Closing Down Spaces

Extending Pitch Control to NFL Tracking Data

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Abstract

This study introduces a novel method to quantify and visualize NFL defense by adapting the concept of pitch control from soccer to American football.

In soccer, pitch control measures each player's potential zone of ball possession. We extend this concept to NFL defense to create tackle zone control.

Tackle zone control quantifies each defender's zone where a tackle is most likely. This is calculated using a monotonic neural network that considers features such as relative velocity, acceleration, and position of the defender, runner.

This approach offers a new way to analyze and visualize NFL defensive strategies and player effectiveness.

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The Baseline Model

What is *Pitch Control* in soccer?

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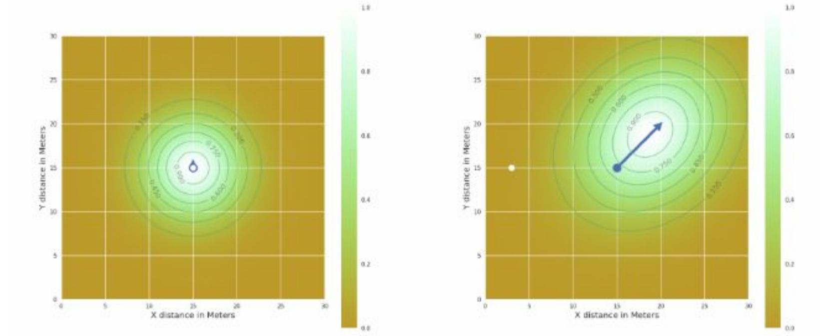
“Wide Open Spaces” by Javier Fernandez & Luke Bornn, MIT SSAC 2018

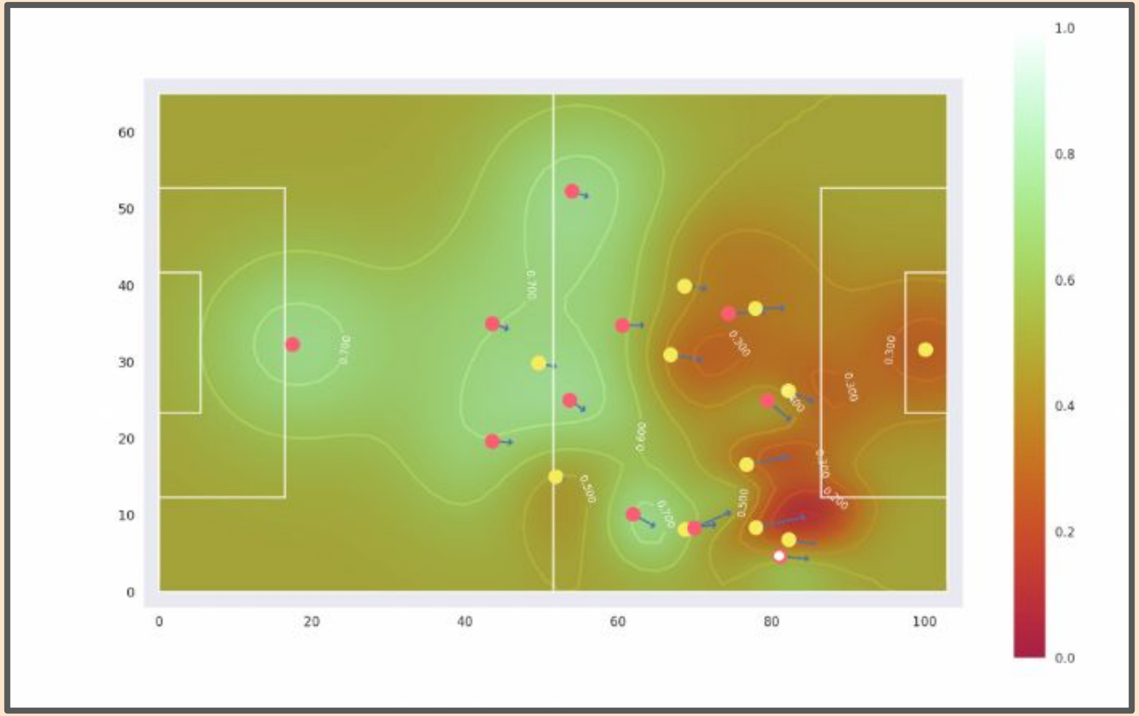
- Soccer is a game where players are without the ball 97% of the time, making off-ball events crucial for understanding the game's complexity.
- The Pitch Control Model: Incorporates motion information, relative distance to the ball, and player position to provide a smooth normal distribution of potential ball control.
- Rewards players based on their controlled space’s relative value, using the position of the ball.



