Tactical Team Behaviour in Australian Rules Football

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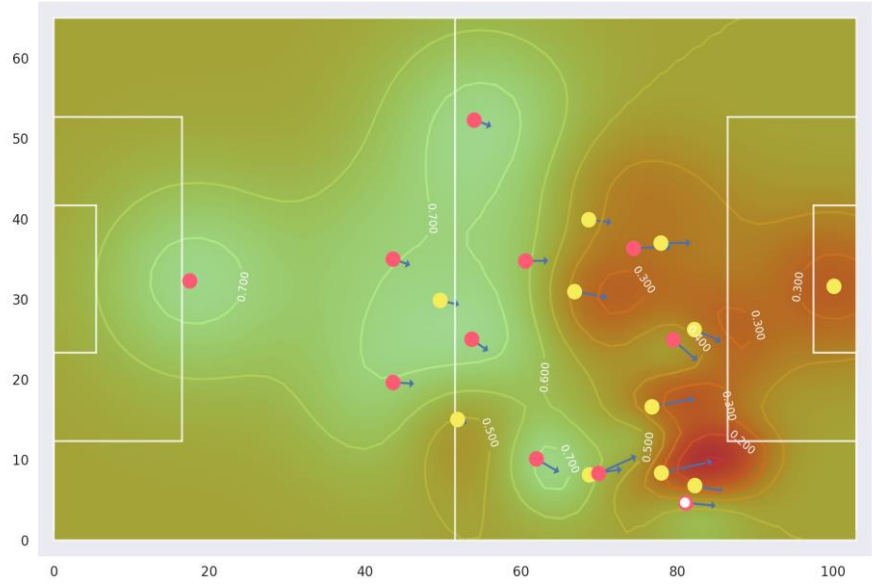
Introduction

- Player positioning used to determine collective organisation across a field of play
- Describe tactical behaviour whereby repetitive movement patterns are formed

- Macroscopic approaches:
  - Spatiotemporal metrics
  - Entropy (movement variation)
  - Heat maps

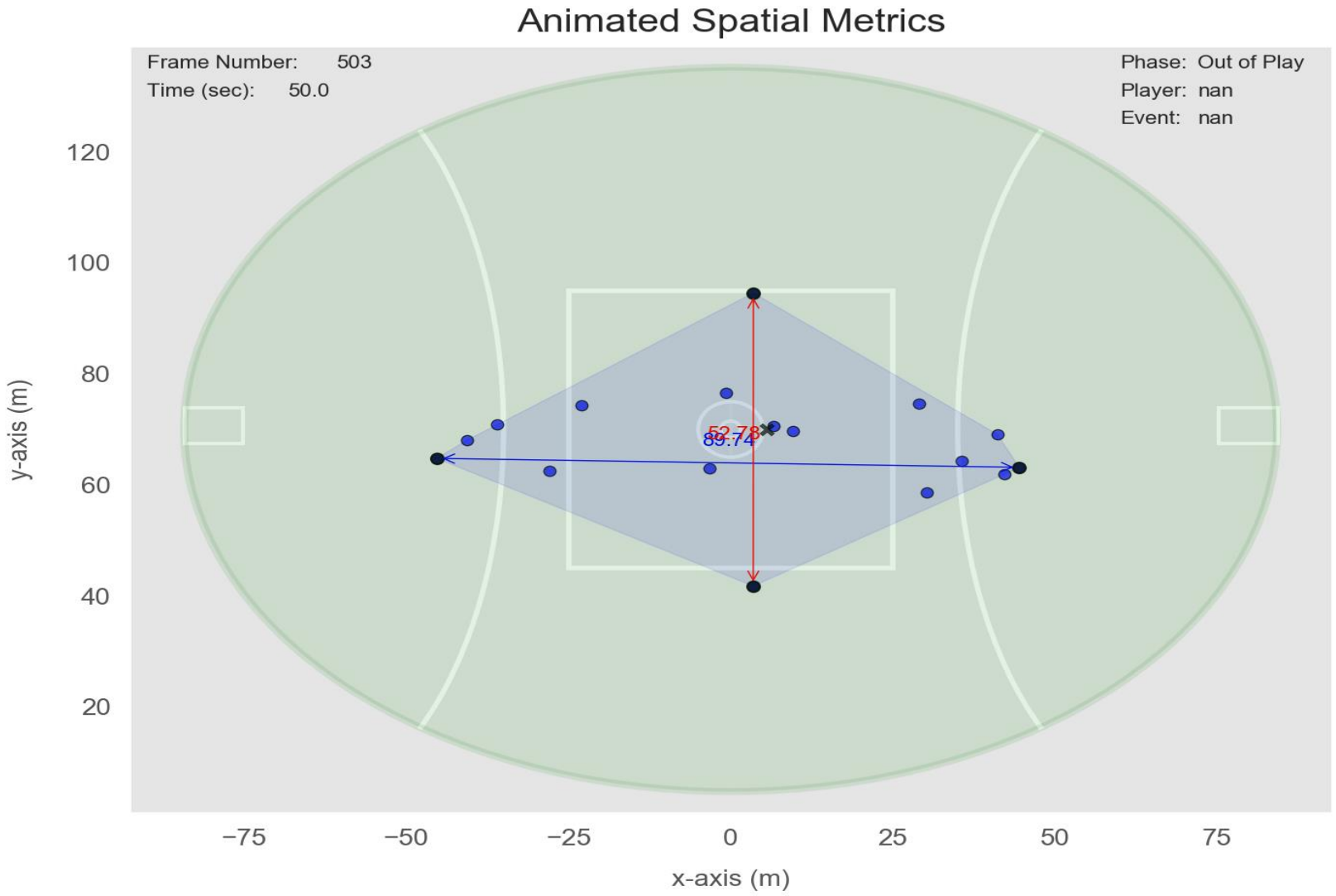
- Microscopic approaches:
  - Dominant Regions
  - Space Control



