Metadata

- Title: **Final Project Report**
- Class: DS 5100
- Date: July 13, 2022
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- This URL: https://github.com/ak7ra/Monte_Carlo_Simulator/blob/main/FinalProjectSubmission.ipynb
- GitHub Repo URL: https://github.com/ak7ra/Monte_Carlo_Simulator

The Monte Carlo Module

In [1]:
```
import numpy as np
import random
import pandas as pd

class Die:

    '''
    The Die object takes in an array or list of values and creates a die.
    Each value in the input array/list becomes a face of the created die.

    Attributes
    ----------
    None
    '''

    def __init__(self, faces):
        '''
        Parameters
        ----------
        faces : numpy array or list
            faces is an numpy array or list of type str or int. It can be of ar

        '''
        faces = np.array(faces)
        self._faces_and_weights = pd.DataFrame(data = faces, columns = ["Faces'
        self._faces_and_weights["Weights"] = np.array([1.0 for i in range(len(f

    def change_weight(self, face, new_weight):
        '''
        A method to change the weight of a single side.

        Parameters
        ----------
        face : str or int
            face of which the weight will be changed
        new_weight : float
            the resulting weight of the face
```

```
        Raises
        ------
        ValueError
            if new_weight is not a float or convertible to float, change_weight
            if face is not on the die, change_weight will throw this error.

        Returns
        -------
        None
        '''
        if not (face in list(self._faces_and_weights['Faces'])):
            raise ValueError("Face value does not exist.")
        else:
            self._faces_and_weights.loc[self._faces_and_weights['Faces'] == fac


    def roll(self, roll_num=1):
        '''
        A method to roll the die one or more times.

        Parameters
        ----------
        roll_num : int
            int type parameter of how many times the die is to be rolled; defau

        Returns
        -------
        result : list
            list of outcomes of the rolls.
        '''
        result = random.choices(self._faces_and_weights["Faces"].values, weight
        return result

    def show_faces_weights(self):
        '''
        A method to show the dataframe consisting of faces and weights of the c

        Returns
        -------
        the pandas dataframe consisting of faces and weights of the die
        '''
        return self._faces_and_weights

#-------------------------------------------------------------

class Game:

    '''
    The Game object takes in a list of die to make a game.
    A game consists of rolling of one or more dice of the same kind one or more

    Attributes
    ----------
    None
    '''

    def __init__(self, list_of_die):
        '''
        Parameters
        ----------
```

```
        list_of_die : list
            list_of_die is a list containing objects of the Die type. It can be

        '''
        self._result = pd.DataFrame()
        self._list_of_die = list_of_die

    def play(self, rolls):
        '''
        A method to play the game; roll each die for a certain amount of time.

        Parameters
        ----------
        rolls : int
            int type parameter of how many times each die is to be rolled.

        Returns
        -------
        None
        '''
        self._result = pd.DataFrame()
        for i in range(len(self._list_of_die)):
            new_res = pd.DataFrame(self._list_of_die[i].roll(rolls))
            new_res.index = [num+1 for num in range(rolls)]
            new_res.index.name = "Roll Number"
            new_res.columns = [i+1]
            new_res.columns.name = "Die Number"
            self._result = pd.concat([self._result, new_res], axis=1)

    def show_result(self, form="wide"):
        '''
        A method to return the dataframe including the most recent result from

        Parameters
        ----------
        form : string
            String parameter to determine the format of the returned dataframe.
            Defaults to "wide"

        Raises
        ------
        ValueError
            if the value of the variable form is not "narrow" or "wide", show_r

        Returns
        -------
        Pandas dataframe including the most recent result from the play method.
        Shows the roll number, the die number and the face rolled for each roll
        '''
        if not (form=="wide" or form=="narrow"):
            raise ValueError("Variable \"form\" must have value of \"wide\" or
            return
        elif form=="wide":
            return self._result
        elif form=="narrow":
            return self._result.stack().to_frame().rename(columns={0:"Face Roll


#--------------------------------------------------------------
```

```
class Analyzer:

    '''
    The Analyzer object takes in a game object and analyzes its results.

    Attributes
    ----------
    jackpot_count : int
        jackpot_count is an int type attribute that contains the amount of jack
        Defaults to 0. Updated to correct amount when jackpot() is called.
    jackpot_dataframe : pandas dataframe
        jackpot_dataframe is a pandas dataframe that contains the rows in which
        Defaults to an empty dataframe. Updated to correct data when jackpot()
    combo_frame : pandas dataframe
        combo_frame is a pandas dataframe that contains all combinations of the
        Defaults to an empty dataframe. Updated to correct data when combo() is
    face_count : pandas dataframe
        face_count is a pandas dataframe that counts the occurrence of each fac
        Defaults to an empty dataframe. Updated to correct data when face_count
    die_type : string
        die_type is a string type attribute. It stores the string specifying th
    '''

    def __init__(self, game):
        """
        Parameters
        ----------
        game : Game
            game is a Game object.

        """
        self._game = game
        self.jackpot_count = 0
        self.jackpot_dataframe = pd.DataFrame()
        self.combo_frame = pd.DataFrame()
        self.face_count = pd.DataFrame()
        self.die_type = type(game._list_of_die[0])

    def jackpot(self):
        '''
        A method to count the occurrence of jackpots in the game.

        Parameters
        ----------
        None

        Returns
        -------
        Pandas dataframe including the rows in which there were jackpots.
        Shows the roll number, the die number and the face rolled for each roll
        '''
        self.jackpot_dataframe = pd.DataFrame()
        for i in range(1, self._game.show_result().T.shape[1]+1):
            if ((len(set(self._game.show_result().loc[[i]].values[0].flatten())
                temp = self._game.show_result().loc[[i]]
                self.jackpot_dataframe = pd.concat([self.jackpot_dataframe, tem
        self.jackpot_count = self.jackpot_dataframe.shape[0]
        return self.jackpot_count

    def combo(self, permutation=False):
```

```
        '''
        A method to return the dataframe that contains all combinations of the

        Parameters
        ----------
        permutation : Boolean
            Boolean parameter to determine whether the function would count per
            Defaults to False.

        Returns
        -------
        Pandas dataframe including all combinations or permutations from a game
        The face values are turned into multi-indexes. The column shows the occ
        '''
        self.combo_frame = pd.DataFrame()
        if permutation:
            new_names = ["#"+str(i)+" die's value" for i in range(1, len(self._
            temp_df = self._game.show_result()
            temp_df.columns = new_names
            x = list(range(len(self._game._list_of_die)))
            return temp_df.set_index(new_names).sort_index().groupby(level=x).s
        else:
            self.combo_frame = self._game.show_result().apply(lambda x: pd.Seri
            self.combo_frame.index.names = ["Face Value #"+str(i) for i in rang
            return self.combo_frame


    def face_counts(self):
        '''
        A method to return the dataframe that counts the occurrence of each fac

        Parameters
        ----------
        None

        Returns
        -------
        Pandas dataframe including the counts of the occurrence of each face va
        The indexes indicate the roll number, and the columns indicate the face
        '''
        self.face_count = self._game.show_result().apply(pd.Series.value_counts
        self.face_count.columns.name = "Face of Die"
        return self.face_count
```

