

# NEURAL NETWORK ASSIGNMENT

## VIVEK REPORT

### Introduction:

The objective of this assignment was to explore and modify a neural network model for binary sentiment classification using the IMDB movie review dataset. The task involved experimenting with different hyperparameters such as the number of hidden layers, hidden units, activation functions, loss functions, and regularization techniques. The goal was to analyze how these modifications affected the model's performance in terms of test accuracy and loss.

### Dataset Overview:

The dataset used is the IMDB Movie Reviews dataset, which is a well-known dataset for binary sentiment classification. It consists of 25,000 labeled reviews for training and 25,000 for testing. The binary labels indicate whether a review is positive (1) or negative (0). The dataset is preprocessed by considering the top 10,000 most frequent words, and the sequences are padded to a fixed length of 500 words.

- Number of Features: 10,000
- Input Sequence Length: 500 words
- Training Data Shape: (25000, 500)
- Testing Data Shape: (25000, 500)

### Experiment Design:

I explored the effects of several hyperparameters on model performance. The key parameters included:

1. Hidden Layers: Testing with 1 and 3 hidden layers.
2. Hidden Units: Configurations with 32, 64, and 128 hidden units.
3. Loss Functions:
  - `'binary_crossentropy'`: The default loss function for binary classification.
  - `'mean_squared_error'` (MSE): Testing the effect of a loss function that is typically used for regression problems.
4. Activation Functions:
  - `'relu'`: Common activation for deep neural networks.
  - `'tanh'`: An older activation function to test its performance.
5. Regularization Techniques:
  - Dropout: To prevent overfitting, I applied a dropout rate of 0.5.
  - L2 Regularization: A penalty of 0.01 was applied to the weights to reduce model complexity.

### Model Architecture:

The neural network models were built using Keras with TensorFlow backend. The architecture for each model consisted of:

- An input layer with an embedding of the input text (500 words, embedding dimension: 128).
- A series of hidden layers (1 or 3 layers) with varying units (32, 64, 128) and activation functions ('relu' or 'tanh').
- Dropout layers after each hidden layer to prevent overfitting.
- An output layer with a single neuron and a 'sigmoid' activation function to handle the binary classification task.

Each model was compiled using the 'adam' optimizer, and either 'binary\_crossentropy' or 'mean\_squared\_error' as the loss function.

### Results:

After training and evaluating models under each configuration, I obtained the following key results:

Hidden Layers	Hidden Units	Activation Function	Loss Function	Dropout Rate	L2 Regularization	Test Accuracy	Test Loss
1	32	relu	binary_crossentropy	0.5	0.01	0.88	0.4
1	64	relu	binary_crossentropy	0.5	0.01	0.88	0.43
1	128	relu	binary_crossentropy	0.5	0.01	0.87	0.44
3	32	relu	binary_crossentropy	0.5	0.01	0.5	0.69
3	64	relu	binary_crossentropy	0.5	0.01	0.87	0.58
3	128	relu	binary_crossentropy	0.5	0.01	0.5	0.69
1	32	relu	mean_squared_error	0.5	0.01	0.88	0.14
1	64	relu	mean_squared_error	0.5	0.01	0.87	0.15

1	128	relu	mean_squared_error	0.5	0.01	0.87	0.15
3	32	relu	mean_squared_error	0.5	0.01	0.5	0.25
3	64	relu	mean_squared_error	0.5	0.01	0.5	0.25
3	128	relu	mean_squared_error	0.5	0.01	0.5	0.25
1	32	tanh	binary_crossentropy	0.5	0.01	0.88	0.38
1	64	tanh	binary_crossentropy	0.5	0.01	0.88	0.38
1	128	tanh	binary_crossentropy	0.5	0.01	0.88	0.4
3	32	tanh	binary_crossentropy	0.5	0.01	0.87	0.44
3	64	tanh	binary_crossentropy	0.5	0.01	0.88	0.44
3	128	tanh	binary_crossentropy	0.5	0.01	0.87	0.52
1	32	tanh	mean_squared_error	0.5	0.01	0.88	0.14
1	64	tanh	mean_squared_error	0.5	0.01	0.88	0.14
1	128	tanh	mean_squared_error	0.5	0.01	0.88	0.14
3	32	tanh	mean_squared_error	0.5	0.01	0.87	0.15
3	64	tanh	mean_squared_error	0.5	0.01	0.87	0.16
3	128	tanh	mean_squared_error	0.5	0.01	0.85	0.18

## Key Observations:

### 1. Hidden Layers:

- 1 hidden layer consistently produced better accuracy (87-88%) compared to 3 hidden layers, which often resulted in accuracy drops (around 50%). The addition of more layers without tuning led to overfitting or underfitting, especially for larger configurations (128 units).

### 2. Hidden Units:

- For both 1 and 3 hidden layers, models with 64 units achieved competitive accuracy with both loss functions and activations. However, increasing the number of hidden units to 128 generally resulted in diminishing returns or increased loss.

### 3. Loss Functions:

- The `'mean_squared_error'` (MSE) loss function, typically used for regression, performed surprisingly well with 1 hidden layer configurations, leading to a significant reduction in test loss (as low as 0.14). However, the test accuracy did not improve over `'binary_crossentropy'`.

### 4. Activation Functions:

- Models using the `'tanh'` activation function performed comparably to those using `'relu'`, with slightly lower loss in some cases. This suggests that `'tanh'` is still a viable choice for activation functions in deep learning.

### 5. Regularization (Dropout & L2):

- Dropout and L2 regularization helped stabilize performance across all configurations. A dropout rate of 0.5 and L2 regularization with a penalty of 0.01 reduced overfitting, particularly for models with multiple hidden layers.

## Conclusion:

This exploration highlighted the importance of tuning hyperparameters when designing neural networks. Key takeaways include:

- Simpler architectures (1 hidden layer, 64 units) often perform as well as or better than more complex architectures for this binary classification task.
- Loss functions matter: while `'binary_crossentropy'` is the default for classification, MSE can significantly reduce loss without drastically affecting accuracy.
- The tanh activation still performs comparably to `'relu'`, showing that older activation functions are not obsolete.
- Regularization techniques like dropout and L2 regularization are essential for avoiding overfitting in deeper models.

# Importing Libraries

```
In [1]: import tensorflow as tf
        from tensorflow.keras import layers, models, regularizers
        from tensorflow.keras.datasets import imdb
        from tensorflow.keras.preprocessing import sequence
        from tensorflow.keras.callbacks import EarlyStopping
        import pandas as pd
        import matplotlib.pyplot as plt
```

## Loading Data

```
In [2]: # Load the IMDB dataset
max_features = 10000 # Number of words to consider as features
maxlen = 500 # Cut texts after this number of words
batch_size = 512

# Load the dataset, keeping only the top 10,000 most common words
(x_train, y_train), (x_test, y_test) = imdb.load_data(num_words=max_features)

# Pad the sequences so that each review is of the same length (500 words)
x_train = sequence.pad_sequences(x_train, maxlen=maxlen)
x_test = sequence.pad_sequences(x_test, maxlen=maxlen)

# Print the shape of the training and test data
print('x_train shape:', x_train.shape)
print('x_test shape:', x_test.shape)
print('y_train shape:', y_train.shape)
print('y_test shape:', y_test.shape)

x_train shape: (25000, 500)
x_test shape: (25000, 500)
y_train shape: (25000,)
y_test shape: (25000,)
```

## Configuration Definition

```
In [3]: # Define different configurations to experiment with
experiment_configs = [
    # 1 Hidden Layer Configurations with relu
    {'hidden_layers': 1, 'hidden_units': 32, 'loss_function': 'binary_crossentropy', '
    {'hidden_layers': 1, 'hidden_units': 64, 'loss_function': 'binary_crossentropy', '
    {'hidden_layers': 1, 'hidden_units': 128, 'loss_function': 'binary_crossentropy',

    # 3 Hidden Layers Configurations with relu
    {'hidden_layers': 3, 'hidden_units': 32, 'loss_function': 'binary_crossentropy', '
    {'hidden_layers': 3, 'hidden_units': 64, 'loss_function': 'binary_crossentropy', '
    {'hidden_layers': 3, 'hidden_units': 128, 'loss_function': 'binary_crossentropy',

    # Change Loss Function to MSE
    # 1 Hidden Layer Configurations with relu
```

```

{'hidden_layers': 1, 'hidden_units': 32, 'loss_function': 'mean_squared_error', 'a
{'hidden_layers': 1, 'hidden_units': 64, 'loss_function': 'mean_squared_error', 'a
{'hidden_layers': 1, 'hidden_units': 128, 'loss_function': 'mean_squared_error', '

# 3 Hidden Layers Configurations with relu
{'hidden_layers': 3, 'hidden_units': 32, 'loss_function': 'mean_squared_error', 'a
{'hidden_layers': 3, 'hidden_units': 64, 'loss_function': 'mean_squared_error', 'a
{'hidden_layers': 3, 'hidden_units': 128, 'loss_function': 'mean_squared_error', '

# Change Activation Function to Tanh
# 1 Hidden Layer Configurations with tanh
{'hidden_layers': 1, 'hidden_units': 32, 'loss_function': 'binary_crossentropy', '
{'hidden_layers': 1, 'hidden_units': 64, 'loss_function': 'binary_crossentropy', '
{'hidden_layers': 1, 'hidden_units': 128, 'loss_function': 'binary_crossentropy', '

# 3 Hidden Layers Configurations with tanh
{'hidden_layers': 3, 'hidden_units': 32, 'loss_function': 'binary_crossentropy', '
{'hidden_layers': 3, 'hidden_units': 64, 'loss_function': 'binary_crossentropy', '
{'hidden_layers': 3, 'hidden_units': 128, 'loss_function': 'binary_crossentropy', '

# Combination: 1 & 3 Hidden Layers with Tanh Activation, MSE Loss
# 1 Hidden Layer Configurations
{'hidden_layers': 1, 'hidden_units': 32, 'loss_function': 'mean_squared_error', 'a
{'hidden_layers': 1, 'hidden_units': 64, 'loss_function': 'mean_squared_error', 'a
{'hidden_layers': 1, 'hidden_units': 128, 'loss_function': 'mean_squared_error', '

# 3 Hidden Layers Configurations
{'hidden_layers': 3, 'hidden_units': 32, 'loss_function': 'mean_squared_error', 'a
{'hidden_layers': 3, 'hidden_units': 64, 'loss_function': 'mean_squared_error', 'a
{'hidden_layers': 3, 'hidden_units': 128, 'loss_function': 'mean_squared_error', '

]

```

## Model Definition

```

In [4]: # Function to build the model based on configuration
def build_model(config):
    model = models.Sequential()

    # Input Layer
    model.add(layers.InputLayer(input_shape=(500,))) # Input shape based on your data
    model.add(layers.Embedding(input_dim=10000, output_dim=128, input_length=500))
    model.add(layers.Flatten()) # Flatten to convert 2D embeddings to 1D

    # Add hidden layers based on the config
    for _ in range(config['hidden_layers']):
        model.add(layers.Dense(config['hidden_units'],
                                activation=config['activation_function'],
                                kernel_regularizer=regularizers.l2(config['l2_reg'])))
        model.add(layers.Dropout(config['dropout_rate']))

    # Output Layer (binary classification)
    model.add(layers.Dense(1, activation='sigmoid'))

    # Compile the model
    model.compile(optimizer='adam',
                  loss=config['loss_function'],

```

```

        metrics=['accuracy'])

    return model

```

```

In [5]: # Train and evaluate models on each configuration
results = []

for config in experiment_configs:
    print(f"Training model with config: {config}")

    # Build the model
    model = build_model(config)

    # Display the model summary
    model.summary()

    # Early stopping to avoid overfitting
    early_stopping = EarlyStopping(monitor='val_loss', patience=3, restore_best_weight

    # Train the model
    history = model.fit(
        x_train, y_train,
        epochs=20,
        batch_size=512,
        validation_data=(x_test, y_test),
        callbacks=[early_stopping],
        verbose=1
    )

    # Evaluate on test data
    test_loss, test_acc = model.evaluate(x_test, y_test, verbose=0)

    # Save the results
    results.append({
        'config': config,
        'history': history.history,
        'test_loss': test_loss,
        'test_acc': test_acc
    })

```

Training model with config: {'hidden\_layers': 1, 'hidden\_units': 32, 'loss\_function': 'binary\_crossentropy', 'activation\_function': 'relu', 'dropout\_rate': 0.5, 'l2\_reg': 0.01}

/usr/local/lib/python3.10/dist-packages/keras/src/layers/core/input\_layer.py:26: UserWarning: Argument `input\_shape` is deprecated. Use `shape` instead.  
 warnings.warn(  
/usr/local/lib/python3.10/dist-packages/keras/src/layers/core/embedding.py:90: UserWarning: Argument `input\_length` is deprecated. Just remove it.  
 warnings.warn(  
Model: "sequential"

Layer (type)	Output Shape	Params
embedding ( <a href="#">Embedding</a> )	(None, 500, 128)	1,280,000
flatten ( <a href="#">Flatten</a> )	(None, 64000)	
dense ( <a href="#">Dense</a> )	(None, 32)	2,048
dropout ( <a href="#">Dropout</a> )	(None, 32)	
dense_1 ( <a href="#">Dense</a> )	(None, 1)	

Total params: 3,328,065 (12.70 MB)

Trainable params: 3,328,065 (12.70 MB)

Non-trainable params: 0 (0.00 B)

Epoch 1/20

49/49 ————— 8s 70ms/step - accuracy: 0.5097 - loss: 0.9208 - val\_accuracy: 0.6620 - val\_loss: 0.7011

Epoch 2/20

49/49 ————— 5s 15ms/step - accuracy: 0.7127 - loss: 0.6355 - val\_accuracy: 0.8597 - val\_loss: 0.4512

Epoch 3/20

49/49 ————— 1s 17ms/step - accuracy: 0.8673 - loss: 0.4450 - val\_accuracy: 0.8611 - val\_loss: 0.4259

Epoch 4/20

49/49 ————— 1s 17ms/step - accuracy: 0.8992 - loss: 0.3790 - val\_accuracy: 0.8791 - val\_loss: 0.3988

Epoch 5/20

49/49 ————— 1s 17ms/step - accuracy: 0.9160 - loss: 0.3457 - val\_accuracy: 0.8806 - val\_loss: 0.4074

Epoch 6/20

49/49 ————— 1s 13ms/step - accuracy: 0.9303 - loss: 0.3291 - val\_accuracy: 0.8792 - val\_loss: 0.4174

Epoch 7/20

49/49 ————— 1s 13ms/step - accuracy: 0.9435 - loss: 0.3085 - val\_accuracy: 0.8722 - val\_loss: 0.4313

Training model with config: {'hidden\_layers': 1, 'hidden\_units': 64, 'loss\_function': 'binary\_crossentropy', 'activation\_function': 'relu', 'dropout\_rate': 0.5, 'l2\_reg': 0.01}

Model: "sequential\_1"

