1 Predicting customer churn using Artificial Neural Networks (ANNs)

1.0.1 Importing essential Libraries

```
[394]: import numpy as np # Importing NumPy library and aliasing it as np import pandas as pd # Importing pandas library and aliasing it as pd from matplotlib import pyplot as plt # Importing pyplot module from matplotlib → and aliasing it as plt from sklearn.preprocessing import MinMaxScaler # Importing MinMaxScaler class → from sklearn.preprocessing
```

```
[395]: import pandas as pd # Importing pandas library and aliasing it as pd

# Read data from a CSV file into a DataFrame

# Assumes that the CSV file is located at "/content/

$\times WA_Fn-UseC_-Telco-Customer-Churn.csv"$

df = pd.read_csv("/content/WA_Fn-UseC_-Telco-Customer-Churn.csv")

# Display the DataFrame

df # Displays the contents of the DataFrame
```

```
[395]:
            customerID gender SeniorCitizen Partner Dependents tenure \
            7590-VHVEG Female
                                                 Yes
      0
                                           0
                                                             No
                                                                      1
      1
            5575-GNVDE
                         Male
                                           0
                                                  No
                                                                     34
                                                             No
      2
            3668-QPYBK
                         Male
                                           0
                                                  No
                                                             No
                                                                      2
      3
            7795-CFOCW
                         Male
                                           0
                                                  No
                                                             No
                                                                     45
      4
            9237-HQITU Female
                                           0
                                                                      2
                                                             No
                                                  •••
      7038 6840-RESVB Male
                                           0
                                                            Yes
                                                 Yes
      7039 2234-XADUH Female
                                           0
                                                 Yes
                                                            Yes
                                                                     72
      7040 4801-JZAZL Female
                                           0
                                                 Yes
                                                            Yes
                                                                     11
      7041 8361-LTMKD
                                                                      4
                         Male
                                                 Yes
                                                             No
                                           1
      7042 3186-AJIEK
                         Male
                                                  No
                                                             No
                                                                     66
```

```
PhoneService MultipleLines InternetService OnlineSecurity ... \
O No No phone service DSL No ...
```

1	Yes		N	Го	DSL		Yes	
2	Yes		N	Ιο	DSL		Yes	
3	No No	o phone	servi	e	DSL		Yes	
4	Yes		Ŋ	lo Fiber	optic		No	
•••	•••							
7038	Yes		Υe	es	DSL		Yes	
7039	Yes		Υe	es Fiber	optic		No	
7040	No No	o phone	servi	e	DSL		Yes	
7041	Yes		Υe	es Fiber	optic		No	
7042	Yes		N	lo Fiber	optic		Yes	
	DeviceProtection	n TechS	upport	StreamingTV	Stream	mingMovies	Contract	: \
0	N)	No	No		No	Month-to-month	ı
1	Ye	3	No	No		No	One year	<u>-</u>
2	N)	No	No		No	Month-to-month	
3	Ye	3	Yes	No		No	One year	<u>-</u>
4	N)	No	No		No	Month-to-month	
 7038	 Ye		Yes	 Yes	•••	Yes	One week	^
7039	Ye		No	Yes		Yes	One year One year	
7040	N:		No	No		No	Month-to-month	
7040	N:		No	No		No No	Month-to-month	
7041	Ye		Yes	Yes		Yes	Two year	
•	PaperlessBillin	-		-		nthlyCharge	_	
0	Ye		EI	ectronic ch		29.8		
1	N			Mailed ch		56.9		
2	Ye			Mailed ch		53.8		
3	N			er (automat		42.3		
4	Ye	5	El	ectronic ch	eck	70.7	0 151.65)
 7038	 Ye	3		 Mailed ch	eck	 84.8	 30 1990.5	5
7039	Ye	s Cr	edit ca	rd (automat	ic)	103.2	7362.9)
7040	Ye			ectronic ch		29.6		5
7041	Ye	3		Mailed ch	eck	74.4	.0 306.6	3
7042	Ye	s Bank	transf	er (automat	ic)	105.6	6844.5	5
	Churn							
0	No							
1	No							
2	Yes							
3	No							
4	Yes							
 7020	 N -							
7038	No No							
7039	No No							
7040	No							

7041 Yes 7042 No

[7043 rows x 21 columns]

2 Data Preprocessing

```
[396]: # Remove the 'customerID' column from the DataFrame
       # 'customerID' is dropped along columns (axis=1) using the drop() method
       # inplace=True ensures that the operation is performed directly on the original
        ⇔DataFrame 'df'
       df.drop('customerID', axis=1, inplace=True)
[397]:
                                                           tenure PhoneService
[397]:
                      SeniorCitizen Partner Dependents
             Female
                                          Yes
                                                       No
                                                                1
                                                                             No
       0
                                   0
                Male
       1
                                           No
                                                       No
                                                               34
                                                                             Yes
       2
                Male
                                   0
                                           No
                                                       No
                                                                2
                                                                             Yes
       3
                Male
                                           Nο
                                                       Nο
                                                                45
                                                                             No
       4
             Female
                                   0
                                           No
                                                       No
                                                                2
                                                                            Yes
       7038
                                   0
                                                               24
                Male
                                          Yes
                                                      Yes
                                                                            Yes
       7039
             Female
                                   0
                                          Yes
                                                      Yes
                                                               72
                                                                            Yes
       7040
             Female
                                   0
                                          Yes
                                                      Yes
                                                                11
                                                                             No
       7041
                Male
                                   1
                                          Yes
                                                      No
                                                                4
                                                                            Yes
       7042
                Male
                                           No
                                                       No
                                                               66
                                                                            Yes
                 MultipleLines InternetService OnlineSecurity OnlineBackup \
       0
              No phone service
                                             DSL
                                                              No
                                                                           Yes
       1
                                                                            No
                             No
                                             DSL
                                                             Yes
       2
                             No
                                             DSL
                                                             Yes
                                                                           Yes
       3
             No phone service
                                             DSL
                                                             Yes
                                                                            No
       4
                             No
                                                              No
                                                                            No
                                    Fiber optic
       7038
                            Yes
                                             DSL
                                                             Yes
                                                                            No
       7039
                            Yes
                                    Fiber optic
                                                              No
                                                                           Yes
       7040
             No phone service
                                             DSL
                                                             Yes
                                                                            No
       7041
                            Yes
                                    Fiber optic
                                                              No
                                                                            No
       7042
                                    Fiber optic
                                                             Yes
            DeviceProtection TechSupport StreamingTV StreamingMovies
                                                                                  Contract
       0
                            No
                                         No
                                                     No
                                                                           Month-to-month
                                                                       No
       1
                          Yes
                                         Nο
                                                      No
                                                                       No
                                                                                  One year
       2
                           No
                                         No
                                                      No
                                                                       No
                                                                           Month-to-month
       3
                          Yes
                                        Yes
                                                      No
                                                                                  One year
                                                                       No
```