Test Module

In [ ]:

```
import unittest
from montecarlo import Die
from montecarlo import Game
from montecarlo import Analyzer
import pandas as pd
import numpy as np
import pandas.testing as pdt

class SimulatorClassesTestCase(unittest.TestCase):
```

```
    def test_change_weight_happypath(self):
        """
        This test tests the change_weight() function with the correct input val
        """
        die = Die([1,2,3,4,5,6])
        die.change_weight(3, 4.0)
        expected = 4
        actual = die.show_faces_weights().loc[die.show_faces_weights()['Faces']
        self.assertEqual(expected, actual)

    def test_change_weight_face_not_exist(self):
        """
        This test tests the change_weight() function with with an incorrect fac
        """
        die = Die([1,2,3,4,5,6])
        with self.assertRaises(ValueError):
            die.change_weight(7, 4.0)

    def test_change_weight_not_float(self):
        """
        This test tests the change_weight() function with an incorrect weight v
        """
        die = Die([1,2,3,4,5,6])
        with self.assertRaises(ValueError):
            die.change_weight(1, "Hi")

    def test_roll_one(self):
        """
        This test tests the roll() function with the default parameter value.
        """
        die = Die([1,2,3,4,5,6])
        expected = 1
        actual = len(die.roll())
        self.assertEqual(expected, actual)

    def test_roll_multiple(self):
        """
        This test tests the roll() function with the non-default parameter valu
        """
        die = Die([1,2,3,4,5,6])
        expected = 5
        actual = len(die.roll(5))
        self.assertEqual(expected, actual)

    def test_show_faces_weights(self):
        """
        This test tests the show_faces_weights() function.
        """
        die = Die([1,2,3,4,5,6])
        expected_dataframe = pd.DataFrame({"Faces":[1,2,3,4,5,6], "Weights":[1.
        actual_dataframe = die.show_faces_weights()
        pdt.assert_frame_equal(expected_dataframe, actual_dataframe)

    def test_play(self):
        """
        This test tests the play() function.
        """
        game = Game([Die([1,2,3]), Die([1,2,3]), Die([1,2,3])])
        game.play(100)
        expected_rows = 100
```

```
        actual_rows = game.show_result().shape[0]
        self.assertEqual(expected_rows, actual_rows)
        expected_columns = 3
        actual_columns = game.show_result().shape[1]
        self.assertEqual(expected_columns, actual_columns)

    def test_show_results_wide(self):
        """
        This test tests the show_results() function with "wide" as the form par
        """
        game = Game([Die([1,2,3]), Die([1,2,3]), Die([1,2,3])])
        game.play(100)
        expected_rows = 100
        actual_rows = game.show_result(form="wide").shape[0]
        self.assertEqual(expected_rows, actual_rows)
        expected_columns = 3
        actual_columns = game.show_result(form="wide").shape[1]
        self.assertEqual(expected_columns, actual_columns)

    def test_show_results_narrow(self):
        """
        This test tests the show_results() function with "narrow" as the form p
        """
        game = Game([Die([1,2,3]), Die([1,2,3]), Die([1,2,3])])
        game.play(100)
        expected_rows = 300
        actual_rows = game.show_result(form="narrow").shape[0]
        self.assertEqual(expected_rows, actual_rows)
        expected_columns = 1
        actual_columns = game.show_result(form="narrow").shape[1]
        self.assertEqual(expected_columns, actual_columns)

    def test_show_results_wrong_input(self):
        """
        This test tests the show_results() function with an inncorrect input ir
        """
        game = Game([Die([1,2,3]), Die([1,2,3]), Die([1,2,3])])
        game.play(100)
        with self.assertRaises(ValueError):
            game.show_result(form="foo")


    def test_jackpot(self):
        """
        This test tests the jackpot() function.
        """
        game = Game([Die([1,2,3]), Die([1,2,3]), Die([1,2,3])])
        game.play(100)
        analyzer = Analyzer(game)
        jackpot_amt = analyzer.jackpot()
        jackpot_dataframe_rows = analyzer.jackpot_dataframe.shape[0]
        self.assertEqual(jackpot_amt, jackpot_dataframe_rows)

    def test_combo(self):
        """
        This test tests the combo() function with default parameters.
        """
        game = Game([Die([1,2,3]), Die([1,2,3]), Die([1,2,3])])
        game.play(100)
        analyzer = Analyzer(game)
```

```
        combo_dataframe = analyzer.combo()
        expected_amt_of_col = 1
        actual_amt_of_col = combo_dataframe.shape[1]
        self.assertEqual(expected_amt_of_col, actual_amt_of_col)
        expected_amt_of_index = 3
        actual_amt_of_index = len(combo_dataframe.index.names)
        self.assertEqual(expected_amt_of_index, actual_amt_of_index)

    def test_combo_permutation(self):
        """
        This test tests the combo() function with the permutation parameter set
        """
        game = Game([Die([1,2,3]), Die([1,2,3]), Die([1,2,3])])
        game.play(100)
        analyzer = Analyzer(game)
        permutation_dataframe = analyzer.combo(permutation=True)
        expected_amt_of_col = 1
        actual_amt_of_col = permutation_dataframe.shape[1]
        self.assertEqual(expected_amt_of_col, actual_amt_of_col)
        expected_amt_of_index = 3
        actual_amt_of_index = len(permutation_dataframe.index.names)
        self.assertEqual(expected_amt_of_index, actual_amt_of_index)


    def test_face_counts(self):
        """
        This test tests the face_counts() function.
        """
        game = Game([Die([1,2,3]), Die([1,2,3]), Die([1,2,3])])
        game.play(100)
        analyzer = Analyzer(game)
        face_count_dataframe = analyzer.face_counts()
        expected_amt_of_col = 3
        actual_amt_of_col = face_count_dataframe.shape[1]
        self.assertEqual(expected_amt_of_col, actual_amt_of_col)
        expected_amt_of_rows = 100
        actual_amt_of_rows = face_count_dataframe.shape[0]
        self.assertEqual(expected_amt_of_rows, actual_amt_of_rows)


if __name__ == '__main__':
    unittest.main(verbosity=2)
```

