In [64]:

```
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
import seaborn as sns
from sklearn.preprocessing import OneHotEncoder
from sklearn.compose import ColumnTransformer
from sklearn.preprocessing import StandardScaler
from keras.models import Sequential
from tensorflow.keras.layers import InputLayer
from tensorflow.keras.layers import Dense
from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV
from sklearn.metrics import classification_report,confusion_matrix
```

In [65]:

```
dataset = pd.read_csv('loan_data.csv').drop_duplicates()
dataset.head()
```

Out[65]:

	credit.policy	purpose	int.rate	installment	log.annual.inc	dti	fico	days.with.cr.line	revol.bal	revol.util	inq.la
0	1	debt_consolidation	0.1189	829.10	11.350407	19.48	737	5639.958333	28854	52.1	
1	1	credit_card	0.1071	228.22	11.082143	14.29	707	2760.000000	33623	76.7	
2	1	debt_consolidation	0.1357	366.86	10.373491	11.63	682	4710.000000	3511	25.6	
3	1	debt_consolidation	0.1008	162.34	11.350407	8.10	712	2699.958333	33667	73.2	
4	1	credit_card	0.1426	102.92	11.299732	14.97	667	4066.000000	4740	39.5	

In [66]:

```
dataset.isnull().any()
```

Out[66]:

```
credit.policy        False
purpose              False
int.rate             False
installment          False
log.annual.inc       False
dti                  False
fico                 False
days.with.cr.line    False
revol.bal            False
revol.util           False
inq.last.6mths       False
delinq.2yrs          False
pub.rec              False
not.fully.paid       False
dtype: bool
```

In [67]:

```
dataset.shape
```

Out[67]:

```
(9578, 14)
```

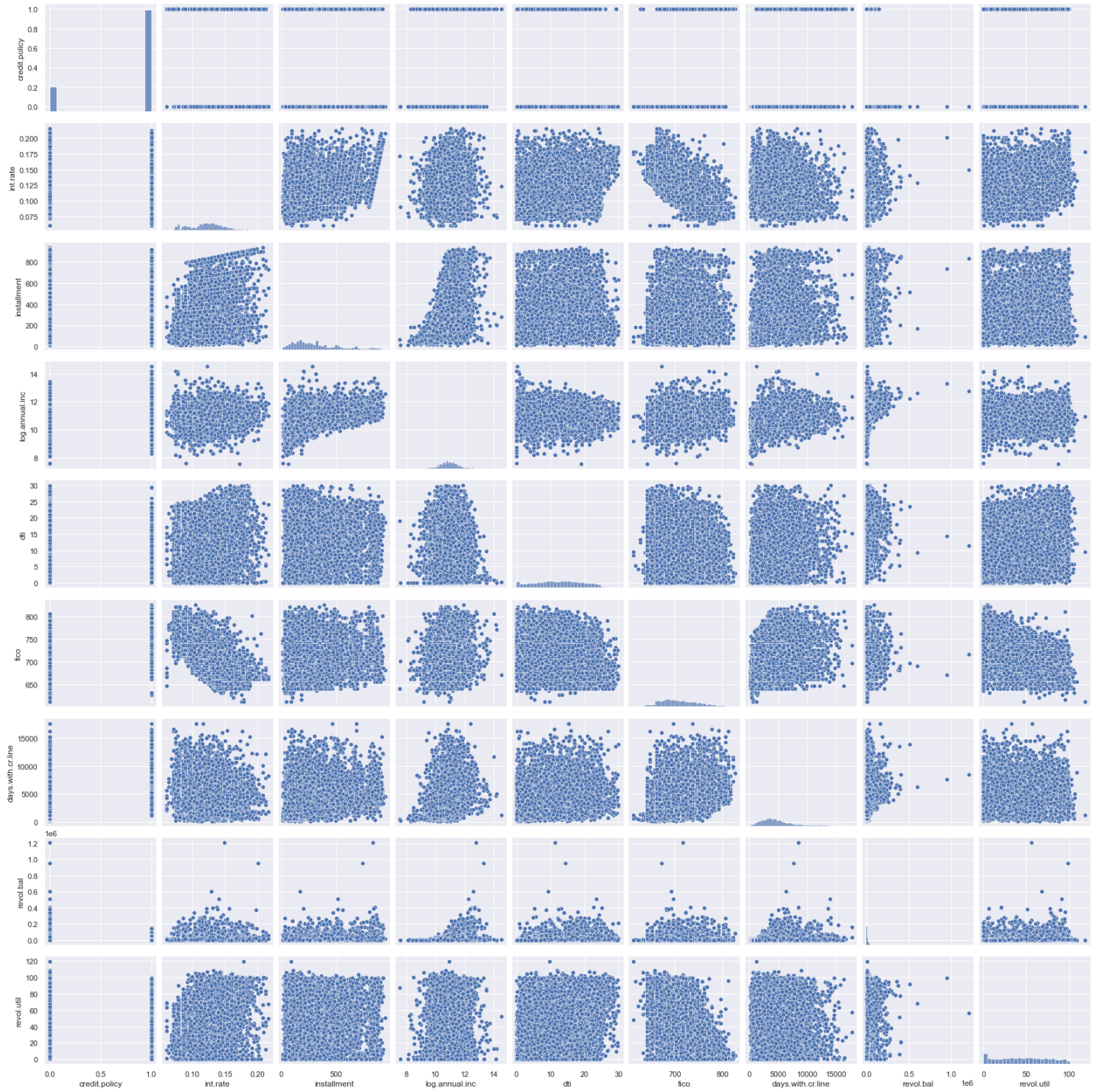
In [68]:

```
sns.pairplot(dataset.drop(columns=['purpose','inq.last.6mths','delinq.2yrs','pub.rec','no
```

```
t.fully.paid']))
```

Out[68]:

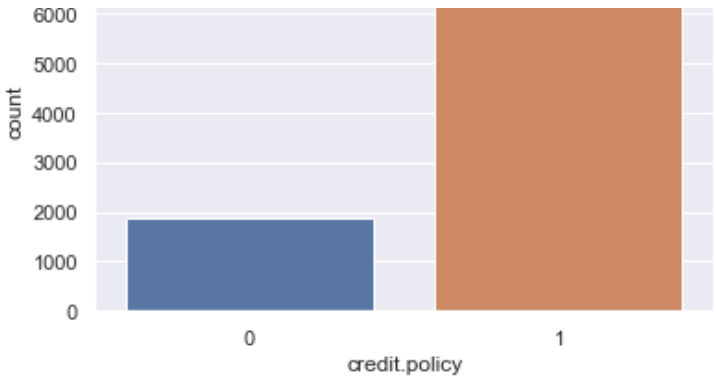
```
<seaborn.axisgrid.PairGrid at 0x196ff2b7fd0>
```



