

```
In [ ]: import numpy as np
import keras
import tensorflow as tf
import pandas as pd
import matplotlib.pyplot as plt
```

```
In [ ]: dataset = pd.read_csv('./dataset/Churn_Modelling.csv')
x = dataset.iloc[:, 3:-1].values
y = dataset.iloc[:, -1].values
```

```
In [ ]: print(dataset)
```

	RowNumber	CustomerId	Surname	CreditScore	Geography	Gender	Age	\
0	1	15634602	Hargrave	619	France	Female	42	
1	2	15647311	Hill	608	Spain	Female	41	
2	3	15619304	Onio	502	France	Female	42	
3	4	15701354	Boni	699	France	Female	39	
4	5	15737888	Mitchell	850	Spain	Female	43	
...
9995	9996	15606229	Obijaku	771	France	Male	39	
9996	9997	15569892	Johnstone	516	France	Male	35	
9997	9998	15584532	Liu	709	France	Female	36	
9998	9999	15682355	Sabbatini	772	Germany	Male	42	
9999	10000	15628319	Walker	792	France	Female	28	

	Tenure	Balance	NumOfProducts	HasCrCard	IsActiveMember	\
0	2	0.00	1	1	1	
1	1	83807.86	1	0	1	
2	8	159660.80	3	1	0	
3	1	0.00	2	0	0	
4	2	125510.82	1	1	1	
...
9995	5	0.00	2	1	0	
9996	10	57369.61	1	1	1	
9997	7	0.00	1	0	1	
9998	3	75075.31	2	1	0	
9999	4	130142.79	1	1	0	

	EstimatedSalary	Exited
0	101348.88	1
1	112542.58	0
2	113931.57	1
3	93826.63	0
4	79084.10	0
...
9995	96270.64	0
9996	101699.77	0
9997	42085.58	1
9998	92888.52	1
9999	38190.78	0


```
[10000 rows x 14 columns]
```

```
In [ ]: dataset = pd.read_csv('./dataset/Churn_Modelling.csv')
```

```
x = dataset.iloc[:, 3:-1].values  
y = dataset.iloc[:, -1].values
```

```
In [ ]: from sklearn.preprocessing import LabelEncoder  
le = LabelEncoder()  
x[:, 2] = le.fit_transform(x[:, 2])
```

```
In [ ]: from sklearn.compose import ColumnTransformer  
from sklearn.preprocessing import OneHotEncoder  
ct = ColumnTransformer(transformers=[('encoder', OneHotEncoder(), [1])], remainder='passthrough')  
x = np.array(ct.fit_transform(x))  
x
```

```
Out[ ]: array([[1.0, 0.0, 0.0, ..., 1, 1, 101348.88],  
               [0.0, 0.0, 1.0, ..., 0, 1, 112542.58],  
               [1.0, 0.0, 0.0, ..., 1, 0, 113931.57],  
               ...,  
               [1.0, 0.0, 0.0, ..., 0, 1, 42085.58],  
               [0.0, 1.0, 0.0, ..., 1, 0, 92888.52],  
               [1.0, 0.0, 0.0, ..., 1, 0, 38190.78]], dtype=object)
```

```
In [ ]: from sklearn.model_selection import train_test_split  
X_train, X_test, y_train, y_test = train_test_split(x, y, test_size = 0.2, random_state=42)  
print(X_train)  
print(y_train)  
print(X_train.dtype, y_train.dtype)  
X_train = X_train.astype('float32')  
  
[[0.0 0.0 1.0 ... 1 0 163830.64]  
 [0.0 1.0 0.0 ... 1 1 57098.0]  
 [1.0 0.0 0.0 ... 1 0 185630.76]  
 ...  
 [1.0 0.0 0.0 ... 1 0 181429.87]  
 [0.0 0.0 1.0 ... 1 1 148750.16]  
 [0.0 1.0 0.0 ... 1 0 118855.26]]  
[0 0 0 ... 0 0 1]  
object int64
```

```
In [ ]: from sklearn.preprocessing import StandardScaler  
sc = StandardScaler()  
X_train = sc.fit_transform(X_train)  
X_test = sc.transform(X_test)  
print(X_train)
```

```
[[ -1.0146067 -0.56984437  1.7430905 ...  0.642595 -1.0322704  
  1.1064317 ]]  
[ -1.0146067  1.754865 -0.5736937 ...  0.642595  0.9687384  
  -0.74866444]  
[  0.9856036 -0.56984437 -0.5736937 ...  0.642595 -1.0322704  
  1.4853348 ]]  
...  
[  0.9856036 -0.56984437 -0.5736937 ...  0.642595 -1.0322704  
  1.41232 ]]  
[ -1.0146067 -0.56984437  1.7430905 ...  0.642595  0.9687384  
  0.8443212 ]]  
[ -1.0146067  1.754865 -0.5736937 ...  0.642595 -1.0322704  
  0.3247246 ]]
```

```
In [ ]: ann = tf.keras.models.Sequential()  
ann.add(tf.keras.layers.Dense(units=6, activation='relu'))  
ann.add(tf.keras.layers.Dense(units=6, activation='relu'))  
ann.add(tf.keras.layers.Dense(units=1, activation='sigmoid'))  
ann.compile(optimizer = 'adam', loss = 'binary_crossentropy', metrics = ['accuracy'])  
adam_history = ann.fit(X_train, y_train, batch_size=32, epochs=100)  
plt.plot(adam_history.history['loss'])
```

```
Epoch 1/100
250/250 [=====] - 2s 3ms/step - loss: 0.5779 - accuracy: 0.
7460
Epoch 2/100
250/250 [=====] - 1s 2ms/step - loss: 0.4831 - accuracy: 0.
7976
Epoch 3/100
250/250 [=====] - 0s 2ms/step - loss: 0.4479 - accuracy: 0.
8048
Epoch 4/100
250/250 [=====] - 1s 3ms/step - loss: 0.4276 - accuracy: 0.
8129
Epoch 5/100
250/250 [=====] - 1s 2ms/step - loss: 0.4127 - accuracy: 0.
8254
Epoch 6/100
250/250 [=====] - 0s 2ms/step - loss: 0.4029 - accuracy: 0.
8295
Epoch 7/100
250/250 [=====] - 1s 2ms/step - loss: 0.3930 - accuracy: 0.
8336
Epoch 8/100
250/250 [=====] - 1s 2ms/step - loss: 0.3845 - accuracy: 0.
8385
Epoch 9/100
250/250 [=====] - 1s 2ms/step - loss: 0.3768 - accuracy: 0.
8440
Epoch 10/100
250/250 [=====] - 1s 2ms/step - loss: 0.3704 - accuracy: 0.
8453
Epoch 11/100
250/250 [=====] - 1s 3ms/step - loss: 0.3644 - accuracy: 0.
8499
Epoch 12/100
250/250 [=====] - 1s 2ms/step - loss: 0.3590 - accuracy: 0.
8510
Epoch 13/100
250/250 [=====] - 1s 2ms/step - loss: 0.3554 - accuracy: 0.
8531
Epoch 14/100
250/250 [=====] - 0s 2ms/step - loss: 0.3524 - accuracy: 0.
8571
Epoch 15/100
250/250 [=====] - 1s 2ms/step - loss: 0.3512 - accuracy: 0.
8576
Epoch 16/100
250/250 [=====] - 1s 2ms/step - loss: 0.3494 - accuracy: 0.
8570
Epoch 17/100
250/250 [=====] - 1s 3ms/step - loss: 0.3482 - accuracy: 0.
8577
Epoch 18/100
250/250 [=====] - 1s 3ms/step - loss: 0.3472 - accuracy: 0.
8595
Epoch 19/100
250/250 [=====] - 1s 3ms/step - loss: 0.3467 - accuracy: 0.
```

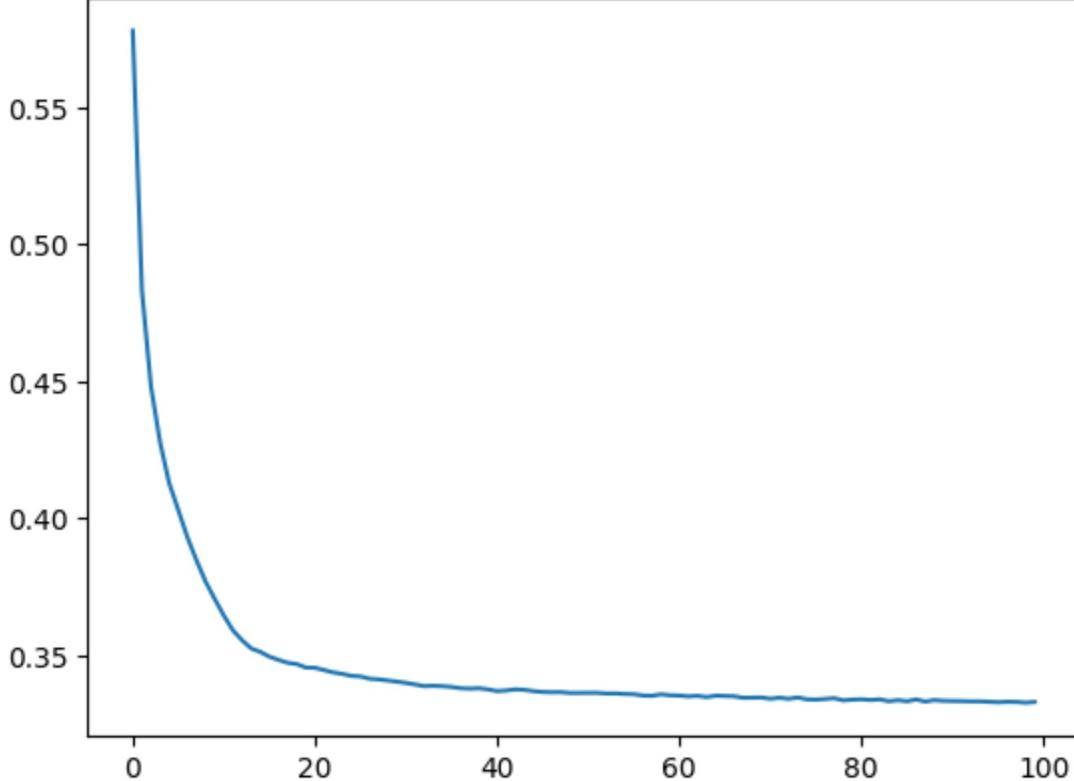
```
8594
Epoch 20/100
250/250 [=====] - 0s 2ms/step - loss: 0.3455 - accuracy: 0.
