Creating a Logistic Regression Model to Predict Breast Cancer Recurrence

Import software libraries and load the dataset

In [1]:
```python
# Import required libraries
import sys                                  # Read system parameters
import os                                   # Interact with the operating system
import numpy as np                          # Work with multi-dimensional arrays and matrices
import pandas as pd                         # Manipulate and analyze data
import matplotlib as mpl                    # Create 2D charts
import scipy as sp                          # Perform scientific computing and advanced mathematics
import sklearn                              # Perform data mining and analysis
import seaborn as sns                       # Perform data visualization

import matplotlib.pyplot as plt
# Summarize software libraries used
print('Libraries used in this project:')
print('- NumPy {}'.format(np.__version__))
print('- Pandas {}'.format(pd.__version__))
print('- Matplotlib {}'.format(mpl.__version__))
print('- SciPy {}'.format(sp.__version__))
print('- Scikit-learn {}'.format(sklearn.__version__))
print('- Python {}\n'.format(sys.version))

# Read the raw dataset based on data from https://archive.ics.uci.edu/ml/datasets/breast+cancer
print('------------------------------------')
print('Loading the dataset.')
#PROJECT_ROOT_DIR = '.'
#DATA_PATH = os.path.join(PROJECT_ROOT_DIR, 'breast_cancer_data')
#print('Data files in this project:', os.listdir(DATA_PATH) )
#data_raw_file = os.path.join( DATA_PATH, 'breast-cancer.csv' )
df = pd.read_csv("breast-cancer.csv")
print('Loaded {} records\n'.format(len(df)))
```

```
Libraries used in this project:
- NumPy 1.19.2
- Pandas 1.1.3
- Matplotlib 3.3.2
- SciPy 1.5.2
- Scikit-learn 0.23.2
- Python 3.8.5 (default, Sep  3 2020, 21:29:08) [MSC v.1916 64 bit (AMD64)]

------------------------------------
Loading the dataset.
Loaded 286 records
```

Get acquainted with the data structure and preview the records

In [2]:
```python
# Show the various features and their data types


# View the first five records
```

In [3]:
```python
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 286 entries, 0 to 285
Data columns (total 12 columns):
 #   Column        Non-Null Count  Dtype
---  ------        --------------  -----
 0   recurrence    286 non-null    int64
 1   age_decade    286 non-null    int64
 2   meno_pre      286 non-null    int64
 3   meno_lt_40    286 non-null    int64
 4   meno_ge_40    286 non-null    int64
 5   tumor_size    286 non-null    int64
 6   inv_nodes     286 non-null    int64
 7   node_caps     286 non-null    int64
 8   deg_malig     286 non-null    int64
 9   breast_left   286 non-null    int64
 10  breast_right  286 non-null    int64
 11  irradiat      286 non-null    int64
dtypes: int64(12)
memory usage: 26.9 KB
```

In [4]:
```python
df.head()
```

Out[4]:

	recurrence	age_decade	meno_pre	meno_lt_40	meno_ge_40	tumor_size	inv_nodes	node_caps	deg_malig	breast_left	breast_right	irra
0	0	30	1	0	0	32	1	0	3	1	0	
1	0	40	1	0	0	42	1	0	2	0	1	
2	0	40	1	0	0	42	1	0	2	1	0	
3	0	60	0	0	1	62	1	0	2	0	1	
4	0	40	1	0	0	42	1	0	2	0	1	

In [5]:
```python
df["recurrence"].value_counts()
```

Out[5]:
```
0    201
1     85
Name: recurrence, dtype: int64
```

Examine descriptive statistics

In [6]:
```python
# Show descriptive statistics

df.describe()
```

Out[6]:

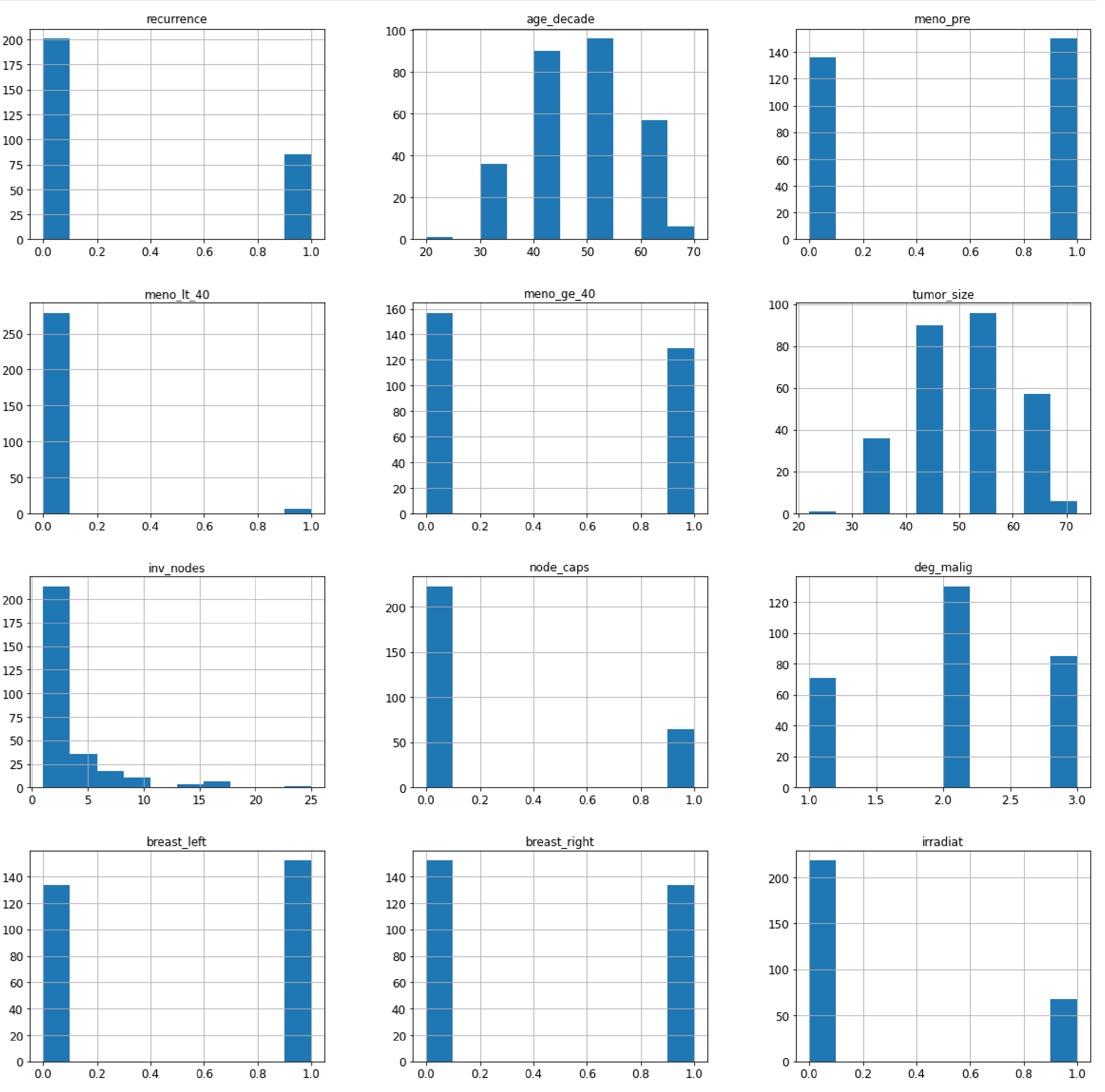
	recurrence	age_decade	meno_pre	meno_lt_40	meno_ge_40	tumor_size	inv_nodes	node_caps	deg_malig	breast_left	breast_rig
count	286.000000	286.000000	286.000000	286.000000	286.000000	286.000000	286.000000	286.000000	286.000000	286.000000	286.0000
mean	0.297203	46.643357	0.524476	0.024476	0.451049	48.643357	2.573427	0.223776	2.048951	0.531469	0.4685
std	0.457828	10.118183	0.500276	0.154791	0.498470	10.118183	3.451904	0.417504	0.738217	0.499883	0.4998
min	0.000000	20.000000	0.000000	0.000000	0.000000	22.000000	1.000000	0.000000	1.000000	0.000000	0.0000
25%	0.000000	40.000000	0.000000	0.000000	0.000000	42.000000	1.000000	0.000000	2.000000	0.000000	0.0000
50%	0.000000	50.000000	1.000000	0.000000	0.000000	52.000000	1.000000	0.000000	2.000000	1.000000	0.0000
75%	1.000000	50.000000	1.000000	0.000000	1.000000	52.000000	4.000000	0.000000	3.000000	1.000000	1.0000
max	1.000000	70.000000	1.000000	1.000000	1.000000	72.000000	25.000000	1.000000	3.000000	1.000000	1.0000

Use histograms to visualize the distribution of various features

In [7]:
```python
# Show histograms for each attribute in the dataset

mpl.rc('axes', labelsize=14)
mpl.rc('xtick', labelsize=12)
mpl.rc('ytick', labelsize=12)

df.hist(figsize=(20,20))
plt.show()
```



