Implementation_2

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0.1 Challenge: A deep dive into Dialogue Act Recognition - PART 2/2

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[17]:
```
%load_ext autoreload
%autoreload 2

import sys
import os

# Assuming your notebook is in a subfolder, and you want to go up 1 or more␣
 ↪levels to project root
project_root = os.path.dirname(os.getcwd())

# Optional: add root to Python path for module imports
if project_root not in sys.path:
    sys.path.append(project_root)

import torch
import json
import torch.utils.data
from tqdm import tqdm
import torch.nn as nn
import numpy as np
from torch.utils.data import Dataset, DataLoader
from precompute_embeddings import run_embedding_extraction
from collections import Counter
import re
import csv
import time
from models import ContextNet
from utils import compute_avg_training_time
from visualisations import plot_curve, generate_and_plot_confusion_matrix, \
plot_top_symmetric_misclassifications, plot_tsne, plot_tsne_zoomed
from train_structures import run_training_loop, evaluate

# Set random seed for reproducibility
seed = 0
```

```
np.random.seed(seed)
torch.manual_seed(seed)

device = torch.device("cuda" if torch.cuda.is_available() else "cpu")
```

```
The autoreload extension is already loaded. To reload it, use:
  %reload_ext autoreload
```

[5]:
```
parent_dir = os.path.dirname(os.getcwd())
path_to_dataset = os.path.join(parent_dir, 'SGD Dataset') # Assuming we're in a␣
 ↪subfolder of the root
path_to_train = os.path.join(path_to_dataset, "TrainSet.json")
path_to_test = os.path.join(path_to_dataset, "TestSet.json")
```

0.1.1 Implementation 2: Paper - "A Context-based Approach for Dialogue Act Recognition using Simple Recurrent Neural Networks"

The first implementation used embeddings of words, sequentially fed into an RNN, to build context-aware representations, based on a single utterance.

This implementation is inspired by the approach proposed in Bothe et al. (2018), *A Context-Based Approach for Dialogue Act Recognition Using Simple Recurrent Neural Networks*, presented at the Eleventh International Conference on Language Resources and Evaluation (LREC 2018).

It has two major upgrades compared to the first implementation: - First: it makes use of utterance-level embeddings, acquired from a model pretrained on a large corpus (~ 80 million amazon product reviews). - Second: the final model stacks these utterance-level embeddings across dialogue turns to model dialogue context.

As a result, the model benefits from semantically richer representations while also having the context of multiple turns in the dialogue.

Preprocessing The preprocessing is the same as implementation 1, we just want to get the act_labels and their corresponding number labels. The rest of the preprocessing is done in the dataset class itself.

[6]:
```
EOD = "<eod>" # Define End of dialogue token as a global variable
```

[7]:
```
def extract_turn_data(file_path):
    all_data = []
    with open(file_path, 'r') as f:
        data = json.load(f)
        for dialogue in data:
            for turn in dialogue['turns']:
                all_data.append({
                    'speaker': turn['speaker'],
                    'utterance': turn['utterance'],
                    'act': turn["dialogue_act"]
                })
```

```
            all_data[-1]['utterance'] += f" {EOD}" # Add an End Of Dialogue␣
 ↪marker at the end of last utterance in turn
    return all_data

extracted_train = extract_turn_data(path_to_train)
extracted_test = extract_turn_data(path_to_test)
```

[8]:
```
# A set makes it easy to find unique elements (removes duplicates)
acts = list(set([data['act'] for data in extracted_train] + [data['act'] for␣
 ↪data in extracted_test]))

acts_labels = {act : i for i, act in enumerate(acts)}
inv_acts_labels = {v: k for k, v in acts_labels.items()}
```

We're only interested in the raw utterances of the test data, since it's just for visualisation purposes.

Code for precomputing an embedding vector for each utterance This code will create a train_embeddings_[average|last].pt test_embeddings_[average|last].pt depending on whether you want the mLSTM with pretrained weights to use the embedding from the last hidden state h_t or from the average of all hidden states. These embeddings can then more easily be acquired during the training of our model.

The paper: **A context-based Approach for DA Recognition using Simple RNN** reads: "*This model consists of a single multiplicative long-short-term memory (mLSTM) network (Krause et al., 2016) layer with 4,096 hidden units. The mLSTM is composed of an LSTM and a multiplicative RNN and considers each possible input in a recurrent transition function. It is trained as a character language model on 80 million Amazon product reviews (Radford et al., 2017).*"

The original pretrained mLSTM can be found here and can be used as is, as a feature extractor. However, since that codebase uses TensorFlow, the one used in this notebook is the one cited as a pytorch fork on that repository.

Running the following code cell will result in the creation of **test_embeddings_average.pt** and **train_embeddings_average.pt** files that contain a list of dialogues, where each dialogue contains an embedding of every utterance that occurs in the dialogue. For the actual implementation, the reader is referred to the code in **precompute_embeddings.py**.

[9]:
```
run_embedding_extraction(model_path='mlstm_ns.pt', path_to_train=path_to_train,␣
 ↪path_to_test=path_to_test)
```

```
Embeddings already exist. Skipping extraction.
```

Dataset In the dataset some extra preprocessing is done, we want to collect the previous n utterances as context, so we make every sample a list of n utterances, with their corresponding labels. Instead of using raw utterances however, we use the embedding version acquired from the pretrained mLSTM, these were precomputed in the previous step.

[10]:
```
class DialogueWindowDataset(Dataset):
    def __init__(self, embeddings_path, file_path, window_size=2):
```

```
        """
        Args:
            embeddings_path (str): Path to the precomputed embeddings file.
            file_path (str): Path to the JSON file containing dialogue data.
            window_size (int): Size of the context window. (e.g. 2 is 2␣
↪previous turns + current turn)
        """
        self.embeddings = torch.load(embeddings_path)
        self.window_size = window_size

        with open(file_path, 'r') as f:
            file_contents = json.load(f)
            dialogues = [dialogue['turns'] for dialogue in file_contents]
            self.data = []
            for dialog_idx, dialog in enumerate(tqdm(dialogues)):
                embeddings = self.embeddings[dialog_idx]
                speakers = [0 if turn['speaker'] == 'USER' else 1 for turn in␣
↪dialog]
                labels = [acts_labels[turn['dialogue_act']] for turn in dialog]

                n = len(embeddings)
                for t in range(n):
                    window_emb = []
                    window_speaker = []
                    for i in range(t - self.window_size, t + 1):
                        if i >= 0:
                            emb = embeddings[i]
                            spk = torch.nn.functional.one_hot(
                                torch.tensor(speakers[i]), num_classes=2
                            ).float()
                        else:
                            emb = torch.zeros(4096)
                            spk = torch.zeros(2)
                        window_emb.append(emb)
                        window_speaker.append(spk)

                    window_emb = torch.stack(window_emb)  # (window_size + 1,␣
↪embed_dim)
                    window_speaker = torch.stack(window_speaker)  #␣
↪(window_size + 1, 2)
                    combined = torch.cat([window_emb, window_speaker], dim=1) ␣
↪# (window_size + 1, embed_dim + 2)
                    label = labels[t]

                    self.data.append((combined, label))

    def __len__(self):
```

```
        return len(self.data)

    def __getitem__(self, idx):
        return self.data[idx]
```

The result is a dataset where each batch contains n embeddings per sample (except at the start of a dialogue where there is no "previous utterance" to speak of).

[11]:
```
# Define the dataset and dataloader
# In accordance with the paper, the average embedding is used for the mLSTM␣
 ↪model, as it contains more information
train_dataset = DialogueWindowDataset(embeddings_path='train_embeddings_average.
 ↪pt', file_path=path_to_train)
train_loader = DataLoader(train_dataset, batch_size=128, shuffle=True)
test_dataset = DialogueWindowDataset(embeddings_path='test_embeddings_average.
 ↪pt', file_path=path_to_test)
test_loader = DataLoader(test_dataset, batch_size=128, shuffle=False)

# Example batch
for batch in train_loader:
    combined, labels = batch
    print(combined.shape)  # (batch_size, 3, embed_dim + 2)
    print(labels.shape)    # (batch_size,)
    break
```

```
C:\Users\Ward\AppData\Local\Temp\ipykernel_10956\3759199132.py:9: FutureWarning:
You are using `torch.load` with `weights_only=False` (the current default
value), which uses the default pickle module implicitly. It is possible to
construct malicious pickle data which will execute arbitrary code during
unpickling (See
https://github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for
more details). In a future release, the default value for `weights_only` will be
flipped to `True`. This limits the functions that could be executed during
unpickling. Arbitrary objects will no longer be allowed to be loaded via this
mode unless they are explicitly allowlisted by the user via
`torch.serialization.add_safe_globals`. We recommend you start setting
`weights_only=True` for any use case where you don't have full control of the
loaded file. Please open an issue on GitHub for any issues related to this
experimental feature.
  self.embeddings = torch.load(embeddings_path)
100%|      | 5403/5403 [00:12<00:00, 436.69it/s]
100%|      | 1331/1331 [00:03<00:00, 409.82it/s]

torch.Size([128, 3, 4098])
torch.Size([128])
```

Architecture The final model's input size is based on the embedding size returned by our pre-trained mLSTM model, which is 4096. The hidden size is kept the same as our previous model.

[12]:
```
# Hyperparameters
input_size = 4096 + 2  # Embedding dimension + speaker one-hot
hidden_size = 32
num_classes = len(acts_labels)  # Number of dialogue acts
pooling_type = 'average'  # 'last_hidden_state' or 'average'

# Initialize model, optimizer, and criterion
model = ContextNet(input_size, hidden_size, num_classes, pooling_type).
 ↪to(device)
```

Training The training, evaluation and visualisation section remains similar to the first implementation, with small adaptations to account for the different input (speaker info is already added in the dataset creation).

[13]:
```
def prepare_batch_v2(batch):
    combined, labels = batch
    return [combined], labels

def forward_v2(model, combined):
    return model(combined)
```

[14]:
```
optimizer = torch.optim.Adam(model.parameters(), lr=0.001)
criterion = nn.CrossEntropyLoss()
num_epochs = 50
```

[ ]:
```
losses, accuracies = run_training_loop(
    model=model,
    train_loader=train_loader,
    optimizer=optimizer,
    criterion=criterion,
    num_epochs=num_epochs,
    prepare_batch=prepare_batch_v2,
    forward=forward_v2,
    save_dir="train_logs"
)
```

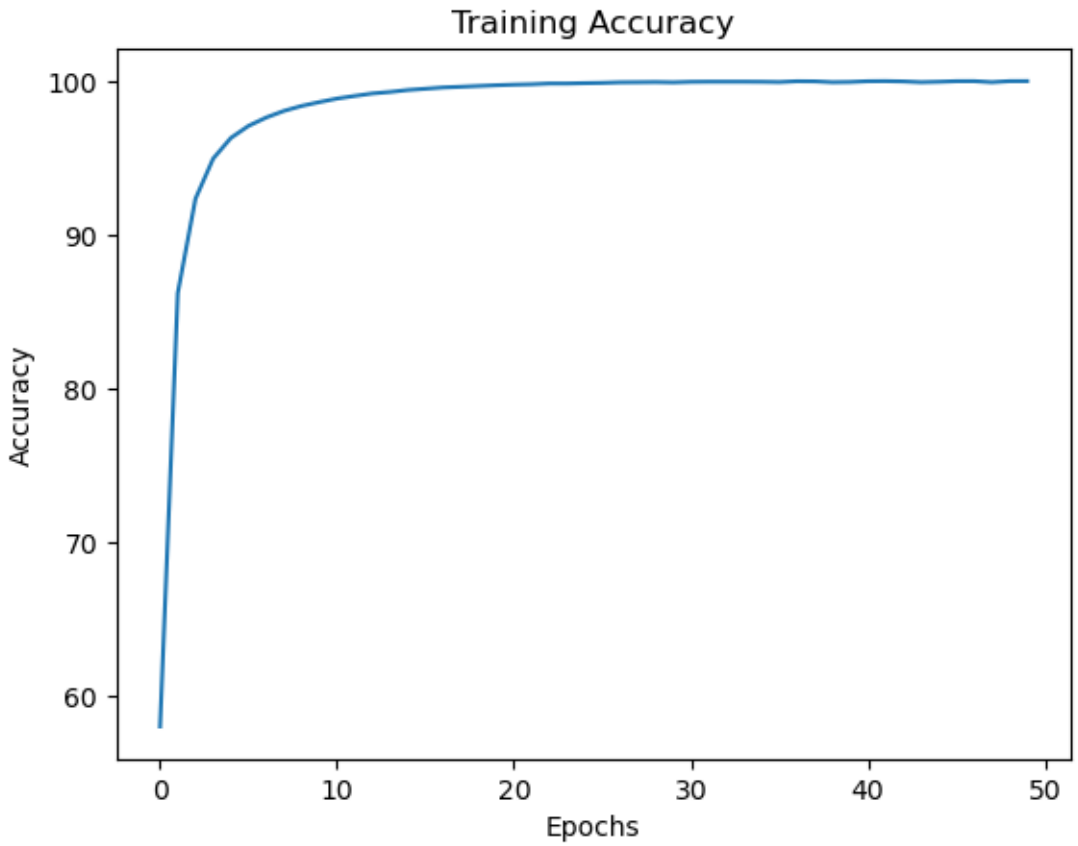
```
100%|      | 646/646 [00:05<00:00, 119.86it/s]
Epoch 1/50, Train Loss: 1.640, Train Accuracy: 57.985
100%|      | 646/646 [00:05<00:00, 126.50it/s]
Epoch 2/50, Train Loss: 0.589, Train Accuracy: 86.195
100%|      | 646/646 [00:05<00:00, 122.87it/s]
Epoch 3/50, Train Loss: 0.362, Train Accuracy: 92.334
100%|      | 646/646 [00:05<00:00, 126.33it/s]
Epoch 4/50, Train Loss: 0.248, Train Accuracy: 94.950
```

```
100%|      | 646/646 [00:05<00:00, 125.00it/s]
Epoch 5/50, Train Loss: 0.182, Train Accuracy: 96.296
100%|      | 646/646 [00:05<00:00, 118.53it/s]
Epoch 6/50, Train Loss: 0.141, Train Accuracy: 97.082
100%|      | 646/646 [00:05<00:00, 122.37it/s]
Epoch 7/50, Train Loss: 0.112, Train Accuracy: 97.627
100%|      | 646/646 [00:05<00:00, 123.75it/s]
Epoch 8/50, Train Loss: 0.092, Train Accuracy: 98.057
100%|      | 646/646 [00:05<00:00, 121.70it/s]
Epoch 9/50, Train Loss: 0.076, Train Accuracy: 98.380
100%|      | 646/646 [00:05<00:00, 115.44it/s]
Epoch 10/50, Train Loss: 0.065, Train Accuracy: 98.629
100%|      | 646/646 [00:05<00:00, 121.43it/s]
Epoch 11/50, Train Loss: 0.055, Train Accuracy: 98.859
100%|      | 646/646 [00:05<00:00, 115.18it/s]
Epoch 12/50, Train Loss: 0.047, Train Accuracy: 99.030
100%|      | 646/646 [00:05<00:00, 119.76it/s]
Epoch 13/50, Train Loss: 0.040, Train Accuracy: 99.192
100%|      | 646/646 [00:05<00:00, 120.36it/s]
Epoch 14/50, Train Loss: 0.035, Train Accuracy: 99.289
100%|      | 646/646 [00:05<00:00, 120.05it/s]
Epoch 15/50, Train Loss: 0.031, Train Accuracy: 99.416
100%|      | 646/646 [00:05<00:00, 123.49it/s]
Epoch 16/50, Train Loss: 0.027, Train Accuracy: 99.499
100%|      | 646/646 [00:05<00:00, 117.47it/s]
Epoch 17/50, Train Loss: 0.024, Train Accuracy: 99.583
100%|      | 646/646 [00:05<00:00, 120.68it/s]
Epoch 18/50, Train Loss: 0.021, Train Accuracy: 99.628
100%|      | 646/646 [00:05<00:00, 113.98it/s]
Epoch 19/50, Train Loss: 0.018, Train Accuracy: 99.679
100%|      | 646/646 [00:05<00:00, 119.60it/s]
Epoch 20/50, Train Loss: 0.016, Train Accuracy: 99.728
```

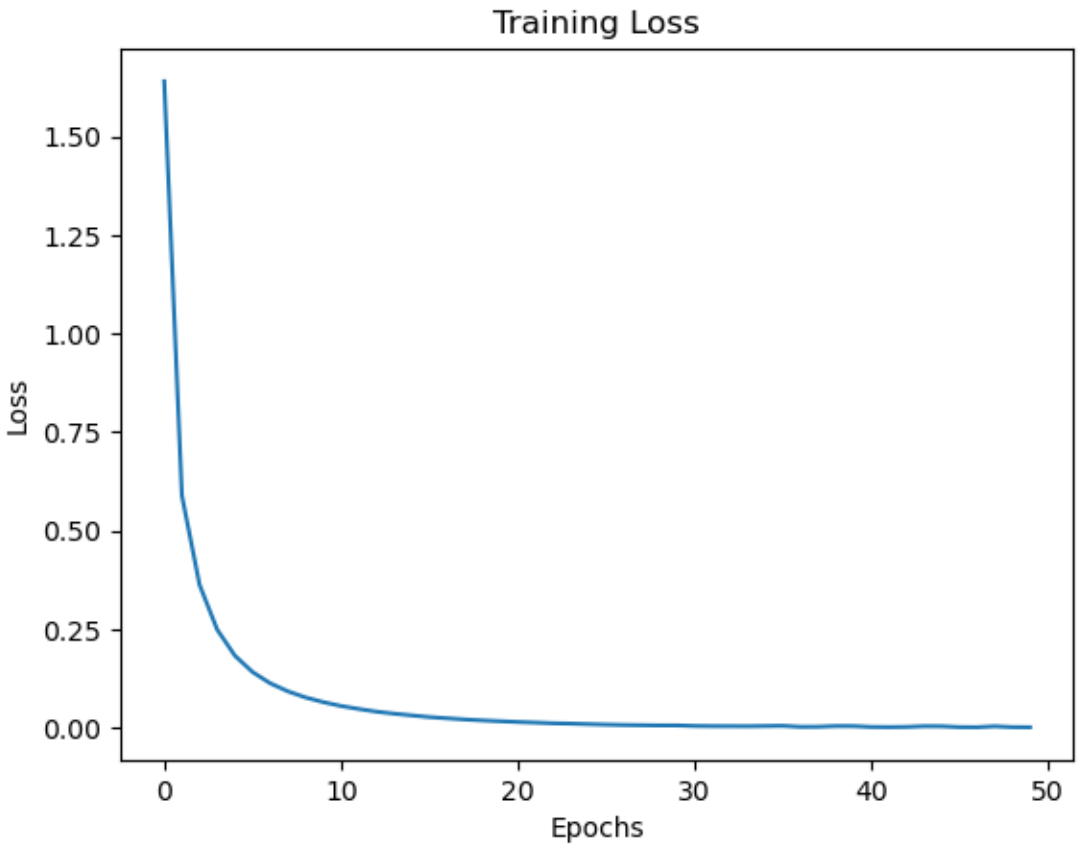
```
100%|      | 646/646 [00:05<00:00, 117.50it/s]
Epoch 21/50, Train Loss: 0.014, Train Accuracy: 99.765
100%|      | 646/646 [00:05<00:00, 116.06it/s]
Epoch 22/50, Train Loss: 0.013, Train Accuracy: 99.792
100%|      | 646/646 [00:05<00:00, 122.35it/s]
Epoch 23/50, Train Loss: 0.011, Train Accuracy: 99.841
100%|      | 646/646 [00:05<00:00, 112.67it/s]
Epoch 24/50, Train Loss: 0.010, Train Accuracy: 99.841
100%|      | 646/646 [00:05<00:00, 121.27it/s]
Epoch 25/50, Train Loss: 0.009, Train Accuracy: 99.864
100%|      | 646/646 [00:05<00:00, 127.50it/s]
Epoch 26/50, Train Loss: 0.007, Train Accuracy: 99.881
100%|      | 646/646 [00:05<00:00, 129.03it/s]
Epoch 27/50, Train Loss: 0.007, Train Accuracy: 99.916
100%|      | 646/646 [00:05<00:00, 128.62it/s]
Epoch 28/50, Train Loss: 0.006, Train Accuracy: 99.924
100%|      | 646/646 [00:05<00:00, 128.63it/s]
Epoch 29/50, Train Loss: 0.005, Train Accuracy: 99.935
100%|      | 646/646 [00:04<00:00, 129.50it/s]
Epoch 30/50, Train Loss: 0.005, Train Accuracy: 99.915
100%|      | 646/646 [00:05<00:00, 127.06it/s]
Epoch 31/50, Train Loss: 0.004, Train Accuracy: 99.949
100%|      | 646/646 [00:05<00:00, 128.08it/s]
Epoch 32/50, Train Loss: 0.004, Train Accuracy: 99.958
100%|      | 646/646 [00:05<00:00, 127.89it/s]
Epoch 33/50, Train Loss: 0.004, Train Accuracy: 99.958
100%|      | 646/646 [00:05<00:00, 125.89it/s]
Epoch 34/50, Train Loss: 0.003, Train Accuracy: 99.958
100%|      | 646/646 [00:05<00:00, 123.95it/s]
Epoch 35/50, Train Loss: 0.004, Train Accuracy: 99.952
100%|      | 646/646 [00:04<00:00, 130.66it/s]
Epoch 36/50, Train Loss: 0.004, Train Accuracy: 99.935
```

```
100%|      | 646/646 [00:04<00:00, 129.27it/s]
Epoch 37/50, Train Loss: 0.002, Train Accuracy: 99.988
100%|      | 646/646 [00:04<00:00, 129.29it/s]
Epoch 38/50, Train Loss: 0.002, Train Accuracy: 99.979
100%|      | 646/646 [00:05<00:00, 128.92it/s]
Epoch 39/50, Train Loss: 0.004, Train Accuracy: 99.925
100%|      | 646/646 [00:05<00:00, 128.67it/s]
Epoch 40/50, Train Loss: 0.004, Train Accuracy: 99.941
100%|      | 646/646 [00:04<00:00, 129.48it/s]
Epoch 41/50, Train Loss: 0.002, Train Accuracy: 99.989
100%|      | 646/646 [00:05<00:00, 129.11it/s]
Epoch 42/50, Train Loss: 0.001, Train Accuracy: 99.996
100%|      | 646/646 [00:05<00:00, 128.19it/s]
Epoch 43/50, Train Loss: 0.002, Train Accuracy: 99.975
100%|      | 646/646 [00:05<00:00, 127.87it/s]
Epoch 44/50, Train Loss: 0.003, Train Accuracy: 99.926
100%|      | 646/646 [00:05<00:00, 128.12it/s]
Epoch 45/50, Train Loss: 0.003, Train Accuracy: 99.953
100%|      | 646/646 [00:05<00:00, 122.35it/s]
Epoch 46/50, Train Loss: 0.001, Train Accuracy: 99.992
100%|      | 646/646 [00:05<00:00, 121.52it/s]
Epoch 47/50, Train Loss: 0.001, Train Accuracy: 99.994
100%|      | 646/646 [00:05<00:00, 128.57it/s]
Epoch 48/50, Train Loss: 0.003, Train Accuracy: 99.926
100%|      | 646/646 [00:05<00:00, 128.91it/s]
Epoch 49/50, Train Loss: 0.001, Train Accuracy: 99.994
100%|      | 646/646 [00:05<00:00, 128.65it/s]
Epoch 50/50, Train Loss: 0.001, Train Accuracy: 99.996

 Training complete. Model saved to 'train_logs\model.pth', stats saved to
'train_logs\train_stats.csv'
```