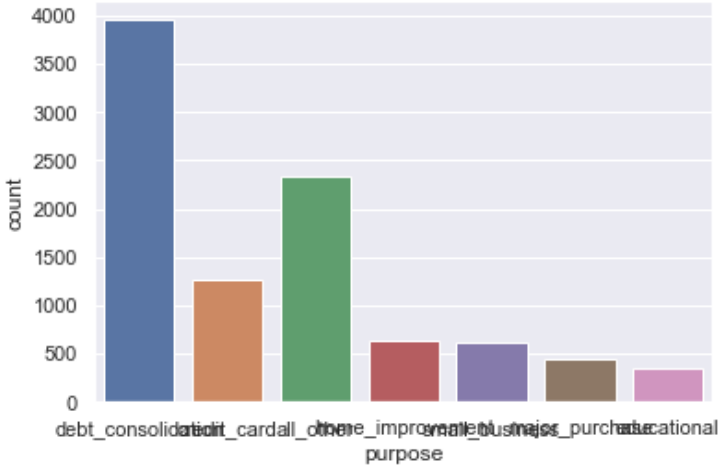
In [69]:

```
sns.set()
cat_var = dataset.drop(columns = ['int.rate','installment','log.annual.inc','dti','fico'
,'days.with.cr.line','revol.bal','revol.util']).copy()
cat_cols = cat_var.columns.values.tolist()
for col in cat_cols:
    sns.countplot(cat_var[col])
    plt.show()
```

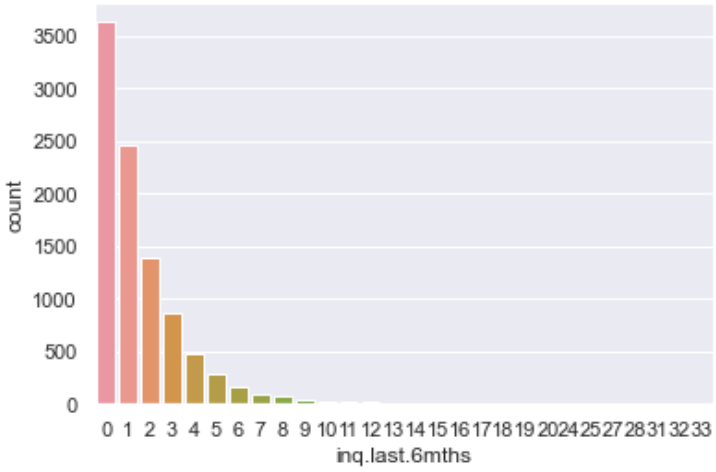
```
c:\Users\97156\AppData\Local\Programs\Python\Python310\lib\site-packages\seaborn\_decorat
ors.py:36: FutureWarning: Pass the following variable as a keyword arg: x. From version 0
.12, the only valid positional argument will be `data`, and passing other arguments witho
ut an explicit keyword will result in an error or misinterpretation.
  warnings.warn(
```



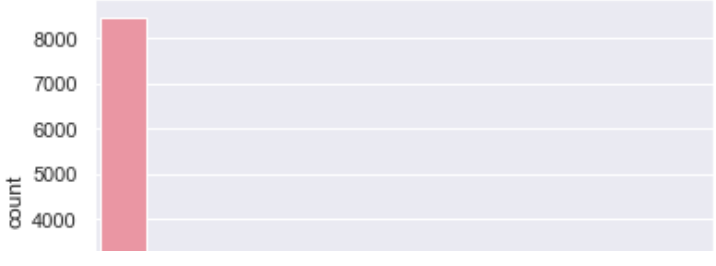

```
c:\Users\97156\AppData\Local\Programs\Python\Python310\lib\site-packages\seaborn\_decorat
ors.py:36: FutureWarning: Pass the following variable as a keyword arg: x. From version 0
.12, the only valid positional argument will be `data`, and passing other arguments witho
ut an explicit keyword will result in an error or misinterpretation.
  warnings.warn(
```

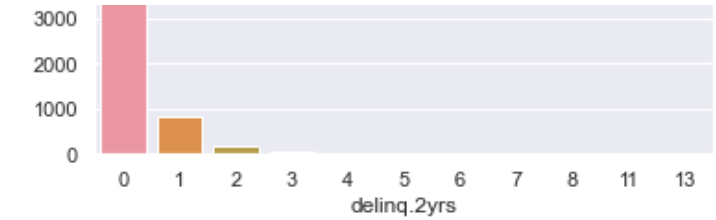



```
c:\Users\97156\AppData\Local\Programs\Python\Python310\lib\site-packages\seaborn\_decorat
ors.py:36: FutureWarning: Pass the following variable as a keyword arg: x. From version 0
.12, the only valid positional argument will be `data`, and passing other arguments witho
ut an explicit keyword will result in an error or misinterpretation.
  warnings.warn(
```

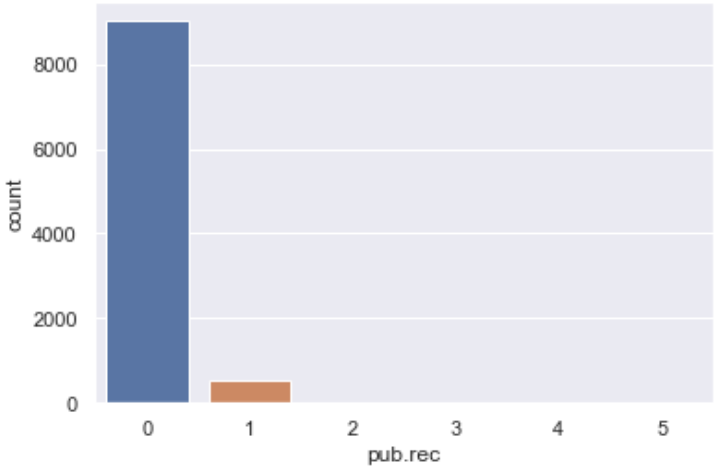



```
c:\Users\97156\AppData\Local\Programs\Python\Python310\lib\site-packages\seaborn\_decorat
ors.py:36: FutureWarning: Pass the following variable as a keyword arg: x. From version 0
.12, the only valid positional argument will be `data`, and passing other arguments witho
ut an explicit keyword will result in an error or misinterpretation.
  warnings.warn(
```

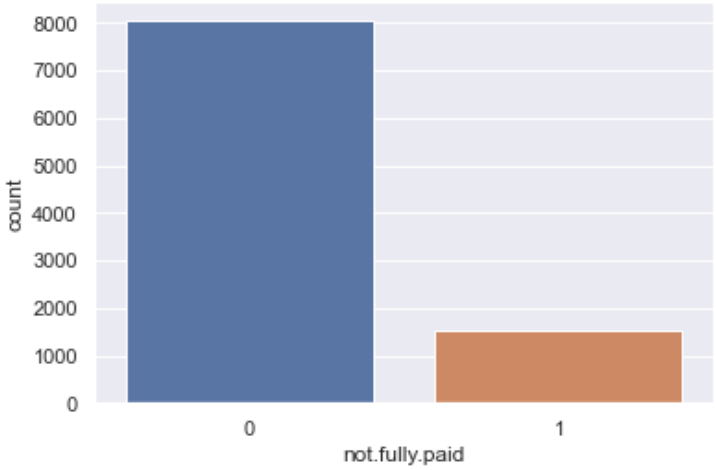





```
c:\Users\97156\AppData\Local\Programs\Python\Python310\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variable as a keyword arg: x. From version 0.12, the only valid positional argument will be `data`, and passing other arguments without an explicit keyword will result in an error or misinterpretation.
  warnings.warn(
```




```
c:\Users\97156\AppData\Local\Programs\Python\Python310\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variable as a keyword arg: x. From version 0.12, the only valid positional argument will be `data`, and passing other arguments without an explicit keyword will result in an error or misinterpretation.
  warnings.warn(
```



