Coupled Dynamical Systems and Defense-Attack Networks: Representation of Soccer Players Interactions.

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Abstract

Applying network science to sports is gaining momentum. For example, the structure and dynamics of soccer teams have been modeled as a complex network resulting from passing interactions between players [Gonçalves et al., 2017]. Typical outputs of the network modeling are the characterization of the contribution of players to the team and the distribution of passing/reception in the field. This is possible using network metrics such as the clustering coefficient and centrality metrics (closeness and betweenness).

Since previous network modeling considered just one team at a time, the dynamics between competing teams has not been studied. Nevertheless, network analysis can include detailed data from both teams to represent the complex processes underlying team tactical behavior [Rein and Memmert, 2016]. In consequence, we obtain the average performance of one team but without the match context, and as we know, teams change their game system according to their opponents.

Also, the methodology applied to soccer analysis is just centered on the analyzing the offensive phases of game-play. We can consider that networks obtained are merely attacking networks. So, what about the defense network of the same team and the opponent team? As we can see, the problem sketched suggests that the natural coupled dynamics of soccer and similar competition games have been overlooked.

In this context, starting from our notion of "Systems with Coupled Dynamics", we introduce the modeling of competition games, such as soccer, as "Defense-Attack Networks". Multi-agent and Multilayer modeling were used to represent the conditions of these two notions.

Under random conditions, the multi-agent model of two soccer teams allowed to obtain for each one the node degree, the giant component and the number of agents in the component (Fig. 1). Also, the multi-agent model generates adjacency matrixes for the following multilayer modeling and characterization. Both models and routines were applied to five minutes intervals of a regular play of two halves of 45 minutes each and results were analyzed.

An advantage that our approach offers is a multi-scale view that clarifies the understanding of structure and dynamics within and among teams. Structure and dynamics arise from coupled dynamics, *i.e.* attack and defense strategies take place at the same time.

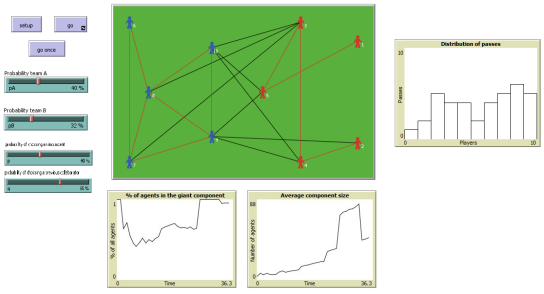

Figure 1: Multi-Agent Modeling of Coupled Soccer Dynamics

References

[Gonçalves et al., 2017] Gonçalves, B., Coutinho, D., Santos, S., Lago-Penas, C., Jiménez, S., and Sampaio, J. (2017). Exploring Team Passing Networks and Player Movement Dynamics in Youth Association Football. *PLOS ONE*, 12(1):e0171156.

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