The Best Defense

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Charlie Olson
Topics to be covered

- Football background (some rules, etc.)
- Strategy Fundamentals
- Learning Defensive Schemes
Game Description

• 6v6 “passing league” rules
• two teams, one ref
• short field dimensions (40 yards, 30 wide)
• each team:
  six players
  one coach
Game Rules (simplified)

- 4 attempts to score a touchdown, starting at the 40
- Ball advances after a completed pass to the spot of the tackle (like usual).
- No first-downs, field-goals, punts, PATs, etc.
- No returning interceptions (simply a turnover)
Game Rules for Learning/Testing

- Simplified even further
- One team plays all-time offense
- Plays always begin at the 40-yard line
- Basic statistics are recorded (used later):
  - # of completions, and total yards
  - # of touchdowns
  - # of interceptions
Strategy Fundamentals

Offense:

**Plays** consist of **Routes**

Defense:

**Schemes** consist of **Zones**
Offensive Strategies

**play**: a collection of individual **routes**

**play-call**: play + specific instruction of where and when to throw

(I usually refer to the specific instruction as a play “variation”)

**strategy**: a distribution of **play-calls**
Defensive Schemes

scheme: a collection of zones

zone: 2x2 dimensional (center and radii)

\[ h = \text{“home”}/\text{center point of zone in R}2 \]

\[ r = \text{radii (vector to corner of rectangle enclosing the coverage ellipse) also in R}2 \]
The Task: 
Learn a Defensive Scheme

• Given: an offensive strategy
• Learn: a defensive scheme that shuts down the offense (force incompletions / deflections).
• Trivial for less than 5 play-calls in strategy
• Something like an online clustering algorithm for 5 clusters (with constraints on the rate of area-growth). The idea is to cover all points while keeping the cluster areas small – all in an online fashion.
Quarterback Rating for Eval.

- “Passer Rating” or “Passer Efficiency Rating”
- maximum value of 158.3*
- higher is better
- average rating is about 75
- for reference, record rating over a season is 121 (Peyton Manning, 2004)
  *probably will switch to the NCAA rating though, which is unbounded, w/ average > 100
The Algorithm

Given a reception-point \( p \):

For each defender, compute three vectors:

\[
\begin{align*}
  h' &= (h * (w - 1) + p) / w \\
  d &= p - h' \\
  \Delta h &= h' - h
\end{align*}
\]

Choose the defender with the minimum value of:

\[ ||d|| * ||\Delta h|| \]  
(in practice \( w * ||d|| \) works better)

update:

\[ h = h' \]

\[ \text{if}(w > 1) \ r = r + |\Delta h| \]
Appropriate Training Data

- Training data should generally belong to a “class” that the particular defensive scheme will specialize in.

- For example: train on many variations of a single play (or many plays from the same formation).

- Then, in a game, select a scheme matching the formation or play, and continue to refine the scheme as necessary.
Results
Results

• Previous Image:
  • 31 attempts
  • 15 completions
  • 7 touchdowns
  • 14 deflections (much better than hand-crafted defense!)
  • 94.40 passer rating (thanks to max. TD & yardage rating)

• Skewed by ridiculous initial TD percentage

• Results not in a pretty table yet, though I promise they will be eventually.
Long-term Goal

- Divide offensive strategies into “classes”
- Learn the best scheme for each class, and calculate expected utility
- Turn play-calling into a 2x2 matrix game of offensive play class vs. defensive scheme.
- Learn a prediction model of the opponents play-calls.
- Choose a defensive scheme that minimizes utility over the offense's predicted play-call (which is actually another probability distribution).
Conclusion

- Demonstrably good experimental results, but not clearly organized in tabular form yet.

- Need to experiment more with updating multiple zones at once, rather than just one after every completion (currently occasionally updates two zones at once under certain circumstances.)
Other Miscellaneous Topics

- Skeletal Animation, Inverse Kinematics, etc.
- Rule-scripting, etc.