Ajoc, Luis Rafael **BSCS 3-A AI**
Sasana, Bonn Jouie **CCS 248**
Robles, John Felmer

1. Introduction

The objective of this project is to design, implement, and evaluate a Deep Neural Network (DNN) trained from scratch to classify depression severity levels based on textual data. The task involves analyzing written text and assigning it to one of several depression severity categories, making it a supervised multi-class text classification problem.

Artificial Neural Networks, particularly models that combine Embedding layers and Long Short-Term Memory (LSTM) networks, are well-suited for this task because they can capture semantic meaning and sequential dependencies in natural language text. This project demonstrates the application of deep learning techniques to a real-world mental health–related classification problem.

2. Dataset Description

The dataset used in this project is a Depression Severity Levels Dataset, consisting of textual samples labeled with different levels of depression severity. The dataset was obtained through https://github.com/KUAS-ubicomp-lab/Depression_Severity_Levels_Dataset.

Data Type

- Text data (sentences or short text entries)
- Categorical labels representing depression severity

Target Classes

The dataset contains four severity levels:

- **Minimum**
- **Mild**
- **Moderate**
- **Severe**

Preprocessing Steps

- Removal of missing values
- Conversion of text data to string type
- Label encoding of categorical severity labels
- Tokenization of text using a fixed vocabulary
- Padding and truncation of sequences to a uniform length

Bias and Privacy Considerations

- The dataset does not contain personally identifiable information.
- Potential bias related to language usage and self-reported text is acknowledged.
- Class imbalance was analyzed and considered during evaluation.

3. Neural Network Architecture

Architecture Overview

- **Input Layer:** Padded integer sequences representing tokenized text
- **Embedding Layer:**
    - Vocabulary size: 10,000
    - Embedding dimension: 128
- **LSTM Layer:**
    - 64 memory units
- **1st Dropout Layer**
    - Rate: 0.3
- **2nd Dropout Layer**
    - Rate: 0.5
- **Output Layer:**
    - Dense layer with 4 neurons
    - Softmax activation for multi-class classification

Early Stopping

Early stopping was applied using validation loss monitoring to prevent overfitting. Training was stopped automatically if no improvement was observed for 10 consecutive epochs, and the best-performing weights were restored.

This architecture allows the model to learn meaningful word representations and capture contextual dependencies across text sequences.

4. Hyperparameter Tuning

a. **Adam with 0.001 learning rate**

Training Configuration

- **Optimizer:** Adam
- **Learning Rate:** 0.001
- **Loss Function:** Sparse Categorical Cross-Entropy
- **Evaluation Metric:** Accuracy
- **Batch Size:** 32
- **Epochs:** Up to 300
- **Vocabulary Size:** 10,000

- **Maximum Sequence Length:** 100
- **LSTM units:** 64
- **1st Dropout Layer Rate:** 0.3
- **2nd Dropout Layer Rate:** 0.5
- **Early Stopping Patience:** 10

Training Results

Epoch 1/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **9s** 9ms/step - accuracy: 0.3843 - loss: 1.2794 - val_accuracy: 0.3801 - val_loss: 1.3296
Epoch 2/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.3846 - loss: 1.2855 - val_accuracy: 0.4066 - val_loss: 1.2395
Epoch 3/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.4362 - loss: 1.1707 - val_accuracy: 0.5002 - val_loss: 1.0366
Epoch 4/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 10ms/step - accuracy: 0.5018 - loss: 1.0256 - val_accuracy: 0.5177 - val_loss: 0.9609
Epoch 5/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **10s** 10ms/step - accuracy: 0.5482 - loss: 0.9079 - val_accuracy: 0.5290 - val_loss: 0.9205
Epoch 6/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 11ms/step - accuracy: 0.5727 - loss: 0.8445 - val_accuracy: 0.5619 - val_loss: 0.8747
Epoch 7/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.6202 - loss: 0.7623 - val_accuracy: 0.5834 - val_loss: 0.8614
Epoch 8/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **11s** 9ms/step - accuracy: 0.6686 - loss: 0.6820 - val_accuracy: 0.6079 - val_loss: 0.8289
Epoch 9/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 10ms/step - accuracy: 0.7039 - loss: 0.6255 - val_accuracy: 0.6297 - val_loss: 0.8284
Epoch 10/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.7349 - loss: 0.5858 - val_accuracy: 0.6328 - val_loss: 0.8388
Epoch 11/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.7792 - loss: 0.5107 - val_accuracy: 0.6419 - val_loss: 0.8777
Epoch 12/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.8074 - loss: 0.4531 - val_accuracy: 0.6484 - val_loss: 0.9585
Epoch 13/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.8345 - loss: 0.3933 - val_accuracy: 0.6420 - val_loss: 0.9738
Epoch 14/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.8551 - loss: 0.3500 - val_accuracy: 0.6420 - val_loss: 1.0786

