q3

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1 Question 3: Outlier Detection (10 points)

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[1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
```

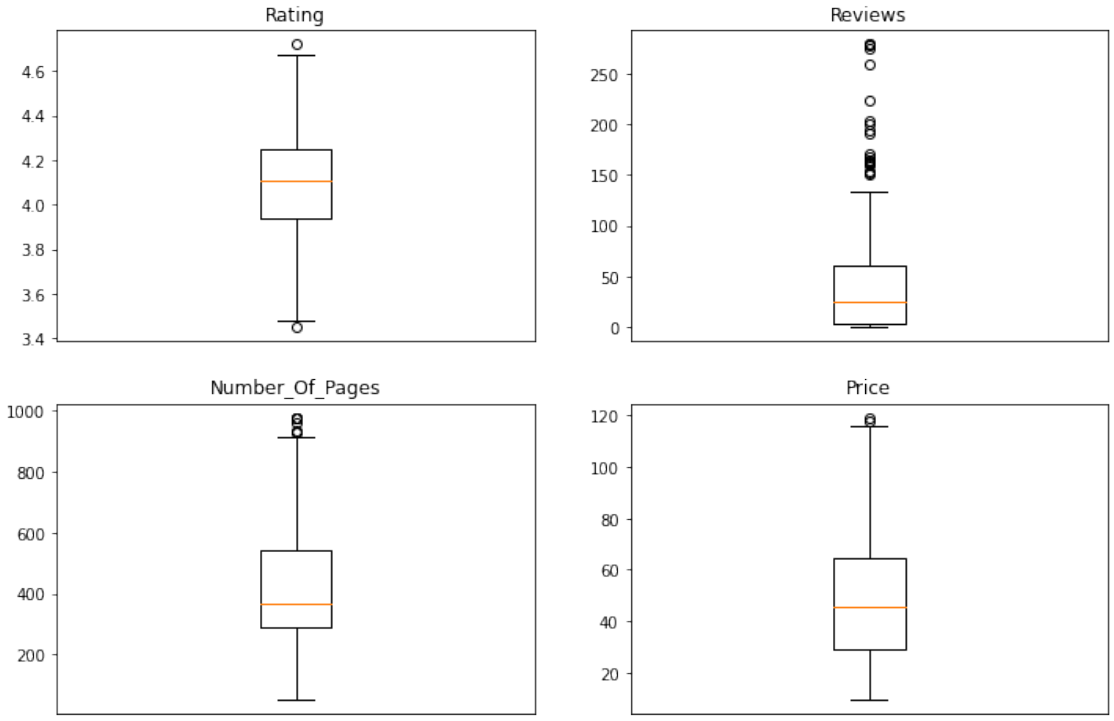
[21]:
```
# read data
df = pd.read_csv("prog_book.csv", thousands=',')
display(df)
```

```
     Rating  Reviews                                          Book_title  \
0      4.17     3829                                The Elements of Style
1      4.01     1406     The Information: A History, a Theory, a Flood
2      3.33        0      Responsive Web Design Overview For Beginners
3      3.97     1658  Ghost in the Wires: My Adventures as the World…
4      4.06     1325                                   How Google Works
..      …       …                                                …
266    3.76        0  3D Game Engine Architecture: Engineering Real-…
267    3.94       22               An Introduction to Database Systems
268    4.49       36  The Art of Computer Programming, Volumes 1-3 B…
269    4.77        4  The Art of Computer Programming, Volumes 1-4a …
270    3.84        5             A Discipline for Software Engineering

                                          Description  Number_Of_Pages  \
0    This style manual offers practical advice on i…              105
1    James Gleick, the author of the best sellers C…              527
2    In Responsive Web Design Overview For Beginner…               50
3    If they were a hall of fame or shame for compu…              393
4    Both Eric Schmidt and Jonathan Rosenberg came …              305
..                                                …                …
266  Dave Eberly's 3D Game Engine Design was the fi…              752
267  Continuing in the eighth edition, An Introduct…             1040
268  Knuth's classic work has been widely acclaimed…              896
269  "The bible of all fundamental algorithms and t…             3168
270  Designed to help individual programmers develo…              789
```

