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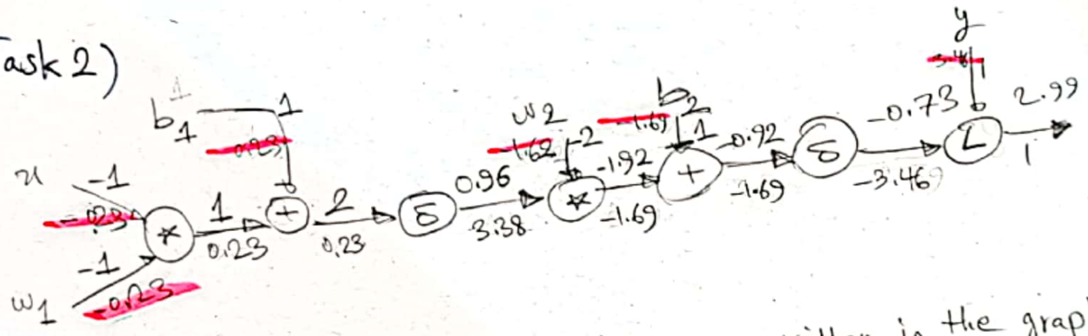
Ex8

Task 1)

$$\frac{\partial \sigma_1(x)}{\partial x} = \frac{-(-e^{-x})}{(1+e^{-x})^2} = \frac{1}{1+e^{-x}}\left(1-\frac{1}{1+e^{-x}}\right) = \sigma_1(x)\left(1-\sigma_1(x)\right)$$

$$\frac{\partial \sigma_2(x)}{\partial x} = \frac{(e^{x}+e^{-x})^2-(e^{x}-e^{-x})^2}{(e^{x}+e^{-x})^2} = 1-\left(\frac{e^{x}-e^{-x}}{e^{x}+e^{-x}}\right)^2 = 1-\sigma_2^2(x)$$

Task 2)



The forward pass values are written in the graph

$$Loss = (f(x)-y)^2 = (-0.73-1)^2 = 2.99$$

$$\frac{\partial L}{\partial L} = 1 \;,\; \frac{\partial L}{\partial y} = -2(f(x)-y) \;,\; \frac{\partial L}{\partial \sigma} = 2(f(x)-y)$$

$$\frac{\partial \sigma}{\partial z} = 1-\sigma^2(z)$$

The backward pass is also denoted on the graph.
The upstream gradient * local gradient = down stream gredient
is used for calculations based on the slides.
The final gredient with respect to each variable is highlighted

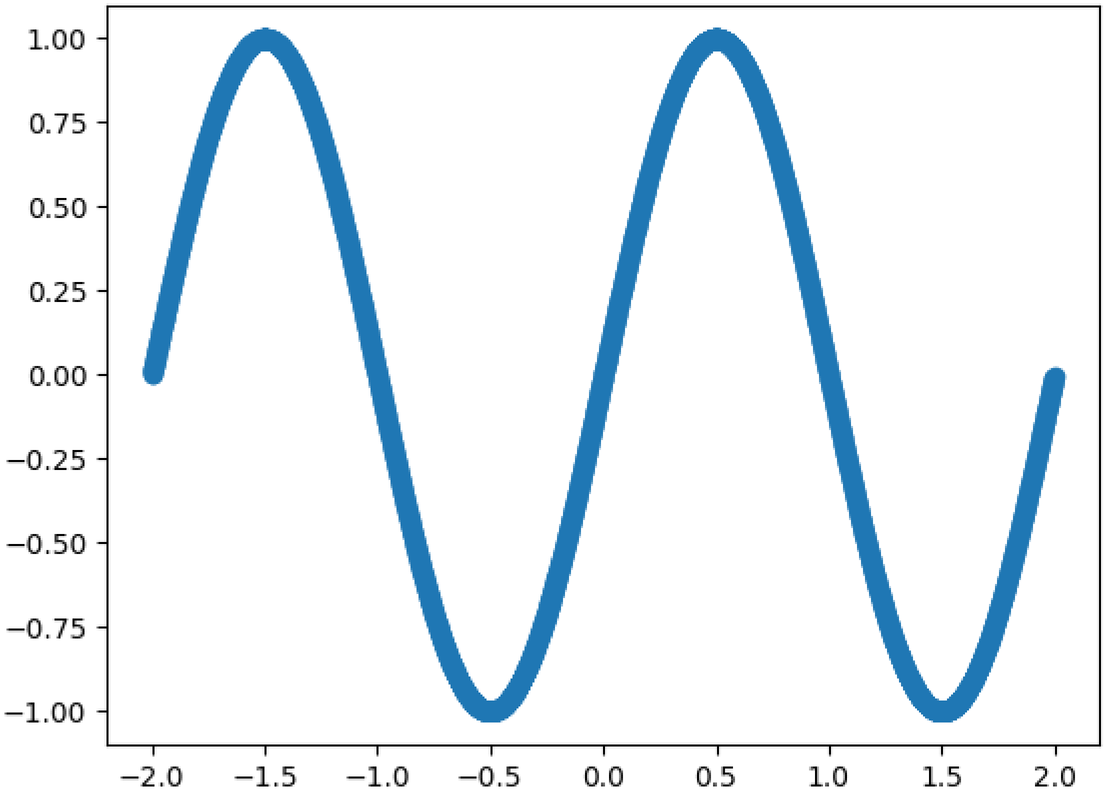
$$\eta=1 \Rightarrow \begin{cases} w_1' = w_1 - \eta\frac{\partial L}{\partial w_1} = -1-(-0.23) = -0.77 \\ b_1' = b_1 - \eta\frac{\partial L}{\partial b_1} = 1-(0.23) = 0.77 \\ w_2' = w_2 - \eta\frac{\partial L}{\partial w_2} = -2-(-1.62) = -0.38 \\ b_2' = b_2 - \eta\frac{\partial L}{\partial b_2} = 1-(-1.69) = 2.69 \end{cases}$$