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Epoch 15/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 7s 9ms/step - accuracy: 0.8689 - loss:
0.3132 - val_accuracy: 0.6436 - val_loss: 1.1090
Epoch 16/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 7s 9ms/step - accuracy: 0.8749 - loss:
0.2777 - val_accuracy: 0.6329 - val_loss: 1.2389
Epoch 17/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 7s 9ms/step - accuracy: 0.8874 - loss:
0.2482 - val_accuracy: 0.6329 - val_loss: 1.4197
Epoch 18/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 8s 10ms/step - accuracy: 0.9018 -
loss: 0.2160 - val_accuracy: 0.6301 - val_loss: 1.4181
Epoch 19/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 7s 10ms/step - accuracy: 0.9021 -
loss: 0.2073 - val_accuracy: 0.6295 - val_loss: 1.5362

<keras.src.callbacks.history.History at 0x7ab1807649b0>
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Test/Validation Result

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262/262 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1s 5ms/step - accuracy: 0.6283 - loss:
0.8581
Test accuracy: 0.6297181248664856
```

```
262/262 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step
              precision    recall  f1-score   support

        mild       0.58      0.45      0.51      2087
     minimum       0.64      0.84      0.73      2112
    moderate       0.79      0.59      0.68      1946
      severe       0.56      0.64      0.59      2227

    accuracy                           0.63      8372
   macro avg       0.64      0.63      0.63      8372
weighted avg       0.64      0.63      0.62      8372
```

b. Adam with 0.0005 learning rate

Training Configuration

- **Optimizer:** Adam
- **Learning Rate:** 0.0005

- **Loss Function:** Sparse Categorical Cross-Entropy
- **Evaluation Metric:** Accuracy
- **Batch Size:** 32
- **Epochs:** Up to 300
- **Vocabulary Size:** 10,000
- **Maximum Sequence Length:** 100
- **LSTM units:** 64
- **1st Dropout Layer Rate:** 0.3
- **2nd Dropout Layer Rate:** 0.5
- **Early Stopping Patience:** 10

Training Results

Epoch 1/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **9s** 9ms/step - accuracy: 0.4109 - loss: 1.2233 - val_accuracy: 0.4938 - val_loss: 1.1053
Epoch 2/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.4684 - loss: 1.1288 - val_accuracy: 0.4995 - val_loss: 1.0150
Epoch 3/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.4909 - loss: 1.0194 - val_accuracy: 0.4981 - val_loss: 1.0454
Epoch 4/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.4536 - loss: 1.0945 - val_accuracy: 0.5219 - val_loss: 0.9582
Epoch 5/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.5258 - loss: 0.9524 - val_accuracy: 0.5404 - val_loss: 0.9004
Epoch 6/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.5647 - loss: 0.8574 - val_accuracy: 0.5492 - val_loss: 0.8715
Epoch 7/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.5858 - loss: 0.8027 - val_accuracy: 0.5581 - val_loss: 0.8587
Epoch 8/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.6145 - loss: 0.7648 - val_accuracy: 0.5382 - val_loss: 0.9079
Epoch 9/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.6326 - loss: 0.7446 - val_accuracy: 0.5665 - val_loss: 0.8771
Epoch 10/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.6528 - loss: 0.6805 - val_accuracy: 0.5667 - val_loss: 0.9103
Epoch 11/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.6815 - loss: 0.6300 - val_accuracy: 0.6036 - val_loss: 0.8736
Epoch 12/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.7366 - loss: 0.5805 - val_accuracy: 0.6205 - val_loss: 0.8761

