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# P1_7 Modelling Imperfections in: The Average Golfer

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**Abstract**

Fox et al. (2021) [1] produced a simulation of the average golfer on an idealised golf course to determine if the sum of 'average' shots was an 'average' score. This paper builds on this simulation and models hazards such as bunkers, water hazards and out of bounds areas. An increase of roughly 11 shots per round was found on average compared to the previous study.

## Introduction

This paper builds on [1] and attempts to model additional factors on the course. Here, out of bounds regions, bunkers, water hazards and a penalty for being in the rough are modelled. This attempts to make the simulations more realistic and further refine the input parameters.

## Method

Building on the previous simulation [1], some new functions are required. Firstly though, the new features need to be assigned. Additional columns are added to the hole information table. Values for water hazards and bunkers include a left and rightmost y position and a width. These values, give positions of rivers and bunkers.

The first new function is the 'Ideal Position' function, when the club is being chosen, this is called to determine the position a shot with each club should land. This is essentially the old 'play shot' function but without the random variance. The output position is then input into a new 'Safe Aim' function. This checks if the hole has any bunkers or water hazards present, then if the proposed position is within these. If so, it returns false. Additionally, the out of bounds regions are also checked. If the shot is 'safe', true is returned. The old choose club function will now also check a shot is 'safe' before assigning a new best club.

When playing the shot, an 'Is Safe' function is called, this is like the Safe Aim function however bunkers are permitted. If the shot is unsafe (out of bounds), the next ball position is set to the previous position. Conveniently, this means that the stroke penalty is naturally imposed and the next shot is taken from the position the poor shot was taken from.

The final modification penalises hitting from bunkers and rough. Two functions check if the ball is within either of these. If so, the distance of each club is multiplied by a 'Lie Factor', approximated as 0.4 and 0.7 respectively. The golfer would expect this so these factors are also added to the club choice function. Hence, a stronger club is chosen, which is inherently less accurate.

## Results

Figure 1 illustrates how the changes have affected the shots attempted. Where in [1] drives were hit towards a 220 yard target, here shorter shots are being attempted to avoid the hazard.

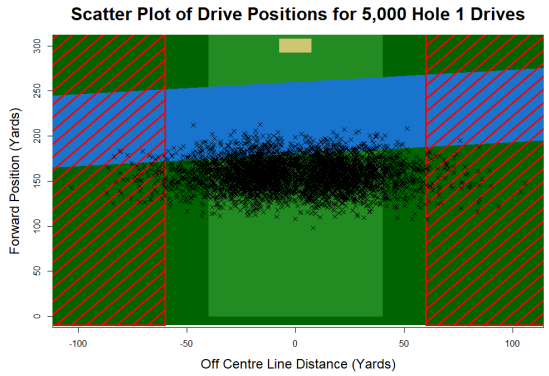


Figure 1: 5000 simulated tee shots on a hole containing a water hazard around the usual tee shot landing point.

Figure 2 shows what happens when a shot is hit into a hazard, here the first tee shot isn't permitted, so the shot is retaken from the tees.

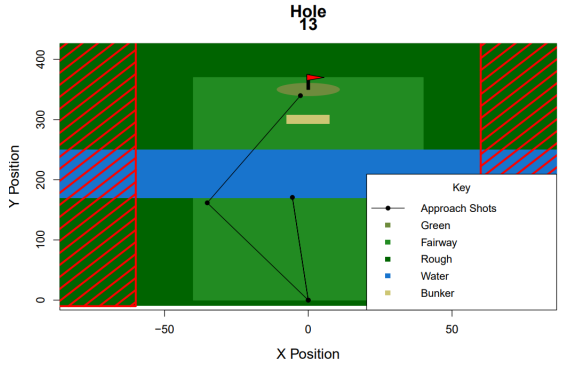


Figure 2: Illustration of a hole being played where a shot lands out of bounds (in water hazard).

Figure 3 shows a histogram of the scores for 100,000 golfers in the new simulation. This gave a mean score of 99.09 with a standard deviation of 5.234. The modal score was 98.

## Analysis and Conclusions

The mean score is worse than in the previous study [1], by roughly 11 strokes per round. This represents the increased difficulty an imperfect course produces. The standard deviation has also increased, showing how disparity is created from having to taking a penalty. The new mean is around 5 over the average as defined by [2], indicating that the variance parameters chosen in the previous study [1] may be too large.

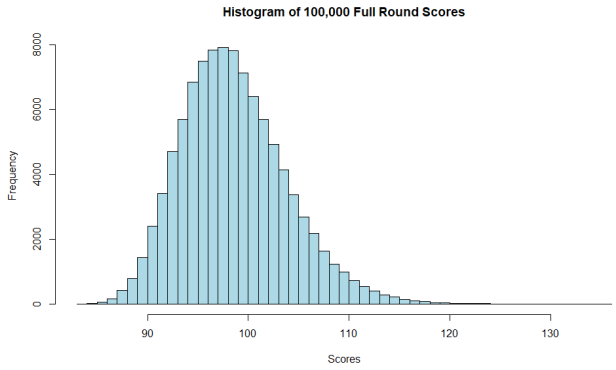


Figure 3: Histogram of scores recorded over 100,000 simulated rounds.

Notably, less rounds are simulated than in [1], as the model is more complex. However, Figure 4 shows that the mean is already converging to well within a single stroke over 100,000 simulations.

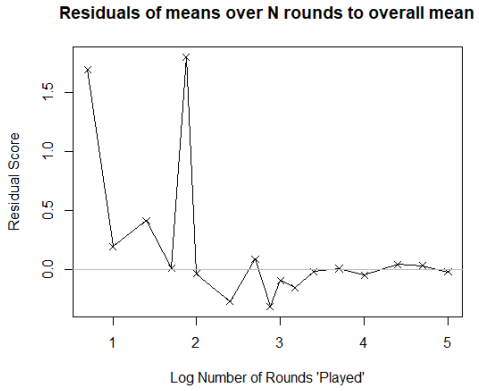


Figure 4: Convergence of means as number of simulations grows larger.

Future work may better model shot paths. For example, the ball must roll to its position but in a water hazard the ball cannot roll. Therefore, shots which only just clear a hazard in this model, may not be possible in reality.

## References

[1] A. Fox, D. Evans, T. Morland-Nuttall and J. Bowes-Reynolds, *P1_6 The Average Golfer*, PST 20, (2021).

[2] `https://www.golfspan.com/what-is-a-good-golf-handicap` [Accessed 30/11/2021]