Layer (type)	Output Shape	Params
embedding_1 ( <a href="#">Embedding</a> )	(None, 500, 128)	1,280,000
flatten_1 ( <a href="#">Flatten</a> )	(None, 64000)	
dense_2 ( <a href="#">Dense</a> )	(None, 64)	4,096
dropout_1 ( <a href="#">Dropout</a> )	(None, 64)	
dense_3 ( <a href="#">Dense</a> )	(None, 1)	

Total params: 5,376,129 (20.51 MB)



Trainable params: 5,376,129 (20.51 MB)

Non-trainable params: 0 (0.00 B)

Epoch 1/20

49/49 ————— 8s 110ms/step - accuracy: 0.5594 - loss: 1.0959 - val\_accuracy: 0.8300 - val\_loss: 0.5429

Epoch 2/20

49/49 ————— 1s 19ms/step - accuracy: 0.8506 - loss: 0.4980 - val\_accuracy: 0.8593 - val\_loss: 0.4556

Epoch 3/20

49/49 ————— 1s 14ms/step - accuracy: 0.8963 - loss: 0.4129 - val\_accuracy: 0.8597 - val\_loss: 0.4606

Epoch 4/20

49/49 ————— 1s 14ms/step - accuracy: 0.9161 - loss: 0.3747 - val\_accuracy: 0.8714 - val\_loss: 0.4523

Epoch 5/20

49/49 ————— 1s 14ms/step - accuracy: 0.9245 - loss: 0.3569 - val\_accuracy: 0.8709 - val\_loss: 0.4532

Epoch 6/20

49/49 ————— 1s 14ms/step - accuracy: 0.9462 - loss: 0.3180 - val\_accuracy: 0.8606 - val\_loss: 0.4739

Epoch 7/20

49/49 ————— 1s 14ms/step - accuracy: 0.9581 - loss: 0.2908 - val\_accuracy: 0.8774 - val\_loss: 0.4513

Epoch 8/20

49/49 ————— 1s 17ms/step - accuracy: 0.9688 - loss: 0.2714 - val\_accuracy: 0.8798 - val\_loss: 0.4482

Epoch 9/20

49/49 ————— 1s 14ms/step - accuracy: 0.9727 - loss: 0.2654 - val\_accuracy: 0.8704 - val\_loss: 0.4600

Epoch 10/20

49/49 ————— 1s 14ms/step - accuracy: 0.9805 - loss: 0.2392 - val\_accuracy: 0.8726 - val\_loss: 0.4407

Epoch 11/20

49/49 ————— 1s 17ms/step - accuracy: 0.9852 - loss: 0.2091 - val\_accuracy: 0.8774 - val\_loss: 0.4281

Epoch 12/20

49/49 ————— 1s 18ms/step - accuracy: 0.9895 - loss: 0.1900 - val\_accuracy: 0.8726 - val\_loss: 0.4393

Epoch 13/20

49/49 ————— 1s 14ms/step - accuracy: 0.9915 - loss: 0.1878 - val\_accuracy: 0.8734 - val\_loss: 0.4454

Epoch 14/20

49/49 ————— 1s 14ms/step - accuracy: 0.9931 - loss: 0.1792 - val\_accuracy: 0.8736 - val\_loss: 0.4317

Training model with config: {'hidden\_layers': 1, 'hidden\_units': 128, 'loss\_function': 'binary\_crossentropy', 'activation\_function': 'relu', 'dropout\_rate': 0.5, 'l2\_regular': 0.01}

Model: "sequential\_2"

Layer (type)	Output Shape	Params
embedding_2 (Embedding)	(None, 500, 128)	1,280
flatten_2 (Flatten)	(None, 64000)	
dense_4 (Dense)	(None, 128)	8,192
dropout_2 (Dropout)	(None, 128)	
dense_5 (Dense)	(None, 1)	

**Total params:** 9,472,257 (36.13 MB)

**Trainable params:** 9,472,257 (36.13 MB)

**Non-trainable params:** 0 (0.00 B)

Epoch 1/20

49/49 ————— 9s 120ms/step - accuracy: 0.5084 - loss: 1.6544 - val\_accuracy: 0.5151 - val\_loss: 0.7367

Epoch 2/20

49/49 ————— 1s 20ms/step - accuracy: 0.5935 - loss: 0.7108 - val\_accuracy: 0.8376 - val\_loss: 0.5065

Epoch 3/20

49/49 ————— 1s 19ms/step - accuracy: 0.8614 - loss: 0.4741 - val\_accuracy: 0.8681 - val\_loss: 0.4523

Epoch 4/20

49/49 ————— 1s 20ms/step - accuracy: 0.8948 - loss: 0.4075 - val\_accuracy: 0.7963 - val\_loss: 0.5928

Epoch 5/20

49/49 ————— 1s 18ms/step - accuracy: 0.8950 - loss: 0.4072 - val\_accuracy: 0.8457 - val\_loss: 0.4999

Epoch 6/20

49/49 ————— 1s 19ms/step - accuracy: 0.9120 - loss: 0.3940 - val\_accuracy: 0.8717 - val\_loss: 0.4428

Epoch 7/20

49/49 ————— 1s 17ms/step - accuracy: 0.9355 - loss: 0.3329 - val\_accuracy: 0.8714 - val\_loss: 0.4589

Epoch 8/20

49/49 ————— 1s 20ms/step - accuracy: 0.9394 - loss: 0.3361 - val\_accuracy: 0.8794 - val\_loss: 0.5092

Epoch 9/20

49/49 ————— 1s 18ms/step - accuracy: 0.9572 - loss: 0.3106 - val\_accuracy: 0.8748 - val\_loss: 0.4485

Training model with config: {'hidden\_layers': 3, 'hidden\_units': 32, 'loss\_function': 'binary\_crossentropy', 'activation\_function': 'relu', 'dropout\_rate': 0.5, 'l2\_reg': 0.01}


**Model:** "sequential\_3"


Layer (type)	Output Shape	Pa
embedding_3 ( <a href="#">Embedding</a> )	( <a href="#">None</a> , 500, 128)	1,28
flatten_3 ( <a href="#">Flatten</a> )	( <a href="#">None</a> , 64000)	
dense_6 ( <a href="#">Dense</a> )	( <a href="#">None</a> , 32)	2,04
dropout_3 ( <a href="#">Dropout</a> )	( <a href="#">None</a> , 32)	
dense_7 ( <a href="#">Dense</a> )	( <a href="#">None</a> , 32)	
dropout_4 ( <a href="#">Dropout</a> )	( <a href="#">None</a> , 32)	
dense_8 ( <a href="#">Dense</a> )	( <a href="#">None</a> , 32)	
dropout_5 ( <a href="#">Dropout</a> )	( <a href="#">None</a> , 32)	
dense_9 ( <a href="#">Dense</a> )	( <a href="#">None</a> , 1)	


Total params: 3,330,177 (12.70 MB)


Trainable params: 3,330,177 (12.70 MB)


Non-trainable params: 0 (0.00 B)


Epoch 1/20  
49/49  10s 121ms/step - accuracy: 0.4994 - loss: 1.4968 - val\_accuracy: 0.5000 - val\_loss: 1.1056


Epoch 2/20  
49/49  3s 15ms/step - accuracy: 0.5034 - loss: 1.0603 - val\_accuracy: 0.5000 - val\_loss: 0.9366


Epoch 3/20  
49/49  1s 13ms/step - accuracy: 0.5030 - loss: 0.9079 - val\_accuracy: 0.5000 - val\_loss: 0.8351


Epoch 4/20  
49/49  1s 13ms/step - accuracy: 0.5031 - loss: 0.8176 - val\_accuracy: 0.5000 - val\_loss: 0.7736


Epoch 5/20  
49/49  1s 13ms/step - accuracy: 0.4997 - loss: 0.7632 - val\_accuracy: 0.5000 - val\_loss: 0.7374


Epoch 6/20  
49/49  1s 16ms/step - accuracy: 0.4941 - loss: 0.7314 - val\_accuracy: 0.5000 - val\_loss: 0.7167


Epoch 7/20  
49/49  1s 13ms/step - accuracy: 0.4999 - loss: 0.7134 - val\_accuracy: 0.5000 - val\_loss: 0.7053


Epoch 8/20  
49/49  1s 13ms/step - accuracy: 0.4965 - loss: 0.7036 - val\_accuracy: 0.5000 - val\_loss: 0.6993

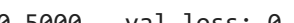
Epoch 9/20  
49/49  1s 17ms/step - accuracy: 0.4955 - loss: 0.6983 - val\_accuracy: 0.5000 - val\_loss: 0.6961

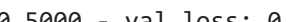
Epoch 10/20  
49/49  1s 18ms/step - accuracy: 0.4962 - loss: 0.6957 - val\_accuracy: 0.5000 - val\_loss: 0.6946


Epoch 11/20  
49/49  1s 15ms/step - accuracy: 0.4990 - loss: 0.6944 - val\_accuracy: 0.5000 - val\_loss: 0.6938


Epoch 12/20  
49/49  1s 13ms/step - accuracy: 0.5038 - loss: 0.6937 - val\_accuracy: 0.5000 - val\_loss: 0.6935


Epoch 13/20  
49/49  1s 17ms/step - accuracy: 0.4970 - loss: 0.6934 - val\_accuracy: 0.5000 - val\_loss: 0.6933


Epoch 14/20  
49/49  1s 16ms/step - accuracy: 0.4884 - loss: 0.6933 - val\_accuracy: 0.5000 - val\_loss: 0.6932


Epoch 15/20  
49/49  1s 13ms/step - accuracy: 0.5007 - loss: 0.6932 - val\_accuracy: 0.5000 - val\_loss: 0.6932

Epoch 16/20  
49/49  1s 13ms/step - accuracy: 0.5065 - loss: 0.6932 - val\_accuracy: 0.5000 - val\_loss: 0.6932

Epoch 17/20  
49/49  1s 13ms/step - accuracy: 0.5046 - loss: 0.6932 - val\_accuracy: 0.5000 - val\_loss: 0.6932

Epoch 18/20  
49/49  1s 16ms/step - accuracy: 0.4998 - loss: 0.6931 - val\_accuracy: 0.5000 - val\_loss: 0.6932

Epoch 19/20  
49/49  1s 17ms/step - accuracy: 0.4992 - loss: 0.6932 - val\_accuracy: 0.5000 - val\_loss: 0.6931

Epoch 20/20  
49/49  1s 13ms/step - accuracy: 0.5028 - loss: 0.6931 - val\_accuracy: 0.5000 - val\_loss: 0.6931

Training model with config: {'hidden\_layers': 3, 'hidden\_units': 64, 'loss\_function': 'binary\_crossentropy', 'activation\_function': 'relu', 'dropout\_rate': 0.5, 'l2\_reg': 0.01}

Model: "sequential\_4"

Layer (type)	Output Shape	Param #
embedding_4 (Embedding)	(None, 500, 128)	1,280,000
flatten_4 (Flatten)	(None, 64000)	0
dense_10 (Dense)	(None, 64)	4,096
dropout_6 (Dropout)	(None, 64)	0
dense_11 (Dense)	(None, 64)	4,160
dropout_7 (Dropout)	(None, 64)	0
dense_12 (Dense)	(None, 64)	4,160
dropout_8 (Dropout)	(None, 64)	0
dense_13 (Dense)	(None, 1)	65

Total params: 5,384,449 (20.54 MB)

Trainable params: 5,384,449 (20.54 MB)

Non-trainable params: 0 (0.00 B)

Epoch 1/20

49/49 ————— 9s 98ms/step - accuracy: 0.5105 - loss: 2.1573 - val\_accuracy: 0.5794 - val\_loss: 1.3467

Epoch 2/20

49/49 ————— 1s 18ms/step - accuracy: 0.6128 - loss: 1.2383 - val\_accuracy: 0.8300 - val\_loss: 0.9024

Epoch 3/20

49/49 ————— 1s 15ms/step - accuracy: 0.8110 - loss: 0.8842 - val\_accuracy: 0.8506 - val\_loss: 0.6783

Epoch 4/20

49/49 ————— 1s 19ms/step - accuracy: 0.8735 - loss: 0.6332 - val\_accuracy: 0.8684 - val\_loss: 0.5890

Epoch 5/20

49/49 ————— 1s 16ms/step - accuracy: 0.9049 - loss: 0.5351 - val\_accuracy: 0.8653 - val\_loss: 0.5848

Epoch 6/20

49/49 ————— 1s 17ms/step - accuracy: 0.9262 - loss: 0.4709 - val\_accuracy: 0.8634 - val\_loss: 0.5879

Epoch 7/20

49/49 ————— 1s 14ms/step - accuracy: 0.9441 - loss: 0.4281 - val\_accuracy: 0.8583 - val\_loss: 0.6362

Epoch 8/20

49/49 ————— 1s 14ms/step - accuracy: 0.9606 - loss: 0.3922 - val\_accuracy: 0.8691 - val\_loss: 0.5952

Training model with config: {'hidden\_layers': 3, 'hidden\_units': 128, 'loss\_function': 'binary\_crossentropy', 'activation\_function': 'relu', 'dropout\_rate': 0.5, 'l2\_reg': 0.01}


Model: "sequential\_5"


Layer (type)	Output Shape	Pa
embedding_5 ( <a href="#">Embedding</a> )	( <a href="#">None</a> , <a href="#">500</a> , <a href="#">128</a> )	<a href="#">1,28</a>
flatten_5 ( <a href="#">Flatten</a> )	( <a href="#">None</a> , <a href="#">64000</a> )	
dense_14 ( <a href="#">Dense</a> )	( <a href="#">None</a> , <a href="#">128</a> )	<a href="#">8,19</a>
dropout_9 ( <a href="#">Dropout</a> )	( <a href="#">None</a> , <a href="#">128</a> )	
dense_15 ( <a href="#">Dense</a> )	( <a href="#">None</a> , <a href="#">128</a> )	<a href="#">:</a>
dropout_10 ( <a href="#">Dropout</a> )	( <a href="#">None</a> , <a href="#">128</a> )	
dense_16 ( <a href="#">Dense</a> )	( <a href="#">None</a> , <a href="#">128</a> )	<a href="#">:</a>
dropout_11 ( <a href="#">Dropout</a> )	( <a href="#">None</a> , <a href="#">128</a> )	
dense_17 ( <a href="#">Dense</a> )	( <a href="#">None</a> , <a href="#">1</a> )	


Total params: [9,505,281](#) (36.26 MB)


Trainable params: [9,505,281](#) (36.26 MB)


Non-trainable params: [0](#) (0.00 B)


Epoch 1/20  
49/49  10s 116ms/step - accuracy: 0.5019 - loss: 3.4294 - val\_accuracy: 0.5511 - val\_loss: 1.6167


Epoch 2/20  
49/49  1s 19ms/step - accuracy: 0.5223 - loss: 1.4061 - val\_accuracy: 0.5364 - val\_loss: 0.9711