```
Epoch 13/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 8s 11ms/step - accuracy: 0.7743 -
loss: 0.5136 - val_accuracy: 0.6409 - val_loss: 0.8588
Epoch 14/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 7s 9ms/step - accuracy: 0.8057 - loss:
0.4608 - val_accuracy: 0.6340 - val_loss: 0.8917
Epoch 15/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 11s 9ms/step - accuracy: 0.8202 -
loss: 0.4278 - val_accuracy: 0.6343 - val_loss: 0.9840
Epoch 16/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 8s 10ms/step - accuracy: 0.8382 -
loss: 0.3849 - val_accuracy: 0.6420 - val_loss: 0.9814
Epoch 17/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 7s 9ms/step - accuracy: 0.8464 - loss:
0.3544 - val_accuracy: 0.6425 - val_loss: 0.9749

<keras.src.callbacks.history.History at 0x7ab246e45af0>
```

Test/Validation Result

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262/262 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1s 5ms/step - accuracy: 0.5525 - loss:
0.8707
Test accuracy: 0.5563784241676331
              precision    recall  f1-score   support

        mild       0.54      0.52      0.53      2087
     minimum       0.53      0.90      0.67      2112
    moderate       0.82      0.29      0.43      1946
      severe       0.53      0.49      0.51      2227

    accuracy                           0.56      8372
   macro avg       0.60      0.55      0.54      8372
weighted avg       0.60      0.56      0.54      8372
```

c. **Adam with 0.0001 learning rate**

Training Configuration

- **Optimizer:** Adam
- **Learning Rate:** 0.0001
- **Loss Function:** Sparse Categorical Cross-Entropy
- **Evaluation Metric:** Accuracy
- **Batch Size:** 32

- **Epochs:** Up to 300
- **Vocabulary Size:** 10,000
- **Maximum Sequence Length:** 100
- **LSTM units:** 64
- **1st Dropout Layer Rate:** 0.3
- **2nd Dropout Layer Rate:** 0.5
- **Early Stopping Patience:** 10

Training Results

Epoch 1/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **9s** 10ms/step - accuracy: 0.3576 - loss: 1.3037 - val_accuracy: 0.4768 - val_loss: 0.9926
Epoch 2/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.4789 - loss: 0.9979 - val_accuracy: 0.5201 - val_loss: 0.9437
Epoch 3/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.4990 - loss: 0.9318 - val_accuracy: 0.5305 - val_loss: 0.9175
Epoch 4/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.5185 - loss: 0.8978 - val_accuracy: 0.5340 - val_loss: 0.9046
Epoch 5/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.5261 - loss: 0.8598 - val_accuracy: 0.5417 - val_loss: 0.9177
Epoch 6/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.5435 - loss: 0.8365 - val_accuracy: 0.5454 - val_loss: 0.9086
Epoch 7/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.5567 - loss: 0.8123 - val_accuracy: 0.5457 - val_loss: 0.9359
Epoch 8/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.5742 - loss: 0.8019 - val_accuracy: 0.5591 - val_loss: 0.9135
Epoch 9/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.5763 - loss: 0.7910 - val_accuracy: 0.5741 - val_loss: 0.8978
Epoch 10/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.6154 - loss: 0.7623 - val_accuracy: 0.5626 - val_loss: 0.9353
Epoch 11/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.6447 - loss: 0.7269 - val_accuracy: 0.6107 - val_loss: 0.8873
Epoch 12/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.6789 - loss: 0.7159 - val_accuracy: 0.6172 - val_loss: 0.8938
Epoch 13/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.7156 - loss: 0.6653 - val_accuracy: 0.6255 - val_loss: 0.9173

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Epoch 14/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 8s 10ms/step - accuracy: 0.7295 -
loss: 0.6424 - val_accuracy: 0.6333 - val_loss: 0.8916
Epoch 15/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 10s 10ms/step - accuracy: 0.7367 -
loss: 0.6283 - val_accuracy: 0.6274 - val_loss: 0.8712
Epoch 16/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 7s 9ms/step - accuracy: 0.7579 - loss:
0.6004 - val_accuracy: 0.6040 - val_loss: 0.9421
Epoch 17/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 8s 10ms/step - accuracy: 0.7629 -
loss: 0.5876 - val_accuracy: 0.6390 - val_loss: 0.9109
Epoch 18/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 7s 9ms/step - accuracy: 0.7709 - loss:
0.5756 - val_accuracy: 0.6350 - val_loss: 0.9677
Epoch 19/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 8s 10ms/step - accuracy: 0.7788 -
loss: 0.5636 - val_accuracy: 0.6495 - val_loss: 0.9306
Epoch 20/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 8s 10ms/step - accuracy: 0.7961 -
loss: 0.5370 - val_accuracy: 0.6380 - val_loss: 0.9436
Epoch 21/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 7s 9ms/step - accuracy: 0.7955 - loss:
0.5400 - val_accuracy: 0.6338 - val_loss: 0.9643
Epoch 22/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 8s 10ms/step - accuracy: 0.8033 -
loss: 0.5220 - val_accuracy: 0.6365 - val_loss: 0.9741
Epoch 23/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 9s 11ms/step - accuracy: 0.8046 -
loss: 0.5182 - val_accuracy: 0.6381 - val_loss: 0.9650
Epoch 24/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 7s 9ms/step - accuracy: 0.8128 - loss:
0.4993 - val_accuracy: 0.6230 - val_loss: 0.9692
Epoch 25/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 8s 10ms/step - accuracy: 0.8063 -
loss: 0.5025 - val_accuracy: 0.6196 - val_loss: 1.0351

