Module_6_Logistic_Regression_and_Applying_GLM

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0.1 Dempsey Wade

1 Module 6: Logistic Regression and Applying GLM

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In this assignment, you will be working on more complicated Python functions, looking at Logistic Regression Models and how to apply GLM to them.

We begin by importing most of the libraries you will need throughout this assignment.

### Index:

1.1 Import Libraries

[1]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import warnings
warnings.filterwarnings('ignore')
%matplotlib inline
```

1.2 Python Functions

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1.3 Question 1

Create a Python function called `multiply` that takes a variable number of arguments and multiplies them. Then multiply the numbers 1,6,3 and 8 and assign the result to a variable called `prod_total`.

[2]:

```
### GRADED

### YOUR SOLUTION HERE
def multiply(*args):
    total = 1
    for i in args:
        total = total*i
    return total

prod_total = multiply(1,6,3,8)
prod_temp = multiply(5,5)
prod_temp = multiply(8, 7)
print(prod_temp)
###
### YOUR CODE HERE
###

### Answer check
print("Result: {}".format(prod_total))
```

```
56
Result: 144
```

[3]:

```
###
### AUTOGRADER TEST - DO NOT REMOVE
###
```

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Python functions can return multiple values. Create a Python function called `calculator` that takes two integers `a` and `b` and returns a tuple. The first element of the tuple must be the sum of `a` and `b`. The second element must be the square of their product.

Call the function with `a=6`, `b=10` and assign the sum to `add_values` and the squared product to `square_values`, respectively.

[4]:

```
### GRADED

### YOUR SOLUTION HERE
a = 6
b = 10

def calculator(a, b):
    add = a+b
    square = (a*b)*(a*b)
    return add, square

add_values, square_values = calculator(a,b)
```

```

###
### YOUR CODE HERE
###

### Answer check
print("Sum: {}\nSquared product: {}".format(add_values, square_values))
```

```
Sum: 16
Squared product: 3600
```

[5]:

```
###
### AUTOGRADER TEST - DO NOT REMOVE
###
```

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Define a function called `subtract` that takes two integers and computes the absolute value of their difference. The result must not be returned but set to the global variable `difference` instead.

Next, call the function `subtract` with arguments 7 and 9 and check the value of `difference`.

Hint: Do not assign the call of `subtract` to `difference` since the function returns `None` and doing so will override the current value of the global variable.

[6]:

```
### GRADED
import math

### YOUR SOLUTION HERE
a = 7
b = 9

def subtract(a, b):
    global difference
    difference = (abs(a-b))

subtract(a,b)
print(difference)

###
### YOUR CODE HERE
###

### Answer check
print("The value of difference is: {}".format(difference))
```

```
2
The value of difference is: 2
```

```
[7]: ###
     ### AUTOGRADER TEST - DO NOT REMOVE
     ###
```

1.4 Logistic Regression Models

In the first part, we will use a fake Instagram data set, indicating whether or not a particular instagram user clicked on an ad in their feed. We will create a model that predicts the likelihood of clicking on another ad based off the features of that user.

The data set contains the following features:

- 'Daily Time Spent on Instagram': user time spent on app in minutes
- 'Age': user age in years
- 'Daily Internet Usage': Avg. minutes a day consumer is on the internet
- 'Ad feed headline': Headline of the Ad
- 'Location': current location of consumer
- 'Sex': 1 for male and 0 for female
- 'Country': Country of consumer
- 'Timestamp': Time at which consumer clicked on Ad or closed window
- 'Clicked on Feed': 0 or 1 indicated clicking on Feed

1.4.1 Read the Data

insta_data = pd.read_csv('data/insta.csv')

```
[8]: #Read in data
     insta_data = pd.read_csv('/Users/dempseywade/Desktop/gitRepo/
      ↪DartmouthCodingAssignments/data/Mod6_insta.csv')
```

1.4.2 Exploratory Data Analysis

Let's use Matplotlib and Seaborn to explore the data.

```
[9]: insta_data.head(10)
```

```
[9]:    Daily Time Spent on Instagram  Age  Daily Internet Usage  \
     0                          82.03   41                187.53
     1                          80.03   44                150.84
     2                          51.38   59                158.56
     3                          77.07   40                261.02
     4                          51.87   50                119.65
     5                          45.99   33                124.61
     6                          61.88   45                108.18
     7                          68.01   25                188.32
     8                          72.84   26                238.63
     9                          73.84   31                121.05

                             Ad feed Headline           Location  Sex  \
0               Intuitive dynamic attitude        Pruittmouth    0
1                 Automated static concept      Christinetown    0
2     Object-based modular functionalities       East Anthony    0
3        Face-to-face analyzing encryption     Stephenborough    0
4           Team-oriented dynamic forecast          Kevinberg    0
5         Face-to-face methodical intranet         South Mark    1
6  Balanced disintermediate conglomeration   North Debrashire    0
7          Ameliorated actuating workforce         Kaylashire    1
8          Progressive empowering alliance           Wongland    0
9        Programmable uniform productivity  South Jasminebury    0