(a) Player influence area for player in possession of the ball and no speed (lower than walking speed) **(b)** Player influence area for player 15 meters away from the ball, running at 6.36 m/s in a 45 degrees angle

Figure 2: Two situations representing the player influence area

Exemplary Pitch Control Visualization for Soccer



To adapt this to American football...

- Dataset: Tracking Data of Weeks 1-9 from the NFL in 2022 (Kaggle)
- What does each defender try to control on the pitch?

Soccer	American Football
At each moment in time, how much valuable space are players off the ball occupying?	At the <u>moment before catch/rush</u>, how much space are defenders <u>closing down</u>?

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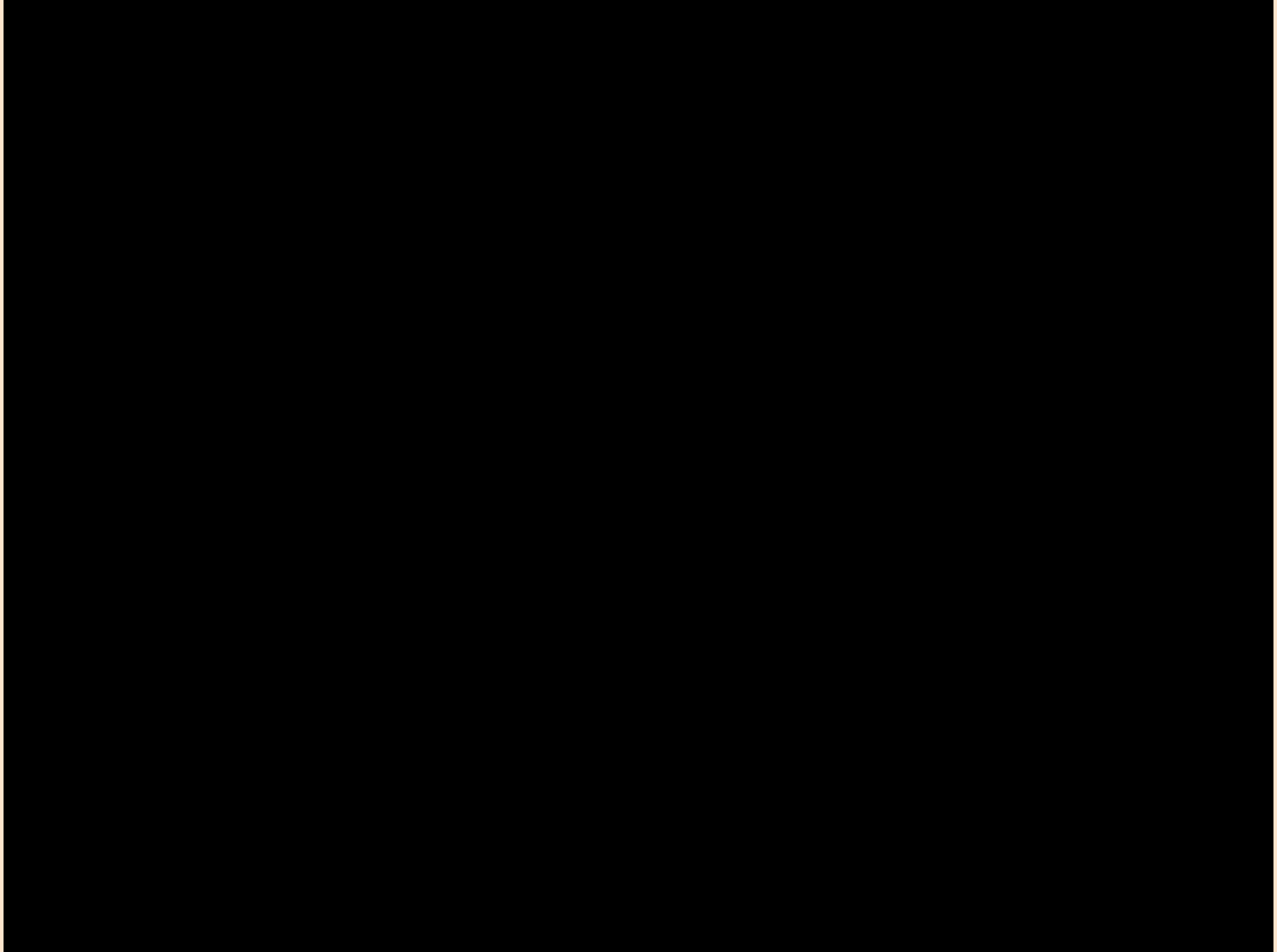