Task 3

In [ ]:
```
# First we import some necessary libraries
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
```

In [ ]:
```
# The following function creates the sine wave data
def sine_wave(i):
    X = np.arange(-2,2,0.001)
    y = np.sin(X* i * np.pi/4)
    return X,y
```

In [ ]:
```
# Plot a sample of the sine wave function
X, y = sine_wave(4)
plt.scatter(X, y)
plt.show()
```



In [ ]:
```
# The following function builds a multilayer perceptron with one hidden layer
def build_network(num_hidden):
    inp = tf.keras.Input(shape=(1,))
    hidden = tf.keras.layers.Dense(num_hidden, activation='sigmoid')(inp)
    outp = tf.keras.layers.Dense(1)(hidden)
    model = tf.keras.Model(inputs=inp, outputs=outp, name='sine_model')
    return model
```

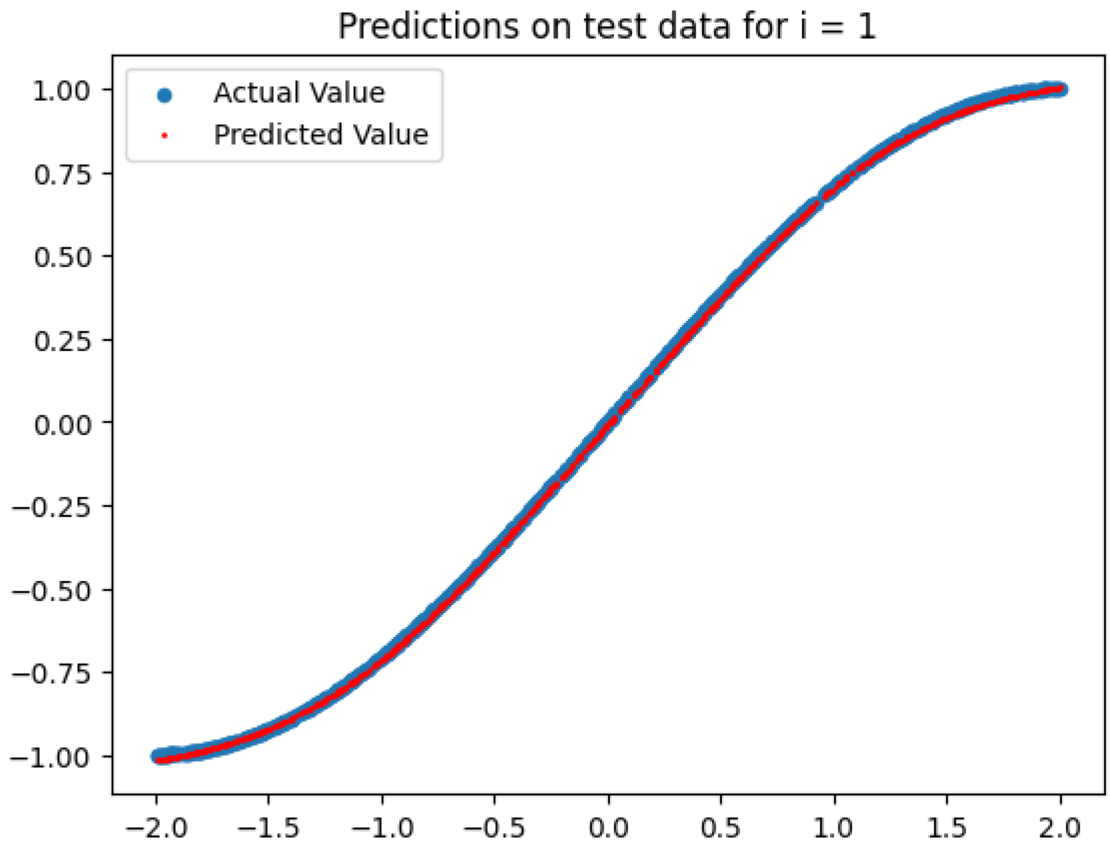
In [ ]:
```
# The following function runs training for a given set of arguments.
def train(num_hidden,i):
    model = build_network(num_hidden)
    X,y = sine_wave(i)
    X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)
    model.compile(
        optimizer=tf.keras.optimizers.Adam(learning_rate=0.1),
        loss=tf.keras.losses.MeanSquaredError()
```

```python
    )
    history = model.fit(X_train,y_train,epochs=50,verbose=False)
    average_training_loss = np.mean(history.history['loss'])
    predictions = model.predict(X_test)
    return average_training_loss, X_test, predictions, y_test
```