[54]:
```
plot_curve(accuracies, "Epochs", "Accuracy", "Training Accuracy")
```



[55]:
```
plot_curve(losses, "Epochs", "Loss", "Training Loss")
```



Evaluation

[72]:
```
# Evaluate on the test set
metrics = evaluate(model, test_loader, prepare_batch_fn=prepare_batch_v2,␣
 ↪forward_fn=forward_v2, inv_act_labels=inv_acts_labels)
```

```
100%|      | 132/132 [00:05<00:00, 23.21it/s]
c:\Users\Ward\anaconda3\envs\multibench\Lib\site-
packages\sklearn\metrics\_classification.py:2480: UserWarning: y_pred contains
classes not in y_true
  warnings.warn("y_pred contains classes not in y_true")


 Evaluation Results:
Top-1 Accuracy: 94.49%
Top-5 Accuracy: 99.49%
Balanced Accuracy: 85.61%

 Classification Report:
                                                    precision    recall  f1-score
support
```

SYSTEM_CONFIRM	0.98	0.95	0.96	1113
SYSTEM_GOODBYE	0.98	0.98	0.98	1331
SYSTEM_INFORM	0.99	0.95	0.97	719
SYSTEM_INFORM|SYSTEM_NOTIFY_SUCCESS	0.99	0.96	0.98	310
SYSTEM_INFORM|SYSTEM_OFFER|SYSTEM_NOTIFY_FAILURE	0.79	0.88	0.83	17
SYSTEM_NOTIFY_FAILURE|SYSTEM_REQ_MORE	0.99	0.92	0.95	79
SYSTEM_NOTIFY_SUCCESS	0.97	0.99	0.98	499
SYSTEM_OFFER	0.91	0.97	0.94	806
SYSTEM_OFFER_INTENT	0.92	0.98	0.95	383
SYSTEM_OFFER|SYSTEM_INFORM_COUNT	0.97	0.96	0.97	608
SYSTEM_OFFER|SYSTEM_NOTIFY_FAILURE	1.00	0.93	0.96	14
SYSTEM_REQUEST	1.00	0.99	0.99	1961
SYSTEM_REQ_MORE	0.96	0.98	0.97	585
USER_AFFIRM	0.98	0.97	0.97	572
USER_AFFIRM_INTENT	0.90	0.93	0.91	139
USER_AFFIRM_INTENT|USER_INFORM	0.89	0.85	0.87	103
USER_INFORM	0.99	0.98	0.98	1961
USER_INFORM_INTENT	0.96	0.93	0.94	658
USER_INFORM_INTENT|USER_NEGATE_INTENT	0.00	0.00	0.00	0
USER_INFORM_INTENT|USER_SELECT	0.81	0.90	0.85	167
USER_INFORM_INTENT|USER_THANK_YOU	0.44	0.33	0.38	12
USER_INFORM|USER_INFORM_INTENT	0.94	0.95	0.95	772
USER_INFORM|USER_INFORM_INTENT|USER_NEGATE_INTENT	0.00	0.00	0.00	0
USER_INFORM|USER_INFORM_INTENT|USER_SELECT	0.84	0.84	0.84	117

```
    USER_INFORM|USER_INFORM_INTENT|USER_THANK_YOU       0.60      0.21      0.32
14
                          USER_INFORM|USER_NEGATE       0.95      0.90      0.93
216
                   USER_INFORM|USER_REQUEST_ALTS       0.84      0.86      0.85
184
                                     USER_NEGATE       0.75      0.43      0.55
7
                               USER_NEGATE_INTENT       0.60      0.72      0.66
69
                  USER_NEGATE_INTENT|USER_GOODBYE       0.71      0.76      0.73
72
                        USER_NEGATE|USER_GOODBYE       0.60      0.67      0.63
9
                      USER_NEGATE|USER_THANK_YOU       0.99      0.99      0.99
587
                                     USER_REQUEST       0.97      0.94      0.95
719
                               USER_REQUEST_ALTS       0.91      0.93      0.92
152
                      USER_REQUEST|USER_AFFIRM       0.95      0.96      0.95
340
                                     USER_SELECT       0.85      0.89      0.87
515
                        USER_SELECT|USER_GOODBYE       0.79      0.68      0.73
279
                                   USER_THANK_YOU       0.80      0.77      0.79
377
                      USER_THANK_YOU|USER_GOODBYE       0.71      0.83      0.77
384

                                        accuracy                           0.94
16850
                                       macro avg       0.83      0.81      0.81
16850
                                    weighted avg       0.95      0.94      0.95
16850
```

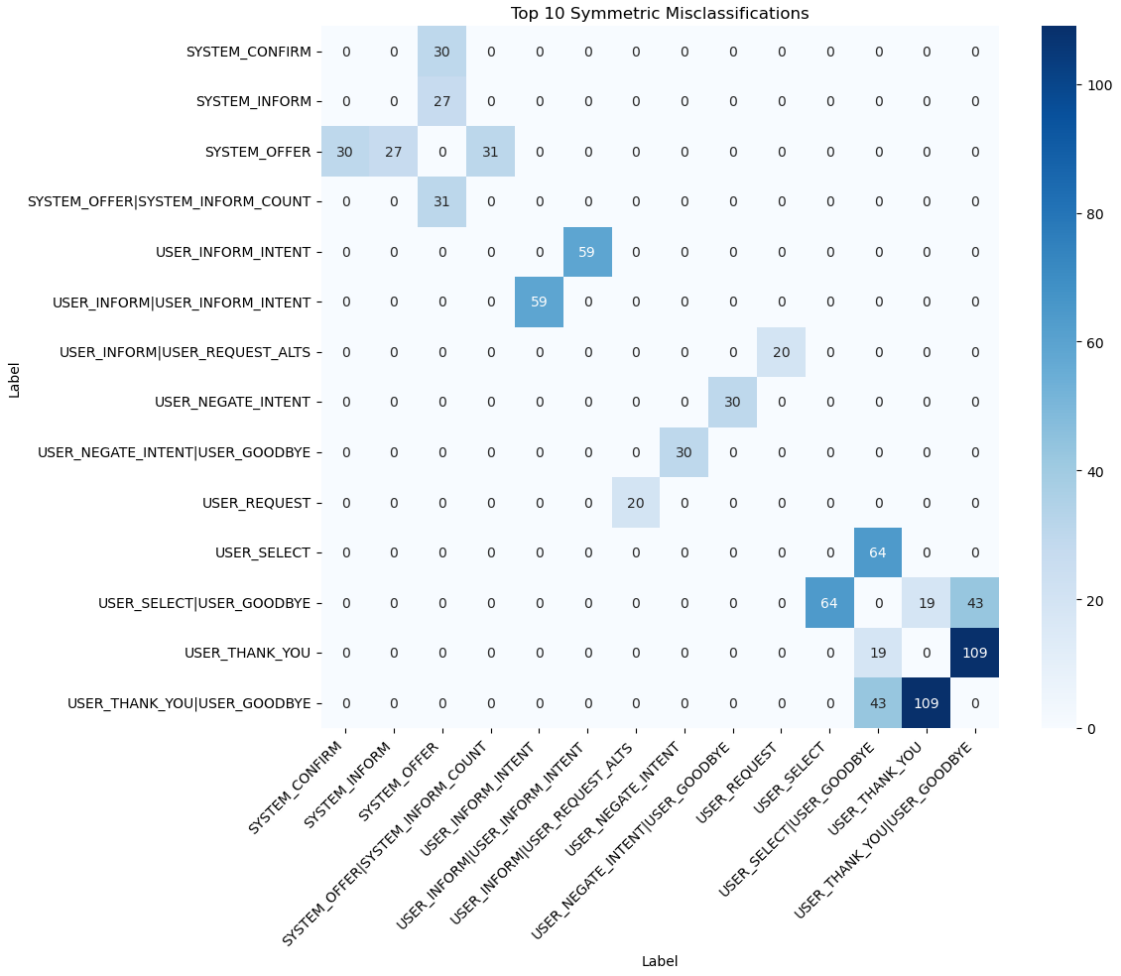
[2]:
```
compute_avg_training_time('train_logs/train_stats.csv')
```

```
Average training time is: 5.2202076244354245 seconds
```

Visualisations

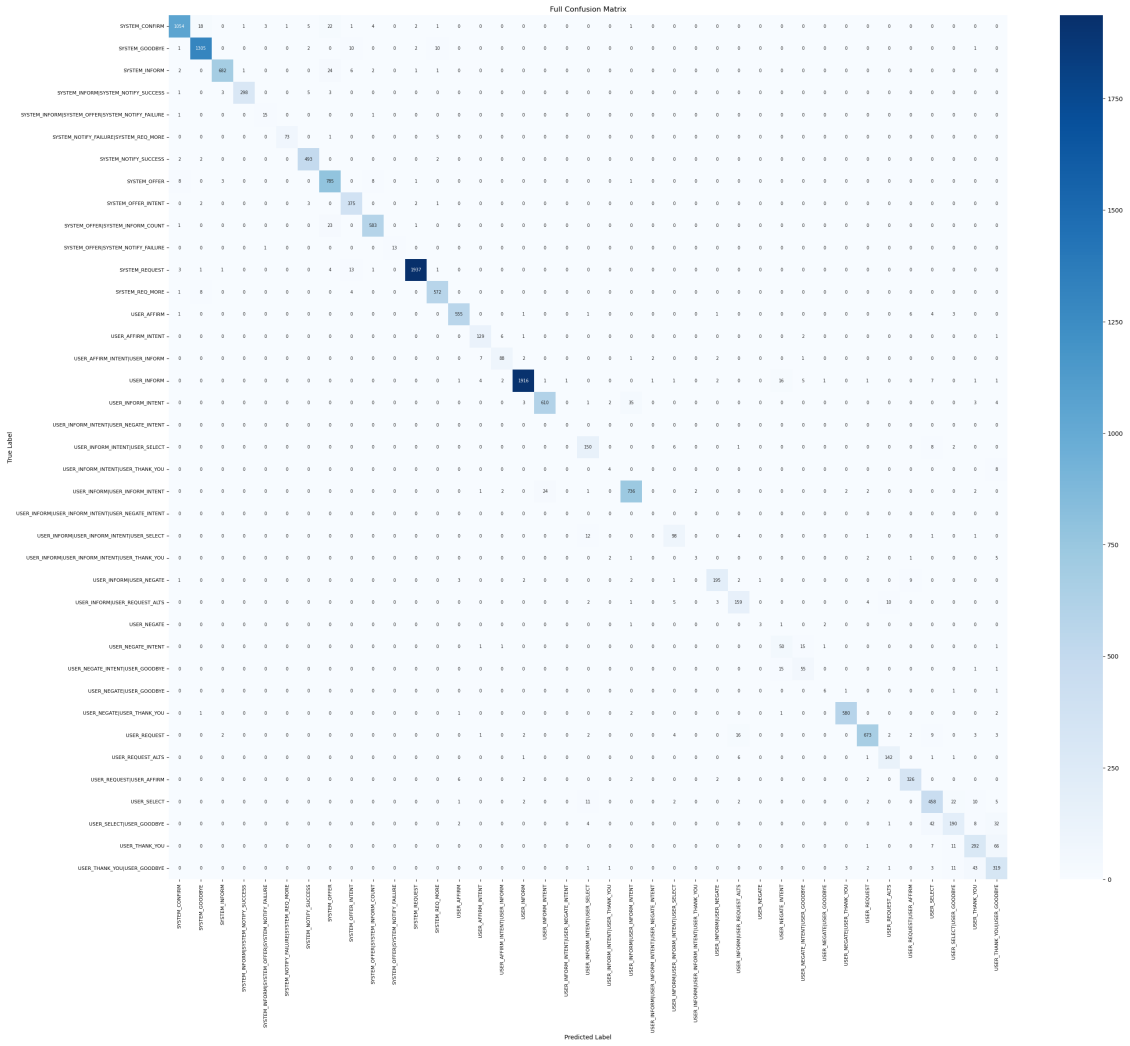
[61]:
```
all_targets_named = metrics['y_true']
all_predictions_named = metrics['y_pred']

# Call the function to plot the top 10 misclassifications
```

```
plot_top_symmetric_misclassifications(all_targets_named, all_predictions_named,␣
↪top_n=10)
```



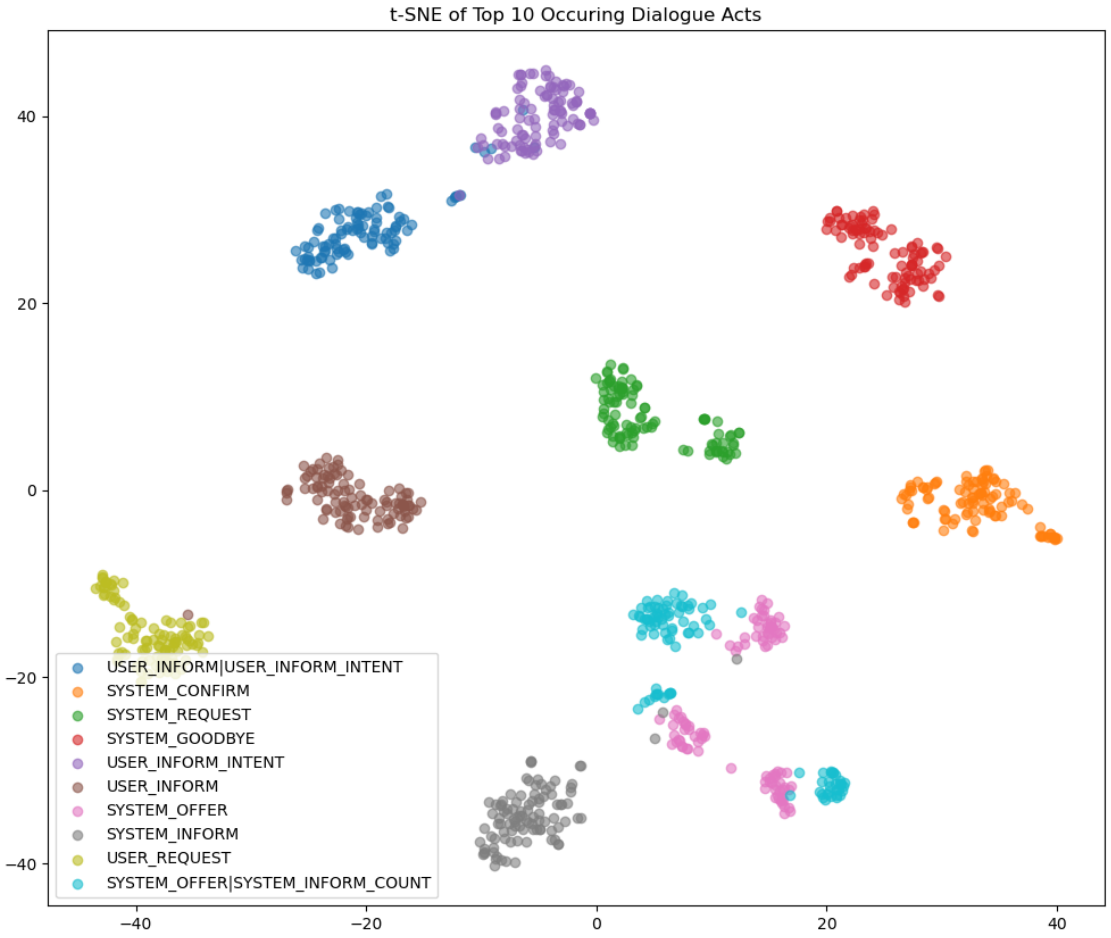
[58]:
```
generate_and_plot_confusion_matrix(
    all_targets_named,
    all_predictions_named,
    figsize=(28, 24),         # Customize plot size
    annot_kws={"size": 7}     # Customize annotation font size
)
```

```
Found 39 unique classes.
Generating confusion matrix plot…
Saved matrix plots to full_confusion_matrix.pdf and .png
```



[73]:
```
utterances = metrics["utterance_vectors"]
labels = metrics["y_true"]

# Filter the utterances and labels to only include the top labels
label_counts = Counter(metrics["y_true"])
top_labels = [label for label, _ in label_counts.most_common(10)]

plot_tsne(utterances, labels, top_labels, max_per_label=100, title="t-SNE of␣
↪Top 10 Occuring Dialogue Acts")
```

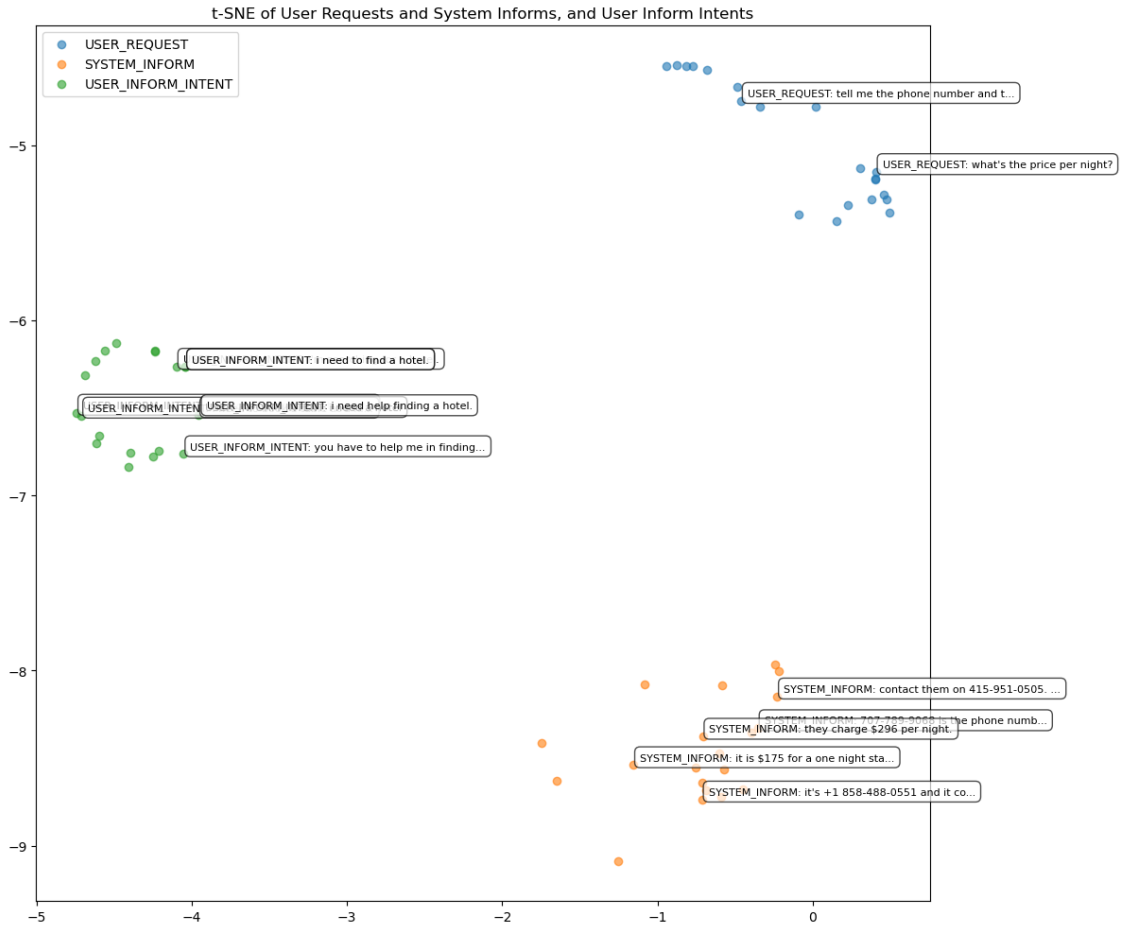
```
Saved plots to t-SNE of Top 10 Occuring Dialogue Acts.png
```



[75]:
```
utterances_test = [data['utterance'].lower() for data in extracted_test]
```

[83]:
```
# Plot zoomed version for just a specific subset of acts
plot_tsne_zoomed(
    vectors=utterances,
    labels=labels,
    texts=utterances_test,
    selected_labels=['USER_REQUEST', 'SYSTEM_INFORM', 'USER_INFORM_INTENT'],  #␣
 ↪Focus on these classes
    max_per_label=20,              # Limit points per class
    annotate_sample=0.3,           # Annotate 30% of points
    zoom_scale=1.0,
    title="t-SNE of User Requests and System Informs, and User Inform Intents",
)
```

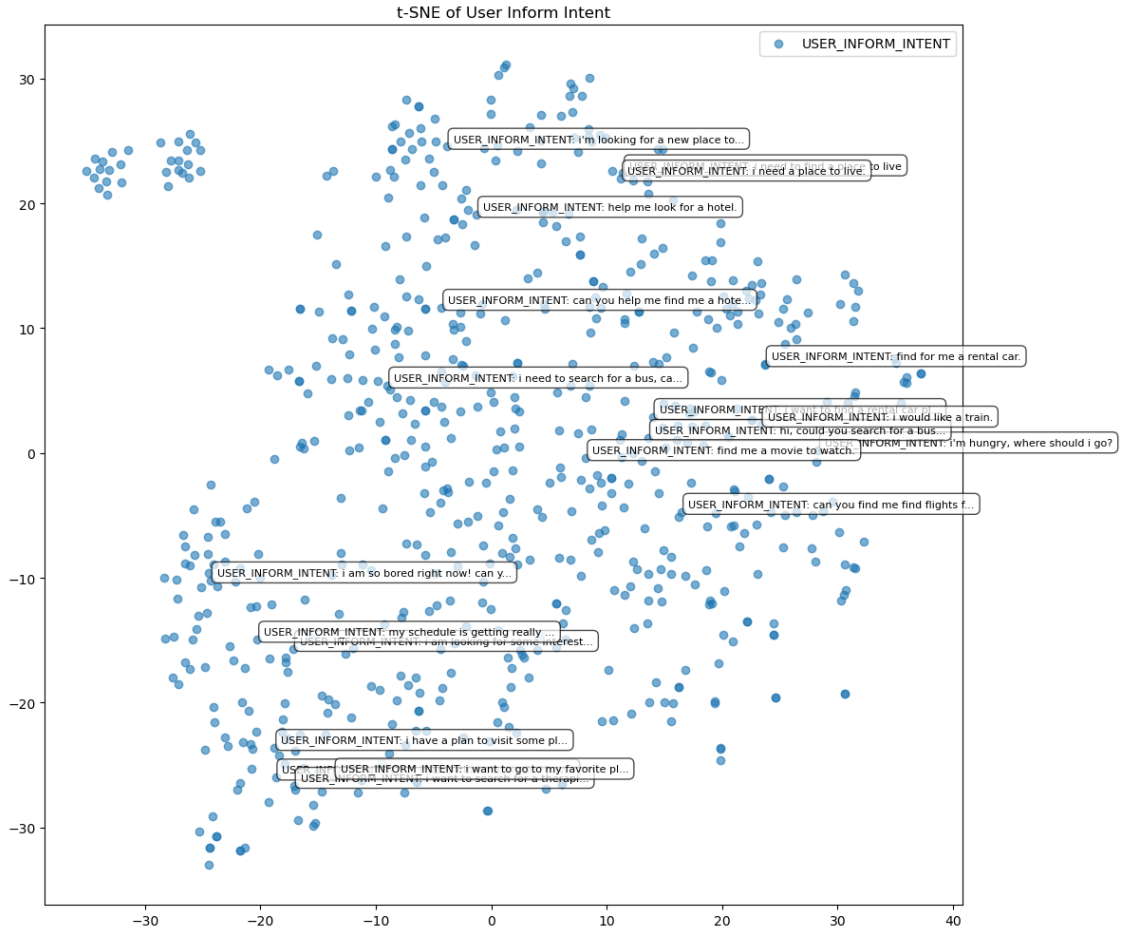
```
Saved plots to t-SNE of User Requests and System Informs, and User Inform
Intents.png
```



The model is so good at clustering that the clusters being this far apart makes it harder to differentiate, let's take a look at one specific dialogue act:

[99]:
```
# Plot zoomed version for just a specific subset of acts
plot_tsne_zoomed(
    vectors=utterances,
    labels=labels,
    texts=utterances_test,
    selected_labels=['USER_INFORM_INTENT'],  # Focus on these classes
    max_per_label=1000,              # Limit points per class
    annotate_sample=0.03,           # Annotate 3% of points
    zoom_scale=1.0,
    title="t-SNE of User Inform Intent",
)
```

```
Saved plots to t-SNE of User Inform Intent.png
```



Ablation study: context window size We will now run an experiment to analyse the impact of window size in the dialogue recognition task. The window size decides how many previous utterances are used as context for the current one. Sizes [0, 10] will be checked, and the resulting accuracies and training times will be saved in a .csv file.