Split the data into training and validation sets and labels

In [8]:
```python
# Import a function to split the dataset

from sklearn.model_selection import train_test_split


# Specify the column to be included in the label set ('recurrence')

X = df.iloc[:,1:]
y = df.iloc[:,0]

# Specify columns to be included in the training and validation sets (all other columns)


# Split the training set, validation set, and labels for both
X_train, X_test, y_train, y_test = train_test_split(X.values, y.values, random_state = 0, stratify=y)

# Compare the number of rows and columns in the original data to the training and validation sets

X_train.shape, y_train.shape, X_test.shape, y_test.shape
```

Out[8]:
```
((214, 11), (214,), (72, 11), (72,))
```

In [9]:
```python
# Preview the training data

X_train
```

Out[9]:
```
array([[30,  1,  0, ...,  1,  0,  0],
       [40,  1,  0, ...,  1,  0,  0],
       [50,  0,  0, ...,  1,  0,  1],
       ...,
       [50,  0,  0, ...,  0,  1,  0],
       [30,  1,  0, ...,  0,  1,  1],
       [50,  0,  1, ...,  1,  0,  0]], dtype=int64)
```

In [10]:
```python
# Preview the labels

y_train
```

Out[10]:
```
array([0, 0, 1, 0, 1, 0, 1, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0,
       0, 0, 1, 1, 0, 0, 1, 0, 0, 0, 1, 1, 0, 0, 1, 0, 0, 1, 1, 0, 1, 0,
       0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 1, 0, 1, 0,
       0, 0, 0, 0, 1, 1, 0, 0, 1, 0, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 1,
       0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 1, 1, 0, 0, 1, 0, 0,
       0, 0, 0, 1, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 1, 0, 1, 0, 1,
       0, 0, 0, 0, 1, 0, 0, 0, 1, 1, 0, 1, 1, 0, 0, 1, 1, 1, 0, 0, 0, 1,
       0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 1, 0, 0,
       0, 0, 1, 0, 0, 1, 0, 0, 1, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1,
       0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 1, 1], dtype=int64)
```

Build the model

In [11]:
```python
# Create a logistic regression model, and use the validation data and labels to score it.

from sklearn.linear_model import LogisticRegressionCV

logistic = LogisticRegressionCV(random_state=0, cv=5, scoring="f1", max_iter=1000)
```

In [12]:
```python
logistic.fit(X_train,y_train)
```

Out[12]:
```
LogisticRegressionCV(cv=5, max_iter=1000, random_state=0, scoring='f1')
```

In [13]:
```python
logistic_pred = logistic.predict(X_test)
```

In [14]:
```python
logistic_pred
```

Out[14]:
```
array([1, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0,
       0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 1, 0, 0], dtype=int64)
```

Test the model

In [15]:
```python
# Add columns to a copy of the test data to compare predictions against actual values.

table = pd.DataFrame(X_test.copy())

# View examples of the predictions compared to actual recurrence.
```

In [16]:
```python
table["Actual Recurrence"] = y_test.copy()
```

In [17]:
```python
table["Predicted Recurrence"] = logistic_pred
```

In [18]:
```python
table
```

Out[18]:

	0	1	2	3	4	5	6	7	8	9	10	Actual Recurrence	Predicted Recurrence
0	30	1	0	0	32	4	1	3	1	0	1	1	1
1	60	0	0	1	62	1	0	1	1	0	0	0	0
2	30	1	0	0	32	1	0	3	1	0	0	1	0
3	40	1	0	0	42	1	0	2	1	0	0	0	0
4	30	1	0	0	32	1	0	1	1	0	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...
67	60	0	0	1	62	7	1	2	0	1	0	0	0
68	60	0	0	1	62	1	0	1	0	1	1	1	0
69	40	1	0	0	42	7	1	3	0	1	0	1	1
70	40	1	0	0	42	1	0	2	1	0	0	0	0
71	30	1	0	0	32	1	0	3	1	0	0	1	0

72 rows × 13 columns

In [19]:
```python
from sklearn.metrics import roc_auc_score, classification_report
```

In [20]:
```python
roc_auc_score(y_test,logistic_pred)
```

Out[20]:
```
0.6078431372549019
```

In [21]:
```python
print(classification_report(y_test,logistic_pred))
```

```
              precision    recall  f1-score   support

           0       0.76      0.88      0.82        51
           1       0.54      0.33      0.41        21

    accuracy                           0.72        72
   macro avg       0.65      0.61      0.61        72
weighted avg       0.70      0.72      0.70        72
```

In [ ]:

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