4	No	No	No	No	${\tt Month-to-month}$	
•••	•••				•••	
7038	Yes	Yes	Yes	Yes	One year	
7039	Yes	No	Yes	Yes	One year	
7040	No	No	No	No	Month-to-month	
7041	No	No	No	No	Month-to-month	
7042	Yes	Yes	Yes	Yes	Two year	
	PaperlessBilling	Pay	mentMethod	MonthlyCharg	es TotalCharges	\
0	Yes	Electr	onic check	29.	85 29.85	
1	No	Ma	ailed check	56.	95 1889.5	
2	Yes	Ma	ailed check	53.	85 108.15	
3	No	Bank transfer ((automatic)	42.	30 1840.75	
4	Yes	Electr	onic check	70.	70 151.65	
•••	•••		•••	•••	•••	
7038	Yes	Ma	iled check	84.	80 1990.5	
7039	Yes	Credit card ((automatic)	103.	20 7362.9	
7040	Yes	Electr	onic check	29.	60 346.45	
7041	Yes	Ma	ailed check	74.	40 306.6	
7042	Yes	Bank transfer ((automatic)	105.	65 6844.5	
	Churn					
0	No					
1	No					

[7043 rows x 20 columns]

2

3

7038

7039

7040

7041

7042

Yes

No Yes

No

No

No

Yes

No

```
[398]: # Display information about the DataFrame
# The info() method provides a concise summary of the DataFrame, including:
# - The number of entries (rows)
# - The number of columns
# - The data types of each column
# - The memory usage of the DataFrame
df.info()
```

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7043 entries, 0 to 7042
Data columns (total 20 columns):

```
Column
 #
                       Non-Null Count
                                       Dtype
     _____
                       _____
                       7043 non-null
                                       object
 0
     gender
 1
                       7043 non-null
                                       int64
     SeniorCitizen
 2
    Partner
                       7043 non-null
                                       object
 3
                       7043 non-null
    Dependents
                                       object
 4
    tenure
                       7043 non-null
                                       int64
    PhoneService
                       7043 non-null
                                       object
                       7043 non-null
 6
    MultipleLines
                                       object
 7
    InternetService
                       7043 non-null
                                       object
 8
    OnlineSecurity
                       7043 non-null
                                       object
     OnlineBackup
                       7043 non-null
                                       object
 10
    DeviceProtection 7043 non-null
                                       object
    TechSupport
                       7043 non-null
                                       object
    StreamingTV
                       7043 non-null
                                       object
 13 StreamingMovies
                      7043 non-null
                                       object
    Contract
                       7043 non-null
                                       object
 15 PaperlessBilling 7043 non-null
                                       object
 16 PaymentMethod
                       7043 non-null
                                       object
 17
    MonthlyCharges
                       7043 non-null
                                       float64
    TotalCharges
                       7043 non-null
                                       object
 19 Churn
                       7043 non-null
                                       object
dtypes: float64(1), int64(2), object(17)
memory usage: 1.1+ MB
```

2.1 Clean the data

```
[399]: # Replace empty strings in the 'TotalCharges' column with 0
# This operation replaces any occurrences of empty strings (' ') in the

□ 'TotalCharges' column with 0
df['TotalCharges'] = df['TotalCharges'].replace({' ': 0})
```

```
[400]: # Convert the 'TotalCharges' column to float data type

# This operation converts the data type of the 'TotalCharges' column from its_

current data type to float

# This is typically done to ensure numerical consistency and enable_

mathematical operations on the column

df['TotalCharges'] = df['TotalCharges'].astype(float)
```

[401]: df.info()

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7043 entries, 0 to 7042
Data columns (total 20 columns):

#	Column	Non-Null Count	Dtype
0	gender	7043 non-null	object
1	SeniorCitizen	7043 non-null	int64

2	Partner	7043	non-null	object
3	Dependents	7043	non-null	object
4	tenure	7043	non-null	int64
5	PhoneService	7043	non-null	object
6	MultipleLines	7043	non-null	object
7	${\tt InternetService}$	7043	non-null	object
8	OnlineSecurity	7043	non-null	object
9	OnlineBackup	7043	non-null	object
10	${\tt DeviceProtection}$	7043	non-null	object
11	TechSupport	7043	non-null	object
12	StreamingTV	7043	non-null	object
13	${\tt StreamingMovies}$	7043	non-null	object
14	Contract	7043	non-null	object
15	PaperlessBilling	7043	non-null	object
16	${\tt PaymentMethod}$	7043	non-null	object
17	${\tt MonthlyCharges}$	7043	non-null	float64
18	TotalCharges	7043	non-null	float64
19	Churn	7043	non-null	object
	07 .04(0) .			~ `

dtypes: float64(2), int64(2), object(16)

Yes

memory usage: 1.1+ MB

[402]: df

7041

[402]:		gender	SeniorCit	tizen	Partner	Dependents	tenure	PhoneService	\
	0	Female		0	Yes	No		No	
	1	Male		0	No	No	34	Yes	
	2	Male		0	No	No	2	Yes	
	3	Male		0	No	No	45	No	
	4	Female		0	No	No	2	Yes	
	•••	•••	•••				•••		
	7038	Male		0	Yes	Yes	24	Yes	
	7039	Female		0	Yes	Yes	72	Yes	
	7040	Female		0	Yes	Yes	11	No	
	7041	Male		1	Yes	No	4	Yes	
	7042	Male		0	No	No	66	Yes	
		M7+		T+	± Q	: O1 : O		O 1 D 1	,
			-	Inte			•	OnlineBackup	\
	0	No phon	e service			OSL	No	Yes	
	1		No			DSL	Yes	No	
	2		No			DSL	Yes	Yes	
	3	No phon	e service]	DSL	Yes	No	
	4		No]	Fiber op	tic	No	No	
			•••		•••	•••		•••	
	7038		Yes]	DSL	Yes	No	
	7039		Yes]	Fiber op	tic	No	Yes	
	7040	No phon	e service]	OSL	Yes	No	

Fiber optic

No

No

7042	N	lo F	iber opt:	ic	Yes		No	
	DeviceProtection	ı TechSııı	port St	reamingTV	StreamingMo	vies	Contract	\
0	No	_	No No	No	20100001118110		Month-to-month	`
1	Yes		No	No		No	One year	
2	No		No	No			Month-to-month	
3	Yes	3	Yes	No		No	One year	
4	No)	No	No		No l	Month-to-month	
•••	•••	•••		••	•••		•••	
7038	Yes	3	Yes	Yes		Yes	One year	
7039	Yes		No	Yes		Yes	One year	
7040	No		No	No			Month-to-month	
7041	No		No	No			Month-to-month	
7042	Yes	3	Yes	Yes		Yes	Two year	
	PaperlessBilling	r	Pa	ayment M eth	od Monthly	Charge	s \	
0	Yes			tronic che	•	29.8		
1	No			Mailed che		56.9		
2	Yes			Mailed che		53.8		
3	No	Bank t		(automati		42.3	0	
4	Yes	3	Elect	tronic che	ck	70.7	0	
•••	•••			•••	•••			
7038	Yes	3	1	Mailed che	ck	84.8	0	
7039	Yes	s Cred	dit card	(automati	c)	103.2	0	
7040	Yes	3	Elect	tronic che	ck	29.6	0	
7041	Yes	3	1	Mailed che	ck	74.4	0	
7042	Yes	s Bank t	transfer	(automati	c)	105.6	5	
	TotalCharges Ch	uirn						
0	29.85	No						
1	1889.50	No						
2	108.15	Yes						
3	1840.75	No						
4	151.65	Yes						
•••	*** ***							
7038	1990.50	No						
7039	7362.90	No						
7040	346.45	No						
7041	306.60	Yes						
7042	6844.50	No						

[7043 rows x 20 columns]