In [70]:

```
ohe =  OneHotEncoder()
ct = ColumnTransformer(transformers=[('encoder', ohe, ['purpose'])], remainder='passthrough')
ct.fit_transform(dataset)
dataset = pd.get_dummies(dataset)
dataset.head()
```

Out[70]:

	credit.policy	int.rate	installment	log.annual.inc	dti	fico	days.with.cr.line	revol.bal	revol.util	inq.last.6mths	delinq.2yrs
0	1	0.1189	829.10	11.350407	19.48	737	5639.958333	28854	52.1	0	0
1	1	0.1071	228.22	11.082143	14.29	707	2760.000000	33623	76.7	0	0
2	1	0.1357	366.86	10.373491	11.63	682	4710.000000	3511	25.6	1	0
3	1	0.1008	162.34	11.350407	8.10	712	2699.958333	33667	73.2	1	0

4	credit.policy	int.rate	installment	log.annual.inc	dti	fico	days.with.cr.line	revol.bal	revol.util	inq.last.6mths	delinq.2yrs
	1	0.1426	102.92	11.299732	14.97	667	4066.000000	4740	39.5	0	1

In [71]:

```
f = plt.figure(figsize=(20,20))
corr = dataset.corr()
corr.style.background_gradient(cmap='coolwarm',vmin=-1,vmax=1)
```

Out[71]:

	credit.policy	int.rate	installment	log.annual.inc	dti	fico	days.with.cr.line	revol.bal
credit.policy	1.000000	-0.294089	0.058770	0.034906	-0.090901	0.348319	0.099026	-0.187518
int.rate	-0.294089	1.000000	0.276140	0.056383	0.220006	-0.714821	-0.124022	0.092527
installment	0.058770	0.276140	1.000000	0.448102	0.050202	0.086039	0.183297	0.233625
log.annual.inc	0.034906	0.056383	0.448102	1.000000	-0.054065	0.114576	0.336896	0.372140
dti	-0.090901	0.220006	0.050202	-0.054065	1.000000	-0.241191	0.060101	0.188748
fico	0.348319	-0.714821	0.086039	0.114576	-0.241191	1.000000	0.263880	-0.015553
days.with.cr.line	0.099026	-0.124022	0.183297	0.336896	0.060101	0.263880	1.000000	0.229344
revol.bal	-0.187518	0.092527	0.233625	0.372140	0.188748	-0.015553	0.229344	1.000000
revol.util	-0.104095	0.464837	0.081356	0.054881	0.337109	-0.541289	-0.024239	0.203779
inq.last.6mths	-0.535511	0.202780	-0.010419	0.029171	0.029189	-0.185293	-0.041736	0.022394
delinq.2yrs	-0.076318	0.156079	-0.004368	0.029203	-0.021792	-0.216340	0.081374	-0.033243
pub.rec	-0.054243	0.098162	-0.032760	0.016506	0.006209	-0.147592	0.071826	-0.031010
not.fully.paid	-0.158119	0.159552	0.049955	-0.033439	0.037362	-0.149666	-0.029237	0.053699
purpose_all_other	-0.025412	-0.124000	-0.203103	-0.080077	-0.125825	0.067184	-0.056574	-0.067728
purpose_credit_card	0.003216	-0.042109	0.000774	0.072942	0.084476	-0.012512	0.046220	0.072316
purpose_debt_consolidation	0.020193	0.123607	0.161658	-0.026214	0.179149	-0.154132	-0.009318	0.005785
purpose_educational	-0.031346	-0.019618	-0.094510	-0.119799	-0.035325	-0.013012	-0.042621	-0.034743
purpose_home_improvement	0.006036	-0.050697	0.023024	0.116375	-0.092788	0.097474	0.068087	0.003258
purpose_major_purchase	0.024281	-0.068978	-0.079836	-0.031020	-0.077719	0.067129	-0.020561	-0.062395
purpose_small_business	-0.003511	0.151247	0.145654	0.091540	-0.069245	0.063292	0.034883	0.083069

<Figure size 1440x1440 with 0 Axes>

We can see that the intrest rate and revol.util are highly coorelated with fico score. and that the fico score has more predictive power than the both. therefore, we will be dropping these two features

In [72]:

```
dataset = dataset.drop(columns=['int.rate','revol.util'])
```

In [73]:

```
X = dataset.iloc[:, 1:].values
y = dataset.iloc[:, 0].values
stdscl = StandardScaler()
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.25, random_state
= 1)
X_train[:,0:9] = stdscl.fit_transform(X_train[:,0:9])
X_test[:,0:9] = stdscl.fit_transform(X_test[:,0:9])
```

In [74]:

```
def build_classifier(optimizer):
    model = tf.keras.models.Sequential()
    model.add(tf.keras.layers.Dense(units = 5, activation = 'relu', input_shape = (17,))
)
    model.add(tf.keras.layers.Dense(units = 5, activation = 'relu'))
    model.add(tf.keras.layers.Dense(units = 10, activation = 'relu'))
    model.add(tf.keras.layers.Dense(units = 1, activation = 'sigmoid'))
    model.compile(optimizer=optimizer,loss = 'binary_crossentropy',metrics = ['accuracy'
])
    return model
```

In [83]:

```
classifier = tf.keras.wrappers.scikit_learn.KerasClassifier(build_fn=build_classifier)
param_grid = {'epochs':[100,5000],'optimizer':[tf.keras.optimizers.Adam(),tf.keras.optim
izers.RMSprop(),tf.keras.optimizers.Adagrad()]}
model = GridSearchCV(estimator=classifier,param_grid=param_grid,scoring='accuracy')
```

```
C:\Users\97156\AppData\Local\Temp\ipykernel_11728\2212760722.py:1: DeprecationWarning: Ke
rasClassifier is deprecated, use Sci-Keras (https://github.com/adriangb/scikeras) instead
. See https://www.adriangb.com/scikeras/stable/migration.html for help migrating.
  classifier = tf.keras.wrappers.scikit_learn.KerasClassifier(build_fn=build_classifier)
```

In [76]:

```
X_train
```

Out[76]:

```
array([[ 0.78416021,  0.95396034, -1.13324201, ...,  0.        ,
         0.        ,  1.        ],
       [ 0.31339588, -0.24590795, -0.0069299 , ...,  0.        ,
         0.        ,  0.        ],
       [ 0.92031809,  0.11887967,  0.67264084, ...,  0.        ,
         0.        ,  0.        ],
       ...,
       [ 0.39985687, -0.17043457, -0.36053951, ...,  0.        ,
         0.        ,  0.        ],
       [ 1.50263404,  0.24973082, -0.50023714, ...,  0.        ,
         0.        ,  1.        ],
       [-1.08300958, -1.31230739,  0.22735466, ...,  0.        ,
         0.        ,  0.        ]])
```

