

IMDb Sentiment Analysis with RNN Architectures

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Abstract

This project implements and compares multiple Recurrent Neural Network (RNN) architectures for binary sentiment classification on the IMDb movie reviews dataset.

The models—RNN, LSTM, and BiLSTM—are evaluated under varying hyperparameters, including activation functions, optimizers, sequence lengths, and gradient clipping.

The results show that **LSTM with ReLU activation and Adam optimizer** consistently achieves the best performance, with an accuracy and F1-score of approximately **0.82** at a sequence length of **100 tokens**.

Dataset and Preprocessing

The dataset used is the IMDb Dataset of **50,000 labeled movie reviews** (balanced between positive and negative sentiments).

Each review was:

- Lowercased and cleaned of HTML tags and punctuation.
- Tokenized using a TextVectorization layer with a vocabulary size of **10,000** and an **<UNK>** token for out-of-vocabulary words.
- Split 50/50 into training and testing sets (25,000 each).
- Sequences were padded or truncated to fixed lengths of **25**, **50**, or **100 tokens**.

Preprocessed datasets were saved as **.npz** files (**imdb_25.npz**, **imdb_50.npz**, **imdb_100.npz**) for reproducibility.

Model Design

Three RNN variants were implemented in **PyTorch**:

- **RNN**: Basic recurrent layer with ReLU or Tanh activation.
- **LSTM**: Long Short-Term Memory with 2 layers and hidden size 64.
- **BiLSTM**: Bidirectional LSTM with the same hidden size.

Common settings:

- Embedding dimension: 100
- Dropout: 0.4
- Batch size: 32
- Loss: **BCEWithLogitsLoss**
- Optimizers tested: Adam, SGD, RMSProp
- Gradient clipping: enabled/disabled (max norm = 1.0)

All experiments were run on CPU with fixed random seeds for full reproducibility.

Experiments and Results

Each experiment trained for **5 epochs** while varying one factor at a time.

Below are summarized results from `results/metrics.csv`:

Architecture	Activation	Optimizer	Seq Length	Clip	Accuracy	F1	Time/Epoch (s)
RNN	ReLU	Adam	50	no	0.588	0.587	13.7
LSTM	ReLU	Adam	50	no	0.771	0.771	12.0
BiLSTM	ReLU	Adam	50	no	0.763	0.763	23.4
LSTM	Sigmoid	Adam	50	no	0.763	0.763	12.3
LSTM	Tanh	Adam	50	no	0.766	0.766	12.1
LSTM	ReLU	SGD	50	no	0.522	0.517	10.0
LSTM	ReLU						