Statistical Thinking in Python Part 2

3). Introduction to hypothesis testing

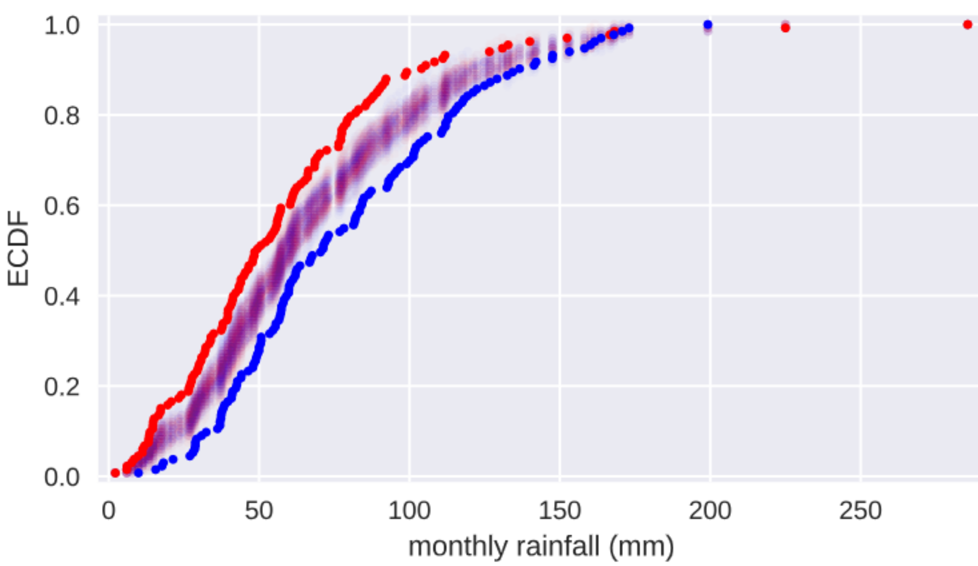
a). Generating a Permutation Sample:

```
def permutation_sample(data1, data2):
    """Generate a permutation sample from two data sets."""

    # Concatenate the data sets: data
    data = np.concatenate((data1,data2))

    # Permute the concatenated array: permuted_data
    permuted_data = np.random.permutation(data)

    # Split the permuted array into two: perm_sample_1, perm_sample_2
    perm_sample_1 = permuted_data[:len(data1)]
    perm_sample_2 = permuted_data[len(data1):]

    return perm_sample_1, perm_sample_2
```

b). Visualizing Permutation Sample:

```
for x in range(50):

    # Generate permutation samples

    perm_sample_1, perm_sample_2 = permutation_sample(rain_june,rain_november)



    # Compute ECDFs

    x_1, y_1 = ecdf(perm_sample_1)

    x_2, y_2 = ecdf(perm_sample_2)
```

```
    # Plot ECDFs of permutation sample
    _ = plt.plot(x_1, y_1, marker='.', linestyle='none',
                 color='red', alpha=0.02)
    _ = plt.plot(x_2, y_2, marker='.', linestyle='none',
                 color='blue', alpha=0.02)

# Create and plot ECDFs from original data
x_1, y_1 = ecdf(rain_june)
x_2, y_2 = ecdf(rain_november)
_ = plt.plot(x_1, y_1, marker='.', linestyle='none', color='red')
_ = plt.plot(x_2, y_2, marker='.', linestyle='none', color='blue')

# Label axes, set margin, and show plot
plt.margins(0.02)
_ = plt.xlabel('monthly rainfall (mm)')
_ = plt.ylabel('ECDF')
plt.show()
```