       Country         Timestamp  Clicked on Feed
0  Afghanistan  02-05-2016 07:00                0
1  Afghanistan  23-07-2016 14:47                1
2  Afghanistan  17-06-2016 17:11                1
3  Afghanistan  01-03-2016 10:01                0
4  Afghanistan  10-03-2016 22:28                1
5  Afghanistan  27-02-2016 15:04                1
6  Afghanistan  30-05-2016 08:02                1
7  Afghanistan  01-01-2016 03:35                0
8      Albania  08-07-2016 21:18                0
9      Albania  18-06-2016 17:23                1
```

```
[10]: insta_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 9 columns):
 #   Column                        Non-Null Count  Dtype
---  ------                        --------------  -----
 0   Daily Time Spent on Instagram  1000 non-null   float64
 1   Age                           1000 non-null   int64
 2   Daily Internet Usage          1000 non-null   float64
 3   Ad feed Headline              1000 non-null   object
 4   Location                      1000 non-null   object
 5   Sex                           1000 non-null   int64
 6   Country                       1000 non-null   object
 7   Timestamp                     1000 non-null   object
 8   Clicked on Feed               1000 non-null   int64
dtypes: float64(2), int64(3), object(4)
memory usage: 70.4+ KB
```

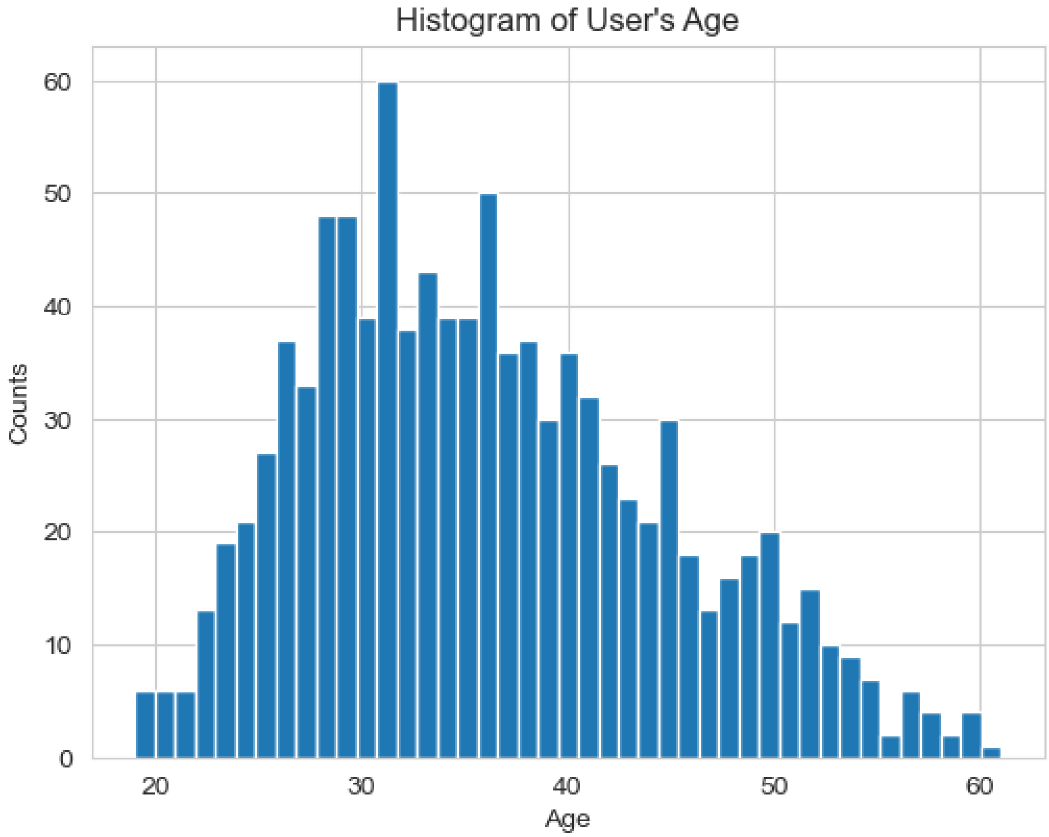
```
[11]: insta_data.describe()
```