2.2 Encode categorical variables

```
[403]: # Get unique values in the 'MultipleLines' column
       # The unique() method returns an array containing unique values present in the \Box
        → 'MultipleLines' column
       df['MultipleLines'].unique()
[403]: array(['No phone service', 'No', 'Yes'], dtype=object)
       df['MultipleLines'] = df['MultipleLines'].replace({'No phone service':'No'})
[405]: df['gender']=df['gender'].replace({'Female':1,'Male':0})
[406]:
[406]:
                      SeniorCitizen Partner Dependents
                                                            tenure PhoneService
              gender
       0
                                    0
                                          Yes
                                                       No
                                                                 1
                                                                               No
                   1
                   0
       1
                                    0
                                           No
                                                       No
                                                                34
                                                                              Yes
       2
                   0
                                    0
                                                                 2
                                           No
                                                       No
                                                                              Yes
       3
                   0
                                    0
                                           No
                                                       No
                                                                45
                                                                               No
       4
                   1
                                    0
                                                                 2
                                           No
                                                       No
                                                                             Yes
                                    0
       7038
                   0
                                          Yes
                                                      Yes
                                                                24
                                                                             Yes
       7039
                                          Yes
                                                      Yes
                                                                              Yes
                   1
                                    0
                                                                72
       7040
                   1
                                    0
                                          Yes
                                                       Yes
                                                                11
                                                                               No
       7041
                   0
                                    1
                                          Yes
                                                       Nο
                                                                 4
                                                                             Yes
       7042
                   0
                                    0
                                                                66
                                           Nο
                                                       No
                                                                             Yes
             MultipleLines InternetService OnlineSecurity OnlineBackup
       0
                         No
                                         DSL
                                                           No
                                                                        Yes
       1
                         No
                                         DSL
                                                          Yes
                                                                         No
                                         DSL
       2
                         No
                                                          Yes
                                                                        Yes
       3
                         No
                                         DSL
                                                          Yes
                                                                         No
       4
                         No
                                Fiber optic
                                                           No
                                                                         No
       7038
                        Yes
                                         DSL
                                                          Yes
                                                                         No
       7039
                        Yes
                                Fiber optic
                                                           No
                                                                        Yes
       7040
                                         DSL
                                                          Yes
                                                                         No
                         No
                                Fiber optic
       7041
                        Yes
                                                           No
                                                                         No
       7042
                         No
                                Fiber optic
                                                          Yes
                                                                         No
            DeviceProtection TechSupport StreamingTV StreamingMovies
                                                                                   Contract
       0
                            No
                                         No
                                                      No
                                                                            Month-to-month
                                                                        No
       1
                           Yes
                                         Nο
                                                      No
                                                                                   One year
                                                                        No
       2
                            No
                                         No
                                                      No
                                                                            Month-to-month
                                                                        No
       3
                           Yes
                                        Yes
                                                      No
                                                                                   One year
       4
                            No
                                         No
                                                      No
                                                                            Month-to-month
```

```
7039
                                                                      Yes
                                                                                                          No
                                                                                                                                         Yes
                                                                                                                                                                                      Yes
                                                                                                                                                                                                                     One year
                   7040
                                                                        No
                                                                                                          No
                                                                                                                                            No
                                                                                                                                                                                         No
                                                                                                                                                                                                    Month-to-month
                   7041
                                                                        No
                                                                                                          No
                                                                                                                                            No
                                                                                                                                                                                                    Month-to-month
                                                                                                                                                                                         No
                   7042
                                                                      Yes
                                                                                                       Yes
                                                                                                                                         Yes
                                                                                                                                                                                      Yes
                                                                                                                                                                                                                     Two year
                                 PaperlessBilling
                                                                                                                     PaymentMethod MonthlyCharges \
                   0
                                                                      Yes
                                                                                                             Electronic check
                                                                                                                                                                                         29.85
                   1
                                                                        No
                                                                                                                        Mailed check
                                                                                                                                                                                         56.95
                   2
                                                                     Yes
                                                                                                                        Mailed check
                                                                                                                                                                                         53.85
                   3
                                                                        No
                                                                                    Bank transfer (automatic)
                                                                                                                                                                                         42.30
                   4
                                                                      Yes
                                                                                                             Electronic check
                                                                                                                                                                                         70.70
                   7038
                                                                                                                                                                                         84.80
                                                                      Yes
                                                                                                                        Mailed check
                   7039
                                                                                                                                                                                      103.20
                                                                     Yes
                                                                                         Credit card (automatic)
                   7040
                                                                                                             Electronic check
                                                                                                                                                                                         29.60
                                                                     Yes
                   7041
                                                                      Yes
                                                                                                                        Mailed check
                                                                                                                                                                                         74.40
                   7042
                                                                                    Bank transfer (automatic)
                                                                                                                                                                                      105.65
                                                                      Yes
                                    TotalCharges Churn
                   0
                                                        29.85
                                                                                 Nο
                   1
                                                  1889.50
                                                                                No
                   2
                                                     108.15
                                                                              Yes
                   3
                                                  1840.75
                                                                                No
                   4
                                                     151.65
                                                                              Yes
                   7038
                                                  1990.50
                                                                                No
                   7039
                                                  7362.90
                                                                                 No
                   7040
                                                     346.45
                                                                                No
                   7041
                                                     306.60
                                                                              Yes
                   7042
                                                  6844.50
                                                                                No
                   [7043 rows x 20 columns]
[407]: # Convert binary categorical variables ('Yes'/'No') to numerical format (1/0)
                    # Replace 'Yes' with 1 and 'No' with 0 in the current column
                   # This transformation makes binary categorical variables compatible with_
                      ⇔machine learning algorithms
                   binary_encoding=['Partner','Dependents','PhoneService','OnlineSecurity','MultipleLines','OnlineSecurity','MultipleLines','OnlineSecurity','Dependents','OnlineSecurity','MultipleChines','OnlineSecurity','Dependents','OnlineSecurity','MultipleChines','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecurity','OnlineSecur
                   for col in binary_encoding:
                              df[col] = df[col].replace({'Yes': 1, 'No': 0})
[408]:
                 df
[408]:
                                    gender
                                                        SeniorCitizen Partner
                                                                                                                          Dependents
                                                                                                                                                               tenure
                                                                                                                                                                                     PhoneService
                   0
                                                  1
                                                                                                                                                                             1
                                                                                                                     1
```

