Data 100, Spring 2023

Discussion #3 Solutions

Data Cleaning and EDA

1. Consider the following *sample* of the baby names table obtained by using `baby_names.sample(5)`.

	State	Sex	Year	Name	Count
0	CA	F	1910	Mary	295
1	CA	F	1910	Helen	239
2	CA	F	1910	Dorothy	220
3	CA	F	1910	Margaret	163
4	CA	F	1910	Frances	134

(a) Consider the name, year, and count variables. What type of variable are each one? (Quantitative discrete, Quantitative continuous, Qualitative nominal, Qualitative ordinal)

> **Solution:** Year is a qualitative ordinal variable. It is *not* a quantitative variable despite being a numerical quantity.
>
> Count is a quantitative discrete variable. Name is a qualitative nominal variable.

(b) Which of the following is a (minimal) primary key for this table (given the sample of the data and reasonable assumptions about what might be in the rest of the data)?
(A *primary key* is the column or minimal set of columns that uniquely determines the values in all the remaining columns. This is a statement about the table structure and should hold for all data that could be put in the table.)

- ☐ A. State and Sex
- ☐ B. Year and Name
- ☐ C. State, Year, and Name
- ☐ D. State, Sex, Year, and Name
- ☐ E. State, Sex, Year, Name, and Count

> **Solution:** The columns **(State, Sex, Year, Name)** form the primary key which uniquely determines the value of count for this data and all data that might go in this table. We would not expect two different values of count for the same State, Sex, Year, and Name.

(c) Mark the following statements as True or False and justify why.
A *foreign key* is a set of 1+ columns in a table that refers to the primary key of another table.

1. (T / F) The foreign key of a table referencing the `babynames` table must always reference the primary key from part (b).
2. (T / F) All tables with a foreign key referencing the `babynames` table must always join or merge on the primary key columns from part (b).
3. (T / F) `babynames` has a primary/foreign key relationship with the `elections` dataset containing the first name and full name of every presidential candidate.
4. (T / F) To join or merge `babynames` with itself, we must join or merge on its primary key columns.

Solution: The first statement is true based on the definition of a foreign key-primary key relationship.

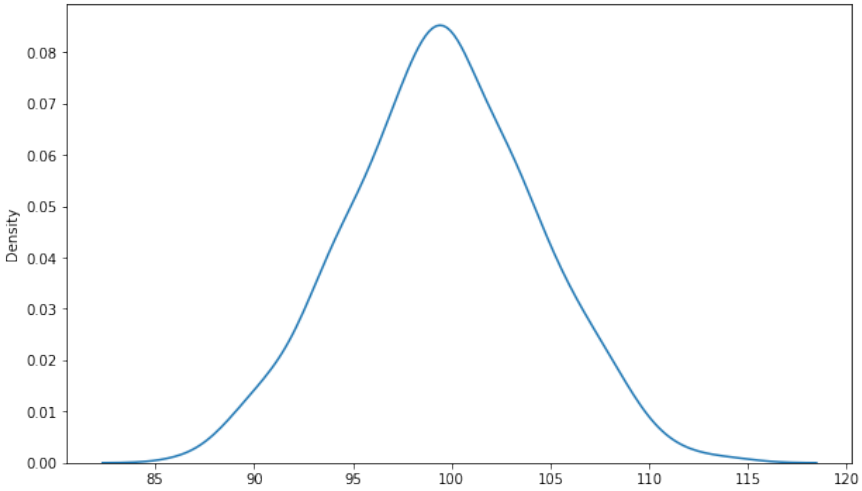
The third statement is false because the elections dataset does not refer to the primary key of babynames.

The second and fourth statements are false because there are no condition that any table must join on any subset of columns as prescribed by the primary key. That being said, that is the most common pattern if there exists a valid primary/foreign key relationship.

Dealing with Missing Data

2. While exploring a climate dataset with a million records, you realize that 20% of atmospheric measurements in different fields are NaN values! You decide to impute or drop these missing values before continuing your EDA. Given the empirical distribution of each of the below atmospheric variables, determine how to solve the missing data problem. Variable distributions are constructed from all valid (non-NaN) values for a given field.

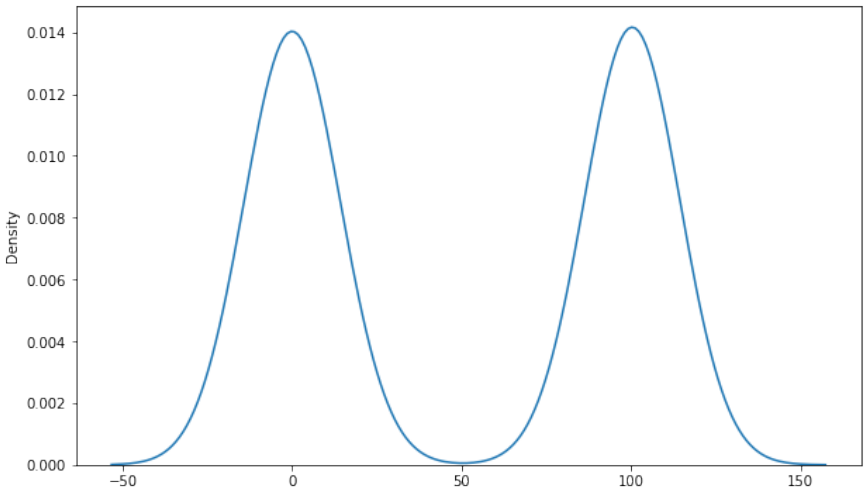
(a) Suppose that you plot the distribution of one atmospheric variable, given below. Which of the following techniques would be **most** effective in solving this issue of missing data? (Note: We visualize our empirical distribution using `df['votes'].plot.kde()`, which a produces a smooth curve. More next week!)



☐ A. Using the mean to impute the missing values
☐ B. Using the mode to impute the missing values
☐ C. Using the median to impute the missing values
☐ D. Dropping any rows with missing values
☐ E. Imputing missing values with zero

Solution: Since this is roughly symmetric, any of the mean, median or mode would yield roughly the same appropriate center of 100. We do not want to drop 20% of the data, and imputing missing values with 0 would make this a bimodal distribution (we don't want to vastly change the distribution of the data because of missing data).

(b) Suppose that the distribution of a second atmospheric variable is given by the following figure. Which of the following techniques would be **most** effective in solving this issue of missing data?



☐ A. Using the mean to impute the missing values
☐ B. Using the mode to impute the missing values

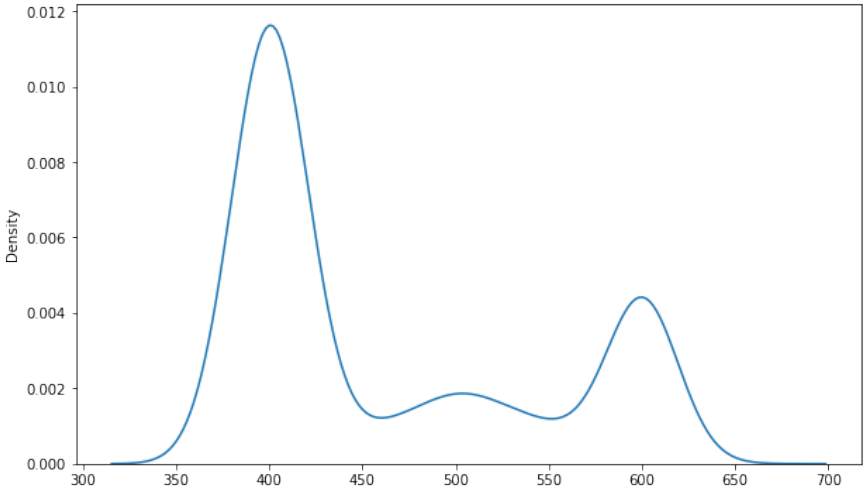
☐ C. Using the median to impute the missing values

☐ D. Dropping any rows with missing values

☐ E. Imputing missing values with zero

Solution: This is bimodal, so the mean or median would yield values around 50, which is where the least amount of data is concentrated. The mode works since either of the modes represent where the majority of the data is concentrated. We again do not want to drop any rows. Imputing missing values with zero is actually alright in this case since one of the modes of the data is 0.

(c) Suppose that the distribution of a third atmospheric variable is given by the following figure. Which of the following techniques would be **reasonably** effective in solving this issue of missing data?



☐ A. Using the mean to impute the missing values

☐ B. Using the mode to impute the missing values

☐ C. Using the median to impute the missing values

☐ D. Dropping any rows with missing values

☐ E. Imputing missing values with zero

Solution: The mean would likely yield a number in the middle rather than at the two "bigger" modes of the data, hence, it wouldn't be as effective. The mode is effective again since that's where the data is most concentrated, and the median would do a reasonable job since it ignores the tail of the distribution far better than the mean. We do not want to drop any rows by the same reasoning as for all subparts, and imputing values with zero adds another mode.

Note: not selecting the median as appropriate would be a reasonable conclusion too simply based on the figure. Mathematically, the median is around 409 for this figure, which is essentially the biggest mode, whereas the mean is 462, which is far worse.

Regular Expressions

Here's a complete list of metacharacters:

```
.  ^  $  *  +  ?  { }  [ ]  \  |  ( )
```

Some reminders on what each can do (this is not exhaustive):

- **"^"** matches the position at the beginning of string (unless used for negation **"[^]"**)
- **"$"** matches the position at the end of string character.
- **"?"** match preceding literal or sub-expression 0 or 1 times.
- **"+"** match preceding literal or sub-expression *one* or more times.
- **"*"** match preceding literal or sub-expression *zero* or more times
- **"."** match any character except new line.
- **"[ ]"** match any one of the characters inside, accepts a range, e.g., **"**`[a-c]`**"**.
- **"( )"** used to create a sub-expression
- **"\d"** match any *digit* character. **"**`\D`**"** is the complement.
- **"\w"** match any *word* character (letters, digits, underscore). **"**`\W`**"** is the complement.
- **"\s"** match any *whitespace* character including tabs and newlines. `\S` is the complement.
- **"*?"** Non-greedy version of *. Not fully discussed in class.
- **"\b"** match boundary between words. Not discussed in class.
- **"+?"** Non-greedy version of +. Not discussed in class.
- **"{m,n}"** The preceding element or subexpression must occur between m and n times, inclusive.

Some useful `re` package functions:

- **`re.split(pattern, string)`** split the `string` at substrings that match the `pattern`. Returns a list.
- **`re.sub(pattern, replace, string)`** apply the `pattern` to `string` replacing matching substrings with `replace`. Returns a string.
- **`re.findall(pattern, string)`** Returns a list of all matches for the given `pattern` in the `string`.

Regular Expressions

3. Which strings contain a match for the following regular expression, `"1+1$"`? The character `"␣"` represents a single space.

   ◯ A. `What␣is␣1+1` ◯ B. `Make␣a␣wish␣at␣11:11` ◯ C. `111␣Ways␣to␣Succeed`

Solution: Recall that `1+` matches on *at least one* occurrence of the character `1`, and `$` marks the end of the string. So the ending `"11"` is matched.

4. Write a regular expression that matches a string which contains only one word containing only lowercase letters and numbers (including the empty string).

Solution:

```
^[a-z0-9]*$
```

5. Given `sometext = "I've␣got␣10␣eggs,␣20␣gooses,␣and␣30␣giants."`, use `re.findall` to extract all the items and quantities from the string. The result should look like **`['10 eggs', '20 gooses', '30 giants']`**. You may assume that a space separates quantity and type, and that each item ends in s.

Solution:

```
re.findall(r"\d+\s\w+s", sometext)
```

6. For each pattern specify the starting and ending position of the first match in the string. The index starts at zero and we are using closed intervals (both endpoints are included).

	`abcdefg`	`abcs!`	`ab␣abc`	`abc,␣123`
`abc*`	$[0, 2]$	$[0, 2]$	$[0, 1]$	$[0, 2]$
`[^\s]+`	$[0, 6]$	$[0, 4]$	$[0, 1]$	$[0, 3]$
`ab.*c`	$[0, 2]$	$[0, 2]$	$[0, 5]$	$[0, 2]$
`[a-z1,9]+`	$[0, 6]$	$[0, 3]$	$[0, 1]$	$[0, 3]$

7. *(Bonus)* Given the following text in a variable `log`:

```
169.237.46.168 - - [26/Jan/2014:10:47:58 -0800]
"GET␣/stat141/Winter04/␣HTTP/1.1" 200 2585
"http://anson.ucdavis.edu/courses/"
```

Fill in the regular expression in the variable `pattern` below so that after it executes, `day` is 26, `month` is Jan, and `year` is 2014.

```
pattern = ...
matches = re.findall(pattern, log)
day, month, year = matches[0]
```

Solution:

```
pattern = "\[(.+)\/(.+)\/([^:]+).*\]"
pattern = "\[(.+)/(.+)/([^:]+).*\]"
matches = re.findall(pattern, log)
day, month, year = matches[0]
```

In python, both escaping or not escaping backslash work. For many other languages, escaping backslash is required to match backslash literally.

8. *(Bonus)* Given that `sometext` is a string, use `re.sub` to replace all clusters of non-vowel characters with a single period. For example `"a␣big␣moon,␣between␣us..."` would be changed to `"a.i.oo.e.ee.u."`.

Solution:

```
re.sub( r"[^aeoiuAEIOU]+", "." , sometext)
```

9. *(Bonus)* Given the text:

```
"<record>␣Josh␣Hug␣<hug@cs.berkeley.edu>␣Faculty␣</record>"
"<record>␣Lisa␣Yan␣<lisa.yan@berkeley.edu>␣Instructor␣</record>"
```

Which of the following matches exactly to the email addresses (including angle brackets)?

◯ A. `<.*@.*>` ◯ B. `<[^>]*@[^>]*>` ◯ C. `<.*@\w+\..*>`

Solution: Greediness matches too much in the first and third choices. Greediness here means that the `".*"` matches everything and doesn't stop matching. For example in choice A, the closing `">"` is not matched with the `">"` in `"<record>..."`, instead the wildcard `".*"` consumes it.