Data 100, Spring 2023

Discussion #4

Visualizations

Many of you have probably heard of Bigfoot before. It's a mysterious ape-like creature that is said to live in North American forests. Most doubt its existence, but a passionate few swear that bigfoot is real. In this discussion, you will be working with a dataset on bigfoot sightings, visualizing variable distributions and combinations thereof to better understand how/when/where bigfoot is reportedly spotted, and possibly either confirm or cast doubt on its existence. The bigfoot data contains a ton of variables about each reported bigfoot spotting, including location information, weather, and moon phase.

This dataset is extremely messy, with observations missing many values across multiple columns. This is normally the case with data based on citizen reports (many do not fill out all required fields). For the purposes of this discussion, we will drop all observations with any missing values and some unneeded columns. However, note this is not a good practice and you should almost never do this in real life!

Here are the first few entries of the `bigfoot` table:

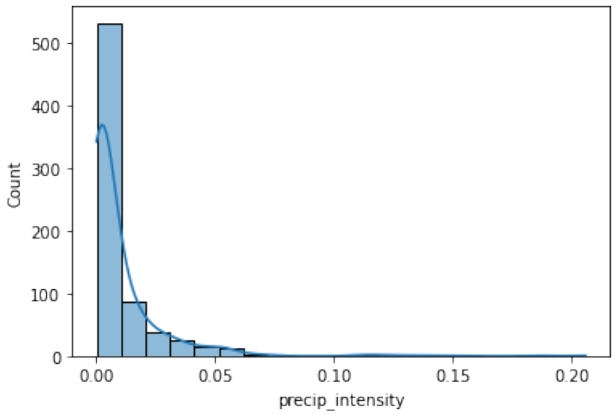
season	date	temperature_high	temperature_low	humidity	cloud_cover	moon_phase	precip_intensity	pressure	uv_index	visibility	wind_speed
Summer	2016-06-07	74.69	53.80	0.79	0.61	0.10	0.0010	998.87	6.0	9.70	0.49
Summer	2015-10-02	49.06	44.24	0.87	0.93	0.67	0.0092	1022.92	3.0	9.16	2.87
Fall	2009-10-31	69.01	34.42	0.77	0.81	0.42	0.0158	1011.48	3.0	1.97	3.94
Summer	1978-07-15	68.56	63.05	0.88	0.80	0.33	0.0285	1014.70	5.0	5.71	5.47
Summer	2015-11-26	20.49	5.35	0.65	0.08	0.54	0.0002	1037.98	1.0	10.00	0.40

1. Let's first look at distributions of individual quantitative variables. Let's say we're interested in `wind_speed`.

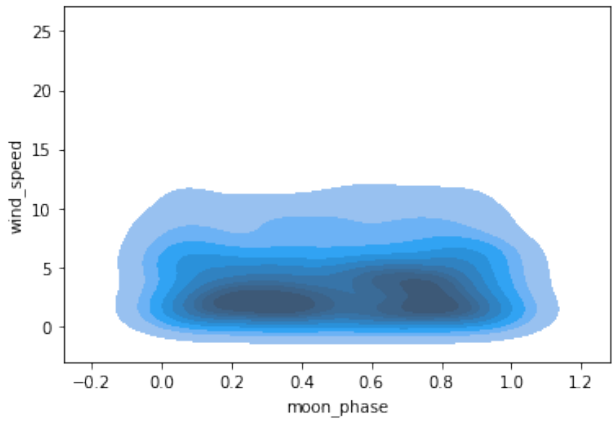
   (a) Which of the following are appropriate visualizations for plotting the distribution of a quantitative continuous variable?

   A. Pie charts
   B. Kernel Density Plot
   C. Scatter plot
   D. Boxplot
   E. Histogram
   F. Hexplots

(b) Write a line of code that produces the visualization that depicts the variable's **distribution** (example shown below).
hint: Use `seaborn(sns.histplot)/matplotlib(plt.hist)`

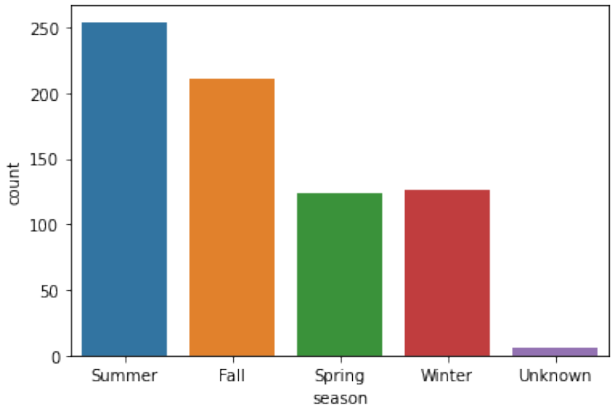


2. Now, let's see how two variables might relate to each other when bigfoot is reportedly out. Fill in the function to produce a visualization that shows what combinations of values of `moon_phase` and `wind_speed` are most common when bigfoot is spotted. **hint:** Use `seaborn(sns.kdeplot)`

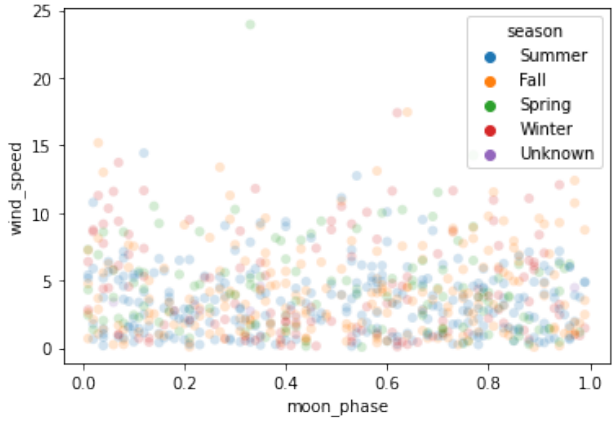



```
#type(variable1) == String
#type(variable2) == String
def plot(variable1,variable2):
    _____________________________
    _____________________________
    _____________________________
plot("moon_phase", "wind_speed")
```

3. Now, let's look at some qualitative variables. Write a line of code that produces a visualization that shows the distribution of bigfoot sightings across the variable `season` (example shown below). **hint:** Use `seaborn(sns.countplot)/matplotlib(plt.bar)`.