Introduction to Australian Rules football

https://www.youtube.com/watch?v=Mnv32s8jPz0

Macroscopic Approach - Metrics



Macroscopic Approach - Metrics

- Length

$$t_l(i) = max\left(P_x(i)\right) - min\left(P_x(i)\right)$$

- Width

$$t_w(i) = \max\left(P_y(i)\right) - min\left(P_y(i)\right)$$

- Surface Area

$$SA = \frac{(x_1y_2 - y_1x_2) + (x_2y_3 - y_3x_2) + \cdots + (x_ny_1 - x_1y_n)}{2}$$

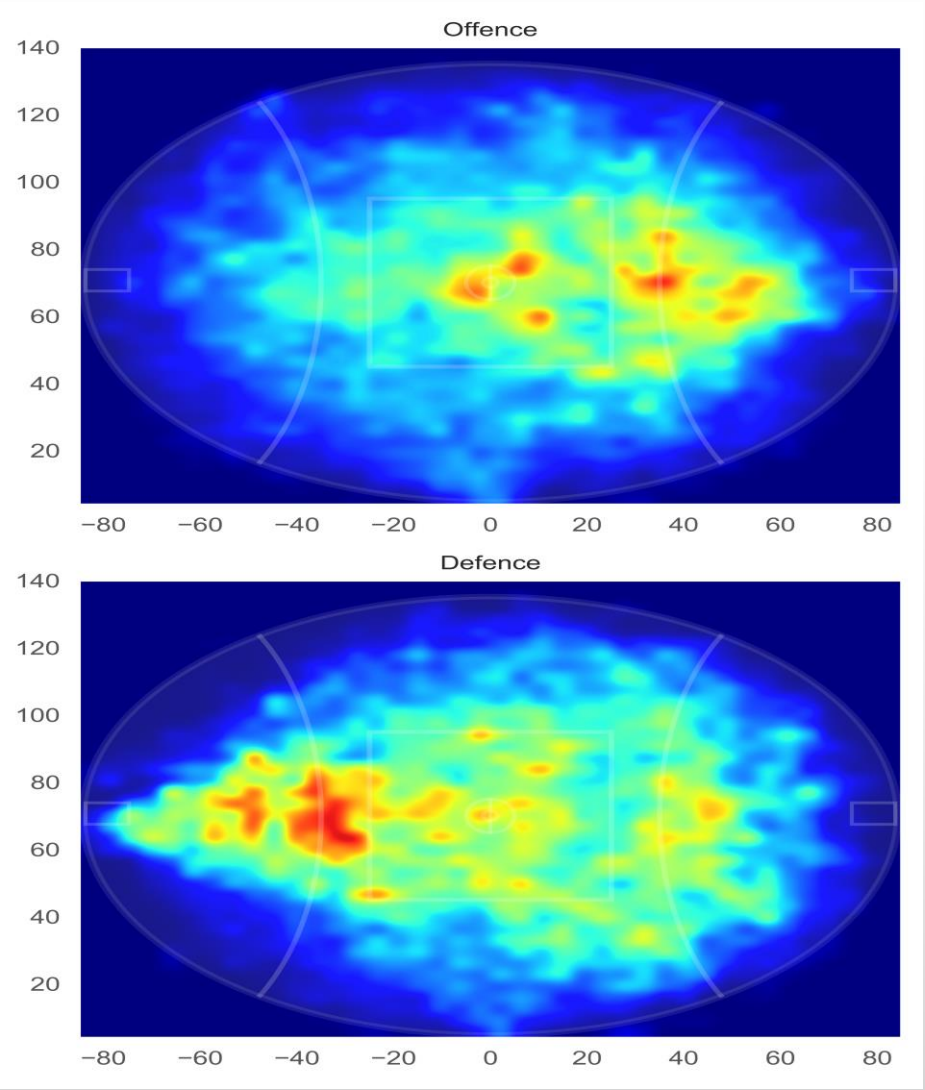
- Centroid

$$C(i) = \left(\frac{\sum_k^N p_{xk}(i)}{N}, \frac{\sum_k^N p_{yk}(i)}{N}\right)$$

Macroscopic Approach – Metrics, Heat Maps

Metric	Offence	Defence
Length (m)	70.45 ± 13.48*	60.03 ± 19.32*
Width (m)	53.34 ± 14.11*	41.11 ± 13.57*
Surface Area (m)	2568 ± 779*	2045 ± 565*
X-centroid (m)	0.74 ± 12.66*	-7.07 ± 11.90*
Y-centroid (m)	-0.76 ± 6.70*	-7.28 ± 6.53*