<keras.src.callbacks.history.History at 0x7ab1809d18b0>
```

Test/Validation Result

```
262/262 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1s 5ms/step - accuracy: 0.6307 - loss:
0.8849
Test accuracy: 0.629359781742096
```

	precision	recall	f1-score	support
mild	0.54	0.52	0.53	2087
minimum	0.53	0.90	0.67	2112
moderate	0.82	0.29	0.43	1946
severe	0.53	0.49	0.51	2227
accuracy			0.56	8372
macro avg	0.60	0.55	0.54	8372
weighted avg	0.60	0.56	0.54	8372

d. RMSprop with 0.001 learning rate

Training Configuration

- **Optimizer:** RMSprop
- **Learning Rate:** 0.001
- **Loss Function:** Sparse Categorical Cross-Entropy
- **Evaluation Metric:** Accuracy
- **Batch Size:** 32
- **Epochs:** Up to 300
- **Vocabulary Size:** 10,000
- **Maximum Sequence Length:** 100
- **LSTM units:** 64
- **1st Dropout Layer Rate:** 0.3
- **2nd Dropout Layer Rate:** 0.5
- **Early Stopping Patience:** 10

Training Results

```
Epoch 1/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 9s 9ms/step - accuracy: 0.3993 - loss: 1.2584 - val_accuracy: 0.4743 - val_loss: 1.1060
Epoch 2/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 8s 10ms/step - accuracy: 0.4678 - loss: 1.1091 - val_accuracy: 0.5137 - val_loss: 0.9696
Epoch 3/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 11s 10ms/step - accuracy: 0.5016 - loss: 1.0200 - val_accuracy: 0.5385 - val_loss: 0.9111
Epoch 4/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 7s 9ms/step - accuracy: 0.5356 - loss: 0.9487 - val_accuracy: 0.5420 - val_loss: 0.9002
```

```
Epoch 5/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 7s 9ms/step - accuracy: 0.5545 - loss:
0.8998 - val_accuracy: 0.5430 - val_loss: 0.8890
Epoch 6/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 8s 10ms/step - accuracy: 0.5723 -
loss: 0.8466 - val_accuracy: 0.5707 - val_loss: 0.8621
Epoch 7/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 7s 9ms/step - accuracy: 0.6076 - loss:
0.8052 - val_accuracy: 0.6015 - val_loss: 0.7960
Epoch 8/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 8s 10ms/step - accuracy: 0.6436 -
loss: 0.7288 - val_accuracy: 0.6521 - val_loss: 0.7500
Epoch 9/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 8s 10ms/step - accuracy: 0.6973 -
loss: 0.6623 - val_accuracy: 0.6744 - val_loss: 0.7057
Epoch 10/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 7s 9ms/step - accuracy: 0.7313 - loss:
0.6086 - val_accuracy: 0.6808 - val_loss: 0.7074
Epoch 11/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 8s 10ms/step - accuracy: 0.7478 -
loss: 0.5687 - val_accuracy: 0.6707 - val_loss: 0.7572
Epoch 12/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 7s 9ms/step - accuracy: 0.7695 - loss:
0.5320 - val_accuracy: 0.6792 - val_loss: 0.7092
Epoch 13/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 8s 10ms/step - accuracy: 0.7744 -
loss: 0.5111 - val_accuracy: 0.6849 - val_loss: 0.7253
Epoch 14/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 10s 10ms/step - accuracy: 0.7990 -
loss: 0.4621 - val_accuracy: 0.6745 - val_loss: 0.7724
Epoch 15/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 7s 9ms/step - accuracy: 0.8176 - loss:
0.4278 - val_accuracy: 0.6722 - val_loss: 0.7701
Epoch 16/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 8s 10ms/step - accuracy: 0.8311 -
loss: 0.3975 - val_accuracy: 0.6733 - val_loss: 0.8126
Epoch 17/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 8s 10ms/step - accuracy: 0.8420 -
loss: 0.3593 - val_accuracy: 0.6633 - val_loss: 0.9388
Epoch 18/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 7s 9ms/step - accuracy: 0.8515 - loss:
0.3496 - val_accuracy: 0.6714 - val_loss: 0.9742
Epoch 19/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 8s 10ms/step - accuracy: 0.8641 -
loss: 0.3119 - val_accuracy: 0.6554 - val_loss: 0.9494