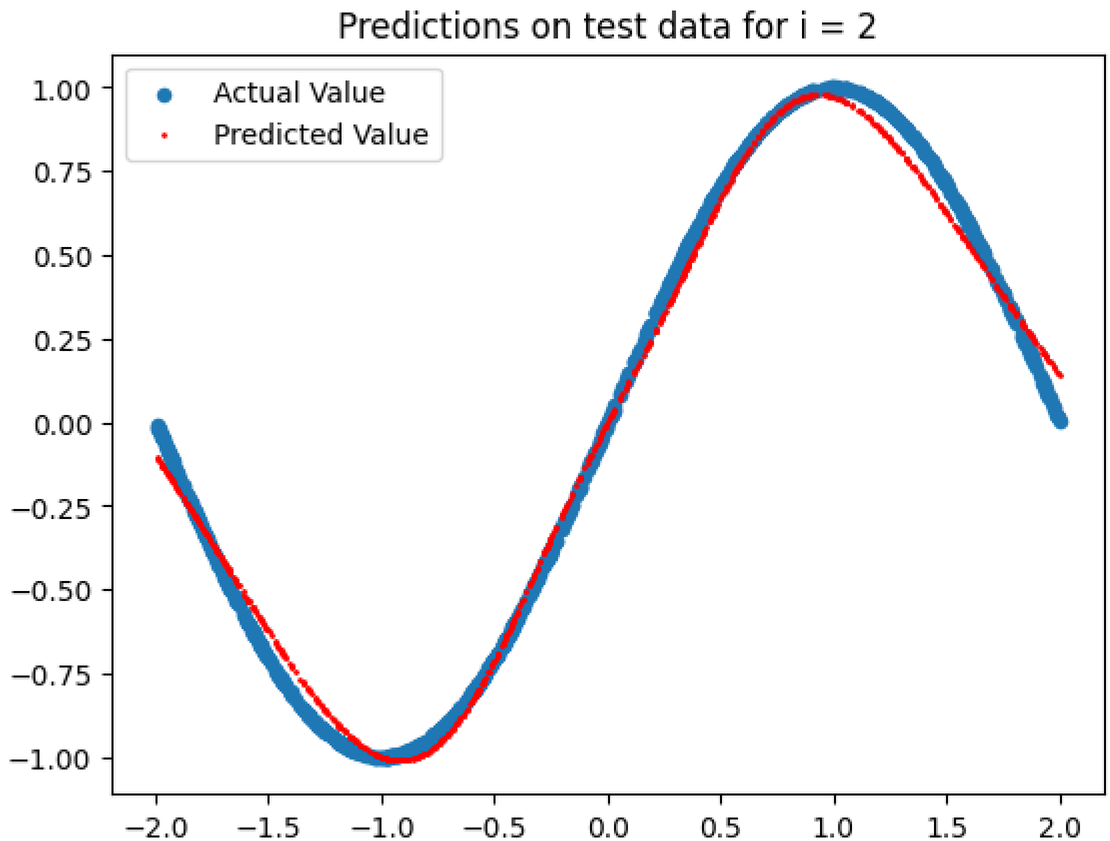
In [ ]:

```python
avgs = []
for i in [1, 2, 4, 6, 8,]:
    average_training_loss, X_test, predictions, y_test = train(3, i)
    avgs.append(average_training_loss)
    fig, ax = plt.subplots()
    ax.scatter(X_test, y_test, label='Actual Value', s=20)
    ax.scatter(X_test, predictions, c='r',label='Predicted Value', s=1)
    ax.set_title(f'Predictions on test data for i = {i}')
    ax.legend()
    plt.show()
```

