Experiment No. 7
Apply Dimensionality Reduction on Adult Census Income Dataset and analyze the performance of the model
Date of Performance: 12/10/23
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Aim: Apply Dimensionality Reduction on Adult Census Income Dataset and analyze the performance of the model.

Objective: Able to perform various feature engineering tasks, perform dimetionality reduction on the given dataset and maximize the accuracy, Precision, Recall, F1 score.

Theory:

In machine learning classification problems, there are often too many factors on the basis of which the final classification is done. These factors are basically variables called features. The higher the number of features, the harder it gets to visualize the training set and then work on it. Sometimes, most of these features are correlated, and hence redundant. This is where dimensionality reduction algorithms come into play. Dimensionality reduction is the process of reducing the number of random variables under consideration, by obtaining a set of principal variables. It can be divided into feature selection and feature extraction.

Dataset:

Predict whether income exceeds $50K/yr based on census data. Also known as "Adult" dataset.

Attribute Information:

Listing of attributes:

>50K, <=50K.

age: continuous.

workclass: Private, Self-emp-not-inc, Self-emp-inc, Federal-gov, Local-gov, State-gov, Without-pay, Never-worked.

fnlwgt: continuous.

education: Bachelors, Some-college, 11th, HS-grad, Prof-school, Assoc-acdm, Assoc-voc, 9th, 7th-8th, 12th, Masters, 1st-4th, 10th, Doctorate, 5th-6th, Preschool.

education-num: continuous.

marital-status: Married-civ-spouse, Divorced, Never-married, Separated, Widowed, Married-spouse-absent, Married-AF-spouse.

occupation: Tech-support, Craft-repair, Other-service, Sales, Exec-managerial, Prof-specialty, Handlers-cleaners, Machine-op-inspct, Adm-clerical, Farming-fishing, Transport-moving, Priv-house-serv, Protective-serv, Armed-Forces.

relationship: Wife, Own-child, Husband, Not-in-family, Other-relative, Unmarried.

race: White, Asian-Pac-Islander, Amer-Indian-Eskimo, Other, Black.

sex: Female, Male.

capital-gain: continuous.

capital-loss: continuous.

hours-per-week: continuous.

native-country: United-States, Cambodia, England, Puerto-Rico, Canada, Germany, Outlying-US(Guam-USVI-etc), India, Japan, Greece, South, China, Cuba, Iran, Honduras, Philippines, Italy, Poland, Jamaica, Vietnam, Mexico, Portugal, Ireland, France, Dominican-Republic, Laos, Ecuador, Taiwan, Haiti, Columbia, Hungary, Guatemala, Nicaragua, Scotland, Thailand, Yugoslavia, El-Salvador, Trinadad & Tobago, Peru, Hong, Holand-Netherlands.

In [2]:
```
import numpy as np
import pandas as pd

df = pd.read_csv("adult.csv")
df.head()
```

Out[2]:

	age	workclass	fnlwgt	education	educational-num	marital-status	occupation	relationship	race	ge
0	25	Private	226802	11th	7	Never-married	Machine-op-inspct	Own-child	Black	
1	38	Private	89814	HS-grad	9	Married-civ-spouse	Farming-fishing	Husband	White	
2	28	Local-gov	336951	Assoc-acdm	12	Married-civ-spouse	Protective-serv	Husband	White	
3	44	Private	160323	Some-college	10	Married-civ-spouse	Machine-op-inspct	Husband	Black	
4	18	?	103497	Some-college	10	Never-married	?	Own-child	White	Fe

In [3]:
```
df.describe()
```

Out[3]:

	age	fnlwgt	educational-num	capital-gain	capital-loss	hours-per-week
count	48842.000000	4.884200e+04	48842.000000	48842.000000	48842.000000	48842.000000
mean	38.643585	1.896641e+05	10.078089	1079.067626	87.502314	40.422382
std	13.710510	1.056040e+05	2.570973	7452.019058	403.004552	12.391444
min	17.000000	1.228500e+04	1.000000	0.000000	0.000000	1.000000
25%	28.000000	1.175505e+05	9.000000	0.000000	0.000000	40.000000
50%	37.000000	1.781445e+05	10.000000	0.000000	0.000000	40.000000
75%	48.000000	2.376420e+05	12.000000	0.000000	0.000000	45.000000
max	90.000000	1.490400e+06	16.000000	99999.000000	4356.000000	99.000000

In [4]:
```
df.shape
```

Out[4]:
```
(48842, 15)
```

```
In [5]: df.info
```

```
Out[5]: <bound method DataFrame.info of        age     workclass  fnlwgt     educati
        on  educational-num  \
        0       25       Private  226802          11th                7
        1       38       Private   89814       HS-grad                9
                                               Assoc-acdm
        2       28     Local-gov  336951                              12
        3       44       Private  160323  Some-college               10
        4       18             ?  103497  Some-college               10
        ...    ...           ...     ...           ...              ...
        48837   27       Private  257302    Assoc-acdm               12
        48838   40       Private  154374       HS-grad                9
                                               HS-grad
        48839   58       Private  151910       HS-grad                9
        48840   22       Private  201490       HS-grad                9
        48841   52  Self-emp-inc  287927                              9
                      marital-status                  relationship   race      \
        0                                   occupation   Own-child           gender
                       Never-married  Machine-op-inspct              Black     Male
        1         Married-civ-spouse    Farming-fishing      Husband  White     Male
        2         Married-civ-spouse    Protective-serv      Husband  White     Male
        3         Married-civ-spouse  Machine-op-inspct      Husband  Black     Male
        4              Never-married                  ?    Own-child  White   Female
        ...                      ...                ...          ...    ...      ...
        48837                              Tech-support         Wife  White   Female
                  Married-civ-spouse  Machine-op-inspct
        48838     Married-civ-spouse       Adm-clerical      Husband  White     Male
        48839                Widowed       Adm-clerical    Unmarried  White   Female
        48840          Never-married                       Own-child  White     Male
        48841     Married-civ-spouse    Exec-managerial         Wife  White   Female


              capital-gain  capital-loss  hours-per-week native-country income
        0                                                 United-States
        1                0             0              50  United-States   <=50K
        2                0             0              40  United-States   <=50K
                                                          United-States    >50K
        3             7688             0              40  United-States    >50K
        4                0             0              30  United-States   <=50K

        ...            ...           ...             ...            ...     ...
        48837            0             0              38  United-States   <=50K
        48838            0             0              40  United-States    >50K
        48839            0             0              40  United-States   <=50K
        48840            0             0              20  United-States   <=50K
        48841        15024             0              40  United-States    >50K

        [48842 rows x 15 columns]>
```

In [7]:
```
df.isnull().sum()
```

Out[7]:
```
age                   0
workclass          2799
fnlwgt                0
education             0
educational-num       0
marital-status        0
occupation         2809
relationship          0
race                  0
gender                0
capital-gain          0
capital-loss          0
hours-per-week        0
native-country      857
income                0
dtype: int64
```

In [9]:
```
for col in ['workclass', 'occupation', 'native-country']:
    df[col].fillna(df[col].mode()[0], inplace=True)
df.isnull().sum()
```

Out[9]:
```
age                0
workclass          0
fnlwgt             0
education          0
educational-num    0
marital-status     0
occupation         0
relationship       0
race               0
gender             0
capital-gain       0
capital-loss       0
hours-per-week     0
native-country     0
income             0
dtype: int64
```

In [11]:
```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.3, ran
```

In [14]:
```
from sklearn import preprocessing
categorical = ['workclass', 'education', 'marital-status', 'occupation', 'rela
for feature in categorical:
    label = preprocessing.LabelEncoder()
    X_train[feature] = label.fit_transform(X_train[feature])
    X_test[feature] = label.transform(X_test[feature])
```

In [15]:
```
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()
X_train = pd.DataFrame(scaler.fit_transform(X_train), columns = X.columns)
X_test = pd.DataFrame(scaler.transform(X_test), columns = X.columns)
X_train.head()
```

Out[15]:

	age	workclass	fnlwgt	education	educational-num	marital-status	occupation	relationship
0	-0.849978	-1.887643	-0.551219	1.212393	-0.027733	-0.406325	-1.554732	0.969833
1	0.241031	-0.094859	1.687545	-2.650223	-1.587187	-0.406325	-1.049322	0.969833
2	-0.486308	1.697924	-1.434052	-0.590161	0.362131	-0.406325	-0.543912	-0.899325
3	-0.195373	-0.094859	-0.384485	1.212393	-0.027733	0.922720	-0.796617	-0.276272
4	-0.704510	-0.094859	1.608144	0.182362	-0.417596	1.587242	1.730434	1.592886

In [18]:
```
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score

LR = LogisticRegression()
LR.fit(X_train, y_train)
```

Out[18]:
```
LogisticRegression()
```
In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook.

On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

In [20]:
```
y_pred = LR.predict(X_test)
accuracy_score(y_test, y_pred)
```

Out[20]:
```
0.8221524602470484
```

In [21]:
```
from sklearn.decomposition import PCA
pca = PCA()
```

In [22]:
```
X_train = pca.fit_transform(X_train)
pca.explained_variance_ratio_
```

Out[22]:
```
array([0.14740223, 0.10130193, 0.08096753, 0.07933632, 0.07433976,
       0.07314763, 0.07066221, 0.06753572, 0.06516078, 0.06093536,
       0.06003764, 0.04864317, 0.04289137, 0.02763835])
```

In [24]:
```
X = df.drop(['income'], axis=1)
y = df['income']
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.3, ra
```

In [25]:
```
categorical = ['workclass', 'education', 'marital-status', 'occupation', 'rela
for feature in categorical:
    lablel = preprocessing.LabelEncoder()
    X_train[feature] = label.fit_transform(X_train[feature])
    X_test[feature] = label.transform(X_test[feature])
```

In [26]:
```
X_train = pd.DataFrame(scaler.fit_transform(X_train), columns = X.columns)
```

In [27]:
```
pca= PCA()
pca.fit(X_train)
cumsum = np.cumsum(pca.explained_variance_ratio_)
dim = np.argmax(cumsum >= 0.90) + 1
print('The number of dimensions required to preserve 90% of variance is',dim)
```

```
The number of dimensions required to preserve 90% of variance is 12
```

In [28]:
```
X = df.drop(['income','native-country', 'hours-per-week'], axis=1)
y = df['income']
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.3, ran
```

In [30]:
```
categorical = ['workclass', 'education', 'marital-status', 'occupation', 'rela
for feature in categorical:
    label = preprocessing.LabelEncoder()
    X_train[feature] = label.fit_transform(X_train[feature])
    X_test[feature] = label.transform(X_test[feature])
X_train = pd.DataFrame(scaler.fit_transform(X_train), columns = X.columns)
X_test = pd.DataFrame(scaler.transform(X_test), columns = X.columns)
```

In [31]:
```
LR2 = LogisticRegression()
LR2.fit(X_train, y_train)
```

Out[31]:
```
LogisticRegression()
```

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In [32]:
```
y_pred = LR2.predict(X_test)
accuracy_score(y_test, y_pred)
```

Out[32]:
```
0.8229031597625059
```

In [33]:

```
from sklearn.metrics import confusion_matrix
import pandas as pd
confusion = confusion_matrix(y_test, y_pred)
df_confusion = pd.DataFrame(confusion, columns=['Predicted No', 'Predicted Yes
from sklearn.metrics import classification_report
print(classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

       <=50K       0.84      0.94      0.89     11138
        >50K       0.71      0.44      0.54      3515

    accuracy                           0.82     14653
   macro avg       0.78      0.69      0.72     14653
weighted avg       0.81      0.82      0.81     14653
```

Conclusion:

1. The Accuracy score obtained by applying principal component analysis on the testing data is 0.82 which means our model is 82% accurate on the testing data.
2. Precision measures the accuracy of the positive predictions and the precision score obtained by our model is 0.84
3. Recall measures the ability of the model to correctly identify all relevant instances and the Recall score obtained by our model is 0.94
4. F1-score is the harmonic mean of precision and recall and provides a balance between the 2 metrics and the F1-score obtained by our model is 0.89