```
                       Type       Price
0                 Hardcover    9.323529
1                 Hardcover   11.000000
2             Kindle Edition   11.267647
3                 Hardcover   12.873529
4             Kindle Edition   13.164706
..                      …         …
266               Hardcover  203.108823
267               Paperback  212.097059
268  Boxed Set - Hardcover   220.385294
269               Hardcover  220.385294
270               Hardcover  235.650000

[271 rows x 7 columns]
```

1.1 Task 1: Univariate Outlier detection (4 points)

[22]:
```
detection_rows = ["Rating", "Reviews", "Number_Of_Pages", "Price"]
def outlier_detection(df, name):
    data = df[[name]].to_numpy()
    # finding the 1st quartile
    q1 = np.quantile(data, 0.25)
    # finding the 3rd quartile
    q3 = np.quantile(data, 0.75)
    med = np.median(data)
    # finding the iqr region
    iqr = q3 - q1
    # finding upper and lower whiskers
    upper_bound = q3 + (1.5 * iqr)
    lower_bound = q1 - (1.5 * iqr)
#     print(iqr, upper_bound, lower_bound)
    # boxplot of data within the whisker
    data = data[(data >= lower_bound) & (data <= upper_bound)]
    plt.boxplot(data)
    plt.xticks([])
    plt.title(name)

plt.figure(figsize = (12,8))
i = 1
for name in detection_rows:
    plt.subplot(2,2,i)
    i += 1
    outlier_detection(df, name)
# plt.show()
```



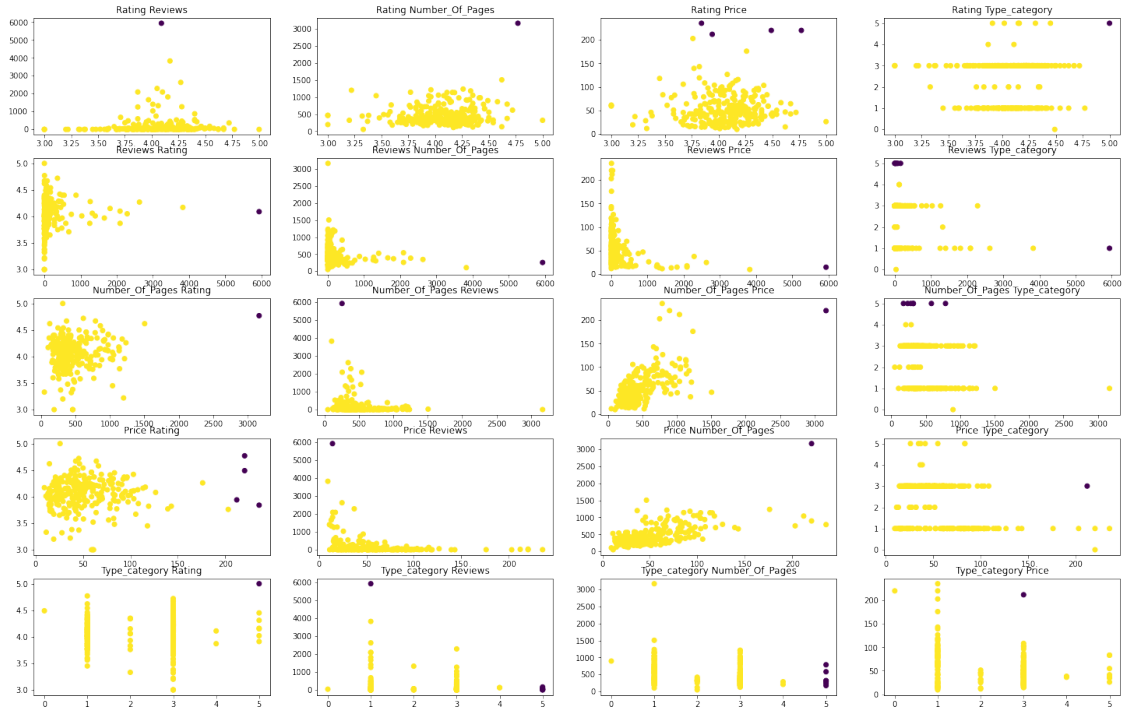
1.2 Task 2: Multivariate Outlier detection (6 points)

1.2.1 bivariate analysis on all possible pairs of the above features and identify any outliers

features = [“Rating”, “Reviews”, “Number_Of_Pages”, “Price”, “Type_category”]

[118]:
```
from sklearn.cluster import DBSCAN
from sklearn.preprocessing import MinMaxScaler, RobustScaler