In [84]:

```
history =  model.fit(X_train, y_train,epochs = 10,validation_data=(X_test, y_test))
```

```
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.5102 - accuracy: 0.7607
- val_loss: 0.3755 - val_accuracy: 0.8125
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3717 - accuracy: 0.8166
- val_loss: 0.3119 - val_accuracy: 0.8685
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3174 - accuracy: 0.8670
- val_loss: 0.2710 - val_accuracy: 0.8931
```

```
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2846 - accuracy: 0.8810
- val_loss: 0.2505 - val_accuracy: 0.9035
Epoch 5/10
180/180 [==============================] - 0s 3ms/step - loss: 0.2685 - accuracy: 0.8970
- val_loss: 0.2408 - val_accuracy: 0.9106
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2593 - accuracy: 0.8999
- val_loss: 0.2339 - val_accuracy: 0.9086
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2522 - accuracy: 0.8999
- val_loss: 0.2297 - val_accuracy: 0.9123
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2476 - accuracy: 0.9032
- val_loss: 0.2259 - val_accuracy: 0.9106
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2435 - accuracy: 0.9038
- val_loss: 0.2234 - val_accuracy: 0.9144
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2402 - accuracy: 0.9067
- val_loss: 0.2216 - val_accuracy: 0.9136
45/45 [==============================] - 0s 1ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.6986 - accuracy: 0.6467
- val_loss: 0.5319 - val_accuracy: 0.8234
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.4620 - accuracy: 0.8331
- val_loss: 0.3997 - val_accuracy: 0.8518
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3501 - accuracy: 0.8712
- val_loss: 0.2970 - val_accuracy: 0.8956
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2821 - accuracy: 0.8977
- val_loss: 0.2550 - val_accuracy: 0.9023
Epoch 5/10
180/180 [==============================] - 0s 3ms/step - loss: 0.2565 - accuracy: 0.8984
- val_loss: 0.2366 - val_accuracy: 0.9077
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2446 - accuracy: 0.9031
- val_loss: 0.2269 - val_accuracy: 0.9115
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2371 - accuracy: 0.9092
- val_loss: 0.2222 - val_accuracy: 0.9132
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2325 - accuracy: 0.9095
- val_loss: 0.2180 - val_accuracy: 0.9144
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2285 - accuracy: 0.9133
- val_loss: 0.2164 - val_accuracy: 0.9177
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2260 - accuracy: 0.9125
- val_loss: 0.2143 - val_accuracy: 0.9177
45/45 [==============================] - 0s 977us/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.5985 - accuracy: 0.7631
- val_loss: 0.4680 - val_accuracy: 0.8125
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.4105 - accuracy: 0.8049
- val_loss: 0.3707 - val_accuracy: 0.8125
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3410 - accuracy: 0.8261
- val_loss: 0.3129 - val_accuracy: 0.8660
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2900 - accuracy: 0.8775
- val_loss: 0.2793 - val_accuracy: 0.8756
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2617 - accuracy: 0.8916
- val_loss: 0.2503 - val_accuracy: 0.9010
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2425 - accuracy: 0.9008
- val_loss: 0.2361 - val_accuracy: 0.9052
Epoch 7/10
```

```
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2348 - accuracy: 0.9050
- val_loss: 0.2299 - val_accuracy: 0.9081
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2290 - accuracy: 0.9065
- val_loss: 0.2250 - val_accuracy: 0.9111
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2246 - accuracy: 0.9069
- val_loss: 0.2209 - val_accuracy: 0.9127
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2212 - accuracy: 0.9078
- val_loss: 0.2181 - val_accuracy: 0.9132
45/45 [==============================] - 0s 2ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.5537 - accuracy: 0.8004
- val_loss: 0.4753 - val_accuracy: 0.8125
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.4402 - accuracy: 0.8009
- val_loss: 0.3798 - val_accuracy: 0.8125
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3482 - accuracy: 0.8168
- val_loss: 0.3058 - val_accuracy: 0.8810
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3054 - accuracy: 0.8846
- val_loss: 0.2778 - val_accuracy: 0.9006
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2882 - accuracy: 0.8930
- val_loss: 0.2621 - val_accuracy: 0.9065
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2759 - accuracy: 0.8968
- val_loss: 0.2523 - val_accuracy: 0.9065
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2665 - accuracy: 0.8984
- val_loss: 0.2436 - val_accuracy: 0.9090
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2587 - accuracy: 0.9012
- val_loss: 0.2387 - val_accuracy: 0.9115
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2539 - accuracy: 0.9010
- val_loss: 0.2335 - val_accuracy: 0.9115
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2488 - accuracy: 0.9046
- val_loss: 0.2297 - val_accuracy: 0.9111
45/45 [==============================] - 0s 1ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.5529 - accuracy: 0.8053
- val_loss: 0.4305 - val_accuracy: 0.8125
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3839 - accuracy: 0.8056
- val_loss: 0.3467 - val_accuracy: 0.8125
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3318 - accuracy: 0.8086
- val_loss: 0.3097 - val_accuracy: 0.8718
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3010 - accuracy: 0.8909
- val_loss: 0.2835 - val_accuracy: 0.9015
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2828 - accuracy: 0.9003
- val_loss: 0.2650 - val_accuracy: 0.9069
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2682 - accuracy: 0.8991
- val_loss: 0.2510 - val_accuracy: 0.9077
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2560 - accuracy: 0.9033
- val_loss: 0.2367 - val_accuracy: 0.9127
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2448 - accuracy: 0.9045
- val_loss: 0.2285 - val_accuracy: 0.9127
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2371 - accuracy: 0.9081
- val_loss: 0.2217 - val_accuracy: 0.9127
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2327 - accuracy: 0.9069
```

- val_loss: 0.2177 - val_accuracy: 0.9161
45/45 [==============================] - 0s 1ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.5631 - accuracy: 0.7473
- val_loss: 0.4249 - val_accuracy: 0.8175
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3748 - accuracy: 0.8322
- val_loss: 0.3121 - val_accuracy: 0.8768
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2994 - accuracy: 0.8862
- val_loss: 0.2717 - val_accuracy: 0.8944
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2704 - accuracy: 0.8973
- val_loss: 0.2537 - val_accuracy: 0.8990
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2545 - accuracy: 0.9025
- val_loss: 0.2410 - val_accuracy: 0.9052
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2444 - accuracy: 0.9036
- val_loss: 0.2294 - val_accuracy: 0.9102
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2369 - accuracy: 0.9060
- val_loss: 0.2256 - val_accuracy: 0.9073
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2314 - accuracy: 0.9069
- val_loss: 0.2186 - val_accuracy: 0.9127
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2272 - accuracy: 0.9076
- val_loss: 0.2180 - val_accuracy: 0.9115
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2243 - accuracy: 0.9099
- val_loss: 0.2132 - val_accuracy: 0.9136
45/45 [==============================] - 0s 1ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.5605 - accuracy: 0.7835
- val_loss: 0.4451 - val_accuracy: 0.8154
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.4098 - accuracy: 0.8260
- val_loss: 0.3676 - val_accuracy: 0.8438
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3452 - accuracy: 0.8618
- val_loss: 0.3152 - val_accuracy: 0.8676
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3069 - accuracy: 0.8775
- val_loss: 0.2861 - val_accuracy: 0.8868
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2880 - accuracy: 0.8844
- val_loss: 0.2705 - val_accuracy: 0.8948
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2764 - accuracy: 0.8891
- val_loss: 0.2614 - val_accuracy: 0.8981
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2683 - accuracy: 0.8905
- val_loss: 0.2546 - val_accuracy: 0.8994
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2626 - accuracy: 0.8933
- val_loss: 0.2476 - val_accuracy: 0.9027
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2567 - accuracy: 0.8945
- val_loss: 0.2426 - val_accuracy: 0.9040
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2518 - accuracy: 0.9003
- val_loss: 0.2386 - val_accuracy: 0.9077
45/45 [==============================] - 0s 1ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.4771 - accuracy: 0.8007
- val_loss: 0.4057 - val_accuracy: 0.8125
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3706 - accuracy: 0.8049
- val_loss: 0.3551 - val_accuracy: 0.8125
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3352 - accuracy: 0.8465