[20]:
```
# Define where to save your results
results_file = "ablation_window_size_results.csv"

# Open CSV file for writing metrics
with open(results_file, mode='w', newline='') as f:
    writer = csv.writer(f)
    writer.writerow([
        "window_size", "accuracy", "top5_accuracy", "balanced_accuracy",␣
↪"dataset_creation_time_sec", "train_time_sec"
    ])

    for window_size in range(0, 11):  # From 0 to 10 inclusive
        print(f"\n=== Running training for window size: {window_size} ===")
```

```
        # Measure training time
        start_time_dataset = time.time()

        # Load datasets
        train_dataset = DialogueWindowDataset(
            embeddings_path='train_embeddings_average.pt',
            file_path=path_to_train,
            window_size=window_size
        )
        train_loader = DataLoader(train_dataset, batch_size=128, shuffle=True)

        test_dataset = DialogueWindowDataset(
            embeddings_path='test_embeddings_average.pt',
            file_path=path_to_test,
            window_size=window_size
        )
        test_loader = DataLoader(test_dataset, batch_size=128, shuffle=False)

        end_time_dataset = time.time()
        dataset_creation_time = end_time_dataset - start_time_dataset

        # Initialize model, optimizer, criterion
        model = ContextNet(input_size, hidden_size, num_classes, pooling_type).
↪to(device)
        optimizer = torch.optim.Adam(model.parameters(), lr=1e-3)
        criterion = torch.nn.CrossEntropyLoss()

        train_start_time = time.time()

        # Train the model
        losses, accuracies = run_training_loop(
            model=model,
            train_loader=train_loader,
            optimizer=optimizer,
            criterion=criterion,
            num_epochs=num_epochs,
            prepare_batch=prepare_batch_v2,
            forward=forward_v2,
            save_dir=f"train_logs/window_{window_size}"
        )

        train_end_time = time.time()
        train_time = train_end_time - train_start_time

        # Evaluate on the test set
        metrics = evaluate(
```

```
            model=model,
            test_loader=test_loader,
            prepare_batch_fn=prepare_batch_v2,
            forward_fn=forward_v2,
            inv_act_labels=inv_acts_labels
        )

        # Write metrics to CSV
        writer.writerow([
            window_size,
            metrics["accuracy"],
            metrics["top5_accuracy"],
            metrics["balanced_accuracy"],
            round(dataset_creation_time, 2),
            round(train_time, 2)
        ])

print(f"\nAblation study completed! Results saved to '{results_file}'")
```

```
=== Running training for window size: 0 ===

C:\Users\Ward\AppData\Local\Temp\ipykernel_10956\3759199132.py:9: FutureWarning:
You are using `torch.load` with `weights_only=False` (the current default
value), which uses the default pickle module implicitly. It is possible to
construct malicious pickle data which will execute arbitrary code during
unpickling (See
https://github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for
more details). In a future release, the default value for `weights_only` will be
flipped to `True`. This limits the functions that could be executed during
unpickling. Arbitrary objects will no longer be allowed to be loaded via this
mode unless they are explicitly allowlisted by the user via
`torch.serialization.add_safe_globals`. We recommend you start setting
`weights_only=True` for any use case where you don't have full control of the
loaded file. Please open an issue on GitHub for any issues related to this
experimental feature.
  self.embeddings = torch.load(embeddings_path)
100%|      | 5403/5403 [00:04<00:00, 1081.68it/s]
100%|      | 1331/1331 [00:00<00:00, 1398.08it/s]
100%|      | 646/646 [00:02<00:00, 231.94it/s]

Epoch 1/50, Train Loss: 1.130, Train Accuracy: 74.588

100%|      | 646/646 [00:02<00:00, 281.60it/s]

Epoch 2/50, Train Loss: 0.401, Train Accuracy: 89.584

100%|      | 646/646 [00:02<00:00, 262.92it/s]

Epoch 3/50, Train Loss: 0.293, Train Accuracy: 91.936
```

```
100%|      | 646/646 [00:02<00:00, 274.78it/s]
Epoch 4/50, Train Loss: 0.245, Train Accuracy: 92.974
100%|      | 646/646 [00:02<00:00, 276.54it/s]
Epoch 5/50, Train Loss: 0.217, Train Accuracy: 93.730
100%|      | 646/646 [00:02<00:00, 277.85it/s]
Epoch 6/50, Train Loss: 0.197, Train Accuracy: 94.238
100%|      | 646/646 [00:02<00:00, 282.34it/s]
Epoch 7/50, Train Loss: 0.182, Train Accuracy: 94.611
100%|      | 646/646 [00:02<00:00, 273.84it/s]
Epoch 8/50, Train Loss: 0.170, Train Accuracy: 94.976
100%|      | 646/646 [00:02<00:00, 282.47it/s]
Epoch 9/50, Train Loss: 0.160, Train Accuracy: 95.222
100%|      | 646/646 [00:02<00:00, 278.09it/s]
Epoch 10/50, Train Loss: 0.151, Train Accuracy: 95.406
100%|      | 646/646 [00:02<00:00, 280.75it/s]
Epoch 11/50, Train Loss: 0.144, Train Accuracy: 95.601
100%|      | 646/646 [00:02<00:00, 276.42it/s]
Epoch 12/50, Train Loss: 0.137, Train Accuracy: 95.869
100%|      | 646/646 [00:02<00:00, 274.78it/s]
Epoch 13/50, Train Loss: 0.131, Train Accuracy: 95.966
100%|      | 646/646 [00:02<00:00, 261.86it/s]
Epoch 14/50, Train Loss: 0.125, Train Accuracy: 96.186
100%|      | 646/646 [00:02<00:00, 270.29it/s]
Epoch 15/50, Train Loss: 0.121, Train Accuracy: 96.328
100%|      | 646/646 [00:02<00:00, 269.95it/s]
Epoch 16/50, Train Loss: 0.116, Train Accuracy: 96.449
100%|      | 646/646 [00:02<00:00, 259.86it/s]
Epoch 17/50, Train Loss: 0.112, Train Accuracy: 96.585
100%|      | 646/646 [00:02<00:00, 276.42it/s]
Epoch 18/50, Train Loss: 0.108, Train Accuracy: 96.698
100%|      | 646/646 [00:02<00:00, 281.97it/s]
Epoch 19/50, Train Loss: 0.103, Train Accuracy: 96.882
```

```
100%|      | 646/646 [00:02<00:00, 281.73it/s]
Epoch 20/50, Train Loss: 0.100, Train Accuracy: 96.962
100%|      | 646/646 [00:02<00:00, 281.11it/s]
Epoch 21/50, Train Loss: 0.097, Train Accuracy: 97.033
100%|      | 646/646 [00:02<00:00, 274.19it/s]
Epoch 22/50, Train Loss: 0.094, Train Accuracy: 97.117
100%|      | 646/646 [00:02<00:00, 275.39it/s]
Epoch 23/50, Train Loss: 0.091, Train Accuracy: 97.231
100%|      | 646/646 [00:02<00:00, 272.63it/s]
Epoch 24/50, Train Loss: 0.088, Train Accuracy: 97.259
100%|      | 646/646 [00:02<00:00, 276.53it/s]
Epoch 25/50, Train Loss: 0.086, Train Accuracy: 97.346
100%|      | 646/646 [00:02<00:00, 264.52it/s]
Epoch 26/50, Train Loss: 0.084, Train Accuracy: 97.432
100%|      | 646/646 [00:02<00:00, 275.09it/s]
Epoch 27/50, Train Loss: 0.081, Train Accuracy: 97.582
100%|      | 646/646 [00:02<00:00, 278.28it/s]
Epoch 28/50, Train Loss: 0.079, Train Accuracy: 97.582
100%|      | 646/646 [00:02<00:00, 277.36it/s]
Epoch 29/50, Train Loss: 0.078, Train Accuracy: 97.588
100%|      | 646/646 [00:02<00:00, 254.49it/s]
Epoch 30/50, Train Loss: 0.076, Train Accuracy: 97.664
100%|      | 646/646 [00:02<00:00, 244.41it/s]
Epoch 31/50, Train Loss: 0.074, Train Accuracy: 97.686
100%|      | 646/646 [00:02<00:00, 261.30it/s]
Epoch 32/50, Train Loss: 0.073, Train Accuracy: 97.728
100%|      | 646/646 [00:02<00:00, 267.97it/s]
Epoch 33/50, Train Loss: 0.071, Train Accuracy: 97.783
100%|      | 646/646 [00:02<00:00, 272.74it/s]
Epoch 34/50, Train Loss: 0.069, Train Accuracy: 97.787
100%|      | 646/646 [00:02<00:00, 273.39it/s]
Epoch 35/50, Train Loss: 0.068, Train Accuracy: 97.833
```

```
100%|      | 646/646 [00:02<00:00, 274.46it/s]
Epoch 36/50, Train Loss: 0.067, Train Accuracy: 97.845
100%|      | 646/646 [00:02<00:00, 276.91it/s]
Epoch 37/50, Train Loss: 0.066, Train Accuracy: 97.944
100%|      | 646/646 [00:02<00:00, 268.63it/s]
Epoch 38/50, Train Loss: 0.065, Train Accuracy: 97.926
100%|      | 646/646 [00:02<00:00, 275.06it/s]
Epoch 39/50, Train Loss: 0.064, Train Accuracy: 97.950
100%|      | 646/646 [00:02<00:00, 271.14it/s]
Epoch 40/50, Train Loss: 0.063, Train Accuracy: 97.969
100%|      | 646/646 [00:02<00:00, 282.12it/s]
Epoch 41/50, Train Loss: 0.062, Train Accuracy: 98.007
100%|      | 646/646 [00:02<00:00, 251.97it/s]
Epoch 42/50, Train Loss: 0.061, Train Accuracy: 98.013
100%|      | 646/646 [00:02<00:00, 276.74it/s]
Epoch 43/50, Train Loss: 0.061, Train Accuracy: 98.066
100%|      | 646/646 [00:02<00:00, 280.50it/s]
Epoch 44/50, Train Loss: 0.060, Train Accuracy: 98.029
100%|      | 646/646 [00:02<00:00, 276.55it/s]
Epoch 45/50, Train Loss: 0.059, Train Accuracy: 98.081
100%|      | 646/646 [00:02<00:00, 277.53it/s]
Epoch 46/50, Train Loss: 0.058, Train Accuracy: 98.076
100%|      | 646/646 [00:02<00:00, 275.83it/s]
Epoch 47/50, Train Loss: 0.058, Train Accuracy: 98.114
100%|      | 646/646 [00:02<00:00, 274.25it/s]
Epoch 48/50, Train Loss: 0.057, Train Accuracy: 98.134
100%|      | 646/646 [00:02<00:00, 278.12it/s]
Epoch 49/50, Train Loss: 0.057, Train Accuracy: 98.077
100%|      | 646/646 [00:02<00:00, 275.38it/s]
Epoch 50/50, Train Loss: 0.056, Train Accuracy: 98.122

 Training complete. Model saved to 'train_logs/window_0\model.pth', stats saved
to 'train_logs/window_0\train_stats.csv'
```

```
100%|      | 132/132 [00:00<00:00, 234.04it/s]
c:\Users\Ward\anaconda3\envs\multibench\Lib\site-
packages\sklearn\metrics\_classification.py:2480: UserWarning: y_pred contains
classes not in y_true
  warnings.warn("y_pred contains classes not in y_true")


 Evaluation Results:
Top-1 Accuracy: 87.69%
Top-5 Accuracy: 98.53%
Balanced Accuracy: 74.69%

 Classification Report:
                                                    precision    recall  f1-score
support

                                SYSTEM_CONFIRM       0.98      0.96      0.97
1113
                                SYSTEM_GOODBYE       0.99      0.98      0.98
1331
                                 SYSTEM_INFORM       0.82      0.92      0.87
719
            SYSTEM_INFORM|SYSTEM_NOTIFY_SUCCESS       0.83      0.83      0.83
310
SYSTEM_INFORM|SYSTEM_OFFER|SYSTEM_NOTIFY_FAILURE       0.79      0.88      0.83
17
          SYSTEM_NOTIFY_FAILURE|SYSTEM_REQ_MORE       0.93      0.99      0.96
79
                           SYSTEM_NOTIFY_SUCCESS       0.92      0.92      0.92
499
                                 SYSTEM_OFFER       0.88      0.85      0.86
806
                            SYSTEM_OFFER_INTENT       0.87      0.97      0.92
383
              SYSTEM_OFFER|SYSTEM_INFORM_COUNT       0.98      0.96      0.97
608
             SYSTEM_OFFER|SYSTEM_NOTIFY_FAILURE       1.00      0.36      0.53
14
                                SYSTEM_REQUEST       0.99      0.96      0.98
1961
                               SYSTEM_REQ_MORE       0.97      0.97      0.97
585
                                   USER_AFFIRM       0.83      0.80      0.81
572
                             USER_AFFIRM_INTENT       0.70      0.82      0.75
139
                 USER_AFFIRM_INTENT|USER_INFORM       0.64      0.71      0.67
103
```

```
                                    USER_INFORM       0.82      0.89      0.85
1961
                               USER_INFORM_INTENT       0.93      0.87      0.90
658
          USER_INFORM_INTENT|USER_NEGATE_INTENT       0.00      0.00      0.00
0
                 USER_INFORM_INTENT|USER_SELECT       0.68      0.83      0.75
167
               USER_INFORM_INTENT|USER_THANK_YOU       0.00      0.00      0.00
12
                 USER_INFORM|USER_INFORM_INTENT       0.82      0.56      0.67
772
      USER_INFORM|USER_INFORM_INTENT|USER_SELECT       0.66      0.78      0.72
117
   USER_INFORM|USER_INFORM_INTENT|USER_THANK_YOU       0.00      0.00      0.00
14
                         USER_INFORM|USER_NEGATE       0.81      0.86      0.84
216
                  USER_INFORM|USER_REQUEST_ALTS       0.66      0.72      0.69
184
                                    USER_NEGATE       1.00      0.14      0.25
7
                               USER_NEGATE_INTENT       0.56      0.75      0.64
69
                 USER_NEGATE_INTENT|USER_GOODBYE       0.63      0.72      0.67
72
                       USER_NEGATE|USER_GOODBYE       0.00      0.00      0.00
9
                     USER_NEGATE|USER_THANK_YOU       0.93      0.89      0.91
587
                                    USER_REQUEST       0.93      0.89      0.91
719
                               USER_REQUEST_ALTS       0.94      0.97      0.95
152
                      USER_REQUEST|USER_AFFIRM       0.86      0.86      0.86
340
                                    USER_SELECT       0.70      0.77      0.73
515
                      USER_SELECT|USER_GOODBYE       0.76      0.66      0.71
279
                                   USER_THANK_YOU       0.79      0.77      0.78
377
                    USER_THANK_YOU|USER_GOODBYE       0.68      0.82      0.74
384

                                      accuracy                           0.88
16850
                                     macro avg       0.74      0.73      0.72
```

```
16850
                                   weighted avg       0.88      0.88      0.88
16850


=== Running training for window size: 1 ===

C:\Users\Ward\AppData\Local\Temp\ipykernel_10956\3759199132.py:9: FutureWarning:
You are using `torch.load` with `weights_only=False` (the current default
value), which uses the default pickle module implicitly. It is possible to
construct malicious pickle data which will execute arbitrary code during
unpickling (See
https://github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for
more details). In a future release, the default value for `weights_only` will be
flipped to `True`. This limits the functions that could be executed during
unpickling. Arbitrary objects will no longer be allowed to be loaded via this
mode unless they are explicitly allowlisted by the user via
`torch.serialization.add_safe_globals`. We recommend you start setting
`weights_only=True` for any use case where you don't have full control of the
loaded file. Please open an issue on GitHub for any issues related to this
experimental feature.
  self.embeddings = torch.load(embeddings_path)
100%|      | 5403/5403 [00:10<00:00, 525.01it/s]
100%|      | 1331/1331 [00:02<00:00, 629.46it/s]
100%|      | 646/646 [00:03<00:00, 164.08it/s]

Epoch 1/50, Train Loss: 1.349, Train Accuracy: 68.132

100%|      | 646/646 [00:03<00:00, 186.59it/s]

Epoch 2/50, Train Loss: 0.409, Train Accuracy: 91.294

100%|      | 646/646 [00:03<00:00, 183.57it/s]

Epoch 3/50, Train Loss: 0.232, Train Accuracy: 95.252

100%|      | 646/646 [00:03<00:00, 172.96it/s]

Epoch 4/50, Train Loss: 0.158, Train Accuracy: 96.585

100%|      | 646/646 [00:03<00:00, 187.11it/s]

Epoch 5/50, Train Loss: 0.118, Train Accuracy: 97.365

100%|      | 646/646 [00:03<00:00, 184.28it/s]

Epoch 6/50, Train Loss: 0.094, Train Accuracy: 97.850

100%|      | 646/646 [00:03<00:00, 178.96it/s]

Epoch 7/50, Train Loss: 0.077, Train Accuracy: 98.219

100%|      | 646/646 [00:03<00:00, 181.87it/s]

Epoch 8/50, Train Loss: 0.065, Train Accuracy: 98.468
```

```
100%|      | 646/646 [00:03<00:00, 183.68it/s]
Epoch 9/50, Train Loss: 0.055, Train Accuracy: 98.701
100%|      | 646/646 [00:03<00:00, 183.02it/s]
Epoch 10/50, Train Loss: 0.048, Train Accuracy: 98.862
100%|      | 646/646 [00:03<00:00, 184.12it/s]
Epoch 11/50, Train Loss: 0.041, Train Accuracy: 99.039
100%|      | 646/646 [00:03<00:00, 184.04it/s]
Epoch 12/50, Train Loss: 0.036, Train Accuracy: 99.180
100%|      | 646/646 [00:03<00:00, 184.35it/s]
Epoch 13/50, Train Loss: 0.032, Train Accuracy: 99.242
100%|      | 646/646 [00:03<00:00, 182.21it/s]
Epoch 14/50, Train Loss: 0.028, Train Accuracy: 99.379
100%|      | 646/646 [00:03<00:00, 182.69it/s]
Epoch 15/50, Train Loss: 0.025, Train Accuracy: 99.421
100%|      | 646/646 [00:03<00:00, 185.83it/s]
Epoch 16/50, Train Loss: 0.022, Train Accuracy: 99.477
100%|      | 646/646 [00:03<00:00, 176.86it/s]
Epoch 17/50, Train Loss: 0.020, Train Accuracy: 99.536
100%|      | 646/646 [00:03<00:00, 182.86it/s]
Epoch 18/50, Train Loss: 0.018, Train Accuracy: 99.571
100%|      | 646/646 [00:03<00:00, 183.08it/s]
Epoch 19/50, Train Loss: 0.016, Train Accuracy: 99.621
100%|      | 646/646 [00:03<00:00, 184.31it/s]
Epoch 20/50, Train Loss: 0.014, Train Accuracy: 99.649
100%|      | 646/646 [00:03<00:00, 168.14it/s]
Epoch 21/50, Train Loss: 0.013, Train Accuracy: 99.692
100%|      | 646/646 [00:03<00:00, 177.93it/s]
Epoch 22/50, Train Loss: 0.011, Train Accuracy: 99.731
100%|      | 646/646 [00:03<00:00, 178.04it/s]
Epoch 23/50, Train Loss: 0.010, Train Accuracy: 99.766
100%|      | 646/646 [00:03<00:00, 173.30it/s]
Epoch 24/50, Train Loss: 0.010, Train Accuracy: 99.760
```

```
100%|      | 646/646 [00:03<00:00, 173.12it/s]
Epoch 25/50, Train Loss: 0.009, Train Accuracy: 99.811
100%|      | 646/646 [00:03<00:00, 173.53it/s]
Epoch 26/50, Train Loss: 0.008, Train Accuracy: 99.818
100%|      | 646/646 [00:03<00:00, 172.56it/s]
Epoch 27/50, Train Loss: 0.007, Train Accuracy: 99.838
100%|      | 646/646 [00:03<00:00, 177.06it/s]
Epoch 28/50, Train Loss: 0.007, Train Accuracy: 99.847
100%|      | 646/646 [00:03<00:00, 168.71it/s]
Epoch 29/50, Train Loss: 0.006, Train Accuracy: 99.851
100%|      | 646/646 [00:03<00:00, 170.63it/s]
Epoch 30/50, Train Loss: 0.006, Train Accuracy: 99.873
100%|      | 646/646 [00:03<00:00, 181.72it/s]
Epoch 31/50, Train Loss: 0.005, Train Accuracy: 99.872
100%|      | 646/646 [00:03<00:00, 170.54it/s]
Epoch 32/50, Train Loss: 0.005, Train Accuracy: 99.876
100%|      | 646/646 [00:03<00:00, 188.50it/s]
Epoch 33/50, Train Loss: 0.005, Train Accuracy: 99.875
100%|      | 646/646 [00:03<00:00, 181.89it/s]
Epoch 34/50, Train Loss: 0.004, Train Accuracy: 99.904
100%|      | 646/646 [00:03<00:00, 172.82it/s]
Epoch 35/50, Train Loss: 0.004, Train Accuracy: 99.915
100%|      | 646/646 [00:03<00:00, 182.43it/s]
Epoch 36/50, Train Loss: 0.004, Train Accuracy: 99.907
100%|      | 646/646 [00:03<00:00, 165.41it/s]
Epoch 37/50, Train Loss: 0.004, Train Accuracy: 99.903
100%|      | 646/646 [00:03<00:00, 186.43it/s]
Epoch 38/50, Train Loss: 0.003, Train Accuracy: 99.921
100%|      | 646/646 [00:03<00:00, 185.23it/s]
Epoch 39/50, Train Loss: 0.003, Train Accuracy: 99.926
100%|      | 646/646 [00:03<00:00, 178.81it/s]
Epoch 40/50, Train Loss: 0.003, Train Accuracy: 99.903
```

```
100%|      | 646/646 [00:03<00:00, 181.31it/s]
Epoch 41/50, Train Loss: 0.003, Train Accuracy: 99.909
100%|      | 646/646 [00:03<00:00, 178.68it/s]
Epoch 42/50, Train Loss: 0.004, Train Accuracy: 99.913
100%|      | 646/646 [00:03<00:00, 175.67it/s]
Epoch 43/50, Train Loss: 0.003, Train Accuracy: 99.931
100%|      | 646/646 [00:03<00:00, 175.90it/s]
Epoch 44/50, Train Loss: 0.004, Train Accuracy: 99.901
100%|      | 646/646 [00:03<00:00, 179.22it/s]
Epoch 45/50, Train Loss: 0.003, Train Accuracy: 99.931
100%|      | 646/646 [00:03<00:00, 182.30it/s]
Epoch 46/50, Train Loss: 0.002, Train Accuracy: 99.944
100%|      | 646/646 [00:03<00:00, 184.43it/s]
Epoch 47/50, Train Loss: 0.003, Train Accuracy: 99.924
100%|      | 646/646 [00:03<00:00, 189.21it/s]
Epoch 48/50, Train Loss: 0.003, Train Accuracy: 99.918
100%|      | 646/646 [00:03<00:00, 182.67it/s]
Epoch 49/50, Train Loss: 0.002, Train Accuracy: 99.955
100%|      | 646/646 [00:03<00:00, 180.95it/s]
Epoch 50/50, Train Loss: 0.002, Train Accuracy: 99.949

 Training complete. Model saved to 'train_logs/window_1\model.pth', stats saved
to 'train_logs/window_1\train_stats.csv'
100%|      | 132/132 [00:00<00:00, 212.12it/s]
c:\Users\Ward\anaconda3\envs\multibench\Lib\site-
packages\sklearn\metrics\_classification.py:2480: UserWarning: y_pred contains
classes not in y_true
  warnings.warn("y_pred contains classes not in y_true")


 Evaluation Results:
Top-1 Accuracy: 94.64%
Top-5 Accuracy: 99.57%
Balanced Accuracy: 86.63%

 Classification Report:
                                                    precision    recall  f1-score
support
```