* = *P* <.001



Entropy (Shannon)

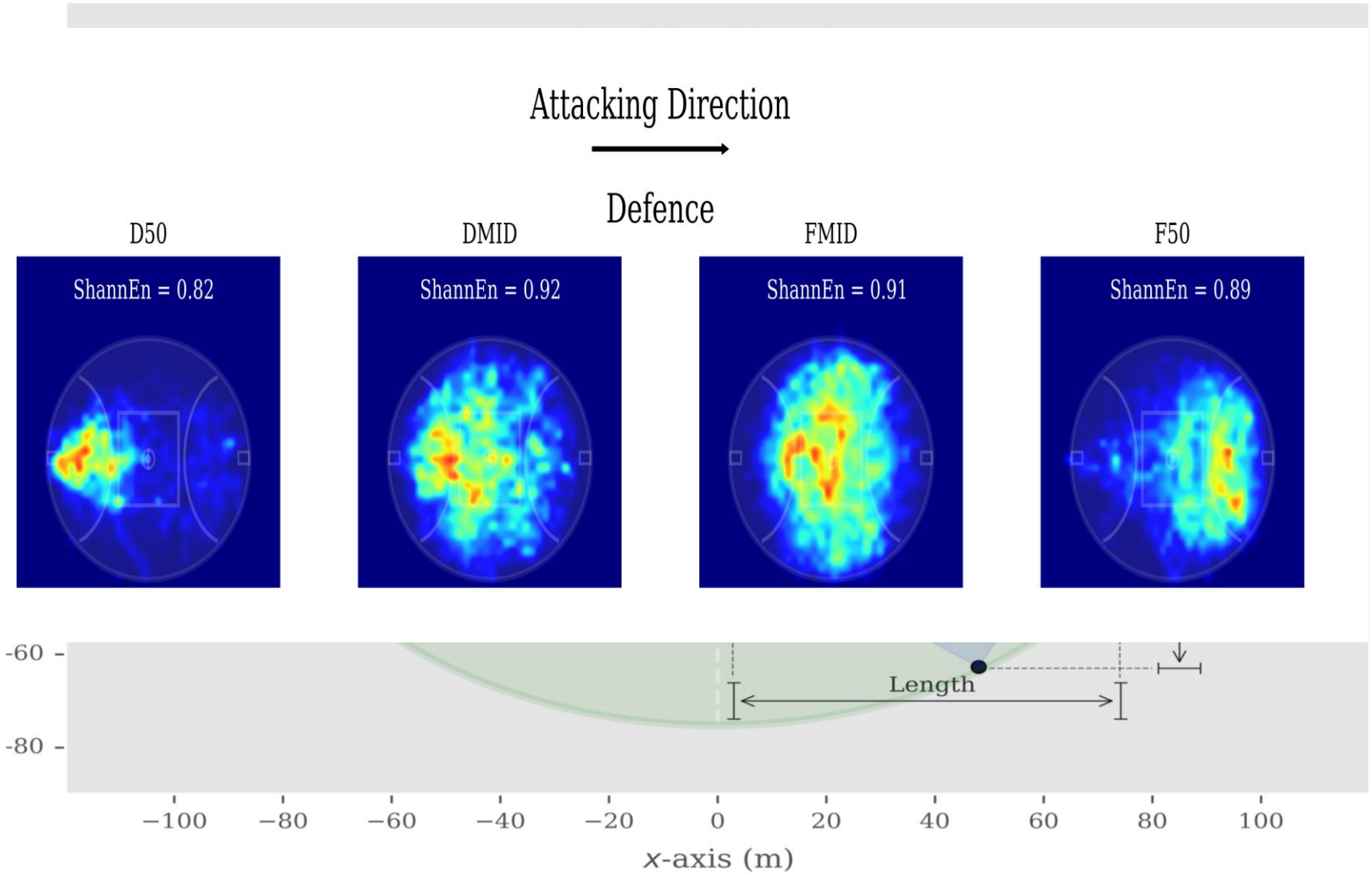
- probability mass function $p_{(i)}$ Where *hi* displays the histogram entry of the density value *i* and N_c is the number of total cells of the field

- Entropy was normalised *N* to match the total time spent in each position

$$p\,(i) = \frac{h(i)}{Nc}$$

$$S = -\sum_{i=0}^{n-1} p\,(i) \log p\,(i)$$

Macroscopic Approach – Metrics, Heat Maps



Microscopic Approach

- More granular comprehension of player movement behaviour
- Attempts to establish impact on ensuing match-play
- Provide initial understanding of relationship with performance outcomes

Dominant Regions

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SCIENCE OF WINNING SOCCER: EMERGENT PATTERN-FORMING DYNAMICS IN ASSOCIATION FOOTBALL*