8610
Epoch 21/100
250/250 [=====] - 1s 2ms/step - loss: 0.3454 - accuracy: 0.
8599
Epoch 22/100
250/250 [=====] - 1s 2ms/step - loss: 0.3445 - accuracy: 0.
8604
Epoch 23/100
250/250 [=====] - 1s 2ms/step - loss: 0.3437 - accuracy: 0.
8615
Epoch 24/100
250/250 [=====] - 1s 2ms/step - loss: 0.3432 - accuracy: 0.
8602
Epoch 25/100
250/250 [=====] - 1s 2ms/step - loss: 0.3424 - accuracy: 0.
8626
Epoch 26/100
250/250 [=====] - 1s 2ms/step - loss: 0.3422 - accuracy: 0.
8605
Epoch 27/100
250/250 [=====] - 1s 2ms/step - loss: 0.3414 - accuracy: 0.
8608
Epoch 28/100
250/250 [=====] - 1s 2ms/step - loss: 0.3412 - accuracy: 0.
8624
Epoch 29/100
250/250 [=====] - 1s 2ms/step - loss: 0.3407 - accuracy: 0.
8619
Epoch 30/100
250/250 [=====] - 1s 2ms/step - loss: 0.3403 - accuracy: 0.
8621
Epoch 31/100
250/250 [=====] - 1s 2ms/step - loss: 0.3398 - accuracy: 0.
8614
Epoch 32/100
250/250 [=====] - 1s 2ms/step - loss: 0.3393 - accuracy: 0.
8612
Epoch 33/100
250/250 [=====] - 0s 2ms/step - loss: 0.3387 - accuracy: 0.
8625
Epoch 34/100
250/250 [=====] - 1s 2ms/step - loss: 0.3388 - accuracy: 0.
8619
Epoch 35/100
250/250 [=====] - 0s 2ms/step - loss: 0.3387 - accuracy: 0.
8620
Epoch 36/100
250/250 [=====] - 1s 2ms/step - loss: 0.3384 - accuracy: 0.
8618
Epoch 37/100
250/250 [=====] - 0s 2ms/step - loss: 0.3379 - accuracy: 0.
8634
Epoch 38/100
```

```
250/250 [=====] - 1s 2ms/step - loss: 0.3378 - accuracy: 0.  
8616  
Epoch 39/100  
250/250 [=====] - 1s 3ms/step - loss: 0.3379 - accuracy: 0.  
8608  
Epoch 40/100  
250/250 [=====] - 0s 2ms/step - loss: 0.3375 - accuracy: 0.  
8595  
Epoch 41/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3369 - accuracy: 0.  
8629  
Epoch 42/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3371 - accuracy: 0.  
8624  
Epoch 43/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3375 - accuracy: 0.  
8620  
Epoch 44/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3373 - accuracy: 0.  
8634  
Epoch 45/100  
250/250 [=====] - 0s 2ms/step - loss: 0.3369 - accuracy: 0.  
8627  
Epoch 46/100  
250/250 [=====] - 0s 2ms/step - loss: 0.3365 - accuracy: 0.  
8627  
Epoch 47/100  
250/250 [=====] - 0s 2ms/step - loss: 0.3365 - accuracy: 0.  
8635  
Epoch 48/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3365 - accuracy: 0.  
8637  
Epoch 49/100  
250/250 [=====] - 1s 3ms/step - loss: 0.3362 - accuracy: 0.  
8636  
Epoch 50/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3362 - accuracy: 0.  
8625  
Epoch 51/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3362 - accuracy: 0.  
8639  
Epoch 52/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3362 - accuracy: 0.  
8640  
Epoch 53/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3360 - accuracy: 0.  
8635  
Epoch 54/100  
250/250 [=====] - 0s 2ms/step - loss: 0.3360 - accuracy: 0.  
8641  
Epoch 55/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3358 - accuracy: 0.  
8634  
Epoch 56/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3357 - accuracy: 0.  
8644
```

```
Epoch 57/100
250/250 [=====] - 1s 2ms/step - loss: 0.3353 - accuracy: 0.
8635
Epoch 58/100
250/250 [=====] - 1s 2ms/step - loss: 0.3352 - accuracy: 0.
8633
Epoch 59/100
250/250 [=====] - 0s 2ms/step - loss: 0.3357 - accuracy: 0.
8635
Epoch 60/100
250/250 [=====] - 1s 2ms/step - loss: 0.3353 - accuracy: 0.
8618
Epoch 61/100
250/250 [=====] - 1s 3ms/step - loss: 0.3352 - accuracy: 0.
8644
Epoch 62/100
250/250 [=====] - 1s 3ms/step - loss: 0.3349 - accuracy: 0.
8634
Epoch 63/100
250/250 [=====] - 1s 3ms/step - loss: 0.3351 - accuracy: 0.
8639
Epoch 64/100
250/250 [=====] - 1s 2ms/step - loss: 0.3347 - accuracy: 0.
8645
Epoch 65/100
250/250 [=====] - 1s 2ms/step - loss: 0.3352 - accuracy: 0.
8636
Epoch 66/100
250/250 [=====] - 1s 3ms/step - loss: 0.3351 - accuracy: 0.
8649
Epoch 67/100
250/250 [=====] - 1s 2ms/step - loss: 0.3350 - accuracy: 0.
8633
Epoch 68/100
250/250 [=====] - 1s 2ms/step - loss: 0.3344 - accuracy: 0.
8646
Epoch 69/100
250/250 [=====] - 0s 2ms/step - loss: 0.3345 - accuracy: 0.
8634
Epoch 70/100
250/250 [=====] - 0s 2ms/step - loss: 0.3345 - accuracy: 0.
8648
Epoch 71/100
250/250 [=====] - 1s 2ms/step - loss: 0.3341 - accuracy: 0.
8631
Epoch 72/100
250/250 [=====] - 1s 2ms/step - loss: 0.3344 - accuracy: 0.
8646
Epoch 73/100
250/250 [=====] - 1s 2ms/step - loss: 0.3340 - accuracy: 0.
8640
Epoch 74/100
250/250 [=====] - 1s 2ms/step - loss: 0.3345 - accuracy: 0.
8635
Epoch 75/100
250/250 [=====] - 1s 2ms/step - loss: 0.3339 - accuracy: 0.
```

```
8633
Epoch 76/100
250/250 [=====] - 1s 2ms/step - loss: 0.3338 - accuracy: 0.
8648
Epoch 77/100
250/250 [=====] - 1s 2ms/step - loss: 0.3340 - accuracy: 0.
8630
Epoch 78/100
250/250 [=====] - 1s 2ms/step - loss: 0.3343 - accuracy: 0.
8641
Epoch 79/100
250/250 [=====] - 1s 2ms/step - loss: 0.3335 - accuracy: 0.
8643
Epoch 80/100
250/250 [=====] - 1s 2ms/step - loss: 0.3338 - accuracy: 0.
8645
Epoch 81/100
250/250 [=====] - 1s 2ms/step - loss: 0.3339 - accuracy: 0.
8631
Epoch 82/100
250/250 [=====] - 1s 2ms/step - loss: 0.3336 - accuracy: 0.
8645
Epoch 83/100
250/250 [=====] - 1s 2ms/step - loss: 0.3339 - accuracy: 0.
8655
Epoch 84/100
250/250 [=====] - 1s 2ms/step - loss: 0.3332 - accuracy: 0.
8626
Epoch 85/100
250/250 [=====] - 1s 2ms/step - loss: 0.3336 - accuracy: 0.
8636
Epoch 86/100
250/250 [=====] - 1s 3ms/step - loss: 0.3332 - accuracy: 0.
8635
Epoch 87/100
250/250 [=====] - 1s 2ms/step - loss: 0.3338 - accuracy: 0.
8614
Epoch 88/100
250/250 [=====] - 1s 2ms/step - loss: 0.3330 - accuracy: 0.
8646
Epoch 89/100
250/250 [=====] - 1s 2ms/step - loss: 0.3336 - accuracy: 0.
8635
Epoch 90/100
250/250 [=====] - 1s 3ms/step - loss: 0.3333 - accuracy: 0.
8635
Epoch 91/100
250/250 [=====] - 1s 2ms/step - loss: 0.3333 - accuracy: 0.
8652
Epoch 92/100
250/250 [=====] - 0s 2ms/step - loss: 0.3332 - accuracy: 0.
8621
Epoch 93/100
250/250 [=====] - 1s 3ms/step - loss: 0.3331 - accuracy: 0.
8635
Epoch 94/100
```

```
250/250 [=====] - 1s 2ms/step - loss: 0.3331 - accuracy: 0.  
8637  
Epoch 95/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3330 - accuracy: 0.  
8625  
Epoch 96/100  
250/250 [=====] - 1s 3ms/step - loss: 0.3328 - accuracy: 0.  
8641  
Epoch 97/100  
250/250 [=====] - 0s 2ms/step - loss: 0.3330 - accuracy: 0.  
8637  
Epoch 98/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3329 - accuracy: 0.  
8639  
Epoch 99/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3327 - accuracy: 0.  
8634  
Epoch 100/100  
250/250 [=====] - 0s 2ms/step - loss: 0.3329 - accuracy: 0.  
8633  
Out[ ]: [<matplotlib.lines.Line2D at 0x20912dfc490>]
```



```
In [ ]: ann = tf.keras.models.Sequential()  
ann.add(tf.keras.layers.Dense(units=6, activation='relu'))  
ann.add(tf.keras.layers.Dense(units=6, activation='relu'))  
ann.add(tf.keras.layers.Dense(units=1, activation='sigmoid'))  
ann.compile(optimizer='adagrad', loss='binary_crossentropy', metrics=['accuracy'])  
  
adagrad_history = ann.fit(X_train, y_train, batch_size = 32, epochs = 100)  
plt.plot(adagrad_history.history['loss'])
```

```
Epoch 1/100
250/250 [=====] - 1s 3ms/step - loss: 0.6145 - accuracy: 0.
7960
Epoch 2/100
250/250 [=====] - 1s 2ms/step - loss: 0.6015 - accuracy: 0.
7960
Epoch 3/100
250/250 [=====] - 0s 2ms/step - loss: 0.5923 - accuracy: 0.
7960
Epoch 4/100
250/250 [=====] - 1s 2ms/step - loss: 0.5847 - accuracy: 0.
7960
Epoch 5/100
250/250 [=====] - 1s 2ms/step - loss: 0.5783 - accuracy: 0.