```
[11]:        Daily Time Spent on Instagram          Age  Daily Internet Usage  \
      count                    1000.000000  1000.000000           1000.000000
      mean                       65.000200    36.009000            180.000100
```

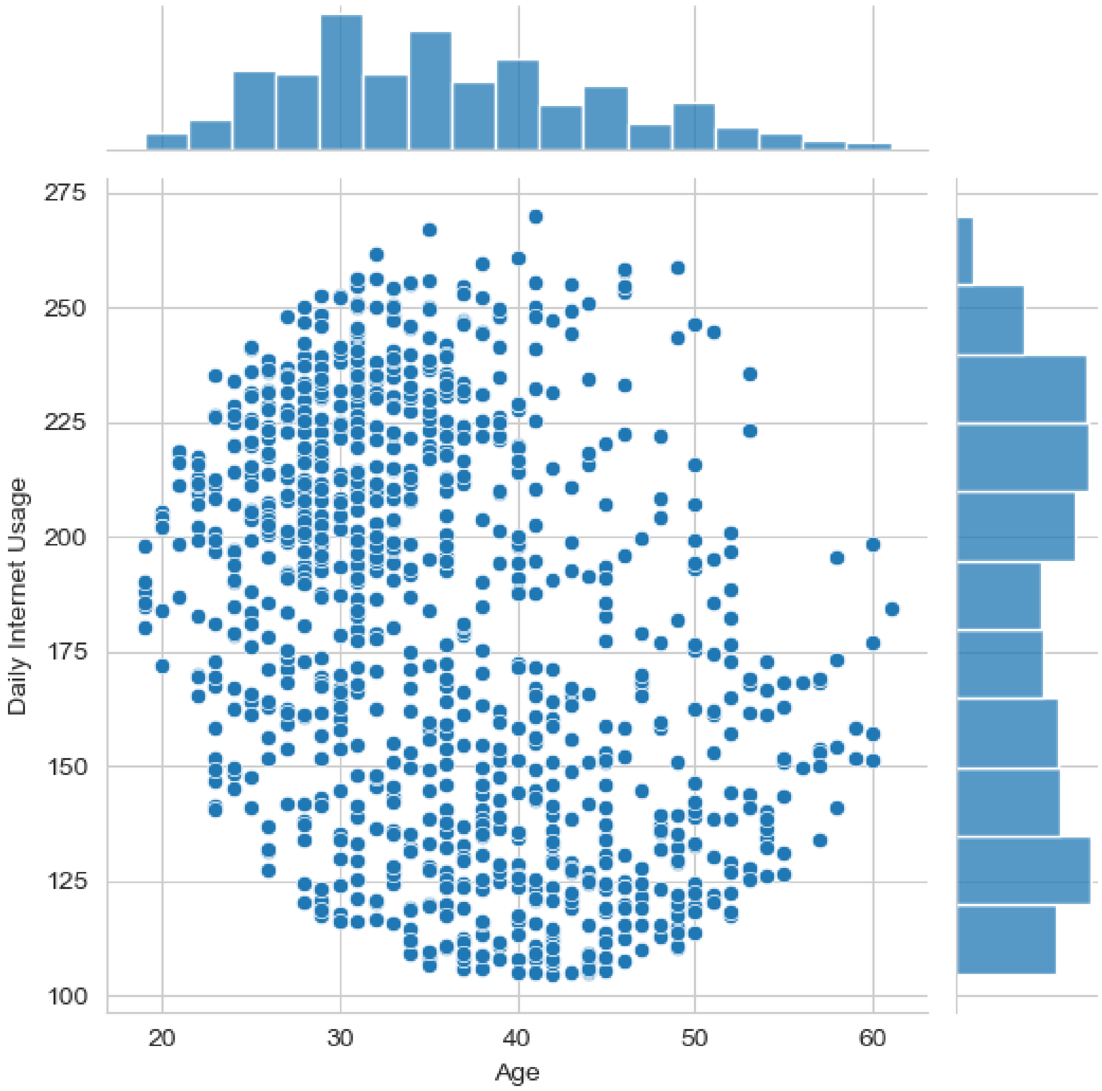
```
std                          15.853615     8.785562              43.902339
min                          32.600000    19.000000             104.780000
25%                          51.360000    29.000000             138.830000
50%                          68.215000    35.000000             183.130000
75%                          78.547500    42.000000             218.792500
max                          91.430000    61.000000             269.960000

