Formation Generation: Deciding Where to Go

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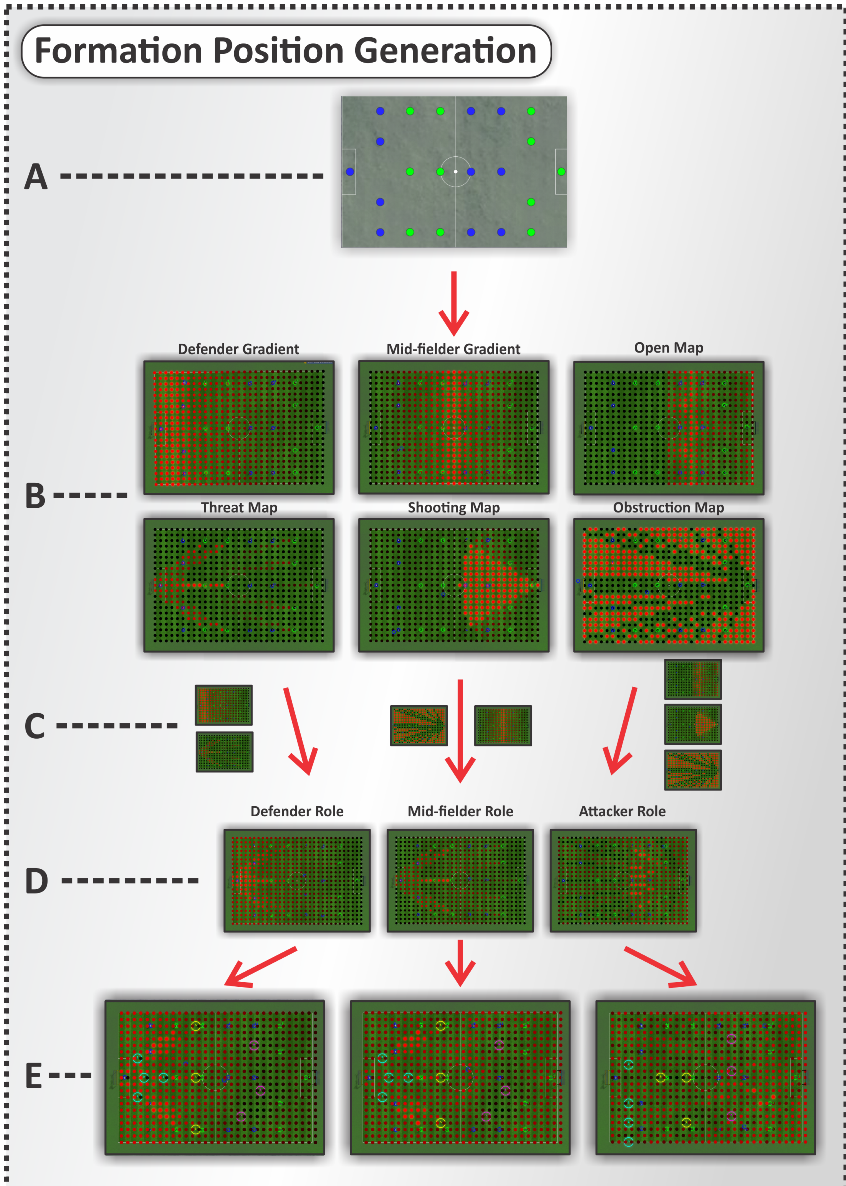

Figure 1: The Formation Position Generation System operates through a structured sequence of steps. Initially, Step A generates a formation based on the current game state. In Step B, individual heatmap evaluations are produced for all points on the field, aligned with a desired objective. Step C involves the selection of appropriate maps for each role. Subsequently, Step D collapses these individual maps using scaling coefficients. Finally, in Step E, a set of points is determined by selecting positions that are maximally highlighted in the heuristic map and by considering previously chosen positions.

In order to play effectively in Robocup, a number of challenges must be tackled. A fundamental task in the game is deciding where each player should be placed when there is no immediate task for that player to perform. The Wits-FC Robocup team has developed a series of heuristic methods which are combined to determine the relative strengths of each field location. First, the desired number of defenders, midfielders and strikers is determined based on the current state of the game. The best field locations for each role are then selected, indicating where the players would be best utilised. Players are then assigned to the selected locations using Hungarian matching.

Heuristics Employed The team currently targets two formations, (4,3,3) and (6,2,2) - attacking and defending ('Step A' in Figure 1)). The formation is selected based on which team is in possession. Once the formation is known, the appropriate field locations must be selected for the roles. This is done by calculating a number of heuristics which encode preferences about where the players should be ('Step B-E' in Figure 1)).

Role Specific Gradients The role-specific gradients can be either radial or linear and are defined by a specific target location. This target location acts as an attractor to help us define where particular roles should gravitate to on the field. For defenders, for example, a linear gradient centred around an x of -12 is used, to encode the notion that defenders should be more likely to be found close to their own goal. Note that other heuristics may override this preference and push the defenders further from their goal.

- **Threat Map:** encodes how useful a particular location would be in order to nullify a threat. First, the threats are identified by determining which players are the most dangerous. For each opposition player, this incorporates the distance to our goal and the distance to the ball. Then, the value of each location on the field is calculated by determining whether it is on the path from threats to the goal and how close to a threat it is. This map is primarily used for defenders and midfielders.
- **Obstruction Map:** encodes how dense the path between each field location and the goal is. Locations with a clear path to the goal will have a higher value than locations with players blocking the goal.
- **Shooting Map:** encodes how likely it is to score from a location with a single kick. This takes into account our maximum kick distance and the kick angle but ignores potential obstructions, which are encoded by the obstruction map.
- **Open map:** encodes the distance from the nearest opponent. This is based on the idea that it is desirable for pass receivers (midfielders and strikers) to be far from opposition players.

Combining the Heuristics The heuristics are linearly summed into role-specific combinations, using appropriate weightings for the specific role ('Step C' in Figure 1)). These weights are hand-tuned.

Selection Positions To iteratively find the optimal positions within the heuristic map for forming our formation, we follow this process ('Step E' in Figure 1)):

- Initial Search: We begin by identifying the maximum value within our heuristic map. This value indicates the most advantageous position according to our criteria.
- Position Selection: The position corresponding to this maximum value is selected and added to our formation.
- Negative Impact: Once a position is selected, we reduce the intensity of the heuristic map around this chosen position. This is done by applying a decay function to the surrounding area, effectively lowering the values in nearby positions. This step ensures that the same region is not repeatedly chosen.
- Repeat Process: We repeat the process of searching for the next maximum value in the updated heuristic map, selecting the corresponding position, and applying the negative impact.
- Termination Condition: This iterative process continues until we have identified and selected 10 positions for our formation.