7960
Epoch 6/100
250/250 [=====] - 1s 3ms/step - loss: 0.5727 - accuracy: 0.
7960
Epoch 7/100
250/250 [=====] - 1s 3ms/step - loss: 0.5676 - accuracy: 0.
7960
Epoch 8/100
250/250 [=====] - 1s 3ms/step - loss: 0.5631 - accuracy: 0.
7960
Epoch 9/100
250/250 [=====] - 1s 2ms/step - loss: 0.5590 - accuracy: 0.
7960
Epoch 10/100
250/250 [=====] - 1s 2ms/step - loss: 0.5553 - accuracy: 0.
7960
Epoch 11/100
250/250 [=====] - 0s 2ms/step - loss: 0.5518 - accuracy: 0.
7960
Epoch 12/100
250/250 [=====] - 1s 2ms/step - loss: 0.5487 - accuracy: 0.
7960
Epoch 13/100
250/250 [=====] - 1s 2ms/step - loss: 0.5457 - accuracy: 0.
7960
Epoch 14/100
250/250 [=====] - 1s 2ms/step - loss: 0.5430 - accuracy: 0.
7960
Epoch 15/100
250/250 [=====] - 1s 2ms/step - loss: 0.5404 - accuracy: 0.
7960
Epoch 16/100
250/250 [=====] - 1s 2ms/step - loss: 0.5380 - accuracy: 0.
7960
Epoch 17/100
250/250 [=====] - 1s 2ms/step - loss: 0.5358 - accuracy: 0.
7960
Epoch 18/100
250/250 [=====] - 1s 3ms/step - loss: 0.5336 - accuracy: 0.
7960
Epoch 19/100
250/250 [=====] - 1s 2ms/step - loss: 0.5316 - accuracy: 0.
```

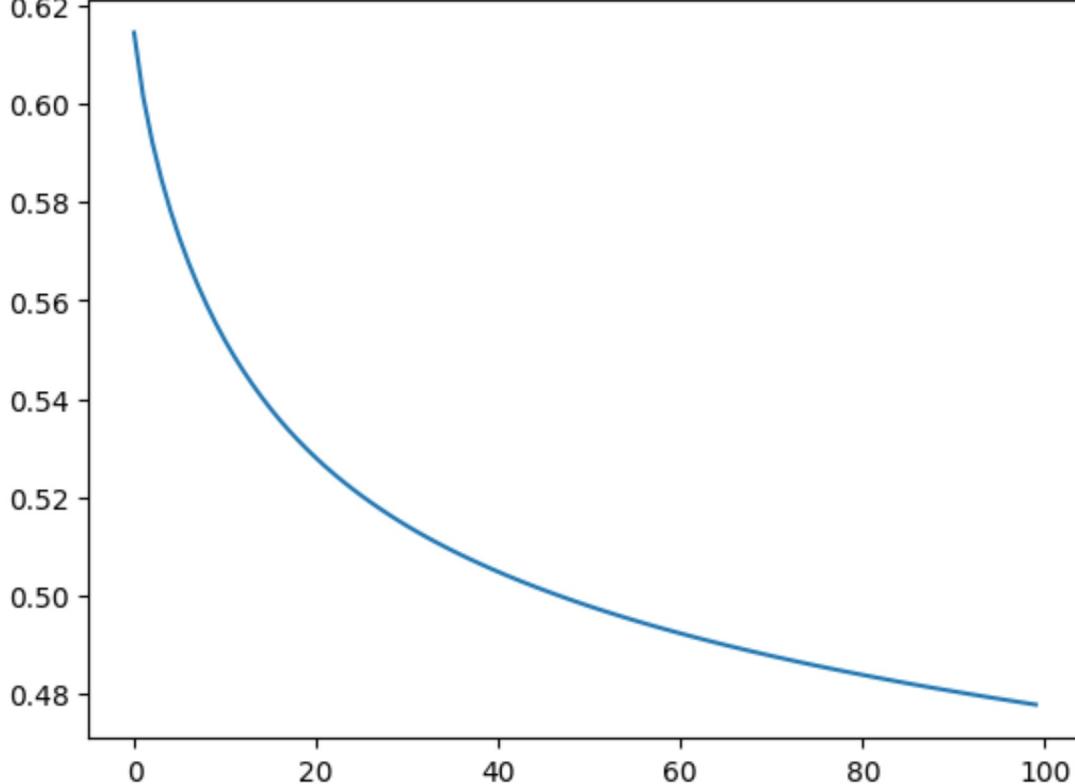
```
7960
Epoch 20/100
250/250 [=====] - 1s 2ms/step - loss: 0.5298 - accuracy: 0.
7960
Epoch 21/100
250/250 [=====] - 0s 2ms/step - loss: 0.5280 - accuracy: 0.
7960
Epoch 22/100
250/250 [=====] - 1s 2ms/step - loss: 0.5263 - accuracy: 0.
7960
Epoch 23/100
250/250 [=====] - 1s 2ms/step - loss: 0.5247 - accuracy: 0.
7960
Epoch 24/100
250/250 [=====] - 1s 2ms/step - loss: 0.5232 - accuracy: 0.
7960
Epoch 25/100
250/250 [=====] - 1s 2ms/step - loss: 0.5217 - accuracy: 0.
7960
Epoch 26/100
250/250 [=====] - 1s 2ms/step - loss: 0.5203 - accuracy: 0.
7960
Epoch 27/100
250/250 [=====] - 1s 2ms/step - loss: 0.5190 - accuracy: 0.
7960
Epoch 28/100
250/250 [=====] - 0s 2ms/step - loss: 0.5177 - accuracy: 0.
7960
Epoch 29/100
250/250 [=====] - 1s 2ms/step - loss: 0.5165 - accuracy: 0.
7960
Epoch 30/100
250/250 [=====] - 1s 3ms/step - loss: 0.5153 - accuracy: 0.
7960
Epoch 31/100
250/250 [=====] - 1s 2ms/step - loss: 0.5142 - accuracy: 0.
7960
Epoch 32/100
250/250 [=====] - 1s 3ms/step - loss: 0.5131 - accuracy: 0.
7960
Epoch 33/100
250/250 [=====] - 1s 2ms/step - loss: 0.5121 - accuracy: 0.
7960
Epoch 34/100
250/250 [=====] - 1s 2ms/step - loss: 0.5111 - accuracy: 0.
7960
Epoch 35/100
250/250 [=====] - 1s 2ms/step - loss: 0.5101 - accuracy: 0.
7960
Epoch 36/100
250/250 [=====] - 1s 2ms/step - loss: 0.5091 - accuracy: 0.
7960
Epoch 37/100
250/250 [=====] - 1s 3ms/step - loss: 0.5082 - accuracy: 0.
7960
Epoch 38/100
```

```
250/250 [=====] - 1s 2ms/step - loss: 0.5074 - accuracy: 0.  
7960  
Epoch 39/100  
250/250 [=====] - 1s 2ms/step - loss: 0.5065 - accuracy: 0.  
7960  
Epoch 40/100  
250/250 [=====] - 1s 2ms/step - loss: 0.5057 - accuracy: 0.  
7960  
Epoch 41/100  
250/250 [=====] - 1s 2ms/step - loss: 0.5049 - accuracy: 0.  
7960  
Epoch 42/100  
250/250 [=====] - 1s 2ms/step - loss: 0.5041 - accuracy: 0.  
7960  
Epoch 43/100  
250/250 [=====] - 1s 2ms/step - loss: 0.5033 - accuracy: 0.  
7960  
Epoch 44/100  
250/250 [=====] - 1s 2ms/step - loss: 0.5026 - accuracy: 0.  
7960  
Epoch 45/100  
250/250 [=====] - 1s 2ms/step - loss: 0.5019 - accuracy: 0.  
7960  
Epoch 46/100  
250/250 [=====] - 1s 3ms/step - loss: 0.5012 - accuracy: 0.  
7960  
Epoch 47/100  
250/250 [=====] - 1s 2ms/step - loss: 0.5005 - accuracy: 0.  
7960  
Epoch 48/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4998 - accuracy: 0.  
7960  
Epoch 49/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4992 - accuracy: 0.  
7960  
Epoch 50/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4985 - accuracy: 0.  
7960  
Epoch 51/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4979 - accuracy: 0.  
7960  
Epoch 52/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4973 - accuracy: 0.  
7960  
Epoch 53/100  
250/250 [=====] - 1s 3ms/step - loss: 0.4967 - accuracy: 0.  
7960  
Epoch 54/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4961 - accuracy: 0.  
7960  
Epoch 55/100  
250/250 [=====] - 0s 2ms/step - loss: 0.4955 - accuracy: 0.  
7960  
Epoch 56/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4950 - accuracy: 0.  
7960
```

```
Epoch 57/100
250/250 [=====] - 1s 2ms/step - loss: 0.4944 - accuracy: 0.
7960
Epoch 58/100
250/250 [=====] - 1s 2ms/step - loss: 0.4939 - accuracy: 0.
7960
Epoch 59/100
250/250 [=====] - 1s 2ms/step - loss: 0.4934 - accuracy: 0.
7960
Epoch 60/100
250/250 [=====] - 1s 3ms/step - loss: 0.4929 - accuracy: 0.
7960
Epoch 61/100
250/250 [=====] - 1s 2ms/step - loss: 0.4924 - accuracy: 0.
7960
Epoch 62/100
250/250 [=====] - 1s 2ms/step - loss: 0.4919 - accuracy: 0.
7960
Epoch 63/100
250/250 [=====] - 1s 2ms/step - loss: 0.4914 - accuracy: 0.
7960
Epoch 64/100
250/250 [=====] - 1s 2ms/step - loss: 0.4909 - accuracy: 0.
7960
Epoch 65/100
250/250 [=====] - 0s 2ms/step - loss: 0.4904 - accuracy: 0.
7960
Epoch 66/100
250/250 [=====] - 0s 2ms/step - loss: 0.4900 - accuracy: 0.
7960
Epoch 67/100
250/250 [=====] - 1s 2ms/step - loss: 0.4895 - accuracy: 0.
7960
Epoch 68/100
250/250 [=====] - 1s 3ms/step - loss: 0.4891 - accuracy: 0.
7960
Epoch 69/100
250/250 [=====] - 1s 2ms/step - loss: 0.4886 - accuracy: 0.
7960
Epoch 70/100
250/250 [=====] - 0s 2ms/step - loss: 0.4882 - accuracy: 0.
7960
Epoch 71/100
250/250 [=====] - 1s 2ms/step - loss: 0.4878 - accuracy: 0.
