Sensitivity and Scenario Analysis - Milestone 6

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Executive Summary

This report displays background information, methodology, experimental results analysis, calculations, and conclusive thoughts. Upon final readings of this documentation the reader will:

- Have new knowledge of how the game of golf works if there is only minimal knowledge of the game.
- Acknowledge the structure of the queuing system of a golf course.
- Acknowledge how time is affected by disorder in the random nature of human error.
- Gain insights into numbers from studies done with a multitude of variables, dynamically changing those numbers to attempt to garner more efficient times and better results.

Contents

1 Introduction

This report aims to provide an experimental representation of how changing specific parameters within the simulation changes the overall function and efficiency of its overall purpose. Exploring the simulation models results, much of the timestamp data, the marshal deployment data, and the data regarding the pace patterns of groups on the golf course will be studied within limits of given scenarios. Variables within the project themselves will be artificially altered to further and closely examine the effects of these individual changes. If these changes show any notably different results, those results will not only be shown, but will be studied to further the knowledge of the concept and how certain aspects of the simulation affected mimic the real life affect of the slowdown in the pace effect.

2 Definitions and Terms

2.1 Pace of Play

Pace of Play is a modeling system that enters a group of golfers into a queue by sending an individual or a group of carts into the track of the golf course at a specified point. Often times that starting point is hole 1 but can definitely be hole 10 or another hole depending on the conditions of the day.

2.2 Par and Strokes

Par is a standard number of shots that should be aimed to achieve when playing the hole. This is a metric of how well the golfer played the hole and essentially is meant to either be met or be scored lower.
Strokes are essentially the number of shots that you take (just another word for shots).

2.3 Group and Cart

Groups in golf typically consist of a variety of numbers of golfers, but for the sake of the scenario of the simulation, the group sizes in the base model are all counted at 4 golfers or 2 carts per group.

2.4 Course

The course in golf is essentially made up of 18 different golf holes with each hole having its own pars and distancing, therefore taking various different times. For the sake of the study, each par number associated with the 18 holes have a standard time that is the goal to achieve.

2.5 Sensitivity Analysis

The sensitivity analysis for this project is a form of methodology to measure how the simulation will be affected by certain changes in variable parameters.

3 Systematic Approach

3.1 Sensitivity Analysis

The sensitivity analysis provides the reader with context of how different variables found within a program can alter the state of the program in such a way that output results change or remain unchanged.

3.1.1 Analysis Elements

1. Key Variables
    - List of Variables to Consider
        - env time = 600 In minutes
        - tee times = list(range(1, 27)) Main value here to look at is the Y value so the top of the range.
        - return gap = 10 In minutes
        - group start delay = 10 In minutes
        - env.timeout = 5 In minutes
        - Time limit to deploy marshal set to 5 minutes
        - golf course "hole number"[1-18]
    - Expected Critical Parameters
        - "group start delay"
        - Time limit to deploy marshal
        - env.timeout
    - Justification
        - The reason that I chose the three critical variables that I chose is because with the groups that circulate and queue onto the course, they start in time intervals. If they are sent out in shorter time intervals, then they will constantly be backed up theoretically because they will be much closer to one another. Another important factor to note is the time limit threshold that is met when a marshal should be deployed for slow pace. If we decrease that variable down to maybe 3, how will this look? Since the marshals job is to correct slow pace, I believe that the deployment, after 3 mins over pace will cause a lot of over working on the marshal but overall might keep the players on better pace whereas if we increase it, there may be more slowdown. As for the environment timeout, the simpy framework based off of this number uses the cart return function to return said carts back to the cart barn in an orderly fashion so there is no backup on the course. This is important because if you have a much longer timeout, you will have a much longer time to wait per group thats present on the course close to finishing.
2. Parameter Ranges
    - The main call for randomized values within this project is the use of randomized integers measuring time in the hole par function where each par 3, 4, or 5 is associated with a time range. For example, par 3's have a range of 10-14 minutes of expected finish, par 4's have a rang of 12-16 minutes of expected finish, and par 5's have a range of 16-20 minutes of expected finish. The variation range for par 3's lays around 16.7 percent, for par 4's around 14.3 percent, and for par 5's around 11.1 percent.

- The statements conclusion was met after reaching out and speaking with a local pro at a golf course about the average times that they see vs expected times that they need to run a tight ship.