               Sex  Clicked on Feed
count  1000.000000       1000.00000
mean      0.481000          0.50000
std       0.499889          0.50025
min       0.000000          0.00000
25%       0.000000          0.00000
50%       0.000000          0.50000
75%       1.000000          1.00000
max       1.000000          1.00000
```

[12]:

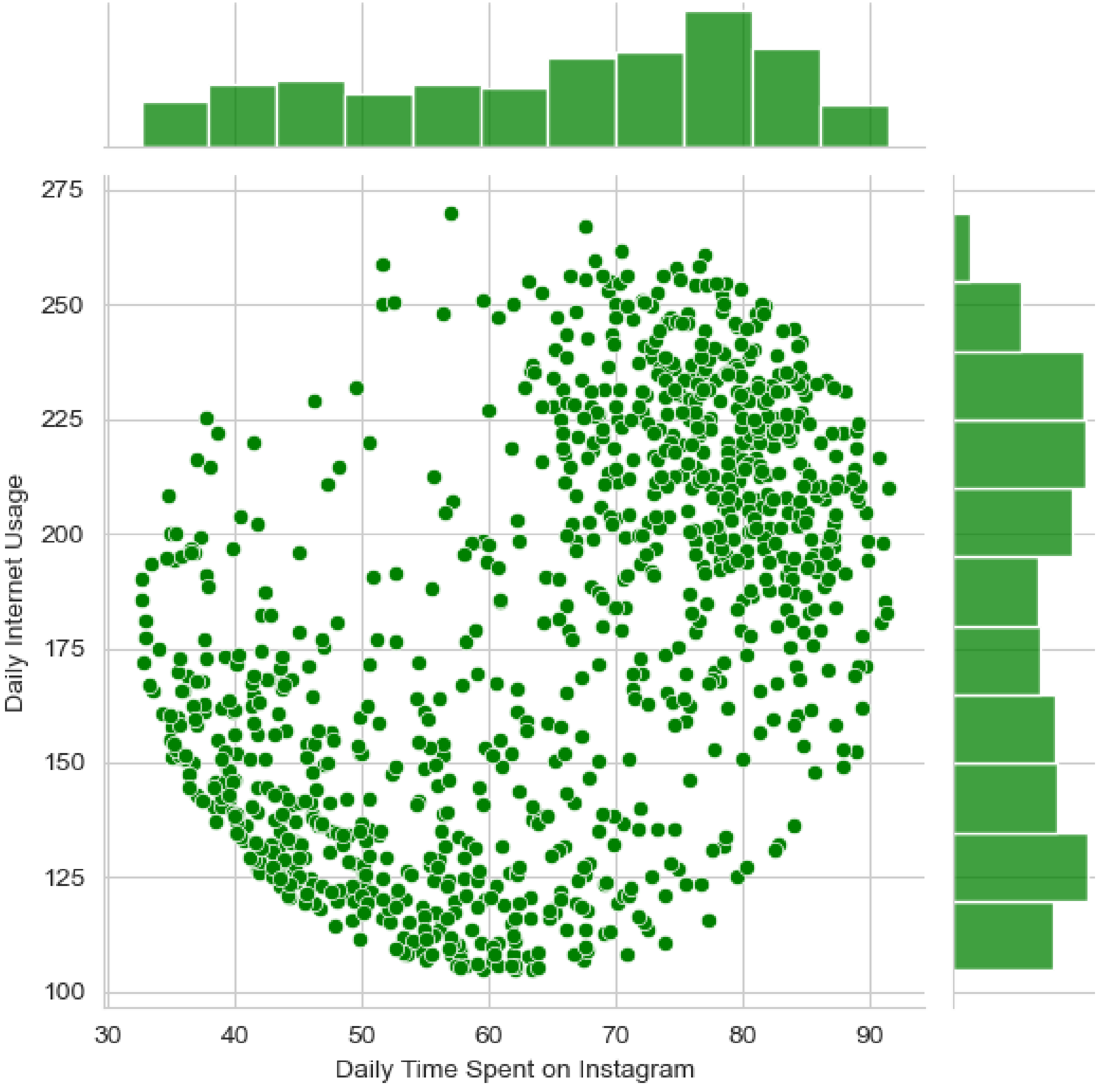
```
# Let's build a histogram for the user's age
sns.set_style('whitegrid')
insta_data['Age'].hist(bins=43)
plt.xlabel('Age')
plt.ylabel('Counts')
plt.title("Histogram of User's Age")
plt.show()
```



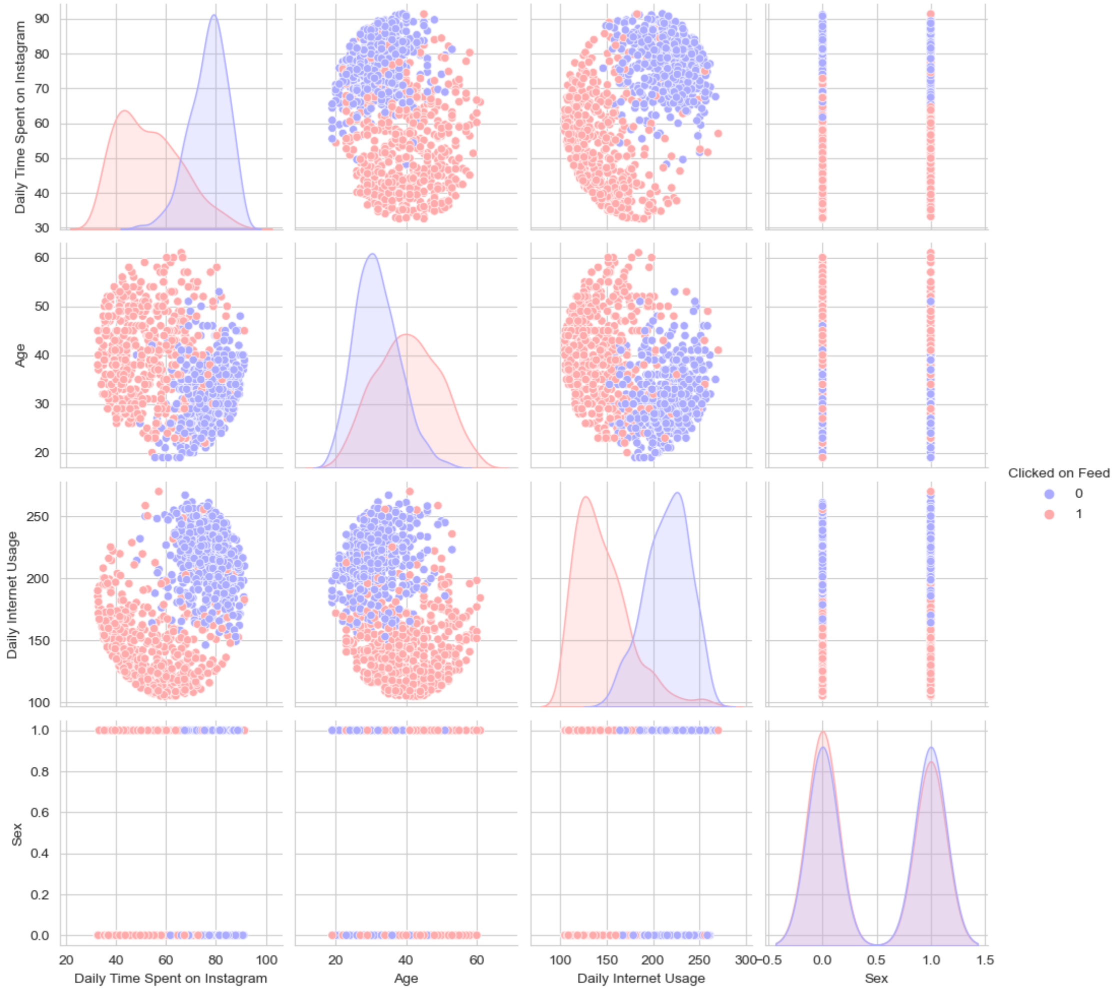
[13]:
```
## Let's build a jointplot showing Daily Time Spent on Instagram versus Age.
sns.jointplot(x='Age',y='Daily Internet Usage',data=insta_data)
plt.show()
```