<keras.src.callbacks.history.History at 0x7ab1b1da5a00>
```

Test/Validation Result

262/262 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **1s** 5ms/step - accuracy: 0.6602 - loss: 0.7311
Test accuracy: 0.6600573062896729

	precision	recall	f1-score	support
mild	0.69	0.47	0.56	2087
minimum	0.78	0.57	0.66	2112
moderate	0.64	0.87	0.74	1946
severe	0.60	0.73	0.66	2227
accuracy			0.66	8372
macro avg	0.68	0.66	0.65	8372
weighted avg	0.68	0.66	0.65	8372

e. **RMSprop with 0.0005 learning rate**

Training Configuration

- **Optimizer:** RMSprop
- **Learning Rate:** 0.0005
- **Loss Function:** Sparse Categorical Cross-Entropy
- **Evaluation Metric:** Accuracy
- **Batch Size:** 32
- **Epochs:** Up to 300
- **Vocabulary Size:** 10,000
- **Maximum Sequence Length:** 100
- **LSTM units:** 64
- **1st Dropout Layer Rate:** 0.3
- **2nd Dropout Layer Rate:** 0.5
- **Early Stopping Patience:** 10

Training Results

Epoch 1/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **9s** 9ms/step - accuracy: 0.3930 - loss: 1.2474 - val_accuracy: 0.5108 - val_loss: 1.0194
Epoch 2/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.4908 - loss: 1.0246 - val_accuracy: 0.5350 - val_loss: 0.9420
Epoch 3/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.5304 - loss:

0.9369 - val_accuracy: 0.5632 - val_loss: 0.8913
Epoch 4/300
785/785 ━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.5687 - loss: 0.8850 - val_accuracy: 0.5751 - val_loss: 0.8713
Epoch 5/300
785/785 ━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.5921 - loss: 0.8466 - val_accuracy: 0.5819 - val_loss: 0.8637
Epoch 6/300
785/785 ━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.6186 - loss: 0.8252 - val_accuracy: 0.5873 - val_loss: 0.8604
Epoch 7/300
785/785 ━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.6377 - loss: 0.7976 - val_accuracy: 0.6316 - val_loss: 0.8105
Epoch 8/300
785/785 ━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.6680 - loss: 0.7596 - val_accuracy: 0.6501 - val_loss: 0.8097
Epoch 9/300
785/785 ━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.6784 - loss: 0.7483 - val_accuracy: 0.6469 - val_loss: 0.8254
Epoch 10/300
785/785 ━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.6866 - loss: 0.7228 - val_accuracy: 0.6236 - val_loss: 0.8192
Epoch 11/300
785/785 ━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.7079 - loss: 0.6951 - val_accuracy: 0.6464 - val_loss: 0.8052
Epoch 12/300
785/785 ━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.7141 - loss: 0.6908 - val_accuracy: 0.6553 - val_loss: 0.7725
Epoch 13/300
785/785 ━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.7280 - loss: 0.6609 - val_accuracy: 0.6462 - val_loss: 0.7900
Epoch 14/300
785/785 ━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.7255 - loss: 0.6496 - val_accuracy: 0.6691 - val_loss: 0.7644
Epoch 15/300
785/785 ━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.7474 - loss: 0.6085 - val_accuracy: 0.6700 - val_loss: 0.7751
Epoch 16/300
785/785 ━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.7550 - loss: 0.5977 - val_accuracy: 0.6707 - val_loss: 0.7570
Epoch 17/300
785/785 ━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.7554 - loss: 0.5820 - val_accuracy: 0.6690 - val_loss: 0.7627
Epoch 18/300
785/785 ━━━━━━━━━━━━━━━━━━━━ **9s** 11ms/step - accuracy: 0.7566 - loss: 0.5799 - val_accuracy: 0.6739 - val_loss: 0.7807
Epoch 19/300
785/785 ━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.7707 - loss: 0.5523 - val_accuracy: 0.6455 - val_loss: 0.8548
Epoch 20/300

785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.7776 - loss: 0.5418 - val_accuracy: 0.6644 - val_loss: 0.8058
Epoch 21/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.7840 - loss: 0.5218 - val_accuracy: 0.6745 - val_loss: 0.7925
Epoch 22/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.7914 - loss: 0.4971 - val_accuracy: 0.6609 - val_loss: 0.8629
Epoch 23/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.7945 - loss: 0.4813 - val_accuracy: 0.6690 - val_loss: 0.8045
Epoch 24/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.8073 - loss: 0.4521 - val_accuracy: 0.6648 - val_loss: 0.8679
Epoch 25/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **10s** 9ms/step - accuracy: 0.8132 - loss: 0.4511 - val_accuracy: 0.6659 - val_loss: 0.8971
Epoch 26/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.8165 - loss: 0.4319 - val_accuracy: 0.6641 - val_loss: 0.9365

<keras.src.callbacks.history.History at 0x7ab1b212b4d0>

Test/Validation Result