SYSTEM_CONFIRM	0.99	0.94	0.96	1113
SYSTEM_GOODBYE	0.98	0.99	0.99	1331
SYSTEM_INFORM	0.95	0.95	0.95	719
SYSTEM_INFORM|SYSTEM_NOTIFY_SUCCESS	0.96	0.89	0.92	310
SYSTEM_INFORM|SYSTEM_OFFER|SYSTEM_NOTIFY_FAILURE	0.88	0.82	0.85	17
SYSTEM_NOTIFY_FAILURE|SYSTEM_REQ_MORE	1.00	0.95	0.97	79
SYSTEM_NOTIFY_SUCCESS	0.97	0.98	0.97	499
SYSTEM_OFFER	0.91	0.97	0.94	806
SYSTEM_OFFER_INTENT	0.92	0.97	0.94	383
SYSTEM_OFFER|SYSTEM_INFORM_COUNT	0.96	0.97	0.97	608
SYSTEM_OFFER|SYSTEM_NOTIFY_FAILURE	0.93	0.93	0.93	14
SYSTEM_REQUEST	0.99	0.98	0.98	1961
SYSTEM_REQ_MORE	0.97	0.99	0.98	585
USER_AFFIRM	0.98	0.96	0.97	572
USER_AFFIRM_INTENT	0.90	0.94	0.92	139
USER_AFFIRM_INTENT|USER_INFORM	0.96	0.90	0.93	103
USER_INFORM	1.00	0.97	0.98	1961
USER_INFORM_INTENT	0.96	0.93	0.94	658
USER_INFORM_INTENT|USER_NEGATE_INTENT	0.00	0.00	0.00	0
USER_INFORM_INTENT|USER_SELECT	0.83	0.89	0.86	167
USER_INFORM_INTENT|USER_THANK_YOU	0.50	0.33	0.40	12
USER_INFORM|USER_INFORM_INTENT	0.95	0.96	0.95	772
USER_INFORM|USER_INFORM_INTENT|USER_SELECT	0.88	0.85	0.87	117
USER_INFORM|USER_INFORM_INTENT|USER_THANK_YOU	0.50	0.14	0.22	

```
14
                    USER_INFORM|USER_NEGATE       0.97      0.94      0.96
216
                USER_INFORM|USER_REQUEST_ALTS       0.85      0.92      0.89
184
                             USER_NEGATE       0.75      0.86      0.80
7
                      USER_NEGATE_INTENT       0.68      0.78      0.72
69
             USER_NEGATE_INTENT|USER_GOODBYE       0.76      0.69      0.72
72
                   USER_NEGATE|USER_GOODBYE       0.62      0.56      0.59
9
                USER_NEGATE|USER_THANK_YOU       0.96      0.99      0.98
587
                             USER_REQUEST       0.98      0.95      0.96
719
                      USER_REQUEST_ALTS       0.95      0.93      0.94
152
                   USER_REQUEST|USER_AFFIRM       0.96      0.96      0.96
340
                             USER_SELECT       0.84      0.91      0.87
515
                   USER_SELECT|USER_GOODBYE       0.78      0.65      0.71
279
                           USER_THANK_YOU       0.81      0.86      0.83
377
                USER_THANK_YOU|USER_GOODBYE       0.73      0.81      0.77
384

                                accuracy                           0.95
16850
                               macro avg       0.86      0.84      0.85
16850
                            weighted avg       0.95      0.95      0.95
16850


=== Running training for window size: 2 ===

C:\Users\Ward\AppData\Local\Temp\ipykernel_10956\3759199132.py:9: FutureWarning:
You are using `torch.load` with `weights_only=False` (the current default
value), which uses the default pickle module implicitly. It is possible to
construct malicious pickle data which will execute arbitrary code during
unpickling (See
https://github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for
more details). In a future release, the default value for `weights_only` will be
flipped to `True`. This limits the functions that could be executed during
```

```
unpickling. Arbitrary objects will no longer be allowed to be loaded via this
mode unless they are explicitly allowlisted by the user via
`torch.serialization.add_safe_globals`. We recommend you start setting
`weights_only=True` for any use case where you don't have full control of the
loaded file. Please open an issue on GitHub for any issues related to this
experimental feature.
  self.embeddings = torch.load(embeddings_path)
100%|      | 5403/5403 [00:12<00:00, 427.38it/s]
100%|      | 1331/1331 [00:01<00:00, 708.23it/s]
100%|      | 646/646 [00:05<00:00, 121.61it/s]

Epoch 1/50, Train Loss: 1.709, Train Accuracy: 54.532

100%|      | 646/646 [00:04<00:00, 137.06it/s]

Epoch 2/50, Train Loss: 0.610, Train Accuracy: 84.959

100%|      | 646/646 [00:04<00:00, 136.14it/s]

Epoch 3/50, Train Loss: 0.385, Train Accuracy: 90.795

100%|      | 646/646 [00:04<00:00, 138.87it/s]

Epoch 4/50, Train Loss: 0.272, Train Accuracy: 94.206

100%|      | 646/646 [00:04<00:00, 136.13it/s]

Epoch 5/50, Train Loss: 0.202, Train Accuracy: 95.978

100%|      | 646/646 [00:04<00:00, 135.38it/s]

Epoch 6/50, Train Loss: 0.155, Train Accuracy: 96.918

100%|      | 646/646 [00:04<00:00, 136.34it/s]

Epoch 7/50, Train Loss: 0.122, Train Accuracy: 97.506

100%|      | 646/646 [00:04<00:00, 140.50it/s]

Epoch 8/50, Train Loss: 0.099, Train Accuracy: 97.974

100%|      | 646/646 [00:04<00:00, 132.89it/s]

Epoch 9/50, Train Loss: 0.082, Train Accuracy: 98.317

100%|      | 646/646 [00:04<00:00, 138.09it/s]

Epoch 10/50, Train Loss: 0.069, Train Accuracy: 98.617

100%|      | 646/646 [00:04<00:00, 139.55it/s]

Epoch 11/50, Train Loss: 0.058, Train Accuracy: 98.859

100%|      | 646/646 [00:04<00:00, 136.47it/s]

Epoch 12/50, Train Loss: 0.050, Train Accuracy: 99.029

100%|      | 646/646 [00:04<00:00, 137.84it/s]

Epoch 13/50, Train Loss: 0.043, Train Accuracy: 99.173
```

```
100%|      | 646/646 [00:04<00:00, 135.98it/s]
Epoch 14/50, Train Loss: 0.037, Train Accuracy: 99.309
100%|      | 646/646 [00:04<00:00, 135.26it/s]
Epoch 15/50, Train Loss: 0.033, Train Accuracy: 99.338
100%|      | 646/646 [00:04<00:00, 133.36it/s]
Epoch 16/50, Train Loss: 0.028, Train Accuracy: 99.447
100%|      | 646/646 [00:04<00:00, 137.06it/s]
Epoch 17/50, Train Loss: 0.025, Train Accuracy: 99.548
100%|      | 646/646 [00:04<00:00, 137.79it/s]
Epoch 18/50, Train Loss: 0.022, Train Accuracy: 99.602
100%|      | 646/646 [00:04<00:00, 135.28it/s]
Epoch 19/50, Train Loss: 0.019, Train Accuracy: 99.663
100%|      | 646/646 [00:05<00:00, 128.56it/s]
Epoch 20/50, Train Loss: 0.017, Train Accuracy: 99.712
100%|      | 646/646 [00:05<00:00, 114.29it/s]
Epoch 21/50, Train Loss: 0.015, Train Accuracy: 99.734
100%|      | 646/646 [00:05<00:00, 118.62it/s]
Epoch 22/50, Train Loss: 0.013, Train Accuracy: 99.787
100%|      | 646/646 [00:05<00:00, 118.15it/s]
Epoch 23/50, Train Loss: 0.012, Train Accuracy: 99.821
100%|      | 646/646 [00:05<00:00, 124.66it/s]
Epoch 24/50, Train Loss: 0.010, Train Accuracy: 99.847
100%|      | 646/646 [00:05<00:00, 127.71it/s]
Epoch 25/50, Train Loss: 0.009, Train Accuracy: 99.858
100%|      | 646/646 [00:05<00:00, 127.17it/s]
Epoch 26/50, Train Loss: 0.007, Train Accuracy: 99.909
100%|      | 646/646 [00:05<00:00, 123.37it/s]
Epoch 27/50, Train Loss: 0.007, Train Accuracy: 99.900
100%|      | 646/646 [00:05<00:00, 125.19it/s]
Epoch 28/50, Train Loss: 0.007, Train Accuracy: 99.912
100%|      | 646/646 [00:04<00:00, 133.33it/s]
Epoch 29/50, Train Loss: 0.005, Train Accuracy: 99.935
```

```
100%|      | 646/646 [00:04<00:00, 132.33it/s]
Epoch 30/50, Train Loss: 0.006, Train Accuracy: 99.912
100%|      | 646/646 [00:04<00:00, 129.95it/s]
Epoch 31/50, Train Loss: 0.005, Train Accuracy: 99.938
100%|      | 646/646 [00:04<00:00, 132.64it/s]
Epoch 32/50, Train Loss: 0.004, Train Accuracy: 99.942
100%|      | 646/646 [00:05<00:00, 129.00it/s]
Epoch 33/50, Train Loss: 0.004, Train Accuracy: 99.954
100%|      | 646/646 [00:04<00:00, 132.32it/s]
Epoch 34/50, Train Loss: 0.005, Train Accuracy: 99.909
100%|      | 646/646 [00:04<00:00, 132.44it/s]
Epoch 35/50, Train Loss: 0.003, Train Accuracy: 99.964
100%|      | 646/646 [00:04<00:00, 131.04it/s]
Epoch 36/50, Train Loss: 0.003, Train Accuracy: 99.972
100%|      | 646/646 [00:04<00:00, 131.03it/s]
Epoch 37/50, Train Loss: 0.002, Train Accuracy: 99.972
100%|      | 646/646 [00:05<00:00, 121.80it/s]
Epoch 38/50, Train Loss: 0.003, Train Accuracy: 99.952
100%|      | 646/646 [00:05<00:00, 114.84it/s]
Epoch 39/50, Train Loss: 0.003, Train Accuracy: 99.965
100%|      | 646/646 [00:05<00:00, 128.56it/s]
Epoch 40/50, Train Loss: 0.003, Train Accuracy: 99.967
100%|      | 646/646 [00:04<00:00, 133.62it/s]
Epoch 41/50, Train Loss: 0.002, Train Accuracy: 99.975
100%|      | 646/646 [00:04<00:00, 137.24it/s]
Epoch 42/50, Train Loss: 0.002, Train Accuracy: 99.972
100%|      | 646/646 [00:04<00:00, 140.47it/s]
Epoch 43/50, Train Loss: 0.002, Train Accuracy: 99.979
100%|      | 646/646 [00:04<00:00, 138.16it/s]
Epoch 44/50, Train Loss: 0.001, Train Accuracy: 99.992
100%|      | 646/646 [00:04<00:00, 133.45it/s]
Epoch 45/50, Train Loss: 0.005, Train Accuracy: 99.873
```

```
100%|      | 646/646 [00:04<00:00, 139.68it/s]
Epoch 46/50, Train Loss: 0.002, Train Accuracy: 99.987
100%|      | 646/646 [00:04<00:00, 135.94it/s]
Epoch 47/50, Train Loss: 0.001, Train Accuracy: 99.996
100%|      | 646/646 [00:04<00:00, 139.74it/s]
Epoch 48/50, Train Loss: 0.001, Train Accuracy: 99.998
100%|      | 646/646 [00:04<00:00, 129.87it/s]
Epoch 49/50, Train Loss: 0.001, Train Accuracy: 99.993
100%|      | 646/646 [00:04<00:00, 133.93it/s]
Epoch 50/50, Train Loss: 0.004, Train Accuracy: 99.909

 Training complete. Model saved to 'train_logs/window_2\model.pth', stats saved
to 'train_logs/window_2\train_stats.csv'
100%|      | 132/132 [00:00<00:00, 157.48it/s]
c:\Users\Ward\anaconda3\envs\multibench\Lib\site-
packages\sklearn\metrics\_classification.py:2480: UserWarning: y_pred contains
classes not in y_true
  warnings.warn("y_pred contains classes not in y_true")


 Evaluation Results:
Top-1 Accuracy: 94.54%
Top-5 Accuracy: 99.53%
Balanced Accuracy: 84.41%

 Classification Report:
                                                    precision    recall  f1-score
support

                                SYSTEM_CONFIRM       0.99      0.95      0.97
1113
                                SYSTEM_GOODBYE       0.99      0.99      0.99
1331
                                 SYSTEM_INFORM       0.99      0.95      0.97
719
             SYSTEM_INFORM|SYSTEM_NOTIFY_SUCCESS       0.98      0.96      0.97
310
 SYSTEM_INFORM|SYSTEM_OFFER|SYSTEM_NOTIFY_FAILURE       0.88      0.88      0.88
17
           SYSTEM_NOTIFY_FAILURE|SYSTEM_REQ_MORE       0.97      0.95      0.96
79
                           SYSTEM_NOTIFY_SUCCESS       0.98      0.98      0.98
499
```

