```
1. Credit card applications
# Import pandas
import pandas as pd
# Load dataset
cc_apps = pd.read_csv("datasets/cc_approvals.data", header=None)
# Inspect data
print(cc_apps.head())
                                     8 9
                                             10 11 12
  0
         1
                2 3
                      4
                         5 6
                                  7
                                                          13
                                                               14 15
0
  b
      30.83
             0.000
                               1.25
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                         W V
                                              1
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                   u
                       g
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                                                f
1
  а
      58.67
             4.460
                    u
                       g
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                            h 3.04 t t
                                              6
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                                                              560
                                                                   +
2
      24.50
                               1.50 t
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             0.500
                    u
                       g
                             h
                                              0
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                                                       00280
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                             v 3.75
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                                                f
4
  b
      20.17
             5.625
                    u
                       q
                          W
                                              0
                                                       00120
                                                                0
                                                                  +
2. Inspecting the applications
# Print summary statistics
cc apps description = cc apps.describe()
print(cc apps description)
print("\n")
# Print DataFrame information
cc apps info = cc apps.info()
print(cc apps info)
print("\n")
# Inspect missing values in the dataset
print(cc apps.tail(17))
                           7
                                       10
                                                      14
       690.000000
                   690.000000
                               690.00000
                                              690,000000
count
         4.758725
                     2.223406
                                 2.40000
                                             1017.385507
mean
std
         4.978163
                     3.346513
                                 4.86294
                                             5210.102598
min
         0.000000
                     0.000000
                                 0.00000
                                                0.00000
25%
         1.000000
                     0.165000
                                 0.00000
                                                0.00000
50%
         2.750000
                     1.000000
                                 0.00000
                                                5.000000
75%
                                 3.00000
         7.207500
                     2.625000
                                              395.500000
        28,000000
                    28.500000
                                67.00000
                                          100000.000000
max
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 690 entries, 0 to 689
Data columns (total 16 columns):
      690 non-null object
0
1
      690 non-null object
```

```
2
3
      690 non-null float64
      690 non-null object
4
      690 non-null object
5
      690 non-null object
6
      690 non-null object
7
      690 non-null float64
      690 non-null object
8
9
      690 non-null object
10
      690 non-null int64
11
      690 non-null object
      690 non-null object
12
13
      690 non-null object
14
      690 non-null int64
      690 non-null object
15
dtypes: float64(2), int64(2), object(12)
```

memory usage: 86.3+ KB

None

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
15 673	?	29.50	2.000	У	p	е	h	2.000	f	f	0	f	g	00256	17
674	а	37.33	2.500	u	g	i	h	0.210	f	f	0	f	g	00260	246
675	a	41.58	1.040	u	g	aa	V	0.665	f	f	0	f	g	00240	237
676	a	30.58	10.665	u	g	q	h	0.085	f	t	12	t	g	00129	3
677	b	19.42	7.250	u	g	m	V	0.040	f	t	1	f	g	00100	1
678	a	17.92	10.210	u	g	ff	ff	0.000	f	f	0	f	g	00000	50
679	a	20.08	1.250	u	g	С	V	0.000	f	f	0	f	g	00000	0
680	b	19.50	0.290	u	g	k	V	0.290	f	f	0	f	g	00280	364
681	b	27.83	1.000	у	p	d	h	3.000	f	f	0	f	g	00176	537
682	b	17.08	3.290	u	g	i	V	0.335	f	f	0	t	g	00140	2
683	b	36.42	0.750	у	p	d	V	0.585	f	f	0	f	g	00240	3
684	b	40.58	3.290	u	g	m	V	3.500	f	f	0	t	S	00400	0
685	b	21.08	10.085	у	p	е	h	1.250	f	f	0	f	g	00260	0
686	a	22.67	0.750	u	g	С	V	2.000	f	t	2	t	g	00200	394
687	а	25.25	13.500	у	р	ff	ff	2.000	f	t	1	t	g	00200	1

```
688
     b
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                                С
                                     h
                                        8.290 f
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3. Handling the missing values (part i)
# Import numpy
import numpy as np
# Inspect missing values in the dataset
print(cc apps.tail(50))
# Replace the '?'s with NaN
cc apps = cc apps.replace('?', np.NaN)
# Inspect the missing values again
print(cc apps.tail(50))
    0
            1
                    2 3
                           4
                               5
                                    6
                                           7
                                              8 9
                                                      10 11 12
                                                                     13
                                                                          14
15
640
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641
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643
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644
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                 2.665
                                        0.165
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646
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647
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652
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5.000 0.000 00000 655 а 21.08 ff ff f f 0 f 0 У р 656 b 25.67 3.250 2.290 f 1 t 00416 21 С h t u q g 657 а 38.92 1.665 0.250 f f 0 f g 00000 390 u g aa ٧ 658 15.75 0.375 f 18 а 1.000 f f 0 00120 u g C 659 28.58 3.750 0.250 f 00040 154 а С t 1 t u g ٧ q 9.000 00000 660 b 22.25 0.085 f f 0 f g 0 u g aa ٧ f 661 b 29.83 3.500 0.165 f f 00216 0 0 u g С 662 а 23.50 1.500 0.875 f f 0 t 00160 0 g u g W ٧ 663 b 32.08 4.000 У p CC ٧ 1.500 f f 0 t g 00120 0 f 664 b 31.08 1.500 0.040 f f 0 S 00160 0 У p W f 665 b 31.83 0.040 0.040 f f 0 00000 0 q У р m ٧ 666 а 21.75 11.750 С 0.250 f f 0 t g 00180 0 u g ٧ 667 17.92 0.540 1.750 f 00080 5 а C t 1 t g u g ٧ 668 b 30.33 0.500 d 0.085 f f t 00252 0 h 0 S u g 669 b 51.83 2.040 У p ff ff 1.500 f f 0 f g 00120 1 f 670 b 47.17 5.835 5.500 f f 0 00465 150 u g W ٧ g 671 25.83 12.835 f f 2 b 0.500 f 0 00000 u g CC672 0.835 0.500 а 50.25 f f 0 t g 00240 117 u g aa ٧ ? 29.50 2.000 f 673 2.000 f f 0 00256 17 У p е h g 674 а 37.33 2.500 i h 0.210 f f 0 f 00260 246 u g g 675 а 41.58 1.040 0.665 f f 0 f g 00240 237 u g aa ٧ 676 30.58 10.665 0.085 f 12 00129 3 а u g q h t t g 677 f b 19.42 7.250 0.040 f t 1 00100 1 u m ٧ g g 678 17.92 10.210 ff ff 0.000 f f f 50 0 00000 а u g g 679 20.08 1.250 0.000 f f 0 f 00000 0 а С ٧ q u g

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681
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682
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                                            0.585
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684
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686
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687
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640
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141
642
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0 -
643
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644
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2 -
645
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646
            20.83
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648
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649
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160
652
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660
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4. Handling the missing values (part ii)
# Impute the missing values with mean imputation
cc apps.fillna(cc apps[[2,7,10,14]].mean(), inplace=True)
# Count the number of NaNs in the dataset to verify
print(cc apps.isnull().sum())
0
      12
1
      12
2
       0
3
       6
4
       6
5
       9
6
       9
7
       0
8
       0
9
       0
10
       0
11
       0
12
       0
13
      13
14
       0
```