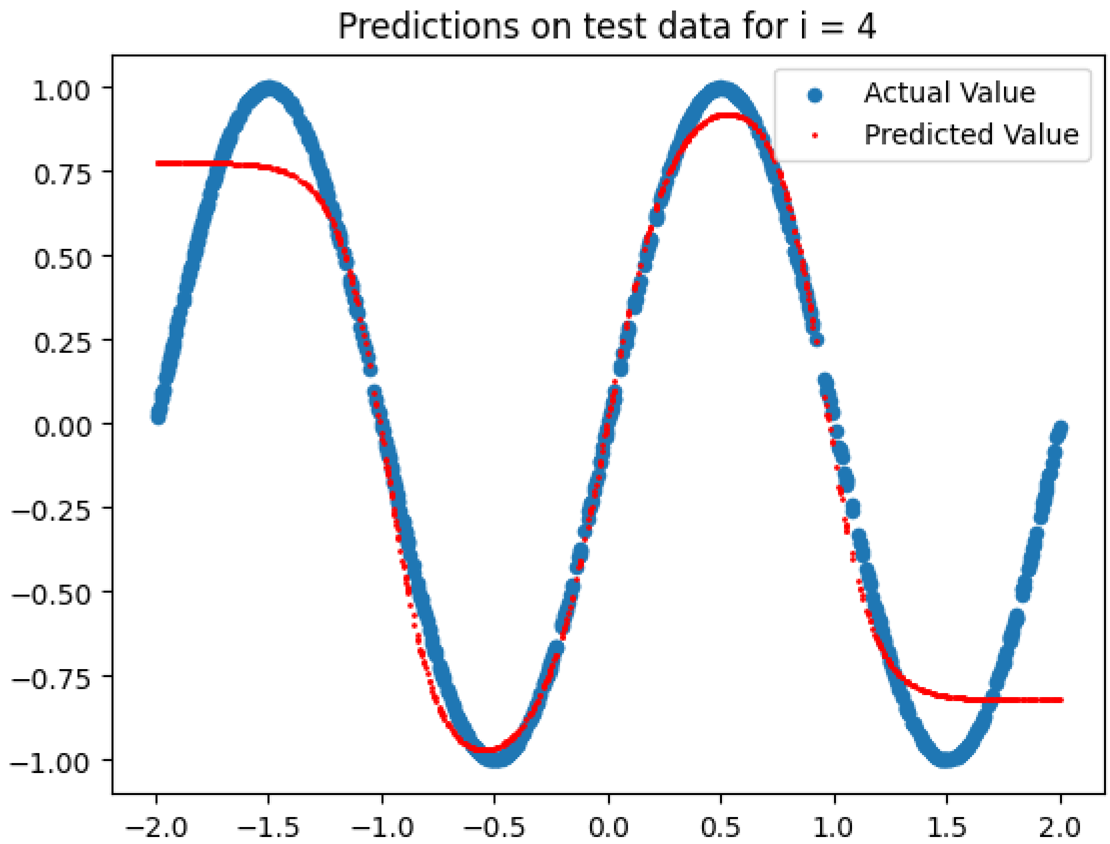
```
25/25 [==============================] - 0s 1ms/step
```