One year

Yes

7038

Yes

Yes

Yes

1	0		0	0	0	34		1	
2	0		0	0	0	2		1	
3	0		0	0	0	45		0	
4	1		0	0	0	2		1	
		•••	•••	•••	***				
7038	0		0	1	1	24		1	
7039			0	1	1	72		1	
7040	1		0	1	1	11		0	
7041	0		1	1	0	4		1	
7042	0		0	0	0	66		1	
	MultipleLine	es Tn	ternetSe	ervice On	lineSecurit	v Online	Backur	· \	
0		0		DSL		0	1		
1		0		DSL		1	C)	
2		0		DSL		1	1		
3		0		DSL		1	C		
4		0	Fiber			0	C		
•••	•••			-F	•••				
7038		1		DSL		1	C)	
7039		1	Fiber	optic		0	1		
7040		0		DSL		1	C)	
7041		1	Fiber	optic		0	C)	
7042		0	Fiber	_		1	C)	
								.	
0	DeviceProtect		TechSupp	_		eamingMo		Contract	\
0	DeviceProtect	0	TechSupp	0	0	eamingMo	0	Month-to-month	\
1	DeviceProtect	0	TechSupj	0	0	${ t eaming}{ t Mo}$	0 0	Month-to-month One year	\
1 2	DeviceProtect	0 1 0	TechSupp	0	0 0 0	eamingMo	0 0 0	Month-to-month One year Month-to-month	\
1 2 3	DeviceProtect	0 1 0 1	TechSupp	0 0 0 1	0 0 0 0	eamingMo	0 0 0	Month-to-month One year Month-to-month One year	\
1 2	DeviceProtect	0 1 0	TechSupj	0	0 0 0	reamingMo	0 0 0	Month-to-month One year Month-to-month	\
1 2 3 4 	DeviceProtect	0 1 0 1 0	TechSupj 	0 0 0 1 0	0 0 0 0	eamingMo 	0 0 0 0	Month-to-month One year Month-to-month One year Month-to-month	\
1 2 3 4 7038	DeviceProtect	0 1 0 1 0	TechSupj 	0 0 0 1 0 	0 0 0 0 0	eamingMo 	0 0 0 0 0	Month-to-month One year Month-to-month One year Month-to-month One year	\
1 2 3 4 7038 7039	DeviceProtect	0 1 0 1 0	TechSupj 	0 0 0 1 0 1	0 0 0 0 0	eamingMo 	0 0 0 0 0	Month-to-month One year Month-to-month One year Month-to-month One year One year	\
1 2 3 4 7038 7039 7040	DeviceProtect	0 1 0 1 0	TechSupj 	0 0 0 1 0 1 0	0 0 0 0 0	eamingMo 	0 0 0 0 0	Month-to-month One year Month-to-month One year Month-to-month One year One year Month-to-month	\
1 2 3 4 7038 7039 7040 7041		0 1 0 1 0	TechSupj 	0 0 0 1 0 1 0 0	0 0 0 0 0 1 1 0	eamingMo 	0 0 0 0 0	Month-to-month One year Month-to-month One year Month-to-month One year One year Month-to-month Month-to-month	\
1 2 3 4 7038 7039 7040		0 1 0 1 0	TechSupj 	0 0 0 1 0 1 0	0 0 0 0 0	eamingMo 	0 0 0 0 0	Month-to-month One year Month-to-month One year Month-to-month One year One year Month-to-month	\
1 2 3 4 7038 7039 7040 7041		0 1 0 1 0	TechSupj 	0 0 0 1 0 1 0 0 0	0 0 0 0 0 1 1 0 0	eamingMo 	0 0 0 0 0 1 1 0 0	Month-to-month One year Month-to-month One year Month-to-month One year One year Month-to-month Month-to-month Two year	\
1 2 3 4 7038 7039 7040 7041	 PaperlessBill	0 1 0 1 0	TechSupj 	0 0 0 1 0 1 0 0 0 1	0 0 0 0 0 1 1 0 0		0 0 0 0 0 1 1 0 0	Month-to-month One year Month-to-month One year Month-to-month One year One year Month-to-month Month-to-month Two year	\
1 2 3 4 7038 7039 7040 7041 7042	 PaperlessBill	0 1 0 1 0 1 1 0 0 1	TechSupj 	0 0 0 1 0 1 0 0 0 1 Payr	0 0 0 0 0 1 1 0 0 1		0 0 0 0 0 1 1 0 0 1	Month-to-month One year Month-to-month One year Month-to-month One year One year Month-to-month Month-to-month Two year	
1 2 3 4 7038 7039 7040 7041 7042	 PaperlessBill	0 1 0 1 0 1 1 0 0 1 	TechSupj 	0 0 0 1 0 1 0 0 0 1 Payr Electro	0 0 0 0 0 1 1 0 0 1 mentMethod		0 0 0 0 0 1 1 0 0 1 Charge	Month-to-month One year Month-to-month One year Month-to-month One year One year Month-to-month Month-to-month Two year	
1 2 3 4 7038 7039 7040 7041 7042	 PaperlessBill	0 1 0 1 0 1 1 0 0 1 	•••	0 0 0 1 0 1 0 0 0 1 Paye Electro	0 0 0 0 0 1 1 0 0 1 mentMethod		0 0 0 0 0 1 1 0 0 1 Charge 29.8 56.9	Month-to-month One year Month-to-month One year Month-to-month One year One year Month-to-month Month-to-month Two year	
1 2 3 4 7038 7039 7040 7041 7042	 PaperlessBill	0 1 0 1 0 1 1 0 0 1 	•••	0 0 0 1 0 1 0 0 0 1 Payr Electro Mai	0 0 0 0 0 1 1 1 0 0 1 mentMethod onic check iled check		0 0 0 0 0 1 1 0 0 1 Charge 29.8 56.9	Month-to-month One year Month-to-month One year Month-to-month One year One year Month-to-month Month-to-month Two year	
1 2 3 4 7038 7039 7040 7041 7042 0 1 2 3 4 		0 1 0 1 0 1 1 0 0 1 -ing Yes No Yes	•••	0 0 0 1 0 1 0 0 0 1 Payr Electro Mai	0 0 0 0 0 1 1 1 0 0 1 mentMethod onic check iled check iled check automatic) onic check		0 0 0 0 0 1 1 0 0 1 Charge 29.8 56.9 53.8 42.3	Month-to-month One year Month-to-month One year Month-to-month One year One year Month-to-month Month-to-month Two year es \ 35 35 36 70	
1 2 3 4 7038 7040 7041 7042 0 1 2 3 4 7038		0 1 0 1 1 0 1 1 0 1 1 ves No Yes No Yes Yes	 Bank t	0 0 0 1 0 1 0 0 0 1 Payr Electro Mai ransfer (a	0 0 0 0 0 1 1 1 0 0 1 mentMethod onic check iled check automatic) onic check iiled check iiled check	 Monthly	0 0 0 0 0 1 1 1 0 0 1 Charge 29.8 56.9 53.8 42.3 70.7	Month-to-month One year Month-to-month One year Month-to-month One year One year Month-to-month Month-to-month Two year	
1 2 3 4 7038 7039 7040 7041 7042 0 1 2 3 4 		0 1 0 1 0 1 1 0 0 1 -ing Yes No Yes	 Bank t	0 0 0 1 0 1 0 0 0 1 Payr Electro Mairansfer (a Electro Mairt card (a it c	0 0 0 0 0 1 1 1 0 0 1 mentMethod onic check iled check iled check automatic) onic check	 Monthly	0 0 0 0 0 1 1 0 0 1 Charge 29.8 56.9 53.8 42.3	Month-to-month One year Month-to-month One year Month-to-month One year One year Month-to-month Two year 85 85 85 86 87 80 80 80	

```
7041
                                                                    74.40
                         Yes
                                            Mailed check
       7042
                         Yes Bank transfer (automatic)
                                                                   105.65
             TotalCharges Churn
       0
                    29.85
                  1889.50
       1
                              No
       2
                   108.15
                            Yes
       3
                  1840.75
                             No
       4
                   151.65
                            Yes
                    ... ...
       7038
                  1990.50
                              No
       7039
                  7362.90
                              No
       7040
                   346.45
                              No
       7041
                   306.60
                             Yes
       7042
                  6844.50
                              No
       [7043 rows x 20 columns]
[409]: | # Get data types of columns 'tenure', 'MonthlyCharges', and 'TotalCharges'
       # This operation applies the dtype attribute to each column to retrieve its \Box
        ⇔data type
       unique_values = df[['tenure', 'MonthlyCharges', 'TotalCharges']].apply(lambda x:

    x.dtype)
      2.3 Scale the features
[410]: normalized_col=['tenure', 'MonthlyCharges', 'TotalCharges']
       scaler = MinMaxScaler()
       for col in normalized_col:
         # Extract the column values and reshape to 2D array
           col_values = df[col].values.reshape(-1, 1)
           # Apply MinMax scaling to the column
           df[col] = scaler.fit_transform(col_values)
[411]: pd.DataFrame(col_values)
[411]:
                   0
       0
               29.85
       1
             1889.50
       2
              108.15
       3
             1840.75
              151.65
       4
       7038 1990.50
       7039 7362.90
       7040
              346.45
```