Epoch 3/20  
49/49  1s 21ms/step - accuracy: 0.5313 - loss: 0.9023 - val\_accuracy: 0.5000 - val\_loss: 0.7661


Epoch 4/20  
49/49  1s 21ms/step - accuracy: 0.5467 - loss: 0.7466 - val\_accuracy: 0.5045 - val\_loss: 0.7102


Epoch 5/20  
49/49  1s 18ms/step - accuracy: 0.6648 - loss: 0.7151 - val\_accuracy: 0.5000 - val\_loss: 1.4821


Epoch 6/20  
49/49  1s 18ms/step - accuracy: 0.5003 - loss: 1.3709 - val\_accuracy: 0.5156 - val\_loss: 0.7703


Epoch 7/20  
49/49  1s 21ms/step - accuracy: 0.5025 - loss: 0.7405 - val\_accuracy: 0.5014 - val\_loss: 0.7063

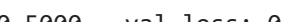
Epoch 8/20  
49/49  1s 20ms/step - accuracy: 0.5056 - loss: 0.7040 - val\_accuracy: 0.5067 - val\_loss: 0.6994

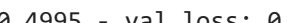
Epoch 9/20  
49/49  1s 20ms/step - accuracy: 0.5024 - loss: 0.6993 - val\_accuracy: 0.5000 - val\_loss: 0.6973


Epoch 10/20  
49/49  1s 20ms/step - accuracy: 0.5026 - loss: 0.6969 - val\_accuracy: 0.5000 - val\_loss: 0.6960


Epoch 11/20  
49/49  1s 21ms/step - accuracy: 0.4982 - loss: 0.6960 - val\_accuracy: 0.5157 - val\_loss: 0.6949


Epoch 12/20  
49/49  1s 19ms/step - accuracy: 0.4958 - loss: 0.6954 - val\_accuracy: 0.5000 - val\_loss: 0.6945


Epoch 13/20  
49/49  1s 19ms/step - accuracy: 0.5060 - loss: 0.6947 - val\_accuracy: 0.5000 - val\_loss: 0.6944


Epoch 14/20  
49/49  1s 21ms/step - accuracy: 0.4985 - loss: 0.6942 - val\_accuracy: 0.4995 - val\_loss: 0.6938

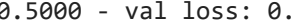
Epoch 15/20  
49/49  1s 19ms/step - accuracy: 0.5048 - loss: 0.6939 - val\_accuracy: 0.5069 - val\_loss: 0.6937

Epoch 16/20  
49/49  1s 18ms/step - accuracy: 0.5100 - loss: 0.6938 - val\_accuracy: 0.5028 - val\_loss: 0.6939

Epoch 17/20  
49/49  1s 18ms/step - accuracy: 0.5152 - loss: 0.6937 - val\_accuracy: 0.5376 - val\_loss: 0.6943

Epoch 18/20  
49/49  1s 19ms/step - accuracy: 0.4989 - loss: 0.6941 - val\_accuracy: 0.5000 - val\_loss: 0.6935

Epoch 19/20  
49/49  1s 18ms/step - accuracy: 0.5085 - loss: 0.6935 - val\_accuracy: 0.5055 - val\_loss: 0.6935

Epoch 20/20  
49/49  1s 22ms/step - accuracy: 0.4980 - loss: 0.6936 - val\_accuracy: 0.5000 - val\_loss: 0.6934

Training model with config: {'hidden\_layers': 1, 'hidden\_units': 32, 'loss\_function': 'mean\_squared\_error', 'activation\_function': 'relu', 'dropout\_rate': 0.5, 'l2\_reg': 0.01}

Model: "sequential\_6"

Layer (type)	Output Shape	Params
embedding_6 (Embedding)	(None, 500, 128)	1,280
flatten_6 (Flatten)	(None, 64000)	
dense_18 (Dense)	(None, 32)	2,048
dropout_12 (Dropout)	(None, 32)	
dense_19 (Dense)	(None, 1)	

Total params: 3,328,065 (12.70 MB)

Trainable params: 3,328,065 (12.70 MB)

Non-trainable params: 0 (0.00 B)

Epoch 1/20

49/49 ————— 5s 58ms/step - accuracy: 0.5140 - loss: 0.4389 - val\_accuracy: 0.7270 - val\_loss: 0.2400

Epoch 2/20

49/49 ————— 1s 14ms/step - accuracy: 0.7825 - loss: 0.2088 - val\_accuracy: 0.8260 - val\_loss: 0.1695

Epoch 3/20

49/49 ————— 1s 13ms/step - accuracy: 0.8662 - loss: 0.1537 - val\_accuracy: 0.8422 - val\_loss: 0.1580

Epoch 4/20

49/49 ————— 1s 14ms/step - accuracy: 0.8828 - loss: 0.1426 - val\_accuracy: 0.8706 - val\_loss: 0.1421

Epoch 5/20

49/49 ————— 1s 15ms/step - accuracy: 0.9013 - loss: 0.1283 - val\_accuracy: 0.8779 - val\_loss: 0.1467

Epoch 6/20

49/49 ————— 1s 15ms/step - accuracy: 0.9075 - loss: 0.1296 - val\_accuracy: 0.8754 - val\_loss: 0.1442

Epoch 7/20

49/49 ————— 1s 13ms/step - accuracy: 0.9202 - loss: 0.1227 - val\_accuracy: 0.8751 - val\_loss: 0.1396

Epoch 8/20

49/49 ————— 1s 13ms/step - accuracy: 0.9281 - loss: 0.1118 - val\_accuracy: 0.8790 - val\_loss: 0.1400

Epoch 9/20

49/49 ————— 1s 13ms/step - accuracy: 0.9433 - loss: 0.1059 - val\_accuracy: 0.8612 - val\_loss: 0.1516

Epoch 10/20

49/49 ————— 1s 13ms/step - accuracy: 0.9381 - loss: 0.1121 - val\_accuracy: 0.8832 - val\_loss: 0.1449

Training model with config: {'hidden\_layers': 1, 'hidden\_units': 64, 'loss\_function': 'mean\_squared\_error', 'activation\_function': 'relu', 'dropout\_rate': 0.5, 'l2\_reg': 0.01}

Model: "sequential\_7"




Layer (type)	Output Shape	Params
embedding_7 ( <a href="#">Embedding</a> )	(None, 500, 128)	1,280
flatten_7 ( <a href="#">Flatten</a> )	(None, 64000)	
dense_20 ( <a href="#">Dense</a> )	(None, 64)	4,096
dropout_13 ( <a href="#">Dropout</a> )	(None, 64)	
dense_21 ( <a href="#">Dense</a> )	(None, 1)	

Total params: 5,376,129 (20.51 MB)


Trainable params: 5,376,129 (20.51 MB)

Non-trainable params: 0 (0.00 B)


Epoch 1/20

49/49  6s 74ms/step - accuracy: 0.5171 - loss: 0.5879 - val\_accuracy: 0.7640 - val\_loss: 0.2331


Epoch 2/20

49/49  1s 17ms/step - accuracy: 0.7911 - loss: 0.2138 - val\_accuracy: 0.8313 - val\_loss: 0.1896


Epoch 3/20

49/49  1s 15ms/step - accuracy: 0.8648 - loss: 0.1620 - val\_accuracy: 0.8714 - val\_loss: 0.1508


Epoch 4/20

49/49  1s 14ms/step - accuracy: 0.8973 - loss: 0.1398 - val\_accuracy: 0.8693 - val\_loss: 0.1527

Epoch 5/20

49/49  1s 14ms/step - accuracy: 0.9078 - loss: 0.1306 - val\_accuracy: 0.8558 - val\_loss: 0.1618

Epoch 6/20

49/49  1s 17ms/step - accuracy: 0.9143 - loss: 0.1304 - val\_accuracy: 0.8670 - val\_loss: 0.1545

Training model with config: {'hidden\_layers': 1, 'hidden\_units': 128, 'loss\_function': 'mean\_squared\_error', 'activation\_function': 'relu', 'dropout\_rate': 0.5, 'l2\_reg': 0.01}










Model: "sequential\_8"

Layer (type)	Output Shape	Params
embedding_8 ( <a href="#">Embedding</a> )	(None, 500, 128)	1,280
flatten_8 ( <a href="#">Flatten</a> )	(None, 64000)	
dense_22 ( <a href="#">Dense</a> )	(None, 128)	8,192
dropout_14 ( <a href="#">Dropout</a> )	(None, 128)	
dense_23 ( <a href="#">Dense</a> )	(None, 1)	

Total params: 9,472,257 (36.13 MB)

Trainable params: 9,472,257 (36.13 MB)

Non-trainable params: 0 (0.00 B)

Epoch 1/20  
**49/49**  **7s** 93ms/step - accuracy: 0.5103 - loss: 0.9063 - val\_accuracy: 0.7004 - val\_loss: 0.2574  
Epoch 2/20  
**49/49**  **5s** 21ms/step - accuracy: 0.7665 - loss: 0.2335 - val\_accuracy: 0.8202 - val\_loss: 0.1909  
Epoch 3/20  
**49/49**  **1s** 21ms/step - accuracy: 0.8638 - loss: 0.1669 - val\_accuracy: 0.8700 - val\_loss: 0.1600  
Epoch 4/20  
**49/49**  **1s** 18ms/step - accuracy: 0.8762 - loss: 0.1625 - val\_accuracy: 0.8563 - val\_loss: 0.1727  
Epoch 5/20  
**49/49**  **1s** 21ms/step - accuracy: 0.8965 - loss: 0.1493 - val\_accuracy: 0.8564 - val\_loss: 0.1746  
Epoch 6/20  
**49/49**  **1s** 23ms/step - accuracy: 0.9029 - loss: 0.1435 - val\_accuracy: 0.8723 - val\_loss: 0.1538  
Epoch 7/20  
**49/49**  **1s** 20ms/step - accuracy: 0.9202 - loss: 0.1281 - val\_accuracy: 0.8757 - val\_loss: 0.1543  
Epoch 8/20  
**49/49**  **1s** 19ms/step - accuracy: 0.9227 - loss: 0.1282 - val\_accuracy: 0.8693 - val\_loss: 0.1595  
Epoch 9/20  
**49/49**  **1s** 18ms/step - accuracy: 0.9298 - loss: 0.1294 - val\_accuracy: 0.8757 - val\_loss: 0.1633  
Training model with config: {'hidden\_layers': 3, 'hidden\_units': 32, 'loss\_function': 'mean\_squared\_error', 'activation\_function': 'relu', 'dropout\_rate': 0.5, 'l2\_reg': 0.01}


**Model: "sequential\_9"**


Layer (type)	Output Shape	Params
embedding_9 ( <a href="#">Embedding</a> )	(None, 500, 128)	1,280,000
flatten_9 ( <a href="#">Flatten</a> )	(None, 64000)	0
dense_24 ( <a href="#">Dense</a> )	(None, 32)	2,048
dropout_15 ( <a href="#">Dropout</a> )	(None, 32)	0
dense_25 ( <a href="#">Dense</a> )	(None, 32)	1,024
dropout_16 ( <a href="#">Dropout</a> )	(None, 32)	0
dense_26 ( <a href="#">Dense</a> )	(None, 32)	1,024
dropout_17 ( <a href="#">Dropout</a> )	(None, 32)	0
dense_27 ( <a href="#">Dense</a> )	(None, 1)	32


**Total params:** 3,330,177 (12.70 MB)


**Trainable params:** 3,330,177 (12.70 MB)


**Non-trainable params:** 0 (0.00 B)


Epoch 1/20  
49/49  10s 119ms/step - accuracy: 0.5007 - loss: 0.9766 - val\_accuracy: 0.5000 - val\_loss: 0.6350


Epoch 2/20  
49/49  3s 16ms/step - accuracy: 0.5016 - loss: 0.5891 - val\_accuracy: 0.5053 - val\_loss: 0.4740


Epoch 3/20  
49/49  1s 14ms/step - accuracy: 0.5030 - loss: 0.4466 - val\_accuracy: 0.5000 - val\_loss: 0.3776


Epoch 4/20  
49/49  1s 14ms/step - accuracy: 0.5013 - loss: 0.3612 - val\_accuracy: 0.5000 - val\_loss: 0.3205


Epoch 5/20  
49/49  1s 14ms/step - accuracy: 0.4957 - loss: 0.3109 - val\_accuracy: 0.5000 - val\_loss: 0.2876


Epoch 6/20  
49/49  1s 14ms/step - accuracy: 0.5002 - loss: 0.2823 - val\_accuracy: 0.5000 - val\_loss: 0.2693


Epoch 7/20  
49/49  1s 17ms/step - accuracy: 0.5034 - loss: 0.2664 - val\_accuracy: 0.5000 - val\_loss: 0.2595


Epoch 8/20  
49/49  1s 15ms/step - accuracy: 0.4997 - loss: 0.2580 - val\_accuracy: 0.5000 - val\_loss: 0.2545

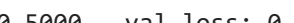
Epoch 9/20  
49/49  1s 18ms/step - accuracy: 0.5008 - loss: 0.2538 - val\_accuracy: 0.5000 - val\_loss: 0.2521

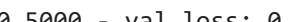
Epoch 10/20  
49/49  1s 18ms/step - accuracy: 0.5000 - loss: 0.2517 - val\_accuracy: 0.5000 - val\_loss: 0.2509


Epoch 11/20  
49/49  1s 14ms/step - accuracy: 0.4999 - loss: 0.2507 - val\_accuracy: 0.5000 - val\_loss: 0.2504


Epoch 12/20  
49/49  1s 17ms/step - accuracy: 0.4972 - loss: 0.2503 - val\_accuracy: 0.5000 - val\_loss: 0.2501


Epoch 13/20  
49/49  1s 13ms/step - accuracy: 0.4953 - loss: 0.2501 - val\_accuracy: 0.5000 - val\_loss: 0.2501


Epoch 14/20  
49/49  1s 14ms/step - accuracy: 0.4899 - loss: 0.2500 - val\_accuracy: 0.5000 - val\_loss: 0.2500


Epoch 15/20  
49/49  1s 14ms/step - accuracy: 0.5027 - loss: 0.2500 - val\_accuracy: 0.5000 - val\_loss: 0.2500

Epoch 16/20  
49/49  1s 17ms/step - accuracy: 0.5045 - loss: 0.2500 - val\_accuracy: 0.5000 - val\_loss: 0.2500

Epoch 17/20  
49/49  1s 17ms/step - accuracy: 0.5016 - loss: 0.2500 - val\_accuracy: 0.5000 - val\_loss: 0.2500

Epoch 18/20  
49/49  1s 17ms/step - accuracy: 0.4971 - loss: 0.2500 - val\_accuracy: 0.5000 - val\_loss: 0.2500

Epoch 19/20  
49/49  1s 13ms/step - accuracy: 0.4972 - loss: 0.2500 - val\_accuracy: 0.5000 - val\_loss: 0.2500

Epoch 20/20  
49/49  1s 16ms/step - accuracy: 0.4954 - loss: 0.2500 - val\_accuracy: 0.5000 - val\_loss: 0.2500