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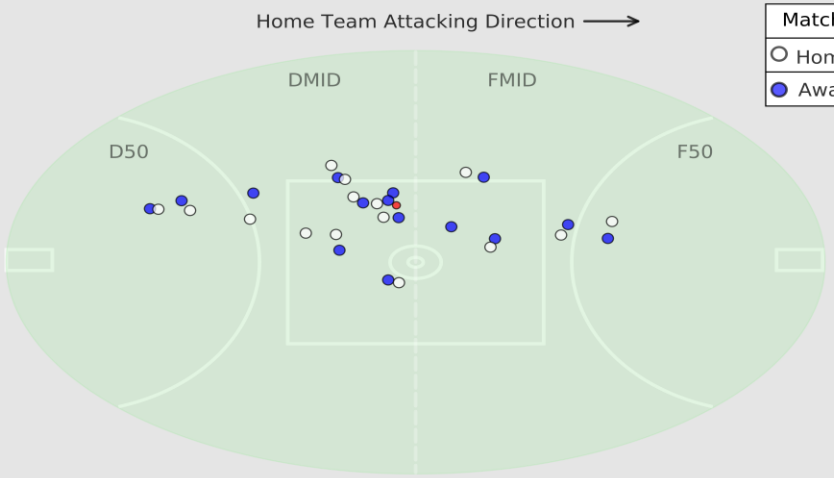
Abstract Quantitative analysis is increasingly being used in team sports to better understand performance in these stylized, delineated, complex social systems. Here, the authors provide a first step toward understanding the pattern-forming dynamics that emerge from collective offensive and defensive behavior in team sports. The authors propose a novel method of analysis that captures how teams occupy sub-areas of the field as the ball changes location. The authors use this method to analyze a game of association football (soccer) based upon a hypothesis that local player numerical dominance is key to defensive stability and offensive opportunity. The authors find that the teams consistently allocated more players than their opponents in sub-areas of play closer to their own goal. This is consistent with a predominantly defensive strategy intended to prevent yielding even a single goal. The authors also find differences between the two teams' strategies: while both adopted the same distribution of defensive, midfield, and attacking players (a 4 : 3 : 3 system of play), one team was significantly more effective in maintaining both defensive and offensive numerical dominance for defensive stability and offensive opportunity. That team indeed won the match with an advantage of one goal (2 to 1) but the analysis shows the advantage in play was more pervasive than the single goal victory would indicate. The proposed focus on the local dynamics of team collective behavior is distinct from the traditional focus on individual player capability. It supports a broader view in which specific player abilities contribute within the context of the dynamics of multiplayer team coordination and coaching strategy. By applying this complex system analysis to association football, the authors can understand how players' and teams' strategies result in successful and unsuccessful relationships between teammates and opponents in the area of play.

Key words Collective behavior, performance analysis, team sports.

Microscopic Approach – Numerical Advantage

	Match Events
Time	00:00:00
Player	Lachie Hunter
Action	Mark
Phase	Offence
Outcome	

	Player Positioning			
	D50	DMID	FMID	F50
Away	2	8	4	1
Home	3	8	3	1
Numerical Advantage	1	0	-1	0

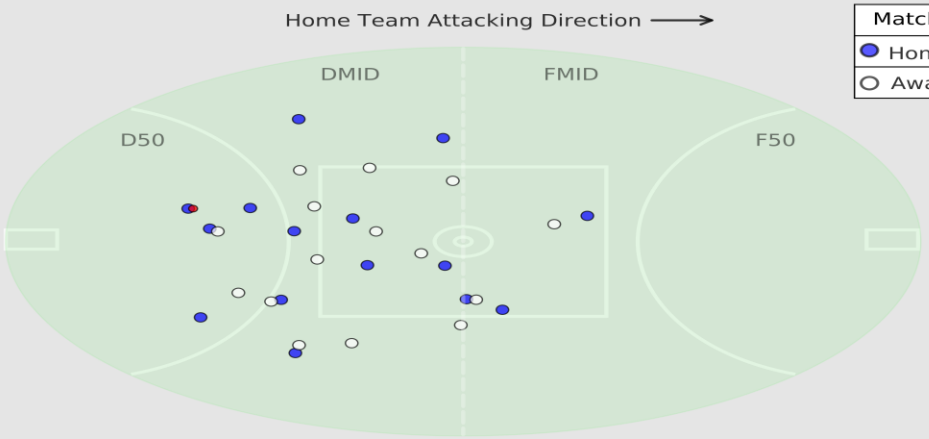


		Score Source									
		Score Breakdown (Goals.Behinds)					Total Match Events				
		D50	DMID	FMID	F50	Total	D50	DMID	FMID	F50	Total
Home	TO	0	0	0.0	0	0.0	0	0	0	0	0
	CL	0	0	0	0	0	0	0	0	0	0
	KI					0					0
	Total					0					
Away	TO	0.0	0	0	0	0.0	0	0	0	0	0
	CL	0	0.0	0.0	0	0.0	0	0	0	0	0
	KI					0					0
	Total					0					

Microscopic Approach – Numerical Advantage

	Match Events
Time	50:00:05
Player	Lachie Hunter
Action	Mark
Phase	Offence
Outcome	

	Player Positioning			
	D50	DMID	FMID	F50
Home	4	8	3	0
Away	2	11	2	0
Numerical Advantage	2	-3	1	0



