모델의 성능 검증하기

1. 데이터의 확인과 예측 실행

In [3]:
```
import warnings
warnings.filterwarnings('ignore')
```

In [4]:
```
import pandas as pd

# 광물 데이터를 불러옵니다.
df = pd.read_csv('./data/sonar3.csv', header=None)

# 첫 5줄을 봅니다.
df.head()
```

Out[4]:

	0	1	2	3	4	5	6	7	8	9	...	51	52	53	54	55	56	5
0	0.0200	0.0371	0.0428	0.0207	0.0954	0.0986	0.1539	0.1601	0.3109	0.2111	...	0.0027	0.0065	0.0159	0.0072	0.0167	0.0180	0.008
1	0.0453	0.0523	0.0843	0.0689	0.1183	0.2583	0.2156	0.3481	0.3337	0.2872	...	0.0084	0.0089	0.0048	0.0094	0.0191	0.0140	0.004
2	0.0262	0.0582	0.1099	0.1083	0.0974	0.2280	0.2431	0.3771	0.5598	0.6194	...	0.0232	0.0166	0.0095	0.0180	0.0244	0.0316	0.016
3	0.0100	0.0171	0.0623	0.0205	0.0205	0.0368	0.1098	0.1276	0.0598	0.1264	...	0.0121	0.0036	0.0150	0.0085	0.0073	0.0050	0.004
4	0.0762	0.0666	0.0481	0.0394	0.0590	0.0649	0.1209	0.2467	0.3564	0.4459	...	0.0031	0.0054	0.0105	0.0110	0.0015	0.0072	0.004

5 rows × 61 columns

In [5]:
```
# 일반 암석(0)과 광석(1)이 몇 개 있는지 확인합니다.
df[60].value_counts()
```

Out[5]:
```
60
1    111
0     97
Name: count, dtype: int64
```

In [6]:
```
# 음파 관련 속성을 X로, 광물의 종류를 y로 저장합니다.
X = df.iloc[:,0:60]
y = df.iloc[:,60]
```