df["Type_category"] = df["Type"].astype('category').cat.codes
features = ["Rating", "Reviews", "Number_Of_Pages", "Price", "Type_category"]
i = 1
j = 0
plt.figure(figsize=(25,16))

outliers = {}

for feature1 in features:
    for feature2 in features:
        if feature1 == feature2:
            continue
        plt.subplot(5,4,i)
        i += 1
```

```
        combined_feature = df[[feature1, feature2]].to_numpy()
        scaled_features = combined_feature.copy()
        # scale to 0,1
        scaler1 = MinMaxScaler()
        scaler1.fit(scaled_features[:,0].reshape(-1, 1))
        scaled_features[:,0] = scaler1.transform(scaled_features[:,0].
↪reshape(-1, 1)).reshape(-1)

        scaler2 = MinMaxScaler()
        scaler2.fit(scaled_features[:,1].reshape(-1, 1))
        scaled_features[:,1] = scaler2.transform(scaled_features[:,1].
↪reshape(-1, 1)).reshape(-1)

        clustering = DBSCAN(eps=0.3, min_samples=10).fit(scaled_features)
        labels = clustering.labels_

        title = feature1 + " " + feature2
        indexs = np.array(np.where(labels < 0)).reshape(-1)
        out = np.array(combined_feature[indexs])
        out = pd.DataFrame(data = out, index = indexs, columns = [feature1,␣
↪feature2])
        outliers[title] = out

        plt.title(title)
        plt.scatter(combined_feature[:,0], combined_feature[:,1], c = labels)

plt.show()
```



[119]:
```
# print the index and value of outliers

print("Outlier indexs and values")
for title, outlier in outliers.items():
    print(title + " : ")
    display(outlier)
```

```
Outlier indexs and values
Rating Reviews :
```

	Rating	Reviews
6	4.09	5938.0

```
Rating Number_Of_Pages :
```

	Rating	Number_Of_Pages
269	4.77	3168.0

```
Rating Price :
```

	Rating	Price
267	3.94	212.097059
268	4.49	220.385294
269	4.77	220.385294
270	3.84	235.650000

```
Rating Type_category :
```

```
    Rating  Type_category
54     5.0            5.0
```

Reviews Rating :

```
   Reviews  Rating
6   5938.0    4.09
```

Reviews Number_Of_Pages :

```
   Reviews  Number_Of_Pages
6     5938              256
```

Reviews Price :

```
   Reviews      Price
6   5938.0  14.232353
```

Reviews Type_category :

```
     Reviews  Type_category
6       5938              1
54         0              5
78        33              5
88       161              5
107       18              5
166       57              5
228       88              5
229        3              5
```

Number_Of_Pages Rating :

```
     Number_Of_Pages  Rating
269           3168.0    4.77
```

Number_Of_Pages Reviews :

```
   Number_Of_Pages  Reviews
6              256     5938
```

Number_Of_Pages Price :

```
     Number_Of_Pages       Price
269           3168.0  220.385294
```

Number_Of_Pages Type_category :

```
     Number_Of_Pages  Type_category
54               317              5
78               237              5
88               176              5
107              320              5
166              283              5
228              787              5
229              582              5
```

Price Rating :

```
          Price  Rating
267  212.097059    3.94
268  220.385294    4.49
269  220.385294    4.77
270  235.650000    3.84
```

Price Reviews :