Match Score	
Home	39
Away	51

		Score Source									
		Score Breakdown (Goals.Behinds)					Total Match Events				
		D50	DMID	FMID	F50	Total	D50	DMID	FMID	F50	Total
Home	TO	1	2	1.2	0	4.2	5	4	8	0	17
	CL	0	1	0	0	1	3	8	5	0	16
	KI					1.1					3
	Total					6.3					
Away	TO	0.1	2	0	1	3.1	6	10	4	4	24
	CL	0	1.1	3.1	0	4.2	3	8	2	1	14
	KI					1					3
	Total					8.3					

The likelihood of gaining possession of the ball increased if a team was able to generate a numerical advantage

Practical Applications

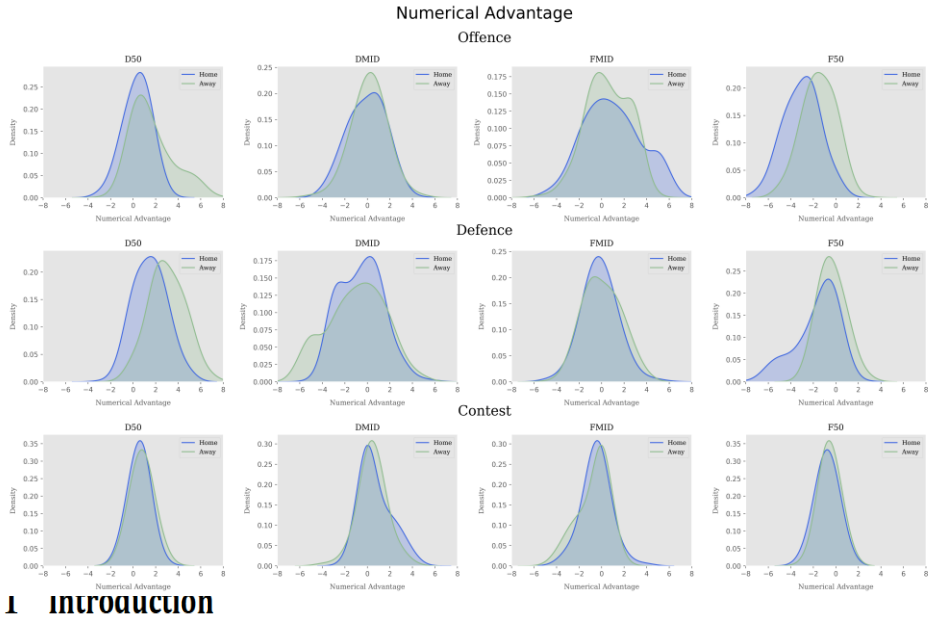
Understand the influence of player positioning on match play in a continuous manner

Granular understanding of tactical team behaviour

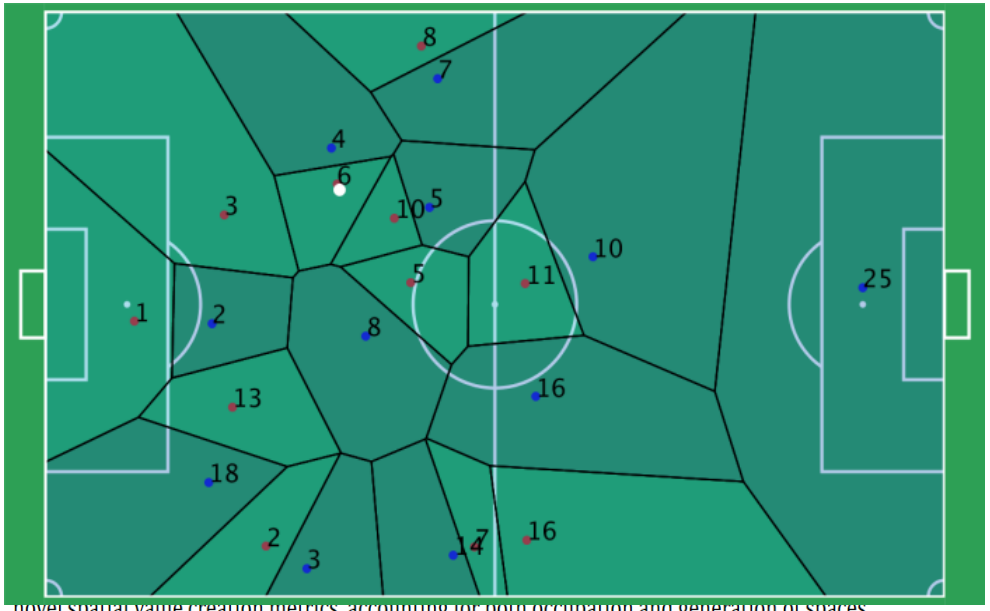
Inform rule changes

Smooth Space Control

- Numerical advantage and Voronoi diagrams solely attribute space to a player
- Uncertainty in who controls areas due to player density
- Probability of control may be more representative
- Bivariate gaussian distribution that accounts for:
  - Velocity
  - Distance to the ball