3. Analysis Design
   - The best ways to analyze the data here would be a combination of group variations. The methodology here would be to take all of the data polls here as groups of variable edits.
   - So, I am planning to take global sensitivity into account above all due to there being many factors within a pace of play system that would prohibit or restrict on pace play.
4. Simulation Run Parameters
   - Env time increased to 700, larger tournament size, behind pace marshal call increased to 10 minutes:
     - 8 Runs total
   - Return gap decreased to 5 minutes, start delay increased to 15 mins, env.timeout increased to 8 minutes:
     - 8 Runs total
   - Hole number rearrangement(start on 10 instead of 1):
     - 8 Runs total
   - Decrease in start delay to 8, time limit to deploy marshal to 8, decreasing env.timeout to 3:
     - 8 Runs total
5. Data Collection and Results
   - Within the appendix, you will find charts pertaining to the specified data gathered from the altered variables in global sensitivity testing. These specific variable changes were utilized for the scenario analysis as well.

     One of the common measurements of data that was used throughout the process was the number of times that the marshal was utilized to speed players on the course up who were playing slow. This data point with the new data runs compared to that of the simulation run is far in several runs compared to the several runs that have been conducted with the parameters set to normal values. There were far less needs for the marshal in these runs, most likely due to the fact that the marshal's time threshold had been increased nearly double over what it had been previously.

     Another aspect of the data that was heavily analyzed was the number of times that players fell ahead of, behind, or within pace. These metrics, in the data tables, were all measured separately, however, they work hand in hand with one another to show the patterns of time on the course. A common observation with this data was that the runs all fell within ballpark of one another in the instance where the return gap was decreased, the start delay was increased, and the timeout was increased and these runs also compared well to the other simulation data sets as well.

     One outstanding difference in the data that was found was that in the study done where the holes were rearranged, the number of groups that stayed within pace significantly dropped. This could be a pitfall within the data where the simulation may have malfunctioned.

4 Scenario Approach

4.1 Scenario Analysis

4.1.1 Analysis Elements

1. Scenarios
   - For the baseline simulation scenario approaches, the programs considerable variables and crucial variables scenario makeup are as follows:
     - Long tournament day
     - Smaller tournament day
     - Shotgun tournament
     - Higher send off rate
   - Alternative simulation scenario approaches in both an optimistic and pessimistic approach could be described as:
     - Fluid day with low marshal stress
     - Congested day with pace discrepancies and high marshal stress
2. Justify Scenarios and Concrete Example
   - The scenarios listed above in regard to baseline simulation runs all are different possibilities based upon real world issues that may arise on the golf course. The moments at the course where a tournament goes off and has many groups traversing the track of the course can cause a lot of buildup in the way that groups interact with one another on the golf course in terms of waiting. On the same side of that coin, some days the luck runs abound and the flow of players through the course is quick and easy. These two scenarios are uniquely random in nature due only to human nature and the way a golfer plays a round in a group. Several factors not important within this scope such as skill level, equipment quality, and just the overall quality of golf the person is playing all fit within factors that influence that randomness. There is truthfully no one group in a tournament that should finish a golf hole in the same amount of time as another. The random nature of man discussed here especially in the golf world affects a lot of factors of the round but the one factor that it affects the absolute most is time.
     - Baseline Scenario: Current marshal demand and stress conditions.
     - Optimistic Scenario: Decrease in marshal stress by at least 20 percent.
     - Pessimistic Scenario: Near constant need for marshal on the course at a 10 percent increase in desperation for fluidity.
3. Parameter Values
   - Long tournament day lasting roughly 11.5 hours
     - Env time = 700 in minutes
     - "tee times" = list(range(1, 32)) - Main value here to look at is the Y value so the top of the range.
     - Time limit to deploy marshal set to 10 minutes
   - Smaller tournament day lasting roughly 8.5 hours
     - return gap = 5 minutes
     - group start delay = 15 minutes
     - env.timeout = 8 mins

- Tournament starting on hole 10 instead of hole 1
  - Rearrange course array to fit test
- Quicker start day
  - group start delay = 8 minutes
  - time limit to deploy marshal = 8 minutes
  - env.timeout = 3 minutes

4. Scenario Simulations

   - In the testing phase of this section, a thorough analysis of 8 runs per scenario was done in order to capture the nature of 8 separate tournament situations across the board. The runs provided display results on the anticipated long tournament, the anticipated short tournament, the shotgun start on hole 10, and the quicker sendoff.