```
       Price  Reviews
6  14.232353   5938.0
```

Price Number_Of_Pages :

```
          Price  Number_Of_Pages
269  220.385294           3168.0
```

Price Type_category :

```
          Price  Type_category
267  212.097059            3.0
```

Type_category Rating :

```
    Type_category  Rating
54            5.0     5.0
```

Type_category Reviews :

```
     Type_category  Reviews
6                1     5938
54               5        0
78               5       33
88               5      161
107              5       18
166              5       57
228              5       88
229              5        3
```

Type_category Number_Of_Pages :

```
     Type_category  Number_Of_Pages
54               5              317
78               5              237
88               5              176
107              5              320
166              5              283
228              5              787
229              5              582
```

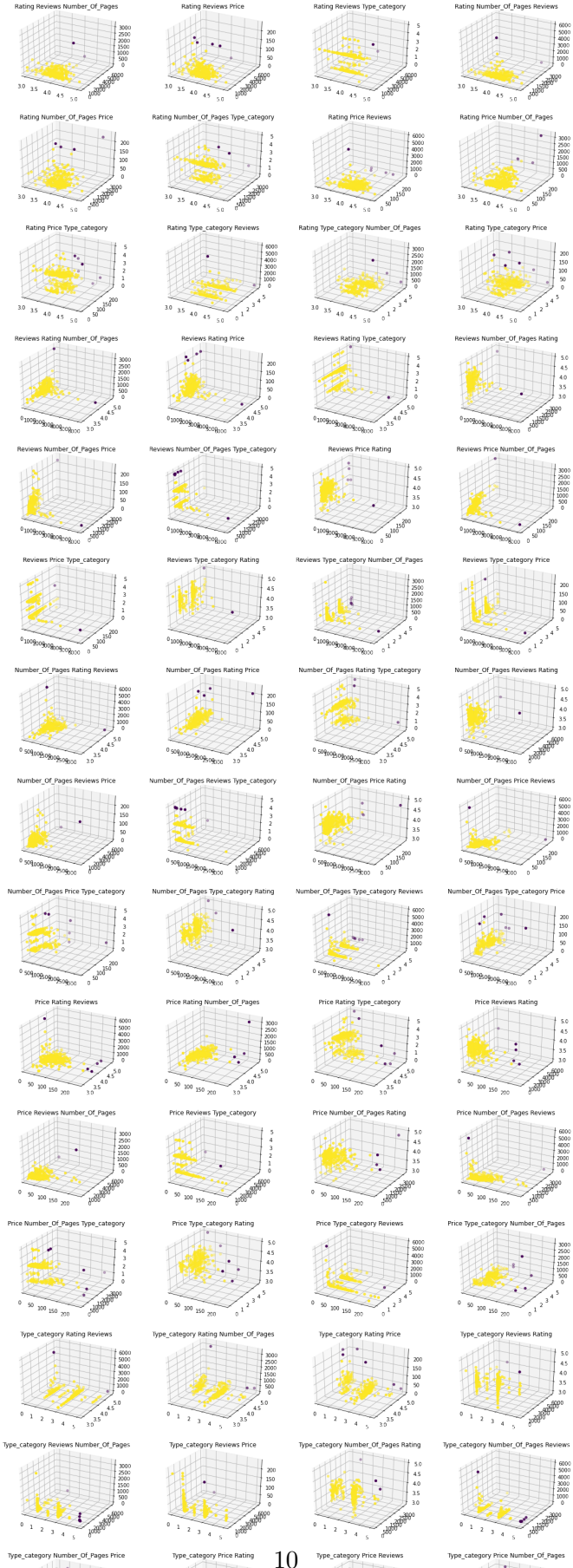
Type_category Price :