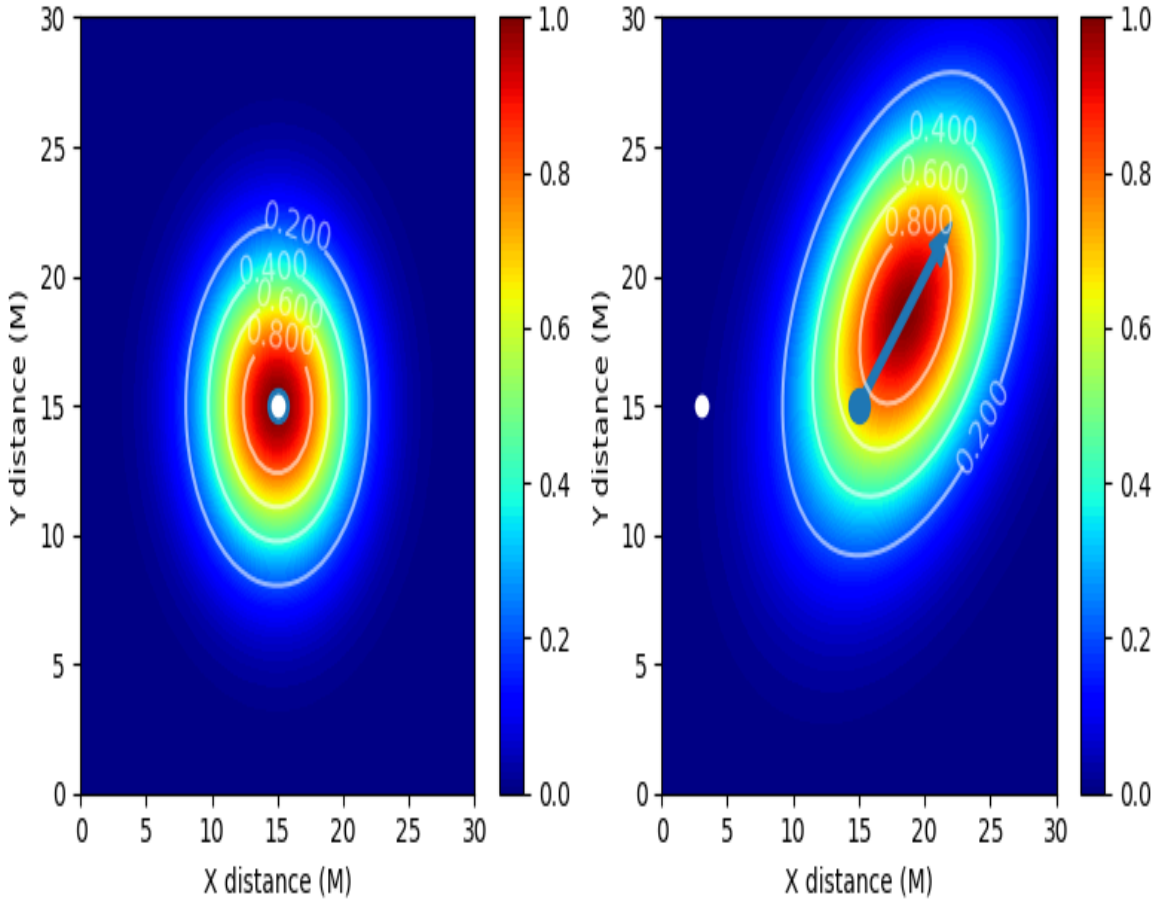
1 Introduction



novel spatial value creation metrics, accounting for both occupation and generation of spaces.

Smooth Space Control

- A player's influence *I* at a provided location *p* at time *t* is defined by a bivariate normal distribution with mean $\mu_i(t)$ and covariance matrix $\sum_i(t)$, given the player's velocity $\vec{s}$ and angle θ
- $I_i(p,t) = \frac{f_i(p,t)}{f_i(p_i(t),t)}$
- Values closer to 1 indicate greater control