```
[14]: # Jointplot of 'Daily Time Spent on Site' vs. 'Daily Internet Usage'
      sns.jointplot(x='Daily Time Spent on Instagram',y='Daily Internet␣
        ↪Usage',data=insta_data,color='green')
      plt.show()
```

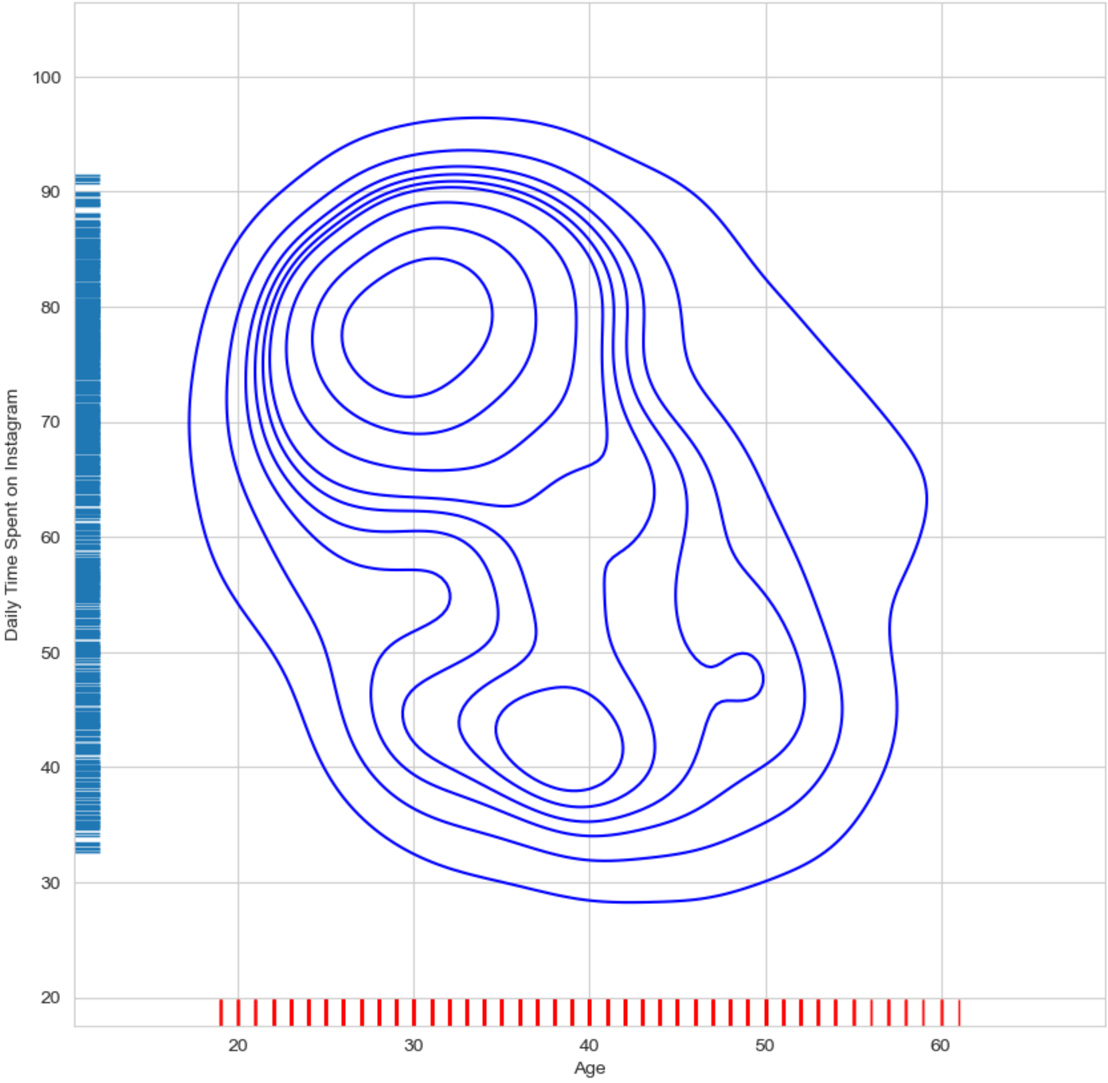


[15]:
```
# Pairplot with a grouping defined by the 'Clicked on Ad' column feature.
sns.pairplot(insta_data,hue='Clicked on Feed',palette='bwr')
plt.show()
```



[16]:
```
# How the user's age and the time spent on instagram are linked.
f, ax = plt.subplots(figsize=(10, 10))
sns.kdeplot(insta_data.Age, insta_data['Daily Time Spent on Instagram'],␣
 ↪color="b", ax=ax)
sns.rugplot(insta_data.Age, color="r", ax=ax)
sns.rugplot(insta_data['Daily Time Spent on Instagram'], vertical=True, ax=ax)
```

[16]:
```
<AxesSubplot:xlabel='Age', ylabel='Daily Time Spent on Instagram'>
```



### Data preparation

We have several categorical variables:

```
[17]: insta_data.select_dtypes(include='object').describe()
```

```
[17]:                  Ad feed Headline   Location Country          Timestamp
      count                        1000       1000    1000               1000
      unique                       1000        969     237                997
      top     Intuitive dynamic attitude  Lisamouth  France  26-05-2016 15:40
      freq                            1          3       9                  2
```

As we can see here, we have a lot of variability in the Ad feed headline, such as the location and country of the user, so for this example we will not use them.

You will eliminate these variables in question 4, and then in question 5 you will deal with the timestamp.

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Eliminate the variables `Ad feed Headline`, `Location` and `Country` from `insta_data` and save your resulting dataframe in a variable called `df`.

[18]:
```
x = insta_data.select_dtypes(include='object').describe()
y = x.columns
y = y[:3]
y
```

[18]:
```
Index(['Ad feed Headline', 'Location', 'Country'], dtype='object')
```

[19]:
```
### GRADED

### YOUR SOLUTION HERE
#insta_data.head(5)
df = insta_data
df = df.drop(y, axis = 1)
df.head(5)

###
### YOUR CODE HERE
###
```

[19]:
```
   Daily Time Spent on Instagram  Age  Daily Internet Usage  Sex  \
0                          82.03   41                187.53    0
1                          80.03   44                150.84    0
2                          51.38   59                158.56    0
3                          77.07   40                261.02    0
4                          51.87   50                119.65    0

          Timestamp  Clicked on Feed
0  02-05-2016 07:00                0
1  23-07-2016 14:47                1
2  17-06-2016 17:11                1
3  01-03-2016 10:01                0
4  10-03-2016 22:28                1
```

[20]:
```
###
### AUTOGRADER TEST - DO NOT REMOVE
###
```

Now let's see our new dataframe

[21]:
```
df.head()
```

```
[21]:    Daily Time Spent on Instagram  Age  Daily Internet Usage  Sex  \
      0                          82.03   41                187.53    0
      1                          80.03   44                150.84    0
      2                          51.38   59                158.56    0
      3                          77.07   40                261.02    0
      4                          51.87   50                119.65    0

                Timestamp  Clicked on Feed
      0  02-05-2016 07:00                0
      1  23-07-2016 14:47                1
      2  17-06-2016 17:11                1
      3  01-03-2016 10:01                0
      4  10-03-2016 22:28                1
```

```
[22]: # Change the name of the variables so it's easier to work with them
      df.columns = ["time_instagram", "age", "time_internet", "sex", "timestamp",␣
       ↪"clicked"]
```

```
[23]: df.head()
```

```
[23]:    time_instagram  age  time_internet  sex         timestamp  clicked
      0           82.03   41         187.53    0  02-05-2016 07:00        0
      1           80.03   44         150.84    0  23-07-2016 14:47        1
      2           51.38   59         158.56    0  17-06-2016 17:11        1
      3           77.07   40         261.02    0  01-03-2016 10:01        0
      4           51.87   50         119.65    0  10-03-2016 22:28        1
```

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Extract time features from the `timestamp` and create the variables:

- `month`: The month when the ad was seen
- `day_of_month`: The day of the month when the ad was seen
- `day_of_week`: The day of the week when the ad was seen
- `hour`: The hour of the day when the ad was seen

Extract the values as numeric features. Then add those features to the dataframe (`df`) as columns using the names indicated. Finally drop the `timestamp` column.

Hint: Transform timestamp to a datetime type object.

```
[24]: ### GRADED

      ### YOUR SOLUTION HERE
      # Remember to cast 'timestamp' to a datetime object

      df['timestamp'] = pd.to_datetime(df['timestamp'])
```

```
df['month'] = df['timestamp'].apply(lambda x:x.month)
df['day_of_month'] = df['timestamp'].apply(lambda x:x.day)
df["day_of_week"] = df['timestamp'].apply(lambda x:x.dayofweek)
df['hour'] = df['timestamp'].apply(lambda x:x.hour)
df = df.drop('timestamp', axis =1)

###
### YOUR CODE HERE
###
```

[25]:

```
###
### AUTOGRADER TEST - DO NOT REMOVE
###
```

[26]:

```
df.head(10)
```

[26]:

```
   time_instagram  age  time_internet  sex  clicked  month  day_of_month  \
0           82.03   41         187.53    0        0      2             5
1           80.03   44         150.84    0        1      7            23
2           51.38   59         158.56    0        1      6            17
3           77.07   40         261.02    0        0      1             3
4           51.87   50         119.65    0        1     10             3
5           45.99   33         124.61    1        1      2            27
6           61.88   45         108.18    0        1      5            30
7           68.01   25         188.32    1        0      1             1
8           72.84   26         238.63    0        0      8             7
9           73.84   31         121.05    0        1      6            18

   day_of_week  hour
0            4     7
1            5    14
2            4    17
3            6    10
4            0    22
5            5    15
6            0     8
7            4     3
8            6    21
9            5    17
```

You will now write Python code to split the data and fit a logistic regression model.

We will first need to split up our data into an `X` dataframe that contains the features to train on and a `y` Series with the target variable, which in this case will be the `clicked` column.

[27]:

```
X = df[df.columns.difference(['clicked'])]
y = df['clicked']
```

[28]:

```
print(X.head(5))
print(y)
```

```
   age  day_of_month  day_of_week  hour  month  sex  time_instagram  \
0   41             5            4     7      2    0           82.03
1   44            23            5    14      7    0           80.03
2   59            17            4    17      6    0           51.38
3   40             3            6    10      1    0           77.07
4   50             3            0    22     10    0           51.87

   time_internet
0         187.53
1         150.84
2         158.56
3         261.02
4         119.65
0      0
1      1
2      1
3      0
4      1
      ..
995    1
996    1
997    1
998    0
999    0
Name: clicked, Length: 1000, dtype: int64
```

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1.4.3 Logistic Regression Model

Split the data into a **training** set and a **testing** set. We will train our model on the training set and then use the test set to evaluate it. Use 30% of the data for testing and the remaining for training. Use 6 as a random state.

[29]:

```
from sklearn.model_selection import train_test_split
### GRADED

### YOUR SOLUTION HERE

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.3,␣
 ↪random_state=6)

###
### YOUR CODE HERE
###
```

[30]:

```
###
### AUTOGRADER TEST - DO NOT REMOVE
###
```

Return to top ## Question 7

Create and fit a Logistic Regression model using the training dataset. Save your fitted model in a variable called `model`.

Make sure to import LogisticRegression from `sklearn`. Use the `lbfgs` solver and `random_state` = 6 arguments when creating the model. Don't pass any other argument or changes to the logistic regression.

[31]:

```
### GRADED

### YOUR SOLUTION HERE
from sklearn import linear_model

model = linear_model.LogisticRegression(random_state=6, solver='lbfgs').
  ↪fit(X_train, y_train)

###
### YOUR CODE HERE
###
```

[32]:

```
###
### AUTOGRADER TEST - DO NOT REMOVE
###
```

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### Model evaluation

Create a predictions variable using your fitted model and the test dataset; call it `y_pred`. Then get the accuracy score of your predictions and save it in a variable called `accuracy`. Finally get the confusion matrix for your predictions and save it in a variable called `confusion_mat`.

Hint: Use the `sklearn.metrics` module.

[33]:

```
### GRADED

from sklearn.metrics import accuracy_score
from sklearn.metrics import confusion_matrix
### YOUR SOLUTION HERE
y_true = y_test
y_pred = model.predict(X_test)
accuracy = accuracy_score(y_true, y_pred)
confusion_mat = confusion_matrix(y_true, y_pred)

###
```

```
### YOUR CODE HERE
###
```

[34]:
```
print('Logistic regression accuracy: {}'.format(accuracy))
```

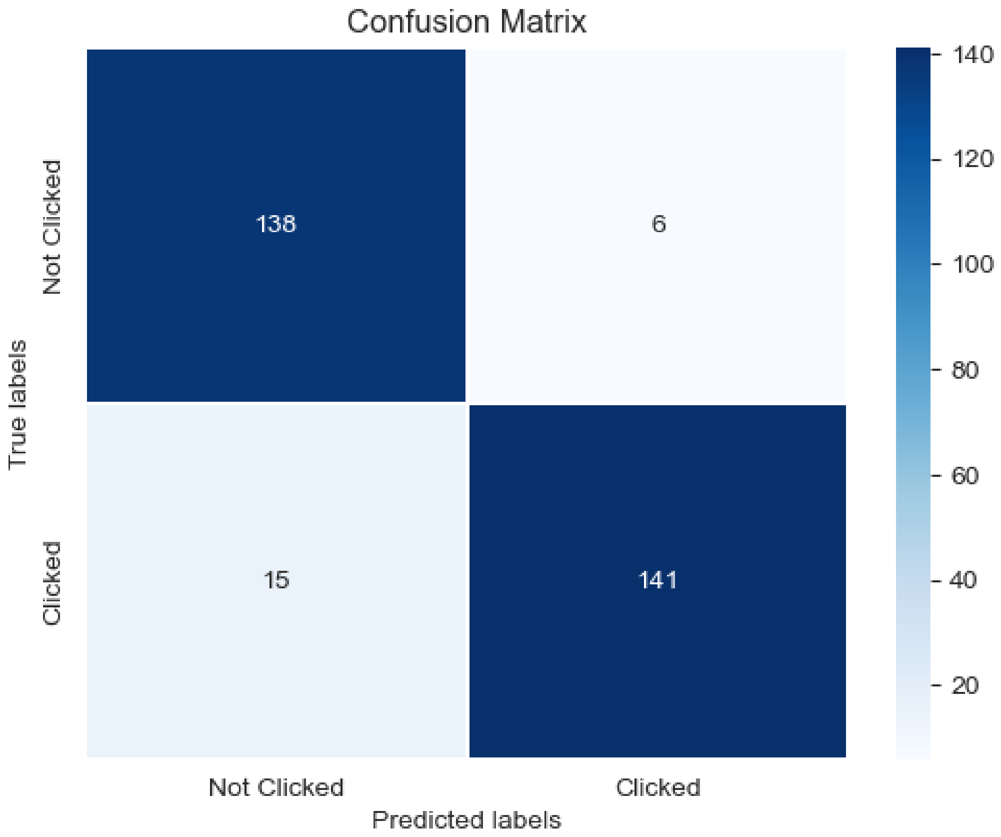
```
Logistic regression accuracy: 0.93
```

[35]:
```
# Plot your confusion matrix
print(confusion_mat)