Result of Unit Testing

Welcome to the Monte Carlo Simulator. test_change_weight_face_not_exist (**main**.SimulatorClassesTestCase) ... ok test_change_weight_happypath (**main**.SimulatorClassesTestCase) ... ok test_change_weight_not_float (**main**.SimulatorClassesTestCase) ... ok test_combo (**main**.SimulatorClassesTestCase) ... ok test_combo_permutation (**main**.SimulatorClassesTestCase) ... ok test_face_counts (**main**.SimulatorClassesTestCase) ... ok test_jackpot (**main**.SimulatorClassesTestCase) ... ok test_play (**main**.SimulatorClassesTestCase) ... ok test_roll_multiple (**main**.SimulatorClassesTestCase) ... ok test_roll_one (**main**.SimulatorClassesTestCase) ... ok test_show_faces_weights (**main**.SimulatorClassesTestCase) ... ok test_show_results_narrow (**main**.SimulatorClassesTestCase) ... ok test_show_results_wide

(**main**.SimulatorClassesTestCase) ... ok test_show_results_wrong_input
(**main**.SimulatorClassesTestCase) ... ok

Ran 14 tests in 0.134s

OK

Scenarios

Code blocks with your scenarios and their outputs.

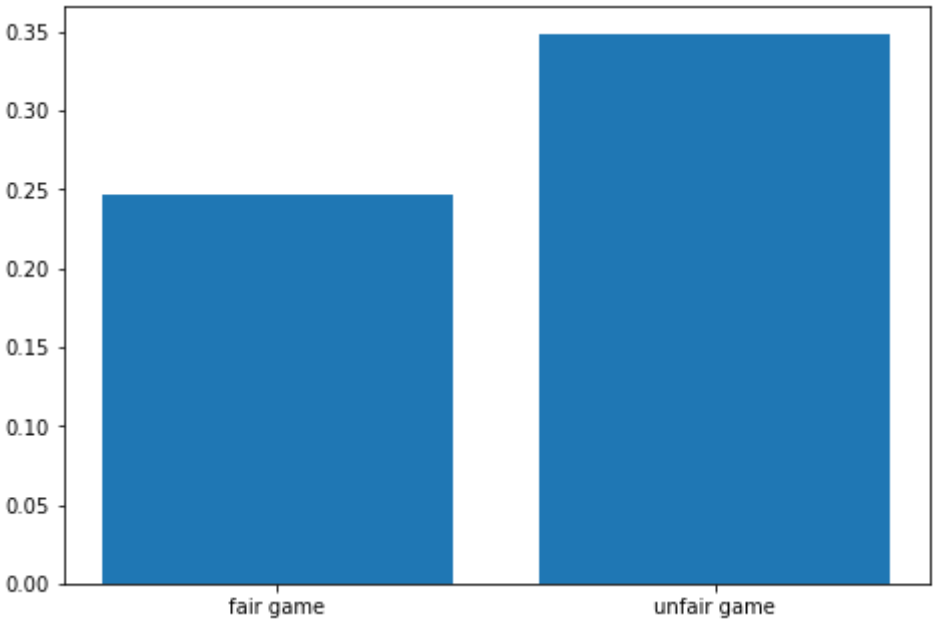
These should have appropriate import statements even though the code is now in the same notebook as the classes it calls.

In [3]:
```
from montecarlo import Die
from montecarlo import Game
from montecarlo import Analyzer
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
```

Scenario 1

In [4]:
```
"""
Create a fair coin (with faces H and T)
and one unfair coin, in which one of the faces has a weight of 5 and the others
"""
fair_die = Die(["H", "T"])
unfair_die = Die(["H", "T"])
unfair_die.change_weight("H", 5)

# Play a game of 1000 flips with all fair dice.
fair_game = Game([fair_die, fair_die, fair_die])
fair_game.play(1000)

# Play a game of 1000 flips with two unfair dice and one fair die.
unfair_game = Game([unfair_die, unfair_die, fair_die])
unfair_game.play(1000)

# For each game, use an Analyzer object to determine the relative frequency of
fair_analyzer = Analyzer(fair_game)
unfair_analyzer = Analyzer(unfair_game)
relative_freq_jackpot = fair_analyzer.jackpot() / unfair_analyzer.jackpot()

# Compute relative frequency as the number of jackpots over the total number of
relative_freq_jackpot_rolls_fair = fair_analyzer.jackpot() / 1000
relative_freq_jackpot_rolls_unfair = unfair_analyzer.jackpot() / 1000

# Show your results, comparing the two relative frequencies, in a simple bar ch
fig = plt.figure()
ax = fig.add_axes([0,0,1,1])
games = ["fair game", "unfair game"]
```

```
freq = [relative_freq_jackpot_rolls_fair, relative_freq_jackpot_rolls_unfair]
ax.bar(games, freq)
plt.show()
```