7960
Epoch 72/100
250/250 [=====] - 1s 3ms/step - loss: 0.4874 - accuracy: 0.
7960
Epoch 73/100
250/250 [=====] - 1s 2ms/step - loss: 0.4870 - accuracy: 0.
7960
Epoch 74/100
250/250 [=====] - 1s 3ms/step - loss: 0.4866 - accuracy: 0.
7960
Epoch 75/100
250/250 [=====] - 1s 2ms/step - loss: 0.4862 - accuracy: 0.
```

```
7960
Epoch 76/100
250/250 [=====] - 1s 3ms/step - loss: 0.4858 - accuracy: 0.
7960
Epoch 77/100
250/250 [=====] - 0s 2ms/step - loss: 0.4854 - accuracy: 0.
7960
Epoch 78/100
250/250 [=====] - 0s 2ms/step - loss: 0.4850 - accuracy: 0.
7960
Epoch 79/100
250/250 [=====] - 0s 2ms/step - loss: 0.4847 - accuracy: 0.
7960
Epoch 80/100
250/250 [=====] - 0s 2ms/step - loss: 0.4843 - accuracy: 0.
7960
Epoch 81/100
250/250 [=====] - 1s 2ms/step - loss: 0.4839 - accuracy: 0.
7960
Epoch 82/100
250/250 [=====] - 1s 2ms/step - loss: 0.4836 - accuracy: 0.
7960
Epoch 83/100
250/250 [=====] - 0s 2ms/step - loss: 0.4832 - accuracy: 0.
7960
Epoch 84/100
250/250 [=====] - 0s 2ms/step - loss: 0.4829 - accuracy: 0.
7960
Epoch 85/100
250/250 [=====] - 1s 2ms/step - loss: 0.4825 - accuracy: 0.
7960
Epoch 86/100
250/250 [=====] - 1s 2ms/step - loss: 0.4822 - accuracy: 0.
7960
Epoch 87/100
250/250 [=====] - 0s 2ms/step - loss: 0.4819 - accuracy: 0.
7960
Epoch 88/100
250/250 [=====] - 0s 2ms/step - loss: 0.4815 - accuracy: 0.
7960
Epoch 89/100
250/250 [=====] - 0s 2ms/step - loss: 0.4812 - accuracy: 0.
7960
Epoch 90/100
250/250 [=====] - 1s 2ms/step - loss: 0.4809 - accuracy: 0.
7960
Epoch 91/100
250/250 [=====] - 1s 3ms/step - loss: 0.4806 - accuracy: 0.
7960
Epoch 92/100
250/250 [=====] - 0s 2ms/step - loss: 0.4803 - accuracy: 0.
7960
Epoch 93/100
250/250 [=====] - 1s 2ms/step - loss: 0.4800 - accuracy: 0.
7960
Epoch 94/100
```

```
250/250 [=====] - 1s 2ms/step - loss: 0.4796 - accuracy: 0.  
7960  
Epoch 95/100  
250/250 [=====] - 1s 3ms/step - loss: 0.4793 - accuracy: 0.  
7960  
Epoch 96/100  
250/250 [=====] - 0s 2ms/step - loss: 0.4790 - accuracy: 0.  
7960  
Epoch 97/100  
250/250 [=====] - 0s 2ms/step - loss: 0.4788 - accuracy: 0.  
7960  
Epoch 98/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4785 - accuracy: 0.  
7960  
Epoch 99/100  
250/250 [=====] - 0s 2ms/step - loss: 0.4782 - accuracy: 0.  
7960  
Epoch 100/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4779 - accuracy: 0.  
7960  
Out[ ]: [<matplotlib.lines.Line2D at 0x209165cf050>]
```



```
In [ ]: ann = tf.keras.models.Sequential()  
ann.add(tf.keras.layers.Dense(units=6, activation='relu'))  
ann.add(tf.keras.layers.Dense(units=6, activation='relu'))  
ann.add(tf.keras.layers.Dense(units=1, activation='sigmoid'))  
ann.compile(optimizer = 'SGD', loss = 'binary_crossentropy', metrics = ['accuracy'])  
SGD_history = ann.fit(X_train, y_train, batch_size = 32, epochs = 100)  
plt.plot(SGD_history.history['loss'])
```

```
Epoch 1/100
250/250 [=====] - 1s 2ms/step - loss: 0.5581 - accuracy: 0.
7960
Epoch 2/100
250/250 [=====] - 1s 2ms/step - loss: 0.5068 - accuracy: 0.
7960
Epoch 3/100
250/250 [=====] - 0s 2ms/step - loss: 0.4879 - accuracy: 0.
7960
Epoch 4/100
250/250 [=====] - 1s 2ms/step - loss: 0.4775 - accuracy: 0.
7960
Epoch 5/100
250/250 [=====] - 0s 2ms/step - loss: 0.4699 - accuracy: 0.
7960
Epoch 6/100
250/250 [=====] - 0s 2ms/step - loss: 0.4637 - accuracy: 0.
7960
Epoch 7/100
250/250 [=====] - 0s 2ms/step - loss: 0.4585 - accuracy: 0.
7960
Epoch 8/100
250/250 [=====] - 1s 2ms/step - loss: 0.4540 - accuracy: 0.
7960
Epoch 9/100
250/250 [=====] - 1s 2ms/step - loss: 0.4502 - accuracy: 0.
7960
Epoch 10/100
250/250 [=====] - 0s 2ms/step - loss: 0.4468 - accuracy: 0.
7960
Epoch 11/100
250/250 [=====] - 1s 2ms/step - loss: 0.4440 - accuracy: 0.
7960
Epoch 12/100
250/250 [=====] - 1s 2ms/step - loss: 0.4416 - accuracy: 0.
7960
Epoch 13/100
250/250 [=====] - 1s 2ms/step - loss: 0.4396 - accuracy: 0.
7960
Epoch 14/100
250/250 [=====] - 1s 2ms/step - loss: 0.4378 - accuracy: 0.
7960
Epoch 15/100
250/250 [=====] - 1s 2ms/step - loss: 0.4362 - accuracy: 0.
7960
Epoch 16/100
250/250 [=====] - 1s 2ms/step - loss: 0.4348 - accuracy: 0.
7960
Epoch 17/100
250/250 [=====] - 0s 2ms/step - loss: 0.4335 - accuracy: 0.
7960
Epoch 18/100
250/250 [=====] - 1s 2ms/step - loss: 0.4324 - accuracy: 0.
7960
Epoch 19/100
250/250 [=====] - 1s 2ms/step - loss: 0.4313 - accuracy: 0.
```

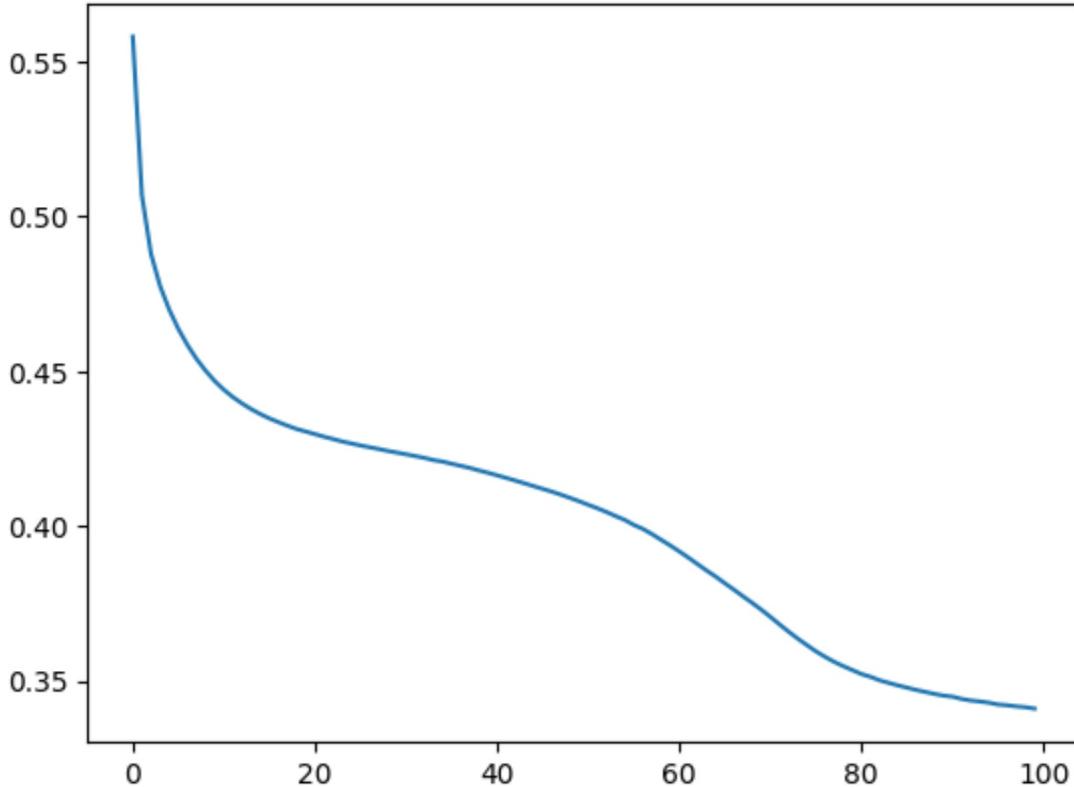
```
7960
Epoch 20/100
250/250 [=====] - 1s 2ms/step - loss: 0.4305 - accuracy: 0.
7960
Epoch 21/100
250/250 [=====] - 1s 2ms/step - loss: 0.4297 - accuracy: 0.
7960
Epoch 22/100
250/250 [=====] - 1s 3ms/step - loss: 0.4288 - accuracy: 0.
7960
Epoch 23/100
250/250 [=====] - 0s 2ms/step - loss: 0.4281 - accuracy: 0.
7960
Epoch 24/100
250/250 [=====] - 1s 2ms/step - loss: 0.4273 - accuracy: 0.
7960
Epoch 25/100
250/250 [=====] - 1s 2ms/step - loss: 0.4267 - accuracy: 0.
7960
Epoch 26/100
250/250 [=====] - 1s 2ms/step - loss: 0.4260 - accuracy: 0.
7960
Epoch 27/100
250/250 [=====] - 1s 2ms/step - loss: 0.4254 - accuracy: 0.
7960
Epoch 28/100
250/250 [=====] - 1s 2ms/step - loss: 0.4249 - accuracy: 0.