ax= plt.subplot()
sns.heatmap(confusion_mat, annot=True, fmt="d", ax = ax, linewidths=1.2,␣
 ↪cmap="Blues"); #annot=True to annotate cells

# labels, title and ticks
ax.set_xlabel('Predicted labels');ax.set_ylabel('True labels');
ax.set_title('Confusion Matrix');
ax.xaxis.set_ticklabels(['Not Clicked', 'Clicked']); ax.yaxis.
 ↪set_ticklabels(['Not Clicked', 'Clicked']);
```

```
[[138   6]
 [ 15 141]]
```



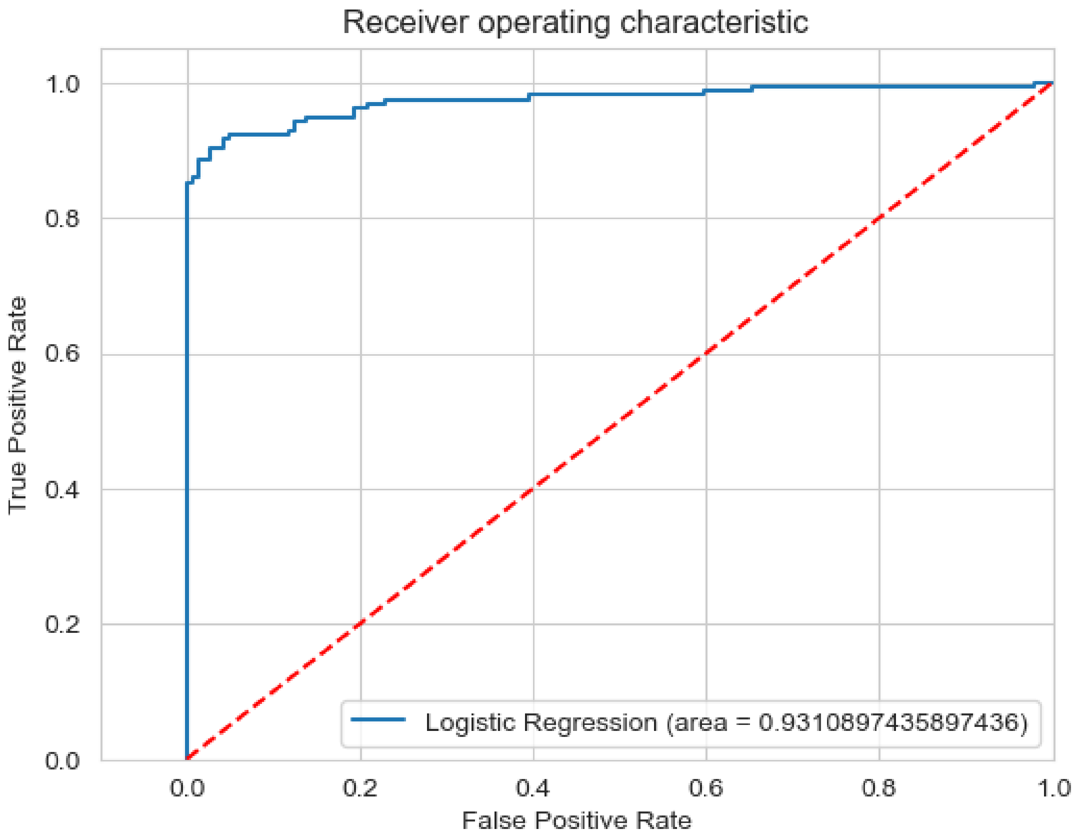
[36]:

```
###
### AUTOGRADER TEST - DO NOT REMOVE
###
```

Finally let's do a plot of our ROC while also getting the AUC.

[37]:

```
from sklearn.metrics import roc_auc_score
from sklearn.metrics import roc_curve
logit_roc_auc = roc_auc_score(y_test, model.predict(X_test))
fpr, tpr, thresholds = roc_curve(y_test, model.predict_proba(X_test)[:,1])
plt.figure()
plt.plot(fpr, tpr, label='Logistic Regression (area = {})'.
  ↪format(logit_roc_auc))
plt.plot([0, 1], [0, 1],'r--')
plt.xlim([-0.1, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver operating characteristic')
plt.legend(loc="lower right")
plt.show()
```


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
Logistic Regression (area = 0.9310897435897436)

[ ]: