GROUP 28

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GUTHUB LINK: [Jain-Laksh/CS203-Lab-10]

CS203: LAB 10

Part 1: A/B Testing using Ad Click Prediction

1] Load the dataset into a pandas DataFrame

```python
ad_data = pd.read_csv("ad_click_dataset.csv")
display(ad_data)
```

Python

	# id	full_name	# age	gender	device_type	ad_position	browsing_history
0	670	User670	22.0	Missing value	Desktop	Top	Shopping
1	3044	User3044	Missing value	Male	Desktop	Top	Missing value
2	5912	User5912	41.0	Non-Binary	Missing value	Side	Education
3	5418	User5418	34.0	Male	Missing value	Missing value	Entertainment
4	9452	User9452	39.0	Non-Binary	Missing value	Missing value	Social Media
5	5942	User5942	Missing value	Non-Binary	Missing value	Bottom	Social Media
6	7808	User7808	26.0	Female	Desktop	Top	Missing value
7	5065	User5065	40.0	Male	Mobile	Side	Missing value
8	7993	User7993	Missing value	Non-Binary	Mobile	Bottom	Social Media
9	4509	User4509	Missing value	Missing value	Missing value	Bottom	Education

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2] Perform necessary data cleaning and preprocessing: **[10 points]**

A] Handle missing values

```python
# Handle missing values
ad_data_clean = ad_data.dropna()
print(ad_data_clean.isnull().sum())
```

```
id                  0
full_name           0
age                 0
gender              0
device_type         0
ad_position         0
browsing_history    0
time_of_day         0
click               0
dtype: int64
```

B] Convert categorical columns (e.g., gender, ad_position)

```python
# Convert categorical columns to numerical values
ad_data_clean["gender"] = ad_data_clean["gender"].astype('category').cat.codes
ad_data_clean["device_type"] = ad_data_clean["device_type"].astype('category').cat.codes
ad_data_clean["browsing_history"] = ad_data_clean["browsing_history"].astype('category').cat.codes
ad_data_clean["time_of_day"] = ad_data_clean["time_of_day"].astype('category').cat.codes
ad_data_clean["click"] = ad_data_clean["click"].astype(int)

ad_data_clean = ad_data_clean[ad_data_clean['ad_position'].isin(['Top', 'Bottom'])].copy()
ad_data_clean['ad_position'] = ad_data_clean['ad_position'].map({'Top': 0, 'Bottom': 1})

ad_data_clean
```

	# id	full_name	# age	# gender	# device_type	# ad_position	# browsing_history
17	188	User188	56.0	0	2	1	
25	4890	User4890	43.0	1	2	1	
33	4985	User4985	37.0	1	1	0	
52	9888	User9888	49.0	1	1	0	
102	8201	User8201	59.0	0	0	1	
154	118	User118	43.0	0	2	1	
158	3007	User3007	42.0	1	0	0	
170	3062	User3062	34.0	1	0	1	
185	2757	User2757	35.0	0	1	1	
204	8530	User8530	52.0	0	1	0	

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3] Split the dataset into two groups: **[10 points]**

```python
# Divide into Group A and Group B
group_a = ad_data_clean[ad_data_clean['ad_position'] == 0].copy() # Users with ad_position = 0 (Top)
group_b = ad_data_clean[ad_data_clean['ad_position'] == 1].copy() # Users with ad_position = 1 (Bottom)
```

GROUP A
Number of samples: 275

	# id	full_name	# age	# gender	# device_type	# ad_position	# browsing_history
33	4985	User4985	37.0	1	1	0	
52	9888	User9888	49.0	1	1	0	
158	3007	User3007	42.0	1	0	0	
204	8530	User8530	52.0	0	1	0	
231	4625	User4625	33.0	2	1	0	

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GROUP B
Number of samples: 283

	# id	full_name	# age	# gender	# device_type	# ad_position	# browsing_history
17	188	User188	56.0	0	2	1	
25	4890	User4890	43.0	1	2	1	
102	8201	User8201	59.0	0	0	1	
154	118	User118	43.0	0	2	1	
170	3062	User3062	34.0	1	0	1	

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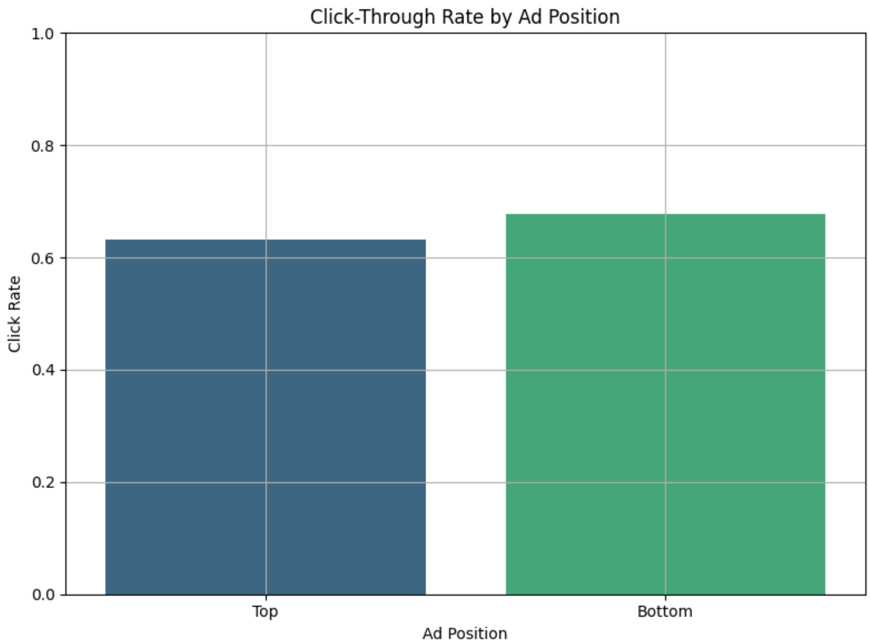
4] Use the scipy's stats.proportions_ztest function to perform an independent two-sample z-test between Group A and Group B.

```python
from statsmodels.stats.proportion import proportions_ztest as ztest

clicks = [group_a['click'].sum(), group_b['click'].sum()]
n_samples = [group_a.shape[0], group_b.shape[0]]
z_stat, p_value = ztest(clicks, n_samples)
print(f"Z-score: {z_stat:.4f}\nP-value: {p_value:.4f}")
```

5] Print the z-score and the p-value

```
Z-score: -1.1365
P-value: 0.2557
```



6] Interpretations

DEFINITIONS

z-score: A z-score tells you how many standard deviations away your observed difference is from zero (i.e., no difference between the two groups). For a difference to be considered statistically significant, we usually look for a z-score beyond ±1.96 (for 95% confidence).

p-value: Represents the probability that the observed difference in click-through rates happened by random chance, assuming there's no real difference between the groups. To reject the null hypothesis, the value must be less than 0.05.

INTERPRETATION:

Based on the z-test, the z-score is -1.1365 and the p-value is 0.2557. Since the p-value is greater than the standard significance level of 0.05, we fail to reject the null hypothesis. This means there is no statistically significant difference in click-through rates between users who saw the ad at the top and those who saw it at the bottom. The observed difference could be due to random chance. The observed click-through rate of Group A (top ad) is slightly lower than Group B (bottom ad), but only by about 1.14 standard deviations.

Part 2: Covariate Shift Detection Using Air Quality Data

1] Load all three datasets using pandas. **[10 points]**

```
train = pd.read_csv("Air_Quality_Dataset/train.csv")
test1 = pd.read_csv("Air_Quality_Dataset/test1.csv")
test2 = pd.read_csv("Air_Quality_Dataset/test2.csv")

display(train)
```

```
# Data Pre-processing

train = train.drop(['Unnamed: 15','Unnamed: 16'], axis=1)
test1 = test1.drop(['Unnamed: 15','Unnamed: 16'], axis=1)
test2 = test2.drop(['Unnamed: 15','Unnamed: 16'], axis=1)

train
```

