The Distance of Golf Balls

Design and Analysis of Experiments
Final Project
Stat 424

Sukyoung Cho
William Hagen
Meenmo Kang

Contents

Motivation

- Golf's variability and many factors
- Distance is important
- Uncontrollable vs. Controllable factors
- Problem statement: Of the ball, shaft, and tee factors which factors or combination of factors interact with one another to significantly affect distance?

Experiment

- Used an indoor golf simulator:
  Controlled environment and accurate measurements

- Automatic Record:
  Simulator measures the distance and the trajectory of the ball.

- Reducing error:
  One subject, most consistent golfer, and repeating replicates

Model Selection & Design

- Three factors with two levels each: 2^3- Factorial Design

  Eight total combinations and three replicates for each combination

- Response variable - Distance (yards) Factors- type of ball (high performance, poorly made), type of shaft (steel, graphite), and tee (on the tee, off the tee)

Model Analysis

$$x_1 = \begin{cases} -1 & \text{if} \quad \text{A} = \text{-} \\ 1 & \text{if} \quad \text{A} = \text{+} \end{cases} \qquad x_2 = \begin{cases} -1 & \text{if} \quad \text{B} = \text{-} \\ 1 & \text{if} \quad \text{B} = \text{+} \end{cases} \qquad x_3 = \begin{cases} -1 & \text{if} \quad \text{C} = \text{-} \\ 1 & \text{if} \quad \text{C} = \text{+} \end{cases}$$

$$y = \mu + \frac{A}{2}x_1 + \frac{B}{2}x_2 + \frac{C}{2}x_3 + \frac{AB}{2}x_1x_2 + \frac{AC}{2}x_1x_3 + \frac{BC}{2}x_2x_3 + \frac{ABC}{2}x_1x_2x_3 + \epsilon$$

Hypothesis test

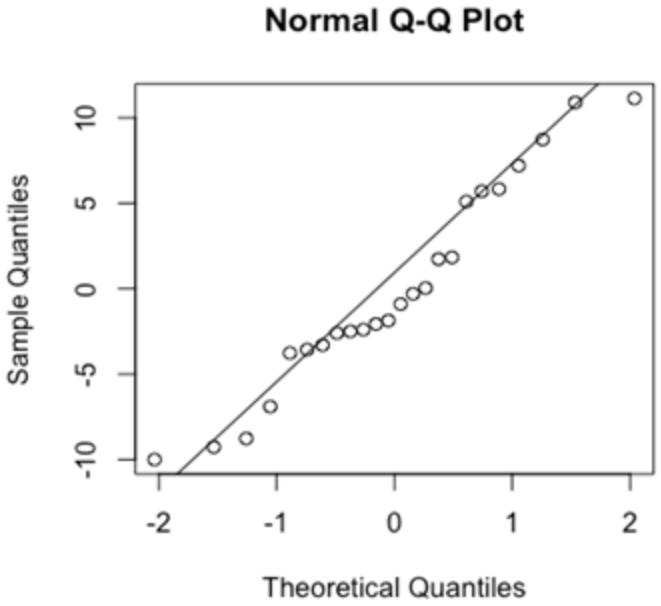
	Df	Sum Sq	Mean Sq	F value	Pr(>F)
iron	1	0.1	0.1	0.003	0.9603
ball	1	71.4	71.4	1.352	0.2620
Tee	1	298.2	298.2	5.644	**0.0303** *
Iron:ball	1	16.3	16.3	0.309	0.5859
Iron:tee	1	110.1	110.1	2.084	0.1682
Ball:tee	1	438.6	438.6	8.302	**0.0109** *
Iron:ball:tee	1	418.3	418.3	7.918	**0.0125** *
Residual	16	845.3	52.8		

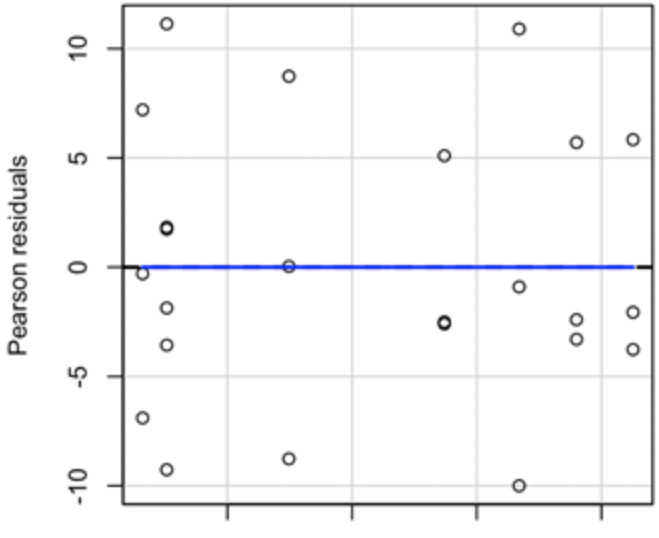
- 95% CI of tee [-6.670308, -0.3796923]
- 95% CI of ball [-1.420308, 4.8703077]

Evaluation of Model

- Simple
- Replicates
- Multicollinearity assumption
- Interval data assumption

Assumption





- Shapiro-Wilk normality test with p-value = 0.3304

Conclusion

Better ball (+), Iron with graphite shaft (-) , No tee (-)

Caution:
- 44.73% of variance
- Human errors
- Only distance