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Chutes and Ladders

Math 114 Mathematical Modeling

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Problem Statement

Hasbro, the manufacturer of the board game Chutes and Ladders is preparing a revision of the game. They asked you do make some estimates of the playing time. From their own in-house testing they know that an adult takes about 10 seconds per turn. When a child is playing with an adult, a child typically takes 15 seconds per turn. When children are playing among themselves, they take about 25 seconds per turn. Make a model of the game and prepare advice for Hasbro on what they should say about playing time and the number of players the game is suitable for. Offer advice on any rule changes that could affect the playing time.

Commentary

In order to solve this problem, we are going to simulate how many turns it takes to play the game. Using this data, we will then simulate how many total turns it takes 2,4,6 people to play the game. We will then convert this to time based upon who is playing the game. Our answer will be an estimation of how long it takes adults, children and adults, and just children. Our final answer will be an equation that takes the number of adults and children playing the game and return how long it will take them to finish.

Modeling

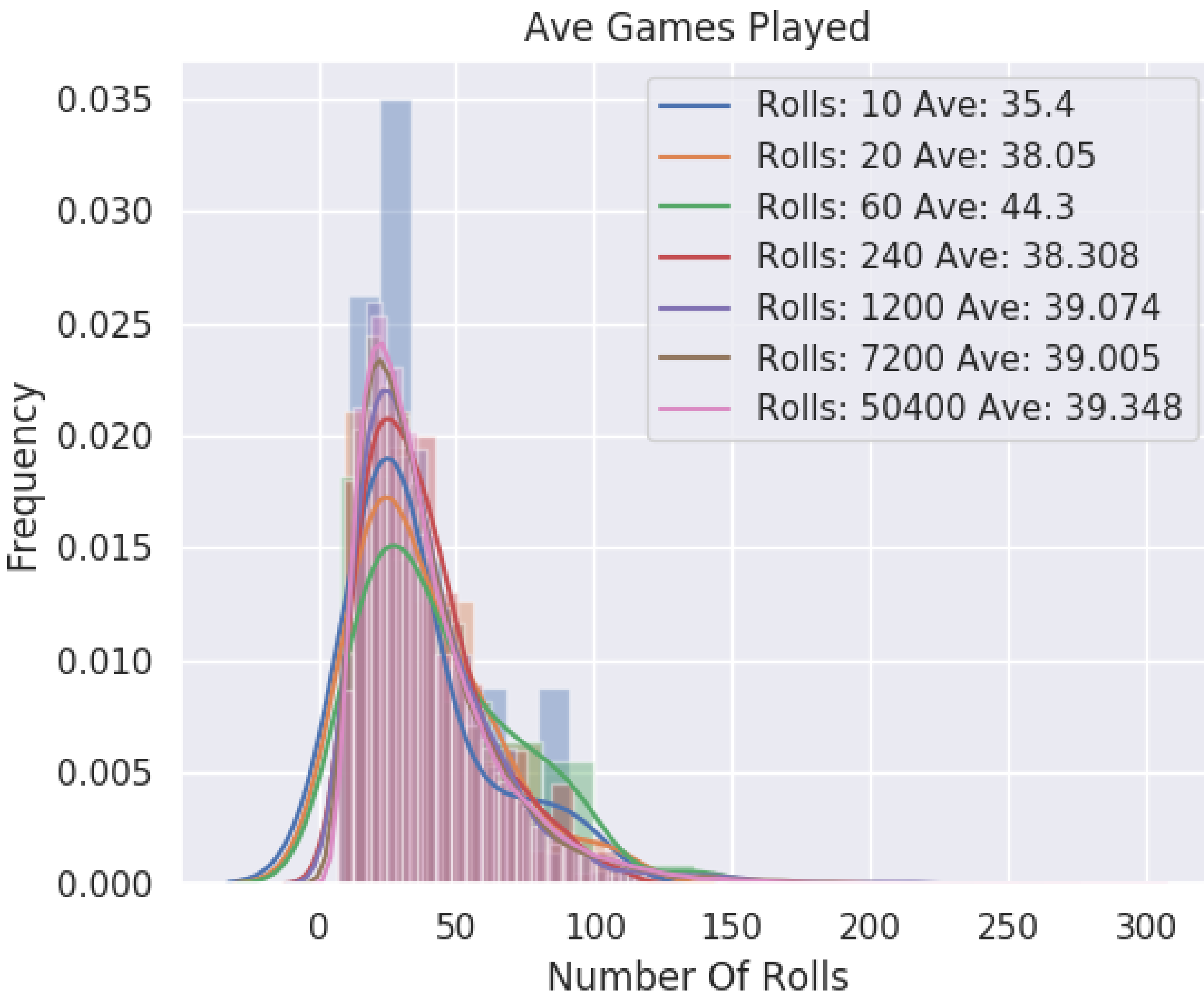
First we need to figure out how many rolls it takes, on average, to complete the game. Every player starts on square zero, rolls a d6, and then moves to the next square based upon what square they landed on. If the square that they are on + their roll ¿ 100, they stay where they are. If the sum = 100, they finish playing the game. Below is the code for modeling this:

```
def roll_d6():
    resp = randint(1, 6)
    return resp


# Index is where the square+roll is.
# square_dict[roll+square] = what square to end up after rolling
square_dict = [0,38, 2,3,14,5,6,7,8,31,10,11,12,13,14,15,6,17,18,
19,20,42,22,23,24,25,26,27,84,29,30,31,32,33,34,35,44,37,38,39,40,
41,42,43,44,45,46,26,48,11,50,67,52,53,54,55,53,57,58,59,60,61,19
,63,60,65,66,67,68,69,70,91,72,73,74,75,76,77,78,79,100,81,82,83,
84,85,86,24,88,89,90,91,92,73,94,75,96,97,78,99,100]


def chutes_and_ladders(roll, square):
    # If the player's roll goes beyond the board, nothing happens
    if (square + roll > 100):
        return square
    else:
```

```
        return square_dict[square+roll]


def play_game()
  square = 0
  rolls = 0
  roll_data = []
  number_of_games = 1000
  # Code that finds the average number of rolls to play the game
  while (square < 100 and len(roll_data) < number_of_games):
      rolls += 1
      roll = roll_d6()
      temp = square
      square = chutes_and_ladders(roll, square)
      # print("Started at {} rolled {}, went to {}".format(temp,roll,square))

      if (square == 100):
          roll_data.append(rolls)
          rolls = 0
          square = 0

    ave = 0
    for i in range(len(roll_data)):
        ave += roll_data[i]
    ave /= len(roll_data)
    print("Ave Rolls: {}".format(ave))
play_game()
```