- val_loss: 0.3318 - val_accuracy: 0.8493
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3195 - accuracy: 0.8568
- val_loss: 0.3192 - val_accuracy: 0.8539
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3084 - accuracy: 0.8625
- val_loss: 0.3078 - val_accuracy: 0.8564
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2936 - accuracy: 0.8730
- val_loss: 0.2896 - val_accuracy: 0.8747
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2757 - accuracy: 0.8876
- val_loss: 0.2696 - val_accuracy: 0.8990
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2628 - accuracy: 0.8996
- val_loss: 0.2575 - val_accuracy: 0.9044
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2558 - accuracy: 0.9008
- val_loss: 0.2499 - val_accuracy: 0.9069
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2504 - accuracy: 0.9041
- val_loss: 0.2440 - val_accuracy: 0.9069
45/45 [==============================] - 1s 1ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.4933 - accuracy: 0.8006
- val_loss: 0.4090 - val_accuracy: 0.8125
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.4056 - accuracy: 0.8009
- val_loss: 0.3586 - val_accuracy: 0.8125
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3664 - accuracy: 0.8009
- val_loss: 0.3259 - val_accuracy: 0.8125
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3370 - accuracy: 0.8504
- val_loss: 0.3024 - val_accuracy: 0.8818
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3159 - accuracy: 0.8780
- val_loss: 0.2857 - val_accuracy: 0.8914
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3012 - accuracy: 0.8888
- val_loss: 0.2755 - val_accuracy: 0.8985
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2896 - accuracy: 0.8951
- val_loss: 0.2673 - val_accuracy: 0.9023
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2804 - accuracy: 0.8979
- val_loss: 0.2597 - val_accuracy: 0.9065
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2733 - accuracy: 0.8989
- val_loss: 0.2544 - val_accuracy: 0.9069
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2663 - accuracy: 0.9034
- val_loss: 0.2496 - val_accuracy: 0.9086
45/45 [==============================] - 0s 1ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.4862 - accuracy: 0.8056
- val_loss: 0.4286 - val_accuracy: 0.8125
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3960 - accuracy: 0.8056
- val_loss: 0.3655 - val_accuracy: 0.8125
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3483 - accuracy: 0.8263
- val_loss: 0.3267 - val_accuracy: 0.8693
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3231 - accuracy: 0.8711
- val_loss: 0.3050 - val_accuracy: 0.8856
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3090 - accuracy: 0.8859
- val_loss: 0.2916 - val_accuracy: 0.8990
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2991 - accuracy: 0.8916
- val_loss: 0.2823 - val_accuracy: 0.9035

