

# Q15

## Loading the modules

```
In [ ]: import numpy as np
        from sklearn.datasets import load_digits
        from sklearn.model_selection import train_test_split
        import tensorflow as tf
```

## Load digits dataset

```
In [ ]: digits = load_digits()
        X = digits.data
        y = digits.target
```

```
In [ ]: # Normalize the features
        X = X / 255.0

        # Split dataset into training and testing sets
        X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, random_state=42)

        # One-hot encode the labels
        num_classes = len(np.unique(y))
        y_train_onehot = tf.one_hot(y_train, depth=num_classes)
        y_test_onehot = tf.one_hot(y_test, depth=num_classes)
```

## Define the architecture of the neural network

```
In [ ]: input_dim = X_train.shape[1]
        output_dim = num_classes
        hidden_dim = 64

        # Define the model
        model = tf.keras.models.Sequential([
            tf.keras.layers.Dense(hidden_dim, input_dim=input_dim, activation='relu'),
            tf.keras.layers.Dense(output_dim, activation='softmax')
        ])
```

c:\Users\user\AppData\Local\Programs\Python\Python311\Lib\site-packages\keras\src\layers\core\dense.py:87: UserWarning: Do not pass an `input\_shape`/`input\_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.


```
super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```


## ANN Training


```
In [ ]: # Compile the model
model.compile(optimizer='adam', loss='sparse_categorical_crossentropy', metrics=['a