Training model with config: {'hidden\_layers': 3, 'hidden\_units': 64, 'loss\_function': 'mean\_squared\_error', 'activation\_function': 'relu', 'dropout\_rate': 0.5, 'l2\_reg': 0.01}



















Model: "sequential\_10"

Layer (type)	Output Shape	Params
embedding_10 (Embedding)	(None, 500, 128)	1,280,000
flatten_10 (Flatten)	(None, 64000)	
dense_28 (Dense)	(None, 64)	4,096,000
dropout_18 (Dropout)	(None, 64)	
dense_29 (Dense)	(None, 64)	
dropout_19 (Dropout)	(None, 64)	
dense_30 (Dense)	(None, 64)	
dropout_20 (Dropout)	(None, 64)	
dense_31 (Dense)	(None, 1)	

Total params: 5,384,449 (20.54 MB)

Trainable params: 5,384,449 (20.54 MB)

Non-trainable params: 0 (0.00 B)














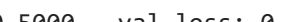
Epoch 1/20  
49/49  8s 91ms/step - accuracy: 0.5012 - loss: 1.6637 - val\_accuracy: 0.5000 - val\_loss: 0.8799  
Epoch 2/20  
49/49  4s 18ms/step - accuracy: 0.5039 - loss: 0.7747 - val\_accuracy: 0.5002 - val\_loss: 0.5334  
Epoch 3/20  
49/49  1s 15ms/step - accuracy: 0.5000 - loss: 0.4841 - val\_accuracy: 0.6304 - val\_loss: 0.3706  
Epoch 4/20  
49/49  1s 18ms/step - accuracy: 0.5036 - loss: 0.3481 - val\_accuracy: 0.5000 - val\_loss: 0.2976  
Epoch 5/20  
49/49  1s 18ms/step - accuracy: 0.5045 - loss: 0.2881 - val\_accuracy: 0.5000 - val\_loss: 0.2674  
Epoch 6/20  
49/49  1s 15ms/step - accuracy: 0.4963 - loss: 0.2637 - val\_accuracy: 0.5000 - val\_loss: 0.2558  
Epoch 7/20  
49/49  1s 18ms/step - accuracy: 0.4994 - loss: 0.2545 - val\_accuracy: 0.5000 - val\_loss: 0.2518  
Epoch 8/20  
49/49  1s 18ms/step - accuracy: 0.5027 - loss: 0.2514 - val\_accuracy: 0.5000 - val\_loss: 0.2505  
Epoch 9/20  
49/49  1s 15ms/step - accuracy: 0.5032 - loss: 0.2504 - val\_accuracy: 0.5000 - val\_loss: 0.2501  
Epoch 10/20  
49/49  1s 15ms/step - accuracy: 0.4983 - loss: 0.2501 - val\_accuracy: 0.5000 - val\_loss: 0.2500  
Epoch 11/20  
49/49  1s 18ms/step - accuracy: 0.5048 - loss: 0.2500 - val\_accuracy: 0.5000 - val\_loss: 0.2500  
Epoch 12/20  
49/49  1s 19ms/step - accuracy: 0.4935 - loss: 0.2500 - val\_accuracy: 0.5000 - val\_loss: 0.2500  
Epoch 13/20  
49/49  1s 20ms/step - accuracy: 0.5041 - loss: 0.2500 - val\_accuracy: 0.5000 - val\_loss: 0.2500  
Epoch 14/20  
49/49  1s 15ms/step - accuracy: 0.4998 - loss: 0.2500 - val\_accuracy: 0.5000 - val\_loss: 0.2500  
Epoch 15/20  
49/49  1s 15ms/step - accuracy: 0.4996 - loss: 0.2500 - val\_accuracy: 0.5000 - val\_loss: 0.2500  
Epoch 16/20  
49/49  1s 14ms/step - accuracy: 0.5008 - loss: 0.2500 - val\_accuracy: 0.5000 - val\_loss: 0.2500  
Epoch 17/20  
49/49  1s 15ms/step - accuracy: 0.4969 - loss: 0.2500 - val\_accuracy: 0.5000 - val\_loss: 0.2500  
Epoch 18/20  
49/49  1s 18ms/step - accuracy: 0.4981 - loss: 0.2500 - val\_accuracy: 0.5000 - val\_loss: 0.2500  
Training model with config: {'hidden\_layers': 3, 'hidden\_units': 128, 'loss\_function': 'mean\_squared\_error', 'activation\_function': 'relu', 'dropout\_rate': 0.5, 'l2\_reg': 0.01}  
Model: "sequential\_11"

Layer (type)	Output Shape	Pa
embedding_11 ( <a href="#">Embedding</a> )	( <a href="#">None</a> , <a href="#">500</a> , <a href="#">128</a> )	<a href="#">1,28</a>
flatten_11 ( <a href="#">Flatten</a> )	( <a href="#">None</a> , <a href="#">64000</a> )	
dense_32 ( <a href="#">Dense</a> )	( <a href="#">None</a> , <a href="#">128</a> )	<a href="#">8,19</a>
dropout_21 ( <a href="#">Dropout</a> )	( <a href="#">None</a> , <a href="#">128</a> )	
dense_33 ( <a href="#">Dense</a> )	( <a href="#">None</a> , <a href="#">128</a> )	<a href="#">:</a>
dropout_22 ( <a href="#">Dropout</a> )	( <a href="#">None</a> , <a href="#">128</a> )	
dense_34 ( <a href="#">Dense</a> )	( <a href="#">None</a> , <a href="#">128</a> )	<a href="#">:</a>
dropout_23 ( <a href="#">Dropout</a> )	( <a href="#">None</a> , <a href="#">128</a> )	
dense_35 ( <a href="#">Dense</a> )	( <a href="#">None</a> , <a href="#">1</a> )	

**Total params:** [9,505,281](#) (36.26 MB)

**Trainable params:** [9,505,281](#) (36.26 MB)

**Non-trainable params:** [0](#) (0.00 B)

Epoch 1/20  
49/49  10s 93ms/step - accuracy: 0.5031 - loss: 2.9362 - val\_accuracy: 0.5010 - val\_loss: 1.1545  
Epoch 2/20  
49/49  3s 21ms/step - accuracy: 0.4950 - loss: 0.9457 - val\_accuracy: 0.5000 - val\_loss: 0.5170  
Epoch 3/20  
49/49  1s 22ms/step - accuracy: 0.4949 - loss: 0.4501 - val\_accuracy: 0.5000 - val\_loss: 0.3181  
Epoch 4/20  
49/49  1s 22ms/step - accuracy: 0.5014 - loss: 0.2995 - val\_accuracy: 0.5000 - val\_loss: 0.2647  
Epoch 5/20  
49/49  1s 22ms/step - accuracy: 0.4940 - loss: 0.2603 - val\_accuracy: 0.5000 - val\_loss: 0.2526  
Epoch 6/20  
49/49  1s 20ms/step - accuracy: 0.5028 - loss: 0.2518 - val\_accuracy: 0.5000 - val\_loss: 0.2504  
Epoch 7/20  
49/49  1s 19ms/step - accuracy: 0.5021 - loss: 0.2503 - val\_accuracy: 0.5000 - val\_loss: 0.2500  
Epoch 8/20  
49/49  1s 21ms/step - accuracy: 0.4971 - loss: 0.2500 - val\_accuracy: 0.5000 - val\_loss: 0.2500  
Epoch 9/20  
49/49  1s 19ms/step - accuracy: 0.4965 - loss: 0.2500 - val\_accuracy: 0.5000 - val\_loss: 0.2500  
Epoch 10/20  
49/49  1s 21ms/step - accuracy: 0.4962 - loss: 0.2500 - val\_accuracy: 0.5000 - val\_loss: 0.2500  
Epoch 11/20  
49/49  1s 19ms/step - accuracy: 0.5037 - loss: 0.2500 - val\_accuracy: 0.5000 - val\_loss: 0.2500  
Epoch 12/20  
49/49  1s 19ms/step - accuracy: 0.5070 - loss: 0.2500 - val\_accuracy: 0.5000 - val\_loss: 0.2500  
Epoch 13/20  
49/49  1s 19ms/step - accuracy: 0.5011 - loss: 0.2500 - val\_accuracy: 0.5000 - val\_loss: 0.2500  
Epoch 14/20  
49/49  1s 19ms/step - accuracy: 0.4954 - loss: 0.2500 - val\_accuracy: 0.5000 - val\_loss: 0.2500  
Training model with config: {'hidden\_layers': 1, 'hidden\_units': 32, 'loss\_function': 'binary\_crossentropy', 'activation\_function': 'tanh', 'dropout\_rate': 0.5, 'l2\_reg': 0.01}  
Model: "sequential\_12"


Layer (type)	Output Shape	Pa
embedding_12 ( <a href="#">Embedding</a> )	(None, 500, 128)	1,28
flatten_12 ( <a href="#">Flatten</a> )	(None, 64000)	
dense_36 ( <a href="#">Dense</a> )	(None, 32)	2,04
dropout_24 ( <a href="#">Dropout</a> )	(None, 32)	
dense_37 ( <a href="#">Dense</a> )	(None, 1)	

**Total params:** 3,328,065 (12.70 MB)


**Trainable params:** 3,328,065 (12.70 MB)

**Non-trainable params:** 0 (0.00 B)


Epoch 1/20

49/49  6s 66ms/step - accuracy: 0.5509 - loss: 1.0644 - val\_accuracy: 0.8328 - val\_loss: 0.5200


Epoch 2/20

49/49  1s 15ms/step - accuracy: 0.8713 - loss: 0.4565 - val\_accuracy: 0.8599 - val\_loss: 0.4189


Epoch 3/20

49/49  1s 13ms/step - accuracy: 0.9034 - loss: 0.3678 - val\_accuracy: 0.8773 - val\_loss: 0.3817


Epoch 4/20

49/49  1s 17ms/step - accuracy: 0.9227 - loss: 0.3216 - val\_accuracy: 0.8715 - val\_loss: 0.3846


Epoch 5/20

49/49  1s 16ms/step - accuracy: 0.9346 - loss: 0.2963 - val\_accuracy: 0.8794 - val\_loss: 0.3779


Epoch 6/20

49/49  1s 17ms/step - accuracy: 0.9477 - loss: 0.2733 - val\_accuracy: 0.8797 - val\_loss: 0.3841

Epoch 7/20

49/49  1s 18ms/step - accuracy: 0.9630 - loss: 0.2503 - val\_accuracy: 0.8809 - val\_loss: 0.3817

Epoch 8/20

49/49  1s 16ms/step - accuracy: 0.9723 - loss: 0.2282 - val\_accuracy: 0.8785 - val\_loss: 0.3799

Training model with config: {'hidden\_layers': 1, 'hidden\_units': 64, 'loss\_function': 'binary\_crossentropy', 'activation\_function': 'tanh', 'dropout\_rate': 0.5, 'l2\_reg': 0.01}

**Model:** "sequential\_13"




Layer (type)	Output Shape	Pa
embedding_13 ( <a href="#">Embedding</a> )	(None, 500, 128)	1,28
flatten_13 ( <a href="#">Flatten</a> )	(None, 64000)	
dense_38 ( <a href="#">Dense</a> )	(None, 64)	4,09
dropout_25 ( <a href="#">Dropout</a> )	(None, 64)	
dense_39 ( <a href="#">Dense</a> )	(None, 1)	

**Total params:** 5,376,129 (20.51 MB)


**Trainable params:** 5,376,129 (20.51 MB)

**Non-trainable params:** 0 (0.00 B)


Epoch 1/20

49/49  6s 72ms/step - accuracy: 0.5078 - loss: 1.6320 - val\_accuracy: 0.5266 - val\_loss: 0.7856


Epoch 2/20

49/49  1s 19ms/step - accuracy: 0.5350 - loss: 0.9003 - val\_accuracy: 0.5483 - val\_loss: 0.7593


Epoch 3/20

49/49  1s 18ms/step - accuracy: 0.5491 - loss: 0.8404 - val\_accuracy: 0.7420 - val\_loss: 0.6610


Epoch 4/20

49/49  1s 19ms/step - accuracy: 0.7684 - loss: 0.5855 - val\_accuracy: 0.8630 - val\_loss: 0.4191


Epoch 5/20

49/49  1s 15ms/step - accuracy: 0.8932 - loss: 0.3761 - val\_accuracy: 0.8717 - val\_loss: 0.3904


Epoch 6/20

49/49  1s 15ms/step - accuracy: 0.9105 - loss: 0.3391 - val\_accuracy: 0.8814 - val\_loss: 0.3771


Epoch 7/20

49/49  1s 14ms/step - accuracy: 0.9282 - loss: 0.3056 - val\_accuracy: 0.8772 - val\_loss: 0.3839

Epoch 8/20

49/49  1s 14ms/step - accuracy: 0.9351 - loss: 0.2934 - val\_accuracy: 0.8692 - val\_loss: 0.3995

Epoch 9/20

49/49  1s 14ms/step - accuracy: 0.9451 - loss: 0.2798 - val\_accuracy: 0.8817 - val\_loss: 0.3903

Training model with config: {'hidden\_layers': 1, 'hidden\_units': 128, 'loss\_function': 'binary\_crossentropy', 'activation\_function': 'tanh', 'dropout\_rate': 0.5, 'l2\_reg': 0.01}

**Model:** "sequential\_14"


Layer (type)	Output Shape	Pa
embedding_14 ( <a href="#">Embedding</a> )	( <a href="#">None</a> , 500, 128)	1,28
flatten_14 ( <a href="#">Flatten</a> )	( <a href="#">None</a> , 64000)	
dense_40 ( <a href="#">Dense</a> )	( <a href="#">None</a> , 128)	8,19
dropout_26 ( <a href="#">Dropout</a> )	( <a href="#">None</a> , 128)	
dense_41 ( <a href="#">Dense</a> )	( <a href="#">None</a> , 1)	

**Total params:** 9,472,257 (36.13 MB)


**Trainable params:** 9,472,257 (36.13 MB)

**Non-trainable params:** 0 (0.00 B)


Epoch 1/20

49/49  7s 92ms/step - accuracy: 0.5167 - loss: 2.1774 - val\_accuracy: 0.5562 - val\_loss: 0.7505


Epoch 2/20

49/49  5s 21ms/step - accuracy: 0.7636 - loss: 0.6018 - val\_accuracy: 0.8643 - val\_loss: 0.4416


Epoch 3/20

49/49  1s 22ms/step - accuracy: 0.8911 - loss: 0.3986 - val\_accuracy: 0.8737 - val\_loss: 0.4076


Epoch 4/20

49/49  1s 22ms/step - accuracy: 0.9099 - loss: 0.3545 - val\_accuracy: 0.8751 - val\_loss: 0.4012


Epoch 5/20

49/49  1s 19ms/step - accuracy: 0.9199 - loss: 0.3335 - val\_accuracy: 0.8764 - val\_loss: 0.4000