8012
Epoch 29/100
250/250 [=====] - 1s 2ms/step - loss: 0.4243 - accuracy: 0.
8048
Epoch 30/100
250/250 [=====] - 1s 2ms/step - loss: 0.4237 - accuracy: 0.
8062
Epoch 31/100
250/250 [=====] - 1s 2ms/step - loss: 0.4232 - accuracy: 0.
8066
Epoch 32/100
250/250 [=====] - 1s 2ms/step - loss: 0.4226 - accuracy: 0.
8074
Epoch 33/100
250/250 [=====] - 1s 2ms/step - loss: 0.4220 - accuracy: 0.
8094
Epoch 34/100
250/250 [=====] - 1s 2ms/step - loss: 0.4213 - accuracy: 0.
8095
Epoch 35/100
250/250 [=====] - 1s 2ms/step - loss: 0.4208 - accuracy: 0.
8115
Epoch 36/100
250/250 [=====] - 0s 2ms/step - loss: 0.4201 - accuracy: 0.
8119
Epoch 37/100
250/250 [=====] - 0s 2ms/step - loss: 0.4195 - accuracy: 0.
8119
Epoch 38/100
```

```
250/250 [=====] - 1s 2ms/step - loss: 0.4188 - accuracy: 0.  
8129  
Epoch 39/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4180 - accuracy: 0.  
8146  
Epoch 40/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4172 - accuracy: 0.  
8148  
Epoch 41/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4164 - accuracy: 0.  
8164  
Epoch 42/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4155 - accuracy: 0.  
8186  
Epoch 43/100  
250/250 [=====] - 1s 3ms/step - loss: 0.4147 - accuracy: 0.  
8183  
Epoch 44/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4138 - accuracy: 0.  
8194  
Epoch 45/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4129 - accuracy: 0.  
8206  
Epoch 46/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4120 - accuracy: 0.  
8213  
Epoch 47/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4111 - accuracy: 0.  
8234  
Epoch 48/100  
250/250 [=====] - 0s 2ms/step - loss: 0.4101 - accuracy: 0.  
8239  
Epoch 49/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4091 - accuracy: 0.  
8245  
Epoch 50/100  
250/250 [=====] - 1s 3ms/step - loss: 0.4080 - accuracy: 0.  
8256  
Epoch 51/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4069 - accuracy: 0.  
8274  
Epoch 52/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4057 - accuracy: 0.  
8280  
Epoch 53/100  
250/250 [=====] - 0s 2ms/step - loss: 0.4045 - accuracy: 0.  
8304  
Epoch 54/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4032 - accuracy: 0.  
8307  
Epoch 55/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4020 - accuracy: 0.  
8309  
Epoch 56/100  
250/250 [=====] - 1s 3ms/step - loss: 0.4004 - accuracy: 0.  
8300
```

```
Epoch 57/100
250/250 [=====] - 1s 2ms/step - loss: 0.3991 - accuracy: 0.
8320
Epoch 58/100
250/250 [=====] - 1s 2ms/step - loss: 0.3974 - accuracy: 0.
8329
Epoch 59/100
250/250 [=====] - 1s 2ms/step - loss: 0.3955 - accuracy: 0.
8338
Epoch 60/100
250/250 [=====] - 1s 2ms/step - loss: 0.3937 - accuracy: 0.
8346
Epoch 61/100
250/250 [=====] - 1s 2ms/step - loss: 0.3918 - accuracy: 0.
8357
Epoch 62/100
250/250 [=====] - 1s 2ms/step - loss: 0.3898 - accuracy: 0.
8375
Epoch 63/100
250/250 [=====] - 1s 2ms/step - loss: 0.3877 - accuracy: 0.
8385
Epoch 64/100
250/250 [=====] - 1s 2ms/step - loss: 0.3856 - accuracy: 0.
8395
Epoch 65/100
250/250 [=====] - 1s 3ms/step - loss: 0.3836 - accuracy: 0.
8413
Epoch 66/100
250/250 [=====] - 1s 3ms/step - loss: 0.3815 - accuracy: 0.
8425
Epoch 67/100
250/250 [=====] - 1s 2ms/step - loss: 0.3794 - accuracy: 0.
8439
Epoch 68/100
250/250 [=====] - 1s 2ms/step - loss: 0.3772 - accuracy: 0.
8466
Epoch 69/100
250/250 [=====] - 1s 3ms/step - loss: 0.3752 - accuracy: 0.
8469
Epoch 70/100
250/250 [=====] - 1s 2ms/step - loss: 0.3730 - accuracy: 0.
8478
Epoch 71/100
250/250 [=====] - 1s 2ms/step - loss: 0.3706 - accuracy: 0.
8482
Epoch 72/100
250/250 [=====] - 1s 2ms/step - loss: 0.3682 - accuracy: 0.
8495
Epoch 73/100
250/250 [=====] - 0s 2ms/step - loss: 0.3659 - accuracy: 0.
8505
Epoch 74/100
250/250 [=====] - 1s 2ms/step - loss: 0.3636 - accuracy: 0.
8526
Epoch 75/100
250/250 [=====] - 1s 2ms/step - loss: 0.3615 - accuracy: 0.
```

```
8540
Epoch 76/100
250/250 [=====] - 1s 2ms/step - loss: 0.3595 - accuracy: 0.
8551
Epoch 77/100
250/250 [=====] - 0s 2ms/step - loss: 0.3577 - accuracy: 0.
8556
Epoch 78/100
250/250 [=====] - 0s 2ms/step - loss: 0.3561 - accuracy: 0.
8570
Epoch 79/100
250/250 [=====] - 1s 2ms/step - loss: 0.3547 - accuracy: 0.
8566
Epoch 80/100
250/250 [=====] - 1s 2ms/step - loss: 0.3534 - accuracy: 0.
8580
Epoch 81/100
250/250 [=====] - 1s 2ms/step - loss: 0.3522 - accuracy: 0.
8583
Epoch 82/100
250/250 [=====] - 1s 2ms/step - loss: 0.3513 - accuracy: 0.
8584
Epoch 83/100
250/250 [=====] - 0s 2ms/step - loss: 0.3501 - accuracy: 0.
8586
Epoch 84/100
250/250 [=====] - 0s 2ms/step - loss: 0.3493 - accuracy: 0.
8594
Epoch 85/100
250/250 [=====] - 0s 2ms/step - loss: 0.3485 - accuracy: 0.
8602
Epoch 86/100
250/250 [=====] - 1s 2ms/step - loss: 0.3478 - accuracy: 0.
8600
Epoch 87/100
250/250 [=====] - 0s 2ms/step - loss: 0.3470 - accuracy: 0.
8600
Epoch 88/100
250/250 [=====] - 1s 2ms/step - loss: 0.3464 - accuracy: 0.
8616
Epoch 89/100
250/250 [=====] - 1s 2ms/step - loss: 0.3458 - accuracy: 0.
8612
Epoch 90/100
250/250 [=====] - 1s 2ms/step - loss: 0.3452 - accuracy: 0.
8612
Epoch 91/100
250/250 [=====] - 1s 2ms/step - loss: 0.3449 - accuracy: 0.
8614
Epoch 92/100
250/250 [=====] - 1s 2ms/step - loss: 0.3441 - accuracy: 0.
8619
Epoch 93/100
250/250 [=====] - 1s 2ms/step - loss: 0.3436 - accuracy: 0.
8621
Epoch 94/100
```

```
250/250 [=====] - 0s 2ms/step - loss: 0.3433 - accuracy: 0.  
8625  
Epoch 95/100  
250/250 [=====] - 0s 2ms/step - loss: 0.3429 - accuracy: 0.  
8625  
Epoch 96/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3423 - accuracy: 0.  
8627  
Epoch 97/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3421 - accuracy: 0.  
8624  
Epoch 98/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3417 - accuracy: 0.  
8631  
Epoch 99/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3415 - accuracy: 0.  
8630  
Epoch 100/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3410 - accuracy: 0.  
8636  
Out[ ]: <matplotlib.lines.Line2D at 0x20918bdbc90>
```



```
In [ ]: ann = tf.keras.models.Sequential()  
ann.add(tf.keras.layers.Dense(units=6, activation='relu'))  
ann.add(tf.keras.layers.Dense(units=6, activation='relu'))  
ann.add(tf.keras.layers.Dense(units=1, activation='sigmoid'))  
ann.compile(optimizer = 'RMSprop', loss = 'binary_crossentropy', metrics = ['accuracy'])  
RMSprop_history = ann.fit(X_train, y_train, batch_size = 32, epochs = 100)  
plt.plot(RMSprop_history.history['loss'])
```

```
Epoch 1/100
250/250 [=====] - 1s 2ms/step - loss: 0.5620 - accuracy: 0.
7930
Epoch 2/100
250/250 [=====] - 1s 3ms/step - loss: 0.4876 - accuracy: 0.
7960
Epoch 3/100
250/250 [=====] - 0s 2ms/step - loss: 0.4666 - accuracy: 0.
7960
Epoch 4/100
250/250 [=====] - 0s 2ms/step - loss: 0.4523 - accuracy: 0.
7960
Epoch 5/100
250/250 [=====] - 1s 2ms/step - loss: 0.4427 - accuracy: 0.
7960
Epoch 6/100
250/250 [=====] - 1s 2ms/step - loss: 0.4359 - accuracy: 0.
7960
Epoch 7/100
250/250 [=====] - 1s 2ms/step - loss: 0.4315 - accuracy: 0.
7996
Epoch 8/100
250/250 [=====] - 1s 2ms/step - loss: 0.4282 - accuracy: 0.
8121
Epoch 9/100
250/250 [=====] - 1s 2ms/step - loss: 0.4254 - accuracy: 0.
8167
Epoch 10/100
250/250 [=====] - 1s 3ms/step - loss: 0.4226 - accuracy: 0.
8186
Epoch 11/100
250/250 [=====] - 1s 2ms/step - loss: 0.4198 - accuracy: 0.
8236
Epoch 12/100
250/250 [=====] - 1s 2ms/step - loss: 0.4169 - accuracy: 0.
8246
Epoch 13/100
250/250 [=====] - 1s 2ms/step - loss: 0.4143 - accuracy: 0.
8275
Epoch 14/100
250/250 [=====] - 1s 2ms/step - loss: 0.4119 - accuracy: 0.
8279
Epoch 15/100
250/250 [=====] - 0s 2ms/step - loss: 0.4099 - accuracy: 0.
8310
Epoch 16/100
250/250 [=====] - 0s 2ms/step - loss: 0.4080 - accuracy: 0.