In [7]:
```
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense

# 모델을 설정합니다.
model = Sequential()
model.add(Dense(24,  input_dim=60, activation='relu'))
model.add(Dense(10, activation='relu'))
model.add(Dense(10, activation='tanh'))
model.add(Dense(1, activation='sigmoid'))

# 모델을 컴파일합니다.
model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy'])

# 모델을 실행합니다.
history=model.fit(X, y, epochs=200, batch_size=10)
```

```
Epoch 1/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.4679 - loss: 0.6946
Epoch 2/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.6176 - loss: 0.6827
Epoch 3/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.6529 - loss: 0.6762
Epoch 4/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.5967 - loss: 0.6674
Epoch 5/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.7231 - loss: 0.6510
Epoch 6/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6870 - loss: 0.6430
Epoch 7/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.7101 - loss: 0.6241
Epoch 8/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.7188 - loss: 0.6049
Epoch 9/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.7126 - loss: 0.5991
Epoch 10/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.7792 - loss: 0.5669
Epoch 11/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8210 - loss: 0.5367
Epoch 12/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7639 - loss: 0.5014
Epoch 13/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8438 - loss: 0.4576
Epoch 14/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8382 - loss: 0.4673
Epoch 15/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8145 - loss: 0.4470
Epoch 16/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.7855 - loss: 0.4771
Epoch 17/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8812 - loss: 0.3981
Epoch 18/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8054 - loss: 0.4225
Epoch 19/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8848 - loss: 0.3428
Epoch 20/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8696 - loss: 0.3533
Epoch 21/200
```

```
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8148 - loss: 0.3763
Epoch 22/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8477 - loss: 0.3643
Epoch 23/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8691 - loss: 0.3255
Epoch 24/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8607 - loss: 0.3109
Epoch 25/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8781 - loss: 0.2866
Epoch 26/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8926 - loss: 0.3054
Epoch 27/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8816 - loss: 0.2820
Epoch 28/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9154 - loss: 0.2915
Epoch 29/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9073 - loss: 0.2847
Epoch 30/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8704 - loss: 0.3049
Epoch 31/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9083 - loss: 0.2559
Epoch 32/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8779 - loss: 0.2890
Epoch 33/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8852 - loss: 0.2888
Epoch 34/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9032 - loss: 0.2747
Epoch 35/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8856 - loss: 0.2833
Epoch 36/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9015 - loss: 0.2358
Epoch 37/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8930 - loss: 0.2577
Epoch 38/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9391 - loss: 0.2064
Epoch 39/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8904 - loss: 0.2416
Epoch 40/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9553 - loss: 0.1795
Epoch 41/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9087 - loss: 0.2435
```

```
Epoch 42/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9405 - loss: 0.1849
Epoch 43/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9537 - loss: 0.1814
Epoch 44/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9336 - loss: 0.1988
Epoch 45/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9371 - loss: 0.1809
Epoch 46/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9524 - loss: 0.1654
Epoch 47/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9439 - loss: 0.1699
Epoch 48/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9674 - loss: 0.1311
Epoch 49/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9392 - loss: 0.1806
Epoch 50/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9438 - loss: 0.1956
Epoch 51/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9262 - loss: 0.1853
Epoch 52/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9483 - loss: 0.1520
Epoch 53/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9725 - loss: 0.1185
Epoch 54/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9765 - loss: 0.1164
Epoch 55/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9352 - loss: 0.1613
Epoch 56/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9684 - loss: 0.1123
Epoch 57/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9642 - loss: 0.1200
Epoch 58/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9606 - loss: 0.1150
Epoch 59/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9524 - loss: 0.1296
Epoch 60/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9696 - loss: 0.0938
Epoch 61/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9666 - loss: 0.1171
Epoch 62/200
```

```
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9858 - loss: 0.0888
Epoch 63/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9464 - loss: 0.1374
Epoch 64/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9776 - loss: 0.0936
Epoch 65/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9570 - loss: 0.1088
Epoch 66/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9500 - loss: 0.1001
Epoch 67/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9837 - loss: 0.0843
Epoch 68/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9692 - loss: 0.0857
Epoch 69/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9864 - loss: 0.0671
Epoch 70/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9756 - loss: 0.0654
Epoch 71/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9849 - loss: 0.0686
Epoch 72/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.9615 - loss: 0.0928
Epoch 73/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9624 - loss: 0.0911
Epoch 74/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9732 - loss: 0.0881
Epoch 75/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9873 - loss: 0.0571
Epoch 76/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9950 - loss: 0.0461
Epoch 77/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9853 - loss: 0.0652
Epoch 78/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9844 - loss: 0.0541
Epoch 79/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9658 - loss: 0.0739
Epoch 80/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9930 - loss: 0.0441
Epoch 81/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9948 - loss: 0.0562
Epoch 82/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9906 - loss: 0.0395
```

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Epoch 83/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9819 - loss: 0.0523
Epoch 84/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9820 - loss: 0.0397
Epoch 85/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9945 - loss: 0.0435
Epoch 86/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9988 - loss: 0.0496
Epoch 87/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9839 - loss: 0.0636
Epoch 88/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9880 - loss: 0.0494
Epoch 89/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0335
Epoch 90/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9980 - loss: 0.0418
Epoch 91/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0362
Epoch 92/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0305
Epoch 93/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 1.0000 - loss: 0.0342
Epoch 94/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0303
Epoch 95/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0331
Epoch 96/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0293
Epoch 97/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9919 - loss: 0.0368
Epoch 98/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9895 - loss: 0.0410
Epoch 99/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9813 - loss: 0.0477
Epoch 100/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9980 - loss: 0.0295
Epoch 101/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9936 - loss: 0.0341
Epoch 102/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0292
Epoch 103/200
```

```
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0215
Epoch 104/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0230
Epoch 105/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0157
Epoch 106/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.9996 - loss: 0.0172
Epoch 107/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.9973 - loss: 0.0295
Epoch 108/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0137
Epoch 109/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0184
Epoch 110/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0172
Epoch 111/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0165
Epoch 112/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0140
Epoch 113/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0150
Epoch 114/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0126
Epoch 115/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0092
Epoch 116/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0102
Epoch 117/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0093
Epoch 118/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0116
Epoch 119/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0109
Epoch 120/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0093
Epoch 121/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0089
Epoch 122/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0086
Epoch 123/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0084
```