Epoch 6/20

49/49  1s 21ms/step - accuracy: 0.9286 - loss: 0.3256 - val\_accuracy: 0.8783 - val\_loss: 0.4079

Epoch 7/20

49/49  1s 21ms/step - accuracy: 0.9431 - loss: 0.2952 - val\_accuracy: 0.8686 - val\_loss: 0.4212

Epoch 8/20

49/49  1s 19ms/step - accuracy: 0.9509 - loss: 0.2837 - val\_accuracy: 0.8774 - val\_loss: 0.4112

Training model with config: {'hidden\_layers': 3, 'hidden\_units': 32, 'loss\_function': 'binary\_crossentropy', 'activation\_function': 'tanh', 'dropout\_rate': 0.5, 'l2\_reg': 0.01}

**Model:** "sequential\_15"

Layer (type)	Output Shape	Pa
embedding_15 ( <a href="#">Embedding</a> )	( <a href="#">None</a> , 500, 128)	1,28
flatten_15 ( <a href="#">Flatten</a> )	( <a href="#">None</a> , 64000)	
dense_42 ( <a href="#">Dense</a> )	( <a href="#">None</a> , 32)	2,04
dropout_27 ( <a href="#">Dropout</a> )	( <a href="#">None</a> , 32)	
dense_43 ( <a href="#">Dense</a> )	( <a href="#">None</a> , 32)	
dropout_28 ( <a href="#">Dropout</a> )	( <a href="#">None</a> , 32)	
dense_44 ( <a href="#">Dense</a> )	( <a href="#">None</a> , 32)	
dropout_29 ( <a href="#">Dropout</a> )	( <a href="#">None</a> , 32)	
dense_45 ( <a href="#">Dense</a> )	( <a href="#">None</a> , 1)	

Total params: 3,330,177 (12.70 MB)

Trainable params: 3,330,177 (12.70 MB)

Non-trainable params: 0 (0.00 B)

Epoch 1/20  
49/49 ————— 12s 147ms/step - accuracy: 0.5254 - loss: 1.6507 - val\_accuracy: 0.7525 - val\_loss: 1.1305  
Epoch 2/20  
49/49 ————— 1s 16ms/step - accuracy: 0.8181 - loss: 1.0075 - val\_accuracy: 0.8654 - val\_loss: 0.7855  
Epoch 3/20  
49/49 ————— 1s 14ms/step - accuracy: 0.9060 - loss: 0.7192 - val\_accuracy: 0.8627 - val\_loss: 0.7159  
Epoch 4/20  
49/49 ————— 1s 14ms/step - accuracy: 0.9422 - loss: 0.5621 - val\_accuracy: 0.8708 - val\_loss: 0.6338  
Epoch 5/20  
49/49 ————— 1s 14ms/step - accuracy: 0.9759 - loss: 0.4285 - val\_accuracy: 0.8712 - val\_loss: 0.5888  
Epoch 6/20  
49/49 ————— 1s 14ms/step - accuracy: 0.9842 - loss: 0.3521 - val\_accuracy: 0.8707 - val\_loss: 0.5686  
Epoch 7/20  
49/49 ————— 1s 14ms/step - accuracy: 0.9916 - loss: 0.2872 - val\_accuracy: 0.8728 - val\_loss: 0.5471  
Epoch 8/20  
49/49 ————— 1s 14ms/step - accuracy: 0.9963 - loss: 0.2350 - val\_accuracy: 0.8749 - val\_loss: 0.4889  
Epoch 9/20  
49/49 ————— 1s 14ms/step - accuracy: 0.9976 - loss: 0.1961 - val\_accuracy: 0.8728 - val\_loss: 0.4777  
Epoch 10/20  
49/49 ————— 1s 17ms/step - accuracy: 0.9991 - loss: 0.1755 - val\_accuracy: 0.8724 - val\_loss: 0.4792  
Epoch 11/20  
49/49 ————— 1s 17ms/step - accuracy: 0.9997 - loss: 0.1614 - val\_accuracy: 0.8715 - val\_loss: 0.4625  
Epoch 12/20  
49/49 ————— 1s 19ms/step - accuracy: 0.9990 - loss: 0.1529 - val\_accuracy: 0.8762 - val\_loss: 0.4549  
Epoch 13/20  
49/49 ————— 1s 14ms/step - accuracy: 0.9997 - loss: 0.1404 - val\_accuracy: 0.8760 - val\_loss: 0.4460  
Epoch 14/20  
49/49 ————— 1s 15ms/step - accuracy: 0.9996 - loss: 0.1358 - val\_accuracy: 0.8764 - val\_loss: 0.4449  
Epoch 15/20  
49/49 ————— 1s 17ms/step - accuracy: 0.9998 - loss: 0.1295 - val\_accuracy: 0.8738 - val\_loss: 0.4489  
Epoch 16/20  
49/49 ————— 1s 14ms/step - accuracy: 0.9998 - loss: 0.1317 - val\_accuracy: 0.8762 - val\_loss: 0.4525  
Epoch 17/20  
49/49 ————— 1s 18ms/step - accuracy: 0.9996 - loss: 0.1312 - val\_accuracy: 0.8743 - val\_loss: 0.4413  
Epoch 18/20  
49/49 ————— 1s 14ms/step - accuracy: 0.9996 - loss: 0.1245 - val\_accuracy: 0.8732 - val\_loss: 0.4624  
Epoch 19/20  
49/49 ————— 1s 14ms/step - accuracy: 0.9997 - loss: 0.1325 - val\_accuracy: 0.8687 - val\_loss: 0.4744  
Epoch 20/20  
49/49 ————— 1s 14ms/step - accuracy: 0.9996 - loss: 0.1311 - val\_accuracy: 0.8743 - val\_loss: 0.4717

Training model with config: {'hidden\_layers': 3, 'hidden\_units': 64, 'loss\_function': 'binary\_crossentropy', 'activation\_function': 'tanh', 'dropout\_rate': 0.5, 'l2\_reg': 0.01}














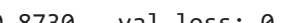

Model: "sequential\_16"

Layer (type)	Output Shape	Param #
embedding_16 (Embedding)	(None, 500, 128)	1,280,000
flatten_16 (Flatten)	(None, 64000)	0
dense_46 (Dense)	(None, 64)	4,096,000
dropout_30 (Dropout)	(None, 64)	0
dense_47 (Dense)	(None, 64)	0
dropout_31 (Dropout)	(None, 64)	0
dense_48 (Dense)	(None, 64)	0
dropout_32 (Dropout)	(None, 64)	0
dense_49 (Dense)	(None, 1)	0

Total params: 5,384,449 (20.54 MB)

Trainable params: 5,384,449 (20.54 MB)

Non-trainable params: 0 (0.00 B)

Epoch 1/20  
49/49  10s 103ms/step - accuracy: 0.5275 - loss: 2.4758 - val\_accuracy: 0.7868 - val\_loss: 1.4516  
Epoch 2/20  
49/49  4s 23ms/step - accuracy: 0.8373 - loss: 1.2672 - val\_accuracy: 0.8634 - val\_loss: 0.9942  
Epoch 3/20  
49/49  1s 18ms/step - accuracy: 0.9216 - loss: 0.8289 - val\_accuracy: 0.8634 - val\_loss: 0.8016  
Epoch 4/20  
49/49  1s 16ms/step - accuracy: 0.9519 - loss: 0.5963 - val\_accuracy: 0.8688 - val\_loss: 0.6694  
Epoch 5/20  
49/49  1s 18ms/step - accuracy: 0.9789 - loss: 0.4178 - val\_accuracy: 0.8688 - val\_loss: 0.6128  
Epoch 6/20  
49/49  1s 16ms/step - accuracy: 0.9916 - loss: 0.3190 - val\_accuracy: 0.8699 - val\_loss: 0.5880  
Epoch 7/20  
49/49  1s 16ms/step - accuracy: 0.9952 - loss: 0.2731 - val\_accuracy: 0.8734 - val\_loss: 0.5332  
Epoch 8/20  
49/49  1s 16ms/step - accuracy: 0.9982 - loss: 0.2134 - val\_accuracy: 0.8745 - val\_loss: 0.4805  
Epoch 9/20  
49/49  1s 15ms/step - accuracy: 0.9988 - loss: 0.1782 - val\_accuracy: 0.8702 - val\_loss: 0.4812  
Epoch 10/20  
49/49  1s 19ms/step - accuracy: 0.9987 - loss: 0.1754 - val\_accuracy: 0.8744 - val\_loss: 0.4703  
Epoch 11/20  
49/49  1s 15ms/step - accuracy: 0.9994 - loss: 0.1634 - val\_accuracy: 0.8728 - val\_loss: 0.4797  
Epoch 12/20  
49/49  1s 19ms/step - accuracy: 0.9993 - loss: 0.1551 - val\_accuracy: 0.8755 - val\_loss: 0.4443  
Epoch 13/20  
49/49  1s 18ms/step - accuracy: 0.9992 - loss: 0.1458 - val\_accuracy: 0.8787 - val\_loss: 0.4526  
Epoch 14/20  
49/49  1s 20ms/step - accuracy: 0.9997 - loss: 0.1413 - val\_accuracy: 0.8730 - val\_loss: 0.4573  
Epoch 15/20  
49/49  1s 20ms/step - accuracy: 0.9995 - loss: 0.1352 - val\_accuracy: 0.8755 - val\_loss: 0.4522  
Training model with config: {'hidden\_layers': 3, 'hidden\_units': 128, 'loss\_function': 'binary\_crossentropy', 'activation\_function': 'tanh', 'dropout\_rate': 0.5, 'l2\_reg': 0.01}  
Model: "sequential\_17"

Layer (type)	Output Shape	Pa
embedding_17 ( <a href="#">Embedding</a> )	( <a href="#">None</a> , <a href="#">500</a> , <a href="#">128</a> )	<a href="#">1,28</a>
flatten_17 ( <a href="#">Flatten</a> )	( <a href="#">None</a> , <a href="#">64000</a> )	
dense_50 ( <a href="#">Dense</a> )	( <a href="#">None</a> , <a href="#">128</a> )	<a href="#">8,19</a>
dropout_33 ( <a href="#">Dropout</a> )	( <a href="#">None</a> , <a href="#">128</a> )	
dense_51 ( <a href="#">Dense</a> )	( <a href="#">None</a> , <a href="#">128</a> )	<a href="#">:</a>
dropout_34 ( <a href="#">Dropout</a> )	( <a href="#">None</a> , <a href="#">128</a> )	
dense_52 ( <a href="#">Dense</a> )	( <a href="#">None</a> , <a href="#">128</a> )	<a href="#">:</a>
dropout_35 ( <a href="#">Dropout</a> )	( <a href="#">None</a> , <a href="#">128</a> )	
dense_53 ( <a href="#">Dense</a> )	( <a href="#">None</a> , <a href="#">1</a> )	

**Total params:** [9,505,281](#) (36.26 MB)

**Trainable params:** [9,505,281](#) (36.26 MB)

**Non-trainable params:** [0](#) (0.00 B)









Epoch 1/20  
 49/49 ————— 11s 137ms/step - accuracy: 0.5207 - loss: 3.8361 - val\_accuracy: 0.7004 - val\_loss: 1.9280  
 Epoch 2/20  
 49/49 ————— 2s 22ms/step - accuracy: 0.7518 - loss: 1.7111 - val\_accuracy: 0.8143 - val\_loss: 1.1042  
 Epoch 3/20  
 49/49 ————— 1s 22ms/step - accuracy: 0.8543 - loss: 0.9215 - val\_accuracy: 0.8708 - val\_loss: 0.7350  
 Epoch 4/20  
 49/49 ————— 1s 22ms/step - accuracy: 0.9004 - loss: 0.6429 - val\_accuracy: 0.8666 - val\_loss: 0.5781  
 Epoch 5/20  
 49/49 ————— 1s 20ms/step - accuracy: 0.9298 - loss: 0.4488 - val\_accuracy: 0.8714 - val\_loss: 0.5786  
 Epoch 6/20  
 49/49 ————— 1s 21ms/step - accuracy: 0.9619 - loss: 0.3757 - val\_accuracy: 0.8692 - val\_loss: 0.5643  
 Epoch 7/20  
 49/49 ————— 1s 22ms/step - accuracy: 0.9826 - loss: 0.3105 - val\_accuracy: 0.8661 - val\_loss: 0.5846  
 Epoch 8/20  
 49/49 ————— 1s 21ms/step - accuracy: 0.9905 - loss: 0.2655 - val\_accuracy: 0.8697 - val\_loss: 0.5256  
 Epoch 9/20  
 49/49 ————— 1s 22ms/step - accuracy: 0.9958 - loss: 0.2208 - val\_accuracy: 0.8672 - val\_loss: 0.5225  
 Epoch 10/20  
 49/49 ————— 1s 23ms/step - accuracy: 0.9764 - loss: 0.3573 - val\_accuracy: 0.4884 - val\_loss: 4.0087  
 Epoch 11/20  
 49/49 ————— 1s 24ms/step - accuracy: 0.4993 - loss: 3.3757 - val\_accuracy: 0.5001 - val\_loss: 1.0791  
 Epoch 12/20  
 49/49 ————— 1s 20ms/step - accuracy: 0.4925 - loss: 0.9362 - val\_accuracy: 0.4950 - val\_loss: 0.7633  
 Training model with config: {'hidden\_layers': 1, 'hidden\_units': 32, 'loss\_function': 'mean\_squared\_error', 'activation\_function': 'tanh', 'dropout\_rate': 0.5, 'l2\_reg': 0.01}

Model: "sequential\_18"

Layer (type)	Output Shape	Params
embedding_18 (Embedding)	(None, 500, 128)	1,280,000
flatten_18 (Flatten)	(None, 64000)	0
dense_54 (Dense)	(None, 32)	2,048
dropout_36 (Dropout)	(None, 32)	0
dense_55 (Dense)	(None, 1)	32

Total params: 3,328,065 (12.70 MB)  
 Trainable params: 3,328,065 (12.70 MB)  
 Non-trainable params: 0 (0.00 B)











Epoch 1/20  
**49/49**  **5s** 62ms/step - accuracy: 0.5609 - loss: 0.4408 - val\_accuracy: 0.8202 - val\_loss: 0.1925  
Epoch 2/20  
**49/49**  **1s** 15ms/step - accuracy: 0.8504 - loss: 0.1723 - val\_accuracy: 0.8586 - val\_loss: 0.1529  
Epoch 3/20  
**49/49**  **1s** 16ms/step - accuracy: 0.8907 - loss: 0.1381 - val\_accuracy: 0.8722 - val\_loss: 0.1432  
Epoch 4/20  
**49/49**  **1s** 16ms/step - accuracy: 0.9100 - loss: 0.1245 - val\_accuracy: 0.8686 - val\_loss: 0.1437  
Epoch 5/20  
**49/49**  **1s** 18ms/step - accuracy: 0.9159 - loss: 0.1211 - val\_accuracy: 0.8812 - val\_loss: 0.1413  
Epoch 6/20  
**49/49**  **1s** 13ms/step - accuracy: 0.9338 - loss: 0.1129 - val\_accuracy: 0.8825 - val\_loss: 0.1438  
Epoch 7/20  
**49/49**  **1s** 14ms/step - accuracy: 0.9382 - loss: 0.1110 - val\_accuracy: 0.8776 - val\_loss: 0.1418  
Epoch 8/20  
**49/49**  **1s** 13ms/step - accuracy: 0.9513 - loss: 0.1025 - val\_accuracy: 0.8710 - val\_loss: 0.1522  
Training model with config: {'hidden\_layers': 1, 'hidden\_units': 64, 'loss\_function': 'mean\_squared\_error', 'activation\_function': 'tanh', 'dropout\_rate': 0.5, 'l2\_reg': 0.01}