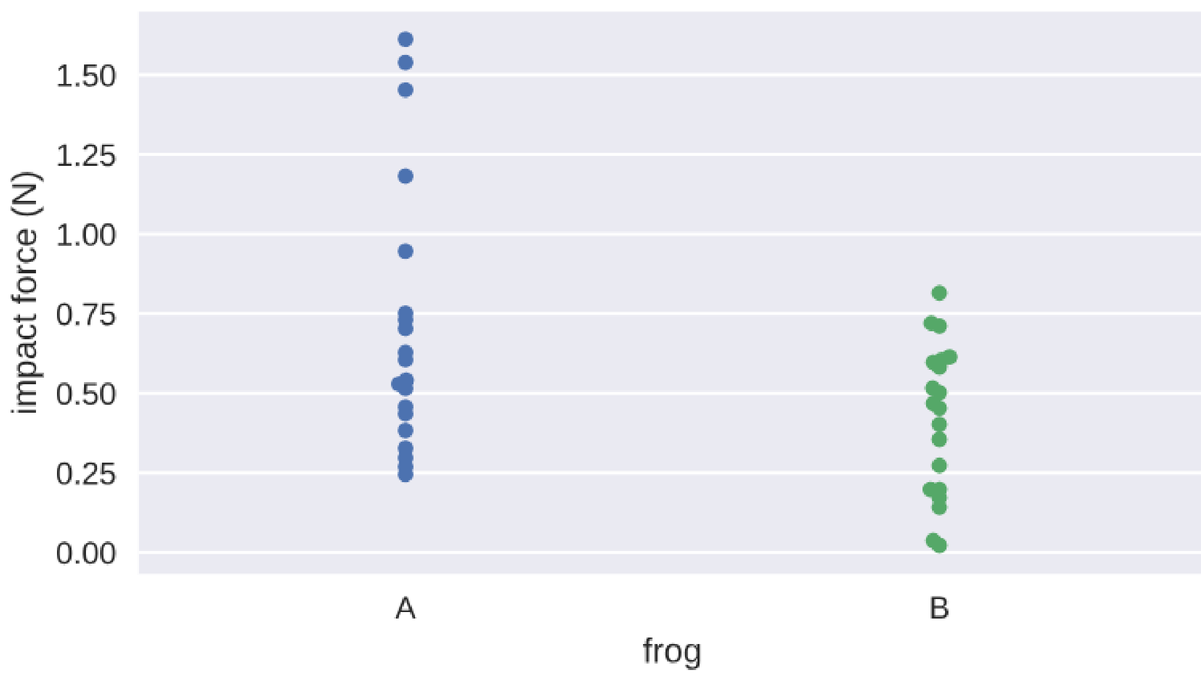


c). Generating Permutation Replicates

```
def draw_perm_reps(data_1, data_2, func, size=1):
    """Generate multiple permutation replicates."""

    # Initialize array of replicates: perm_replicates
    perm_replicates = np.empty(size)

    for i in range(size):
        # Generate permutation sample
        perm_sample_1, perm_sample_2 = permutation_sample(data_1, data_2)

        # Compute the test statistic
        perm_replicates[i] = func(perm_sample_1, perm_sample_2)

    return perm_replicates
```

d). Look Before You Leap: EDA Before Hypothesis Testing

```
# Make bee swarm plot
_ = sns.swarmplot(x='ID',y='impact_force',data='df')

# Label axes
_ = plt.xlabel('frog')
_ = plt.ylabel('impact force (N)')

# Show the plot
plt.show()
```



e). Permutation Test on Frog data

```
def diff_of_means(data_1, data_2):
    """Difference in means of two arrays."""

    # The difference of means of data_1, data_2: diff
    diff = np.mean(data_1)-np.mean(data_2)

    return diff

# Compute difference of mean impact force from experiment: empirical_diff_means
empirical_diff_means = diff_of_means(force_a, force_b)

# Draw 10,000 permutation replicates: perm_replicates
perm_replicates = draw_perm_reps(force_a, force_b,
                                 func(diff_of_means), size=10000)

# Compute p-value: p
p = np.sum(perm_replicates >= empirical_diff_means) / len(perm_replicates)

# Print the result
print('p-value =', p)

<script.py> output:
    p-value = 0.0063
```

f). <u>A one sample bootstrap hypothesis test</u>

```
# Make an array of translated impact forces: translated_force_b
translated_force_b = force_b-np.mean(force_b)+0.55

# Take bootstrap replicates of Frog B's translated impact forces: bs_replicates
bs_replicates = draw_bs_reps(translated_force_b, np.mean, 10000)

# Compute fraction of replicates that are less than the observed Frog B force: p
p = np.sum(bs_replicates <= np.mean(force_b)) / 10000

# Print the p-value
print('p = ', p)
```

<script.py> output:

```
p =  0.0046
```

g). A bootstrap test for identical distribution

```
# Compute difference of mean impact force from experiment: empirical_diff_means
empirical_diff_means = diff_of_means(force_a, force_b)

# Concatenate forces: forces_concat
forces_concat = np.concatenate((force_a, force_b))

# Initialize bootstrap replicates: bs_replicates
bs_replicates = np.empty(10000)

for i in range(10000):
    # Generate bootstrap sample
    bs_sample = np.random.choice(forces_concat, size=len(forces_concat))

    # Compute replicate
    bs_replicates[i] = diff_of_means(bs_sample[:len(force_a)],
                                     bs_sample[len(force_a):])

# Compute and print p-value: p
p = np.sum(bs_replicates >= empirical_diff_means) / float(len(bs_replicates))
print('p-value =', p)
```

<script.py> output:

```
p-value = 0.0055
```

h). A two sample bootstrap hypothesis test for difference of means

```
# Compute mean of all forces: mean_force
mean_force = np.mean(forces_concat)

# Generate shifted arrays
force_a_shifted = force_a - np.mean(force_a) + mean_force
force_b_shifted = force_b - np.mean(force_b) + mean_force

# Compute 10,000 bootstrap replicates from shifted arrays
bs_replicates_a = draw_bs_reps(force_a_shifted, np.mean, 10000)
bs_replicates_b = draw_bs_reps(force_b_shifted, np.mean, 10000)

# Get replicates of difference of means: bs_replicates
bs_replicates = bs_replicates_a - bs_replicates_b

# Compute and print p-value: p
p = np.sum(bs_replicates>= empirical_diff_means) / len(bs_replicates)
print('p-value =', p)
```

<script.py> output:

```
p-value = 0.0043
```