262/262 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **2s** 7ms/step - accuracy: 0.6603 - loss: 0.7740
Test accuracy: 0.660893440246582

	precision	recall	f1-score	support
mild	0.63	0.66	0.64	2087
minimum	0.77	0.54	0.64	2112
moderate	0.64	0.85	0.73	1946
severe	0.64	0.61	0.62	2227
accuracy			0.66	8372
macro avg	0.67	0.67	0.66	8372
weighted avg	0.67	0.66	0.66	8372

f. RMSprop with 0.0001 learning rate

Training Configuration

- **Optimizer:** RMSprop
- **Learning Rate:** 0.0001
- **Loss Function:** Sparse Categorical Cross-Entropy
- **Evaluation Metric:** Accuracy
- **Batch Size:** 32
- **Epochs:** Up to 300
- **Vocabulary Size:** 10,000
- **Maximum Sequence Length:** 100
- **LSTM units:** 64
- **1st Dropout Layer Rate:** 0.3
- **2nd Dropout Layer Rate:** 0.5
- **Early Stopping Patience:** 10

Training Results

Epoch 1/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **9s** 9ms/step - accuracy: 0.3575 - loss: 1.3243 - val_accuracy: 0.4052 - val_loss: 1.2757
Epoch 2/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.4684 - loss: 1.0663 - val_accuracy: 0.4902 - val_loss: 0.9731
Epoch 3/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.4756 - loss: 0.9977 - val_accuracy: 0.5295 - val_loss: 0.9580
Epoch 4/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.4987 - loss: 0.9609 - val_accuracy: 0.5305 - val_loss: 0.9291
Epoch 5/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.5093 - loss: 0.9366 - val_accuracy: 0.5387 - val_loss: 0.9090
Epoch 6/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.5202 - loss: 0.9237 - val_accuracy: 0.5452 - val_loss: 0.8990
Epoch 7/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.5305 - loss: 0.9092 - val_accuracy: 0.5366 - val_loss: 0.9210
Epoch 8/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **11s** 10ms/step - accuracy: 0.5392 - loss: 0.8883 - val_accuracy: 0.5498 - val_loss: 0.9057
Epoch 9/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.5612 - loss: 0.8688 - val_accuracy: 0.5624 - val_loss: 0.8802
Epoch 10/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.5671 - loss: 0.8625 - val_accuracy: 0.5724 - val_loss: 0.8793
Epoch 11/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.5792 - loss: 0.8582 - val_accuracy: 0.5748 - val_loss: 0.8713
Epoch 12/300

785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **10s** 10ms/step - accuracy: 0.6069 - loss: 0.8293 - val_accuracy: 0.5861 - val_loss: 0.8664
Epoch 13/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.6189 - loss: 0.8208 - val_accuracy: 0.6007 - val_loss: 0.8647
Epoch 14/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.6367 - loss: 0.7936 - val_accuracy: 0.6144 - val_loss: 0.8517
Epoch 15/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.6485 - loss: 0.7851 - val_accuracy: 0.6220 - val_loss: 0.8460
Epoch 16/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.6660 - loss: 0.7693 - val_accuracy: 0.6206 - val_loss: 0.8659
Epoch 17/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.6821 - loss: 0.7432 - val_accuracy: 0.6401 - val_loss: 0.8301
Epoch 18/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.6944 - loss: 0.7291 - val_accuracy: 0.6517 - val_loss: 0.8139
Epoch 19/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.7096 - loss: 0.7110 - val_accuracy: 0.6510 - val_loss: 0.8088
Epoch 20/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 11ms/step - accuracy: 0.7158 - loss: 0.6958 - val_accuracy: 0.6591 - val_loss: 0.8016
Epoch 21/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.7238 - loss: 0.6782 - val_accuracy: 0.6590 - val_loss: 0.8066
Epoch 22/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.7267 - loss: 0.6709 - val_accuracy: 0.6543 - val_loss: 0.8056
Epoch 23/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.7365 - loss: 0.6565 - val_accuracy: 0.6511 - val_loss: 0.8366
Epoch 24/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.7418 - loss: 0.6443 - val_accuracy: 0.6623 - val_loss: 0.7957
Epoch 25/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.7420 - loss: 0.6460 - val_accuracy: 0.6602 - val_loss: 0.8101
Epoch 26/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **7s** 9ms/step - accuracy: 0.7453 - loss: 0.6327 - val_accuracy: 0.6578 - val_loss: 0.8491
Epoch 27/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.7528 - loss: 0.6158 - val_accuracy: 0.6627 - val_loss: 0.7965
Epoch 28/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ **8s** 10ms/step - accuracy: 0.7579 - loss: 0.6036 - val_accuracy: 0.6636 - val_loss: 0.8116

