** give us relative notions of "importance" of a node in a network
- ***Closeness centrality:*** Mean distance from a node to the other ones

$$C_i = \frac{20}{\sum_{j\neq i} \frac{1}{A_{ij}+1} + \sum_{j\neq i} \frac{1}{A_{ji}+1}} - 1$$

- ***Pagerank centrality:*** Recursive notion of "popularity". A player is popular if receives passes from other popular players

$$x_i = p \sum_j A_{ji} \frac{x_j}{k_j^{\text{out}}} + (1-p)$$

  - $k_j^{\text{out}} = \sum_i A_{ji} =$ total number of passes made by j
  - $p =$ probability of passing the ball ($p \simeq 0.85$ works well)
- ***Betweenness centrality:*** How much the team suffers when a player is removed

$$C_B(i) = \frac{1}{10^2} \sum_{j,k\neq i} \frac{d_{jk}(i)}{d_{jk}}$$

$d_{jk} =$ distance from j to k, $d_{jk}(i) =$ distance after removing i

Centralities for Dutch players

	Player	Closeness	Pagerank	Betweenness
1	Stekelenburg	0.842	8.22%	2.042
3	Heitinga	1.296	9.27%	2.669
4	Mathijsen	1.046	6.34%	1.233
5	Van Bronkhorst	1.578	11.12%	4.159
6	Van Bommel	1.749	9.55%	3.585
7	Kuyt	1.655	11.67%	4.835
9	Van Persie	0.961	10.13%	1.402
10	Sneijder	1.724	11.67%	4.219
11	Robben	0.589	8.55%	0.792
12	Boulahrouz	0.529	6.10%	0.726
14	De Zeeuw	0.348	7.30%	0.333

Centralities for Spanish players

	Player	Closeness	Pagerank	Betweenness
1	Casillas	0.672	5.47%	0
3	Piqué	3.347	8.96%	1.19
5	Puyol	1.849	8.89%	0.92
6	Iniesta	1.889	8.35%	0.12
7	Villa	1.798	10.17%	1.19
8	Xavi	4.358	10.26%	2.49
9	Torres	0.578	8.30%	0
11	Capdevilla	2.975	8.96%	1.19
14	Alonso	3.742	10.26%	2.49
15	Ramos	2.251	10.17%	1.19
16	Busquets	3.239	10.17%	1.19

What do network tell us?

- Different teams have very different networks
- Quick overview of a team style
  - Most used areas of the court
  - Short distance or long distance passes
  - Players not participating enough
  - Problems between players
- Centrality measures give information about players
- Plenty of useful information for a coach!

Future work

- Keep track of unsuccessful passes
- Add an extra node for the gate to keep track of shoots
- Keep data consistent when a player gets changed