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Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2919 - accuracy: 0.8965
- val_loss: 0.2754 - val_accuracy: 0.9044
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2864 - accuracy: 0.8989
- val_loss: 0.2724 - val_accuracy: 0.9044
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2822 - accuracy: 0.9001
- val_loss: 0.2678 - val_accuracy: 0.9048
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2790 - accuracy: 0.9022
- val_loss: 0.2638 - val_accuracy: 0.9065
45/45 [==============================] - 0s 1ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.6711 - accuracy: 0.7812
- val_loss: 0.6613 - val_accuracy: 0.8163
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6568 - accuracy: 0.8023
- val_loss: 0.6493 - val_accuracy: 0.8180
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6465 - accuracy: 0.8013
- val_loss: 0.6393 - val_accuracy: 0.8154
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6375 - accuracy: 0.7995
- val_loss: 0.6305 - val_accuracy: 0.8134
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6294 - accuracy: 0.7990
- val_loss: 0.6223 - val_accuracy: 0.8134
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6217 - accuracy: 0.7985
- val_loss: 0.6145 - val_accuracy: 0.8129
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6145 - accuracy: 0.7981
- val_loss: 0.6070 - val_accuracy: 0.8125
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6075 - accuracy: 0.7978
- val_loss: 0.5998 - val_accuracy: 0.8125
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6007 - accuracy: 0.7978
- val_loss: 0.5929 - val_accuracy: 0.8125
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5941 - accuracy: 0.7976
- val_loss: 0.5861 - val_accuracy: 0.8125
45/45 [==============================] - 0s 1ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.7136 - accuracy: 0.5238
- val_loss: 0.7000 - val_accuracy: 0.6150
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6944 - accuracy: 0.6399
- val_loss: 0.6851 - val_accuracy: 0.6814
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6817 - accuracy: 0.6921
- val_loss: 0.6736 - val_accuracy: 0.7177
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6714 - accuracy: 0.7269
- val_loss: 0.6638 - val_accuracy: 0.7474
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6625 - accuracy: 0.7508
- val_loss: 0.6551 - val_accuracy: 0.7704
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6544 - accuracy: 0.7652
- val_loss: 0.6471 - val_accuracy: 0.7829
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6469 - accuracy: 0.7765
- val_loss: 0.6396 - val_accuracy: 0.7871
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6397 - accuracy: 0.7859
- val_loss: 0.6325 - val_accuracy: 0.7937
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6328 - accuracy: 0.7889
- val_loss: 0.6255 - val_accuracy: 0.8021
Epoch 10/10
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Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6261 - accuracy: 0.7926
- val_loss: 0.6188 - val_accuracy: 0.8071
45/45 [==============================] - 0s 1ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.6019 - accuracy: 0.8049
- val_loss: 0.5880 - val_accuracy: 0.8125
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5818 - accuracy: 0.8049
- val_loss: 0.5721 - val_accuracy: 0.8125
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5679 - accuracy: 0.8049
- val_loss: 0.5598 - val_accuracy: 0.8125
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5567 - accuracy: 0.8049
- val_loss: 0.5496 - val_accuracy: 0.8125
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5472 - accuracy: 0.8049
- val_loss: 0.5406 - val_accuracy: 0.8125
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5388 - accuracy: 0.8049
- val_loss: 0.5327 - val_accuracy: 0.8125
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5314 - accuracy: 0.8049
- val_loss: 0.5256 - val_accuracy: 0.8125
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5247 - accuracy: 0.8049
- val_loss: 0.5191 - val_accuracy: 0.8125
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5186 - accuracy: 0.8049
- val_loss: 0.5133 - val_accuracy: 0.8125
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5130 - accuracy: 0.8049
- val_loss: 0.5079 - val_accuracy: 0.8125
45/45 [==============================] - 0s 1ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.6460 - accuracy: 0.8008
- val_loss: 0.6354 - val_accuracy: 0.8125
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6276 - accuracy: 0.8009
- val_loss: 0.6209 - val_accuracy: 0.8125
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6151 - accuracy: 0.8009
- val_loss: 0.6097 - val_accuracy: 0.8125
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6051 - accuracy: 0.8009
- val_loss: 0.6002 - val_accuracy: 0.8125
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5964 - accuracy: 0.8009
- val_loss: 0.5920 - val_accuracy: 0.8125
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5887 - accuracy: 0.8009
- val_loss: 0.5846 - val_accuracy: 0.8125
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5818 - accuracy: 0.8009
- val_loss: 0.5779 - val_accuracy: 0.8125
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5755 - accuracy: 0.8009
- val_loss: 0.5717 - val_accuracy: 0.8125
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5697 - accuracy: 0.8009
- val_loss: 0.5661 - val_accuracy: 0.8125
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5643 - accuracy: 0.8009
- val_loss: 0.5608 - val_accuracy: 0.8125
45/45 [==============================] - 0s 1ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.6666 - accuracy: 0.6864
- val_loss: 0.6551 - val_accuracy: 0.7428
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6431 - accuracy: 0.7715
- val_loss: 0.6369 - val_accuracy: 0.7875
Epoch 3/10
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Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6274 - accuracy: 0.7908
- val_loss: 0.6231 - val_accuracy: 0.8021
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6149 - accuracy: 0.8006
- val_loss: 0.6118 - val_accuracy: 0.8071
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6045 - accuracy: 0.8039
- val_loss: 0.6022 - val_accuracy: 0.8092
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5954 - accuracy: 0.8049
- val_loss: 0.5937 - val_accuracy: 0.8113
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5874 - accuracy: 0.8056
- val_loss: 0.5862 - val_accuracy: 0.8113
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5803 - accuracy: 0.8056
- val_loss: 0.5795 - val_accuracy: 0.8121
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5739 - accuracy: 0.8056
- val_loss: 0.5734 - val_accuracy: 0.8121
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5680 - accuracy: 0.8056
- val_loss: 0.5678 - val_accuracy: 0.8121
45/45 [==============================] - 0s 1ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.5579 - accuracy: 0.7971
- val_loss: 0.4557 - val_accuracy: 0.8125
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.4095 - accuracy: 0.8053
- val_loss: 0.3481 - val_accuracy: 0.8522
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3115 - accuracy: 0.8829
- val_loss: 0.2871 - val_accuracy: 0.8877
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2700 - accuracy: 0.8991
- val_loss: 0.2606 - val_accuracy: 0.8981
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2566 - accuracy: 0.9008
- val_loss: 0.2537 - val_accuracy: 0.8994
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2499 - accuracy: 0.9045
- val_loss: 0.2465 - val_accuracy: 0.9027
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2454 - accuracy: 0.9046
- val_loss: 0.2434 - val_accuracy: 0.9044
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2414 - accuracy: 0.9043
- val_loss: 0.2424 - val_accuracy: 0.9002
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2391 - accuracy: 0.9076
- val_loss: 0.2372 - val_accuracy: 0.9048
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2358 - accuracy: 0.9086
- val_loss: 0.2359 - val_accuracy: 0.9061
45/45 [==============================] - 0s 1ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.5391 - accuracy: 0.8011
- val_loss: 0.4401 - val_accuracy: 0.8125
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.4092 - accuracy: 0.8032
- val_loss: 0.3643 - val_accuracy: 0.8138
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3522 - accuracy: 0.8113
- val_loss: 0.3197 - val_accuracy: 0.8288
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3161 - accuracy: 0.8442
- val_loss: 0.2886 - val_accuracy: 0.8848
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2930 - accuracy: 0.8895
- val_loss: 0.2715 - val_accuracy: 0.9006
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2771 - accuracy: 0.8942
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- val_loss: 0.2569 - val_accuracy: 0.9031
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2626 - accuracy: 0.9006
- val_loss: 0.2477 - val_accuracy: 0.9010
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2535 - accuracy: 0.9010
- val_loss: 0.2384 - val_accuracy: 0.9094
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2460 - accuracy: 0.9029
- val_loss: 0.2331 - val_accuracy: 0.9106
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2413 - accuracy: 0.9043
- val_loss: 0.2306 - val_accuracy: 0.9077
45/45 [==============================] - 0s 1ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.5841 - accuracy: 0.7910
- val_loss: 0.4578 - val_accuracy: 0.8125
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.4034 - accuracy: 0.8049
- val_loss: 0.3666 - val_accuracy: 0.8125
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3456 - accuracy: 0.8162
- val_loss: 0.3147 - val_accuracy: 0.8806
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2947 - accuracy: 0.8883
- val_loss: 0.2685 - val_accuracy: 0.9010
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2680 - accuracy: 0.8959
- val_loss: 0.2523 - val_accuracy: 0.9040
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2587 - accuracy: 0.8982
- val_loss: 0.2468 - val_accuracy: 0.9052
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2536 - accuracy: 0.9010
- val_loss: 0.2436 - val_accuracy: 0.9061
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2501 - accuracy: 0.9015
- val_loss: 0.2417 - val_accuracy: 0.9081
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2469 - accuracy: 0.9048
- val_loss: 0.2410 - val_accuracy: 0.9052
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2454 - accuracy: 0.9055
- val_loss: 0.2399 - val_accuracy: 0.9094
45/45 [==============================] - 0s 2ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.5603 - accuracy: 0.7689
- val_loss: 0.4357 - val_accuracy: 0.8205
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3699 - accuracy: 0.8511
- val_loss: 0.2901 - val_accuracy: 0.8885
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2767 - accuracy: 0.8932
- val_loss: 0.2449 - val_accuracy: 0.9031
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2494 - accuracy: 0.9038
- val_loss: 0.2315 - val_accuracy: 0.9069
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2401 - accuracy: 0.9064
- val_loss: 0.2279 - val_accuracy: 0.9069
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2358 - accuracy: 0.9078
- val_loss: 0.2253 - val_accuracy: 0.9081
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2335 - accuracy: 0.9097
- val_loss: 0.2208 - val_accuracy: 0.9111
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2308 - accuracy: 0.9097
- val_loss: 0.2197 - val_accuracy: 0.9115
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2288 - accuracy: 0.9099
- val_loss: 0.2214 - val_accuracy: 0.9111

```
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2280 - accuracy: 0.9118
- val_loss: 0.2158 - val_accuracy: 0.9148
45/45 [==============================] - 0s 2ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.5948 - accuracy: 0.7458
- val_loss: 0.4331 - val_accuracy: 0.8330
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3460 - accuracy: 0.8625
- val_loss: 0.2908 - val_accuracy: 0.8902
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2766 - accuracy: 0.8909
- val_loss: 0.2594 - val_accuracy: 0.8994
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2606 - accuracy: 0.8991
- val_loss: 0.2524 - val_accuracy: 0.9027
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2556 - accuracy: 0.8993
- val_loss: 0.2484 - val_accuracy: 0.9006
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2515 - accuracy: 0.9003
- val_loss: 0.2459 - val_accuracy: 0.9010
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2490 - accuracy: 0.8998
- val_loss: 0.2427 - val_accuracy: 0.9027
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2466 - accuracy: 0.9024
- val_loss: 0.2419 - val_accuracy: 0.9044
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2455 - accuracy: 0.9043
- val_loss: 0.2401 - val_accuracy: 0.9056
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2434 - accuracy: 0.9050
- val_loss: 0.2387 - val_accuracy: 0.9069
45/45 [==============================] - 0s 1ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.5067 - accuracy: 0.8333
- val_loss: 0.3998 - val_accuracy: 0.8605
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3637 - accuracy: 0.8754
- val_loss: 0.3058 - val_accuracy: 0.8931
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3089 - accuracy: 0.8860
- val_loss: 0.2709 - val_accuracy: 0.9010
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2848 - accuracy: 0.8895
- val_loss: 0.2521 - val_accuracy: 0.9073
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2708 - accuracy: 0.8933
- val_loss: 0.2421 - val_accuracy: 0.9069
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2609 - accuracy: 0.8971
- val_loss: 0.2338 - val_accuracy: 0.9090
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2543 - accuracy: 0.8987
- val_loss: 0.2293 - val_accuracy: 0.9111
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2491 - accuracy: 0.9010
- val_loss: 0.2259 - val_accuracy: 0.9102
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2436 - accuracy: 0.9013
- val_loss: 0.2221 - val_accuracy: 0.9119
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2388 - accuracy: 0.9036
- val_loss: 0.2186 - val_accuracy: 0.9119
45/45 [==============================] - 0s 1ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.6013 - accuracy: 0.7607
- val_loss: 0.4843 - val_accuracy: 0.8301
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3981 - accuracy: 0.8524
- val_loss: 0.3175 - val_accuracy: 0.8914
```

```
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2948 - accuracy: 0.8911
- val_loss: 0.2626 - val_accuracy: 0.9035
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2679 - accuracy: 0.8964
- val_loss: 0.2482 - val_accuracy: 0.9081
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2588 - accuracy: 0.8985
- val_loss: 0.2416 - val_accuracy: 0.9090
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2541 - accuracy: 0.9008
- val_loss: 0.2372 - val_accuracy: 0.9094
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2503 - accuracy: 0.9015
- val_loss: 0.2345 - val_accuracy: 0.9115
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2478 - accuracy: 0.9005
- val_loss: 0.2328 - val_accuracy: 0.9102
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2458 - accuracy: 0.9027
- val_loss: 0.2315 - val_accuracy: 0.9069
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2441 - accuracy: 0.9013
- val_loss: 0.2287 - val_accuracy: 0.9102
45/45 [==============================] - 0s 1ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.4646 - accuracy: 0.8049
- val_loss: 0.3923 - val_accuracy: 0.8125
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3671 - accuracy: 0.8079
- val_loss: 0.3365 - val_accuracy: 0.8547
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3257 - accuracy: 0.8662
- val_loss: 0.3068 - val_accuracy: 0.8898
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3031 - accuracy: 0.8843
- val_loss: 0.2884 - val_accuracy: 0.8985
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2870 - accuracy: 0.8919
- val_loss: 0.2743 - val_accuracy: 0.9006
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2750 - accuracy: 0.8945
- val_loss: 0.2633 - val_accuracy: 0.9035
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2661 - accuracy: 0.8992
- val_loss: 0.2551 - val_accuracy: 0.9065
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2589 - accuracy: 0.9015
- val_loss: 0.2486 - val_accuracy: 0.9081
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2525 - accuracy: 0.9064
- val_loss: 0.2437 - val_accuracy: 0.9106
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2470 - accuracy: 0.9052
- val_loss: 0.2378 - val_accuracy: 0.9098
45/45 [==============================] - 0s 1ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.5360 - accuracy: 0.7982
- val_loss: 0.4530 - val_accuracy: 0.8125
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.4249 - accuracy: 0.8009
- val_loss: 0.3842 - val_accuracy: 0.8125
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3655 - accuracy: 0.8023
- val_loss: 0.3305 - val_accuracy: 0.8184
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3252 - accuracy: 0.8477
- val_loss: 0.2999 - val_accuracy: 0.8864
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2993 - accuracy: 0.8852
- val_loss: 0.2775 - val_accuracy: 0.8981
Epoch 6/10
```

```
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2823 - accuracy: 0.8926
- val_loss: 0.2634 - val_accuracy: 0.8985
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2699 - accuracy: 0.8942
- val_loss: 0.2514 - val_accuracy: 0.9035
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2602 - accuracy: 0.8968
- val_loss: 0.2452 - val_accuracy: 0.9069
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2526 - accuracy: 0.8984
- val_loss: 0.2399 - val_accuracy: 0.9094
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2464 - accuracy: 0.9031
- val_loss: 0.2319 - val_accuracy: 0.9090
45/45 [==============================] - 0s 1ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.5254 - accuracy: 0.7990
- val_loss: 0.4148 - val_accuracy: 0.8125
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3899 - accuracy: 0.8056
- val_loss: 0.3461 - val_accuracy: 0.8125
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.3339 - accuracy: 0.8427
- val_loss: 0.2944 - val_accuracy: 0.8960
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2954 - accuracy: 0.8883
- val_loss: 0.2645 - val_accuracy: 0.9081
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2715 - accuracy: 0.8972
- val_loss: 0.2472 - val_accuracy: 0.9098
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2566 - accuracy: 0.9015
- val_loss: 0.2363 - val_accuracy: 0.9119
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2454 - accuracy: 0.9046
- val_loss: 0.2264 - val_accuracy: 0.9132
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2377 - accuracy: 0.9067
- val_loss: 0.2207 - val_accuracy: 0.9136
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2320 - accuracy: 0.9076
- val_loss: 0.2161 - val_accuracy: 0.9157
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.2282 - accuracy: 0.9092
- val_loss: 0.2134 - val_accuracy: 0.9177
45/45 [==============================] - 0s 1ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.6585 - accuracy: 0.7450
- val_loss: 0.6469 - val_accuracy: 0.8025
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6396 - accuracy: 0.7932
- val_loss: 0.6314 - val_accuracy: 0.8125
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6264 - accuracy: 0.7976
- val_loss: 0.6194 - val_accuracy: 0.8125
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6156 - accuracy: 0.7976
- val_loss: 0.6092 - val_accuracy: 0.8125
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6063 - accuracy: 0.7976
- val_loss: 0.6002 - val_accuracy: 0.8125
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5981 - accuracy: 0.7976
- val_loss: 0.5922 - val_accuracy: 0.8125
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5907 - accuracy: 0.7976
- val_loss: 0.5849 - val_accuracy: 0.8125
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5840 - accuracy: 0.7976
- val_loss: 0.5782 - val_accuracy: 0.8125
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5778 - accuracy: 0.7976
```