7041 306.60 7042 6844.50

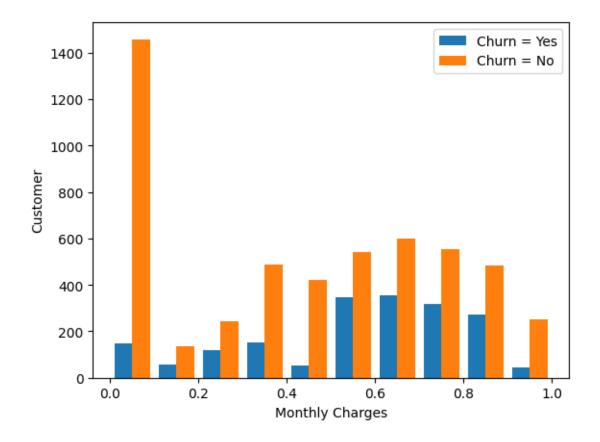
[7043 rows x 1 columns]

PaperlessBilling

[412]:	df													
[412]:		gender	SeniorCit	cizen		Depender		tenure	Pho	oneService	\			
	0	1		0	1		0	0.013889		0				
	1	0		0	0		0	0.472222		1				
	2	0		0	0		0	0.027778		1				
	3	0		0	0		0	0.625000		0				
	4	1		0	0		0	0.027778		1				
	•••	•••	•••	•••			•	•••						
	7038	0		0	1		1	0.333333		1				
	7039	1		0	1		1	1.000000		1				
	7040	1		0	1		1	0.152778		0				
	7041	0		1	1		0	0.055556		1				
	7042	0		0	0		0	0.916667		1				
	MultipleLines InternetService OnlineSecurity OnlineBackup \													
	0		0		DSL			0		1				
	1		0		DSL			1	()				
	2		0		DSL			1		1				
	3		0		DSL			1	()				
	4		0	Fiber	optic			0	()				
			•••	•••		•••		•••		_				
	7038		1		DSL			1)				
	7039		1	Fiber	optic			0		1				
	7040		0		DSL			1)				
	7041		1		optic			0)				
	7042		0	Fiber	optic			1	()				
		DeviceP:	rotection 1	ГесhЅuр	port Str	reamingTV	Str	eamingMovi	es	Contr	act	\		
	0		0		0	0			0	Month-to-mo	nth			
	1		1		0	0			0	One y	ear			
	2		0		0	0			0	Month-to-mo	nth			
	3		1		1	0			0	One y	ear			
	4		0		0	0			0	Month-to-mo	nth			
	•••		•••	•••	••			•••		•••				
	7038		1		1	1			1	One y				
	7039		1		0	1			1	One y				
	7040		0		0	0			0	Month-to-mo				
	7041		0		0	0			0	Month-to-mo				
	7042		1		1	1			1	Two y	ear			

PaymentMethod MonthlyCharges \

```
0
                          Yes
                                        Electronic check
                                                                 0.115423
       1
                                            Mailed check
                                                                  0.385075
                          No
       2
                          Yes
                                            Mailed check
                                                                  0.354229
       3
                               Bank transfer (automatic)
                           No
                                                                  0.239303
       4
                          Yes
                                        Electronic check
                                                                  0.521891
                                            Mailed check
       7038
                                                                  0.662189
                          Yes
                                 Credit card (automatic)
       7039
                          Yes
                                                                 0.845274
       7040
                                        Electronic check
                          Yes
                                                                 0.112935
       7041
                          Yes
                                            Mailed check
                                                                  0.558706
       7042
                          Yes Bank transfer (automatic)
                                                                  0.869652
             TotalCharges Churn
       0
                 0.003437
                              No
       1
                 0.217564
                              No
       2
                 0.012453
                             Yes
       3
                 0.211951
                              No
       4
                 0.017462
                             Yes
       7038
                 0.229194
                              No
       7039
                 0.847792
                              No
       7040
                 0.039892
                              Nο
       7041
                 0.035303
                             Yes
       7042
                 0.788101
                              No
       [7043 rows x 20 columns]
[413]: df.shape #Print Rows and Columns
[413]: (7043, 20)
[414]: | # Extract MonthlyCharges for customers with churn='Yes' and churn='No'
       x = df[df.Churn=='Yes'].MonthlyCharges
       y = df[df.Churn=='No'].MonthlyCharges
       # Plot histogram for MonthlyCharges distribution
       # Two histograms are plotted for churn='Yes' and churn='No' categories
       plt.hist([x, y], label=['Churn = Yes', 'Churn = No'])
       # Add legend, xlabel, and ylabel
       plt.legend()
       plt.xlabel("Monthly Charges")
       plt.ylabel("Customer")
       # Show the plot
       plt.show()
```



```
[415]: column=['gender', 'SeniorCitizen', 'Partner', 'Dependents'
                                                                                                                                                                                                                                           ,'tenure',
                                                                                                                                                                                                                                                                                                        'PhoneService
                       for col in column:
                                     if df[col].dtype == 'object':
                                                 print(f"{col}: {df[col].unique()}")
                     InternetService: ['DSL' 'Fiber optic' 'No']
                     OnlineSecurity: [0 1 'No internet service']
                     OnlineBackup: [1 0 'No internet service']
                     DeviceProtection: [0 1 'No internet service']
                     TechSupport: [0 1 'No internet service']
                     StreamingTV: [0 1 'No internet service']
                     StreamingMovies: [0 1 'No internet service']
                     Contract: ['Month-to-month' 'One year' 'Two year']
                     PaperlessBilling: ['Yes' 'No']
                     PaymentMethod: ['Electronic check' 'Mailed check' 'Bank transfer (automatic)'
                        'Credit card (automatic)']
                     Churn: ['No' 'Yes']
[416]: column=['OnlineSecurity','OnlineBackup','DeviceProtection','TechSupport','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','StreamingTV','Strea
                       for col in column:
                              df[col]=df[col].replace({'No internet service':0})
```

```
[417]: column=['gender', 'SeniorCitizen', 'Partner', 'Dependents'
                                                                            ,'tenure',
                                                                                                'PhoneService
       for col in column:
            if df[col].dtype == 'object':
                print(f"{col}: {df[col].unique()}")
      InternetService: ['DSL' 'Fiber optic' 'No']
      Contract: ['Month-to-month' 'One year' 'Two year']
      PaperlessBilling: ['Yes' 'No']
      PaymentMethod: ['Electronic check' 'Mailed check' 'Bank transfer (automatic)'
        'Credit card (automatic)']
      Churn: ['No' 'Yes']
[418]: df
[418]:
             gender SeniorCitizen Partner Dependents
                                                               tenure PhoneService \
                                                             0.013889
       0
                   1
                                             1
       1
                   0
                                   0
                                             0
                                                          0
                                                             0.472222
                                                                                    1
       2
                   0
                                   0
                                             0
                                                          0
                                                             0.027778
                                                                                    1
       3
                   0
                                   0
                                             0
                                                             0.625000
                                                                                    0
       4
                   1
                                   0
                                             0
                                                             0.027778
                                                                                    1
       7038
                   0
                                   0
                                                             0.333333
                                             1
                                                          1
                                                                                    1
       7039
                                                            1.000000
                   1
                                   0
                                             1
                                                                                    1
                                                          1
       7040
                   1
                                   0
                                             1
                                                          1
                                                             0.152778
                                                                                    0
       7041
                   0
                                                             0.055556
                                   1
                                             1
                                                          0
                                                                                    1
       7042
                   0
                                   0
                                             0
                                                             0.916667
                                                                                    1
              MultipleLines InternetService OnlineSecurity
                                                                 OnlineBackup
       0
                          0
                                          DSL
                                                             0
       1
                          0
                                          DSI.
                                                             1
                                                                             0
       2
                          0
                                          DSI.
                                                             1
                                                                             1
       3
                          0
                                          DSL
                                                             1
                                                                             0
       4
                           0
                                 Fiber optic
                                                             0
                                                                             0
       7038
                           1
                                          DSL
                                                                             0
                                                              1
       7039
                           1
                                 Fiber optic
                                                             0
                                                                             1
       7040
                           0
                                          DSL
                                                              1
                                                                             0
       7041
                           1
                                 Fiber optic
                                                             0
                                                                             0
       7042
                           0
                                 Fiber optic
                                                              1
                                                                             0
                                               {\tt StreamingTV}
                                                             {\tt Streaming Movies}
                                 TechSupport
             DeviceProtection
       0
                              0
                                            0
                                                          0
                                                                             0
                              1
                                            0
       1
                                                          0
                                                                             0
       2
                              0
                                            0
                                                          0
                                                                             0
       3
                                            1
                                                          0
                                                                             0
                              1
       4
                              0
                                            0
                                                          0
                                                                             0
```

```
7042
                                           1
                             1
                                                        1
                                                                          1
                    Contract PaperlessBilling
                                                            PaymentMethod \
       0
             Month-to-month
                                           Yes
                                                         Electronic check
       1
                    One year
                                            No
                                                              Mailed check
       2
             Month-to-month
                                           Yes
                                                             Mailed check
       3
                    One year
                                            No
                                                Bank transfer (automatic)
       4
             Month-to-month
                                           Yes
                                                         Electronic check
       7038
                   One year
                                           Yes
                                                             Mailed check
       7039
                                                  Credit card (automatic)
                   One year
                                           Yes
       7040
             Month-to-month
                                           Yes
                                                         Electronic check
       7041
                                                              Mailed check
             Month-to-month
                                           Yes
       7042
                                           Yes
                                                Bank transfer (automatic)
                    Two year
             MonthlyCharges
                              TotalCharges Churn
       0
                    0.115423
                                  0.003437
                                               No
       1
                   0.385075
                                               Nο
                                  0.217564
       2
                   0.354229
                                  0.012453
                                              Yes
       3
                    0.239303
                                               No
                                  0.211951
       4
                   0.521891
                                  0.017462
                                              Yes
       7038
                   0.662189
                                  0.229194
                                               No
       7039
                   0.845274
                                  0.847792
                                               No
       7040
                   0.112935
                                  0.039892
                                               No
       7041
                    0.558706
                                  0.035303
                                              Yes
       7042
                   0.869652
                                  0.788101
                                               No
       [7043 rows x 20 columns]
[419]: column=['gender', 'SeniorCitizen', 'Partner', 'Dependents'
                                                                          ,'tenure',
                                                                                             'PhoneService
       for col in column:
               print(f"{col}: {df[col].unique()}")
      gender: [1 0]
      SeniorCitizen: [0 1]
      Partner: [1 0]
      Dependents: [0 1]
      tenure: [0.01388889 0.47222222 0.02777778 0.625
                                                              0.11111111 0.3055556
       0.13888889 0.38888889 0.86111111 0.18055556 0.22222222 0.80555556
       0.68055556 0.34722222 0.95833333 0.72222222 0.98611111 0.29166667
       0.16666667 0.41666667 0.65277778 1.
                                                     0.23611111 0.375
```