SYSTEM_OFFER	0.91	0.98	0.94	806
SYSTEM_OFFER_INTENT	0.96	0.97	0.97	383
SYSTEM_OFFER|SYSTEM_INFORM_COUNT	0.97	0.95	0.96	608
SYSTEM_OFFER|SYSTEM_NOTIFY_FAILURE	1.00	0.93	0.96	14
SYSTEM_REQUEST	0.99	0.99	0.99	1961
SYSTEM_REQ_MORE	0.97	0.98	0.98	585
USER_AFFIRM	0.96	0.96	0.96	572
USER_AFFIRM_INTENT	0.91	0.91	0.91	139
USER_AFFIRM_INTENT|USER_INFORM	0.94	0.85	0.89	103
USER_INFORM	0.99	0.97	0.98	1961
USER_INFORM_INTENT	0.95	0.94	0.95	658
USER_INFORM_INTENT|USER_NEGATE_INTENT	0.00	0.00	0.00	0
USER_INFORM_INTENT|USER_SELECT	0.77	0.90	0.83	167
USER_INFORM_INTENT|USER_THANK_YOU	0.75	0.25	0.38	12
USER_INFORM|USER_INFORM_INTENT	0.96	0.95	0.96	772
USER_INFORM|USER_INFORM_INTENT|USER_NEGATE_INTENT	0.00	0.00	0.00	0
USER_INFORM|USER_INFORM_INTENT|USER_SELECT	0.83	0.80	0.82	117
USER_INFORM|USER_INFORM_INTENT|USER_THANK_YOU	0.33	0.07	0.12	14
USER_INFORM|USER_NEGATE	0.95	0.91	0.93	216
USER_INFORM|USER_REQUEST_ALTS	0.76	0.92	0.84	184
USER_NEGATE	0.42	0.71	0.53	7
USER_NEGATE_INTENT	0.60	0.72	0.65	69
USER_NEGATE_INTENT|USER_GOODBYE	0.75	0.83	0.79	72
USER_NEGATE|USER_GOODBYE	0.50	0.11	0.18	9

```
                    USER_NEGATE|USER_THANK_YOU       0.98      0.99      0.99
587
                                 USER_REQUEST       0.97      0.92      0.94
719
                            USER_REQUEST_ALTS       0.91      0.89      0.90
152
                      USER_REQUEST|USER_AFFIRM       0.96      0.93      0.95
340
                                 USER_SELECT       0.85      0.91      0.88
515
                      USER_SELECT|USER_GOODBYE       0.75      0.71      0.73
279
                             USER_THANK_YOU       0.82      0.78      0.80
377
                  USER_THANK_YOU|USER_GOODBYE       0.74      0.80      0.77
384

                                    accuracy                           0.95
16850
                                   macro avg       0.82      0.80      0.80
16850
                                weighted avg       0.95      0.95      0.95
16850


=== Running training for window size: 3 ===

C:\Users\Ward\AppData\Local\Temp\ipykernel_10956\3759199132.py:9: FutureWarning:
You are using `torch.load` with `weights_only=False` (the current default
value), which uses the default pickle module implicitly. It is possible to
construct malicious pickle data which will execute arbitrary code during
unpickling (See
https://github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for
more details). In a future release, the default value for `weights_only` will be
flipped to `True`. This limits the functions that could be executed during
unpickling. Arbitrary objects will no longer be allowed to be loaded via this
mode unless they are explicitly allowlisted by the user via
`torch.serialization.add_safe_globals`. We recommend you start setting
`weights_only=True` for any use case where you don't have full control of the
loaded file. Please open an issue on GitHub for any issues related to this
experimental feature.
  self.embeddings = torch.load(embeddings_path)
100%|      | 5403/5403 [00:19<00:00, 270.40it/s]
100%|      | 1331/1331 [00:03<00:00, 412.92it/s]
100%|      | 646/646 [00:17<00:00, 36.07it/s]

Epoch 1/50, Train Loss: 1.970, Train Accuracy: 45.085

100%|      | 646/646 [00:05<00:00, 108.69it/s]
```

```
Epoch 2/50, Train Loss: 0.869, Train Accuracy: 77.950
100%|      | 646/646 [00:05<00:00, 113.46it/s]
Epoch 3/50, Train Loss: 0.558, Train Accuracy: 86.640
100%|      | 646/646 [00:05<00:00, 112.16it/s]
Epoch 4/50, Train Loss: 0.402, Train Accuracy: 90.955
100%|      | 646/646 [00:05<00:00, 110.41it/s]
Epoch 5/50, Train Loss: 0.302, Train Accuracy: 93.566
100%|      | 646/646 [00:05<00:00, 112.81it/s]
Epoch 6/50, Train Loss: 0.234, Train Accuracy: 95.233
100%|      | 646/646 [00:05<00:00, 111.91it/s]
Epoch 7/50, Train Loss: 0.185, Train Accuracy: 96.320
100%|      | 646/646 [00:05<00:00, 111.65it/s]
Epoch 8/50, Train Loss: 0.149, Train Accuracy: 97.138
100%|      | 646/646 [00:05<00:00, 110.34it/s]
Epoch 9/50, Train Loss: 0.123, Train Accuracy: 97.601
100%|      | 646/646 [00:05<00:00, 112.76it/s]
Epoch 10/50, Train Loss: 0.102, Train Accuracy: 98.040
100%|      | 646/646 [00:05<00:00, 113.21it/s]
Epoch 11/50, Train Loss: 0.086, Train Accuracy: 98.300
100%|      | 646/646 [00:05<00:00, 114.71it/s]
Epoch 12/50, Train Loss: 0.073, Train Accuracy: 98.640
100%|      | 646/646 [00:05<00:00, 114.77it/s]
Epoch 13/50, Train Loss: 0.062, Train Accuracy: 98.830
100%|      | 646/646 [00:05<00:00, 113.76it/s]
Epoch 14/50, Train Loss: 0.053, Train Accuracy: 99.059
100%|      | 646/646 [00:05<00:00, 115.01it/s]
Epoch 15/50, Train Loss: 0.046, Train Accuracy: 99.166
100%|      | 646/646 [00:05<00:00, 111.47it/s]
Epoch 16/50, Train Loss: 0.040, Train Accuracy: 99.320
100%|      | 646/646 [00:05<00:00, 113.32it/s]
Epoch 17/50, Train Loss: 0.034, Train Accuracy: 99.445
100%|      | 646/646 [00:05<00:00, 115.18it/s]
```

```
Epoch 18/50, Train Loss: 0.030, Train Accuracy: 99.539
100%|      | 646/646 [00:05<00:00, 114.23it/s]
Epoch 19/50, Train Loss: 0.026, Train Accuracy: 99.617
100%|      | 646/646 [00:05<00:00, 115.16it/s]
Epoch 20/50, Train Loss: 0.022, Train Accuracy: 99.690
100%|      | 646/646 [00:05<00:00, 115.33it/s]
Epoch 21/50, Train Loss: 0.019, Train Accuracy: 99.742
100%|      | 646/646 [00:05<00:00, 113.11it/s]
Epoch 22/50, Train Loss: 0.017, Train Accuracy: 99.800
100%|      | 646/646 [00:05<00:00, 113.14it/s]
Epoch 23/50, Train Loss: 0.014, Train Accuracy: 99.841
100%|      | 646/646 [00:05<00:00, 111.57it/s]
Epoch 24/50, Train Loss: 0.013, Train Accuracy: 99.850
100%|      | 646/646 [00:05<00:00, 113.96it/s]
Epoch 25/50, Train Loss: 0.011, Train Accuracy: 99.893
100%|      | 646/646 [00:05<00:00, 110.74it/s]
Epoch 26/50, Train Loss: 0.009, Train Accuracy: 99.912
100%|      | 646/646 [00:05<00:00, 114.75it/s]
Epoch 27/50, Train Loss: 0.008, Train Accuracy: 99.937
100%|      | 646/646 [00:05<00:00, 114.50it/s]
Epoch 28/50, Train Loss: 0.007, Train Accuracy: 99.924
100%|      | 646/646 [00:05<00:00, 114.44it/s]
Epoch 29/50, Train Loss: 0.008, Train Accuracy: 99.930
100%|      | 646/646 [00:05<00:00, 114.40it/s]
Epoch 30/50, Train Loss: 0.005, Train Accuracy: 99.977
100%|      | 646/646 [00:05<00:00, 114.58it/s]
Epoch 31/50, Train Loss: 0.004, Train Accuracy: 99.990
100%|      | 646/646 [00:05<00:00, 114.88it/s]
Epoch 32/50, Train Loss: 0.004, Train Accuracy: 99.987
100%|      | 646/646 [00:05<00:00, 112.13it/s]
Epoch 33/50, Train Loss: 0.004, Train Accuracy: 99.960
100%|      | 646/646 [00:05<00:00, 114.13it/s]
```

```
Epoch 34/50, Train Loss: 0.007, Train Accuracy: 99.886
100%|      | 646/646 [00:05<00:00, 114.38it/s]
Epoch 35/50, Train Loss: 0.003, Train Accuracy: 99.994
100%|      | 646/646 [00:05<00:00, 113.79it/s]
Epoch 36/50, Train Loss: 0.002, Train Accuracy: 99.993
100%|      | 646/646 [00:05<00:00, 111.97it/s]
Epoch 37/50, Train Loss: 0.002, Train Accuracy: 99.995
100%|      | 646/646 [00:05<00:00, 114.04it/s]
Epoch 38/50, Train Loss: 0.002, Train Accuracy: 99.994
100%|      | 646/646 [00:05<00:00, 114.61it/s]
Epoch 39/50, Train Loss: 0.004, Train Accuracy: 99.912
100%|      | 646/646 [00:05<00:00, 113.84it/s]
Epoch 40/50, Train Loss: 0.006, Train Accuracy: 99.909
100%|      | 646/646 [00:05<00:00, 114.92it/s]
Epoch 41/50, Train Loss: 0.002, Train Accuracy: 99.992
100%|      | 646/646 [00:05<00:00, 114.95it/s]
Epoch 42/50, Train Loss: 0.001, Train Accuracy: 99.996
100%|      | 646/646 [00:05<00:00, 114.45it/s]
Epoch 43/50, Train Loss: 0.001, Train Accuracy: 99.999
100%|      | 646/646 [00:05<00:00, 114.83it/s]
Epoch 44/50, Train Loss: 0.001, Train Accuracy: 99.995
100%|      | 646/646 [00:05<00:00, 113.87it/s]
Epoch 45/50, Train Loss: 0.001, Train Accuracy: 99.998
100%|      | 646/646 [00:05<00:00, 114.26it/s]
Epoch 46/50, Train Loss: 0.007, Train Accuracy: 99.822
100%|      | 646/646 [00:05<00:00, 113.14it/s]
Epoch 47/50, Train Loss: 0.003, Train Accuracy: 99.964
100%|      | 646/646 [00:06<00:00, 102.72it/s]
Epoch 48/50, Train Loss: 0.001, Train Accuracy: 99.992
100%|      | 646/646 [00:06<00:00, 101.91it/s]
Epoch 49/50, Train Loss: 0.001, Train Accuracy: 99.999
100%|      | 646/646 [00:05<00:00, 112.27it/s]
```

```
Epoch 50/50, Train Loss: 0.001, Train Accuracy: 99.998

 Training complete. Model saved to 'train_logs/window_3\model.pth', stats saved
to 'train_logs/window_3\train_stats.csv'

100%|      | 132/132 [00:01<00:00, 128.91it/s]
c:\Users\Ward\anaconda3\envs\multibench\Lib\site-
packages\sklearn\metrics\_classification.py:2480: UserWarning: y_pred contains
classes not in y_true
  warnings.warn("y_pred contains classes not in y_true")


 Evaluation Results:
Top-1 Accuracy: 94.29%
Top-5 Accuracy: 99.55%
Balanced Accuracy: 82.53%

 Classification Report:
                                                    precision    recall  f1-score
support

                                SYSTEM_CONFIRM       0.96      0.95      0.96
1113
                                SYSTEM_GOODBYE       0.98      0.98      0.98
1331
                                 SYSTEM_INFORM       0.97      0.95      0.96
719
            SYSTEM_INFORM|SYSTEM_NOTIFY_SUCCESS       0.97      0.95      0.96
310
SYSTEM_INFORM|SYSTEM_OFFER|SYSTEM_NOTIFY_FAILURE       0.73      0.65      0.69
17
          SYSTEM_NOTIFY_FAILURE|SYSTEM_REQ_MORE       0.91      0.87      0.89
79
                         SYSTEM_NOTIFY_SUCCESS       0.98      0.98      0.98
499
                                   SYSTEM_OFFER       0.90      0.94      0.92
806
                            SYSTEM_OFFER_INTENT       0.94      0.98      0.96
383
              SYSTEM_OFFER|SYSTEM_INFORM_COUNT       0.94      0.94      0.94
608
             SYSTEM_OFFER|SYSTEM_NOTIFY_FAILURE       1.00      0.79      0.88
14
                                SYSTEM_REQUEST       0.98      0.98      0.98
1961
                               SYSTEM_REQ_MORE       0.98      0.97      0.97
585
                                   USER_AFFIRM       0.96      0.96      0.96
572
```

USER_AFFIRM_INTENT	0.92	0.94	0.93	139
USER_AFFIRM_INTENT|USER_INFORM	0.97	0.86	0.91	103
USER_INFORM	0.99	0.98	0.98	1961
USER_INFORM_INTENT	0.97	0.89	0.93	658
USER_INFORM_INTENT|USER_NEGATE_INTENT	0.00	0.00	0.00	0
USER_INFORM_INTENT|USER_SELECT	0.77	0.87	0.81	167
USER_INFORM_INTENT|USER_THANK_YOU	0.00	0.00	0.00	12
USER_INFORM|USER_INFORM_INTENT	0.92	0.96	0.94	772
USER_INFORM|USER_INFORM_INTENT|USER_SELECT	0.78	0.74	0.76	117
USER_INFORM|USER_INFORM_INTENT|USER_THANK_YOU	0.00	0.00	0.00	14
USER_INFORM|USER_NEGATE	0.92	0.96	0.94	216
USER_INFORM|USER_REQUEST_ALTS	0.86	0.86	0.86	184
USER_NEGATE	0.80	0.57	0.67	7
USER_NEGATE_INTENT	0.66	0.77	0.71	69
USER_NEGATE_INTENT|USER_GOODBYE	0.69	0.75	0.72	72
USER_NEGATE|USER_GOODBYE	0.75	0.33	0.46	9
USER_NEGATE|USER_THANK_YOU	0.97	0.99	0.98	587
USER_REQUEST	0.95	0.95	0.95	719
USER_REQUEST_ALTS	0.92	0.93	0.92	152
USER_REQUEST|USER_AFFIRM	0.98	0.97	0.97	340
USER_SELECT	0.86	0.93	0.89	515
USER_SELECT|USER_GOODBYE	0.86	0.71	0.78	279
USER_THANK_YOU	0.83	0.84	0.84	377
USER_THANK_YOU|USER_GOODBYE	0.77	0.84	0.80	384

```
                                    accuracy                           0.94
16850
                                   macro avg       0.82      0.80      0.81
16850
                                weighted avg       0.94      0.94      0.94
16850


=== Running training for window size: 4 ===

C:\Users\Ward\AppData\Local\Temp\ipykernel_10956\3759199132.py:9: FutureWarning:
You are using `torch.load` with `weights_only=False` (the current default
value), which uses the default pickle module implicitly. It is possible to
construct malicious pickle data which will execute arbitrary code during
unpickling (See
https://github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for
more details). In a future release, the default value for `weights_only` will be
flipped to `True`. This limits the functions that could be executed during
unpickling. Arbitrary objects will no longer be allowed to be loaded via this
mode unless they are explicitly allowlisted by the user via
`torch.serialization.add_safe_globals`. We recommend you start setting
`weights_only=True` for any use case where you don't have full control of the
loaded file. Please open an issue on GitHub for any issues related to this
experimental feature.
  self.embeddings = torch.load(embeddings_path)
100%|      | 5403/5403 [00:25<00:00, 211.99it/s]
100%|      | 1331/1331 [00:08<00:00, 155.41it/s]
100%|      | 646/646 [00:09<00:00, 64.84it/s]

Epoch 1/50, Train Loss: 2.160, Train Accuracy: 35.546

100%|      | 646/646 [00:07<00:00, 90.42it/s]

Epoch 2/50, Train Loss: 1.118, Train Accuracy: 66.195

100%|      | 646/646 [00:06<00:00, 93.25it/s]

Epoch 3/50, Train Loss: 0.753, Train Accuracy: 80.202

100%|      | 646/646 [00:06<00:00, 94.29it/s]

Epoch 4/50, Train Loss: 0.553, Train Accuracy: 86.054

100%|      | 646/646 [00:06<00:00, 95.13it/s]

Epoch 5/50, Train Loss: 0.427, Train Accuracy: 89.790

100%|      | 646/646 [00:06<00:00, 94.23it/s]

Epoch 6/50, Train Loss: 0.337, Train Accuracy: 92.459

100%|      | 646/646 [00:06<00:00, 93.92it/s]

Epoch 7/50, Train Loss: 0.272, Train Accuracy: 94.160
```

```
100%|      | 646/646 [00:06<00:00, 93.38it/s]
Epoch 8/50, Train Loss: 0.222, Train Accuracy: 95.396
100%|      | 646/646 [00:06<00:00, 93.35it/s]
Epoch 9/50, Train Loss: 0.183, Train Accuracy: 96.268
100%|      | 646/646 [00:06<00:00, 94.27it/s]
Epoch 10/50, Train Loss: 0.153, Train Accuracy: 96.958
100%|      | 646/646 [00:06<00:00, 95.61it/s]
Epoch 11/50, Train Loss: 0.129, Train Accuracy: 97.495
100%|      | 646/646 [00:06<00:00, 94.78it/s]
Epoch 12/50, Train Loss: 0.109, Train Accuracy: 97.968
100%|      | 646/646 [00:06<00:00, 94.32it/s]
Epoch 13/50, Train Loss: 0.093, Train Accuracy: 98.281
100%|      | 646/646 [00:06<00:00, 95.05it/s]
Epoch 14/50, Train Loss: 0.081, Train Accuracy: 98.608
100%|      | 646/646 [00:06<00:00, 94.51it/s]
Epoch 15/50, Train Loss: 0.069, Train Accuracy: 98.884
100%|      | 646/646 [00:06<00:00, 94.59it/s]
Epoch 16/50, Train Loss: 0.059, Train Accuracy: 99.060
100%|      | 646/646 [00:06<00:00, 92.59it/s]
Epoch 17/50, Train Loss: 0.051, Train Accuracy: 99.284
100%|      | 646/646 [00:06<00:00, 95.17it/s]
Epoch 18/50, Train Loss: 0.044, Train Accuracy: 99.410
100%|      | 646/646 [00:06<00:00, 95.63it/s]
Epoch 19/50, Train Loss: 0.038, Train Accuracy: 99.508
100%|      | 646/646 [00:06<00:00, 94.96it/s]
Epoch 20/50, Train Loss: 0.033, Train Accuracy: 99.610
100%|      | 646/646 [00:06<00:00, 95.17it/s]
Epoch 21/50, Train Loss: 0.029, Train Accuracy: 99.701
100%|      | 646/646 [00:06<00:00, 94.42it/s]
Epoch 22/50, Train Loss: 0.025, Train Accuracy: 99.742
100%|      | 646/646 [00:06<00:00, 95.34it/s]
Epoch 23/50, Train Loss: 0.022, Train Accuracy: 99.795
```

```
100%|      | 646/646 [00:06<00:00, 96.05it/s]
Epoch 24/50, Train Loss: 0.019, Train Accuracy: 99.838
100%|      | 646/646 [00:06<00:00, 95.08it/s]
Epoch 25/50, Train Loss: 0.016, Train Accuracy: 99.889
100%|      | 646/646 [00:06<00:00, 92.66it/s]
Epoch 26/50, Train Loss: 0.015, Train Accuracy: 99.886
100%|      | 646/646 [00:06<00:00, 95.85it/s]
Epoch 27/50, Train Loss: 0.012, Train Accuracy: 99.931
100%|      | 646/646 [00:06<00:00, 95.84it/s]
Epoch 28/50, Train Loss: 0.012, Train Accuracy: 99.896
100%|      | 646/646 [00:06<00:00, 95.12it/s]
Epoch 29/50, Train Loss: 0.010, Train Accuracy: 99.935
100%|      | 646/646 [00:06<00:00, 95.75it/s]
Epoch 30/50, Train Loss: 0.008, Train Accuracy: 99.964
100%|      | 646/646 [00:06<00:00, 95.03it/s]
Epoch 31/50, Train Loss: 0.007, Train Accuracy: 99.966
100%|      | 646/646 [00:06<00:00, 95.84it/s]
Epoch 32/50, Train Loss: 0.011, Train Accuracy: 99.870
100%|      | 646/646 [00:06<00:00, 95.42it/s]
Epoch 33/50, Train Loss: 0.006, Train Accuracy: 99.982
100%|      | 646/646 [00:06<00:00, 95.64it/s]
Epoch 34/50, Train Loss: 0.005, Train Accuracy: 99.989
100%|      | 646/646 [00:06<00:00, 92.57it/s]
Epoch 35/50, Train Loss: 0.004, Train Accuracy: 99.990
100%|      | 646/646 [00:06<00:00, 95.07it/s]
Epoch 36/50, Train Loss: 0.008, Train Accuracy: 99.884
100%|      | 646/646 [00:06<00:00, 95.56it/s]
Epoch 37/50, Train Loss: 0.005, Train Accuracy: 99.970
100%|      | 646/646 [00:06<00:00, 95.19it/s]
Epoch 38/50, Train Loss: 0.006, Train Accuracy: 99.923
100%|      | 646/646 [00:06<00:00, 95.79it/s]
Epoch 39/50, Train Loss: 0.003, Train Accuracy: 99.993
```

```
100%|      | 646/646 [00:06<00:00, 95.74it/s]
Epoch 40/50, Train Loss: 0.002, Train Accuracy: 99.996
100%|      | 646/646 [00:06<00:00, 96.00it/s]
Epoch 41/50, Train Loss: 0.002, Train Accuracy: 99.995
100%|      | 646/646 [00:06<00:00, 95.55it/s]
Epoch 42/50, Train Loss: 0.002, Train Accuracy: 99.994
100%|      | 646/646 [00:06<00:00, 95.86it/s]
Epoch 43/50, Train Loss: 0.009, Train Accuracy: 99.811
100%|      | 646/646 [00:06<00:00, 92.69it/s]
Epoch 44/50, Train Loss: 0.003, Train Accuracy: 99.990
100%|      | 646/646 [00:06<00:00, 94.95it/s]
Epoch 45/50, Train Loss: 0.002, Train Accuracy: 99.998
100%|      | 646/646 [00:06<00:00, 95.65it/s]
Epoch 46/50, Train Loss: 0.002, Train Accuracy: 99.999
100%|      | 646/646 [00:06<00:00, 95.67it/s]
Epoch 47/50, Train Loss: 0.001, Train Accuracy: 99.999
100%|      | 646/646 [00:06<00:00, 96.50it/s]
Epoch 48/50, Train Loss: 0.001, Train Accuracy: 99.999
100%|      | 646/646 [00:06<00:00, 95.95it/s]
Epoch 49/50, Train Loss: 0.001, Train Accuracy: 99.998
100%|      | 646/646 [00:06<00:00, 96.06it/s]
Epoch 50/50, Train Loss: 0.009, Train Accuracy: 99.766

 Training complete. Model saved to 'train_logs/window_4\model.pth', stats saved
to 'train_logs/window_4\train_stats.csv'
100%|      | 132/132 [00:01<00:00, 110.60it/s]
c:\Users\Ward\anaconda3\envs\multibench\Lib\site-
packages\sklearn\metrics\_classification.py:2480: UserWarning: y_pred contains
classes not in y_true
  warnings.warn("y_pred contains classes not in y_true")


 Evaluation Results:
Top-1 Accuracy: 93.09%
Top-5 Accuracy: 99.35%
Balanced Accuracy: 80.16%
```

```
 Classification Report:
                                                    precision    recall  f1-score
support

                                SYSTEM_CONFIRM       0.98      0.88      0.93
1113
                                SYSTEM_GOODBYE       0.99      0.98      0.99
1331
                                 SYSTEM_INFORM       0.97      0.90      0.93
719
             SYSTEM_INFORM|SYSTEM_NOTIFY_SUCCESS       0.91      0.95      0.93
310
 SYSTEM_INFORM|SYSTEM_OFFER|SYSTEM_NOTIFY_FAILURE       0.92      0.65      0.76
17
          SYSTEM_NOTIFY_FAILURE|SYSTEM_REQ_MORE       0.88      0.87      0.88
79
                          SYSTEM_NOTIFY_SUCCESS       0.98      0.98      0.98
499
                                   SYSTEM_OFFER       0.84      0.98      0.91
806
                             SYSTEM_OFFER_INTENT       0.95      0.96      0.96
383
               SYSTEM_OFFER|SYSTEM_INFORM_COUNT       0.95      0.94      0.95
608
             SYSTEM_OFFER|SYSTEM_NOTIFY_FAILURE       1.00      0.71      0.83
14
                                SYSTEM_REQUEST       0.97      0.98      0.97
1961
                               SYSTEM_REQ_MORE       0.93      0.98      0.96
585
                                   USER_AFFIRM       0.97      0.92      0.94
572
                             USER_AFFIRM_INTENT       0.90      0.87      0.89
139
                  USER_AFFIRM_INTENT|USER_INFORM       0.92      0.84      0.88
103
                                   USER_INFORM       0.99      0.97      0.98
1961
                             USER_INFORM_INTENT       0.94      0.93      0.94
658
          USER_INFORM_INTENT|USER_NEGATE_INTENT       0.00      0.00      0.00
0
                 USER_INFORM_INTENT|USER_SELECT       0.78      0.87      0.83
167
               USER_INFORM_INTENT|USER_THANK_YOU       0.00      0.00      0.00
12
                  USER_INFORM|USER_INFORM_INTENT       0.94      0.95      0.94
772
```

```
USER_INFORM|USER_INFORM_INTENT|USER_NEGATE_INTENT       0.00      0.00      0.00
0
       USER_INFORM|USER_INFORM_INTENT|USER_SELECT       0.75      0.72      0.73
117
    USER_INFORM|USER_INFORM_INTENT|USER_THANK_YOU       0.00      0.00      0.00
14
                         USER_INFORM|USER_NEGATE       0.94      0.83      0.88
216
                   USER_INFORM|USER_REQUEST_ALTS       0.79      0.88      0.83
184
                                     USER_NEGATE       0.57      0.57      0.57
7
                                USER_NEGATE_INTENT       0.65      0.80      0.71
69
                 USER_NEGATE_INTENT|USER_GOODBYE       0.70      0.62      0.66
72
                       USER_NEGATE|USER_GOODBYE       1.00      0.11      0.20
9
                     USER_NEGATE|USER_THANK_YOU       0.96      0.98      0.97
587
                                   USER_REQUEST       0.93      0.94      0.94
719
                              USER_REQUEST_ALTS       0.88      0.90      0.89
152
                       USER_REQUEST|USER_AFFIRM       0.95      0.94      0.94
340
                                   USER_SELECT       0.79      0.95      0.86
515
                       USER_SELECT|USER_GOODBYE       0.87      0.66      0.75
279
                                  USER_THANK_YOU       0.81      0.80      0.81
377
                     USER_THANK_YOU|USER_GOODBYE       0.74      0.84      0.79
384

                                      accuracy                           0.93
16850
                                     macro avg       0.80      0.76      0.77
16850
                                  weighted avg       0.93      0.93      0.93
16850


=== Running training for window size: 5 ===

C:\Users\Ward\AppData\Local\Temp\ipykernel_10956\3759199132.py:9: FutureWarning:
You are using `torch.load` with `weights_only=False` (the current default
value), which uses the default pickle module implicitly. It is possible to
```

```
construct malicious pickle data which will execute arbitrary code during
unpickling (See
https://github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for
more details). In a future release, the default value for `weights_only` will be
flipped to `True`. This limits the functions that could be executed during
unpickling. Arbitrary objects will no longer be allowed to be loaded via this
mode unless they are explicitly allowlisted by the user via
`torch.serialization.add_safe_globals`. We recommend you start setting
`weights_only=True` for any use case where you don't have full control of the
loaded file. Please open an issue on GitHub for any issues related to this
experimental feature.
  self.embeddings = torch.load(embeddings_path)
100%|      | 5403/5403 [00:56<00:00, 95.69it/s]
100%|      | 1331/1331 [00:03<00:00, 426.95it/s]
100%|      | 646/646 [00:31<00:00, 20.53it/s]

Epoch 1/50, Train Loss: 2.330, Train Accuracy: 32.535

100%|      | 646/646 [00:08<00:00, 79.00it/s]

Epoch 2/50, Train Loss: 1.398, Train Accuracy: 56.592

100%|      | 646/646 [00:07<00:00, 81.54it/s]

Epoch 3/50, Train Loss: 1.012, Train Accuracy: 71.383

100%|      | 646/646 [00:07<00:00, 82.50it/s]

Epoch 4/50, Train Loss: 0.761, Train Accuracy: 80.474

100%|      | 646/646 [00:07<00:00, 82.74it/s]

Epoch 5/50, Train Loss: 0.596, Train Accuracy: 85.652

100%|      | 646/646 [00:07<00:00, 82.92it/s]

Epoch 6/50, Train Loss: 0.478, Train Accuracy: 89.129

100%|      | 646/646 [00:07<00:00, 82.87it/s]

Epoch 7/50, Train Loss: 0.394, Train Accuracy: 91.287

100%|      | 646/646 [00:07<00:00, 82.22it/s]

Epoch 8/50, Train Loss: 0.330, Train Accuracy: 92.966

100%|      | 646/646 [00:07<00:00, 83.09it/s]

Epoch 9/50, Train Loss: 0.281, Train Accuracy: 94.109

100%|      | 646/646 [00:07<00:00, 80.78it/s]

Epoch 10/50, Train Loss: 0.238, Train Accuracy: 95.235

100%|      | 646/646 [00:07<00:00, 82.98it/s]

Epoch 11/50, Train Loss: 0.204, Train Accuracy: 96.085

100%|      | 646/646 [00:07<00:00, 82.14it/s]
```

```
Epoch 12/50, Train Loss: 0.176, Train Accuracy: 96.772
100%|      | 646/646 [00:07<00:00, 82.90it/s]
Epoch 13/50, Train Loss: 0.156, Train Accuracy: 97.243
100%|      | 646/646 [00:07<00:00, 82.50it/s]
Epoch 14/50, Train Loss: 0.133, Train Accuracy: 97.772
100%|      | 646/646 [00:07<00:00, 83.20it/s]
Epoch 15/50, Train Loss: 0.115, Train Accuracy: 98.097
100%|      | 646/646 [00:07<00:00, 82.89it/s]
Epoch 16/50, Train Loss: 0.101, Train Accuracy: 98.414
100%|      | 646/646 [00:08<00:00, 80.10it/s]
Epoch 17/50, Train Loss: 0.089, Train Accuracy: 98.621
100%|      | 646/646 [00:09<00:00, 67.67it/s]
Epoch 18/50, Train Loss: 0.077, Train Accuracy: 98.844
100%|      | 646/646 [00:10<00:00, 59.29it/s]
Epoch 19/50, Train Loss: 0.068, Train Accuracy: 99.033
100%|      | 646/646 [00:08<00:00, 76.26it/s]
Epoch 20/50, Train Loss: 0.060, Train Accuracy: 99.196
100%|      | 646/646 [00:08<00:00, 76.43it/s]
Epoch 21/50, Train Loss: 0.052, Train Accuracy: 99.338
100%|      | 646/646 [00:10<00:00, 62.91it/s]
Epoch 22/50, Train Loss: 0.046, Train Accuracy: 99.471
100%|      | 646/646 [00:08<00:00, 79.95it/s]
Epoch 23/50, Train Loss: 0.042, Train Accuracy: 99.519
100%|      | 646/646 [00:08<00:00, 78.30it/s]
Epoch 24/50, Train Loss: 0.035, Train Accuracy: 99.648
100%|      | 646/646 [00:07<00:00, 81.13it/s]
Epoch 25/50, Train Loss: 0.031, Train Accuracy: 99.714
100%|      | 646/646 [00:07<00:00, 82.49it/s]
Epoch 26/50, Train Loss: 0.028, Train Accuracy: 99.751
100%|      | 646/646 [00:07<00:00, 82.69it/s]
Epoch 27/50, Train Loss: 0.031, Train Accuracy: 99.661
100%|      | 646/646 [00:07<00:00, 83.02it/s]
```

```
Epoch 28/50, Train Loss: 0.023, Train Accuracy: 99.820
100%|      | 646/646 [00:07<00:00, 84.59it/s]
Epoch 29/50, Train Loss: 0.020, Train Accuracy: 99.855
100%|      | 646/646 [00:07<00:00, 83.72it/s]
Epoch 30/50, Train Loss: 0.017, Train Accuracy: 99.892
100%|      | 646/646 [00:07<00:00, 84.16it/s]
Epoch 31/50, Train Loss: 0.016, Train Accuracy: 99.893
100%|      | 646/646 [00:07<00:00, 81.11it/s]
Epoch 32/50, Train Loss: 0.015, Train Accuracy: 99.908
100%|      | 646/646 [00:08<00:00, 79.58it/s]
Epoch 33/50, Train Loss: 0.014, Train Accuracy: 99.906
100%|      | 646/646 [00:07<00:00, 81.55it/s]
Epoch 34/50, Train Loss: 0.011, Train Accuracy: 99.952
100%|      | 646/646 [00:07<00:00, 82.32it/s]
Epoch 35/50, Train Loss: 0.015, Train Accuracy: 99.815
100%|      | 646/646 [00:07<00:00, 82.70it/s]
Epoch 36/50, Train Loss: 0.010, Train Accuracy: 99.954
100%|      | 646/646 [00:07<00:00, 82.79it/s]
Epoch 37/50, Train Loss: 0.008, Train Accuracy: 99.966
100%|      | 646/646 [00:07<00:00, 81.66it/s]
Epoch 38/50, Train Loss: 0.007, Train Accuracy: 99.969
100%|      | 646/646 [00:07<00:00, 82.75it/s]
Epoch 39/50, Train Loss: 0.012, Train Accuracy: 99.810
100%|      | 646/646 [00:07<00:00, 82.49it/s]
Epoch 40/50, Train Loss: 0.013, Train Accuracy: 99.856
100%|      | 646/646 [00:07<00:00, 82.94it/s]
Epoch 41/50, Train Loss: 0.006, Train Accuracy: 99.985
100%|      | 646/646 [00:07<00:00, 82.85it/s]
Epoch 42/50, Train Loss: 0.005, Train Accuracy: 99.983
100%|      | 646/646 [00:07<00:00, 82.55it/s]
Epoch 43/50, Train Loss: 0.004, Train Accuracy: 99.985
100%|      | 646/646 [00:07<00:00, 81.87it/s]
```

```
Epoch 44/50, Train Loss: 0.004, Train Accuracy: 99.990
100%|      | 646/646 [00:07<00:00, 82.41it/s]
Epoch 45/50, Train Loss: 0.004, Train Accuracy: 99.989
100%|      | 646/646 [00:07<00:00, 82.96it/s]
Epoch 46/50, Train Loss: 0.016, Train Accuracy: 99.672
100%|      | 646/646 [00:07<00:00, 81.88it/s]
Epoch 47/50, Train Loss: 0.008, Train Accuracy: 99.884
100%|      | 646/646 [00:08<00:00, 75.86it/s]
Epoch 48/50, Train Loss: 0.004, Train Accuracy: 99.987
100%|      | 646/646 [00:08<00:00, 73.29it/s]
Epoch 49/50, Train Loss: 0.003, Train Accuracy: 99.994
100%|      | 646/646 [00:08<00:00, 80.49it/s]
Epoch 50/50, Train Loss: 0.003, Train Accuracy: 99.994

 Training complete. Model saved to 'train_logs/window_5\model.pth', stats saved
to 'train_logs/window_5\train_stats.csv'
100%|      | 132/132 [00:07<00:00, 17.03it/s]
c:\Users\Ward\anaconda3\envs\multibench\Lib\site-
packages\sklearn\metrics\_classification.py:2480: UserWarning: y_pred contains
classes not in y_true
  warnings.warn("y_pred contains classes not in y_true")


 Evaluation Results:
Top-1 Accuracy: 92.61%
Top-5 Accuracy: 99.31%
Balanced Accuracy: 80.24%

 Classification Report:
                                                    precision    recall  f1-score
support

                                SYSTEM_CONFIRM       0.94      0.91      0.92
1113
                                SYSTEM_GOODBYE       0.97      0.97      0.97
1331
                                 SYSTEM_INFORM       0.95      0.94      0.95
719
             SYSTEM_INFORM|SYSTEM_NOTIFY_SUCCESS       0.97      0.95      0.96
310
 SYSTEM_INFORM|SYSTEM_OFFER|SYSTEM_NOTIFY_FAILURE       1.00      0.65      0.79
17
```