- val_loss: 0.5721 - val_accuracy: 0.8125
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5721 - accuracy: 0.7976
- val_loss: 0.5664 - val_accuracy: 0.8125
45/45 [==============================] - 0s 1ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.6770 - accuracy: 0.6662
- val_loss: 0.6661 - val_accuracy: 0.7182
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6580 - accuracy: 0.7470
- val_loss: 0.6516 - val_accuracy: 0.7658
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6459 - accuracy: 0.7845
- val_loss: 0.6406 - val_accuracy: 0.7896
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6361 - accuracy: 0.7986
- val_loss: 0.6313 - val_accuracy: 0.8046
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6277 - accuracy: 0.8035
- val_loss: 0.6232 - val_accuracy: 0.8109
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6203 - accuracy: 0.8040
- val_loss: 0.6158 - val_accuracy: 0.8125
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6134 - accuracy: 0.8046
- val_loss: 0.6088 - val_accuracy: 0.8125
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6070 - accuracy: 0.8039
- val_loss: 0.6022 - val_accuracy: 0.8121
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6008 - accuracy: 0.8035
- val_loss: 0.5959 - val_accuracy: 0.8125
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5949 - accuracy: 0.8033
- val_loss: 0.5898 - val_accuracy: 0.8125
45/45 [==============================] - 0s 1ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.6550 - accuracy: 0.7964
- val_loss: 0.6463 - val_accuracy: 0.8125
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6391 - accuracy: 0.8049
- val_loss: 0.6332 - val_accuracy: 0.8125
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6275 - accuracy: 0.8049
- val_loss: 0.6224 - val_accuracy: 0.8125
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6175 - accuracy: 0.8049
- val_loss: 0.6129 - val_accuracy: 0.8125
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6085 - accuracy: 0.8049
- val_loss: 0.6044 - val_accuracy: 0.8125
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6004 - accuracy: 0.8049
- val_loss: 0.5965 - val_accuracy: 0.8125
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5929 - accuracy: 0.8049
- val_loss: 0.5892 - val_accuracy: 0.8125
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5859 - accuracy: 0.8049
- val_loss: 0.5824 - val_accuracy: 0.8125
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5793 - accuracy: 0.8049
- val_loss: 0.5759 - val_accuracy: 0.8125
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5731 - accuracy: 0.8049
- val_loss: 0.5699 - val_accuracy: 0.8125
45/45 [==============================] - 0s 1ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.6637 - accuracy: 0.8006
- val_loss: 0.6312 - val_accuracy: 0.8125
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6363 - accuracy: 0.8009