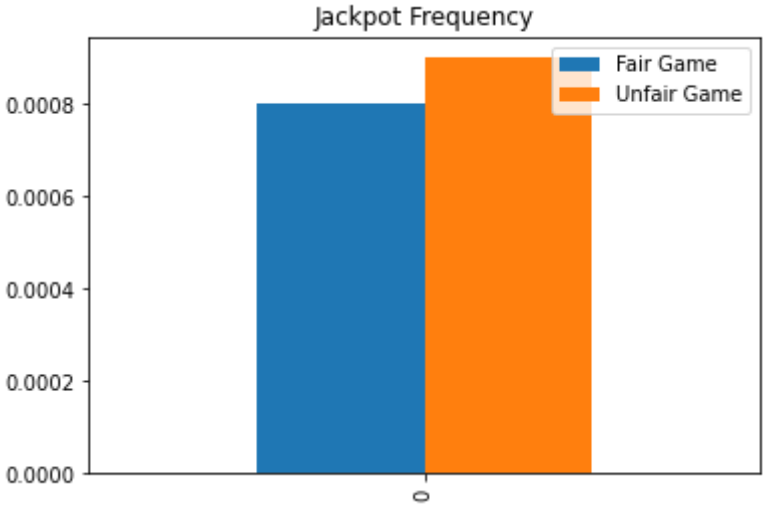


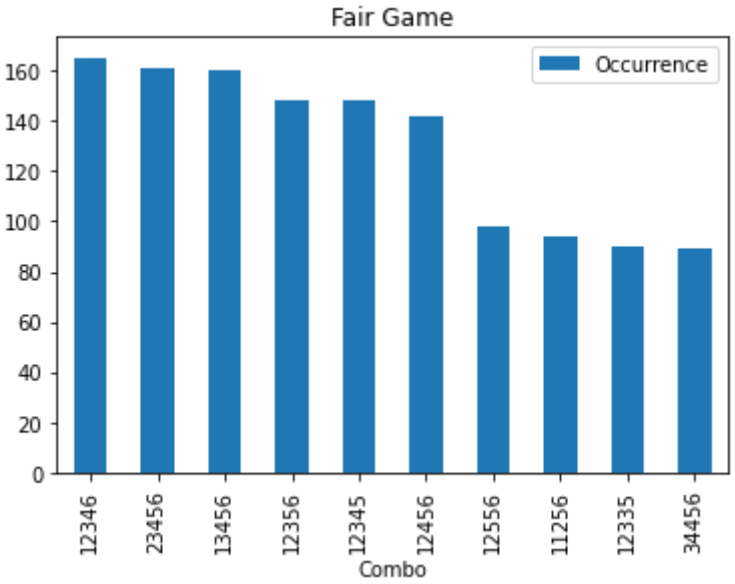
Scenario 2

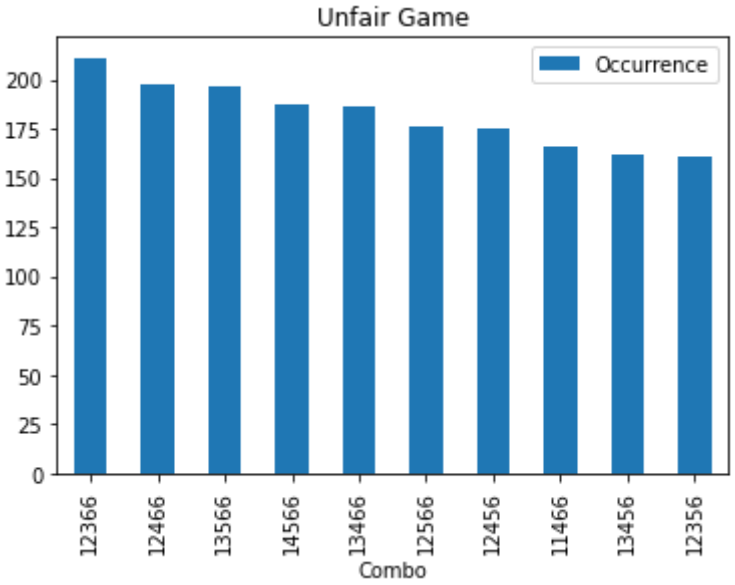
In [5]:

```
"""
Create a fair die and two unfair dice, all of six sides with the faces 1 throug
One unfair die (Type 1) will weight 6 five times more than the others (i.e. it
The other unfair die (Type 2) will  weight 1 five times more than the others.
"""
fair_die_six_sides = Die([1,2,3,4,5,6])
unfair_die_six_sides_1 = Die([1,2,3,4,5,6])
unfair_die_six_sides_1.change_weight(6, 5)
unfair_die_six_sides_2 = Die([1,2,3,4,5,6])
unfair_die_six_sides_2.change_weight(1, 5)

# Play a game of 10000 rolls with 5 fair dice.
fair_game_six_sides = Game([fair_die_six_sides, fair_die_six_sides, fair_die_si
fair_game_six_sides.play(10000)

# Play a game of 10000 rolls with 2 unfair dice of type 1, 1 unfair die of type
unfair_game_six_sides = Game([unfair_die_six_sides_1, unfair_die_six_sides_1, u
unfair_game_six_sides.play(10000)

# For each game, use an Analyzer object to determine the relative frequency of
fair_analyzer_six_sides = Analyzer(fair_game_six_sides)
unfair_analyzer_six_sides = Analyzer(unfair_game_six_sides)
fair_analyzer_six_sides_jackpot_freq = fair_analyzer_six_sides.jackpot() / 1000
unfair_analyzer_six_sides_jackpot_freq = unfair_analyzer_six_sides.jackpot() /

jackpot_freq = pd.DataFrame({"Fair Game":[fair_analyzer_six_sides_jackpot_freq]
jackpot_freq.plot.bar(title="Jackpot Frequency")
plt.show()

# Also compute 10 most frequent combinations of faces for each game. Plot each
fair_analyzer_six_sides_combos = fair_analyzer_six_sides.combo()['Occurrence'].
fair_analyzer_six_sides_combos["Combo"] = fair_analyzer_six_sides_combos["Face
```

```
fair_analyzer_six_sides_combos.plot.bar(x="Combo", y="Occurrence", title="Fair
plt.show()

unfair_analyzer_six_sides_combos = unfair_analyzer_six_sides.combo()['Occurrenc
unfair_analyzer_six_sides_combos["Combo"] = unfair_analyzer_six_sides_combos["F
unfair_analyzer_six_sides_combos.plot.bar(x="Combo", y="Occurrence", title="Unf
plt.show()
```