8311
Epoch 17/100
250/250 [=====] - 0s 2ms/step - loss: 0.4065 - accuracy: 0.
8331
Epoch 18/100
250/250 [=====] - 1s 2ms/step - loss: 0.4053 - accuracy: 0.
8326
Epoch 19/100
250/250 [=====] - 0s 2ms/step - loss: 0.4043 - accuracy: 0.
```

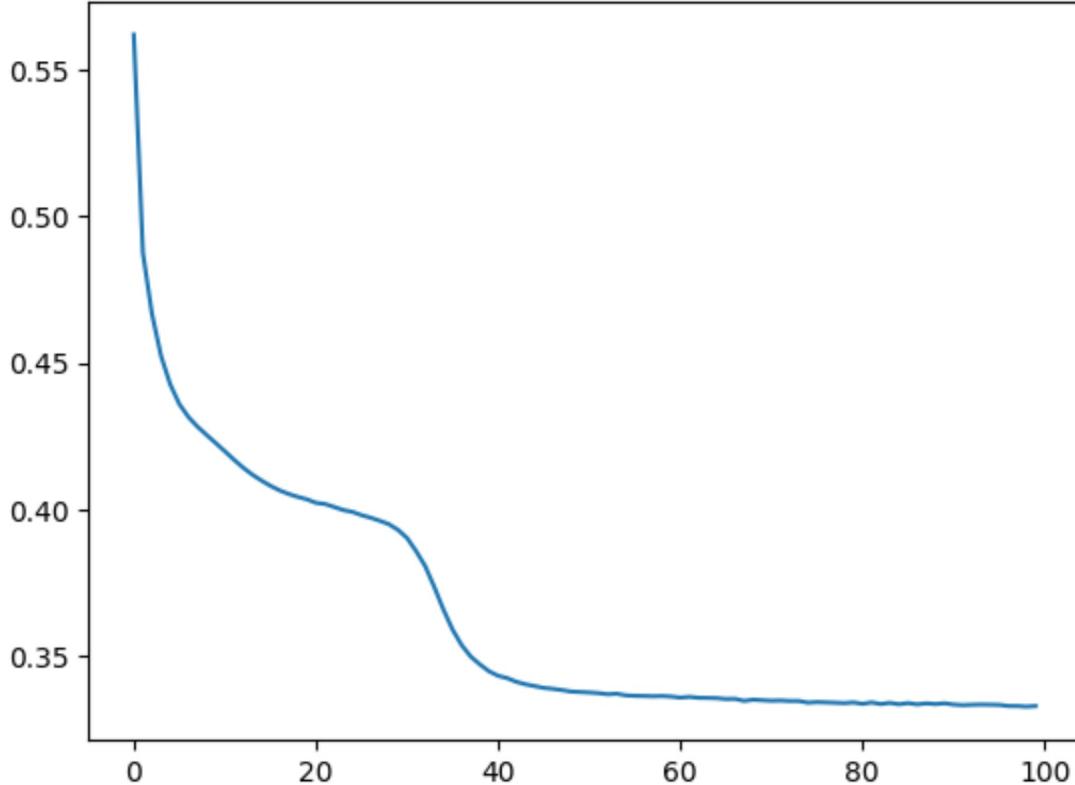
```
8332
Epoch 20/100
250/250 [=====] - 0s 2ms/step - loss: 0.4034 - accuracy: 0.
8320
Epoch 21/100
250/250 [=====] - 1s 2ms/step - loss: 0.4022 - accuracy: 0.
8336
Epoch 22/100
250/250 [=====] - 1s 2ms/step - loss: 0.4018 - accuracy: 0.
8339
Epoch 23/100
250/250 [=====] - 0s 2ms/step - loss: 0.4008 - accuracy: 0.
8346
Epoch 24/100
250/250 [=====] - 0s 2ms/step - loss: 0.3998 - accuracy: 0.
8332
Epoch 25/100
250/250 [=====] - 1s 2ms/step - loss: 0.3991 - accuracy: 0.
8338
Epoch 26/100
250/250 [=====] - 1s 2ms/step - loss: 0.3980 - accuracy: 0.
8321
Epoch 27/100
250/250 [=====] - 1s 2ms/step - loss: 0.3971 - accuracy: 0.
8353
Epoch 28/100
250/250 [=====] - 1s 2ms/step - loss: 0.3961 - accuracy: 0.
8332
Epoch 29/100
250/250 [=====] - 0s 2ms/step - loss: 0.3949 - accuracy: 0.
8351
Epoch 30/100
250/250 [=====] - 1s 2ms/step - loss: 0.3930 - accuracy: 0.
8353
Epoch 31/100
250/250 [=====] - 1s 2ms/step - loss: 0.3902 - accuracy: 0.
8399
Epoch 32/100
250/250 [=====] - 1s 2ms/step - loss: 0.3857 - accuracy: 0.
8403
Epoch 33/100
250/250 [=====] - 0s 2ms/step - loss: 0.3806 - accuracy: 0.
8413
Epoch 34/100
250/250 [=====] - 1s 2ms/step - loss: 0.3734 - accuracy: 0.
8470
Epoch 35/100
250/250 [=====] - 1s 2ms/step - loss: 0.3657 - accuracy: 0.
8511
Epoch 36/100
250/250 [=====] - 1s 2ms/step - loss: 0.3589 - accuracy: 0.
8565
Epoch 37/100
250/250 [=====] - 1s 2ms/step - loss: 0.3536 - accuracy: 0.
8570
Epoch 38/100
```

```
250/250 [=====] - 1s 2ms/step - loss: 0.3497 - accuracy: 0.  
8589  
Epoch 39/100  
250/250 [=====] - 0s 2ms/step - loss: 0.3471 - accuracy: 0.  
8571  
Epoch 40/100  
250/250 [=====] - 0s 2ms/step - loss: 0.3447 - accuracy: 0.  
8583  
Epoch 41/100  
250/250 [=====] - 0s 2ms/step - loss: 0.3432 - accuracy: 0.  
8590  
Epoch 42/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3424 - accuracy: 0.  
8589  
Epoch 43/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3411 - accuracy: 0.  
8579  
Epoch 44/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3403 - accuracy: 0.  
8600  
Epoch 45/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3397 - accuracy: 0.  
8605  
Epoch 46/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3391 - accuracy: 0.  
8619  
Epoch 47/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3387 - accuracy: 0.  
8621  
Epoch 48/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3383 - accuracy: 0.  
8596  
Epoch 49/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3378 - accuracy: 0.  
8618  
Epoch 50/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3377 - accuracy: 0.  
8608  
Epoch 51/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3375 - accuracy: 0.  
8616  
Epoch 52/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3373 - accuracy: 0.  
8615  
Epoch 53/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3369 - accuracy: 0.  
8622  
Epoch 54/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3371 - accuracy: 0.  
8614  
Epoch 55/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3365 - accuracy: 0.  
8610  
Epoch 56/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3364 - accuracy: 0.  
8624
```

```
Epoch 57/100
250/250 [=====] - 1s 2ms/step - loss: 0.3363 - accuracy: 0.
8624
Epoch 58/100
250/250 [=====] - 0s 2ms/step - loss: 0.3362 - accuracy: 0.
8612
Epoch 59/100
250/250 [=====] - 0s 2ms/step - loss: 0.3363 - accuracy: 0.
8622
Epoch 60/100
250/250 [=====] - 0s 2ms/step - loss: 0.3361 - accuracy: 0.
8619
Epoch 61/100
250/250 [=====] - 1s 2ms/step - loss: 0.3357 - accuracy: 0.
8599
Epoch 62/100
250/250 [=====] - 1s 2ms/step - loss: 0.3360 - accuracy: 0.
8616
Epoch 63/100
250/250 [=====] - 1s 2ms/step - loss: 0.3357 - accuracy: 0.
8619
Epoch 64/100
250/250 [=====] - 1s 2ms/step - loss: 0.3356 - accuracy: 0.
8611
Epoch 65/100
250/250 [=====] - 1s 2ms/step - loss: 0.3356 - accuracy: 0.
8615
Epoch 66/100
250/250 [=====] - 1s 2ms/step - loss: 0.3353 - accuracy: 0.
8627
Epoch 67/100
250/250 [=====] - 1s 2ms/step - loss: 0.3353 - accuracy: 0.
8611
Epoch 68/100
250/250 [=====] - 1s 2ms/step - loss: 0.3346 - accuracy: 0.
8622
Epoch 69/100
250/250 [=====] - 1s 2ms/step - loss: 0.3350 - accuracy: 0.
8625
Epoch 70/100
250/250 [=====] - 1s 2ms/step - loss: 0.3348 - accuracy: 0.
8625
Epoch 71/100
250/250 [=====] - 1s 2ms/step - loss: 0.3347 - accuracy: 0.
8612
Epoch 72/100
250/250 [=====] - 0s 2ms/step - loss: 0.3348 - accuracy: 0.
8624
Epoch 73/100
250/250 [=====] - 1s 2ms/step - loss: 0.3346 - accuracy: 0.
8608
Epoch 74/100
250/250 [=====] - 1s 2ms/step - loss: 0.3346 - accuracy: 0.
8635
Epoch 75/100
250/250 [=====] - 1s 2ms/step - loss: 0.3340 - accuracy: 0.
```

```
8626
Epoch 76/100
250/250 [=====] - 1s 2ms/step - loss: 0.3342 - accuracy: 0.
8635
Epoch 77/100
250/250 [=====] - 1s 2ms/step - loss: 0.3341 - accuracy: 0.
8630
Epoch 78/100
250/250 [=====] - 1s 2ms/step - loss: 0.3340 - accuracy: 0.
8631
Epoch 79/100
250/250 [=====] - 1s 2ms/step - loss: 0.3338 - accuracy: 0.
8631
Epoch 80/100
250/250 [=====] - 1s 2ms/step - loss: 0.3341 - accuracy: 0.
8621
Epoch 81/100
250/250 [=====] - 1s 2ms/step - loss: 0.3336 - accuracy: 0.
8624
Epoch 82/100
250/250 [=====] - 0s 2ms/step - loss: 0.3341 - accuracy: 0.
8624
Epoch 83/100
250/250 [=====] - 0s 2ms/step - loss: 0.3335 - accuracy: 0.
8634
Epoch 84/100
250/250 [=====] - 0s 2ms/step - loss: 0.3339 - accuracy: 0.
8630
Epoch 85/100
250/250 [=====] - 0s 2ms/step - loss: 0.3335 - accuracy: 0.