- val_loss: 0.6110 - val_accuracy: 0.8125
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6191 - accuracy: 0.8009
- val_loss: 0.5962 - val_accuracy: 0.8125
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6057 - accuracy: 0.8009
- val_loss: 0.5842 - val_accuracy: 0.8125
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5947 - accuracy: 0.8009
- val_loss: 0.5741 - val_accuracy: 0.8125
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5851 - accuracy: 0.8009
- val_loss: 0.5653 - val_accuracy: 0.8125
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5767 - accuracy: 0.8009
- val_loss: 0.5574 - val_accuracy: 0.8125
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5692 - accuracy: 0.8009
- val_loss: 0.5503 - val_accuracy: 0.8125
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5622 - accuracy: 0.8009
- val_loss: 0.5437 - val_accuracy: 0.8125
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5558 - accuracy: 0.8009
- val_loss: 0.5376 - val_accuracy: 0.8125
45/45 [==============================] - 0s 1ms/step
Epoch 1/10
180/180 [==============================] - 1s 3ms/step - loss: 0.6424 - accuracy: 0.8048
- val_loss: 0.6385 - val_accuracy: 0.8125
Epoch 2/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6261 - accuracy: 0.8056
- val_loss: 0.6256 - val_accuracy: 0.8125
Epoch 3/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6153 - accuracy: 0.8056
- val_loss: 0.6158 - val_accuracy: 0.8125
Epoch 4/10
180/180 [==============================] - 0s 2ms/step - loss: 0.6068 - accuracy: 0.8056
- val_loss: 0.6077 - val_accuracy: 0.8125
Epoch 5/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5995 - accuracy: 0.8056
- val_loss: 0.6007 - val_accuracy: 0.8125
Epoch 6/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5932 - accuracy: 0.8056
- val_loss: 0.5945 - val_accuracy: 0.8125
Epoch 7/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5875 - accuracy: 0.8056
- val_loss: 0.5889 - val_accuracy: 0.8125
Epoch 8/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5823 - accuracy: 0.8056
- val_loss: 0.5838 - val_accuracy: 0.8125
Epoch 9/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5775 - accuracy: 0.8056
- val_loss: 0.5791 - val_accuracy: 0.8125
Epoch 10/10
180/180 [==============================] - 0s 2ms/step - loss: 0.5731 - accuracy: 0.8056
- val_loss: 0.5747 - val_accuracy: 0.8125
45/45 [==============================] - 0s 1ms/step
Epoch 1/10
225/225 [==============================] - 1s 3ms/step - loss: 0.5434 - accuracy: 0.7690
- val_loss: 0.4275 - val_accuracy: 0.8125
Epoch 2/10
225/225 [==============================] - 0s 2ms/step - loss: 0.3952 - accuracy: 0.8025
- val_loss: 0.3419 - val_accuracy: 0.8125
Epoch 3/10
225/225 [==============================] - 0s 2ms/step - loss: 0.3229 - accuracy: 0.8463
- val_loss: 0.2783 - val_accuracy: 0.9006
Epoch 4/10
225/225 [==============================] - 0s 2ms/step - loss: 0.2774 - accuracy: 0.8939
- val_loss: 0.2528 - val_accuracy: 0.9077
Epoch 5/10
225/225 [==============================] - 0s 2ms/step - loss: 0.2607 - accuracy: 0.8986
- val_loss: 0.2440 - val_accuracy: 0.9090

```
Epoch 6/10
225/225 [==============================] - 0s 2ms/step - loss: 0.2526 - accuracy: 0.9023
- val_loss: 0.2373 - val_accuracy: 0.9111
Epoch 7/10
225/225 [==============================] - 0s 2ms/step - loss: 0.2474 - accuracy: 0.9020
- val_loss: 0.2338 - val_accuracy: 0.9077
Epoch 8/10
225/225 [==============================] - 0s 2ms/step - loss: 0.2430 - accuracy: 0.9042
- val_loss: 0.2304 - val_accuracy: 0.9102
Epoch 9/10
225/225 [==============================] - 0s 2ms/step - loss: 0.2394 - accuracy: 0.9063
- val_loss: 0.2266 - val_accuracy: 0.9140
Epoch 10/10
225/225 [==============================] - 0s 2ms/step - loss: 0.2351 - accuracy: 0.9078
- val_loss: 0.2244 - val_accuracy: 0.9115
```

In [78]:

```
print(model.best_params_)
```

```
{'epochs': 1000, 'optimizer': <keras.optimizers.optimizer_v2.adam.Adam object at 0x000001
9685E6A350>}
```

In [79]:

```
print(model.best_score_)
```

```
0.9039388776137225
```

In [80]:

```
y_pred = (model.predict(X_test)>0.5).astype('int64')
```

```
75/75 [==============================] - 0s 958us/step
```

In [81]:

```
print(confusion_matrix(y_test,y_pred))
print(classification_report(y_test,y_pred))
```

```
[[ 331  118]
 [  65 1881]]
              precision    recall  f1-score   support

           0       0.84      0.74      0.78       449
           1       0.94      0.97      0.95      1946

    accuracy                           0.92      2395
   macro avg       0.89      0.85      0.87      2395
weighted avg       0.92      0.92      0.92      2395
```