**Model: "sequential\_19"**













Layer (type)	Output Shape	Params
embedding_19 ( <a href="#">Embedding</a> )	( <a href="#">None</a> , <a href="#">500</a> , <a href="#">128</a> )	<a href="#">1,280</a>
flatten_19 ( <a href="#">Flatten</a> )	( <a href="#">None</a> , <a href="#">64000</a> )	
dense_56 ( <a href="#">Dense</a> )	( <a href="#">None</a> , <a href="#">64</a> )	<a href="#">4,096</a>
dropout_37 ( <a href="#">Dropout</a> )	( <a href="#">None</a> , <a href="#">64</a> )	
dense_57 ( <a href="#">Dense</a> )	( <a href="#">None</a> , <a href="#">1</a> )	

**Total params:** [5,376,129](#) (20.51 MB)  
**Trainable params:** [5,376,129](#) (20.51 MB)  
**Non-trainable params:** [0](#) (0.00 B)

Epoch 1/20  
**49/49**  **8s** 108ms/step - accuracy: 0.5491 - loss: 0.6377 - val\_accuracy: 0.8264 - val\_loss: 0.1946  
Epoch 2/20  
**49/49**  **5s** 18ms/step - accuracy: 0.8565 - loss: 0.1742 - val\_accuracy: 0.8624 - val\_loss: 0.1561  
Epoch 3/20  
**49/49**  **1s** 16ms/step - accuracy: 0.8830 - loss: 0.1447 - val\_accuracy: 0.8725 - val\_loss: 0.1460  
Epoch 4/20  
**49/49**  **1s** 16ms/step - accuracy: 0.8969 - loss: 0.1358 - val\_accuracy: 0.8539 - val\_loss: 0.1601  
Epoch 5/20  
**49/49**  **1s** 17ms/step - accuracy: 0.9095 - loss: 0.1304 - val\_accuracy: 0.8795 - val\_loss: 0.1431  
Epoch 6/20  
**49/49**  **1s** 18ms/step - accuracy: 0.9263 - loss: 0.1185 - val\_accuracy: 0.8815 - val\_loss: 0.1441  
Epoch 7/20  
**49/49**  **1s** 17ms/step - accuracy: 0.9344 - loss: 0.1161 - val\_accuracy: 0.8754 - val\_loss: 0.1535  
Epoch 8/20  
**49/49**  **1s** 19ms/step - accuracy: 0.9385 - loss: 0.1203 - val\_accuracy: 0.8666 - val\_loss: 0.1644  
Training model with config: {'hidden\_layers': 1, 'hidden\_units': 128, 'loss\_function': 'mean\_squared\_error', 'activation\_function': 'tanh', 'dropout\_rate': 0.5, 'l2\_reg': 0.01}  
**Model: "sequential\_20"**

Layer (type)	Output Shape	Params
embedding_20 ( <a href="#">Embedding</a> )	( <a href="#">None</a> , <a href="#">500</a> , <a href="#">128</a> )	<a href="#">1,280</a>
flatten_20 ( <a href="#">Flatten</a> )	( <a href="#">None</a> , <a href="#">64000</a> )	
dense_58 ( <a href="#">Dense</a> )	( <a href="#">None</a> , <a href="#">128</a> )	<a href="#">8,192</a>
dropout_38 ( <a href="#">Dropout</a> )	( <a href="#">None</a> , <a href="#">128</a> )	
dense_59 ( <a href="#">Dense</a> )	( <a href="#">None</a> , <a href="#">1</a> )	

**Total params:** [9,472,257](#) (36.13 MB)  
**Trainable params:** [9,472,257](#) (36.13 MB)  
**Non-trainable params:** [0](#) (0.00 B)


Epoch 1/20  
49/49  6s 77ms/step - accuracy: 0.4982 - loss: 1.0835 - val\_accuracy: 0.5290 - val\_loss: 0.3513  
Epoch 2/20  
49/49  1s 23ms/step - accuracy: 0.5164 - loss: 0.3818 - val\_accuracy: 0.5219 - val\_loss: 0.3298  
Epoch 3/20  
49/49  1s 22ms/step - accuracy: 0.5301 - loss: 0.3601 - val\_accuracy: 0.5328 - val\_loss: 0.3297  
Epoch 4/20  
49/49  1s 21ms/step - accuracy: 0.6094 - loss: 0.3081 - val\_accuracy: 0.8303 - val\_loss: 0.1855  
Epoch 5/20  
49/49  1s 22ms/step - accuracy: 0.8476 - loss: 0.1710 - val\_accuracy: 0.8585 - val\_loss: 0.1547  
Epoch 6/20  
49/49  1s 19ms/step - accuracy: 0.8810 - loss: 0.1438 - val\_accuracy: 0.8643 - val\_loss: 0.1636  
Epoch 7/20  
49/49  1s 23ms/step - accuracy: 0.8904 - loss: 0.1400 - val\_accuracy: 0.8733 - val\_loss: 0.1438  
Epoch 8/20  
49/49  1s 21ms/step - accuracy: 0.9071 - loss: 0.1256 - val\_accuracy: 0.8717 - val\_loss: 0.1461  
Epoch 9/20  
49/49  1s 20ms/step - accuracy: 0.9166 - loss: 0.1221 - val\_accuracy: 0.8806 - val\_loss: 0.1427  
Epoch 10/20  
49/49  1s 19ms/step - accuracy: 0.9228 - loss: 0.1202 - val\_accuracy: 0.8730 - val\_loss: 0.1451  
Epoch 11/20  
49/49  1s 21ms/step - accuracy: 0.9280 - loss: 0.1182 - val\_accuracy: 0.8783 - val\_loss: 0.1438  
Epoch 12/20  
49/49  1s 19ms/step - accuracy: 0.9349 - loss: 0.1119 - val\_accuracy: 0.8778 - val\_loss: 0.1514  
Training model with config: {'hidden\_layers': 3, 'hidden\_units': 32, 'loss\_function': 'mean\_squared\_error', 'activation\_function': 'tanh', 'dropout\_rate': 0.5, 'l2\_reg': 0.01}  
Model: "sequential\_21"


Layer (type)	Output Shape	Pa
embedding_21 ( <a href="#">Embedding</a> )	( <a href="#">None</a> , 500, 128)	1,28
flatten_21 ( <a href="#">Flatten</a> )	( <a href="#">None</a> , 64000)	
dense_60 ( <a href="#">Dense</a> )	( <a href="#">None</a> , 32)	2,04
dropout_39 ( <a href="#">Dropout</a> )	( <a href="#">None</a> , 32)	
dense_61 ( <a href="#">Dense</a> )	( <a href="#">None</a> , 32)	
dropout_40 ( <a href="#">Dropout</a> )	( <a href="#">None</a> , 32)	
dense_62 ( <a href="#">Dense</a> )	( <a href="#">None</a> , 32)	
dropout_41 ( <a href="#">Dropout</a> )	( <a href="#">None</a> , 32)	
dense_63 ( <a href="#">Dense</a> )	( <a href="#">None</a> , 1)	


**Total params:** 3,330,177 (12.70 MB)


**Trainable params:** 3,330,177 (12.70 MB)


**Non-trainable params:** 0 (0.00 B)


Epoch 1/20  
49/49  9s 92ms/step - accuracy: 0.5236 - loss: 1.0710 - val\_accuracy: 0.7465 - val\_loss: 0.6642


Epoch 2/20  
49/49  4s 21ms/step - accuracy: 0.7899 - loss: 0.5925 - val\_accuracy: 0.8621 - val\_loss: 0.4220


Epoch 3/20  
49/49  1s 14ms/step - accuracy: 0.8824 - loss: 0.3925 - val\_accuracy: 0.8740 - val\_loss: 0.3150


Epoch 4/20  
49/49  1s 17ms/step - accuracy: 0.9114 - loss: 0.2821 - val\_accuracy: 0.8767 - val\_loss: 0.2438


Epoch 5/20  
49/49  1s 14ms/step - accuracy: 0.9295 - loss: 0.2116 - val\_accuracy: 0.8674 - val\_loss: 0.2173


Epoch 6/20  
49/49  1s 17ms/step - accuracy: 0.9361 - loss: 0.1803 - val\_accuracy: 0.8783 - val\_loss: 0.1916


Epoch 7/20  
49/49  1s 14ms/step - accuracy: 0.9571 - loss: 0.1461 - val\_accuracy: 0.8736 - val\_loss: 0.1865


Epoch 8/20  
49/49  1s 14ms/step - accuracy: 0.9659 - loss: 0.1343 - val\_accuracy: 0.8604 - val\_loss: 0.1929

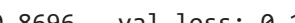
Epoch 9/20  
49/49  1s 17ms/step - accuracy: 0.9483 - loss: 0.1447 - val\_accuracy: 0.8722 - val\_loss: 0.1939


Epoch 10/20  
49/49  1s 14ms/step - accuracy: 0.9234 - loss: 0.1585 - val\_accuracy: 0.8655 - val\_loss: 0.1645


Epoch 11/20  
49/49  1s 14ms/step - accuracy: 0.9726 - loss: 0.1036 - val\_accuracy: 0.8760 - val\_loss: 0.1623


Epoch 12/20  
49/49  1s 19ms/step - accuracy: 0.9816 - loss: 0.0988 - val\_accuracy: 0.8771 - val\_loss: 0.1603


Epoch 13/20  
49/49  1s 16ms/step - accuracy: 0.9832 - loss: 0.0967 - val\_accuracy: 0.8752 - val\_loss: 0.1627


Epoch 14/20  
49/49  1s 15ms/step - accuracy: 0.9854 - loss: 0.0926 - val\_accuracy: 0.8696 - val\_loss: 0.1636


Epoch 15/20  
49/49  1s 14ms/step - accuracy: 0.9897 - loss: 0.0883 - val\_accuracy: 0.8755 - val\_loss: 0.1562

Epoch 16/20  
49/49  1s 14ms/step - accuracy: 0.9911 - loss: 0.0852 - val\_accuracy: 0.8764 - val\_loss: 0.1517

Epoch 17/20  
49/49  1s 17ms/step - accuracy: 0.9934 - loss: 0.0799 - val\_accuracy: 0.8730 - val\_loss: 0.1565

Epoch 18/20  
49/49  1s 14ms/step - accuracy: 0.9937 - loss: 0.0795 - val\_accuracy: 0.8746 - val\_loss: 0.1538

Epoch 19/20  
49/49  1s 14ms/step - accuracy: 0.9937 - loss: 0.0762 - val\_accuracy: 0.8766 - val\_loss: 0.1512

Epoch 20/20  
49/49  1s 17ms/step - accuracy: 0.9944 - loss: 0.0769 - val\_accuracy: 0.8738 - val\_loss: 0.1496

Training model with config: {'hidden\_layers': 3, 'hidden\_units': 64, 'loss\_function': 'mean\_squared\_error', 'activation\_function': 'tanh', 'dropout\_rate': 0.5, 'l2\_reg': 0.01}


Model: "sequential\_22"


Layer (type)	Output Shape	Param #
embedding_22 (Embedding)	(None, 500, 128)	1,280,000
flatten_22 (Flatten)	(None, 64000)	0
dense_64 (Dense)	(None, 64)	4,096,000
dropout_42 (Dropout)	(None, 64)	0
dense_65 (Dense)	(None, 64)	0
dropout_43 (Dropout)	(None, 64)	0
dense_66 (Dense)	(None, 64)	0
dropout_44 (Dropout)	(None, 64)	0
dense_67 (Dense)	(None, 1)	0


Total params: 5,384,449 (20.54 MB)


Trainable params: 5,384,449 (20.54 MB)


Non-trainable params: 0 (0.00 B)


Epoch 1/20  
49/49  9s 94ms/step - accuracy: 0.5315 - loss: 1.7536 - val\_accuracy: 0.7412 - val\_loss: 0.9077


Epoch 2/20  
49/49  1s 20ms/step - accuracy: 0.7958 - loss: 0.7739 - val\_accuracy: 0.8478 - val\_loss: 0.4991


Epoch 3/20  
49/49  1s 18ms/step - accuracy: 0.8732 - loss: 0.4338 - val\_accuracy: 0.8552 - val\_loss: 0.3167


Epoch 4/20  
49/49  1s 15ms/step - accuracy: 0.9023 - loss: 0.2687 - val\_accuracy: 0.8706 - val\_loss: 0.2289


Epoch 5/20  
49/49  1s 19ms/step - accuracy: 0.9171 - loss: 0.1967 - val\_accuracy: 0.8803 - val\_loss: 0.1910


Epoch 6/20  
49/49  1s 20ms/step - accuracy: 0.9380 - loss: 0.1565 - val\_accuracy: 0.8772 - val\_loss: 0.1855


Epoch 7/20  
49/49  1s 19ms/step - accuracy: 0.9468 - loss: 0.1440 - val\_accuracy: 0.8689 - val\_loss: 0.1850


Epoch 8/20  
49/49  1s 18ms/step - accuracy: 0.9575 - loss: 0.1318 - val\_accuracy: 0.8755 - val\_loss: 0.1793

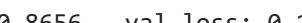
Epoch 9/20  
49/49  1s 18ms/step - accuracy: 0.9647 - loss: 0.1283 - val\_accuracy: 0.8699 - val\_loss: 0.1848


Epoch 10/20  
49/49  1s 15ms/step - accuracy: 0.9725 - loss: 0.1221 - val\_accuracy: 0.8688 - val\_loss: 0.1828

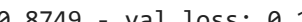
Epoch 11/20  
49/49  1s 15ms/step - accuracy: 0.9772 - loss: 0.1160 - val\_accuracy: 0.8742 - val\_loss: 0.1743


Epoch 12/20  
49/49  1s 15ms/step - accuracy: 0.9829 - loss: 0.1078 - val\_accuracy: 0.8661 - val\_loss: 0.1797


Epoch 13/20  
49/49  1s 15ms/step - accuracy: 0.9847 - loss: 0.1099 - val\_accuracy: 0.8638 - val\_loss: 0.1768


Epoch 14/20  
49/49  1s 16ms/step - accuracy: 0.9874 - loss: 0.1004 - val\_accuracy: 0.8656 - val\_loss: 0.1695