# Train the model
model.fit(X_train, y_train, epochs=50, batch_size=32, validation_split=0.1)


# Evaluate the model
loss, accuracy = model.evaluate(X_test, y_test)
print("Test Accuracy:", accuracy)
```


Epoch 1/50  
36/36  1s 9ms/step - accuracy: 0.1298 - loss: 2.2954 - val\_accuracy: 0.4524 - val\_loss: 2.2680


Epoch 2/50  
36/36  0s 3ms/step - accuracy: 0.5135 - loss: 2.2612 - val\_accuracy: 0.6429 - val\_loss: 2.2274


Epoch 3/50  
36/36  0s 3ms/step - accuracy: 0.6894 - loss: 2.2162 - val\_accuracy: 0.7857 - val\_loss: 2.1710


Epoch 4/50  
36/36  0s 3ms/step - accuracy: 0.7762 - loss: 2.1640 - val\_accuracy: 0.8254 - val\_loss: 2.1051


Epoch 5/50  
36/36  0s 3ms/step - accuracy: 0.7622 - loss: 2.0983 - val\_accuracy: 0.8095 - val\_loss: 2.0240


Epoch 6/50  
36/36  0s 3ms/step - accuracy: 0.7787 - loss: 2.0158 - val\_accuracy: 0.8254 - val\_loss: 1.9347


Epoch 7/50  
36/36  0s 3ms/step - accuracy: 0.7817 - loss: 1.9354 - val\_accuracy: 0.8571 - val\_loss: 1.8327


Epoch 8/50  
36/36  0s 3ms/step - accuracy: 0.7890 - loss: 1.8362 - val\_accuracy: 0.8492 - val\_loss: 1.7269


Epoch 9/50  
36/36  0s 4ms/step - accuracy: 0.8094 - loss: 1.7265 - val\_accuracy: 0.8810 - val\_loss: 1.6254


Epoch 10/50  
36/36  0s 3ms/step - accuracy: 0.8309 - loss: 1.6218 - val\_accuracy: 0.8651 - val\_loss: 1.5210


Epoch 11/50  
36/36  0s 3ms/step - accuracy: 0.8121 - loss: 1.5271 - val\_accuracy: 0.8810 - val\_loss: 1.4179


Epoch 12/50  
36/36  0s 3ms/step - accuracy: 0.8380 - loss: 1.4032 - val\_accuracy: 0.8730 - val\_loss: 1.3153


Epoch 13/50  
36/36  0s 3ms/step - accuracy: 0.8099 - loss: 1.3507 - val\_accuracy: 0.8889 - val\_loss: 1.2287


Epoch 14/50  
36/36  0s 3ms/step - accuracy: 0.8314 - loss: 1.2427 - val\_accuracy: 0.8651 - val\_loss: 1.1473



















Epoch 15/50  
36/36  0s 3ms/step - accuracy: 0.8232 - loss: 1.1766 - val\_accuracy: 0.8730 - val\_loss: 1.0782


Epoch 16/50  
36/36  0s 3ms/step - accuracy: 0.8405 - loss: 1.0889 - val\_accuracy: 0.8730 - val\_loss: 1.0054


Epoch 17/50  
36/36  0s 4ms/step - accuracy: 0.8684 - loss: 1.0074 - val\_accuracy: 0.8810 - val\_loss: 0.9466


Epoch 18/50  
36/36  0s 3ms/step - accuracy: 0.8530 - loss: 0.9671 - val\_accuracy: 0.9048 - val\_loss: 0.8938


Epoch 19/50  
36/36  0s 3ms/step - accuracy: 0.8559 - loss: 0.9229 - val\_accuracy:


acy: 0.9048 - val\_loss: 0.8442  
Epoch 20/50  
36/36  0s 3ms/step - accuracy: 0.8689 - loss: 0.8571 - val\_accu  
acy: 0.9048 - val\_loss: 0.7980  
Epoch 21/50  
36/36  0s 3ms/step - accuracy: 0.8698 - loss: 0.8319 - val\_accu  
acy: 0.9048 - val\_loss: 0.7589  
Epoch 22/50  
36/36  0s 3ms/step - accuracy: 0.8850 - loss: 0.7715 - val\_accu  
acy: 0.9048 - val\_loss: 0.7170  
Epoch 23/50  
36/36  0s 3ms/step - accuracy: 0.8800 - loss: 0.7246 - val\_accu  
acy: 0.9048 - val\_loss: 0.6873  
Epoch 24/50  
36/36  0s 3ms/step - accuracy: 0.8875 - loss: 0.6987 - val\_accu  
acy: 0.9048 - val\_loss: 0.6566  
Epoch 25/50  
36/36  0s 3ms/step - accuracy: 0.8985 - loss: 0.6450 - val\_accu  
acy: 0.9048 - val\_loss: 0.6327  
Epoch 26/50  
36/36  0s 3ms/step - accuracy: 0.8925 - loss: 0.6506 - val\_accu  
acy: 0.9048 - val\_loss: 0.6021  
Epoch 27/50  
36/36  0s 3ms/step - accuracy: 0.9026 - loss: 0.6189 - val\_accu  
acy: 0.9048 - val\_loss: 0.5784  
Epoch 28/50  
36/36  0s 2ms/step - accuracy: 0.9006 - loss: 0.5966 - val\_accu  
acy: 0.9048 - val\_loss: 0.5587  
Epoch 29/50  
36/36  0s 3ms/step - accuracy: 0.8957 - loss: 0.6022 - val\_accu  
acy: 0.9127 - val\_loss: 0.5347  
Epoch 30/50  
36/36  0s 3ms/step - accuracy: 0.9186 - loss: 0.5373 - val\_accu  
acy: 0.9048 - val\_loss: 0.5173  
Epoch 31/50  
36/36  0s 3ms/step - accuracy: 0.9025 - loss: 0.5541 - val\_accu  
acy: 0.9048 - val\_loss: 0.5020  
Epoch 32/50  
36/36  0s 6ms/step - accuracy: 0.9144 - loss: 0.5234 - val\_accu  
acy: 0.9127 - val\_loss: 0.4836  
Epoch 33/50  
36/36  0s 3ms/step - accuracy: 0.9203 - loss: 0.4877 - val\_accu  
acy: 0.9127 - val\_loss: 0.4697  
Epoch 34/50  
36/36  0s 3ms/step - accuracy: 0.9194 - loss: 0.4826 - val\_accu  
acy: 0.9206 - val\_loss: 0.4513  
Epoch 35/50  
36/36  0s 4ms/step - accuracy: 0.9131 - loss: 0.4829 - val\_accu  
acy: 0.9127 - val\_loss: 0.4411  
Epoch 36/50  
36/36  0s 3ms/step - accuracy: 0.9260 - loss: 0.4503 - val\_accu  
acy: 0.9206 - val\_loss: 0.4254  
Epoch 37/50  
36/36  0s 3ms/step - accuracy: 0.9231 - loss: 0.4320 - val\_accu  
acy: 0.9206 - val\_loss: 0.4154  
Epoch 38/50


36/36  0s 3ms/step - accuracy: 0.9249 - loss: 0.4360 - val\_accuracy: 0.9206 - val\_loss: 0.4041  
Epoch 39/50


36/36  0s 3ms/step - accuracy: 0.9181 - loss: 0.4391 - val\_accuracy: 0.9206 - val\_loss: 0.3929  
Epoch 40/50


36/36  0s 3ms/step - accuracy: 0.9354 - loss: 0.4066 - val\_accuracy: 0.9206 - val\_loss: 0.3836  
Epoch 41/50


36/36  0s 3ms/step - accuracy: 0.9448 - loss: 0.3809 - val\_accuracy: 0.9206 - val\_loss: 0.3721  
Epoch 42/50


36/36  0s 3ms/step - accuracy: 0.9439 - loss: 0.3568 - val\_accuracy: 0.9206 - val\_loss: 0.3668  
Epoch 43/50


36/36  0s 3ms/step - accuracy: 0.9446 - loss: 0.3577 - val\_accuracy: 0.9206 - val\_loss: 0.3507  
Epoch 44/50


36/36  0s 3ms/step - accuracy: 0.9363 - loss: 0.3561 - val\_accuracy: 0.9206 - val\_loss: 0.3477  
Epoch 45/50


36/36  0s 3ms/step - accuracy: 0.9327 - loss: 0.3597 - val\_accuracy: 0.9206 - val\_loss: 0.3392  
Epoch 46/50


36/36  0s 3ms/step - accuracy: 0.9308 - loss: 0.3619 - val\_accuracy: 0.9206 - val\_loss: 0.3316  
Epoch 47/50

36/36  0s 3ms/step - accuracy: 0.9326 - loss: 0.3507 - val\_accuracy: 0.9206 - val\_loss: 0.3249  
Epoch 48/50

36/36  0s 3ms/step - accuracy: 0.9389 - loss: 0.3197 - val\_accuracy: 0.9206 - val\_loss: 0.3182  
Epoch 49/50

36/36  0s 2ms/step - accuracy: 0.9428 - loss: 0.3198 - val\_accuracy: 0.9206 - val\_loss: 0.3127  
Epoch 50/50

36/36  0s 3ms/step - accuracy: 0.9499 - loss: 0.3049 - val\_accuracy: 0.9206 - val\_loss: 0.3054

17/17  0s 1ms/step - accuracy: 0.9282 - loss: 0.2927

Test Accuracy: 0.9222221970558167