8639
Epoch 86/100
250/250 [=====] - 1s 2ms/step - loss: 0.3339 - accuracy: 0.
8629
Epoch 87/100
250/250 [=====] - 1s 2ms/step - loss: 0.3334 - accuracy: 0.
8637
Epoch 88/100
250/250 [=====] - 1s 2ms/step - loss: 0.3338 - accuracy: 0.
8624
Epoch 89/100
250/250 [=====] - 1s 2ms/step - loss: 0.3335 - accuracy: 0.
8626
Epoch 90/100
250/250 [=====] - 1s 2ms/step - loss: 0.3338 - accuracy: 0.
8637
Epoch 91/100
250/250 [=====] - 1s 2ms/step - loss: 0.3334 - accuracy: 0.
8637
Epoch 92/100
250/250 [=====] - 1s 2ms/step - loss: 0.3332 - accuracy: 0.
8636
Epoch 93/100
250/250 [=====] - 1s 2ms/step - loss: 0.3333 - accuracy: 0.
8640
Epoch 94/100
```

```
250/250 [=====] - 0s 2ms/step - loss: 0.3334 - accuracy: 0.  
8629  
Epoch 95/100  
250/250 [=====] - 0s 2ms/step - loss: 0.3333 - accuracy: 0.  
8633  
Epoch 96/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3333 - accuracy: 0.  
8648  
Epoch 97/100  
250/250 [=====] - 0s 2ms/step - loss: 0.3329 - accuracy: 0.  
8630  
Epoch 98/100  
250/250 [=====] - 0s 2ms/step - loss: 0.3329 - accuracy: 0.  
8643  
Epoch 99/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3327 - accuracy: 0.  
8655  
Epoch 100/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3329 - accuracy: 0.  
8661  
Out[ ]: [<matplotlib.lines.Line2D at 0x2091e469390>]
```



```
In [ ]: ann = tf.keras.models.Sequential()  
ann.add(tf.keras.layers.Dense(units=6, activation='relu'))  
ann.add(tf.keras.layers.Dense(units=6, activation='relu'))  
ann.add(tf.keras.layers.Dense(units=1, activation='sigmoid'))  
ann.compile(optimizer = 'Nadam', loss = 'binary_crossentropy', metrics = ['accuracy'])  
Nadam_history = ann.fit(X_train, y_train, batch_size = 32, epochs = 100)  
plt.plot(Nadam_history.history['loss'])
```

```
Epoch 1/100
250/250 [=====] - 2s 2ms/step - loss: 0.4969 - accuracy: 0.
7859
Epoch 2/100
250/250 [=====] - 1s 2ms/step - loss: 0.4512 - accuracy: 0.
7960
Epoch 3/100
250/250 [=====] - 1s 2ms/step - loss: 0.4388 - accuracy: 0.
7960
Epoch 4/100
250/250 [=====] - 1s 2ms/step - loss: 0.4323 - accuracy: 0.
7981
Epoch 5/100
250/250 [=====] - 0s 2ms/step - loss: 0.4284 - accuracy: 0.
8081
Epoch 6/100
250/250 [=====] - 1s 3ms/step - loss: 0.4265 - accuracy: 0.
8106
Epoch 7/100
250/250 [=====] - 1s 2ms/step - loss: 0.4244 - accuracy: 0.
8126
Epoch 8/100
250/250 [=====] - 1s 2ms/step - loss: 0.4227 - accuracy: 0.
8149
Epoch 9/100
250/250 [=====] - 1s 2ms/step - loss: 0.4211 - accuracy: 0.
8163
Epoch 10/100
250/250 [=====] - 1s 2ms/step - loss: 0.4195 - accuracy: 0.
8179
Epoch 11/100
250/250 [=====] - 1s 2ms/step - loss: 0.4182 - accuracy: 0.
8195
Epoch 12/100
250/250 [=====] - 1s 2ms/step - loss: 0.4169 - accuracy: 0.
8196
Epoch 13/100
250/250 [=====] - 1s 2ms/step - loss: 0.4157 - accuracy: 0.
8216
Epoch 14/100
250/250 [=====] - 1s 2ms/step - loss: 0.4146 - accuracy: 0.
8220
Epoch 15/100
250/250 [=====] - 1s 2ms/step - loss: 0.4137 - accuracy: 0.
8235
Epoch 16/100
250/250 [=====] - 0s 2ms/step - loss: 0.4130 - accuracy: 0.
8249
Epoch 17/100
250/250 [=====] - 1s 2ms/step - loss: 0.4121 - accuracy: 0.
8261
Epoch 18/100
250/250 [=====] - 1s 2ms/step - loss: 0.4114 - accuracy: 0.
8261
Epoch 19/100
250/250 [=====] - 1s 2ms/step - loss: 0.4108 - accuracy: 0.
```

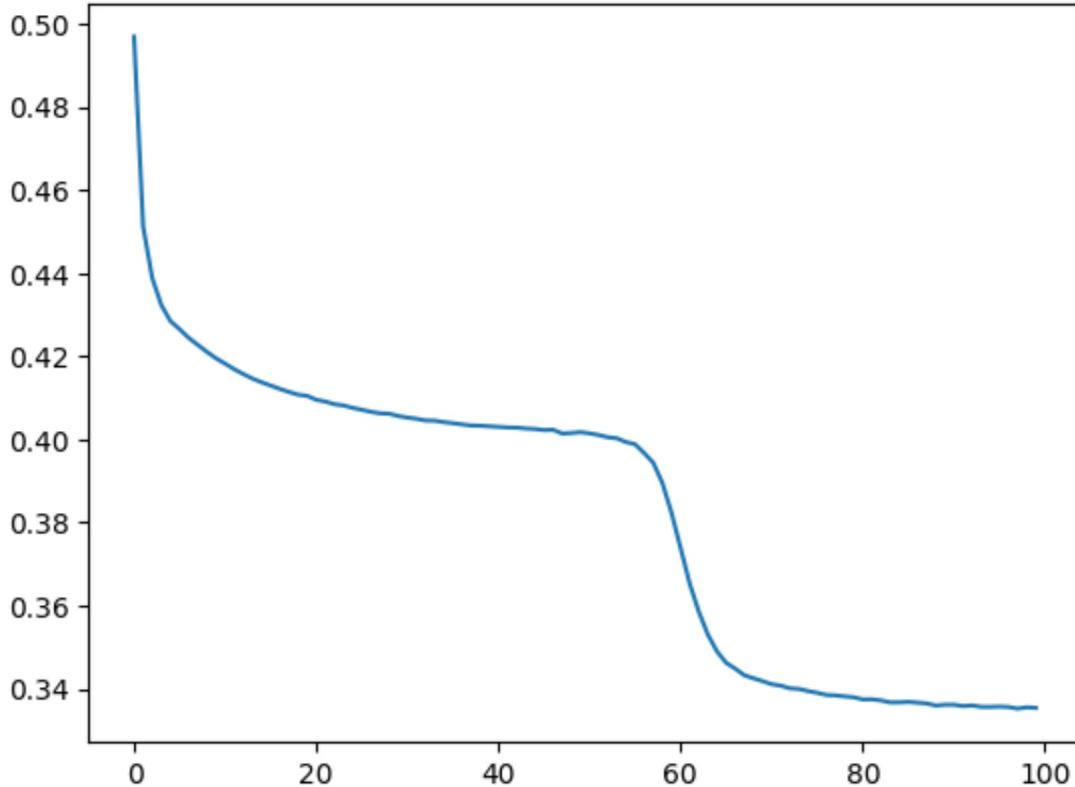
```
8266
Epoch 20/100
250/250 [=====] - 1s 2ms/step - loss: 0.4105 - accuracy: 0.
8270
Epoch 21/100
250/250 [=====] - 1s 2ms/step - loss: 0.4095 - accuracy: 0.
8267
Epoch 22/100
250/250 [=====] - 0s 2ms/step - loss: 0.4091 - accuracy: 0.
8278
Epoch 23/100
250/250 [=====] - 0s 2ms/step - loss: 0.4085 - accuracy: 0.
8282
Epoch 24/100
250/250 [=====] - 1s 2ms/step - loss: 0.4082 - accuracy: 0.
8288
Epoch 25/100
250/250 [=====] - 1s 2ms/step - loss: 0.4076 - accuracy: 0.
8300
Epoch 26/100
250/250 [=====] - 1s 2ms/step - loss: 0.4071 - accuracy: 0.
8295
Epoch 27/100
250/250 [=====] - 1s 2ms/step - loss: 0.4066 - accuracy: 0.
8291
Epoch 28/100
250/250 [=====] - 1s 2ms/step - loss: 0.4063 - accuracy: 0.
8325
Epoch 29/100
250/250 [=====] - 1s 2ms/step - loss: 0.4062 - accuracy: 0.
8305
Epoch 30/100
250/250 [=====] - 1s 2ms/step - loss: 0.4056 - accuracy: 0.
8316
Epoch 31/100
250/250 [=====] - 0s 2ms/step - loss: 0.4053 - accuracy: 0.
8314
Epoch 32/100
250/250 [=====] - 0s 2ms/step - loss: 0.4050 - accuracy: 0.
8329
Epoch 33/100
250/250 [=====] - 1s 2ms/step - loss: 0.4046 - accuracy: 0.
8331
Epoch 34/100
250/250 [=====] - 1s 2ms/step - loss: 0.4045 - accuracy: 0.
8320
Epoch 35/100
250/250 [=====] - 1s 2ms/step - loss: 0.4042 - accuracy: 0.
8340
Epoch 36/100
250/250 [=====] - 1s 2ms/step - loss: 0.4039 - accuracy: 0.
8329
Epoch 37/100
250/250 [=====] - 0s 2ms/step - loss: 0.4036 - accuracy: 0.
8340
Epoch 38/100
```

```
250/250 [=====] - 1s 2ms/step - loss: 0.4033 - accuracy: 0.  
8328  
Epoch 39/100  
250/250 [=====] - 1s 3ms/step - loss: 0.4033 - accuracy: 0.  
8354  
Epoch 40/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4031 - accuracy: 0.  
8346  
Epoch 41/100  
250/250 [=====] - 0s 2ms/step - loss: 0.4030 - accuracy: 0.  
8347  
Epoch 42/100  
250/250 [=====] - 0s 2ms/step - loss: 0.4029 - accuracy: 0.  
8332  
Epoch 43/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4028 - accuracy: 0.  
8344  
Epoch 44/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4026 - accuracy: 0.  
8340  
Epoch 45/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4025 - accuracy: 0.  
