Implementing Monopoly in R

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Using R6 library to implement object-oriented classes and class specific functions for a traditional Monopoly game, followed by a variety of test cases and a simulation of 1000 games.

```
library(R6)

# gameboard and decks

gameboard <- data.frame(
  space = 1:40,
  title = c(
    "Go", "Mediterranean Avenue", "Community Chest", "Baltic Avenue",
    "Income Tax", "Reading Railroad", "Oriental Avenue", "Chance",
    "Vermont Avenue", "Connecticut Avenue", "Jail", "St. Charles Place",
    "Electric Company", "States Avenue", "Virginia Avenue",
    "Pennsylvania Railroad", "St. James Place", "Community Chest",
    "Tennessee Avenue", "New York Avenue", "Free Parking",
    "Kentucky Avenue", "Chance", "Indiana Avenue", "Illinois Avenue",
    "B & O Railroad", "Atlantic Avenue", "Ventnor Avenue", "Water Works",
    "Marvin Gardens", "Go to jail", "Pacific Avenue",
    "North Carolina Avenue", "Community Chest", "Pennsylvania Avenue",
    "Short Line Railroad", "Chance", "Park Place", "Luxury Tax",
    "Boardwalk"), stringsAsFactors = FALSE)
chancedeck <- data.frame(
  index = 1:15,
  card = c(
    "Advance to Go", "Advance to Illinois Ave.",
    "Advance to St. Charles Place", "Advance token to nearest Utility",
    "Advance token to the nearest Railroad",
    "Take a ride on the Reading Railroad",
    "Take a walk on the Boardwalk", "Go to Jail", "Go Back 3 Spaces",
    "Bank pays you dividend of $50", "Get out of Jail Free",
    "Make general repairs on all your property", "Pay poor tax of $15",
    "You have been elected Chairman of the Board",
    "Your building loan matures"), stringsAsFactors = FALSE)
communitydeck <- data.frame(
  index = 1:16,
  card = c(
    "Advance to Go", "Go to Jail",
```

```
    "Bank error in your favor. Collect $200", "Doctor's fees Pay $50",
    "From sale of stock you get $45", "Get Out of Jail Free",
    "Grand Opera Night Opening", "Xmas Fund matures", "Income tax refund",
    "Life insurance matures. Collect $100", "Pay hospital fees of $100",
    "Pay school tax of $150", "Receive for services $25",
    "You are assessed for street repairs",
    "You have won second prize in a beauty contest",
    "You inherit $100"), stringsAsFactors = FALSE)

# RandomDice class

RandomDice <- R6Class(
  classname = "RandomDice",
  public = list(
    verbose = NA,
    initialize = function(verbose = FALSE){
      stopifnot(is.logical(verbose))
      self$verbose = verbose
    },
    roll = function() {
      outcome <- sample(1:6, size = 2, replace = TRUE)
      if(self$verbose){
        cat("Dice Rolled:", outcome[1], outcome[2], "\n")
      }
      outcome
    }
  )
)

# Preset Dice

PresetDice <- R6Class(
  classname = "PresetDice",
  public = list(
    verbose = NA,
    preset_rolls = double(0),
    position = 1,
    initialize = function(rolls, verbose = FALSE){
      stopifnot(is.logical(verbose))
      stopifnot(is.numeric(rolls))
      self$preset_rolls = rolls
      self$verbose = verbose
    },
    roll = function(){
      if(self$position > length(self$preset_rolls)){
        stop("You have run out of predetermined dice outcomes.")
      }
      outcome <- c(self$preset_rolls[self$position],
                   self$preset_rolls[self$position + 1])
      self$position <- self$position + 2
      if(self$verbose){
        cat("Dice Rolled:", outcome[1], outcome[2], "\n")
      }
```

```
      outcome
    }
  )
)


# Chance and Community Decks