```
     Type_category       Price
267            3.0  212.097059
```

1.2.2 all combinations of three variables

[128]:
```
df["Type_category"] = df["Type"].astype('category').cat.codes
features = ["Rating", "Reviews", "Number_Of_Pages", "Price", "Type_category"]
i = 1
j = 0
fig = plt.figure(figsize=(20,60))

outliers = {}

for feature1 in features:
    for feature2 in features:
        if feature1 == feature2:
            continue
        for feature3 in features:
            if feature2 == feature3 or feature3 == feature1:
                continue
            ax = fig.add_subplot(15, 4, i, projection='3d')
            i += 1
            combined_feature = df[[feature1, feature2, feature3]].to_numpy()
            scaled_features = combined_feature.copy()
            # scale to 0,1
            scaler1 = MinMaxScaler()
            scaler1.fit(scaled_features[:,0].reshape(-1, 1))
            scaled_features[:,0] = scaler1.transform(scaled_features[:,0].
 ↪reshape(-1, 1)).reshape(-1)

            scaler2 = MinMaxScaler()
            scaler2.fit(scaled_features[:,1].reshape(-1, 1))
            scaled_features[:,1] = scaler2.transform(scaled_features[:,1].
 ↪reshape(-1, 1)).reshape(-1)

            scaler3 = MinMaxScaler()
            scaler3.fit(scaled_features[:,2].reshape(-1, 1))
            scaled_features[:,2] = scaler3.transform(scaled_features[:,2].
 ↪reshape(-1, 1)).reshape(-1)

            clustering = DBSCAN(eps=0.3, min_samples=10).fit(scaled_features)
            labels = clustering.labels_

            title = feature1 + " " + feature2 + " " + feature3
            indexs = np.array(np.where(labels < 0)).reshape(-1)
            out = np.array(combined_feature[indexs])
            out = pd.DataFrame(data = out, index = indexs, columns = [feature1,␣
 ↪feature2, feature3])
            outliers[title] = out
```

```
            ax.set_title(title)
            ax.scatter3D(combined_feature[:,0], combined_feature[:,1],␣
 ↪combined_feature[:,2], c = labels)

plt.show()
```


Rating Reviews Number_Of_Pages
Rating Reviews Price
Rating Reviews Type_category
Rating Number_Of_Pages Reviews
Rating Number_Of_Pages Price
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Rating Price Reviews
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Type_category Number_Of_Pages Price
Type_category Price Rating
Type_category Price Reviews
Type_category Price Number_Of_Pages

[129]:
```
print("Outlier indexs and values")
for title, outlier in outliers.items():
    print(title + " : ")
    display(outlier)
```

```
Outlier indexs and values
Rating Reviews Number_Of_Pages :
```

	Rating	Reviews	Number_Of_Pages
6	4.09	5938.0	256.0
269	4.77	4.0	3168.0

```
Rating Reviews Price :
```

	Rating	Reviews	Price
6	4.09	5938.0	14.232353
267	3.94	22.0	212.097059
268	4.49	36.0	220.385294
269	4.77	4.0	220.385294
270	3.84	5.0	235.650000

```
Rating Reviews Type_category :
```

	Rating	Reviews	Type_category
6	4.09	5938.0	1.0
54	5.00	0.0	5.0

```
Rating Number_Of_Pages Reviews :
```

	Rating	Number_Of_Pages	Reviews
6	4.09	256.0	5938.0
269	4.77	3168.0	4.0

```
Rating Number_Of_Pages Price :
```

	Rating	Number_Of_Pages	Price
267	3.94	1040.0	212.097059
268	4.49	896.0	220.385294
269	4.77	3168.0	220.385294
270	3.84	789.0	235.650000

```
Rating Number_Of_Pages Type_category :
```

	Rating	Number_Of_Pages	Type_category
54	5.00	317.0	5.0
228	4.45	787.0	5.0
269	4.77	3168.0	1.0

```
Rating Price Reviews :
```

	Rating	Price	Reviews
6	4.09	14.232353	5938.0

```
267    3.94  212.097059     22.0
268    4.49  220.385294     36.0
269    4.77  220.385294      4.0
270    3.84  235.650000      5.0
```

Rating Price Number_Of_Pages :