SYSTEM_NOTIFY_FAILURE|SYSTEM_REQ_MORE	0.94	0.81	0.87	79
SYSTEM_NOTIFY_SUCCESS	0.98	0.96	0.97	499
SYSTEM_OFFER	0.89	0.92	0.91	806
SYSTEM_OFFER_INTENT	0.90	0.98	0.94	383
SYSTEM_OFFER|SYSTEM_INFORM_COUNT	0.89	0.95	0.92	608
SYSTEM_OFFER|SYSTEM_NOTIFY_FAILURE	1.00	0.71	0.83	14
SYSTEM_REQUEST	0.98	0.96	0.97	1961
SYSTEM_REQ_MORE	0.92	0.96	0.94	585
USER_AFFIRM	0.95	0.91	0.93	572
USER_AFFIRM_INTENT	0.87	0.88	0.87	139
USER_AFFIRM_INTENT|USER_INFORM	0.94	0.88	0.91	103
USER_INFORM	0.99	0.96	0.98	1961
USER_INFORM_INTENT	0.95	0.91	0.93	658
USER_INFORM_INTENT|USER_NEGATE_INTENT	0.00	0.00	0.00	0
USER_INFORM_INTENT|USER_SELECT	0.73	0.85	0.79	167
USER_INFORM_INTENT|USER_THANK_YOU	0.20	0.17	0.18	12
USER_INFORM|USER_INFORM_INTENT	0.94	0.95	0.94	772
USER_INFORM|USER_INFORM_INTENT|USER_NEGATE_INTENT	0.00	0.00	0.00	0
USER_INFORM|USER_INFORM_INTENT|USER_SELECT	0.76	0.74	0.75	117
USER_INFORM|USER_INFORM_INTENT|USER_THANK_YOU	0.00	0.00	0.00	14
USER_INFORM|USER_NEGATE	0.93	0.87	0.89	216
USER_INFORM|USER_REQUEST_ALTS	0.84	0.84	0.84	184
USER_NEGATE	0.38	0.43	0.40	7
USER_NEGATE_INTENT	0.56	0.83	0.67	69

```
                  USER_NEGATE_INTENT|USER_GOODBYE       0.64      0.54      0.59
72
                        USER_NEGATE|USER_GOODBYE       0.50      0.22      0.31
9
                     USER_NEGATE|USER_THANK_YOU       0.95      0.99      0.97
587
                                  USER_REQUEST       0.94      0.94      0.94
719
                             USER_REQUEST_ALTS       0.89      0.94      0.91
152
                       USER_REQUEST|USER_AFFIRM       0.95      0.94      0.95
340
                                  USER_SELECT       0.81      0.93      0.86
515
                       USER_SELECT|USER_GOODBYE       0.80      0.71      0.75
279
                                USER_THANK_YOU       0.78      0.79      0.79
377
                    USER_THANK_YOU|USER_GOODBYE       0.75      0.79      0.77
384

                                     accuracy                           0.93
16850
                                    macro avg       0.78      0.76      0.77
16850
                                 weighted avg       0.93      0.93      0.93
16850


=== Running training for window size: 6 ===

C:\Users\Ward\AppData\Local\Temp\ipykernel_10956\3759199132.py:9: FutureWarning:
You are using `torch.load` with `weights_only=False` (the current default
value), which uses the default pickle module implicitly. It is possible to
construct malicious pickle data which will execute arbitrary code during
unpickling (See
https://github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for
more details). In a future release, the default value for `weights_only` will be
flipped to `True`. This limits the functions that could be executed during
unpickling. Arbitrary objects will no longer be allowed to be loaded via this
mode unless they are explicitly allowlisted by the user via
`torch.serialization.add_safe_globals`. We recommend you start setting
`weights_only=True` for any use case where you don't have full control of the
loaded file. Please open an issue on GitHub for any issues related to this
experimental feature.
  self.embeddings = torch.load(embeddings_path)
100%|      | 5403/5403 [00:48<00:00, 110.83it/s]
100%|      | 1331/1331 [00:07<00:00, 175.15it/s]
```

```
100%|      | 646/646 [01:29<00:00,  7.25it/s]
Epoch 1/50, Train Loss: 2.451, Train Accuracy: 28.739
100%|      | 646/646 [00:16<00:00, 38.26it/s]
Epoch 2/50, Train Loss: 1.543, Train Accuracy: 53.210
100%|      | 646/646 [00:10<00:00, 62.77it/s]
Epoch 3/50, Train Loss: 1.180, Train Accuracy: 65.443
100%|      | 646/646 [00:10<00:00, 62.72it/s]
Epoch 4/50, Train Loss: 0.934, Train Accuracy: 74.645
100%|      | 646/646 [00:10<00:00, 63.59it/s]
Epoch 5/50, Train Loss: 0.740, Train Accuracy: 81.104
100%|      | 646/646 [00:10<00:00, 63.55it/s]
Epoch 6/50, Train Loss: 0.607, Train Accuracy: 84.488
100%|      | 646/646 [00:09<00:00, 65.39it/s]
Epoch 7/50, Train Loss: 0.514, Train Accuracy: 86.896
100%|      | 646/646 [00:09<00:00, 65.66it/s]
Epoch 8/50, Train Loss: 0.441, Train Accuracy: 88.839
100%|      | 646/646 [00:09<00:00, 66.05it/s]
Epoch 9/50, Train Loss: 0.382, Train Accuracy: 90.559
100%|      | 646/646 [00:09<00:00, 65.95it/s]
Epoch 10/50, Train Loss: 0.331, Train Accuracy: 92.328
100%|      | 646/646 [00:09<00:00, 65.40it/s]
Epoch 11/50, Train Loss: 0.285, Train Accuracy: 93.732
100%|      | 646/646 [00:10<00:00, 64.01it/s]
Epoch 12/50, Train Loss: 0.249, Train Accuracy: 94.747
100%|      | 646/646 [00:10<00:00, 62.67it/s]
Epoch 13/50, Train Loss: 0.222, Train Accuracy: 95.470
100%|      | 646/646 [00:09<00:00, 64.68it/s]
Epoch 14/50, Train Loss: 0.192, Train Accuracy: 96.289
100%|      | 646/646 [00:09<00:00, 66.39it/s]
Epoch 15/50, Train Loss: 0.169, Train Accuracy: 96.852
100%|      | 646/646 [00:09<00:00, 66.12it/s]
Epoch 16/50, Train Loss: 0.149, Train Accuracy: 97.285
```

```
100%|      | 646/646 [00:10<00:00, 64.19it/s]
Epoch 17/50, Train Loss: 0.133, Train Accuracy: 97.702
100%|      | 646/646 [00:09<00:00, 66.48it/s]
Epoch 18/50, Train Loss: 0.118, Train Accuracy: 97.992
100%|      | 646/646 [00:09<00:00, 65.92it/s]
Epoch 19/50, Train Loss: 0.104, Train Accuracy: 98.261
100%|      | 646/646 [00:09<00:00, 66.50it/s]
Epoch 20/50, Train Loss: 0.092, Train Accuracy: 98.546
100%|      | 646/646 [00:09<00:00, 66.70it/s]
Epoch 21/50, Train Loss: 0.083, Train Accuracy: 98.740
100%|      | 646/646 [00:09<00:00, 66.58it/s]
Epoch 22/50, Train Loss: 0.074, Train Accuracy: 98.897
100%|      | 646/646 [00:09<00:00, 67.05it/s]
Epoch 23/50, Train Loss: 0.066, Train Accuracy: 99.063
100%|      | 646/646 [00:09<00:00, 65.03it/s]
Epoch 24/50, Train Loss: 0.059, Train Accuracy: 99.206
100%|      | 646/646 [00:09<00:00, 66.45it/s]
Epoch 25/50, Train Loss: 0.054, Train Accuracy: 99.281
100%|      | 646/646 [00:09<00:00, 65.85it/s]
Epoch 26/50, Train Loss: 0.046, Train Accuracy: 99.479
100%|      | 646/646 [00:09<00:00, 66.11it/s]
Epoch 27/50, Train Loss: 0.044, Train Accuracy: 99.493
100%|      | 646/646 [00:09<00:00, 71.03it/s]
Epoch 28/50, Train Loss: 0.038, Train Accuracy: 99.616
100%|      | 646/646 [00:09<00:00, 66.70it/s]
Epoch 29/50, Train Loss: 0.034, Train Accuracy: 99.673
100%|      | 646/646 [00:09<00:00, 65.36it/s]
Epoch 30/50, Train Loss: 0.029, Train Accuracy: 99.770
100%|      | 646/646 [00:09<00:00, 66.24it/s]
Epoch 31/50, Train Loss: 0.026, Train Accuracy: 99.812
100%|      | 646/646 [00:09<00:00, 66.26it/s]
Epoch 32/50, Train Loss: 0.023, Train Accuracy: 99.851
```

```
100%|      | 646/646 [00:09<00:00, 65.58it/s]
Epoch 33/50, Train Loss: 0.028, Train Accuracy: 99.697
100%|      | 646/646 [00:09<00:00, 66.21it/s]
Epoch 34/50, Train Loss: 0.020, Train Accuracy: 99.876
100%|      | 646/646 [00:09<00:00, 69.45it/s]
Epoch 35/50, Train Loss: 0.016, Train Accuracy: 99.933
100%|      | 646/646 [00:09<00:00, 64.84it/s]
Epoch 36/50, Train Loss: 0.014, Train Accuracy: 99.944
100%|      | 646/646 [00:09<00:00, 65.74it/s]
Epoch 37/50, Train Loss: 0.020, Train Accuracy: 99.793
100%|      | 646/646 [00:09<00:00, 65.11it/s]
Epoch 38/50, Train Loss: 0.013, Train Accuracy: 99.955
100%|      | 646/646 [00:09<00:00, 64.73it/s]
Epoch 39/50, Train Loss: 0.011, Train Accuracy: 99.969
100%|      | 646/646 [00:09<00:00, 65.92it/s]
Epoch 40/50, Train Loss: 0.011, Train Accuracy: 99.948
100%|      | 646/646 [00:09<00:00, 65.15it/s]
Epoch 41/50, Train Loss: 0.014, Train Accuracy: 99.893
100%|      | 646/646 [00:10<00:00, 63.25it/s]
Epoch 42/50, Train Loss: 0.011, Train Accuracy: 99.930
100%|      | 646/646 [00:09<00:00, 65.53it/s]
Epoch 43/50, Train Loss: 0.008, Train Accuracy: 99.979
100%|      | 646/646 [00:10<00:00, 62.29it/s]
Epoch 44/50, Train Loss: 0.008, Train Accuracy: 99.967
100%|      | 646/646 [00:09<00:00, 66.49it/s]
Epoch 45/50, Train Loss: 0.006, Train Accuracy: 99.989
100%|      | 646/646 [00:09<00:00, 66.22it/s]
Epoch 46/50, Train Loss: 0.005, Train Accuracy: 99.989
100%|      | 646/646 [00:09<00:00, 65.94it/s]
Epoch 47/50, Train Loss: 0.011, Train Accuracy: 99.797
100%|      | 646/646 [00:10<00:00, 64.54it/s]
Epoch 48/50, Train Loss: 0.009, Train Accuracy: 99.946
```

```
100%|      | 646/646 [00:09<00:00, 66.14it/s]
Epoch 49/50, Train Loss: 0.009, Train Accuracy: 99.910
100%|      | 646/646 [00:10<00:00, 64.03it/s]
Epoch 50/50, Train Loss: 0.006, Train Accuracy: 99.972

 Training complete. Model saved to 'train_logs/window_6\model.pth', stats saved
to 'train_logs/window_6\train_stats.csv'
100%|      | 132/132 [00:16<00:00,  8.21it/s]
c:\Users\Ward\anaconda3\envs\multibench\Lib\site-
packages\sklearn\metrics\_classification.py:2480: UserWarning: y_pred contains
classes not in y_true
  warnings.warn("y_pred contains classes not in y_true")


 Evaluation Results:
Top-1 Accuracy: 90.77%
Top-5 Accuracy: 98.93%
Balanced Accuracy: 76.81%

 Classification Report:
                                                    precision    recall  f1-score
support

                                SYSTEM_CONFIRM       0.92      0.88      0.90
1113
                                SYSTEM_GOODBYE       0.98      0.96      0.97
1331
                                 SYSTEM_INFORM       0.97      0.93      0.95
719
            SYSTEM_INFORM|SYSTEM_NOTIFY_SUCCESS       0.95      0.92      0.93
310
 SYSTEM_INFORM|SYSTEM_OFFER|SYSTEM_NOTIFY_FAILURE       0.71      0.29      0.42
17
          SYSTEM_NOTIFY_FAILURE|SYSTEM_REQ_MORE       0.86      0.72      0.79
79
                         SYSTEM_NOTIFY_SUCCESS       0.93      0.96      0.95
499
                                   SYSTEM_OFFER       0.85      0.93      0.89
806
                            SYSTEM_OFFER_INTENT       0.91      0.98      0.94
383
              SYSTEM_OFFER|SYSTEM_INFORM_COUNT       0.94      0.91      0.92
608
            SYSTEM_OFFER|SYSTEM_NOTIFY_FAILURE       0.61      0.79      0.69
14
                                SYSTEM_REQUEST       0.96      0.94      0.95
```