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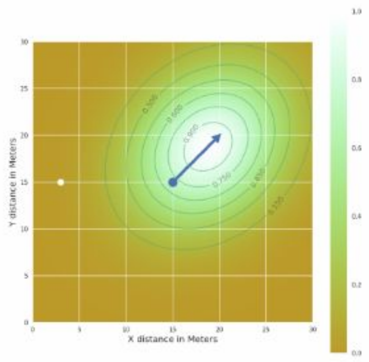
How to … ve this?



(b) Player influence area for player 15 meters away from the ball, running at 6.36 m/s in a 45 degrees angle

enting the player influence area

Which part of the baseline model is most specific to soccer?

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Monotonic Neural Networks

Joseph Sill, NeurIPS 1997

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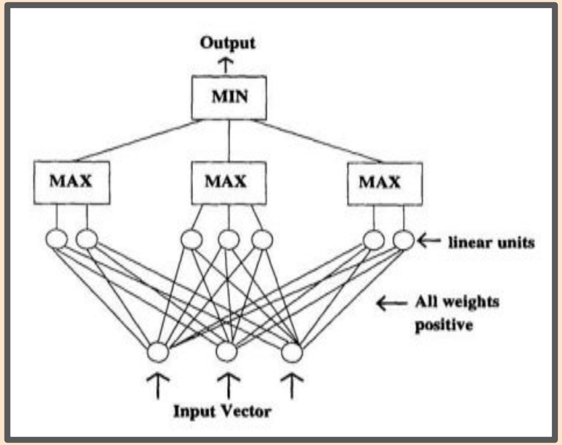
“Monotonic Networks” by Joseph Sill, NeurIPS 1997

- Enforces a monotonic relationship between input features and output.
  - Improved interpretability compared to traditional neural networks.
  - Predictable decision-making process with monotonic constraints.
  - Suitable for any application requiring transparent decision-making.
- Advantages:
  - Balances accuracy with explainability.
  - Facilitates understanding of how input changes affect predictions.
- Impact:
  - Opens new research avenues for interpretable models.
  - Addresses the "black box" problem of conventional neural networks.



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MNNs for the Tackle Zone Control problem

- Lack of data
- Imbalanced dataset (Only the tackler is labeled, for the last second before tackle)

⇒ To utilize a neural network, we need <u>hard-coded features</u> with guidelines (like the monotonicity <u>constraint</u>)

  - 'distance', 'rel_speed', 'defender_speed', 'carrier_speed'
  - 'relative_x', 'relative_y', 'cosine_similarity (of velocity vector)’