Scenario 3

In [7]:
```
# Create a "die" of letters from a to z with weights based on their frequency c
alphabet = [chr(i) for i in range(65, 91)]
alphabet_weights = {"A":8.4966, "B":2.0720, "C":4.5388, "D":3.3844, "E":11.1607
                    "I":7.5448, "J":0.1965, "K":1.1016, "L":5.4893, "M":3.0129,
                    "Q":0.1962, "R":7.5809, "S":5.7351, "T":6.9509, "U":3.6308,
                    "Y":1.7779, "Z":0.2722}
alphabet_die = Die(alphabet)
for x in alphabet_weights:
    alphabet_die.change_weight(x, alphabet_weights[x])

# Play a game involving 5 of these dice with 1000 rolls.
alphabet_game = Game([alphabet_die, alphabet_die, alphabet_die, alphabet_die, a
alphabet_game.play(1000)

# How many combos can you that look like actual English words? ← NOTE: "combo"
alphabet_analyzer = Analyzer(alphabet_game)
alphabet_combo_df = alphabet_analyzer.combo(permutation=True)
word = []
for i in range(1000):
    word.append("".join(list(alphabet_combo_df.iloc[i].name)))
np.array(word)
# Based on your eye count, what is the relative frequency of these words versus
# There were 3 words within the 1000 rolls; the frequency is 0.3%
```