```
Epoch 124/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0098
Epoch 125/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0085
Epoch 126/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0068
Epoch 127/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0091
Epoch 128/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0069
Epoch 129/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0079
Epoch 130/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0072
Epoch 131/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0077
Epoch 132/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0065
Epoch 133/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0056
Epoch 134/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0078
Epoch 135/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0066
Epoch 136/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0052
Epoch 137/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0061
Epoch 138/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0049
Epoch 139/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0062
Epoch 140/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0063
Epoch 141/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0062
Epoch 142/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0035
Epoch 143/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0037
Epoch 144/200
```

```
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0052
Epoch 145/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0041
Epoch 146/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0033
Epoch 147/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0037
Epoch 148/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0040
Epoch 149/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0041
Epoch 150/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0040
Epoch 151/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0045
Epoch 152/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0040
Epoch 153/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0030
Epoch 154/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0049
Epoch 155/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0038
Epoch 156/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0043
Epoch 157/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0038
Epoch 158/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0036
Epoch 159/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0032
Epoch 160/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0032
Epoch 161/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0031
Epoch 162/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0037
Epoch 163/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0025
Epoch 164/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0032
```

```
Epoch 165/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0028
Epoch 166/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0042
Epoch 167/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0026
Epoch 168/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0027
Epoch 169/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0024
Epoch 170/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0028
Epoch 171/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0053
Epoch 172/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0037
Epoch 173/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0037
Epoch 174/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0018
Epoch 175/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0021
Epoch 176/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0019
Epoch 177/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0020
Epoch 178/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0022
Epoch 179/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0021
Epoch 180/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0018
Epoch 181/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0019
Epoch 182/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0023
Epoch 183/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0015
Epoch 184/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0017
Epoch 185/200
```

```
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0015
Epoch 186/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0015
Epoch 187/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0017
Epoch 188/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0016
Epoch 189/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0021
Epoch 190/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0018
Epoch 191/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0016
Epoch 192/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0013
Epoch 193/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0014
Epoch 194/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 1.0000 - loss: 0.0013
Epoch 195/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0017
Epoch 196/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0013
Epoch 197/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0012
Epoch 198/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0013
Epoch 199/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 1.0000 - loss: 0.0013
Epoch 200/200
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0012
```

3. 학습셋과 테스트셋

In [9]:
```python
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense
from sklearn.model_selection import train_test_split

import pandas as pd
```

In [10]:
```
# 광물 데이터를 불러옵니다.
df = pd.read_csv('./data/sonar3.csv', header=None)
```

In [11]:
```
# 음파 관련 속성을 X로, 광물의 종류를 y로 저장합니다.
X = df.iloc[:,0:60]
y = df.iloc[:,60]
```

In [12]:
```
# 학습셋과 테스트셋을 구분합니다.
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, shuffle=True)
```

In [13]:
```
# 모델을 설정합니다.
model = Sequential()
model.add(Dense(24,  input_dim=60, activation='relu'))
model.add(Dense(10, activation='relu'))
model.add(Dense(1, activation='sigmoid'))