5. Analysis

   - In the numerous runs that took place with this data, the comparisons that were made among the different data sets were interesting. One important part to note about the various data sets is in the set that measures the number of times that a group says within pace. You will observe a green line in the line graph that represents the effects of starting groups all on a new configuration of the course. This of course caused major issues in the data where there were many more times that the groups fell behind in pace than stayed within pace or ahead of pace. Another visual to observe is the marshal assistance need graph. In the rounds that are anticipated to be long and strenuous tournaments, the overall need for a marshal is much lower, due to there being less of a demand time wise for them to come out to the course whereas on days that are anticipated to be short, there is a much more dire need to have them on the course and there is way more stress on them as a whole. In looking at the visual data on the graphs,the number of times that golfers were ahead vs behind data is pretty ballpark similar to each other. There are a few data spots where the graph falls short like in run one where the day is anticipated to be short, but overall it seems like by the minute itself, there is a sense of pace being kept. Essentially, as you study these charts, the flatter and least dynamic the bar graphs are in comparison to one another, the better.

   - Below you will find data comparisons done between the data sets previously mentioned. (I don't have a clue what has happened to the formatting of the images, I tried forever but was never able to come to a resolution. I also am using images because as I tried to get tables and charts made here, for some reason I was having just as many formatting issues if not more.)

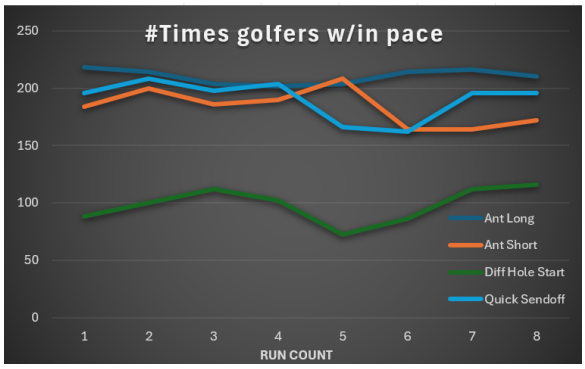

Figure 1: Graph 1: Comparing Scenarios and the number of times golfers fell within pace for 8 tournaments

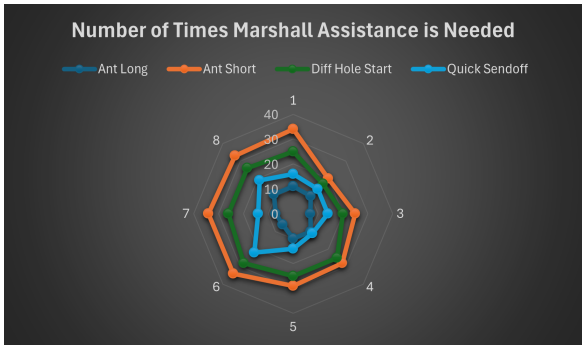

Figure 2: Graph 2: Comparing Scenarios and the number of times the marshals assistance is needed throughout each run

4.2 Discussion

- As we look at the data and the graphs and study the differences in the data from the first simulation runs and the now tweaked simulation runs to account for the analyses, there are many good points of data research that have come out of this study. For one, the variables that were explained earlier within the document, all cooperate with one another when studying sensitivity and scenarios specifically, the four scenarios that have been laid out. In many cases, there is a big talk about how to speed people up in an effective manner to where the golf course not only makes their money faster, but the groups that play have an enjoyable experience and so as a result in this program and study there have been many data points that have been picked up on by myself that I can confidently pinpoint as issues that slow down the pace of play on a golf course.

  For one, the pace of play threshold. This metric of time has been used for years and while not always being at 5 minutes like my own standard metric, it is still quite low for many courses that most definitely should have a higher time threshold. One thing from the data that I myself learned is that just because you rush groups onto the course for the tournament, does not necessarily mean you are going to run less of a risk of burning valuable time (also money) on the golf course for other non tournament playing golfers. Most of the time in cases like these, your cart turnover is going to be significantly slower compared to having a more structured way of sending groups out to play. Another factor that I can confidently say influences the time

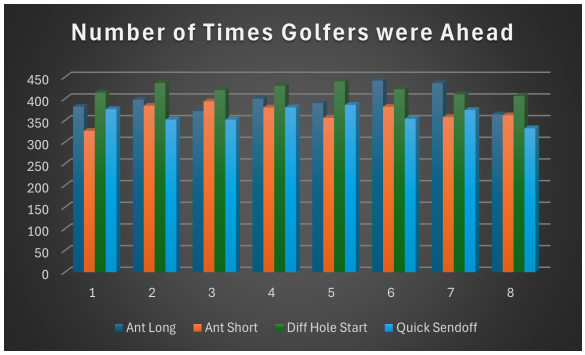

Figure 3: Graph 3: Comparing Scenarios and the number of times the groups were ahead of pace by at least a minute

