A Dynamic Programming Approach to the Northern Virginia Senior Softball Player Assignment Model

Christopher Teixeira
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Background

Northern Virginia Senior Softball (NVSS) league is a nonprofit, co-ed, slow pitch softball league for seniors. The teams in the league are reorganized every year with the desire to make them as even as possible and promote social interactions. NVSS is seeking assistance in developing a methodology to produce team assignments for players such that the teams are equal in regards to player ability and other attributes.

Problem Description

Given the player ability assessments, the problem is to develop a methodology to create teams of equal ability by choice of skill and position subject to carpools, managers, personality and availability. The NVSS has several goals that they try to accomplish by assigning players. Their first attempt at assigning players included a heuristic that went through several goals and assigned players one goal at a time. This approach works quickly, but not efficiently since it cannot handle every goal proposed by the NVSS.

A recent approach to the problem was to look at the assignment problem from a integer programming perspective. This perspective proved to be beneficial since each constraint could be relaxed and the problem could be transformed into a goal programming problem. The problems with taking this approach lies in the technology used. As the size of the problem increases, the open source software used to compile and solve the problem becomes increasing slower. This could be solved using a commercial license, but the price range for this license exists out of the budget for the NVSS.

Dynamic programming should prove to be another potential solution that could have similar results compared to the integer programming solution. Similar to the integer programming methodology, dynamic programming will produce an optimal solution to the problem. Dynamic programming has the advantage of not requiring expensive modeling software and the ability to solve the problem in a shorter amount of time. It also has the flexibility of incorporating any goal identified by the NVSS committee.

Proposed Solution

Formulation

The purpose of this paper is to formulate the existing problem as a dynamic programming problem. The first step in designing a dynamic program model is to identify the main pieces to the model. The main pieces consist of the stage, state, decision, and the value function. This problem follows the typical resource allocation problems where each player is a resource being assigned to a team for the season. The complicated part of designing this model will be in the

cost function within the value function.

The stages can be defined as the number of teams wanted in each conference. The number of teams is predetermined by the NVSS committee directing the team assignments. They base their decision on the number of players available and a couple of rules. The rules set upper and lower bounds to each of the teams. For example, the NVSS rules say that there are to be eleven players on field during defense. Unfortunately due to absenteeism and injuries, they try to set each team to approximately fourteen players.

Similar to other resource allocation problems, the state of the model will be the amount of resources left to assign. For this problem, the players to be assigned to a team will be the resource in the model. This means that each resource is a unique player with a set of attributes and statistics. Since each of the players has a unique set of attributes, the decision to assign that player to a team will have to be separated per player. The decision will be made to minimize the costs of assigning or not assigning that player to that team.

The value function for this model will be built on the penalties associated with not completing a goal set by the NVSS committee. The goals set by the committee are based around characteristics for each of the players. The majority of goals revolve around spreading out players with a certain characteristic across the teams. For example, players with a certain level of Extra Base Batting Average[1] are considered to be power hitters. The league does not want any one team to have too many power hitters so one goal is to spread them out evenly across each team. The full list of goals can be found in Appendix A.

Using the original heuristic for assigning players, each of the goals were ranked according to their priority given in the heuristic. The Rank-Sum method was used to calculate weights for each of the goals. Ideally these weights should be elicited from the NVSS assignment committee to give some verification of each goal's importance to the team assignment model. These weights are then applied to the corresponding penalties for each goal.

The cost function will be a sum of the product between the penalties and weights for having assigned or not assigned that player to the team. The number of teams in each conference will determine the number of players per team with each of the characteristics. The total weighted value of characteristics per team will set the final goal for each team. Since the value function is defined in terms of penalties for assigning players and not benefits, the decision to assign a player to a team is optimized such that the minimum number of penalties with be incurred with that player's assignment to the team. Therefore, as a player is assigned to a team, the characteristics of that player are added to the team's total pool of abilities. As the list of abilities fills with player assignments, the cost function will start assigning penalties for going over or falling short of the team's requirement.

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[1]Extra Base Batting Average is calculated by taking the total number of extra bases (total number of bases minus the number of hits) and dividing them by the net times up to bat (number of trips to the plate minus the number of sacrifice fly).

Analysis Approach

In order to solve the dynamic programming model described above, a reaching method is suggested for getting the solution. The reaching method would allow you to go through each of the stages as you make a decision on each resource. In context of this problem, it implies that you can go through the list of players for one team at a time.

In general, there are some problems that might occur with solving the problem using dynamic programming. The curse of dimensionality might occur given that the player pool to select from can be large. However, due to some of the goals identified by the NVSS, the possible players to assign to a team from will be decreased for some of the teams. The inclusion of these goals will decrease the solution space and increase the overall speed of the model.

The tough part will be analyzing the solution to the model. Dynamic programming guarantees that there will be an optimal solution to the problem. However, there might be more than one optimal solution in the feasible region. A method for solving the problem can be utilized to identify all the possible optimal solutions for the problem. However, the question remains if one solution is better than the other. The introduction of the weights for each of the penalties in the model should handle this situation. In the case of multiple optimal solutions, it is recommended to reevaluate the set of weights used and solve the problem again with the new weights. Another recommendation would be to have the NVSS assignment committee produce an objective judgment on the equality of the teams. In addition to the committee reviewing the solution, they should review the input data read into the model. The order of the players as they enter the model will have an effect on the multiple solution scenario. Depending on the order, it would produce a different solution.

References

Denardo, Eric V. *Dynamic Programming: Models and Applications*. Mineola, NY: Dover Publications, 2003. Print.

Hillier, Frederick S., and Gerald J. Lieberman. *Introduction to Operations Research*. Boston: McGraw-Hill Higher Education, 2005. Print.

Winston, Wayne and Jeffrey Goldberg. *Operations Research*. Australia: Thomson Brooks/Cole, 2004. Print.

Appendix A: NVSS Goals

This table gives the full list of goals set by the NVSS when measuring the equality of teams.

Goal	Description
Power Hitters	Spread out the power hitters across the conference
Speed Base Runners	Spread out the players that have a high speed characteristic across the conference
Slow Base Runners	Spread out the players that have a low speed characteristic across the conference
Versatile Players	Spread out the players that can play multiple positions across the conference
Pitching Experience	Spread out the players with pitching experience across the conference
New Players	Spread out the players that did not play in the previous year across the conference
Thursday Only Players	Spread out the players who only play on Thursdays across the conference
Tuesday Only Players	Spread out the players who only play on Tuesdays across the conference
Either Thursday or Tuesday Players	Spread out the players who only play once a week across the conference
Pitchers	Spread out the players whose primary position is pitcher across the conference
Corner Infielders	Spread out the players whose primary position is catcher, third base, or first base across the conference
Middle Infielders	Spread out the players whose primary position is shortstop, second base, or middle infielder across the conference
Outfielders	Spread out the players whose primary position is in the outfield across the conference

Defensive Ability	Combine players such that all teams are equal in defensive ability across all the positions
Carpools	Assign carpool players to the same team
Consecutive Years	Players must play on different teams in consecutive years
Social Restrictions	Assign players that cannot play together to separate teams
Managers	Assign managers to teams before other players