Probability & Visualization

Python & Statistics Bootcamp

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Set up

Data

1. Go to https://nmbrodnax.github.io/python-stats/ and click on *Probability & Visualization*
2. Download the *County Demographics 2016* file and save it in your `bootcamp` directory
3. For your project, choose any other dataset, download it, and save it in your `bootcamp` directory

Jupyter notebook

1. Launch Jupyter from the command line: `jupyter notebook`, or from the Anaconda Navigator graphical interface
2. Navigate to the browser where your notebook is running
3. Create a new Python 3 notebook called `Visualization`

Working with Pandas

Statistics

Descriptive Statistics

Visualization

The pandas package

Pandas provides high-performance data manipulation and analysis. It was designed to allows users to load, prepare, manipulate, model, and analyze data.

Features

- A DataFrame object, which is similar to a two-dimensional array but allows different data types
- Tools for loading data from files of different formats
- Routines for merging, joining, and reshaping data
- Label-based slicing, indexing and subsetting

Data structures in pandas

series – one-dimensional, labeled array; it can be created from various inputs such as an array or dictionary

data frame – two-dimensional, labeled tabular structure with columns of the same or of different types

panel – three-dimensional, size-mutable array; rarely used

Working with pandas

```
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print(s)
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```
df = pd.read_csv("county_demographics_2016.csv")
print(df[:10])
```

pandas: useful features

- Reference by label

```
med_inc = df['median_income']
print(med_inc[:10])
```

- View a subset of rows

```
print(med_inc.head())
```

- Compute summary statistics

```
print(df.describe())
```

Activity: Use the `.isnull()` method to determine the number of rows of missing observations in median income.

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Statistics

Statistics is the science of collecting, organizing, summarizing, analyzing, and drawing conclusions from data

- Descriptive statistics involves summarizing and presenting data
- Inferential statistics involves generalizing from samples to populations, performing estimations and hypothesis tests, determining relationships among variables, and making predictions

Why probability?

Deterministic thinking: 0 or 1, known with certainty

Probabilistic thinking: 0 to 1, known with uncertainty

- Events have some chance of occurring
- Use probability to quantify uncertainty
- Can be based on on what we observe or what we believe based on prior information

Probability

Probability is the chance of an event occurring, denoted $P(E)$

- Classical – all outcomes are equally likely to occur (e.g., coin flip)
- Empirical – outcomes may not be equally likely (e.g., World Cup winner) so we estimate the probability by observing how frequently those outcomes occur

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Probability Rules

- A given probability must fall between 0 and 1
- A probability and its complement must sum to 1
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Q: What are some examples of classical and empirical probability events?

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Descriptive statistics

A variable is the unit of description we use to describe data

- characteristic or attribute that can assume different values
- called a **random variable** when values are determined by chance

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Ways to describe data

- Qualitative (categorical) or quantitative (numerical)
- Discrete (countable) or continuous
- Type of measurement
  - nominal – name, category, label
  - ordinal – ordered in some way
  - interval – ordered and we can measure the differences
  - ratio – zero has a true meaning and we can calculate ratios across populations

Describing data

Measures of central tendency

- Mean
- Median
- Mode

Measures of spread

- Variance
- Standard deviation

Activity: describing data

1. Download the dataset you would like to use for your project from https://nmbrodnax.github.io/python-stats/ on the *Probability & Visualization* page
2. Confirm that the dataset is saved in the same directory as your notebook (in the `bootcamp` folder
3. Review the pandas documentation for `.isnull()`, `.notnull()`, and `.fillna()`
4. Create a data frame object for your dataset
5. Create a subset with three quantitative variables
6. Are your variables missing observations? If so, how many?
7. Compute the following descriptive statistics for each variable: mean, variance, and standard deviation

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Visualization

The matplotlib package

Matplotlib is a powerful visualization library

- built on numpy
- works well with many operating systems
- creates many types of outputs, including: png, jpeg, eps, pdf, and tiff

Working with matplotlib

Load matplotlib

```
import numpy as np
import pandas as pd
import matplotlib as mpl
import matplotlib.pyplot as plt
```

Create a figure

```
x = np.linspace(0, 10, 100)

fig1 = plt.figure()
plt.plot(x, np.sin(x))
plt.plot(x, np.cos(x))

plt.show()
```