# 모델을 컴파일합니다.
model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy'])

# 모델을 실행합니다.
history=model.fit(X_train, y_train, epochs=200, batch_size=10)
```

```
Epoch 1/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.5643 - loss: 0.7115
Epoch 2/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.4810 - loss: 0.6977
Epoch 3/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.5370 - loss: 0.6768
Epoch 4/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.5361 - loss: 0.6791
Epoch 5/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.5708 - loss: 0.6708
Epoch 6/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.5971 - loss: 0.6664
Epoch 7/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6034 - loss: 0.6712
Epoch 8/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.5928 - loss: 0.6631
Epoch 9/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6435 - loss: 0.6359
Epoch 10/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6504 - loss: 0.6543
Epoch 11/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7170 - loss: 0.6274
Epoch 12/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7243 - loss: 0.6057
Epoch 13/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6932 - loss: 0.6316
Epoch 14/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6990 - loss: 0.6090
Epoch 15/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7324 - loss: 0.6082
Epoch 16/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7516 - loss: 0.6023
Epoch 17/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6742 - loss: 0.5957
Epoch 18/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.7771 - loss: 0.5893
Epoch 19/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7868 - loss: 0.5649
Epoch 20/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7897 - loss: 0.5754
Epoch 21/200
```

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15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7911 - loss: 0.5496
Epoch 22/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7968 - loss: 0.5856
Epoch 23/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7991 - loss: 0.5398
Epoch 24/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8452 - loss: 0.5183
Epoch 25/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8195 - loss: 0.5375
Epoch 26/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8502 - loss: 0.5028
Epoch 27/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8205 - loss: 0.4852
Epoch 28/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7792 - loss: 0.5276
Epoch 29/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8615 - loss: 0.4781
Epoch 30/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8140 - loss: 0.4805
Epoch 31/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8191 - loss: 0.4648
Epoch 32/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8656 - loss: 0.4528
Epoch 33/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8746 - loss: 0.4136
Epoch 34/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8896 - loss: 0.4199
Epoch 35/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8914 - loss: 0.3969
Epoch 36/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9095 - loss: 0.3988
Epoch 37/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8570 - loss: 0.3984
Epoch 38/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8349 - loss: 0.4217
Epoch 39/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8862 - loss: 0.3924
Epoch 40/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8504 - loss: 0.3897
Epoch 41/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8646 - loss: 0.3647
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Epoch 42/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8514 - loss: 0.3653
Epoch 43/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8927 - loss: 0.3061
Epoch 44/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8588 - loss: 0.3796
Epoch 45/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8977 - loss: 0.3293
Epoch 46/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9150 - loss: 0.3264
Epoch 47/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9119 - loss: 0.2923
Epoch 48/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9419 - loss: 0.2859
Epoch 49/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9381 - loss: 0.2740
Epoch 50/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8995 - loss: 0.2733
Epoch 51/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9089 - loss: 0.3004
Epoch 52/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9027 - loss: 0.2803
Epoch 53/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9099 - loss: 0.2624
Epoch 54/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.9342 - loss: 0.2691
Epoch 55/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.9236 - loss: 0.2497
Epoch 56/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8583 - loss: 0.3067
Epoch 57/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8954 - loss: 0.2895
Epoch 58/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8905 - loss: 0.2958
Epoch 59/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9429 - loss: 0.2406
Epoch 60/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9443 - loss: 0.2300
Epoch 61/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9468 - loss: 0.2445
Epoch 62/200
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15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9215 - loss: 0.2288
Epoch 63/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9140 - loss: 0.2422
Epoch 64/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9307 - loss: 0.2292
Epoch 65/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9323 - loss: 0.2106
Epoch 66/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9418 - loss: 0.2337
Epoch 67/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9463 - loss: 0.2420
Epoch 68/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9487 - loss: 0.2106
Epoch 69/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9672 - loss: 0.1906
Epoch 70/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9508 - loss: 0.2019
Epoch 71/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9294 - loss: 0.2078
Epoch 72/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9329 - loss: 0.2071
Epoch 73/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9560 - loss: 0.2001
Epoch 74/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9251 - loss: 0.2314
Epoch 75/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9118 - loss: 0.2269
Epoch 76/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9354 - loss: 0.2151
Epoch 77/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9163 - loss: 0.2131
Epoch 78/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9568 - loss: 0.1751
Epoch 79/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9255 - loss: 0.2157
Epoch 80/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.9526 - loss: 0.1837
Epoch 81/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9793 - loss: 0.1546
Epoch 82/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9776 - loss: 0.1469
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Epoch 83/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9522 - loss: 0.1564
Epoch 84/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9611 - loss: 0.1770
Epoch 85/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9439 - loss: 0.1813
Epoch 86/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9818 - loss: 0.1484
Epoch 87/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9613 - loss: 0.1772
Epoch 88/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9713 - loss: 0.1290
Epoch 89/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9654 - loss: 0.1558
Epoch 90/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9713 - loss: 0.1443
Epoch 91/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9544 - loss: 0.1404
Epoch 92/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9758 - loss: 0.1423
Epoch 93/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9843 - loss: 0.1444
Epoch 94/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9502 - loss: 0.1354