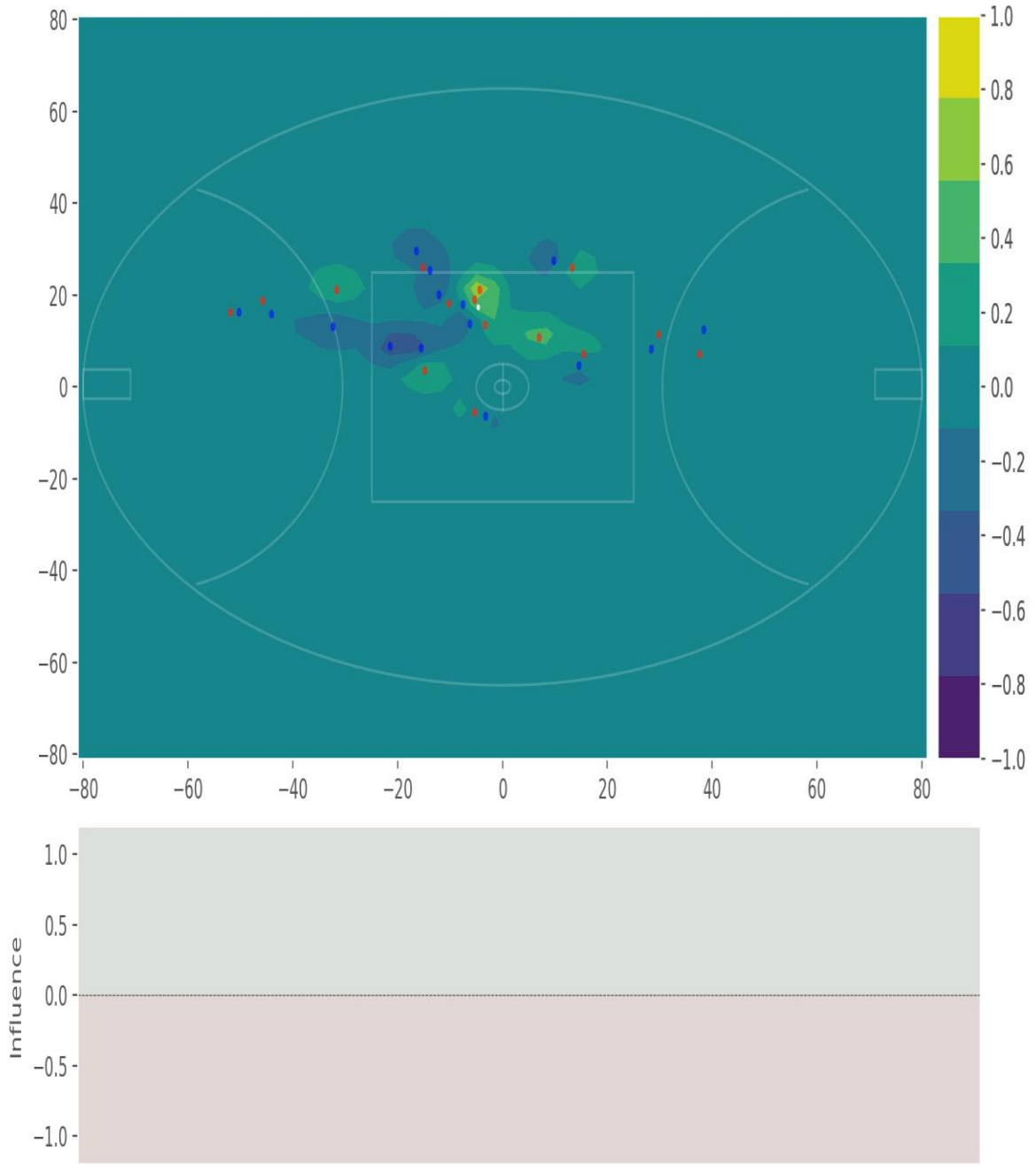
Left Figure: Player has possession of the ball and is stationary

Right Figure: Ball is 12.5m away and player is running at 5m/s on a 45 degree angle.