4. Produce a single visualization that showcases how the prevalence of bigfoot sightings at particular combinations of `moon_phase` and `wind_speed` vary across each season. **hint:** Think about color as the third information channel on the plot.



Kernel Density Estimation (KDE)

1. Kernel Density Estimation is used to estimate a probability density function (or density curve) from a set of data. A kernel with a bandwidth parameter α is placed on data observations x_i with $i \in \{1, ..., n\}$, and the density estimation is calculated by averaging all kernels. Below, Gaussian and Boxcar kernel equations are listed:

   - Gaussian Kernel: $K_\alpha(x, x_i) = \frac{1}{\sqrt{2\pi\alpha^2}} \exp\left(-\frac{(x-x_i)^2}{2\alpha^2}\right)$
   - Boxcar Kernel: $B_\alpha(x, x_i) = \begin{cases} \frac{1}{\alpha} & \text{if } -\frac{\alpha}{2} \leq x - x_i \leq \frac{\alpha}{2} \\ 0 & \text{else} \end{cases}$

   The KDE is calculated as follows: $f_\alpha(x) = \frac{1}{n} \sum_{i=1}^{n} K_\alpha(x, x_i)$.

   (a) Draw a KDE plot (by hand is fine) for data points `[1, 4, 8, 9]` using Gaussian Kernel and $\alpha = 1$. On the plot show x, x_i, α, and the KDE.

   (b) We wish to compare the results of KDE using a Gaussian kernel and a boxcar kernel. For $\alpha > 0$, which of the following statements is true? Choose all that apply.

   A. Decreasing α for a Gaussian kernel decreases the smoothness of the KDE.

   B. The Gaussian kernel is always better than the boxcar kernel for KDEs.

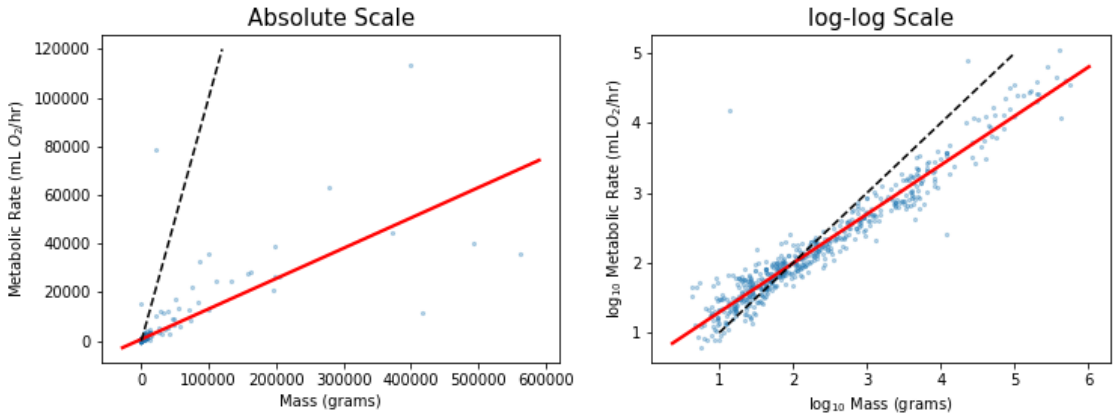
   C. Because the Gaussian kernel is smooth, we can safely use large α values for kernel density estimation without worrying about the actual distribution of data.

   D. The area under the boxcar kernel is 1, regardless of the value of α.

   E. None of the above.

Logarithmic Transformations

1. One of your friends at a biology lab asks you to help them analyze `panTHERIA`, a database of mammals. They are interested in the relationship between mass, measured in grams, and metabolic rate ("energy expenditure"), measured by oxygen use per hour. Originally, they showed you the data on a linear (absolute) scale, shown on the left. You notice that the values on both axes vary over a large range with many data points clustered around the smaller values, so you suggest that they instead plot the data on a log-log scale, shown on the right. The solid red line is a "line of best fit" (we'll formalize this later in the course) while the black dashed line represents the identity line $y = x$.



(a) Let C and k be some constant values and x and y represent mass and metabolic rate, respectively. Based on the plots, which of the following best describes the pattern seen in the data? **Reminder:** $log(a \times b) = log(a) + log(b)$.

◯ A. $y = C + kx$ ◯ B. $y = C \times 10^{kx}$ ◯ C. $y = C + k\log_{10}(x)$ ◯ D. $y = Cx^k$

(b) What parts of the plots could you use to make initial guesses on C and k?

(c) Your friend points to the solid line on the log-log plot and says "since this line is going up and to the right, we can say that, in general, the bigger a mammal is, the greater its metabolic rate". Is this a reasonable interpretation of the plot?

(d) Suppose that instead of plotting positive quantities, our data contained some zero and negative values. How can we reasonably apply a logarithmic transform to this data?