1

0

0

0

1

1

0

0

1

1

0

0

1

1

0

0

7038

7039

7040

7041

0.59722222

0.06944444 0.63888889 0.15277778 0.97222222 0.875

```
0.43055556 0.69444444 0.88888889 0.77777778 0.09722222 0.58333333
       0.48611111 0.66666667 0.40277778 0.90277778 0.52777778 0.94444444
       0.4444444 0.76388889 0.51388889 0.5
                                                    0.56944444 0.08333333
       0.0555556 0.45833333 0.93055556 0.31944444 0.79166667 0.84722222
       0.19444444 0.27777778 0.73611111 0.55555556 0.81944444 0.33333333
       0.61111111 0.26388889 0.75
                                        0.70833333 0.36111111 0.
       0.54166667]
      PhoneService: [0 1]
      MultipleLines: [0 1]
      InternetService: ['DSL' 'Fiber optic' 'No']
      OnlineSecurity: [0 1]
      OnlineBackup: [1 0]
      DeviceProtection: [0 1]
      TechSupport: [0 1]
      StreamingTV: [0 1]
      StreamingMovies: [0 1]
      Contract: ['Month-to-month' 'One year' 'Two year']
      PaperlessBilling: ['Yes' 'No']
      PaymentMethod: ['Electronic check' 'Mailed check' 'Bank transfer (automatic)'
       'Credit card (automatic)']
      MonthlyCharges: [0.11542289 0.38507463 0.35422886 ... 0.44626866 0.25820896
      0.601492547
      TotalCharges: [0.00343704 0.21756402 0.01245279 ... 0.03989153 0.03530306
      0.78810105]
      Churn: ['No' 'Yes']
[420]: # Perform one-hot encoding using pandas get dummies function
       df = pd.get_dummies(df,columns=['InternetService','Contract','PaymentMethod'])
[421]: df
[421]:
             gender SeniorCitizen Partner Dependents
                                                            tenure PhoneService \
       0
                                                       0 0.013889
                  1
                                 0
                                          1
       1
                  0
                                 0
                                          0
                                                       0 0.472222
                                                                               1
       2
                  0
                                 0
                                          0
                                                       0 0.027778
                                                                               1
       3
                  0
                                 0
                                          0
                                                       0 0.625000
                                                                               0
       4
                  1
                                 0
                                          0
                                                          0.027778
                                                                               1
       7038
                  0
                                 0
                                                       1 0.333333
                                                                               1
       7039
                  1
                                 0
                                          1
                                                       1 1.000000
       7040
                  1
                                 0
                                          1
                                                       1 0.152778
       7041
                  0
                                 1
                                          1
                                                       0 0.055556
                                                                               1
       7042
                  0
                                 0
                                          0
                                                          0.916667
                                                                               1
             MultipleLines OnlineSecurity OnlineBackup DeviceProtection ... \
       0
                         0
                                                                          0
                                         0
```