```
     Rating       Price  Number_Of_Pages
267    3.94  212.097059           1040.0
268    4.49  220.385294            896.0
269    4.77  220.385294           3168.0
270    3.84  235.650000            789.0
```

Rating Price Type_category :

```
     Rating       Price  Type_category
54     5.00   25.855882            5.0
228    4.45   83.202941            5.0
267    3.94  212.097059            3.0
268    4.49  220.385294            0.0
269    4.77  220.385294            1.0
270    3.84  235.650000            1.0
```

Rating Type_category Reviews :

```
    Rating  Type_category  Reviews
6     4.09            1.0   5938.0
54    5.00            5.0      0.0
```

Rating Type_category Number_Of_Pages :

```
     Rating  Type_category  Number_Of_Pages
54     5.00            5.0            317.0
228    4.45            5.0            787.0
269    4.77            1.0           3168.0
```

Rating Type_category Price :

```
     Rating  Type_category       Price
54     5.00            5.0   25.855882
228    4.45            5.0   83.202941
267    3.94            3.0  212.097059
268    4.49            0.0  220.385294
269    4.77            1.0  220.385294
270    3.84            1.0  235.650000
```

Reviews Rating Number_Of_Pages :

```
     Reviews  Rating  Number_Of_Pages
6     5938.0    4.09            256.0
269      4.0    4.77           3168.0
```

Reviews Rating Price :

```
     Reviews  Rating       Price
6     5938.0    4.09   14.232353
267     22.0    3.94  212.097059
268     36.0    4.49  220.385294
269      4.0    4.77  220.385294
270      5.0    3.84  235.650000
```

Reviews Rating Type_category :

```
    Reviews  Rating  Type_category
6    5938.0    4.09            1.0
54      0.0    5.00            5.0
```

Reviews Number_Of_Pages Rating :

```
     Reviews  Number_Of_Pages  Rating
6     5938.0            256.0    4.09
269      4.0           3168.0    4.77
```

Reviews Number_Of_Pages Price :

```
     Reviews  Number_Of_Pages       Price
6     5938.0            256.0   14.232353
269      4.0           3168.0  220.385294
```

Reviews Number_Of_Pages Type_category :

```
     Reviews  Number_Of_Pages  Type_category
6       5938              256              1
54         0              317              5
78        33              237              5
88       161              176              5
107       18              320              5
166       57              283              5
228       88              787              5
229        3              582              5
```

Reviews Price Rating :

```
     Reviews       Price  Rating
6     5938.0   14.232353    4.09
267     22.0  212.097059    3.94
268     36.0  220.385294    4.49
269      4.0  220.385294    4.77
270      5.0  235.650000    3.84
```

Reviews Price Number_Of_Pages :

```
     Reviews       Price  Number_Of_Pages
6     5938.0   14.232353            256.0
269      4.0  220.385294           3168.0
```

Reviews Price Type_category :

```
     Reviews       Price  Type_category
6     5938.0   14.232353            1.0
267     22.0  212.097059            3.0
```

Reviews Type_category Rating :

```
    Reviews  Type_category  Rating
6    5938.0            1.0    4.09
54      0.0            5.0    5.00
```

Reviews Type_category Number_Of_Pages :

```
     Reviews  Type_category  Number_Of_Pages
6       5938              1              256
54         0              5              317
78        33              5              237
88       161              5              176
107       18              5              320
166       57              5              283
228       88              5              787
229        3              5              582
```

Reviews Type_category Price :

```
     Reviews  Type_category       Price
6     5938.0            1.0   14.232353
267     22.0            3.0  212.097059
```

Number_Of_Pages Rating Reviews :

```
     Number_Of_Pages  Rating  Reviews
6              256.0    4.09   5938.0
269           3168.0    4.77      4.0
```

Number_Of_Pages Rating Price :

```
     Number_Of_Pages  Rating       Price
267           1040.0    3.94  212.097059
268            896.0    4.49  220.385294
269           3168.0    4.77  220.385294
270            789.0    3.84  235.650000
```

Number_Of_Pages Rating Type_category :