Out[7]:
```
array(['AAANR', 'AADRI', 'AAFIT', 'AALBL', 'AANUE', 'AASLO', 'AAZIA',
       'ABRPE', 'ACNHI', 'ACPBL', 'ACUEI', 'ADIAL', 'ADRTK', 'AEARC',
       'AEIDN', 'AELBN', 'AELGI', 'AENLM', 'AEOOI', 'AESCS', 'AETSR',
       'AFDBE', 'AFMOI', 'AFRTN', 'AGHNT', 'AGMCM', 'AHEEH', 'AHITI',
       'AHNNG', 'AHSIA', 'AIAHR', 'AIAIE', 'AIMOT', 'AIOEJ', 'AISIH',
       'AITSY', 'AIUIZ', 'AJVCP', 'ALBTR', 'ALRHB', 'ALSZO', 'ALWNO',
       'ANAWA', 'ANDRO', 'ANERE', 'ANODN', 'ANOTA', 'ANRGS', 'ANSPM',
       'AOARD', 'AOELU', 'AOERI', 'AOREU', 'AOSMI', 'AOSRD', 'AOUNN',
       'APHED', 'APMNR', 'APRNA', 'ARAHF', 'ARCBO', 'ARCBT', 'ARHRA',
       'ARIOL', 'ARRVE', 'ARTRI', 'ASEOE', 'ASFFI', 'ASHOT', 'ASRIR',
       'ASTSR', 'ATADR', 'ATAEO', 'ATLRI', 'ATRZO', 'AUOCT', 'AURAN',
       'AUSAG', 'AVLRY', 'AWLUE', 'AWMOS', 'AYRPO', 'BACHL', 'BAORA',
       'BARTI', 'BCEIE', 'BDOUA', 'BDUNA', 'BEHST', 'BELEU', 'BETHE',
       'BFNGI', 'BFUDI', 'BGBLC', 'BHFAN', 'BHPDD', 'BICME', 'BIHTL',
       'BISEE', 'BLSUE', 'BNEIS', 'BNTRN', 'BOAEA', 'BOANR', 'BRDCE',
       'BROIP', 'BRUIR', 'BSMOB', 'BSTGH', 'BTTLR', 'BUAHP', 'BXAOI',
       'BYSEL', 'CAEFC', 'CANAR', 'CBNLN', 'CBORB', 'CCCWS', 'CCUIN',
       'CCVDO', 'CDRAE', 'CEFAR', 'CEIAA', 'CEONN', 'CFURO', 'CGEPM',
       'CHNMG', 'CIALA', 'CIFEN', 'CIIOI', 'CIITE', 'CIORC', 'CIRTE',
       'CITES', 'CLENN', 'CLINM', 'CLOUM', 'CMFUE', 'CMNLT', 'CMNTL',
       'CNLOA', 'CNSGE', 'CNSOT', 'COAAA', 'COBOC', 'COEMU', 'COOCS',
       'COTFE', 'CREOE', 'CREWO', 'CRHRO', 'CRKEU', 'CRLCG', 'CRLZT',
       'CRMAI', 'CRORV', 'CROTR', 'CSDEA', 'CSEEN', 'CSIOR', 'CSRAE',
       'CSTES', 'CSUGO', 'CTESP', 'CUAAR', 'CUHTW', 'CULBC', 'CVRIR',
       'CYYIO', 'DATIL', 'DBAAE', 'DBIYP', 'DBLOE', 'DCHPQ', 'DCOLT',
       'DDCEE', 'DDEML', 'DDUGE', 'DELOU', 'DGUAN', 'DIGAP', 'DIOAL',
       'DIUTI', 'DKRHE', 'DMOAA', 'DNABR', 'DNRNR', 'DOCCR', 'DOTMM',
       'DPKCE', 'DRFID', 'DRLLG', 'DSOHE', 'DWFIS', 'EAAPH', 'EAGLE',
       'EAILT', 'EANCA', 'EANEI', 'EANME', 'EAOTE', 'EAPTU', 'EASIE',
       'EASOF', 'EATTT', 'EAYPL', 'EBIME', 'EBMEM', 'ECFOR', 'ECSIL',
       'EDOEU', 'EDUOI', 'EEAHW', 'EEECA', 'EEETU', 'EEOUN', 'EEOYI',
       'EERES', 'EETNE', 'EFESH', 'EFMRD', 'EGHDI', 'EHLMO', 'EHOOC',
       'EHTDN', 'EHTEI', 'EICEU', 'EICRP', 'EIECN', 'EIERM', 'EIHOD',
       'EIIPU', 'EIKQR', 'EILES', 'EILKU', 'EIMND', 'EINOA', 'EIOSU',
       'EISCE', 'EITAB', 'EIUPM', 'EKALR', 'EKDWI', 'EKUEP', 'ELERA',
       'ELERD', 'ELEUI', 'ELIEA', 'ELMHA', 'ELNEH', 'ELORA', 'ELTIH',
       'ELYTR', 'EMEAD', 'EMEHN', 'EMODT', 'EMSMR', 'EMSRP', 'ENAAT',
       'ENARL', 'ENBST', 'ENDAN', 'ENDIH', 'ENKLT', 'ENOAR', 'ENTIR',
       'EOAAE', 'EOAMS', 'EOITT', 'EOLSP', 'EOMFS', 'EORAB', 'EPBJI',
       'EPKIR', 'EPONM', 'EPPRI', 'ERAAC', 'ERBPI', 'ERDIE', 'EREMS',
       'ERIEA', 'ERLUT', 'ERXIA', 'ESBYN', 'ESLRU', 'ESNOA', 'ESPAL',
       'ESSRS', 'ETAIS', 'ETGMI', 'ETRRE', 'EUECG', 'EUHDP', 'EUILO',
       'EUMUO', 'EUPNU', 'EURIN', 'EUTAI', 'EVRDN', 'EWARO', 'EWIOP',
       'EYARL', 'EYHOO', 'FCOLL', 'FCYBO', 'FDMHM', 'FFPGA', 'FHGEY',
       'FINBU', 'FLCAI', 'FMEAO', 'FPWOE', 'FRBIT', 'FSIPL', 'FUDKT',
       'FUPLH', 'FYLTE', 'GATCO', 'GBBIS', 'GDCDP', 'GDETT', 'GDIEF',
       'GDTTR', 'GECBL', 'GEEEO', 'GEYUE', 'GFNRU', 'GHNDL', 'GIAAK',
       'GIIAE', 'GITIN', 'GKTIN', 'GLEIG', 'GLEMT', 'GNELP', 'GOLNN',
       'GOUIL', 'GRENR', 'GRIOS', 'GROCE', 'GSIMA', 'GSIOE', 'GSTOO',
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       'HDECR', 'HDEWN', 'HDIOO', 'HEEAD', 'HESES', 'HIEKD', 'HIIDT',
       'HISIT', 'HLEHI', 'HLIPI', 'HMANB', 'HNLEC', 'HNMAH', 'HNNNA',
       'HNRYR', 'HOADD', 'HOEUT', 'HOMEA', 'HRLOA', 'HRWAR', 'HSCFE',
       'HSCIP', 'HSNRE', 'HTELN', 'HTGLI', 'HTNLD', 'HTOEI', 'HTYCT',
       'HUAMI', 'HXLPR', 'IALIU', 'IATIS', 'IAWBS', 'IBHMD', 'ICAIA',
       'ICIPR', 'ICLPN', 'ICOLO', 'IDFYN', 'IDRAS', 'IDTMT', 'IECEN',
       'IEEAT', 'IEEEE', 'IEISA', 'IEITO', 'IENEH', 'IEOFS', 'IEPIE',
       'IERON', 'IERSL', 'IFAYN', 'IGADA', 'IGLJN', 'IGRWG', 'IGTAB',
       'IHLFU', 'IIECU', 'IIIEL', 'IILTT', 'IINLE', 'IIPET', 'IJSDC',
       'IKLLL', 'IKRHK', 'ILLKE', 'ILNPN', 'ILRUL', 'IMOIG', 'INAHS',
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'INDML', 'INERF', 'INLNH', 'INNST', 'INVEP', 'IOAGT', 'IODAO',
'IODKR', 'IOIDN', 'IOMTL', 'IOPLR', 'IOUAA', 'IPOLY', 'IRENF',
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'ISANI', 'ISBVH', 'ISDEC', 'ISEAS', 'ISODU', 'ISTRI', 'ITATR',
'ITEOG', 'ITIHE', 'ITLEM', 'ITMFL', 'ITOEE', 'ITONO', 'IUMHE',
'IUNYB', 'IUOBO', 'IUOHG', 'IWLGM', 'IXELU', 'IYCOP', 'JITNL',