0.91666667 0.125

0.04166667

0.20833333 0.83333333 0.25

```
1
                    0
                                                      0
                                      1
                                                                          1
2
                    0
                                      1
                                                      1
3
                    0
4
7038
                    1
                                      1
                                                      0
                                                                          1
7039
                                      0
                                                                          1
                    1
                                                      1
7040
                    0
                                      1
                                                      0
                                                      0
7041
                    1
                                      0
                                                                          0
7042
                    0
                                      1
                                                      0
      InternetService_DSL
                             InternetService_Fiber optic InternetService_No
0
                                                           0
1
                           1
                                                                                  0
2
                           1
                                                           0
                                                                                  0
3
                                                           0
                           1
                                                                                  0
4
                           0
                                                           1
                                                                                  0
7038
                                                                                  0
                           1
                                                           0
7039
                           0
                                                           1
                                                                                  0
7040
                           1
                                                           0
                                                                                  0
7041
                           0
                                                           1
                                                                                  0
7042
                           0
                                                           1
                                                                                  0
     Contract_Month-to-month Contract_One year Contract_Two year
0
                                                   0
                              1
                              0
                                                                         0
1
                                                   1
2
                                                   0
                              1
                                                                         0
3
                              0
                                                                         0
                                                   1
4
                                                   0
                                                                         0
                              1
7038
                              0
                                                                         0
                                                   1
7039
                              0
                                                   1
                                                                         0
7040
                                                   0
                                                                         0
                              1
7041
                              1
                                                   0
7042
                              0
                                                                         1
     PaymentMethod_Bank transfer (automatic)
0
1
                                                0
2
                                                0
3
                                                1
4
                                                0
7038
                                                0
7039
                                                0
7040
                                                0
```

```
PaymentMethod_Credit card (automatic) PaymentMethod_Electronic check \
       0
       1
                                                    0
                                                                                      0
       2
                                                    0
                                                                                      0
       3
                                                    0
                                                                                      0
       4
                                                    0
                                                                                      1
       7038
                                                    0
                                                                                      0
       7039
                                                    1
                                                                                      0
       7040
                                                    0
                                                                                      1
       7041
                                                    0
                                                                                      0
       7042
                                                    0
                                                                                      0
             PaymentMethod_Mailed check
       0
       1
                                        1
       2
                                        1
       3
                                        0
       4
                                        0
       7038
                                        1
       7039
                                        0
                                        0
       7040
       7041
                                        1
       7042
                                        0
       [7043 rows x 27 columns]
[422]: # Get a list of column names from the DataFrame
       column_names = df.columns.tolist()
[423]: columns=['gender',
        'SeniorCitizen',
        'Partner',
        'Dependents',
        'tenure',
        'PhoneService',
        'MultipleLines',
        'OnlineSecurity',
        'OnlineBackup',
        'DeviceProtection',
        'TechSupport',
        'StreamingTV',
        'StreamingMovies',
```

```
'PaperlessBilling',
        'MonthlyCharges',
        'TotalCharges',
        'Churn',
        'InternetService_DSL',
        'InternetService_Fiber optic',
        'InternetService_No',
        'Contract_Month-to-month',
        'Contract One year',
        'Contract_Two year',
        'PaymentMethod Bank transfer (automatic)',
        'PaymentMethod_Credit card (automatic)',
        'PaymentMethod_Electronic check',
        'PaymentMethod_Mailed check']
       for col in columns:
         if df[col].dtype=='object':
           print(f'{col}: {df[col].unique()}')
      PaperlessBilling: ['Yes' 'No']
      Churn: ['No' 'Yes']
[424]: | # Replace 'Yes' with 1 and 'No' with 0 in the 'PaperlessBilling' column
       df['PaperlessBilling'] = df['PaperlessBilling'].replace({'Yes': 1, 'No': 0})
       # Replace 'Yes' with 1 and 'No' with 0 in the 'Churn' column
       df['Churn'] = df['Churn'].replace({'Yes': 1, 'No': 0})
[425]: df.dtypes
[425]: gender
                                                     int64
       SeniorCitizen
                                                     int64
                                                     int64
       Partner
       Dependents
                                                     int64
                                                   float64
       tenure
       PhoneService
                                                     int.64
       MultipleLines
                                                     int64
                                                     int64
       OnlineSecurity
       OnlineBackup
                                                     int64
       DeviceProtection
                                                     int64
       TechSupport
                                                     int64
       StreamingTV
                                                     int64
                                                     int64
       StreamingMovies
      PaperlessBilling
                                                     int64
       MonthlyCharges
                                                   float64
                                                   float64
       TotalCharges
                                                     int64
       Churn
```

InternetService_DSL	uint8
<pre>InternetService_Fiber optic</pre>	uint8
InternetService_No	uint8
Contract_Month-to-month	uint8
Contract_One year	uint8
Contract_Two year	uint8
PaymentMethod_Bank transfer (automatic)	uint8
PaymentMethod_Credit card (automatic)	uint8
PaymentMethod_Electronic check	uint8
PaymentMethod_Mailed check	uint8
dtype: object	

F 4 0 0 7	
[426]	df
	u_

[426]:		gender	Senior	Citizen	Partner	Dependents	tenure	PhoneSer	vice	\	
	0	1		0	1	0	0.013889		0		
	1	0		0	0	0	0.472222		1		
	2	0		0	0	0	0.027778		1		
	3	0		0	0	0	0.625000		0		
	4	1		0	0	0	0.027778		1		
	•••				•		•••				
	7038	0		0	1	1	0.333333		1		
	7039	1		0	1	1	1.000000		1		
	7040	1		0	1	1	0.152778		0		
	7041	0		1	1	0	0.055556		1		
	7042	0		0	0	0	0.916667		1		
		Multipl		OnlineS	·	OnlineBackup			\	\	
	0		0		0	1		0	•••		
	1		0		1	0		1	•••		
	2		0		1	1		0	•••		
	3		0		1	0		1	•••		
	4		0		0	0		0	•••		
	 7020						•••				
	7038 7039		1		1	0		1	•••		
	7039		1		0	1		1 0	•••		
	7040				1	_			•••		
	7041		1 0		0	0		0	•••		
	7042		U		1	U		1	•••		
		Interne	tServic	e DSL I	InternetS	ervice_Fiber	optic Int	ternetServ	ice N	No	\
	0			1		_	0		_	0	
	1			1			0			0	
	2			1			0			0	
	3			1			0			0	
	4			0			1			0	

```
7038
                                                           0
                                                                                 0
                          1
7039
                                                                                 0
                          0
                                                           1
7040
                                                           0
                                                                                 0
                          1
7041
                          0
                                                           1
7042
                          0
                                                           1
                                                                                 0
      Contract_Month-to-month Contract_One year
                                                       Contract_Two year
0
1
                               0
                                                                         0
                                                    1
2
                               1
                                                    0
                                                                         0
3
                               0
                                                                         0
                                                    1
4
                               1
                                                    0
                                                                         0
7038
                               0
                                                    1
                                                                         0
7039
                               0
                                                    1
                                                                         0
7040
                                                    0
                                                                         0
                               1
7041
                               1
                                                    0
                                                                         0
7042
                               0
      PaymentMethod_Bank transfer (automatic)
0
1
                                                 0
2
                                                 0
3
                                                 1
4
                                                 0
7038
                                                 0
7039
                                                 0
7040
                                                 0
7041
                                                 0
7042
                                                 1
      PaymentMethod_Credit card (automatic) PaymentMethod_Electronic check
0
                                                                                   1
                                               0
                                                                                   0
1
2
                                               0
                                                                                  0
3
                                               0
                                                                                  0
4
                                               0
                                                                                   1
7038
                                               0
                                                                                  0
7039
                                               1
                                                                                  0
7040
                                               0
                                                                                  1
7041
                                               0
                                                                                  0
7042
                                               0
                                                                                  0
      PaymentMethod_Mailed check
0
```

```
1
                                     1
2
                                     1
3
                                     0
4
7038
                                     1
7039
                                     0
7040
                                     0
7041
                                     1
7042
                                     0
```