```
     Number_Of_Pages  Rating  Type_category
54             317.0    5.00            5.0
228            787.0    4.45            5.0
269           3168.0    4.77            1.0
```

Number_Of_Pages Reviews Rating :

```
     Number_Of_Pages  Reviews  Rating
6              256.0   5938.0    4.09
269           3168.0      4.0    4.77
```

Number_Of_Pages Reviews Price :

	Number_Of_Pages	Reviews	Price
6	256.0	5938.0	14.232353
269	3168.0	4.0	220.385294

Number_Of_Pages Reviews Type_category :

	Number_Of_Pages	Reviews	Type_category
6	256	5938	1
54	317	0	5
78	237	33	5
88	176	161	5
107	320	18	5
166	283	57	5
228	787	88	5
229	582	3	5

Number_Of_Pages Price Rating :

	Number_Of_Pages	Price	Rating
267	1040.0	212.097059	3.94
268	896.0	220.385294	4.49
269	3168.0	220.385294	4.77
270	789.0	235.650000	3.84

Number_Of_Pages Price Reviews :

	Number_Of_Pages	Price	Reviews
6	256.0	14.232353	5938.0
269	3168.0	220.385294	4.0

Number_Of_Pages Price Type_category :

	Number_Of_Pages	Price	Type_category
228	787.0	83.202941	5.0
229	582.0	83.211765	5.0
267	1040.0	212.097059	3.0
268	896.0	220.385294	0.0
269	3168.0	220.385294	1.0
270	789.0	235.650000	1.0

Number_Of_Pages Type_category Rating :

	Number_Of_Pages	Type_category	Rating
54	317.0	5.0	5.00
228	787.0	5.0	4.45
269	3168.0	1.0	4.77

Number_Of_Pages Type_category Reviews :

	Number_Of_Pages	Type_category	Reviews
6	256	1	5938
54	317	5	0

```
78               237              5       33
88               176              5      161
107              320              5       18
166              283              5       57
228              787              5       88
229              582              5        3
```

Number_Of_Pages Type_category Price :

```
     Number_Of_Pages  Type_category       Price
228            787.0            5.0   83.202941
229            582.0            5.0   83.211765
267           1040.0            3.0  212.097059
268            896.0            0.0  220.385294
269           3168.0            1.0  220.385294
270            789.0            1.0  235.650000
```

Price Rating Reviews :

```
          Price  Rating  Reviews
6     14.232353    4.09   5938.0
267  212.097059    3.94     22.0
268  220.385294    4.49     36.0
269  220.385294    4.77      4.0
270  235.650000    3.84      5.0
```

Price Rating Number_Of_Pages :

```
          Price  Rating  Number_Of_Pages
267  212.097059    3.94           1040.0
268  220.385294    4.49            896.0
269  220.385294    4.77           3168.0
270  235.650000    3.84            789.0
```

Price Rating Type_category :

```
          Price  Rating  Type_category
54    25.855882    5.00            5.0
228   83.202941    4.45            5.0
267  212.097059    3.94            3.0
268  220.385294    4.49            0.0
269  220.385294    4.77            1.0
270  235.650000    3.84            1.0
```

Price Reviews Rating :