8353  
Epoch 46/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4022 - accuracy: 0.  
8356  
Epoch 47/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4023 - accuracy: 0.  
8350  
Epoch 48/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4014 - accuracy: 0.  
8359  
Epoch 49/100  
250/250 [=====] - 0s 2ms/step - loss: 0.4015 - accuracy: 0.  
8356  
Epoch 50/100  
250/250 [=====] - 0s 2ms/step - loss: 0.4017 - accuracy: 0.  
8361  
Epoch 51/100  
250/250 [=====] - 0s 2ms/step - loss: 0.4015 - accuracy: 0.  
8356  
Epoch 52/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4010 - accuracy: 0.  
8351  
Epoch 53/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4005 - accuracy: 0.  
8361  
Epoch 54/100  
250/250 [=====] - 1s 2ms/step - loss: 0.4003 - accuracy: 0.  
8347  
Epoch 55/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3994 - accuracy: 0.  
8342  
Epoch 56/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3988 - accuracy: 0.  
8338
```

```
Epoch 57/100
250/250 [=====] - 1s 2ms/step - loss: 0.3967 - accuracy: 0.
8349
Epoch 58/100
250/250 [=====] - 1s 2ms/step - loss: 0.3944 - accuracy: 0.
8350
Epoch 59/100
250/250 [=====] - 1s 2ms/step - loss: 0.3895 - accuracy: 0.
8376
Epoch 60/100
250/250 [=====] - 1s 2ms/step - loss: 0.3824 - accuracy: 0.
8418
Epoch 61/100
250/250 [=====] - 1s 2ms/step - loss: 0.3739 - accuracy: 0.
8510
Epoch 62/100
250/250 [=====] - 1s 2ms/step - loss: 0.3653 - accuracy: 0.
8553
Epoch 63/100
250/250 [=====] - 1s 2ms/step - loss: 0.3586 - accuracy: 0.
8566
Epoch 64/100
250/250 [=====] - 1s 2ms/step - loss: 0.3530 - accuracy: 0.
8586
Epoch 65/100
250/250 [=====] - 1s 2ms/step - loss: 0.3490 - accuracy: 0.
8589
Epoch 66/100
250/250 [=====] - 1s 3ms/step - loss: 0.3463 - accuracy: 0.
8605
Epoch 67/100
250/250 [=====] - 1s 2ms/step - loss: 0.3449 - accuracy: 0.
8590
Epoch 68/100
250/250 [=====] - 1s 2ms/step - loss: 0.3433 - accuracy: 0.
8600
Epoch 69/100
250/250 [=====] - 0s 2ms/step - loss: 0.3425 - accuracy: 0.
8606
Epoch 70/100
250/250 [=====] - 1s 2ms/step - loss: 0.3419 - accuracy: 0.
8614
Epoch 71/100
250/250 [=====] - 0s 2ms/step - loss: 0.3411 - accuracy: 0.
8616
Epoch 72/100
250/250 [=====] - 0s 2ms/step - loss: 0.3408 - accuracy: 0.
8620
Epoch 73/100
250/250 [=====] - 0s 2ms/step - loss: 0.3401 - accuracy: 0.
8629
Epoch 74/100
250/250 [=====] - 1s 2ms/step - loss: 0.3400 - accuracy: 0.
8629
Epoch 75/100
250/250 [=====] - 1s 2ms/step - loss: 0.3395 - accuracy: 0.
```

```
8629
Epoch 76/100
250/250 [=====] - 1s 2ms/step - loss: 0.3390 - accuracy: 0.
8641
Epoch 77/100
250/250 [=====] - 1s 2ms/step - loss: 0.3385 - accuracy: 0.
8626
Epoch 78/100
250/250 [=====] - 0s 2ms/step - loss: 0.3384 - accuracy: 0.
8637
Epoch 79/100
250/250 [=====] - 1s 2ms/step - loss: 0.3382 - accuracy: 0.
8639
Epoch 80/100
250/250 [=====] - 1s 2ms/step - loss: 0.3380 - accuracy: 0.
8630
Epoch 81/100
250/250 [=====] - 1s 2ms/step - loss: 0.3375 - accuracy: 0.
8636
Epoch 82/100
250/250 [=====] - 1s 2ms/step - loss: 0.3375 - accuracy: 0.
8629
Epoch 83/100
250/250 [=====] - 1s 2ms/step - loss: 0.3372 - accuracy: 0.
8649
Epoch 84/100
250/250 [=====] - 1s 2ms/step - loss: 0.3367 - accuracy: 0.
8634
Epoch 85/100
250/250 [=====] - 1s 2ms/step - loss: 0.3367 - accuracy: 0.
8633
Epoch 86/100
250/250 [=====] - 1s 2ms/step - loss: 0.3369 - accuracy: 0.
8629
Epoch 87/100
250/250 [=====] - 1s 2ms/step - loss: 0.3367 - accuracy: 0.
8630
Epoch 88/100
250/250 [=====] - 1s 2ms/step - loss: 0.3365 - accuracy: 0.
8636
Epoch 89/100
250/250 [=====] - 1s 3ms/step - loss: 0.3360 - accuracy: 0.
8637
Epoch 90/100
250/250 [=====] - 1s 2ms/step - loss: 0.3362 - accuracy: 0.
8633
Epoch 91/100
250/250 [=====] - 1s 2ms/step - loss: 0.3362 - accuracy: 0.
8625
Epoch 92/100
250/250 [=====] - 1s 2ms/step - loss: 0.3359 - accuracy: 0.
8625
Epoch 93/100
250/250 [=====] - 1s 2ms/step - loss: 0.3360 - accuracy: 0.
8630
Epoch 94/100
```

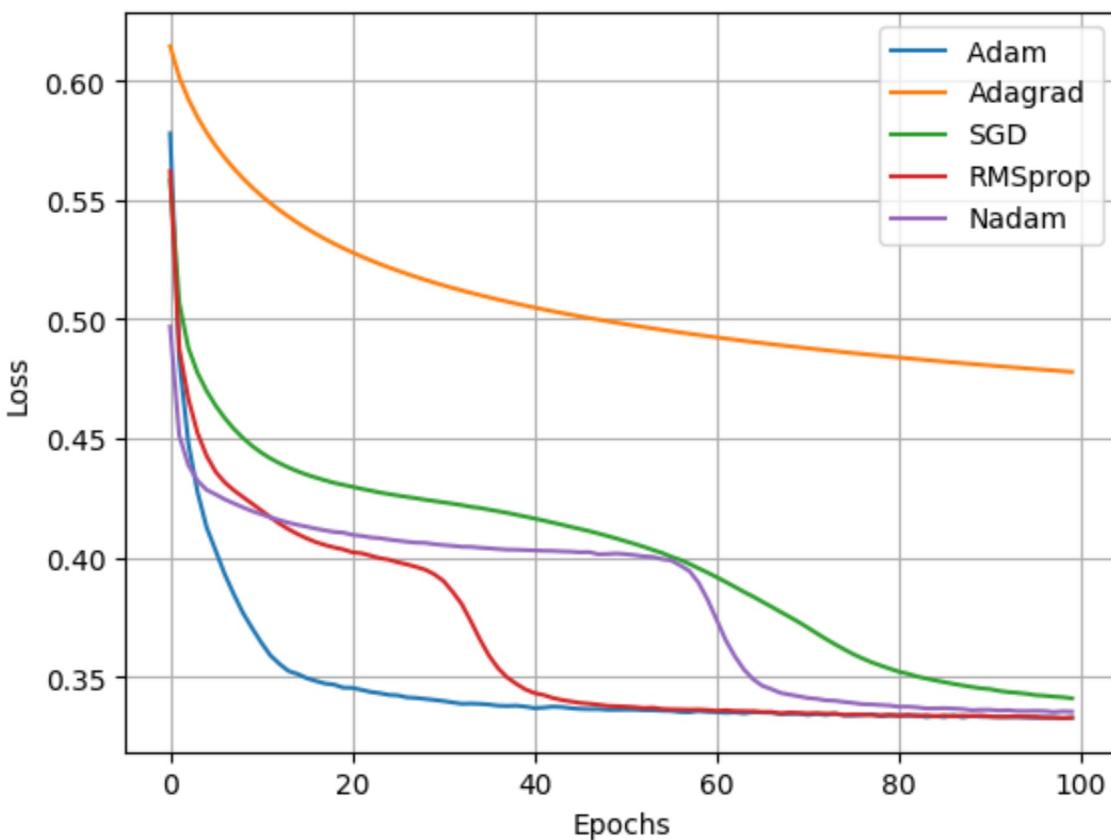
```
250/250 [=====] - 1s 3ms/step - loss: 0.3357 - accuracy: 0.  
8644  
Epoch 95/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3357 - accuracy: 0.  
8637  
Epoch 96/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3357 - accuracy: 0.  
8627  
Epoch 97/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3356 - accuracy: 0.  
8633  
Epoch 98/100  
250/250 [=====] - 1s 3ms/step - loss: 0.3352 - accuracy: 0.  
8646  
Epoch 99/100  
250/250 [=====] - 0s 2ms/step - loss: 0.3356 - accuracy: 0.  
8630  
Epoch 100/100  
250/250 [=====] - 1s 2ms/step - loss: 0.3354 - accuracy: 0.  
8636  
Out[ ]: [<matplotlib.lines.Line2D at 0x2092029a110>]
```



```
In [ ]: plt.plot(adam_history.history['loss'], label='Adam' , )  
plt.plot(adagrad_history.history['loss'], label='Adagrad')  
plt.plot(SGD_history.history['loss'], label='SGD')  
plt.plot(RMSprop_history.history['loss'], label='RMSprop')  
plt.plot(Nadam_history.history['loss'], label='Nadam')  
print(adam_history.history['loss'][-1])  
print(SGD_history.history['loss'][-1])  
print(adagrad_history.history['loss'][-1])  
plt.xlabel('Epochs' )
```

```
plt.ylabel('Loss')
plt.legend()
plt.grid(True)
plt.show()
```

```
0.3329037129878998
0.34099456667900085
0.47788652777671814
```



```
In [ ]: plt.plot(adam_history.history['loss'][0:40], label='Adam')
plt.plot(adagrad_history.history['loss'][0:40], label='Adagrad')
plt.plot(SGD_history.history['loss'][0:40], label='SGD')
plt.plot(RMSprop_history.history['loss'][0:40], label='RMSprop')
plt.plot(Nadam_history.history['loss'][0:40], label='Nadam')

plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()
plt.show()
```