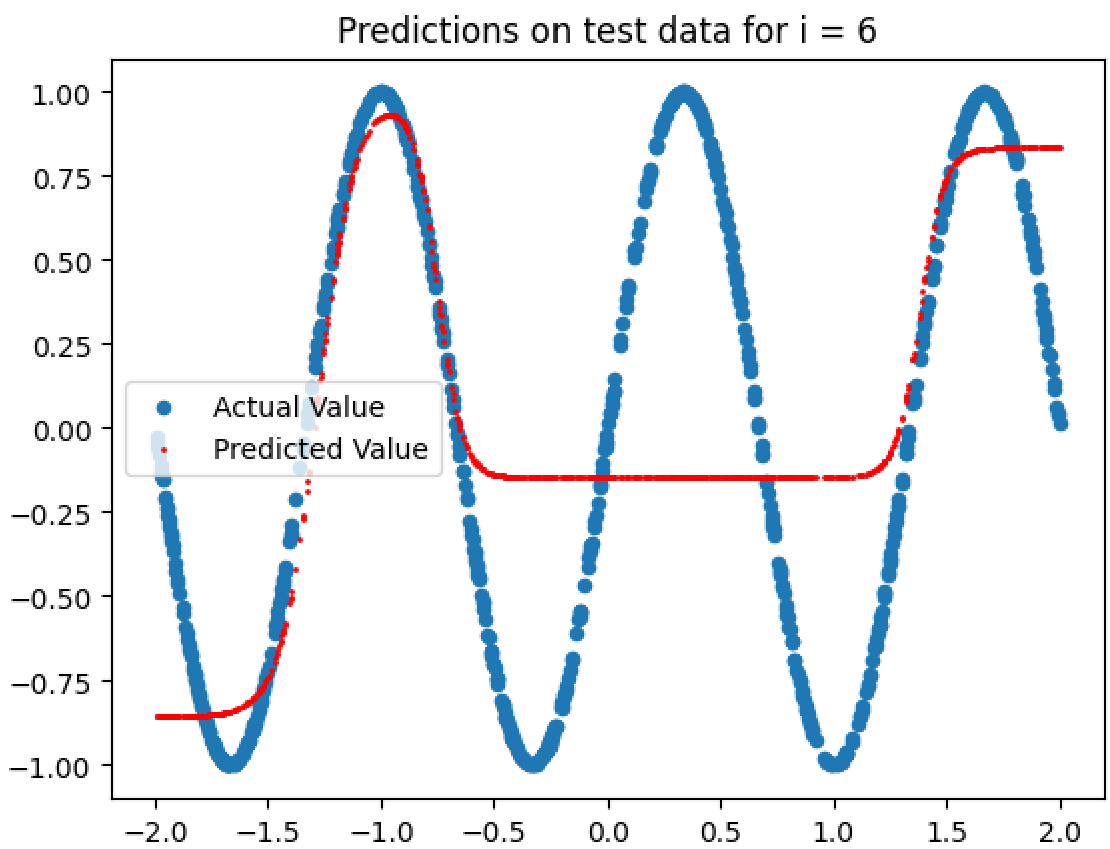

```
25/25 [==============================] - 0s 2ms/step
```