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Monotonic NN videos

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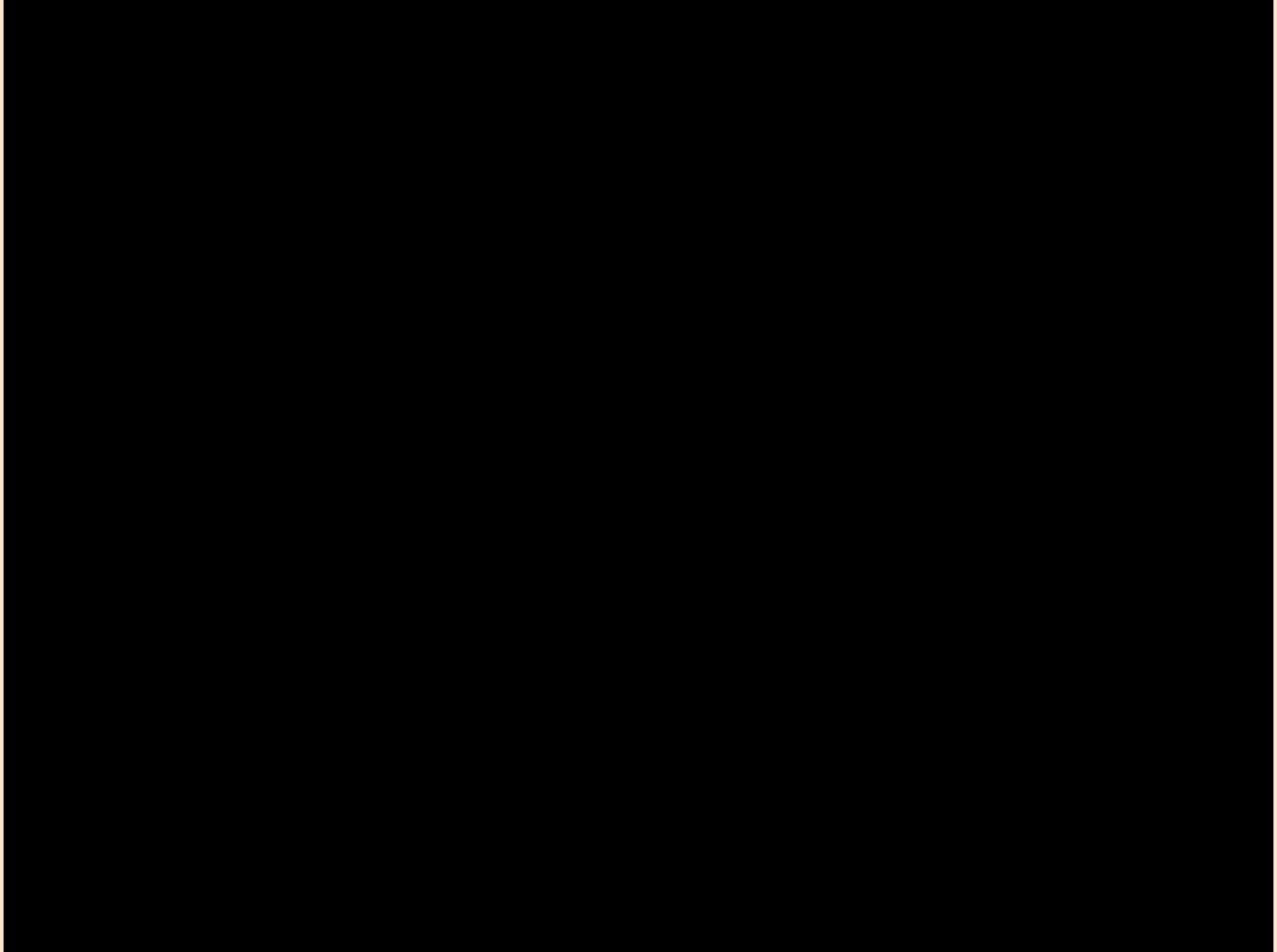

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Future Work

- Train more! (more data, more epochs, smaller cross-entropy loss)
- Player-specific neural networks to personalize tackle zones
- Defender Rankings:
  - Who outperforms the MNN-predicted tackle success probabilities across a season?
  - Who is always in a good position to tackle on average?
- Team Rankings:
  - Which defending teams cover the most possible receivers?
  - Which defending teams have the largest cumulative tackle control of the receiver on average?
- "Catch Zone Control" to extend concept to catches, swats, and interceptions.

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Thank you.