# This R6 class object shuffles the card deck when initialized.
# It has one method $draw(), which will draw a card from the deck.
# If all the cards have been drawn (position = deck length), then it will
# shuffle the cards again.
# The verbose option cats the card that is drawn on to the screen.
CardDeck <- R6Class(
  classname = "CardDeck",
  public = list(
    verbose = NA,
    deck_order = double(0),
    deck = data.frame(),
    position = 1,
    initialize = function(deck, verbose = FALSE){
      stopifnot(is.data.frame(deck),
                is.numeric(deck[[1]]),
                is.character(deck[[2]]))
      self$deck_order <- sample(length(deck[[1]]))
      self$verbose <- verbose
      self$deck <- deck
    },
    draw = function(){
      if(self$position > length(self$deck_order)){
        # if we run out of cards, shuffle deck
        # and reset the position to 1
        if(self$verbose){
          cat("Shuffling deck.\n")
        }
        self$deck_order <- sample(length(self$deck[[1]]))
        self$position <- 1
      }
      outcome <- c(self$deck_order[self$position]) # outcome is the value at position
      self$position <- self$position + 1 # advance the position by 1
      if(self$verbose){
        cat("Card:", self$deck[outcome, 2], "\n")
      }
      outcome # return the outcome
    }
  )
)


# R6 Class SpaceTracker

SpaceTracker <- R6Class(
  classname = "SpaceTracker",
```

```
  public = list(
    counts = rep(0, 40),
    verbose = TRUE,
    tally = function(x){
      self$counts[x] <- self$counts[x] + 1
      if(self$verbose){
        cat("Added tally to ", x, ": ", gameboard$title[x], ".\n", sep = "")
      }
    },
    initialize = function(verbose){
      self$verbose <- verbose
    }
  )
)

# R6 Class Player

Player <- R6Class(
  classname = "Player",
  public = list(
    pos = 1,
    verbose = TRUE,
    jail = FALSE,
    jail_num = 0,
    move_fwd = function(n){
      self$pos <- self$pos + n
      if(self$pos > 40){
        self$pos <- self$pos - 40
      }
      if(self$verbose){
        cat("Player is now at ", self$pos, ": " , gameboard$title[self$pos], "\n", sep = "")
      }
    },
    initialize = function(verbose = FALSE, pos = 1, jail = FALSE, jail_num = 0) {
      self$verbose <- verbose
      self$pos <- pos
      self$jail <- jail
      self$jail_num <- jail_num
    }
  )
)


# turn taking example

community_chest_result <- function(n) {
  if(n == 1) {
    return(1)
  } else if(n == 2) {
    return(11)
  } else {
    return(0)
  }
```

```
}
chance_result <- function(n, player_rolling) {
  if(n == 1) {
    return(1)
  } else if(n == 2) {
    return(25)
  } else if(n == 3) {
    return(12)
  } else if(n == 4) {
    current <- player_rolling$pos
    if(current == 23) {
      return(29)
    } else {
      return(13)
    }
  } else if(n == 5) {
    current <- player_rolling$pos
    if(current == 8) {
      return(16)
    } else if(current == 23) {
      return(26)
    } else {
      return(6)
    }
  } else if(n == 6) {
    return(6)
  } else if(n == 7) {
    return(40)
  } else if(n == 8) {
    return(11)
  } else if(n == 9) {
    return(player_rolling$pos - 3)
  } else {
    return(0)
  }
}



take_turn <- function(player, spacetracker){
    doubles <- TRUE
    num_doubles <- 0
    while(doubles) {
      dice_rolls <- dice$roll()
      if(player$jail) {
        if(dice_rolls[1] == dice_rolls[2]) {
          if(player$verbose) {
            cat("In jail but rolled doubles.", "\n")
            cat("Player exits jail.", "\n")
          }
          player$jail_num <- 0
          doubles <- FALSE
          player$jail <- FALSE
```

```
      player$jail_num <- 0
    } else if(player$jail_num == 2){
      if(player$verbose) {
        cat("Player's third turn in jail. Player must exit jail.", "\n")
      }
      doubles <- FALSE
      player$jail <- FALSE
      player$jail_num <- 0
    } else {
      if(player$verbose) {
        cat("Player stays in jail.", "\n")
      }
      player$jail_num <- player$jail_num + 1
      doubles <- FALSE
      spacetracker$tally(player$pos)
      break
    }
  } else if(dice_rolls[1] != dice_rolls[2]) {
    doubles <- FALSE
  } else {
    num_doubles <- num_doubles + 1
    if(player$verbose) {
      cat("Doubles count is now", num_doubles, "\n")
    }
  }
  if(num_doubles == 3) {
    player$pos <- 11
    player$jail <- TRUE
    if(player$verbose) {
      cat("Player goes to Jail.", "\n")
    }
    spacetracker$tally(player$pos)
    break
  }
  if(player$verbose) {