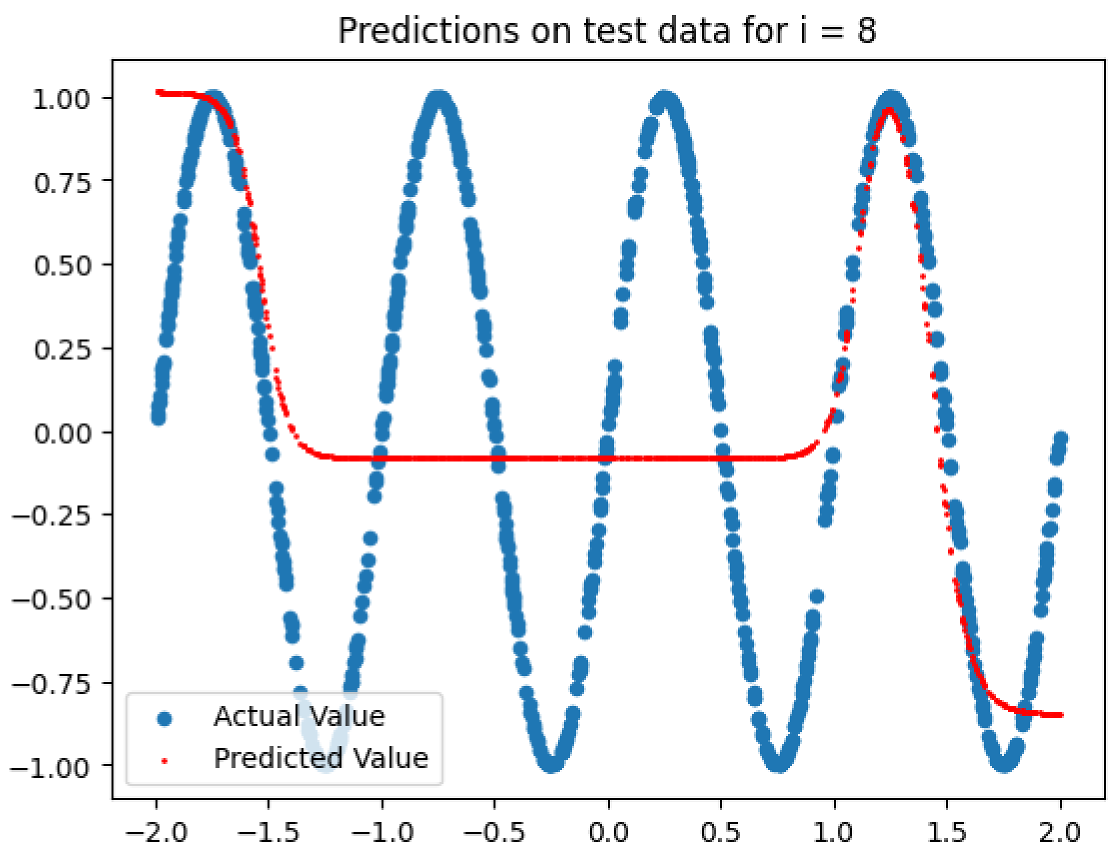

```
25/25 [==============================] - 0s 2ms/step
```



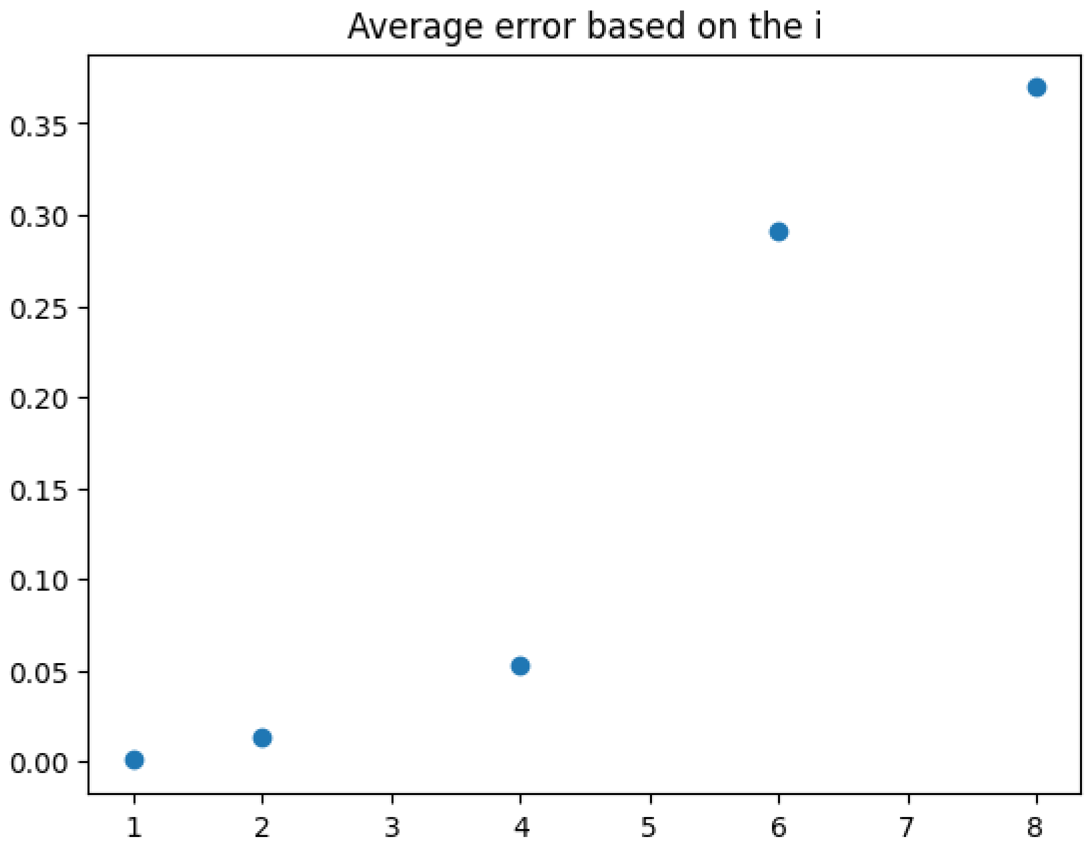

```
25/25 [==============================] - 0s 1ms/step
```




```
25/25 [==============================] - 0s 2ms/step
```