'JRITA', 'JSTBF', 'KAAEI', 'KARYE', 'KCNEI', 'KCYLR', 'KDSEA',
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'LAEIA', 'LAISS', 'LAMPC', 'LASOC', 'LATAI', 'LCDEN', 'LDLAR',
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'LHEAE', 'LHEPA', 'LHIBE', 'LIEOA', 'LIPRP', 'LIPSN', 'LIXRW',
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'LOOLN', 'LORWE', 'LORYO', 'LOYLA', 'LPDOH', 'LRADO', 'LRDLT',
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'LTDAD', 'LTELI', 'LTNEC', 'LUCIR', 'LUCVP', 'LUMOO', 'LUUFH',
'LVECG', 'LVWLO', 'LZSAE', 'MAMEA', 'MASEE', 'MBCRC', 'MCASN',
'MCCFN', 'MCFND', 'MEBRT', 'MEDOE', 'MEDOT', 'MEOJS', 'MEUGD',
'MHILO', 'MIANE', 'MKENB', 'MLAAE', 'MNIST', 'MNTUR', 'MOOTS',
'MOSSR', 'MRILE', 'MRITO', 'MRUCN', 'MSHMB', 'MSOIO', 'MSSTS',
'MTPLE', 'MTSII', 'MTTDK', 'MTTZR', 'MTYGO', 'MUHIM', 'MVRSR',
'MWOMI', 'MYECT', 'NADDH', 'NAJLO', 'NALHI', 'NANTE', 'NATAI',
'NATCN', 'NATLE', 'NAYCP', 'NAYLS', 'NBRAU', 'NCCSM', 'NEAEE',
'NEATP', 'NELBE', 'NEOCO', 'NETGW', 'NFAWP', 'NGGTA', 'NHERS',
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'NITRP', 'NKEAH', 'NLAER', 'NLAIS', 'NLCTT', 'NLERR', 'NLHPC',
'NLTNN', 'NMARO', 'NMOLT', 'NNEIR', 'NNRES', 'NNYGG', 'NNYSP',
'NOBBD', 'NOCAT', 'NODCW', 'NODRN', 'NOENU', 'NOIID', 'NOINH',
'NOTLM', 'NOTTS', 'NPATE', 'NPELW', 'NRCKR', 'NRNSY', 'NRTNR',
'NRTTS', 'NSCPR', 'NSITT', 'NSOOV', 'NSRIE', 'NSTNL', 'NSYIF',
'NTCST', 'NTEIH', 'NTPNA', 'NTPQD', 'NUEHE', 'NUMON', 'NWBIS',
'NXERP', 'OAAMS', 'OAAOD', 'OAFHN', 'OAKPE', 'OAYOC', 'OAYPO',
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'OLARE', 'OLONE', 'OLOYL', 'OMSNM', 'ONOUC', 'ONRAC', 'ONRIA',
'ONTDE', 'ONYAO', 'OOIEE', 'OOIRE', 'OOLBM', 'OOLRD', 'OOMNA',
'OOYLC', 'OPRAY', 'ORANI', 'ORCCR', 'ORCYH', 'ORRAY', 'OSRNE',
'OSTRT', 'OTELP', 'OTRLE', 'OTSET', 'OTTUV', 'OTYKV', 'OUINM',
'OUVAE', 'OWIKN', 'OWOTE', 'OYCUT', 'PASFD', 'PAXEA', 'PBROG',
'PCBNG', 'PDFEH', 'PEEAO', 'PEIDO', 'PEIEA', 'PEMLI', 'PHOBN',
'PIDYI', 'PITFB', 'PLGES', 'PLNRV', 'PNEMT', 'PNHZN', 'PNSIR',
'PNXGR', 'POPPR', 'PRLTS', 'PRSON', 'PSIAO', 'PTTYI', 'PWPPC',
'PYALR', 'QDACU', 'RALEA', 'RASCO', 'RBLPE', 'RCCTR', 'RCINO',
'RCRGU', 'RCURR', 'RDAHE', 'RDMOE', 'RDTAC', 'RDUGR', 'RECAL',
'REEEE', 'REERI', 'RELRT', 'REOOY', 'REUDR', 'REVUP', 'RFERT',
'RFLRN', 'RFREF', 'RGAFR', 'RGASD', 'RGEEF', 'RHACO', 'RHECI',
'RHNCC', 'RHNLC', 'RIDTO', 'RIJLF', 'RILAT', 'RIPEE', 'RIRPT',
'RITMT', 'RKHAO', 'RLEAY', 'RLILB', 'RLLGD', 'RLMRE', 'RMEHP',
'RMOTE', 'RMRAT', 'RMWOM', 'RNCGS', 'RNCRR', 'RNECG', 'RNERU',
'RNIDC', 'RNIEO', 'RNOAL', 'RNPUM', 'RNSAV', 'RNVSS', 'ROEUA',
'ROHTS', 'RONAF', 'RONNP', 'RPCMW', 'RPPRE', 'RRENA', 'RRTWL',
'RSAOM', 'RSIHA', 'RSLIG', 'RSOEL', 'RSUIT', 'RTIPE', 'RTUTE',
'RUNCL', 'RUNPI', 'RVBFN', 'RVSNC', 'RVUNO', 'RWESA', 'RWKOI',
'RXHIC', 'SAEAE', 'SALIA', 'SAOOT', 'SBOAI', 'SBYXE', 'SCERN',
'SDNWI', 'SDSBY', 'SEDYV', 'SEEAS', 'SEFVO', 'SEILN', 'SEIRN',
'SELIO', 'SEMOS', 'SERIR', 'SESIB', 'SFBVS', 'SFHHA', 'SFWAI',
'SGNWI', 'SHOTS', 'SHRRR', 'SIANY', 'SIEGS', 'SIODR', 'SISHR',
'SIYEO', 'SKDIE', 'SKHEG', 'SMCIA', 'SMYOP', 'SNINF', 'SNSTG',
'SOAOH', 'SOECO', 'SOLAA', 'SONAR', 'SOODG', 'SOSTT', 'SRFNL',
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'SRIAA', 'SRLTC', 'SRSSU', 'SSYTN', 'STCOM', 'STHUO', 'STLUO',
'STSSR', 'STSWT', 'STTAO', 'STTOE', 'SUCDI', 'SYRMN', 'TABRT',
'TAHAE', 'TALOE', 'TANNI', 'TAOCI', 'TAOET', 'TASPR', 'TATEY',
'TAYOF', 'TCCAO', 'TCCES', 'TCELB', 'TCIDE', 'TCLST', 'TCLTO',
'TCRNA', 'TCRRO', 'TDIFH', 'TDPHN', 'TEANN', 'TEIFI', 'TEMEP',
'TEMKI', 'TENOU', 'TEUBE', 'TGEEU', 'TGHSX', 'THAMO', 'THDSU',
'THLAE', 'THLIO', 'THTAA', 'TIKAN', 'TINAP', 'TIOYO', 'TIVTT',
'TJSLC', 'TLDAA', 'TLUGP', 'TMMTA', 'TNBOD', 'TNORQ', 'TNYTB',
'TOBRA', 'TOFLT', 'TOHRH', 'TOPTE', 'TORAC', 'TOSCT', 'TOWAH',
'TPEDL', 'TPIOT', 'TRBPN', 'TRDFH', 'TRLUM', 'TRTGM', 'TRTUS',
'TRUIE', 'TSIAV', 'TSIER', 'TSNRA', 'TSRFH', 'TTCFC', 'TTEFO',
'TTTEA', 'TUERB', 'TURRI', 'TWGBP', 'TYEAI', 'TYELD', 'TYFCE',
'TYRYC', 'UAAEE', 'UADRO', 'UAEUS', 'UCNAE', 'UEOKI', 'UGRTC',
'UGRWE', 'UGSPU', 'UIIAE', 'UIIRM', 'UINUI', 'UIOUL', 'UIUIR',
'UJCSA', 'UKART', 'ULANL', 'ULAOR', 'ULLHC', 'UMPDE', 'UNEIE',
'UNMHC', 'UNOOS', 'UOEUT', 'UOKPR', 'URSNU', 'UTCCG', 'UTCNE',
'UTEEO', 'UTRCA', 'UTTIE', 'UUIER', 'UWSDE', 'UXROB', 'UYHCI',
'UYLST', 'VALAL', 'VFUKU', 'VLEXA', 'VNAUB', 'VQEIF', 'VUEAS',
'WEANT', 'WECHN', 'WELAL', 'WERIN', 'WOERD', 'WOICL', 'WOMTD',
'WPOES', 'WRRSC', 'WSAPB', 'WSSCY', 'WTITR', 'XFTTR', 'XHAPC',
'XIRTE', 'XUGTI', 'YCIEB', 'YEOOC', 'YITSS', 'YLRHE', 'YMHSI',
'YNAHR', 'YNETM', 'YNOGN', 'YOFTO', 'YOPIT', 'YRPDE', 'YUARA',
'YXITI', 'ZANIO', 'ZCCIS', 'ZEPIH', 'ZERZG', 'ZFHIN'], dtype='<U5')
```

Directory Listing

A code block that executes the following bash command:

```
!ls -lRF -o
```

In [1]:
```
!ls -lRF -o
```

```
total 352
-rw-r--r--  1 amikano  85700 Jul 15 08:54 FinalProjectSubmission.ipynb
-rw-r--r--  1 amikano   1065 Jul 13 14:13 LICENSE
drwxr-xr-x  6 amikano    192 Jul 13 22:46 Monte_Carlo_Simulator.egg-info/
-rw-r--r--  1 amikano   1002 Jul 14 11:57 Montecarlo_test_results.txt
-rw-r--r--@ 1 amikano   1139 Jul 14 09:21 README.md
drwxr-xr-x  5 amikano    160 Jul 13 14:07 __pycache__/
drwxr-xr-x  7 amikano    224 Jul 14 19:58 montecarlo/
-rw-r--r--  1 amikano  59066 Jul 13 23:17 montecarlo_demo.ipynb
-rw-r--r--@ 1 amikano   6369 Jul 15 08:54 montecarlo_tests.py
-rw-r--r--@ 1 amikano    376 Jul 13 14:14 setup.py
-rw-r--r--  1 amikano   5761 Jul  9 16:40 simulator_classes.pyc

./Monte_Carlo_Simulator.egg-info:
total 32
-rw-r--r--  1 amikano  318 Jul 13 22:46 PKG-INFO
-rw-r--r--  1 amikano  254 Jul 13 22:46 SOURCES.txt
-rw-r--r--  1 amikano    1 Jul 13 22:46 dependency_links.txt
-rw-r--r--  1 amikano   11 Jul 13 22:46 top_level.txt

./__pycache__:
total 48
-rw-r--r--  1 amikano  9424 Jul 13 14:07 montecarlo.cpython-39.pyc
-rw-r--r--  1 amikano  2313 Jul  7 16:35 simulator_classes.cpython-310.pyc
-rw-r--r--  1 amikano  4687 Jul 10 15:23 simulator_classes.cpython-39.pyc

./montecarlo:
total 32
-rw-r--r--@ 1 amikano   137 Jul 13 14:16 __init__.py
drwxr-xr-x  4 amikano   128 Jul 14 11:57 __pycache__/
-rw-r--r--@ 1 amikano  9302 Jul 14 19:58 montecarlo.py

./montecarlo/__pycache__:
total 32
-rw-r--r--  1 amikano   324 Jul 13 17:16 __init__.cpython-39.pyc
-rw-r--r--  1 amikano  9959 Jul 14 11:57 montecarlo.cpython-39.pyc
```

Installation Output Listing

A code block that executes the code to install your your package and outputs a successful installation.

In [9]:
```
!pip install .
```

```
Processing /Users/amikano/Documents/MSDS/DS5100/Monte_Carlo_Simulator
  DEPRECATION: A future pip version will change local packages to be built in-
place without first copying to a temporary directory. We recommend you use --u
se-feature=in-tree-build to test your packages with this new behavior before i
t becomes the default.
   pip 21.3 will remove support for this functionality. You can find discussio
n regarding this at https://github.com/pypa/pip/issues/7555.
Building wheels for collected packages: Monte-Carlo-Simulator
  Building wheel for Monte-Carlo-Simulator (setup.py) ... done
  Created wheel for Monte-Carlo-Simulator: filename=Monte_Carlo_Simulator-0.1-
py3-none-any.whl size=4633 sha256=046bdc642fd5cbef1e5bca77ca886027d2b840d9729c
028fad0513c75e6d5d22
  Stored in directory: /private/var/folders/fz/w6ggb67x2gj04ph736q3_nnm0000gn/
T/pip-ephem-wheel-cache-ba0ic2n5/wheels/09/07/93/0f02a2853d12ee799896c024be84a
1804f01b95f2f6e0f09a9
Successfully built Monte-Carlo-Simulator
Installing collected packages: Monte-Carlo-Simulator
  Attempting uninstall: Monte-Carlo-Simulator
    Found existing installation: Monte-Carlo-Simulator 0.1
    Uninstalling Monte-Carlo-Simulator-0.1:
      Successfully uninstalled Monte-Carlo-Simulator-0.1
Successfully installed Monte-Carlo-Simulator-0.1
```