15

0 dtype: int64

```
5. Handling the missing values (part iii)
# Iterate over each column of cc_apps
for col in cc apps.columns:
    # Check if the column is of object type
    if cc apps[col].dtypes == 'object':
        # Impute with the most frequent value
        cc_apps = cc_apps.fillna(cc_apps[col].value_counts().index[0])
# Count the number of NaNs in the dataset and print the counts to
verify
print(cc apps.isnull().sum())
      0
0
1
      0
2
      0
3
      0
4
      0
5
      0
6
      0
7
      0
8
      0
9
      0
10
      0
11
      0
12
      0
13
      0
14
      0
15
      0
dtype: int64
6. Preprocessing the data (part i)
# Import LabelEncoder
from sklearn.preprocessing import LabelEncoder
# Instantiate LabelEncoder
le=LabelEncoder()
# Iterate over all the values of each column and extract their dtypes
for col in cc apps.columns:
    # Compare if the dtype is object
    if cc apps[col].dtypes=='object':
    # Use LabelEncoder to do the numeric transformation
cc apps[col]=le.fit(cc apps[col].values).transform(cc apps[col].values
7. Splitting the dataset into train and test sets
# Import train test split
from sklearn.model_selection import train_test_split
```

```
# Drop the features 11 and 13 and convert the DataFrame to a NumPy
array
cc apps = cc apps.drop([11, 13], axis=1)
cc_apps = cc_apps.values
# Segregate features and labels into separate variables
X,y = cc apps[:,0:13] , cc apps[:,13]
# Split into train and test sets
X_train, X_test, y_train, y_test = train_test_split(X, y,
                                test size=0.33,
                                 random state=42)
8. Preprocessing the data (part ii)
# Import MinMaxScaler
from sklearn.preprocessing import MinMaxScaler
# Instantiate MinMaxScaler and use it to rescale X train and X test
scaler = MinMaxScaler(feature range=(0,1))
rescaledX_train = scaler.fit_transform(X_train)
rescaledX test = scaler.fit transform(X test)
9. Fitting a logistic regression model to the train set
# Import LogisticRegression
from sklearn.linear model import LogisticRegression
# Instantiate a LogisticRegression classifier with default parameter
values
logreg = LogisticRegression()
# Fit logreg to the train set
logreg.fit(rescaledX train, y train)
LogisticRegression(C=1.0, class weight=None, dual=False,
fit intercept=True,
          intercept scaling=1, max iter=100, multi class='ovr',
n_jobs=1,
          penalty='l2', random state=None, solver='liblinear',
tol=0.0001,
          verbose=0, warm start=False)
10. Making predictions and evaluating performance
# Import confusion matrix
from sklearn.metrics import confusion matrix
# Use logreg to predict instances from the test set and store it
y pred = logreg.predict(rescaledX test)
```

```
# Get the accuracy score of logreg model and print it
print("Accuracy of logistic regression classifier: ",
logreg.score(rescaledX_test, y_test))
# Print the confusion matrix of the logreg model
print(confusion matrix(y test, y pred))
Accuracy of logistic regression classifier: 0.8377192982456141
[[92 11]
[26 99]]
11. Grid searching and making the model perform better
# Import GridSearchCV
from sklearn.model selection import GridSearchCV
# Define the grid of values for tol and max iter
tol = [0.01, 0.001, 0.0001]
\max iter = [100, 150, 200]
# Create a dictionary where tol and max iter are keys and the lists of
their values are corresponding values
param grid = dict(tol=tol, max iter=max iter)
12. Finding the best performing model
# Instantiate GridSearchCV with the required parameters
grid model = GridSearchCV(estimator=logreg, param grid=param grid,
cv=5)
# Use scaler to rescale X and assign it to rescaledX
rescaledX = scaler.fit transform(X)
# Fit data to grid model
grid_model_result = grid_model.fit(rescaledX, y)
# Summarize results
best score, best params = grid model result.best score,
grid model result.best params
print("Best: %f using %s" % (best_score, best_params))
Best: 0.853623 using {'tol': 0.01, 'max iter': 100}
```