```
          Price  Reviews  Rating
6     14.232353   5938.0    4.09
267  212.097059     22.0    3.94
268  220.385294     36.0    4.49
269  220.385294      4.0    4.77
270  235.650000      5.0    3.84
```

Price Reviews Number_Of_Pages :

	Price	Reviews	Number_Of_Pages
6	14.232353	5938.0	256.0
269	220.385294	4.0	3168.0

Price Reviews Type_category :

	Price	Reviews	Type_category
6	14.232353	5938.0	1.0
267	212.097059	22.0	3.0

Price Number_Of_Pages Rating :

	Price	Number_Of_Pages	Rating
267	212.097059	1040.0	3.94
268	220.385294	896.0	4.49
269	220.385294	3168.0	4.77
270	235.650000	789.0	3.84

Price Number_Of_Pages Reviews :

	Price	Number_Of_Pages	Reviews
6	14.232353	256.0	5938.0
269	220.385294	3168.0	4.0

Price Number_Of_Pages Type_category :

	Price	Number_Of_Pages	Type_category
228	83.202941	787.0	5.0
229	83.211765	582.0	5.0
267	212.097059	1040.0	3.0
268	220.385294	896.0	0.0
269	220.385294	3168.0	1.0
270	235.650000	789.0	1.0

Price Type_category Rating :

	Price	Type_category	Rating
54	25.855882	5.0	5.00
228	83.202941	5.0	4.45
267	212.097059	3.0	3.94
268	220.385294	0.0	4.49
269	220.385294	1.0	4.77
270	235.650000	1.0	3.84

Price Type_category Reviews :

	Price	Type_category	Reviews
6	14.232353	1.0	5938.0
267	212.097059	3.0	22.0

Price Type_category Number_Of_Pages :

```
          Price  Type_category  Number_Of_Pages
228   83.202941            5.0            787.0
229   83.211765            5.0            582.0
267  212.097059            3.0           1040.0
268  220.385294            0.0            896.0
269  220.385294            1.0           3168.0
270  235.650000            1.0            789.0
```

Type_category Rating Reviews :

```
    Type_category  Rating  Reviews
6             1.0    4.09   5938.0
54            5.0    5.00      0.0
```

Type_category Rating Number_Of_Pages :

```
     Type_category  Rating  Number_Of_Pages
54             5.0    5.00            317.0
228            5.0    4.45            787.0
269            1.0    4.77           3168.0
```

Type_category Rating Price :

```
     Type_category  Rating       Price
54             5.0    5.00   25.855882
228            5.0    4.45   83.202941
267            3.0    3.94  212.097059
268            0.0    4.49  220.385294
269            1.0    4.77  220.385294
270            1.0    3.84  235.650000
```

Type_category Reviews Rating :

```
    Type_category  Reviews  Rating
6             1.0   5938.0    4.09
54            5.0      0.0    5.00
```

Type_category Reviews Number_Of_Pages :

```
     Type_category  Reviews  Number_Of_Pages
6                1     5938              256
54               5        0              317
78               5       33              237
88               5      161              176
107              5       18              320
166              5       57              283
228              5       88              787
229              5        3              582
```

Type_category Reviews Price :

```
     Type_category  Reviews       Price
6              1.0   5938.0   14.232353
267            3.0     22.0  212.097059
```

Type_category Number_Of_Pages Rating :

	Type_category	Number_Of_Pages	Rating
54	5.0	317.0	5.00
228	5.0	787.0	4.45
269	1.0	3168.0	4.77

Type_category Number_Of_Pages Reviews :

	Type_category	Number_Of_Pages	Reviews
6	1	256	5938
54	5	317	0
78	5	237	33
88	5	176	161
107	5	320	18
166	5	283	57
228	5	787	88
229	5	582	3

Type_category Number_Of_Pages Price :

	Type_category	Number_Of_Pages	Price
228	5.0	787.0	83.202941
229	5.0	582.0	83.211765
267	3.0	1040.0	212.097059
268	0.0	896.0	220.385294
269	1.0	3168.0	220.385294
270	1.0	789.0	235.650000

Type_category Price Rating :

	Type_category	Price	Rating
54	5.0	25.855882	5.00
228	5.0	83.202941	4.45
267	3.0	212.097059	3.94
268	0.0	220.385294	4.49
269	1.0	220.385294	4.77
270	1.0	235.650000	3.84

Type_category Price Reviews :

	Type_category	Price	Reviews
6	1.0	14.232353	5938.0
267	3.0	212.097059	22.0

Type_category Price Number_Of_Pages :

	Type_category	Price	Number_Of_Pages
228	5.0	83.202941	787.0
229	5.0	83.211765	582.0
267	3.0	212.097059	1040.0
268	0.0	220.385294	896.0

269	1.0	220.385294	3168.0
270	1.0	235.650000	789.0