Epoch 15/20  
49/49  1s 15ms/step - accuracy: 0.9899 - loss: 0.0976 - val\_accuracy: 0.8722 - val\_loss: 0.1712

Epoch 16/20  
49/49  1s 16ms/step - accuracy: 0.9908 - loss: 0.0952 - val\_accuracy: 0.8749 - val\_loss: 0.1670

Epoch 17/20  
49/49  1s 18ms/step - accuracy: 0.9941 - loss: 0.0853 - val\_accuracy: 0.8706 - val\_loss: 0.1689

Epoch 18/20  
49/49  1s 21ms/step - accuracy: 0.9949 - loss: 0.0857 - val\_accuracy: 0.8731 - val\_loss: 0.1641

Epoch 19/20  
49/49  1s 17ms/step - accuracy: 0.9956 - loss: 0.0810 - val\_accuracy: 0.8724 - val\_loss: 0.1600

Epoch 20/20  
49/49  1s 16ms/step - accuracy: 0.9964 - loss: 0.0786 - val\_accuracy: 0.8722 - val\_loss: 0.1648

Training model with config: {'hidden\_layers': 3, 'hidden\_units': 128, 'loss\_function': 'mean\_squared\_error', 'activation\_function': 'tanh', 'dropout\_rate': 0.5, 'l2\_reg': 0.01}

Model: "sequential\_23"











Layer (type)	Output Shape	Param #
embedding_23 (Embedding)	(None, 500, 128)	1,280,000
flatten_23 (Flatten)	(None, 64000)	0
dense_68 (Dense)	(None, 128)	8,192
dropout_45 (Dropout)	(None, 128)	0
dense_69 (Dense)	(None, 128)	16,384
dropout_46 (Dropout)	(None, 128)	0
dense_70 (Dense)	(None, 128)	16,384
dropout_47 (Dropout)	(None, 128)	0
dense_71 (Dense)	(None, 1)	128

Total params: 9,505,281 (36.26 MB)

Trainable params: 9,505,281 (36.26 MB)

Non-trainable params: 0 (0.00 B)



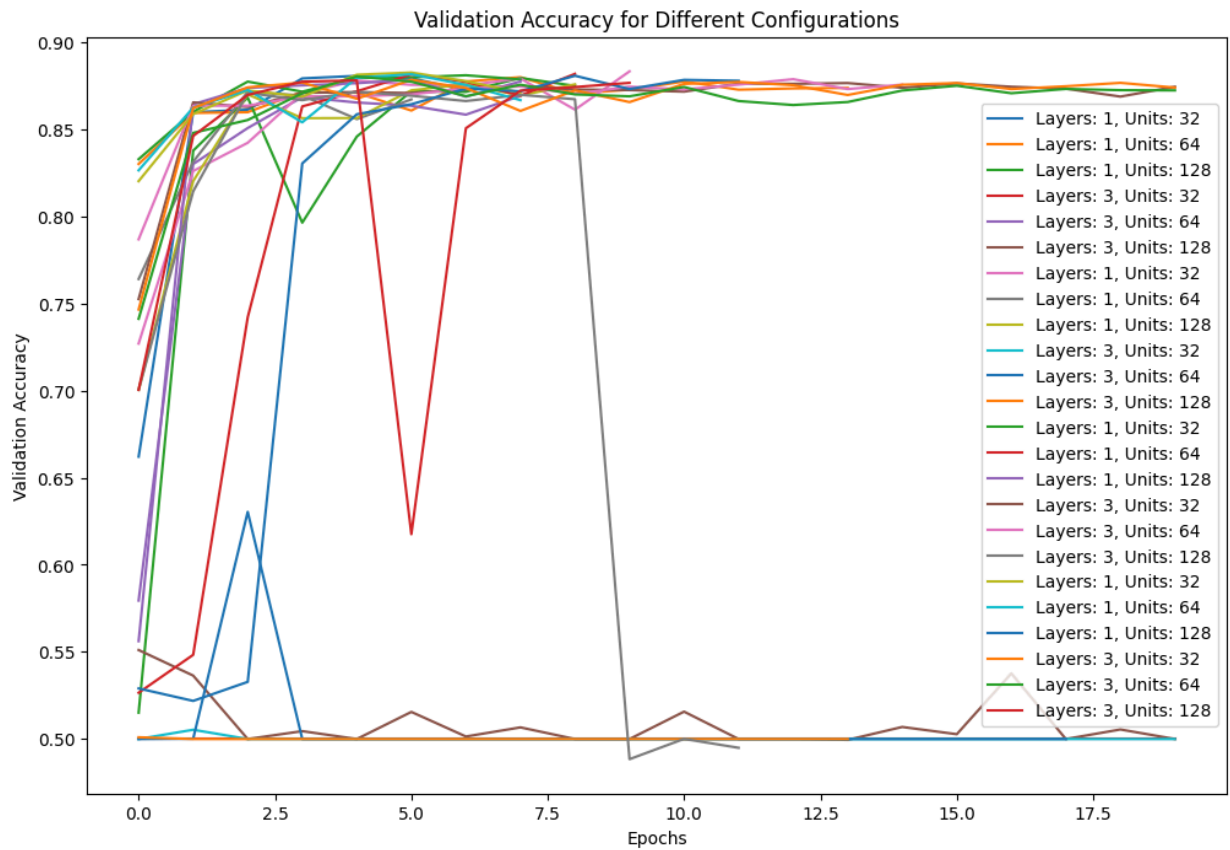
Epoch 1/20  
**49/49**  **10s** 120ms/step - accuracy: 0.5075 - loss: 3.0979 - val\_accuracy: 0.7004 - val\_loss: 1.2557  
Epoch 2/20  
**49/49**  **3s** 24ms/step - accuracy: 0.7646 - loss: 1.0087 - val\_accuracy: 0.8461 - val\_loss: 0.5281  
Epoch 3/20  
**49/49**  **1s** 20ms/step - accuracy: 0.8820 - loss: 0.4329 - val\_accuracy: 0.8696 - val\_loss: 0.2756  
Epoch 4/20  
**49/49**  **1s** 20ms/step - accuracy: 0.9072 - loss: 0.2360 - val\_accuracy: 0.8772 - val\_loss: 0.2108  
Epoch 5/20  
**49/49**  **1s** 20ms/step - accuracy: 0.9215 - loss: 0.1785 - val\_accuracy: 0.8780 - val\_loss: 0.1976  
Epoch 6/20  
**49/49**  **1s** 21ms/step - accuracy: 0.6653 - loss: 0.3867 - val\_accuracy: 0.6176 - val\_loss: 0.2648  
Epoch 7/20  
**49/49**  **1s** 21ms/step - accuracy: 0.6225 - loss: 0.2664 - val\_accuracy: 0.8505 - val\_loss: 0.1786  
Epoch 8/20  
**49/49**  **1s** 22ms/step - accuracy: 0.9160 - loss: 0.1496 - val\_accuracy: 0.8721 - val\_loss: 0.1822  
Epoch 9/20  
**49/49**  **1s** 23ms/step - accuracy: 0.9393 - loss: 0.1461 - val\_accuracy: 0.8742 - val\_loss: 0.1865  
Epoch 10/20  
**49/49**  **1s** 19ms/step - accuracy: 0.9506 - loss: 0.1419 - val\_accuracy: 0.9506 - val\_loss: 0.1419

## Results Comparison

```
In [6]: # Plot the validation accuracy of all experiments
plt.figure(figsize=(12, 8))

for result in results:
    plt.plot(result['history']['val_accuracy'], label=f"Layers: {result['config']['hid

plt.title('Validation Accuracy for Different Configurations')
plt.xlabel('Epochs')
plt.ylabel('Validation Accuracy')
plt.legend()
plt.show()
```



```
In [7]: import pandas as pd

# Sample data from your experiments (from the results list we saved earlier)
results_data = []

for result in results:
    config = result['config']
    results_data.append({
        'Hidden Layers': config['hidden_layers'],
        'Hidden Units': config['hidden_units'],
        'Activation Function': config['activation_function'],
        'Loss Function': config['loss_function'],
        'Dropout Rate': config['dropout_rate'],
        'L2 Regularization': config['l2_reg'],
        'Test Accuracy': result['test_acc'],
        'Test Loss': result['test_loss']
    })

# Create a DataFrame from the results
df_results = pd.DataFrame(results_data)

# To display the table in a nicer format in Jupyter or notebooks:
df_results.style.format({
    'Test Accuracy': '{:.2f}',
    'Test Loss': '{:.2f}'
})
```

Out[7]:

	Hidden Layers	Hidden Units	Activation Function	Loss Function	Dropout Rate	L2 Regularization	Test Accuracy	Test Loss
0	1	32	relu	binary_crossentropy	0.500000	0.010000	0.88	0.40
1	1	64	relu	binary_crossentropy	0.500000	0.010000	0.88	0.43
2	1	128	relu	binary_crossentropy	0.500000	0.010000	0.87	0.44
3	3	32	relu	binary_crossentropy	0.500000	0.010000	0.50	0.69
4	3	64	relu	binary_crossentropy	0.500000	0.010000	0.87	0.58
5	3	128	relu	binary_crossentropy	0.500000	0.010000	0.50	0.69
6	1	32	relu	mean_squared_error	0.500000	0.010000	0.88	0.14
7	1	64	relu	mean_squared_error	0.500000	0.010000	0.87	0.15
8	1	128	relu	mean_squared_error	0.500000	0.010000	0.87	0.15
9	3	32	relu	mean_squared_error	0.500000	0.010000	0.50	0.25
10	3	64	relu	mean_squared_error	0.500000	0.010000	0.50	0.25
11	3	128	relu	mean_squared_error	0.500000	0.010000	0.50	0.25
12	1	32	tanh	binary_crossentropy	0.500000	0.010000	0.88	0.38
13	1	64	tanh	binary_crossentropy	0.500000	0.010000	0.88	0.38
14	1	128	tanh	binary_crossentropy	0.500000	0.010000	0.88	0.40
15	3	32	tanh	binary_crossentropy	0.500000	0.010000	0.87	0.44
16	3	64	tanh	binary_crossentropy	0.500000	0.010000	0.88	0.44
17	3	128	tanh	binary_crossentropy	0.500000	0.010000	0.87	0.52
18	1	32	tanh	mean_squared_error	0.500000	0.010000	0.88	0.14
19	1	64	tanh	mean_squared_error	0.500000	0.010000	0.88	0.14
20	1	128	tanh	mean_squared_error	0.500000	0.010000	0.88	0.14
21	3	32	tanh	mean_squared_error	0.500000	0.010000	0.87	0.15
22	3	64	tanh	mean_squared_error	0.500000	0.010000	0.87	0.16
23	3	128	tanh	mean_squared_error	0.500000	0.010000	0.85	0.18

In [8]:

```
import seaborn as sns

sns.set(style="whitegrid")

# 1. Test Accuracy vs Hidden Layers and Hidden Units
plt.figure(figsize=(10, 6))
sns.barplot(x='Hidden Layers', y='Test Accuracy', hue='Hidden Units', data=df_results,
plt.title('Test Accuracy vs Hidden Layers and Hidden Units')
plt.ylabel('Test Accuracy')
plt.xlabel('Hidden Layers')
plt.legend(title='Hidden Units')
plt.show()

# 2. Test Loss vs Hidden Layers and Hidden Units
```

```

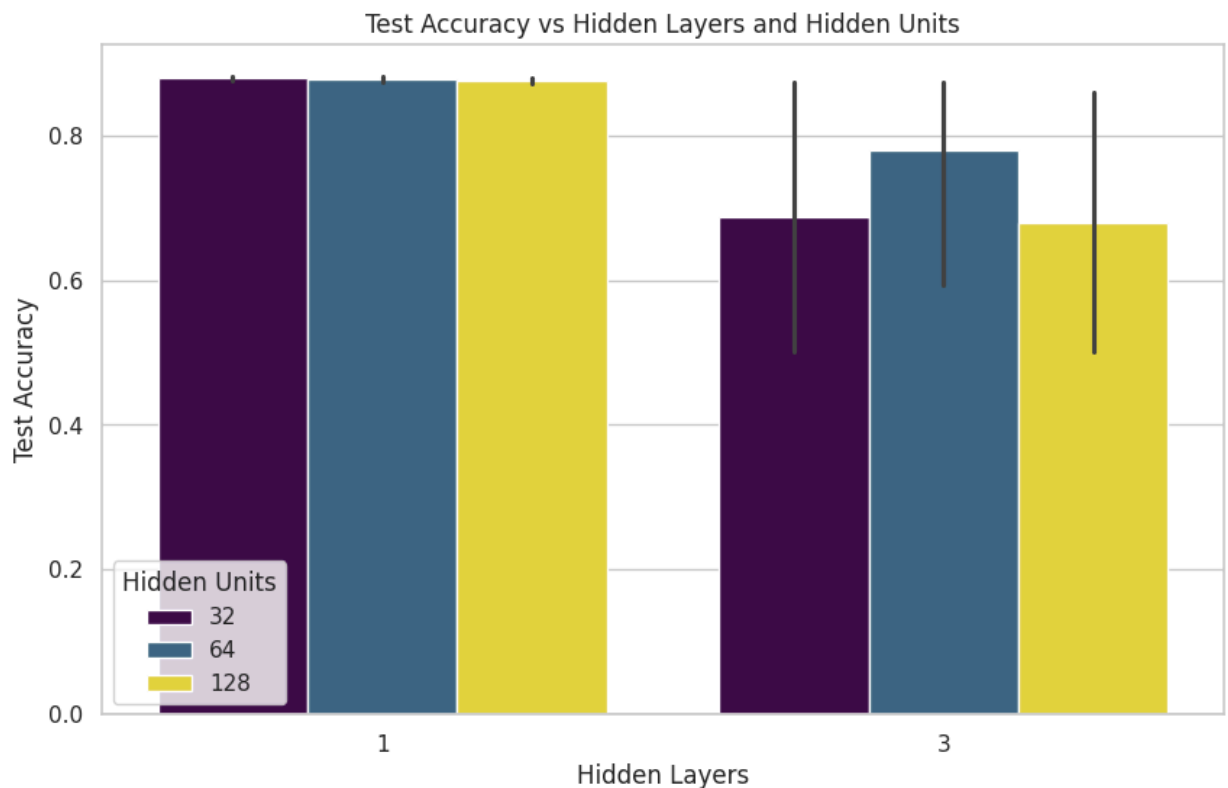
plt.figure(figsize=(10, 6))
sns.barplot(x='Hidden Layers', y='Test Loss', hue='Hidden Units', data=df_results, palette="Set2")
plt.title('Test Loss vs Hidden Layers and Hidden Units')
plt.ylabel('Test Loss')
plt.xlabel('Hidden Layers')
plt.legend(title='Hidden Units')
plt.show()

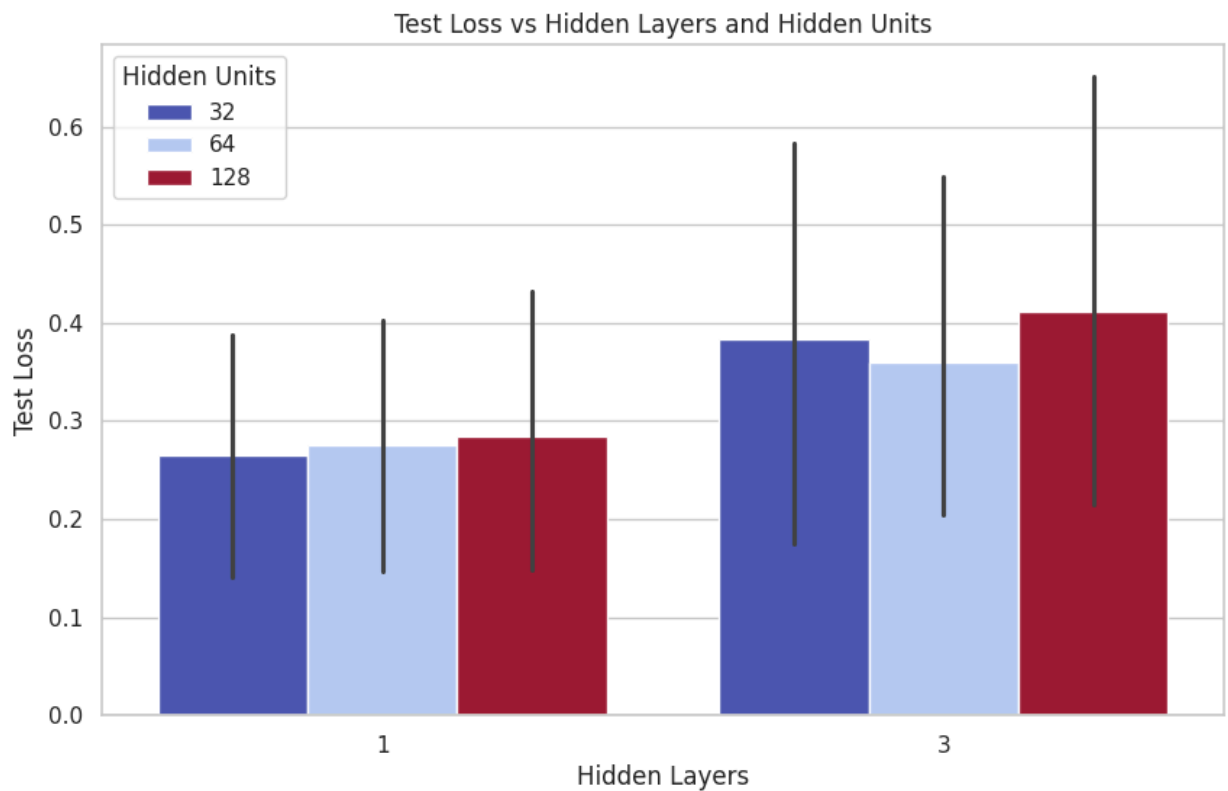
# 3. Test Accuracy vs Loss Function
plt.figure(figsize=(10, 6))
sns.boxplot(x='Loss Function', y='Test Accuracy', data=df_results, palette="Set2")
plt.title('Test Accuracy vs Loss Function')
plt.ylabel('Test Accuracy')
plt.xlabel('Loss Function')
plt.show()

# 4. Test Loss vs Activation Function
plt.figure(figsize=(10, 6))
sns.boxplot(x='Activation Function', y='Test Loss', data=df_results, palette="Set3")
plt.title('Test Loss vs Activation Function')
plt.ylabel('Test Loss')
plt.xlabel('Activation Function')
plt.show()

# 5. Comparing Dropout Rate and L2 Regularization on Test Accuracy
plt.figure(figsize=(10, 6))
sns.scatterplot(x='Dropout Rate', y='Test Accuracy', size='L2 Regularization', data=df_results)
plt.title('Dropout Rate and L2 Regularization vs Test Accuracy')
plt.xlabel('Dropout Rate')
plt.ylabel('Test Accuracy')
plt.legend(title='Hidden Layers')
plt.show()