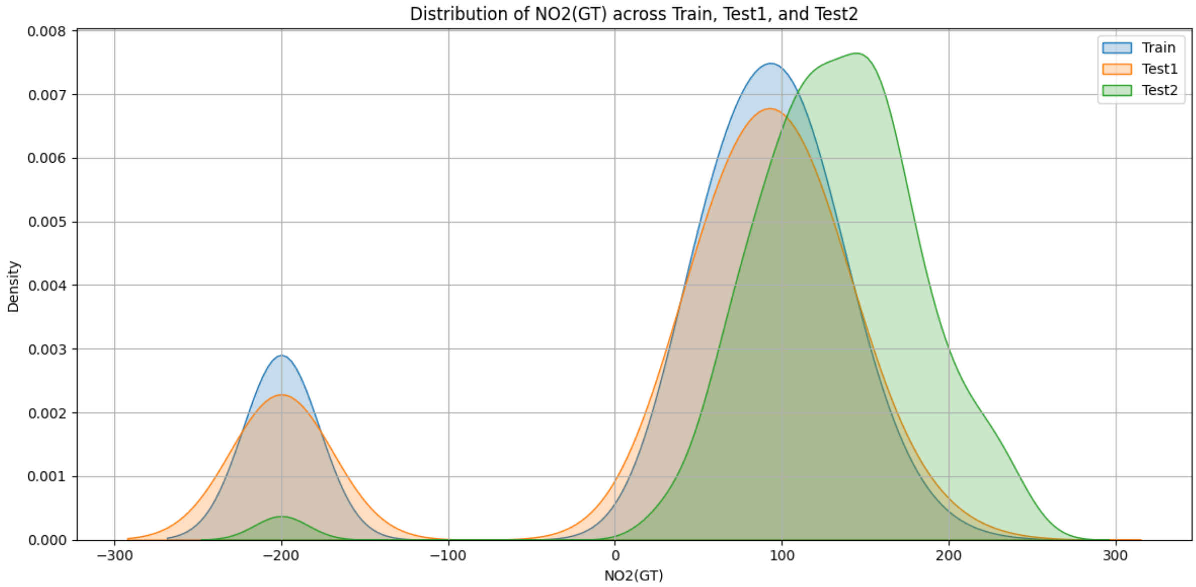
2] For each test dataset (test1.csv and test2.csv), compare it with train.csv using the **Kolmogorov–Smirnov test** (scipy.stats.ks_2samp). Perform the KS test on the **NO2(GT)** column to identify whether there are any distributional differences. **[20 points]**

```
from scipy.stats import ks_2samp

train_no2 = train['NO2(GT)'].dropna()
test1_no2 = test1['NO2(GT)'].dropna()
test2_no2 = test2['NO2(GT)'].dropna()

# KS test between train and test1
ks_stat_test1, p_value_test1 = ks_2samp(train_no2, test1_no2)

# KS test between train and test2
ks_stat_test2, p_value_test2 = ks_2samp(train_no2, test2_no2)
```

3] Report the KS statistic and p-value for each feature. **[10 points]**

```
KS Test: Train vs Test1
KS Statistic: 0.0191
P-value: 0.9722

KS Test: Train vs Test2
KS Statistic: 0.4075
P-value: 0.0000
```

4] Determine which of the two test datasets (test1.csv or test2.csv) exhibits a covariate shift relative to the training dataset (train.csv). Use the results of the Kolmogorov–Smirnov test to support your answer. **[10 points]**



DEFINITIONS

1] KS (Kolmogorov-Smirnov) statistic: Measures the maximum difference between the cumulative distributions of two datasets. The higher the KS score, the greater the difference between the two distributions. A low KS score means the distributions are very similar.

2] P-value: Measures the probability of observing the data, assuming the null hypothesis (that the two distributions are the same) is true. A low p-value (< 0.05) suggests that the null hypothesis can be rejected, meaning the two distributions are likely different. A high p-value (> 0.05) indicates that we fail to reject the null hypothesis, suggesting no significant difference between the distributions.

INTERPRETATION

1] Train vs Test1

The numbers indicate that the distributions of NO2(GT) for the training set and test1 are nearly identical. The very high p-value suggests that we fail to reject the null hypothesis, meaning there is no statistically significant difference between these two distributions.

2] Train vs Test2

The values show a significant difference between the distributions. The high KS statistic and extremely low p-value lead us to reject the null hypothesis, indicating that the distribution of NO2(GT) in test2 is notably different from that in the training set.

CONCLUSION

Test2 exhibits a covariate shift relative to the training dataset, as its distribution for NO2(GT) is statistically significantly different from the training set (p-value = 0.0000). In contrast, Test1 does not exhibit a covariate shift (p-value = 0.9722).