1961				
	SYSTEM_REQ_MORE	0.92	0.96	0.94
585				
	USER_AFFIRM	0.91	0.91	0.91
572				
	USER_AFFIRM_INTENT	0.79	0.87	0.83
139				
	USER_AFFIRM_INTENT|USER_INFORM	0.83	0.75	0.79
103				
	USER_INFORM	0.98	0.95	0.97
1961				
	USER_INFORM_INTENT	0.95	0.90	0.93
658				
	USER_INFORM_INTENT|USER_NEGATE_INTENT	0.00	0.00	0.00
0				
	USER_INFORM_INTENT|USER_SELECT	0.66	0.72	0.69
167				
	USER_INFORM_INTENT|USER_THANK_YOU	0.33	0.42	0.37
12				
	USER_INFORM|USER_INFORM_INTENT	0.91	0.95	0.93
772				
USER_INFORM|USER_INFORM_INTENT|USER_NEGATE_INTENT		0.00	0.00	0.00
0				
USER_INFORM|USER_INFORM_INTENT|USER_SELECT		0.53	0.62	0.57
117				
USER_INFORM|USER_INFORM_INTENT|USER_THANK_YOU		0.00	0.00	0.00
14				
	USER_INFORM|USER_NEGATE	0.82	0.82	0.82
216				
	USER_INFORM|USER_REQUEST_ALTS	0.71	0.79	0.75
184				
	USER_NEGATE	1.00	0.43	0.60
7				
	USER_NEGATE_INTENT	0.62	0.74	0.68
69				
	USER_NEGATE_INTENT|USER_GOODBYE	0.68	0.56	0.61
72				
	USER_NEGATE|USER_GOODBYE	0.00	0.00	0.00
9				
	USER_NEGATE|USER_THANK_YOU	0.97	0.98	0.97
587				
	USER_REQUEST	0.96	0.89	0.92
719				
	USER_REQUEST_ALTS	0.82	0.92	0.87
152				
	USER_REQUEST|USER_AFFIRM	0.92	0.92	0.92
340				
	USER_SELECT	0.80	0.92	0.86

```
515
                      USER_SELECT|USER_GOODBYE       0.81      0.60      0.69
279
                                 USER_THANK_YOU       0.80      0.73      0.76
377
                    USER_THANK_YOU|USER_GOODBYE       0.67      0.85      0.75
384

                                      accuracy                           0.91
16850
                                     macro avg       0.74      0.73      0.73
16850
                                  weighted avg       0.91      0.91      0.91
16850


=== Running training for window size: 7 ===

C:\Users\Ward\AppData\Local\Temp\ipykernel_10956\3759199132.py:9: FutureWarning:
You are using `torch.load` with `weights_only=False` (the current default
value), which uses the default pickle module implicitly. It is possible to
construct malicious pickle data which will execute arbitrary code during
unpickling (See
https://github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for
more details). In a future release, the default value for `weights_only` will be
flipped to `True`. This limits the functions that could be executed during
unpickling. Arbitrary objects will no longer be allowed to be loaded via this
mode unless they are explicitly allowlisted by the user via
`torch.serialization.add_safe_globals`. We recommend you start setting
`weights_only=True` for any use case where you don't have full control of the
loaded file. Please open an issue on GitHub for any issues related to this
experimental feature.
  self.embeddings = torch.load(embeddings_path)
100%|      | 5403/5403 [01:15<00:00, 71.48it/s]
100%|      | 1331/1331 [00:13<00:00, 99.69it/s]
100%|      | 646/646 [02:36<00:00,  4.13it/s]

Epoch 1/50, Train Loss: 2.508, Train Accuracy: 25.890

100%|      | 646/646 [00:39<00:00, 16.33it/s]

Epoch 2/50, Train Loss: 1.789, Train Accuracy: 44.786

100%|      | 646/646 [00:14<00:00, 44.84it/s]

Epoch 3/50, Train Loss: 1.483, Train Accuracy: 53.200

100%|      | 646/646 [00:18<00:00, 35.13it/s]

Epoch 4/50, Train Loss: 1.228, Train Accuracy: 62.159

100%|      | 646/646 [00:12<00:00, 53.25it/s]
```

```
Epoch 5/50, Train Loss: 1.015, Train Accuracy: 70.966
100%|      | 646/646 [00:14<00:00, 46.04it/s]
Epoch 6/50, Train Loss: 0.847, Train Accuracy: 77.447
100%|      | 646/646 [00:20<00:00, 31.86it/s]
Epoch 7/50, Train Loss: 0.719, Train Accuracy: 81.631
100%|      | 646/646 [00:11<00:00, 56.26it/s]
Epoch 8/50, Train Loss: 0.615, Train Accuracy: 84.706
100%|      | 646/646 [00:15<00:00, 42.98it/s]
Epoch 9/50, Train Loss: 0.516, Train Accuracy: 87.663
100%|      | 646/646 [00:14<00:00, 44.84it/s]
Epoch 10/50, Train Loss: 0.443, Train Accuracy: 89.657
100%|      | 646/646 [00:13<00:00, 46.38it/s]
Epoch 11/50, Train Loss: 0.387, Train Accuracy: 91.267
100%|      | 646/646 [00:12<00:00, 51.19it/s]
Epoch 12/50, Train Loss: 0.343, Train Accuracy: 92.464
100%|      | 646/646 [00:21<00:00, 29.91it/s]
Epoch 13/50, Train Loss: 0.302, Train Accuracy: 93.656
100%|      | 646/646 [00:15<00:00, 42.57it/s]
Epoch 14/50, Train Loss: 0.265, Train Accuracy: 94.602
100%|      | 646/646 [00:23<00:00, 27.70it/s]
Epoch 15/50, Train Loss: 0.234, Train Accuracy: 95.372
100%|      | 646/646 [00:12<00:00, 51.23it/s]
Epoch 16/50, Train Loss: 0.210, Train Accuracy: 95.952
100%|      | 646/646 [00:11<00:00, 55.54it/s]
Epoch 17/50, Train Loss: 0.187, Train Accuracy: 96.503
100%|      | 646/646 [00:11<00:00, 55.76it/s]
Epoch 18/50, Train Loss: 0.166, Train Accuracy: 96.989
100%|      | 646/646 [00:11<00:00, 54.82it/s]
Epoch 19/50, Train Loss: 0.150, Train Accuracy: 97.300
100%|      | 646/646 [00:14<00:00, 43.92it/s]
Epoch 20/50, Train Loss: 0.134, Train Accuracy: 97.689
100%|      | 646/646 [00:11<00:00, 54.52it/s]
```

```
Epoch 21/50, Train Loss: 0.120, Train Accuracy: 97.972
100%|      | 646/646 [00:11<00:00, 54.76it/s]
Epoch 22/50, Train Loss: 0.108, Train Accuracy: 98.242
100%|      | 646/646 [00:11<00:00, 54.93it/s]
Epoch 23/50, Train Loss: 0.097, Train Accuracy: 98.558
100%|      | 646/646 [00:11<00:00, 55.95it/s]
Epoch 24/50, Train Loss: 0.088, Train Accuracy: 98.687
100%|      | 646/646 [00:12<00:00, 52.95it/s]
Epoch 25/50, Train Loss: 0.081, Train Accuracy: 98.850
100%|      | 646/646 [00:12<00:00, 50.78it/s]
Epoch 26/50, Train Loss: 0.071, Train Accuracy: 99.074
100%|      | 646/646 [00:11<00:00, 55.30it/s]
Epoch 27/50, Train Loss: 0.064, Train Accuracy: 99.225
100%|      | 646/646 [00:17<00:00, 37.63it/s]
Epoch 28/50, Train Loss: 0.058, Train Accuracy: 99.340
100%|      | 646/646 [00:15<00:00, 41.59it/s]
Epoch 29/50, Train Loss: 0.052, Train Accuracy: 99.456
100%|      | 646/646 [00:19<00:00, 32.39it/s]
Epoch 30/50, Train Loss: 0.047, Train Accuracy: 99.548
100%|      | 646/646 [00:25<00:00, 25.43it/s]
Epoch 31/50, Train Loss: 0.045, Train Accuracy: 99.583
100%|      | 646/646 [00:11<00:00, 57.73it/s]
Epoch 32/50, Train Loss: 0.038, Train Accuracy: 99.703
100%|      | 646/646 [00:11<00:00, 57.70it/s]
Epoch 33/50, Train Loss: 0.034, Train Accuracy: 99.775
100%|      | 646/646 [00:16<00:00, 39.11it/s]
Epoch 34/50, Train Loss: 0.031, Train Accuracy: 99.791
100%|      | 646/646 [00:13<00:00, 47.88it/s]
Epoch 35/50, Train Loss: 0.028, Train Accuracy: 99.833
100%|      | 646/646 [00:15<00:00, 40.88it/s]
Epoch 36/50, Train Loss: 0.030, Train Accuracy: 99.753
100%|      | 646/646 [00:12<00:00, 53.28it/s]
```

```
Epoch 37/50, Train Loss: 0.024, Train Accuracy: 99.873
100%|      | 646/646 [00:12<00:00, 52.04it/s]
Epoch 38/50, Train Loss: 0.020, Train Accuracy: 99.932
100%|      | 646/646 [00:11<00:00, 53.92it/s]
Epoch 39/50, Train Loss: 0.018, Train Accuracy: 99.926
100%|      | 646/646 [00:11<00:00, 54.14it/s]
Epoch 40/50, Train Loss: 0.020, Train Accuracy: 99.893
100%|      | 646/646 [00:14<00:00, 43.60it/s]
Epoch 41/50, Train Loss: 0.024, Train Accuracy: 99.780
100%|      | 646/646 [00:12<00:00, 53.68it/s]
Epoch 42/50, Train Loss: 0.014, Train Accuracy: 99.960
100%|      | 646/646 [00:12<00:00, 52.55it/s]
Epoch 43/50, Train Loss: 0.012, Train Accuracy: 99.971
100%|      | 646/646 [00:12<00:00, 53.18it/s]
Epoch 44/50, Train Loss: 0.011, Train Accuracy: 99.975
100%|      | 646/646 [00:12<00:00, 53.82it/s]
Epoch 45/50, Train Loss: 0.010, Train Accuracy: 99.977
100%|      | 646/646 [00:12<00:00, 52.73it/s]
Epoch 46/50, Train Loss: 0.017, Train Accuracy: 99.806
100%|      | 646/646 [00:12<00:00, 50.86it/s]
Epoch 47/50, Train Loss: 0.009, Train Accuracy: 99.979
100%|      | 646/646 [00:12<00:00, 52.21it/s]
Epoch 48/50, Train Loss: 0.008, Train Accuracy: 99.983
100%|      | 646/646 [00:12<00:00, 53.33it/s]
Epoch 49/50, Train Loss: 0.014, Train Accuracy: 99.821
100%|      | 646/646 [00:12<00:00, 52.67it/s]
Epoch 50/50, Train Loss: 0.014, Train Accuracy: 99.883

 Training complete. Model saved to 'train_logs/window_7\model.pth', stats saved
to 'train_logs/window_7\train_stats.csv'
100%|      | 132/132 [00:17<00:00,  7.46it/s]
c:\Users\Ward\anaconda3\envs\multibench\Lib\site-
packages\sklearn\metrics\_classification.py:2480: UserWarning: y_pred contains
```

```
classes not in y_true
  warnings.warn("y_pred contains classes not in y_true")


 Evaluation Results:
Top-1 Accuracy: 90.79%
Top-5 Accuracy: 98.96%
Balanced Accuracy: 78.69%

 Classification Report:
                                                    precision    recall  f1-score
support

                                SYSTEM_CONFIRM       0.91      0.89      0.90
1113
                                SYSTEM_GOODBYE       0.94      0.96      0.95
1331
                                 SYSTEM_INFORM       0.97      0.92      0.94
719
             SYSTEM_INFORM|SYSTEM_NOTIFY_SUCCESS       0.95      0.92      0.93
310
 SYSTEM_INFORM|SYSTEM_OFFER|SYSTEM_NOTIFY_FAILURE       1.00      0.59      0.74
17
           SYSTEM_NOTIFY_FAILURE|SYSTEM_REQ_MORE       0.86      0.70      0.77
79
                           SYSTEM_NOTIFY_SUCCESS       0.98      0.89      0.93
499
                                  SYSTEM_OFFER       0.86      0.94      0.90
806
                             SYSTEM_OFFER_INTENT       0.85      0.97      0.91
383
               SYSTEM_OFFER|SYSTEM_INFORM_COUNT       0.92      0.93      0.93
608
              SYSTEM_OFFER|SYSTEM_NOTIFY_FAILURE       0.86      0.86      0.86
14
                                SYSTEM_REQUEST       0.96      0.95      0.96
1961
                              SYSTEM_REQ_MORE       0.89      0.94      0.91
585
                                   USER_AFFIRM       0.94      0.88      0.91
572
                             USER_AFFIRM_INTENT       0.77      0.82      0.79
139
                  USER_AFFIRM_INTENT|USER_INFORM       0.83      0.85      0.84
103
                                   USER_INFORM       0.97      0.95      0.96
1961
                             USER_INFORM_INTENT       0.95      0.91      0.93
```

```
658
            USER_INFORM_INTENT|USER_NEGATE_INTENT       0.00      0.00      0.00
0
                  USER_INFORM_INTENT|USER_SELECT       0.68      0.83      0.75
167
               USER_INFORM_INTENT|USER_THANK_YOU       0.27      0.25      0.26
12
                  USER_INFORM|USER_INFORM_INTENT       0.93      0.93      0.93
772
USER_INFORM|USER_INFORM_INTENT|USER_NEGATE_INTENT       0.00      0.00      0.00
0
      USER_INFORM|USER_INFORM_INTENT|USER_SELECT       0.74      0.65      0.69
117
   USER_INFORM|USER_INFORM_INTENT|USER_THANK_YOU       0.00      0.00      0.00
14
                        USER_INFORM|USER_NEGATE       0.83      0.85      0.84
216
                  USER_INFORM|USER_REQUEST_ALTS       0.80      0.84      0.82
184
                                    USER_NEGATE       0.57      0.57      0.57
7
                               USER_NEGATE_INTENT       0.53      0.74      0.61
69
                 USER_NEGATE_INTENT|USER_GOODBYE       0.67      0.65      0.66
72
                       USER_NEGATE|USER_GOODBYE       0.33      0.11      0.17
9
                    USER_NEGATE|USER_THANK_YOU       0.96      0.94      0.95
587
                                    USER_REQUEST       0.94      0.92      0.93
719
                               USER_REQUEST_ALTS       0.88      0.92      0.90
152
                      USER_REQUEST|USER_AFFIRM       0.91      0.91      0.91
340
                                    USER_SELECT       0.81      0.91      0.86
515
                       USER_SELECT|USER_GOODBYE       0.80      0.64      0.71
279
                                   USER_THANK_YOU       0.75      0.79      0.77
377
                     USER_THANK_YOU|USER_GOODBYE       0.78      0.80      0.79
384

                                      accuracy                           0.91
16850
                                     macro avg       0.76      0.75      0.75
16850
```

```
                                   weighted avg       0.91      0.91      0.91
16850


=== Running training for window size: 8 ===

C:\Users\Ward\AppData\Local\Temp\ipykernel_10956\3759199132.py:9: FutureWarning:
You are using `torch.load` with `weights_only=False` (the current default
value), which uses the default pickle module implicitly. It is possible to
construct malicious pickle data which will execute arbitrary code during
unpickling (See
https://github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for
more details). In a future release, the default value for `weights_only` will be
flipped to `True`. This limits the functions that could be executed during
unpickling. Arbitrary objects will no longer be allowed to be loaded via this
mode unless they are explicitly allowlisted by the user via
`torch.serialization.add_safe_globals`. We recommend you start setting
`weights_only=True` for any use case where you don't have full control of the
loaded file. Please open an issue on GitHub for any issues related to this
experimental feature.
  self.embeddings = torch.load(embeddings_path)
100%|      | 5403/5403 [01:06<00:00, 81.32it/s]
100%|      | 1331/1331 [00:11<00:00, 115.17it/s]
100%|      | 646/646 [02:17<00:00,  4.69it/s]

Epoch 1/50, Train Loss: 2.609, Train Accuracy: 23.254

100%|      | 646/646 [01:29<00:00,  7.25it/s]

Epoch 2/50, Train Loss: 1.889, Train Accuracy: 41.823

100%|      | 646/646 [01:16<00:00,  8.49it/s]

Epoch 3/50, Train Loss: 1.545, Train Accuracy: 51.638

100%|      | 646/646 [01:24<00:00,  7.68it/s]

Epoch 4/50, Train Loss: 1.312, Train Accuracy: 59.675

100%|      | 646/646 [00:58<00:00, 11.13it/s]

Epoch 5/50, Train Loss: 1.124, Train Accuracy: 67.149

100%|      | 646/646 [01:14<00:00,  8.73it/s]

Epoch 6/50, Train Loss: 0.977, Train Accuracy: 72.759

100%|      | 646/646 [00:45<00:00, 14.34it/s]

Epoch 7/50, Train Loss: 0.860, Train Accuracy: 76.955

100%|      | 646/646 [00:51<00:00, 12.55it/s]

Epoch 8/50, Train Loss: 0.740, Train Accuracy: 80.810

100%|      | 646/646 [00:44<00:00, 14.63it/s]
```

```
Epoch 9/50, Train Loss: 0.628, Train Accuracy: 84.355
100%|      | 646/646 [00:48<00:00, 13.28it/s]
Epoch 10/50, Train Loss: 0.532, Train Accuracy: 87.277
100%|      | 646/646 [01:05<00:00,  9.89it/s]
Epoch 11/50, Train Loss: 0.464, Train Accuracy: 89.197
100%|      | 646/646 [00:44<00:00, 14.57it/s]
Epoch 12/50, Train Loss: 0.409, Train Accuracy: 90.786
100%|      | 646/646 [00:37<00:00, 17.22it/s]
Epoch 13/50, Train Loss: 0.364, Train Accuracy: 92.042
100%|      | 646/646 [00:38<00:00, 16.96it/s]
Epoch 14/50, Train Loss: 0.324, Train Accuracy: 93.039
100%|      | 646/646 [00:29<00:00, 21.98it/s]
Epoch 15/50, Train Loss: 0.307, Train Accuracy: 93.524
100%|      | 646/646 [00:24<00:00, 26.80it/s]
Epoch 16/50, Train Loss: 0.265, Train Accuracy: 94.571
100%|      | 646/646 [00:27<00:00, 23.53it/s]
Epoch 17/50, Train Loss: 0.238, Train Accuracy: 95.320
100%|      | 646/646 [00:28<00:00, 22.64it/s]
Epoch 18/50, Train Loss: 0.215, Train Accuracy: 95.876
100%|      | 646/646 [00:26<00:00, 24.15it/s]
Epoch 19/50, Train Loss: 0.194, Train Accuracy: 96.282
100%|      | 646/646 [00:33<00:00, 19.19it/s]
Epoch 20/50, Train Loss: 0.177, Train Accuracy: 96.688
100%|      | 646/646 [00:29<00:00, 21.93it/s]
Epoch 21/50, Train Loss: 0.161, Train Accuracy: 97.066
100%|      | 646/646 [00:12<00:00, 50.18it/s]
Epoch 22/50, Train Loss: 0.147, Train Accuracy: 97.389
100%|      | 646/646 [00:19<00:00, 33.37it/s]
Epoch 23/50, Train Loss: 0.134, Train Accuracy: 97.692
100%|      | 646/646 [00:29<00:00, 21.79it/s]
Epoch 24/50, Train Loss: 0.122, Train Accuracy: 98.007
100%|      | 646/646 [00:20<00:00, 31.69it/s]
```

```
Epoch 25/50, Train Loss: 0.111, Train Accuracy: 98.279
100%|      | 646/646 [00:13<00:00, 49.67it/s]
Epoch 26/50, Train Loss: 0.110, Train Accuracy: 98.247
100%|      | 646/646 [00:19<00:00, 33.43it/s]
Epoch 27/50, Train Loss: 0.093, Train Accuracy: 98.685
100%|      | 646/646 [00:19<00:00, 33.75it/s]
Epoch 28/50, Train Loss: 0.085, Train Accuracy: 98.836
100%|      | 646/646 [00:22<00:00, 28.85it/s]
Epoch 29/50, Train Loss: 0.078, Train Accuracy: 98.976
100%|      | 646/646 [01:12<00:00,  8.89it/s]
Epoch 30/50, Train Loss: 0.071, Train Accuracy: 99.179
100%|      | 646/646 [00:39<00:00, 16.51it/s]
Epoch 31/50, Train Loss: 0.066, Train Accuracy: 99.250
100%|      | 646/646 [00:36<00:00, 17.51it/s]
Epoch 32/50, Train Loss: 0.059, Train Accuracy: 99.413
100%|      | 646/646 [00:31<00:00, 20.53it/s]
Epoch 33/50, Train Loss: 0.054, Train Accuracy: 99.498
100%|      | 646/646 [00:37<00:00, 17.19it/s]
Epoch 34/50, Train Loss: 0.051, Train Accuracy: 99.522
100%|      | 646/646 [00:44<00:00, 14.36it/s]
Epoch 35/50, Train Loss: 0.046, Train Accuracy: 99.613
100%|      | 646/646 [00:40<00:00, 16.13it/s]
Epoch 36/50, Train Loss: 0.040, Train Accuracy: 99.748
100%|      | 646/646 [00:51<00:00, 12.50it/s]
Epoch 37/50, Train Loss: 0.037, Train Accuracy: 99.768
100%|      | 646/646 [00:27<00:00, 23.26it/s]
Epoch 38/50, Train Loss: 0.042, Train Accuracy: 99.636
100%|      | 646/646 [00:31<00:00, 20.42it/s]
Epoch 39/50, Train Loss: 0.032, Train Accuracy: 99.824
100%|      | 646/646 [00:34<00:00, 18.96it/s]
Epoch 40/50, Train Loss: 0.028, Train Accuracy: 99.884
100%|      | 646/646 [00:34<00:00, 18.63it/s]
```

```
Epoch 41/50, Train Loss: 0.026, Train Accuracy: 99.895
100%|      | 646/646 [00:28<00:00, 22.85it/s]
Epoch 42/50, Train Loss: 0.024, Train Accuracy: 99.896
100%|      | 646/646 [00:18<00:00, 34.99it/s]
Epoch 43/50, Train Loss: 0.024, Train Accuracy: 99.901
100%|      | 646/646 [00:15<00:00, 42.82it/s]
Epoch 44/50, Train Loss: 0.019, Train Accuracy: 99.939
100%|      | 646/646 [00:18<00:00, 35.40it/s]
Epoch 45/50, Train Loss: 0.018, Train Accuracy: 99.933
100%|      | 646/646 [00:12<00:00, 49.90it/s]
Epoch 46/50, Train Loss: 0.026, Train Accuracy: 99.772
100%|      | 646/646 [00:17<00:00, 35.98it/s]
Epoch 47/50, Train Loss: 0.015, Train Accuracy: 99.959
100%|      | 646/646 [00:22<00:00, 28.66it/s]
Epoch 48/50, Train Loss: 0.013, Train Accuracy: 99.975
100%|      | 646/646 [00:13<00:00, 46.85it/s]
Epoch 49/50, Train Loss: 0.012, Train Accuracy: 99.977
100%|      | 646/646 [00:16<00:00, 38.57it/s]
Epoch 50/50, Train Loss: 0.012, Train Accuracy: 99.977

 Training complete. Model saved to 'train_logs/window_8\model.pth', stats saved
to 'train_logs/window_8\train_stats.csv'
100%|      | 132/132 [00:20<00:00,  6.45it/s]
c:\Users\Ward\anaconda3\envs\multibench\Lib\site-
packages\sklearn\metrics\_classification.py:2480: UserWarning: y_pred contains
classes not in y_true
  warnings.warn("y_pred contains classes not in y_true")


 Evaluation Results:
Top-1 Accuracy: 87.98%
Top-5 Accuracy: 98.29%
Balanced Accuracy: 69.34%

 Classification Report:
                                                    precision    recall  f1-score
support

                                SYSTEM_CONFIRM       0.88      0.89      0.89
```

```
1113
                                SYSTEM_GOODBYE       0.97      0.94      0.96
1331
                                 SYSTEM_INFORM       0.96      0.92      0.94
719
            SYSTEM_INFORM|SYSTEM_NOTIFY_SUCCESS       0.93      0.95      0.94
310
 SYSTEM_INFORM|SYSTEM_OFFER|SYSTEM_NOTIFY_FAILURE       0.50      0.18      0.26
17
          SYSTEM_NOTIFY_FAILURE|SYSTEM_REQ_MORE       0.70      0.48      0.57
79
                          SYSTEM_NOTIFY_SUCCESS       0.93      0.92      0.92
499
                                  SYSTEM_OFFER       0.80      0.93      0.86
806
                            SYSTEM_OFFER_INTENT       0.86      0.96      0.91
383
              SYSTEM_OFFER|SYSTEM_INFORM_COUNT       0.92      0.87      0.90
608
            SYSTEM_OFFER|SYSTEM_NOTIFY_FAILURE       0.67      0.43      0.52
14
                                 SYSTEM_REQUEST       0.96      0.93      0.94
1961
                               SYSTEM_REQ_MORE       0.89      0.90      0.89
585
                                    USER_AFFIRM       0.92      0.88      0.90
572
                              USER_AFFIRM_INTENT       0.66      0.63      0.65
139
                 USER_AFFIRM_INTENT|USER_INFORM       0.60      0.68      0.64
103
                                    USER_INFORM       0.97      0.93      0.95
1961
                              USER_INFORM_INTENT       0.93      0.89      0.91
658
          USER_INFORM_INTENT|USER_NEGATE_INTENT       0.00      0.00      0.00
0
                 USER_INFORM_INTENT|USER_SELECT       0.44      0.66      0.53
167
              USER_INFORM_INTENT|USER_THANK_YOU       0.08      0.08      0.08
12
                 USER_INFORM|USER_INFORM_INTENT       0.91      0.94      0.92
772
USER_INFORM|USER_INFORM_INTENT|USER_NEGATE_INTENT       0.00      0.00      0.00
0
       USER_INFORM|USER_INFORM_INTENT|USER_SELECT       0.40      0.50      0.44
117
    USER_INFORM|USER_INFORM_INTENT|USER_THANK_YOU       0.00      0.00      0.00
```

```
14
                    USER_INFORM|USER_NEGATE       0.81      0.77      0.79
216
                USER_INFORM|USER_REQUEST_ALTS       0.62      0.79      0.69
184
                             USER_NEGATE       1.00      0.14      0.25
7
                        USER_NEGATE_INTENT       0.59      0.57      0.58
69
               USER_NEGATE_INTENT|USER_GOODBYE       0.64      0.50      0.56
72
                   USER_NEGATE|USER_GOODBYE       0.00      0.00      0.00
9
                USER_NEGATE|USER_THANK_YOU       0.98      0.93      0.95
587
                             USER_REQUEST       0.93      0.86      0.90
719
                      USER_REQUEST_ALTS       0.81      0.80      0.80
152
                USER_REQUEST|USER_AFFIRM       0.85      0.92      0.88
340
                             USER_SELECT       0.76      0.90      0.82
515
                USER_SELECT|USER_GOODBYE       0.80      0.52      0.63
279
                           USER_THANK_YOU       0.71      0.67      0.69
377
               USER_THANK_YOU|USER_GOODBYE       0.70      0.79      0.74
384

                                accuracy                           0.88
16850
                               macro avg       0.69      0.66      0.66
16850
                            weighted avg       0.89      0.88      0.88
16850


=== Running training for window size: 9 ===

C:\Users\Ward\AppData\Local\Temp\ipykernel_10956\3759199132.py:9: FutureWarning:
You are using `torch.load` with `weights_only=False` (the current default
value), which uses the default pickle module implicitly. It is possible to
construct malicious pickle data which will execute arbitrary code during
unpickling (See
https://github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for
more details). In a future release, the default value for `weights_only` will be
flipped to `True`. This limits the functions that could be executed during
```

```
unpickling. Arbitrary objects will no longer be allowed to be loaded via this
mode unless they are explicitly allowlisted by the user via
`torch.serialization.add_safe_globals`. We recommend you start setting
`weights_only=True` for any use case where you don't have full control of the
loaded file. Please open an issue on GitHub for any issues related to this
experimental feature.
  self.embeddings = torch.load(embeddings_path)
100%|      | 5403/5403 [00:56<00:00, 96.48it/s]
100%|      | 1331/1331 [00:49<00:00, 26.77it/s]
100%|      | 646/646 [03:08<00:00,  3.44it/s]

Epoch 1/50, Train Loss: 2.674, Train Accuracy: 20.693

100%|      | 646/646 [01:34<00:00,  6.82it/s]

Epoch 2/50, Train Loss: 2.094, Train Accuracy: 34.621

100%|      | 646/646 [01:33<00:00,  6.92it/s]

Epoch 3/50, Train Loss: 1.807, Train Accuracy: 43.883

100%|      | 646/646 [01:17<00:00,  8.38it/s]

Epoch 4/50, Train Loss: 1.599, Train Accuracy: 49.491

100%|      | 646/646 [01:06<00:00,  9.72it/s]

Epoch 5/50, Train Loss: 1.395, Train Accuracy: 56.094

100%|      | 646/646 [00:48<00:00, 13.38it/s]

Epoch 6/50, Train Loss: 1.054, Train Accuracy: 68.751

100%|      | 646/646 [01:14<00:00,  8.70it/s]

Epoch 7/50, Train Loss: 0.871, Train Accuracy: 75.109

100%|      | 646/646 [00:43<00:00, 14.97it/s]

Epoch 8/50, Train Loss: 0.767, Train Accuracy: 78.630

100%|      | 646/646 [01:12<00:00,  8.89it/s]

Epoch 9/50, Train Loss: 0.677, Train Accuracy: 82.229

100%|      | 646/646 [00:41<00:00, 15.56it/s]

Epoch 10/50, Train Loss: 0.602, Train Accuracy: 84.819

100%|      | 646/646 [00:59<00:00, 10.92it/s]

Epoch 11/50, Train Loss: 0.538, Train Accuracy: 86.841

100%|      | 646/646 [01:09<00:00,  9.36it/s]

Epoch 12/50, Train Loss: 0.483, Train Accuracy: 88.495

100%|      | 646/646 [00:45<00:00, 14.19it/s]

Epoch 13/50, Train Loss: 0.433, Train Accuracy: 89.971
```

```
100%|      | 646/646 [00:48<00:00, 13.45it/s]
Epoch 14/50, Train Loss: 0.388, Train Accuracy: 91.221
100%|      | 646/646 [01:04<00:00, 10.07it/s]
Epoch 15/50, Train Loss: 0.349, Train Accuracy: 92.257
100%|      | 646/646 [00:31<00:00, 20.74it/s]
Epoch 16/50, Train Loss: 0.318, Train Accuracy: 93.167
100%|      | 646/646 [00:40<00:00, 16.12it/s]
Epoch 17/50, Train Loss: 0.286, Train Accuracy: 93.826
100%|      | 646/646 [00:27<00:00, 23.64it/s]
Epoch 18/50, Train Loss: 0.267, Train Accuracy: 94.299
100%|      | 646/646 [00:36<00:00, 17.86it/s]
Epoch 19/50, Train Loss: 0.241, Train Accuracy: 94.936
100%|      | 646/646 [00:32<00:00, 19.85it/s]
Epoch 20/50, Train Loss: 0.217, Train Accuracy: 95.584
100%|      | 646/646 [00:29<00:00, 21.54it/s]
Epoch 21/50, Train Loss: 0.200, Train Accuracy: 95.945
100%|      | 646/646 [00:25<00:00, 25.08it/s]
Epoch 22/50, Train Loss: 0.185, Train Accuracy: 96.262
100%|      | 646/646 [00:17<00:00, 37.16it/s]
Epoch 23/50, Train Loss: 0.169, Train Accuracy: 96.687
100%|      | 646/646 [00:16<00:00, 40.24it/s]
Epoch 24/50, Train Loss: 0.156, Train Accuracy: 97.020
100%|      | 646/646 [00:23<00:00, 27.33it/s]
Epoch 25/50, Train Loss: 0.148, Train Accuracy: 97.214
100%|      | 646/646 [00:26<00:00, 24.53it/s]
Epoch 26/50, Train Loss: 0.134, Train Accuracy: 97.573
100%|      | 646/646 [00:19<00:00, 33.08it/s]
Epoch 27/50, Train Loss: 0.123, Train Accuracy: 97.859
100%|      | 646/646 [00:28<00:00, 23.02it/s]
Epoch 28/50, Train Loss: 0.114, Train Accuracy: 98.117
100%|      | 646/646 [00:20<00:00, 30.91it/s]
Epoch 29/50, Train Loss: 0.105, Train Accuracy: 98.306
```

```
100%|      | 646/646 [00:25<00:00, 25.42it/s]
Epoch 30/50, Train Loss: 0.097, Train Accuracy: 98.495
100%|      | 646/646 [00:19<00:00, 33.83it/s]
Epoch 31/50, Train Loss: 0.091, Train Accuracy: 98.667
100%|      | 646/646 [00:13<00:00, 47.21it/s]
Epoch 32/50, Train Loss: 0.082, Train Accuracy: 98.913
100%|      | 646/646 [00:13<00:00, 47.26it/s]
Epoch 33/50, Train Loss: 0.077, Train Accuracy: 99.020
100%|      | 646/646 [00:13<00:00, 48.07it/s]
Epoch 34/50, Train Loss: 0.074, Train Accuracy: 99.102
100%|      | 646/646 [00:13<00:00, 48.06it/s]
Epoch 35/50, Train Loss: 0.070, Train Accuracy: 99.140
100%|      | 646/646 [00:13<00:00, 48.14it/s]
Epoch 36/50, Train Loss: 0.060, Train Accuracy: 99.362
100%|      | 646/646 [00:13<00:00, 48.00it/s]
Epoch 37/50, Train Loss: 0.055, Train Accuracy: 99.483
100%|      | 646/646 [00:17<00:00, 36.12it/s]
Epoch 38/50, Train Loss: 0.054, Train Accuracy: 99.498
100%|      | 646/646 [00:17<00:00, 37.98it/s]
Epoch 39/50, Train Loss: 0.055, Train Accuracy: 99.465
100%|      | 646/646 [00:15<00:00, 40.55it/s]
Epoch 40/50, Train Loss: 0.047, Train Accuracy: 99.637
100%|      | 646/646 [00:15<00:00, 40.40it/s]
Epoch 41/50, Train Loss: 0.041, Train Accuracy: 99.708
100%|      | 646/646 [00:15<00:00, 40.79it/s]
Epoch 42/50, Train Loss: 0.038, Train Accuracy: 99.777
100%|      | 646/646 [00:17<00:00, 36.26it/s]
Epoch 43/50, Train Loss: 0.034, Train Accuracy: 99.818
100%|      | 646/646 [00:24<00:00, 26.27it/s]
Epoch 44/50, Train Loss: 0.039, Train Accuracy: 99.672
100%|      | 646/646 [00:15<00:00, 42.69it/s]
Epoch 45/50, Train Loss: 0.031, Train Accuracy: 99.864
```

```
100%|      | 646/646 [00:13<00:00, 47.41it/s]
Epoch 46/50, Train Loss: 0.031, Train Accuracy: 99.835
100%|      | 646/646 [00:13<00:00, 46.73it/s]
Epoch 47/50, Train Loss: 0.031, Train Accuracy: 99.792
100%|      | 646/646 [00:14<00:00, 43.37it/s]
Epoch 48/50, Train Loss: 0.024, Train Accuracy: 99.913
100%|      | 646/646 [00:18<00:00, 34.95it/s]
Epoch 49/50, Train Loss: 0.023, Train Accuracy: 99.915
100%|      | 646/646 [00:20<00:00, 31.68it/s]
Epoch 50/50, Train Loss: 0.029, Train Accuracy: 99.787

 Training complete. Model saved to 'train_logs/window_9\model.pth', stats saved
to 'train_logs/window_9\train_stats.csv'
100%|      | 132/132 [00:24<00:00,  5.38it/s]
c:\Users\Ward\anaconda3\envs\multibench\Lib\site-
packages\sklearn\metrics\_classification.py:2480: UserWarning: y_pred contains
classes not in y_true
  warnings.warn("y_pred contains classes not in y_true")


 Evaluation Results:
Top-1 Accuracy: 86.93%
Top-5 Accuracy: 98.00%
Balanced Accuracy: 66.98%

 Classification Report:
                                                    precision    recall  f1-score
support

                                SYSTEM_CONFIRM       0.89      0.84      0.87
1113
                                SYSTEM_GOODBYE       0.94      0.94      0.94
1331
                                 SYSTEM_INFORM       0.93      0.92      0.92
719
            SYSTEM_INFORM|SYSTEM_NOTIFY_SUCCESS       0.89      0.90      0.90
310
SYSTEM_INFORM|SYSTEM_OFFER|SYSTEM_NOTIFY_FAILURE       0.33      0.12      0.17
17
          SYSTEM_NOTIFY_FAILURE|SYSTEM_REQ_MORE       0.76      0.39      0.52
79
                           SYSTEM_NOTIFY_SUCCESS       0.92      0.82      0.86
499
```

