Towards Quantifying Interaction Networks in a Football Match

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Abstract. We present several novel methods quantifying dynamic interactions in simulated football games. These interactions are captured in directed networks that represent significant coupled dynamics, detected information-theoretically. The model-free approach measures information dynamics of both pair-wise players' interactions as well as local tactical contests produced during RoboCup 2D Simulation League games. This analysis involves computation of information transfer and storage, relating the information transfer to responsiveness of the players and the team, and the information storage within the team to the team's rigidity and lack of tactical flexibility. The resultant directed networks (interaction diagrams) and the measures of responsiveness and rigidity reveal implicit interactions, across teams, that may be delayed and/or long-ranged. The analysis was verified with a number of experiments, identifying the zones of the most intense competition and the extent of interactions.

1 Introduction

Many team games, real and virtual, are characterised by rich interactions occurring dynamically and shaping the course of the contest both locally and globally. The interactions across the teams are created by typically opposing objectives of competing players and tactical schemes. The interactions within a team are usually constrained by cooperation and shared plans. Generally, the interactions are directed (e.g., a defender is marking an opponent's forward), varying in strength over time and/or space, and typically do not result from direct messaging or communications — rather they manifest some tacit correlations that often are delayed in time and/or are long-ranged over the play-field.

While a significant number of patterns emerging during a game may be evident even without an in-depth analysis, most of the interactions may appear intractable to an external observer who does not have an access to the logic and neural processing of the players. One then may formulate a general problem: how can an external observer identify most generic interaction networks that link together autonomous players, without re-constructing the players' behaviour and using only the positional data, such as planar coordinates and their changes? The problem is difficult as some of the dependencies between players are not discernible simply by correlating their dynamic locations over time — one needs to take into the account a possibly directed nature of such correlations, where dynamics of one of the players affects the positioning of another.

In general, as mentioned by Vilar et al. [1], "quantitative analysis is increasingly being used in team sports to better understand performance in these stylized, delineated, complex social systems". One of the older examples is "sabermetrics" — the specialised analysis of baseball through objective evidence, e.g. baseball statistics measuring in-game activity [2]. Another recent example is described by Fewell et al. [3] who analysed basketball games as networks, where