Data Analysis

We can try to calculate a more accurate average by increasing the number of games that before finding the average game length. This results in the following graph:



This model suggests that the average number of rolls it takes to finish a game is 39-40 rolls. Using this estimation, we can predict how long it takes one person to play a game.

When Play Time is Over

Our model estimates that the average number of roles is 39. Using this, we can write the following equation to predict how long a game will take. $K_n = NumberofKids$ $A_n = NumberofAdults$.

If there are adults:

$$Seconds = 39 * 10 * A_n + 39 * 15 * K_n$$

If there are no adults:

$$Seconds = 39 * 25 * A_n$$

Changing Play Time

A few things could be done to change the play time. If we wanted to increase the play time, we could decrease the magnitude of all ladders by 1 everytime someone landed on a ladder and increase the magnitude of all chutes by 1 everytime someone landed on a chute. We could flip this if we wanted to decrease the play time. For both examples, we would need to bound the chutes and ladders so that they could not go below 1 or above 100. If we wanted to increase the play time, we could allow people whose roll directs them to a position greater than 100 back to that position minus 100. This would result in them effectively restarting the game, which would certainly increase the play time. We could also move around where the chutes and ladders are positioned. If we wanted to make it very difficult to get beyond a certain square, we could put 5 chutes in a row, giving the player a 1 in 6 shot of making it through, depending how far away they were from the first chute. We could of course do the same thing with ladders if we wanted to make a particular section very easy.