In [ ]:
```
fig, ax = plt.subplots()
ax.scatter([1, 2, 4, 6, 8,], avgs)
ax.set_title(f'Average error based on the i')
plt.show()
```



In [ ]:

```
ranges = range(2, 9)
avgs = []
for i in ranges:
    average_training_loss, X_test, predictions, y_test = train(i, 6)
    avgs.append(average_training_loss)
fig, ax = plt.subplots()
ax.scatter(ranges, avgs)
ax.set_title(f'Average error based on the number of hidden layer neurons')
plt.show()
```

```
25/25 [==============================] - 0s 1ms/step
25/25 [==============================] - 0s 2ms/step
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```

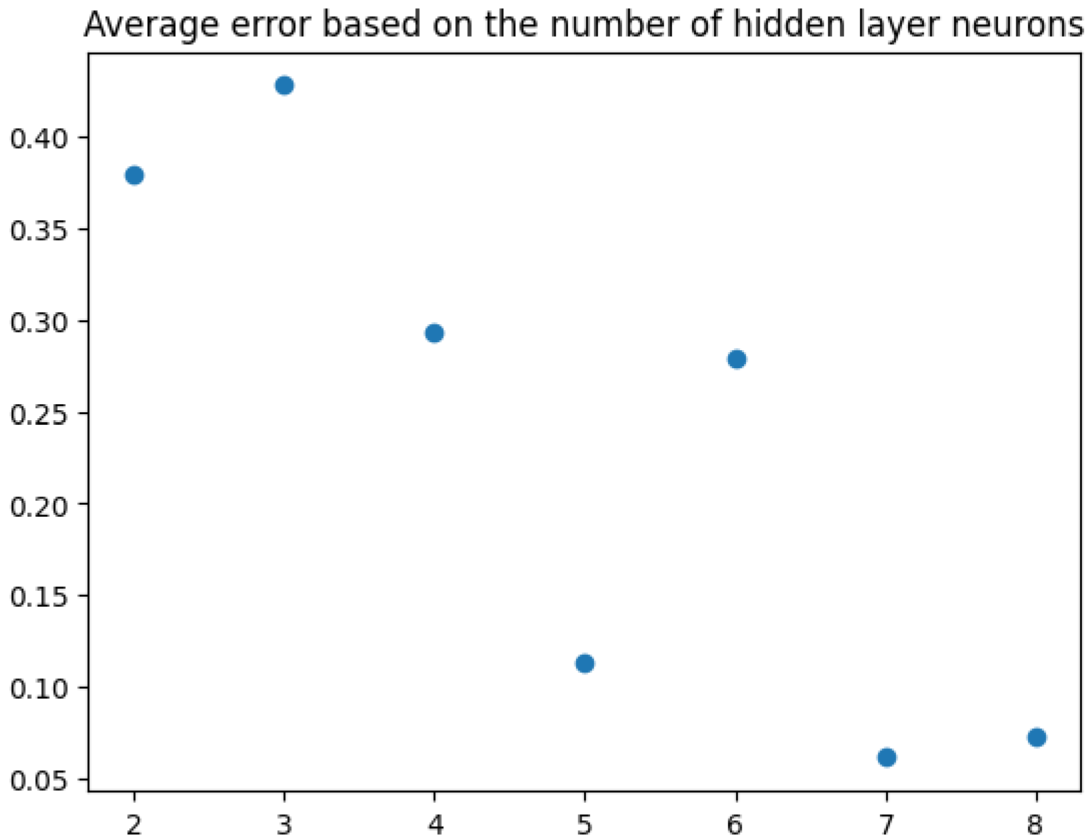


```
In [ ]:
```