```
Epoch 29/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 7s 9ms/step - accuracy: 0.7585 - loss:
0.5976 - val_accuracy: 0.6438 - val_loss: 0.8353
Epoch 30/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 8s 10ms/step - accuracy: 0.7640 -
loss: 0.5999 - val_accuracy: 0.6546 - val_loss: 0.8484
Epoch 31/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 7s 9ms/step - accuracy: 0.7723 - loss:
0.5861 - val_accuracy: 0.6609 - val_loss: 0.8019
Epoch 32/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 10s 9ms/step - accuracy: 0.7647 -
loss: 0.5818 - val_accuracy: 0.6571 - val_loss: 0.8264
Epoch 33/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 8s 10ms/step - accuracy: 0.7715 -
loss: 0.5793 - val_accuracy: 0.6675 - val_loss: 0.8034
Epoch 34/300
785/785 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 8s 10ms/step - accuracy: 0.7781 -
loss: 0.5713 - val_accuracy: 0.6592 - val_loss: 0.8213

<keras.src.callbacks.history.History at 0x7ab1b1beade0>
```

Test/Validation Result

```
262/262 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1s 5ms/step - accuracy: 0.6589 - loss:
0.8041
Test accuracy: 0.655398964881897
```

	precision	recall	f1-score	support
mild	0.65	0.62	0.63	2087
minimum	0.64	0.65	0.64	2112
moderate	0.66	0.75	0.71	1946
severe	0.67	0.60	0.64	2227
accuracy			0.66	8372
macro avg	0.66	0.66	0.66	8372
weighted avg	0.66	0.66	0.65	8372

7. Tools and Technologies Used

- **Programming Language:** Python
- **Deep Learning Framework:** TensorFlow / Keras
- **Data Processing:** Pandas, NumPy
- **Visualization:** Matplotlib, Seaborn

- **Machine Learning Utilities:** Scikit-learn
- **Development Environment:** Google Colab

8. Conclusion

This project successfully demonstrates the use of a deep neural network trained from scratch to solve a real-world text classification problem related to depression severity detection. The use of Embedding and LSTM layers enables the model to learn contextual and semantic features from text data without relying on pretrained models.

The final model, which utilizes the RMSprop optimizer with a learning rate of 0.0005, achieves an accuracy of 66.09%, exceeding the minimum performance expectations for the project. Overall, the results confirm that deep learning approaches are effective for natural language–based mental health classification tasks when combined with appropriate preprocessing and model design.