matplotlib: useful features

Embed figures into your Jupyter notebook

```
%matplotlib inline
```

Specify a style

```
plt.style.use('classic')
```

Save a figure

```
fig1.savefig('myfig.png')
```

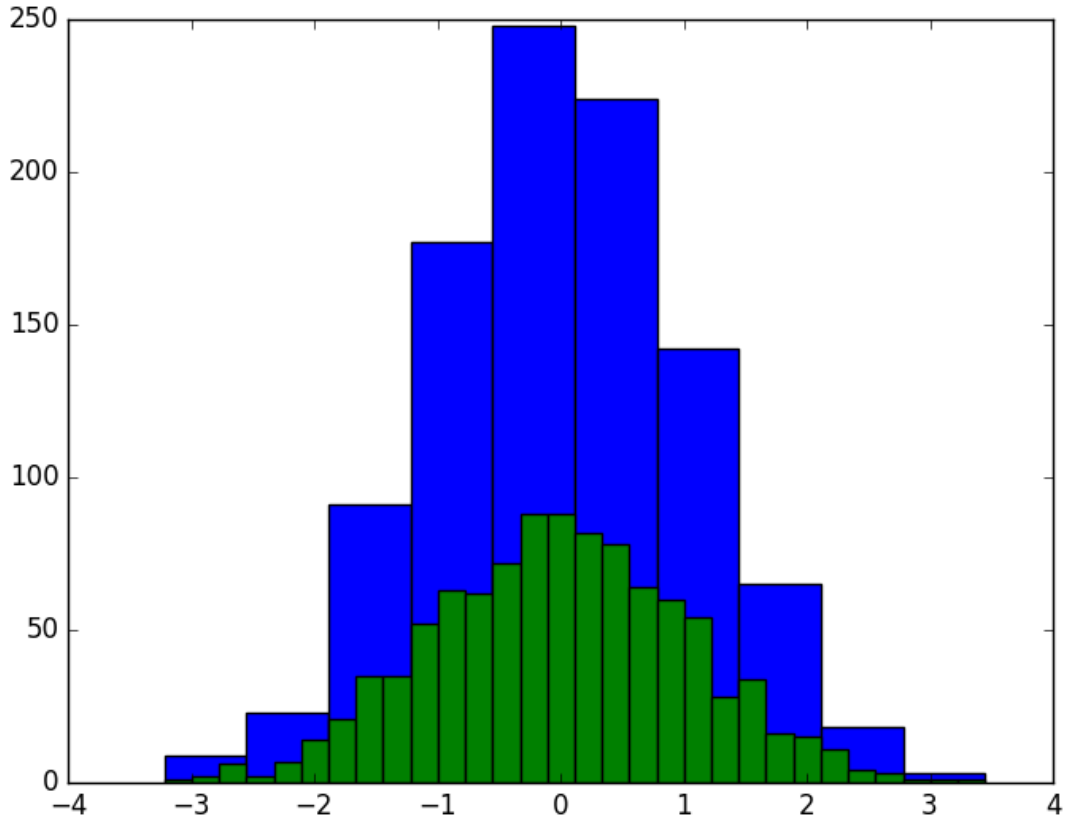
Add labels

```
fig2 = plt.figure()
plt.plot(x, np.sin(x))

plt.title("A Sine Curve")
plt.xlabel("x")
plt.ylabel("sin(x)")
```

Plot a histogram

```
data = np.random.randn(1000)
fig3 = plt.figure()
plt.hist(data)
plt.hist(data, bins=30)
fig3.savefig('myhist.png')
```



Probability distributions

A **probability distribution** is a list of values that a random variable can take and the corresponding probabilities of the values based on those frequencies

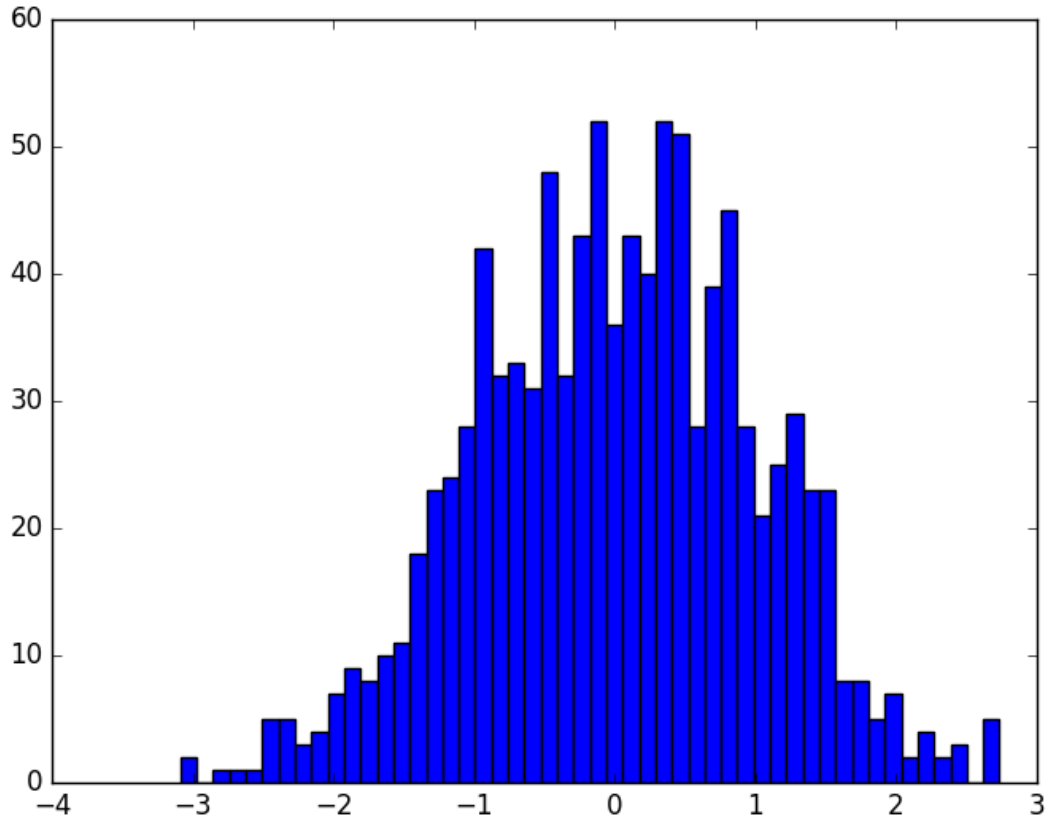
Standard Normal Distribution

- continuous, bell-shaped, and symmetric
- mean = median = mode
- 99% of area falls within three standard deviations
- characterized by the function

$$y = \frac{e^{-(X-\mu)^2/(2\sigma^2)}}{\sigma\sqrt{2\pi}} \tag{1}$$

Plot the normal distribution

```
norm = np.random.standard_normal(1000)
fig4 = plt.figure()
plt.hist(norm, bins=50)
fig4.savefig('normal.png')
```



Questions?