```

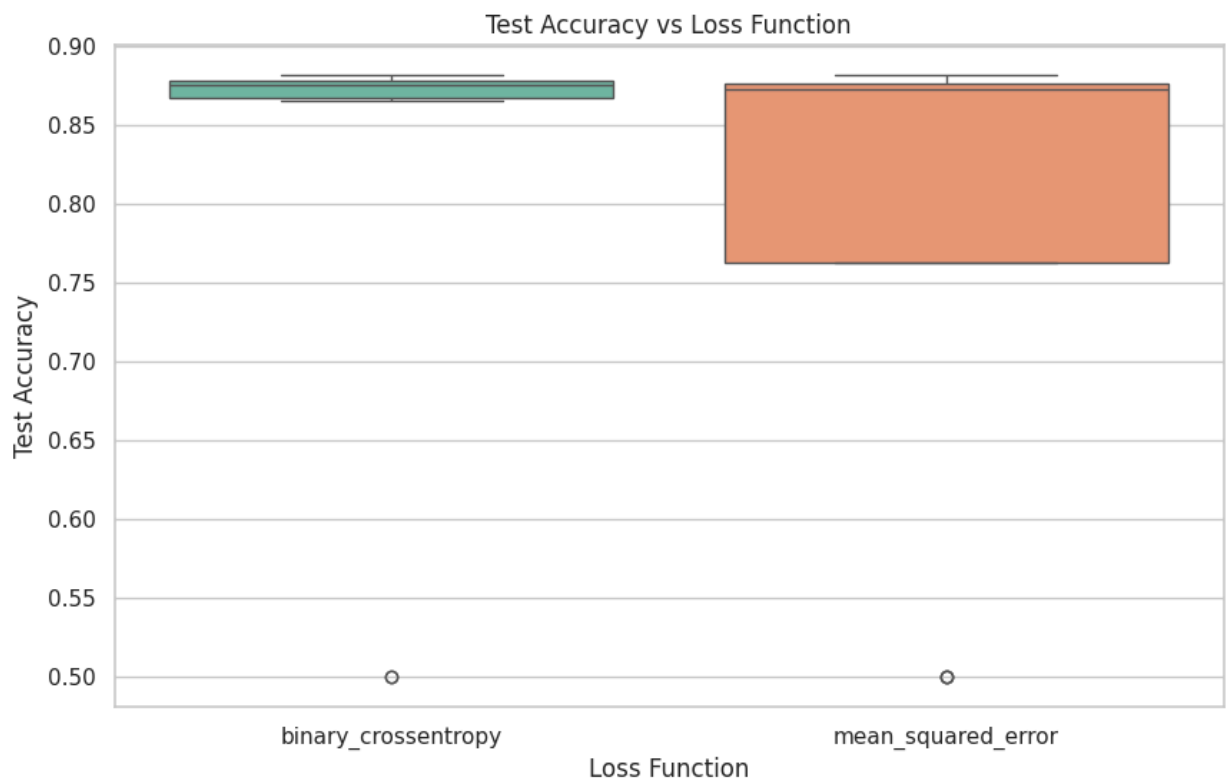




```
<ipython-input-8-be9289220f55>:25: FutureWarning:
```

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `legend=False` for the same effect.

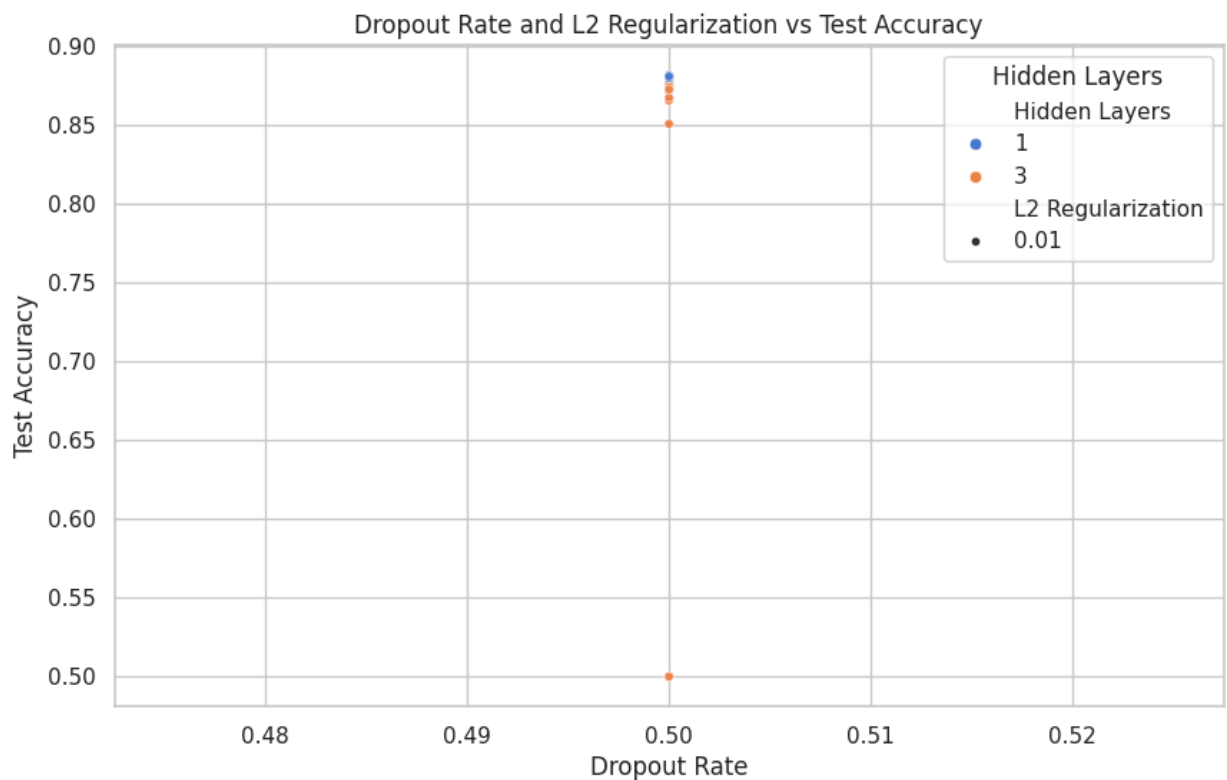
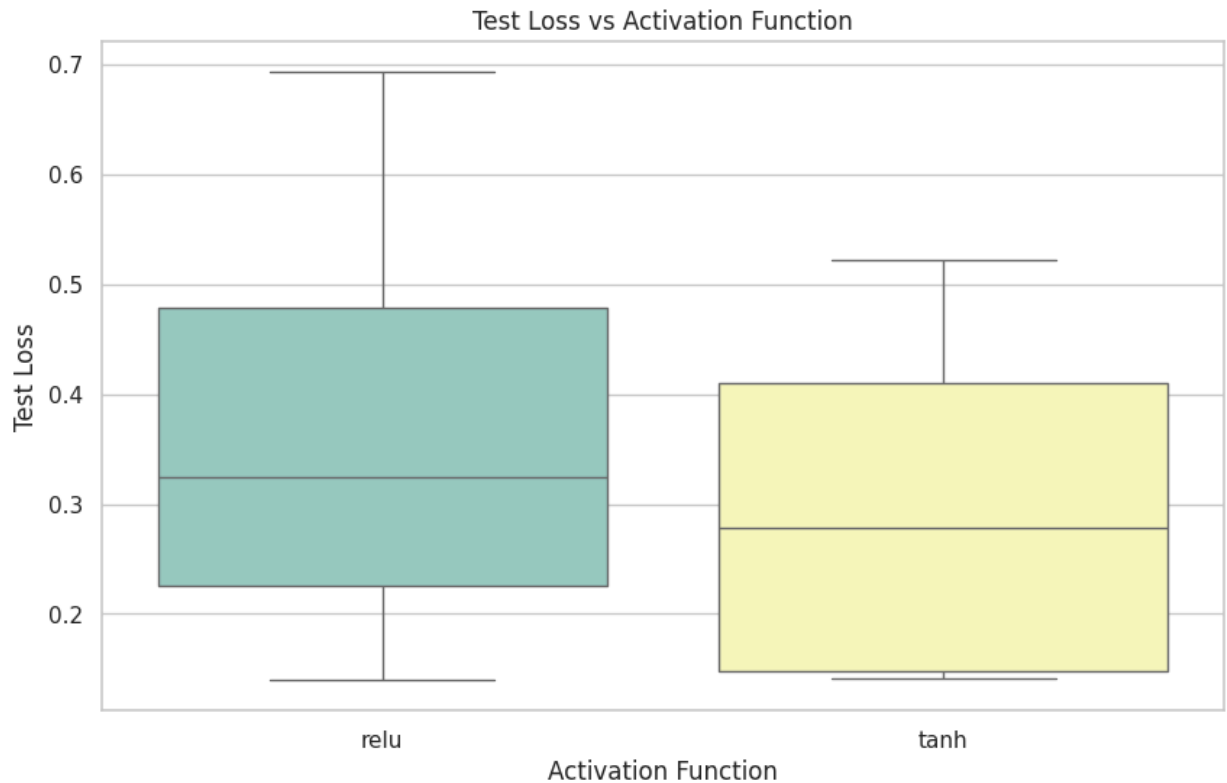
```
sns.boxplot(x='Loss Function', y='Test Accuracy', data=df_results, palette="Set2")
```



```
<ipython-input-8-be9289220f55>:33: FutureWarning:
```

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `legend=False` for the same effect.

```
sns.boxplot(x='Activation Function', y='Test Loss', data=df_results, palette="Set 3")
```



```
In [9]: import matplotlib.pyplot as plt
import seaborn as sns
```

```
# Set a seaborn style
sns.set(style="whitegrid")

# Create a FacetGrid to compare test accuracy across different configurations
g = sns.FacetGrid(df_results, col="Activation Function", row="Loss Function",
                  hue="Hidden Layers", palette="viridis", margin_titles=True, despine=

# Map the scatter plot to each facet
g.map(sns.scatterplot, "Hidden Units", "Test Accuracy", alpha=0.7)
g.set_axis_labels("Hidden Units", "Test Accuracy")
g.set_titles(col_template="{col_name}", row_template="{row_name}")
g.add_legend()

# Show the plot
plt.subplots_adjust(top=0.9)
g.fig.suptitle('Test Accuracy Comparison across Configurations', fontsize=16)
plt.show()
```



```
In [10]: # Create a FacetGrid to compare test loss across different configurations
g = sns.FacetGrid(df_results, col="Activation Function", row="Loss Function",
                  hue="Hidden Layers", palette="coolwarm", margin_titles=True, despine=

# Map the scatter plot to each facet
g.map(sns.scatterplot, "Hidden Units", "Test Loss", alpha=0.7)
g.set_axis_labels("Hidden Units", "Test Loss")
g.set_titles(col_template="{col_name}", row_template="{row_name}")
g.add_legend()
```

```
# Show the plot
plt.subplots_adjust(top=0.9)
g.fig.suptitle('Test Loss Comparison across Configurations', fontsize=16)
plt.show()
```