[7043 rows x 27 columns]

```
[427]: df['PaperlessBilling']
[427]: 0
               1
               0
       1
       2
                1
       3
               0
               1
       7038
       7039
               1
       7040
               1
       7041
               1
       7042
       Name: PaperlessBilling, Length: 7043, dtype: int64
```

3 Split Data

```
[428]: # Separate features (X) and target variable (y)
# Remove the 'Churn' column from the DataFrame to get the feature matrix (X)
x = df.drop('Churn', axis='columns')

# Get the 'Churn' column as the target variable (y)
y = df['Churn']
```

```
[429]: from sklearn.model_selection import train_test_split

# Split the dataset into training and testing sets

# x_train and x_test contain the features, y_train and y_test contain the_

starget variable

# The test_size parameter specifies the proportion of the dataset to include in_

the test split

# The random_state parameter ensures reproducibility of the split
```

```
→random_state=42)
[430]: x_train.dtypes
                                                     int64
[430]: gender
                                                     int.64
      SeniorCitizen
                                                     int64
       Partner
                                                     int64
      Dependents
       tenure
                                                   float64
       PhoneService
                                                     int64
       MultipleLines
                                                     int64
       OnlineSecurity
                                                     int64
       OnlineBackup
                                                     int64
       DeviceProtection
                                                     int64
       TechSupport
                                                     int64
                                                     int64
       StreamingTV
       StreamingMovies
                                                     int64
       PaperlessBilling
                                                     int64
       MonthlyCharges
                                                   float64
                                                   float64
       TotalCharges
       InternetService DSL
                                                     uint8
       InternetService_Fiber optic
                                                     uint8
       InternetService No
                                                     uint8
       Contract_Month-to-month
                                                     uint8
       Contract_One year
                                                     uint8
       Contract_Two year
                                                     uint8
       PaymentMethod_Bank transfer (automatic)
                                                     uint8
       PaymentMethod_Credit card (automatic)
                                                     uint8
       PaymentMethod_Electronic check
                                                     uint8
       PaymentMethod_Mailed check
                                                     uint8
       dtype: object
[431]: import numpy as np
       # Convert input arrays to float32
       x_train = x_train.astype(np.float32)
       y_train = y_train.astype(np.float32)
```

x_train, x_test, y_train, y_test = train_test_split(x, y, test_size=0.2,_

4 Build the Neural Network

```
[432]: import tensorflow as tf
from tensorflow import keras

# Define the model
model = tf.keras.Sequential([
```

```
tf.keras.layers.Input(shape=(26,)), # Input layer with 26 features
     tf.keras.layers.Activation('relu'),
     tf.keras.layers.Dense(1, activation='sigmoid') # Output layer with sigmoid_
    \rightarrowactivation
   ])
   # Compile the model
   model.compile(optimizer='sgd', loss='binary_crossentropy', metrics=['accuracy'])
   # Train the model
   model.fit(x_train, y_train, epochs=10)
   Epoch 1/10
   accuracy: 0.6713
   Epoch 2/10
   accuracy: 0.7469
   Epoch 3/10
   accuracy: 0.7579
   Epoch 4/10
   accuracy: 0.7636
   Epoch 5/10
   accuracy: 0.7725
   Epoch 6/10
   177/177 [===========] - Os 2ms/step - loss: 0.4614 -
   accuracy: 0.7758
   Epoch 7/10
   accuracy: 0.7812
   Epoch 8/10
   accuracy: 0.7835
   Epoch 9/10
   accuracy: 0.7851
   Epoch 10/10
   accuracy: 0.7863
[432]: <keras.src.callbacks.History at 0x7932a0148b20>
[433]: y_test[:5]
```

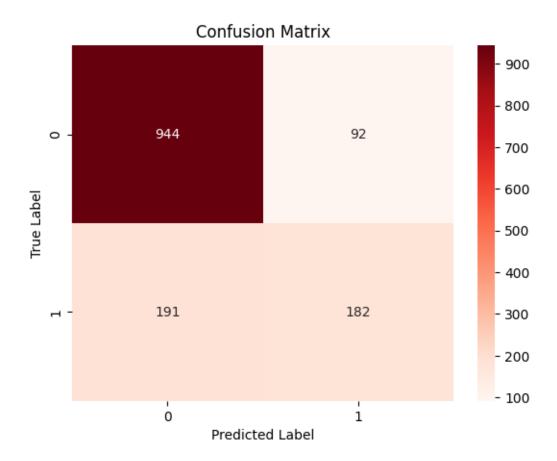
```
[433]: 185
              1
      2715
              0
      3825
              0
      1807
              1
      132
              0
      Name: Churn, dtype: int64
[434]: y_predict = model.predict(x_test)
      y_predict[:5]
      45/45 [========= ] - Os 1ms/step
[434]: array([[0.5838442],
             [0.28379503],
             [0.03805858],
             [0.6105663],
             [0.07433899]], dtype=float32)
[435]: y_predict = model.predict(x_test)
      # Threshold the predicted probabilities to binary predictions
      y_binary_predict = []
      for element in y_predict:
          if element < 0.5:</pre>
              y_binary_predict.append(0)
          else:
              y_binary_predict.append(1)
      # Display the first five binary predictions
      print(y_binary_predict[:5])
      45/45 [========= ] - Os 1ms/step
      [1, 0, 0, 1, 0]
```

5 Evaluate the Model

```
[436]: from sklearn.metrics import classification_report print(classification_report(y_test, y_binary_predict))
```

	precision	recall	f1-score	support
0	0.83 0.66	0.91	0.87 0.56	1036 373
_	0.00	0.10	0.00	010
accuracy			0.80	1409
macro avg	0.75	0.70	0.72	1409
weighted avg	0.79	0.80	0.79	1409

```
[437]: import seaborn as sns
       import matplotlib.pyplot as plt
       from sklearn.metrics import confusion_matrix
       # Assuming you have already obtained y_predict and thresholded it into binary.
        \hookrightarrowpredictions
       \# y\_predict = model.predict(x\_test)
       # y_binary_predict = [1 if pred > 0.5 else 0 for pred in y_predict]
       # Generate the confusion matrix
       conf_matrix = confusion_matrix(y_test, y_binary_predict)
       # Create a heatmap for the confusion matrix
       sns.heatmap(conf_matrix, annot=True, fmt='d', cmap='Reds')
       # Add labels and title
       plt.xlabel('Predicted Label')
       plt.ylabel('True Label')
       plt.title('Confusion Matrix')
       # Show plot
       plt.show()
```



To interpret the confusion matrix and extract the values of true positives, false positives, false negatives, and true negatives:

- 1. True Positive (TP): The number of samples that were correctly predicted as positive by the model
- 2. False Positive (FP): The number of samples that were incorrectly predicted as positive by the model (i.e., the model predicted positive when the actual value was negative).
- 3. False Negative (FN): The number of samples that were incorrectly predicted as negative by the model (i.e., the model predicted negative when the actual value was positive).
- 4. True Negative (TN): The number of samples that were correctly predicted as negative by the model.
- The top-left cell (948) represents the number of samples that were correctly predicted as positive (True Positives).
- The top-right cell (88) represents the number of samples that were incorrectly predicted as positive (False Positives).
- The bottom-left cell (203) represents the number of samples that were incorrectly predicted as negative (False Negatives).
- The bottom-right cell (170) represents the number of samples that were correctly predicted as negative (True Negatives).