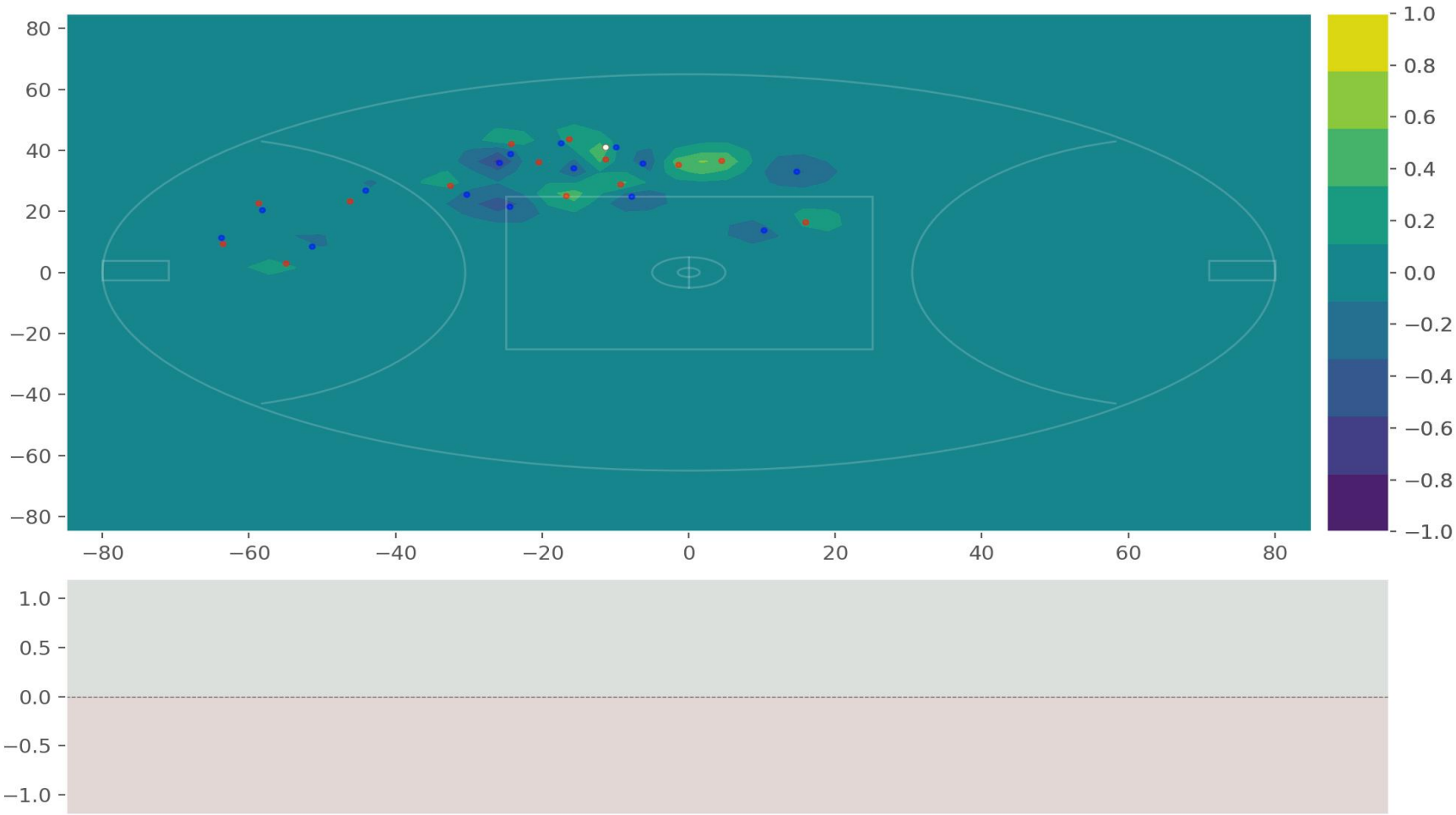
Smooth Space Control

- **Probability** of control or influence

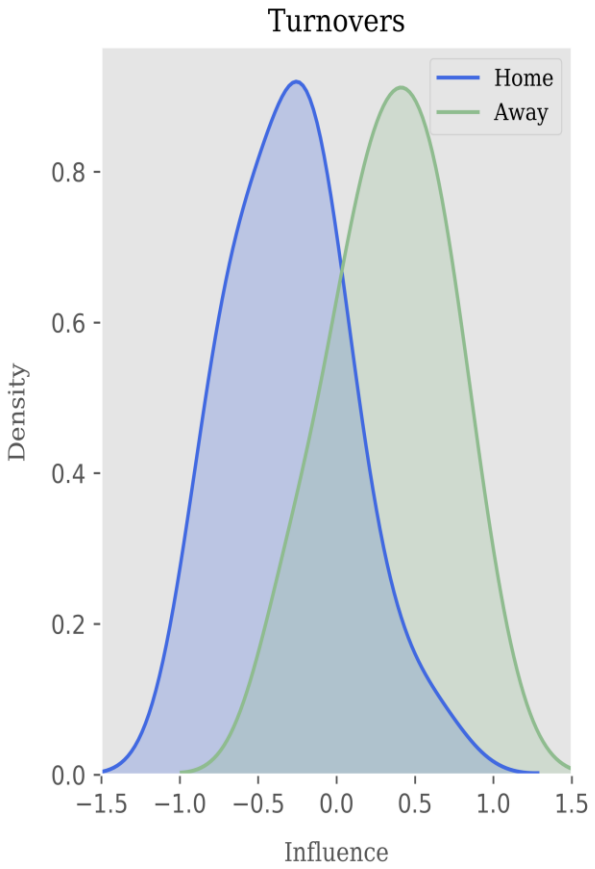
- Probability values closer to 1 indicate own team control
- Probability values closer to -1 indicate opposition control

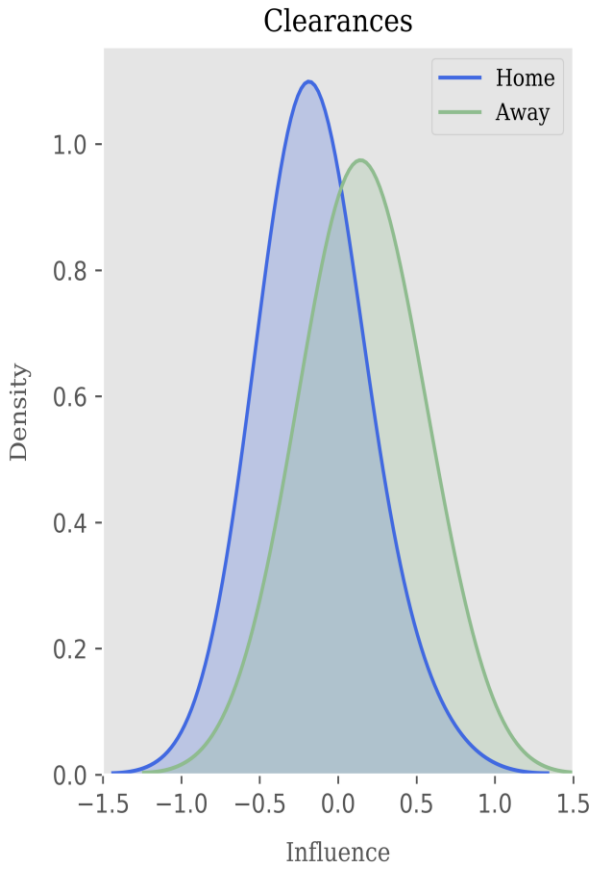


Smooth Space Control



Results





- Away Team Control = 0 to 1
- Home Team Control = 0 to -1

- Both teams had greater control over the area where a turnover occurred

Practical Applications

Realistic understanding of team spatial control

Determine how specific structures/formations provide control over specific regions

Establish how this control impacts continuous match play and performance