Epoch 95/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9608 - loss: 0.1528
Epoch 96/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9687 - loss: 0.1269
Epoch 97/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9879 - loss: 0.1448
Epoch 98/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9796 - loss: 0.1191
Epoch 99/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9761 - loss: 0.1341
Epoch 100/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.9497 - loss: 0.1296
Epoch 101/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9806 - loss: 0.1154
Epoch 102/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9725 - loss: 0.1232
Epoch 103/200
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15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9710 - loss: 0.1345
Epoch 104/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9879 - loss: 0.1184
Epoch 105/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9701 - loss: 0.1217
Epoch 106/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9863 - loss: 0.1272
Epoch 107/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9614 - loss: 0.1384
Epoch 108/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9808 - loss: 0.1153
Epoch 109/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9773 - loss: 0.1171
Epoch 110/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9534 - loss: 0.1116
Epoch 111/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9799 - loss: 0.1081
Epoch 112/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9808 - loss: 0.1152
Epoch 113/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9914 - loss: 0.1020
Epoch 114/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9704 - loss: 0.1054
Epoch 115/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9965 - loss: 0.1063
Epoch 116/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9897 - loss: 0.0985
Epoch 117/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9923 - loss: 0.1042
Epoch 118/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9753 - loss: 0.1022
Epoch 119/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.1022
Epoch 120/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9833 - loss: 0.0886
Epoch 121/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9965 - loss: 0.0938
Epoch 122/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.9790 - loss: 0.0957
Epoch 123/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9838 - loss: 0.0833
```

```
Epoch 124/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9859 - loss: 0.0929
Epoch 125/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9950 - loss: 0.0727
Epoch 126/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9987 - loss: 0.0899
Epoch 127/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0759
Epoch 128/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0990
Epoch 129/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9950 - loss: 0.0892
Epoch 130/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9982 - loss: 0.0970
Epoch 131/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0883
Epoch 132/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9931 - loss: 0.0835
Epoch 133/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0559
Epoch 134/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9918 - loss: 0.0735
Epoch 135/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0713
Epoch 136/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9959 - loss: 0.0712
Epoch 137/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9971 - loss: 0.0708
Epoch 138/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 1.0000 - loss: 0.0747
Epoch 139/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0720
Epoch 140/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9941 - loss: 0.0702
Epoch 141/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9941 - loss: 0.0770
Epoch 142/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9958 - loss: 0.0618
Epoch 143/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9965 - loss: 0.0711
Epoch 144/200
```

```
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0681
Epoch 145/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9977 - loss: 0.0700
Epoch 146/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9987 - loss: 0.0668
Epoch 147/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0506
Epoch 148/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0740
Epoch 149/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0669
Epoch 150/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0675
Epoch 151/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0528
Epoch 152/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0456
Epoch 153/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0590
Epoch 154/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0676
Epoch 155/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9941 - loss: 0.0576
Epoch 156/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0493
Epoch 157/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0552
Epoch 158/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9971 - loss: 0.0463
Epoch 159/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9991 - loss: 0.0474
Epoch 160/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0543
Epoch 161/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0475
Epoch 162/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0448
Epoch 163/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0513
Epoch 164/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0468
```

```
Epoch 165/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.9918 - loss: 0.0521
Epoch 166/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0465
Epoch 167/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0411
Epoch 168/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0454
Epoch 169/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0452
Epoch 170/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0424
Epoch 171/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0364
Epoch 172/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0364
Epoch 173/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0389
Epoch 174/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0366
Epoch 175/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0368
Epoch 176/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0431
Epoch 177/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0428
Epoch 178/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0370
Epoch 179/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0360
Epoch 180/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0388
Epoch 181/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0381
Epoch 182/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 1.0000 - loss: 0.0353
Epoch 183/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 1.0000 - loss: 0.0344
Epoch 184/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0347
Epoch 185/200
```

```
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0314
Epoch 186/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0390
Epoch 187/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0321
Epoch 188/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0363
Epoch 189/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0284
Epoch 190/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0387
Epoch 191/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0262
Epoch 192/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0308
Epoch 193/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0317
Epoch 194/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0300
Epoch 195/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0332
Epoch 196/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0320
Epoch 197/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0255
Epoch 198/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0320
Epoch 199/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0322
Epoch 200/200
15/15 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 1.0000 - loss: 0.0311
```

In [14]:
```python
# 모델을 테스트셋에 적용해 정확도를 구합니다.
score=model.evaluate(X_test, y_test)
print('Test accuracy:', score[1])
```

```
2/2 ━━━━━━━━━━━━━━━━━━━━ 0s 13ms/step - accuracy: 0.8527 - loss: 0.2586
Test accuracy: 0.8571428656578064
```

4. 모델 저장과 재사용

In [16]:
```
# 모델 이름과 저장할 위치를 함께 지정합니다.
model.save('./data/model/my_model.hdf5')
```

```
WARNING:absl:You are saving your model as an HDF5 file via `model.save()` or `keras.saving.save_model(model)`. This file format is considered legacy. We recommend using instead the native Keras format, e.g. `model.save('my_model.keras')` or `keras.saving.save_model(model, 'my_model.keras')`.
```

In [17]:
```
from tensorflow.keras.models import Sequential, load_model
```

In [18]:
```
# 테스트를 위해 조금 전 사용한 모델을 메모리에서 삭제합니다.
del model
```

In [19]:
```
# 모델을 새로 불러옵니다.
model = load_model('./data/model/my_model.hdf5')

# 불러온 모델을 테스트셋에 적용해 정확도를 구합니다.
score=model.evaluate(X_test, y_test)
print('Test accuracy:', score[1])
```

```
WARNING:absl:Compiled the loaded model, but the compiled metrics have yet to be built. `model.compile_metrics` will be empty until you train or evaluate the model.
2/2 ━━━━━━━━━━━━━━━━━━━━ 0s 14ms/step - accuracy: 0.8527 - loss: 0.2586
Test accuracy: 0.8571428656578064
```

5. k겹 교차 검증

In [21]:
```
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense
from sklearn.model_selection import KFold
from sklearn.metrics import accuracy_score

import pandas as pd

# 광물 데이터를 불러옵니다.
df = pd.read_csv('./data/sonar3.csv', header=None)
```

```
# 음파 관련 속성을 X로, 광물의 종류를 y로 저장합니다.
X = df.iloc[:,0:60]
y = df.iloc[:,60]
```

In [22]:

```
# 몇 겹으로 나눌 것인지를 정합니다.
k=5

# KFold 함수를 불러옵니다. 분할하기 전에 샘플이 치우치지 않도록 섞어 줍니다.
kfold = KFold(n_splits=k, shuffle=True)

# 정확도가 채워질 빈 리스트를 준비합니다.
acc_score = []

def model_fn():
    model = Sequential() # 딥러닝 모델의 구조를 시작합니다.
    model.add(Dense(24, input_dim=60, activation='relu'))
    model.add(Dense(10, activation='relu'))
    model.add(Dense(1, activation='sigmoid'))
    return model

# K겹 교차 검증을 이용해 k번의 학습을 실행합니다.
for train_index , test_index in kfold.split(X):  # for 문에 의해서 k번 반복합니다. spilt()에 의해 k개의 학습셋, 테스트셋으로 분
    X_train , X_test = X.iloc[train_index,:], X.iloc[test_index,:]
    y_train , y_test = y.iloc[train_index], y.iloc[test_index]

    model = model_fn()
    model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy'])
    history=model.fit(X_train, y_train, epochs=200, batch_size=10, verbose=0)

    accuracy = model.evaluate(X_test, y_test)[1]  # 정확도를 구합니다.
    acc_score.append(accuracy)  # 정확도 리스트에 저장합니다.

# k번 실시된 정확도의 평균을 구합니다.
avg_acc_score = sum(acc_score)/k

# 결과를 출력합니다.
print('정확도:', acc_score)
print('정확도 평균:', avg_acc_score)
```

```
2/2 ━━━━━━━━━━━━━━━━━━━━ 0s 16ms/step - accuracy: 0.8527 - loss: 0.6711
2/2 ━━━━━━━━━━━━━━━━━━━━ 0s 18ms/step - accuracy: 0.8001 - loss: 0.6283
2/2 ━━━━━━━━━━━━━━━━━━━━ 0s 16ms/step - accuracy: 0.7842 - loss: 0.8059
2/2 ━━━━━━━━━━━━━━━━━━━━ 0s 16ms/step - accuracy: 0.8399 - loss: 0.4406
2/2 ━━━━━━━━━━━━━━━━━━━━ 0s 15ms/step - accuracy: 0.8237 - loss: 0.5660
정확도: [0.8571428656578064, 0.8095238208770752, 0.7857142686843872, 0.8536585569381714, 0.8292682766914368]
정확도 평균: 0.8270615577697754
```