    cat("Player starts at ", player$pos, ": ", gameboard$title[player$pos], "\n", sep = "")
  }
  player$move_fwd(sum(dice_rolls))
  if(player$pos == 31) {
    if(player$verbose) {
      cat("Player goes to jail.", "\n")
    }
    player$pos <- 11
    player$jail <- TRUE
    spacetracker$tally(player$pos)
    break
  }
  if(player$pos %in% c(3, 18, 34) ) {
    num <- community$draw()
    result <- community_chest_result(num)
    if(result != 0) {
      if(result == 11) {
        spacetracker$tally(player$pos)
```

```
          if(player$verbose) {
            cat("Player goes to jail.", "\n")
          }
          player$pos <- 11
          player$jail <- TRUE
          spacetracker$tally(player$pos)
          break
        } else {
          spacetracker$tally(player$pos)
          player$move_fwd(40 + result - player$pos)
        }
      }
    }
    if(player$pos %in% c(8, 23, 37) ) {
      num <- chance$draw()
      result <- chance_result(num, player)
      if(result != 0) {
        if(result == 11) {
          spacetracker$tally(player$pos)
          if(player$verbose) {
            cat("Player goes to jail.", "\n")
          }
          player$pos <- 11
          player$jail <- TRUE
          spacetracker$tally(player$pos)
          break
        } else {
          spacetracker$tally(player$pos)
          player$move_fwd(40 + result - player$pos)
        }
      }
    }
    spacetracker$tally(player$pos)
    if(doubles && player$verbose) {
      cat("\n", "Player rolled doubles, so they take another turn.", "\n", sep = "")
    }
  }
}
```

Part 1: Test Cases

do not alter the code for the test cases

Test Case 1: Space: Go to Jail

```
dice <- PresetDice$new(
  rolls = c(3,4),
  verbose = TRUE
)
set.seed(16)
player1 <- Player$new(verbose = TRUE, pos = 24)
monopoly <- SpaceTracker$new(verbose = TRUE)

for(i in 1:1){
  cat("--- Turn", i,"---\n")
  take_turn(player1, monopoly)
  cat("\n")
}
```

```
## --- Turn 1 ---
## Dice Rolled: 3 4
## Player starts at 24: Indiana Avenue
## Player is now at 31: Go to jail
## Player goes to jail.
## Added tally to 11: Jail.
```

```
print(setNames(monopoly$counts, 1:40))
```

```
##  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
##  0  0  0  0  0  0  0  0  0  0  1  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
## 27 28 29 30 31 32 33 34 35 36 37 38 39 40
##  0  0  0  0  0  0  0  0  0  0  0  0  0  0
```

Test Case 2: Chance Card and Doubles Tests: Advance to Go, Reading Railroad, Nearest Railroad, Nearest Utility, No Movement

```
dice <- PresetDice$new(
  rolls = c(3,4, 4,3, 1,1, 3,4, 5,3),
  verbose = TRUE
)
RNGkind(sample.kind = "Rejection")
set.seed(135)
chance <- CardDeck$new(chancedeck, verbose = TRUE)
community <- CardDeck$new(communitydeck, verbose = TRUE)
player1 <- Player$new(verbose = TRUE)
monopoly <- SpaceTracker$new(verbose = TRUE)

for(i in 1:4){
  cat("--- Turn", i,"---\n")
  take_turn(player1, monopoly)
  cat("\n")
}
```

```
## --- Turn 1 ---
## Dice Rolled: 3 4
## Player starts at 1: Go
## Player is now at 8: Chance
## Card: Advance to Go
## Added tally to 8: Chance.
## Player is now at 1: Go
## Added tally to 1: Go.
##
## --- Turn 2 ---
## Dice Rolled: 4 3
## Player starts at 1: Go
## Player is now at 8: Chance
## Card: Take a ride on the Reading Railroad
## Added tally to 8: Chance.
## Player is now at 6: Reading Railroad
## Added tally to 6: Reading Railroad.
##
## --- Turn 3 ---
## Dice Rolled: 1 1
## Doubles count is now 1
## Player starts at 6: Reading Railroad
## Player is now at 8: Chance
## Card: Advance token to the nearest Railroad
## Added tally to 8: Chance.
## Player is now at 16: Pennsylvania Railroad
## Added tally to 16: Pennsylvania Railroad.
##
## Player rolled doubles, so they take another turn.
## Dice Rolled: 3 4
## Player starts at 16: Pennsylvania Railroad
## Player is now at 23: Chance
## Card: Advance token to nearest Utility
```

```
## Added tally to 23: Chance.
## Player is now at 29: Water Works
## Added tally to 29: Water Works.
##
## --- Turn 4 ---
## Dice Rolled: 5 3
## Player starts at 29: Water Works
## Player is now at 37: Chance
## Card: Bank pays you dividend of $50
## Added tally to 37: Chance.
```

```
print(setNames(monopoly$counts, 1:40))
```

```
##  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
##  1  0  0  0  0  1  0  3  0  0  0  0  0  0  0  1  0  0  0  0  0  0  1  0  0  0
## 27 28 29 30 31 32 33 34 35 36 37 38 39 40
##  0  0  1  0  0  0  0  0  0  0  1  0  0  0
```

Test Case 3: Multiple doubles. Community Chest.

```
dice <- PresetDice$new(
  rolls = c(3,3, 2,2, 2,1, 3,1), verbose = TRUE)

player1 <- Player$new(verbose = TRUE)
monopoly <- SpaceTracker$new(verbose = TRUE)
for(i in 1:2){
  cat("--- Turn", i,"---\n")
  take_turn(player1, monopoly)
  cat("\n")
}
```

```
## --- Turn 1 ---
## Dice Rolled: 3 3
## Doubles count is now 1
## Player starts at 1: Go
## Player is now at 7: Oriental Avenue
## Added tally to 7: Oriental Avenue.
##
## Player rolled doubles, so they take another turn.
## Dice Rolled: 2 2
## Doubles count is now 2
## Player starts at 7: Oriental Avenue
## Player is now at 11: Jail
## Added tally to 11: Jail.
##
## Player rolled doubles, so they take another turn.
## Dice Rolled: 2 1
## Player starts at 11: Jail
## Player is now at 14: States Avenue
## Added tally to 14: States Avenue.
##
## --- Turn 2 ---
## Dice Rolled: 3 1
## Player starts at 14: States Avenue
## Player is now at 18: Community Chest
## Card: Life insurance matures. Collect $100
## Added tally to 18: Community Chest.
```

```
print(setNames(monopoly$counts, 1:40))
```

```
##  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
##  0  0  0  0  0  0  1  0  0  0  1  0  0  1  0  0  0  1  0  0  0  0  0  0  0  0
## 27 28 29 30 31 32 33 34 35 36 37 38 39 40
##  0  0  0  0  0  0  0  0  0  0  0  0  0  0
```

Test Case 4: Doubles three times. Three turns in jail.

```
dice <- PresetDice$new(
  rolls = c(3,3, 3,3, 3,3, 5,6, 5,6, 5,6),
  verbose = TRUE
)

player1 <- Player$new(verbose = TRUE)
monopoly <- SpaceTracker$new(verbose = TRUE)

for(i in 1:4){
  cat("--- Turn", i,"---\n")
  take_turn(player1, monopoly)
  cat("\n")
}
```

```
## --- Turn 1 ---
## Dice Rolled: 3 3
## Doubles count is now 1
## Player starts at 1: Go
## Player is now at 7: Oriental Avenue
## Added tally to 7: Oriental Avenue.
##
## Player rolled doubles, so they take another turn.
## Dice Rolled: 3 3
## Doubles count is now 2
## Player starts at 7: Oriental Avenue
## Player is now at 13: Electric Company
## Added tally to 13: Electric Company.
##
## Player rolled doubles, so they take another turn.
## Dice Rolled: 3 3
## Doubles count is now 3
## Player goes to Jail.
## Added tally to 11: Jail.
##
## --- Turn 2 ---
## Dice Rolled: 5 6
## Player stays in jail.
## Added tally to 11: Jail.
##
## --- Turn 3 ---
## Dice Rolled: 5 6
## Player stays in jail.
## Added tally to 11: Jail.
##
## --- Turn 4 ---
## Dice Rolled: 5 6
## Player's third turn in jail. Player must exit jail.
## Player starts at 11: Jail
## Player is now at 22: Kentucky Avenue
## Added tally to 22: Kentucky Avenue.
```

```r
print(setNames(monopoly$counts, 1:40))
```

```
##  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
##  0  0  0  0  0  0  1  0  0  0  3  0  1  0  0  0  0  0  0  0  1  0  0  0  0
## 27 28 29 30 31 32 33 34 35 36 37 38 39 40
##  0  0  0  0  0  0  0  0  0  0  0  0  0  0
```

Test Case 5: After going to Jail, player's turn ends immediately. Rolling doubles while in Jail gets player out of jail.

```
dice <- PresetDice$new(
  rolls = c(3,3, 1,2, 3,3, 3,4),
  verbose = TRUE
)

player1 <- Player$new(verbose = TRUE, pos = 25)
monopoly <- SpaceTracker$new(verbose = TRUE)

for(i in 1:3){
  cat("--- Turn", i,"---\n")
  take_turn(player1, monopoly)
  cat("\n")
}
```

```
## --- Turn 1 ---
## Dice Rolled: 3 3
## Doubles count is now 1
## Player starts at 25: Illinois Avenue
## Player is now at 31: Go to jail
## Player goes to jail.
## Added tally to 11: Jail.
##
## --- Turn 2 ---
## Dice Rolled: 1 2
## Player stays in jail.
## Added tally to 11: Jail.
##
## --- Turn 3 ---
## Dice Rolled: 3 3
## In jail but rolled doubles.
## Player exits jail.
## Player starts at 11: Jail
## Player is now at 17: St. James Place
## Added tally to 17: St. James Place.
```

```
print(setNames(monopoly$counts, 1:40))
```

```
##  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
##  0  0  0  0  0  0  0  0  0  0  2  0  0  0  0  0  1  0  0  0  0  0  0  0  0  0
## 27 28 29 30 31 32 33 34 35 36 37 38 39 40
##  0  0  0  0  0  0  0  0  0  0  0  0  0  0
```

Test Case 6: 20 Predetermined Turns

```
## You must use these dice for Part 1
dice <- PresetDice$new(
  rolls = c(6,4, 5,3, 3,5, 4,4, 4,4, 2,2, 4,3, 4,4, 1,4,
            3,4, 1,2, 3,6, 5,4, 5,5, 1,2, 5,4, 3,3, 6,1,
            1,1, 2,3, 5,5, 5,4, 4,1, 2,2, 2,4),
  verbose = TRUE
)
set.seed(2)
chance <- CardDeck$new(chancedeck, verbose = TRUE)
community <- CardDeck$new(communitydeck, verbose = TRUE)
```

```
player1 <- Player$new(verbose = TRUE)
monopoly <- SpaceTracker$new(verbose = TRUE)

for(i in 1:20){
  cat("--- Turn", i,"---\n")
  take_turn(player1, monopoly)
  cat("\n")
}
```

```
## --- Turn 1 ---
## Dice Rolled: 6 4
## Player starts at 1: Go
## Player is now at 11: Jail
## Added tally to 11: Jail.
##
## --- Turn 2 ---
## Dice Rolled: 5 3
## Player starts at 11: Jail
## Player is now at 19: Tennessee Avenue
## Added tally to 19: Tennessee Avenue.
##
## --- Turn 3 ---
## Dice Rolled: 3 5
## Player starts at 19: Tennessee Avenue
## Player is now at 27: Atlantic Avenue
## Added tally to 27: Atlantic Avenue.
##
## --- Turn 4 ---
## Dice Rolled: 4 4
## Doubles count is now 1
## Player starts at 27: Atlantic Avenue
## Player is now at 35: Pennsylvania Avenue
## Added tally to 35: Pennsylvania Avenue.
##
## Player rolled doubles, so they take another turn.
## Dice Rolled: 4 4
## Doubles count is now 2
## Player starts at 35: Pennsylvania Avenue
## Player is now at 3: Community Chest
```

```
## Card: You have won second prize in a beauty contest
## Added tally to 3: Community Chest.
##
## Player rolled doubles, so they take another turn.
## Dice Rolled: 2 2
## Doubles count is now 3
## Player goes to Jail.
## Added tally to 11: Jail.
##
## --- Turn 5 ---
## Dice Rolled: 4 3
## Player stays in jail.
## Added tally to 11: Jail.
##
## --- Turn 6 ---
## Dice Rolled: 4 4
## In jail but rolled doubles.
## Player exits jail.
## Player starts at 11: Jail
## Player is now at 19: Tennessee Avenue
## Added tally to 19: Tennessee Avenue.
##
## --- Turn 7 ---
## Dice Rolled: 1 4
## Player starts at 19: Tennessee Avenue
## Player is now at 24: Indiana Avenue
## Added tally to 24: Indiana Avenue.
##
## --- Turn 8 ---
## Dice Rolled: 3 4
## Player starts at 24: Indiana Avenue
## Player is now at 31: Go to jail
## Player goes to jail.
## Added tally to 11: Jail.
##
## --- Turn 9 ---
## Dice Rolled: 1 2
## Player stays in jail.
## Added tally to 11: Jail.
##
## --- Turn 10 ---
## Dice Rolled: 3 6
## Player stays in jail.
## Added tally to 11: Jail.
##
## --- Turn 11 ---
## Dice Rolled: 5 4
## Player's third turn in jail. Player must exit jail.
## Player starts at 11: Jail
## Player is now at 20: New York Avenue
## Added tally to 20: New York Avenue.
##
## --- Turn 12 ---
## Dice Rolled: 5 5
```

```
## Doubles count is now 1
## Player starts at 20: New York Avenue
## Player is now at 30: Marvin Gardens
## Added tally to 30: Marvin Gardens.
##
## Player rolled doubles, so they take another turn.
## Dice Rolled: 1 2
## Player starts at 30: Marvin Gardens
## Player is now at 33: North Carolina Avenue
## Added tally to 33: North Carolina Avenue.
##
## --- Turn 13 ---
## Dice Rolled: 5 4
## Player starts at 33: North Carolina Avenue
## Player is now at 2: Mediterranean Avenue
## Added tally to 2: Mediterranean Avenue.
##
## --- Turn 14 ---
## Dice Rolled: 3 3
## Doubles count is now 1
## Player starts at 2: Mediterranean Avenue
## Player is now at 8: Chance
## Card: Advance token to the nearest Railroad
## Added tally to 8: Chance.
## Player is now at 16: Pennsylvania Railroad
## Added tally to 16: Pennsylvania Railroad.
##
## Player rolled doubles, so they take another turn.
## Dice Rolled: 6 1
## Player starts at 16: Pennsylvania Railroad
## Player is now at 23: Chance
## Card: Take a ride on the Reading Railroad
## Added tally to 23: Chance.
## Player is now at 6: Reading Railroad
## Added tally to 6: Reading Railroad.
##
## --- Turn 15 ---
## Dice Rolled: 1 1
## Doubles count is now 1
## Player starts at 6: Reading Railroad
## Player is now at 8: Chance
## Card: You have been elected Chairman of the Board
## Added tally to 8: Chance.
##
## Player rolled doubles, so they take another turn.
## Dice Rolled: 2 3
## Player starts at 8: Chance
## Player is now at 13: Electric Company
## Added tally to 13: Electric Company.
##
## --- Turn 16 ---
## Dice Rolled: 5 5
## Doubles count is now 1
## Player starts at 13: Electric Company
```

```
## Player is now at 23: Chance
## Card: Go to Jail
## Added tally to 23: Chance.
## Player goes to jail.
## Added tally to 11: Jail.
##
## --- Turn 17 ---
## Dice Rolled: 5 4
## Player stays in jail.
## Added tally to 11: Jail.
##
## --- Turn 18 ---
## Dice Rolled: 4 1
## Player stays in jail.
## Added tally to 11: Jail.
##
## --- Turn 19 ---
## Dice Rolled: 2 2
## In jail but rolled doubles.
## Player exits jail.
## Player starts at 11: Jail
## Player is now at 15: Virginia Avenue
## Added tally to 15: Virginia Avenue.
##
## --- Turn 20 ---
## Dice Rolled: 2 4
## Player starts at 15: Virginia Avenue
## Player is now at 21: Free Parking
## Added tally to 21: Free Parking.
```

```
monopoly$counts
```

```
##  [1] 0 1 1 0 0 1 0 2 0 0 9 0 1 0 1 1 0 0 2 1 1 0 2 1 0 0 1 0 0 1 0 0 1 0 1 0 0 0
## [39] 0 0
```

```
cbind(gameboard, counts = monopoly$counts)
```

```
##    space                 title counts
## 1      1                    Go      0
## 2      2  Mediterranean Avenue      1
## 3      3       Community Chest      1
## 4      4         Baltic Avenue      0
## 5      5            Income Tax      0
## 6      6      Reading Railroad      1
## 7      7       Oriental Avenue      0
## 8      8               Chance      2
## 9      9        Vermont Avenue      0
## 10    10    Connecticut Avenue      0
## 11    11                  Jail      9
## 12    12     St. Charles Place      0
## 13    13      Electric Company      1
## 14    14         States Avenue      0
## 15    15       Virginia Avenue      1
```

```
## 16    16 Pennsylvania Railroad      1
## 17    17       St. James Place      0
## 18    18       Community Chest      0
## 19    19      Tennessee Avenue      2
## 20    20       New York Avenue      1
## 21    21          Free Parking      1
## 22    22       Kentucky Avenue      0
## 23    23                Chance      2
## 24    24        Indiana Avenue      1
## 25    25       Illinois Avenue      0
## 26    26        B & O Railroad      0
## 27    27       Atlantic Avenue      1
## 28    28        Ventnor Avenue      0
## 29    29           Water Works      0
## 30    30        Marvin Gardens      1
## 31    31            Go to jail      0
## 32    32        Pacific Avenue      0
## 33    33 North Carolina Avenue      1
## 34    34       Community Chest      0
## 35    35   Pennsylvania Avenue      1
## 36    36   Short Line Railroad      0
## 37    37               Chance      0
## 38    38            Park Place      0
## 39    39            Luxury Tax      0
## 40    40             Boardwalk      0
```

Part 2: 1000 simulated games

```
library(dplyr)
```

```
set.seed(2)
chance <- CardDeck$new(chancedeck, verbose = FALSE)
community <- CardDeck$new(communitydeck, verbose = FALSE)
dice <- RandomDice$new()

player1 <- Player$new(verbose = FALSE)
player2 <- Player$new(verbose = FALSE)
monopoly <- SpaceTracker$new(verbose = FALSE)

for(g in 1:1000) {
  if(g %% 100 == 0) {
    cat("#### SIMULATING GAME", g, "##### \n")
  }
  for(i in 1:150){
    take_turn(player1, monopoly)
    take_turn(player2, monopoly)
  }
}
```

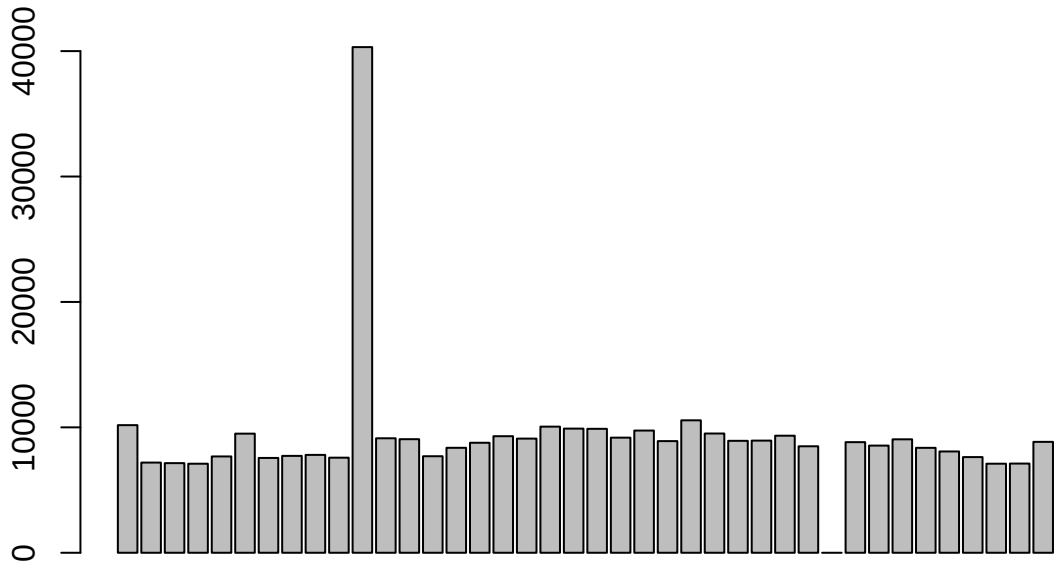
```
## #### SIMULATING GAME 100 #####
## #### SIMULATING GAME 200 #####
```

```
## #### SIMULATING GAME 300 #####
## #### SIMULATING GAME 400 #####
## #### SIMULATING GAME 500 #####
## #### SIMULATING GAME 600 #####
## #### SIMULATING GAME 700 #####
## #### SIMULATING GAME 800 #####
## #### SIMULATING GAME 900 #####
## #### SIMULATING GAME 1000 #####
```

```
print(setNames(monopoly$counts, 1:40))
```

```
##     1     2     3     4     5     6     7     8     9    10    11    12    13
## 10177  7192  7147  7100  7680  9498  7562  7724  7803  7582 40320  9128  9056
##    14    15    16    17    18    19    20    21    22    23    24    25    26
##  7698  8370  8771  9295  9102 10057  9901  9884  9179  9744  8902 10561  9508
##    27    28    29    30    31    32    33    34    35    36    37    38    39
##  8926  8944  9334  8491     0  8819  8545  9045  8366  8078  7630  7101  7113
##    40
##  8844
```

```
barplot(monopoly$counts)
```




```
results <- cbind(gameboard, tally = monopoly$counts)
results <- cbind(results, rel = monopoly$counts/sum(monopoly$counts))
print(results)
```

```
##    space                title tally        rel
## 1      1                   Go 10177 0.02764160
## 2      2  Mediterranean Avenue  7192 0.01953408
## 3      3       Community Chest  7147 0.01941186
## 4      4         Baltic Avenue  7100 0.01928420
## 5      5            Income Tax  7680 0.02085953
## 6      6      Reading Railroad  9498 0.02579737
## 7      7       Oriental Avenue  7562 0.02053903
## 8      8               Chance  7724 0.02097904
## 9      9        Vermont Avenue  7803 0.02119361
## 10    10    Connecticut Avenue  7582 0.02059336
## 11    11                  Jail 40320 0.10951254
## 12    12     St. Charles Place  9128 0.02479242
## 13    13      Electric Company  9056 0.02459687
## 14    14         States Avenue  7698 0.02090842
## 15    15       Virginia Avenue  8370 0.02273363
## 16    16 Pennsylvania Railroad  8771 0.02382278
## 17    17       St. James Place  9295 0.02524601
## 18    18       Community Chest  9102 0.02472181
## 19    19      Tennessee Avenue 10057 0.02731567
## 20    20       New York Avenue  9901 0.02689196
## 21    21          Free Parking  9884 0.02684578
## 22    22       Kentucky Avenue  9179 0.02493094
## 23    23               Chance  9744 0.02646553
## 24    24        Indiana Avenue  8902 0.02417859
## 25    25       Illinois Avenue 10561 0.02868457
## 26    26        B & O Railroad  9508 0.02582454
## 27    27       Atlantic Avenue  8926 0.02424377
## 28    28        Ventnor Avenue  8944 0.02429266
## 29    29           Water Works  9334 0.02535194
## 30    30        Marvin Gardens  8491 0.02306228
## 31    31            Go to jail     0 0.00000000
## 32    32        Pacific Avenue  8819 0.02395315
## 33    33 North Carolina Avenue  8545 0.02320895
## 34    34       Community Chest  9045 0.02456699
## 35    35   Pennsylvania Avenue  8366 0.02272277
## 36    36   Short Line Railroad  8078 0.02194053
## 37    37               Chance  7630 0.02072373
## 38    38            Park Place  7101 0.01928692
## 39    39            Luxury Tax  7113 0.01931951
## 40    40             Boardwalk  8844 0.02402106
```

```
arrange(results, desc(tally))
```

```
##    space                title tally        rel
## 1     11                  Jail 40320 0.10951254
## 2     25       Illinois Avenue 10561 0.02868457
## 3      1                   Go 10177 0.02764160
## 4     19      Tennessee Avenue 10057 0.02731567
## 5     20       New York Avenue  9901 0.02689196
## 6     21          Free Parking  9884 0.02684578
## 7     23               Chance  9744 0.02646553
## 8     26        B & O Railroad  9508 0.02582454
## 9      6      Reading Railroad  9498 0.02579737
```

```
## 10    29           Water Works  9334 0.02535194
## 11    17       St. James Place  9295 0.02524601
## 12    22       Kentucky Avenue  9179 0.02493094
## 13    12     St. Charles Place  9128 0.02479242
## 14    18       Community Chest  9102 0.02472181
## 15    13      Electric Company  9056 0.02459687
## 16    34       Community Chest  9045 0.02456699
## 17    28        Ventnor Avenue  8944 0.02429266
## 18    27       Atlantic Avenue  8926 0.02424377
## 19    24        Indiana Avenue  8902 0.02417859
## 20    40             Boardwalk  8844 0.02402106
## 21    32        Pacific Avenue  8819 0.02395315
## 22    16 Pennsylvania Railroad  8771 0.02382278
## 23    33 North Carolina Avenue  8545 0.02320895
## 24    30        Marvin Gardens  8491 0.02306228
## 25    15       Virginia Avenue  8370 0.02273363
## 26    35   Pennsylvania Avenue  8366 0.02272277
## 27    36   Short Line Railroad  8078 0.02194053
## 28     9        Vermont Avenue  7803 0.02119361
## 29     8                Chance  7724 0.02097904
## 30    14         States Avenue  7698 0.02090842
## 31     5            Income Tax  7680 0.02085953
## 32    37                Chance  7630 0.02072373
## 33    10    Connecticut Avenue  7582 0.02059336
## 34     7       Oriental Avenue  7562 0.02053903
## 35     2  Mediterranean Avenue  7192 0.01953408
## 36     3       Community Chest  7147 0.01941186
## 37    39            Luxury Tax  7113 0.01931951
## 38    38            Park Place  7101 0.01928692
## 39     4         Baltic Avenue  7100 0.01928420
## 40    31            Go to jail     0 0.00000000
```