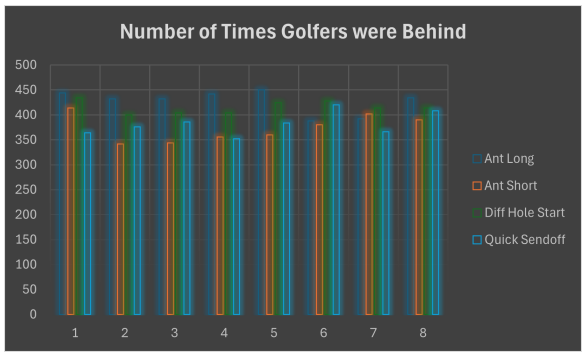

Figure 4: Graph 4: Comparing Scenarios and the number of times the groups were behind pace by at least a minute

that it takes a golf course to complete a tournament is the number of groups per tournament. One major factor in a large tournament is always going to be slow play solely because there are just so many people out on the course at a given moment. There are most definitely pitfalls in this study, one being the overall formatting of the visuals needed to display the points, the overall errant behavior in a few outlying pieces of data but overall of the data that has been reliably and easily retrieved, I can firmly say that the objectives that were tackled in the data study itself yielded the results that sought.

5 Conclusive Statements

Throughout the 32 runs of data that were studied among all of the grouped variable changes, one common thing has not changed since the standard simulation run and that is that time prevails, no matter the arrangement. This report displayed a background of information about the project, the methodology used to analyze the data, and the experimental results that were yielded in both discussion and visual aid. From doing this project, new knowledge has been gained about the pace of play model and certain aspects that promote slow play and marshal stress the most have been pinpointed. Throughout this milestone, the goal has been to find discrepancies at a high level so that later this program can be utilized at much deeper low level to solve the issues of the real world.

5.1 References

- W3schools.com. W3Schools Online Web Tutorials. (n.d.). https://www.w3schools.com/python/python_regex.asp

5.2 Appendix - (Items below Can be found at the end of the document)

- code snippets
- SSA Data Charts from analysis (Improper formatting problem)

```python
def get_standard_time(self, hole_number):
    if hole_number in [3, 6, 13, 16]:  # Par 3 holes
        return 12
    elif hole_number in [2, 4, 5, 7, 9, 10, 11, 12, 14, 17]:  # Par 4 holes
        return 14
    else:  # Par 5 holes (holes 1, 8, 15, 18)
        return 18
```

Figure 5: Course structure in relation to time

```python
if self.group_over_limit[group_id] >= 8:
    self.send_marshal(group_id)
```

Figure 6: Used as marshal threshold time

```python
def get_par_wait_time(self, hole_number):
    if hole_number in [3, 6, 13, 16]:  # Par 3 holes
        return hole_par.par_3()
    elif hole_number in [2, 4, 5, 7, 9, 10, 11, 12, 14, 17]:  # Par 4 holes
        return hole_par.par_4()
    else:  # Par 5 holes (holes 1, 8, 15, 18)
        return hole_par.par_5()
```

Figure 7: Function to set course orientation

Anticipated Long Tournament Day	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8
Needs for marshal	11	10	7	10	10	6	7	11
Number of times groups fell ahead pace	382	398	372	400	390	442	436	364
Number of times groups fell behind pace	444	432	432	442	450	388	392	434
Number of times groups were within pace	218	214	204	202	204	214	216	210

Figure 8: Data Chart Associated with the first set of parameter changes in the Sensitivity Analysis and also the first scenario

Anticipated Short Tournament Day	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8
Needs for marshal	34	20	25	28	29	34	34	33
Number of times groups fell ahead pace	326	384	394	380	356	382	358	362
Number of times groups fell behind pace	414	342	344	356	360	380	402	390
Number of times groups were within pace	184	200	186	190	208	164	164	172

Figure 9: Data Chart Associated with the second set of parameter changes in the Sensitivity Analysis and also the second scenario

Different Hole Start	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8
Needs for marshal	25	17	20	25	25	28	26	26
Number of times groups fell ahead pace	414	436	420	430	440	422	410	406
Number of times groups fell behind pace	434	400	404	404	424	428	414	414
Number of times groups were within pace	88	100	112	102	72	86	112	116

Figure 10: Data Chart Associated with the third set of parameter changes in the Sensitivity Analysis and also the third scenario

Quicker Sendoff	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8
Needs for marshal	16	14	14	11	14	22	14	19
Number of times groups fell ahead pace	376	352	352	380	386	354	374	332
Number of times groups fell behind pace	364	376	386	352	384	420	366	408
Number of times groups were within pace	196	208	198	204	166	162	196	196

Figure 11: Data Chart Associated with the fourth set of parameter changes in the Sensitivity Analysis and also the fourth scenario