SYSTEM_OFFER	0.83	0.94	0.88	806
SYSTEM_OFFER_INTENT	0.80	0.94	0.87	383
SYSTEM_OFFER|SYSTEM_INFORM_COUNT	0.91	0.92	0.91	608
SYSTEM_OFFER|SYSTEM_NOTIFY_FAILURE	0.50	0.07	0.12	14
SYSTEM_REQUEST	0.95	0.94	0.95	1961
SYSTEM_REQ_MORE	0.85	0.85	0.85	585
USER_AFFIRM	0.85	0.74	0.79	572
USER_AFFIRM_INTENT	0.72	0.88	0.79	139
USER_AFFIRM_INTENT|USER_INFORM	0.80	0.72	0.76	103
USER_INFORM	0.95	0.96	0.96	1961
USER_INFORM_INTENT	0.92	0.91	0.92	658
USER_INFORM_INTENT|USER_NEGATE_INTENT	0.00	0.00	0.00	0
USER_INFORM_INTENT|USER_SELECT	0.55	0.68	0.61	167
USER_INFORM_INTENT|USER_THANK_YOU	0.20	0.08	0.12	12
USER_INFORM|USER_INFORM_INTENT	0.94	0.93	0.93	772
USER_INFORM|USER_INFORM_INTENT|USER_SELECT	0.47	0.47	0.47	117
USER_INFORM|USER_INFORM_INTENT|USER_THANK_YOU	0.00	0.00	0.00	14
USER_INFORM|USER_NEGATE	0.86	0.69	0.76	216
USER_INFORM|USER_REQUEST_ALTS	0.62	0.72	0.67	184
USER_NEGATE	0.00	0.00	0.00	7
USER_NEGATE_INTENT	0.65	0.58	0.61	69
USER_NEGATE_INTENT|USER_GOODBYE	0.48	0.57	0.52	72
USER_NEGATE|USER_GOODBYE	0.00	0.00	0.00	9
USER_NEGATE|USER_THANK_YOU	0.95	0.91	0.93	587

```
                                USER_REQUEST       0.93      0.84      0.88
719
                           USER_REQUEST_ALTS       0.69      0.84      0.76
152
                  USER_REQUEST|USER_AFFIRM       0.80      0.85      0.82
340
                                USER_SELECT       0.69      0.90      0.79
515
                  USER_SELECT|USER_GOODBYE       0.76      0.48      0.59
279
                             USER_THANK_YOU       0.75      0.66      0.70
377
               USER_THANK_YOU|USER_GOODBYE       0.64      0.77      0.70
384

                                  accuracy                           0.87
16850
                                 macro avg       0.68      0.65      0.65
16850
                              weighted avg       0.87      0.87      0.87
16850


=== Running training for window size: 10 ===

C:\Users\Ward\AppData\Local\Temp\ipykernel_10956\3759199132.py:9: FutureWarning:
You are using `torch.load` with `weights_only=False` (the current default
value), which uses the default pickle module implicitly. It is possible to
construct malicious pickle data which will execute arbitrary code during
unpickling (See
https://github.com/pytorch/pytorch/blob/main/SECURITY.md#untrusted-models for
more details). In a future release, the default value for `weights_only` will be
flipped to `True`. This limits the functions that could be executed during
unpickling. Arbitrary objects will no longer be allowed to be loaded via this
mode unless they are explicitly allowlisted by the user via
`torch.serialization.add_safe_globals`. We recommend you start setting
`weights_only=True` for any use case where you don't have full control of the
loaded file. Please open an issue on GitHub for any issues related to this
experimental feature.
  self.embeddings = torch.load(embeddings_path)
100%|      | 5403/5403 [01:19<00:00, 67.58it/s]
100%|      | 1331/1331 [00:27<00:00, 48.45it/s]
100%|      | 646/646 [03:31<00:00,  3.06it/s]

Epoch 1/50, Train Loss: 2.697, Train Accuracy: 20.932

100%|      | 646/646 [00:36<00:00, 17.55it/s]

Epoch 2/50, Train Loss: 2.150, Train Accuracy: 32.265
```

```
100%|      | 646/646 [02:10<00:00,  4.96it/s]
Epoch 3/50, Train Loss: 1.849, Train Accuracy: 41.505
100%|      | 646/646 [01:35<00:00,  6.75it/s]
Epoch 4/50, Train Loss: 1.628, Train Accuracy: 47.973
100%|      | 646/646 [00:45<00:00, 14.10it/s]
Epoch 5/50, Train Loss: 1.450, Train Accuracy: 54.038
100%|      | 646/646 [00:47<00:00, 13.71it/s]
Epoch 6/50, Train Loss: 1.305, Train Accuracy: 60.136
100%|      | 646/646 [00:52<00:00, 12.36it/s]
Epoch 7/50, Train Loss: 1.179, Train Accuracy: 65.568
100%|      | 646/646 [00:57<00:00, 11.28it/s]
Epoch 8/50, Train Loss: 1.066, Train Accuracy: 70.528
100%|      | 646/646 [00:39<00:00, 16.53it/s]
Epoch 9/50, Train Loss: 0.958, Train Accuracy: 75.031
100%|      | 646/646 [00:47<00:00, 13.68it/s]
Epoch 10/50, Train Loss: 0.835, Train Accuracy: 79.353
100%|      | 646/646 [00:37<00:00, 17.30it/s]
Epoch 11/50, Train Loss: 0.692, Train Accuracy: 84.047
100%|      | 646/646 [00:42<00:00, 15.29it/s]
Epoch 12/50, Train Loss: 0.602, Train Accuracy: 86.189
100%|      | 646/646 [00:37<00:00, 17.41it/s]
Epoch 13/50, Train Loss: 0.533, Train Accuracy: 87.947
100%|      | 646/646 [00:46<00:00, 14.02it/s]
Epoch 14/50, Train Loss: 0.478, Train Accuracy: 89.436
100%|      | 646/646 [00:49<00:00, 13.17it/s]
Epoch 15/50, Train Loss: 0.431, Train Accuracy: 90.552
100%|      | 646/646 [00:43<00:00, 14.95it/s]
Epoch 16/50, Train Loss: 0.394, Train Accuracy: 91.500
100%|      | 646/646 [00:45<00:00, 14.22it/s]
Epoch 17/50, Train Loss: 0.359, Train Accuracy: 92.286
100%|      | 646/646 [01:13<00:00,  8.77it/s]
Epoch 18/50, Train Loss: 0.324, Train Accuracy: 93.257
```

```
100%|      | 646/646 [01:57<00:00,  5.50it/s]
Epoch 19/50, Train Loss: 0.296, Train Accuracy: 93.962
100%|      | 646/646 [01:47<00:00,  6.01it/s]
Epoch 20/50, Train Loss: 0.270, Train Accuracy: 94.574
100%|      | 646/646 [01:27<00:00,  7.40it/s]
Epoch 21/50, Train Loss: 0.248, Train Accuracy: 95.129
100%|      | 646/646 [02:10<00:00,  4.94it/s]
Epoch 22/50, Train Loss: 0.228, Train Accuracy: 95.603
100%|      | 646/646 [00:55<00:00, 11.67it/s]
Epoch 23/50, Train Loss: 0.219, Train Accuracy: 95.830
100%|      | 646/646 [00:56<00:00, 11.37it/s]
Epoch 24/50, Train Loss: 0.195, Train Accuracy: 96.406
100%|      | 646/646 [00:53<00:00, 12.14it/s]
Epoch 25/50, Train Loss: 0.179, Train Accuracy: 96.801
100%|      | 646/646 [01:10<00:00,  9.10it/s]
Epoch 26/50, Train Loss: 0.165, Train Accuracy: 97.124
100%|      | 646/646 [01:03<00:00, 10.13it/s]
Epoch 27/50, Train Loss: 0.151, Train Accuracy: 97.465
100%|      | 646/646 [00:56<00:00, 11.49it/s]
Epoch 28/50, Train Loss: 0.142, Train Accuracy: 97.647
100%|      | 646/646 [00:45<00:00, 14.22it/s]
Epoch 29/50, Train Loss: 0.130, Train Accuracy: 97.897
100%|      | 646/646 [00:48<00:00, 13.18it/s]
Epoch 30/50, Train Loss: 0.119, Train Accuracy: 98.192
100%|      | 646/646 [01:15<00:00,  8.51it/s]
Epoch 31/50, Train Loss: 0.115, Train Accuracy: 98.225
100%|      | 646/646 [00:51<00:00, 12.48it/s]
Epoch 32/50, Train Loss: 0.104, Train Accuracy: 98.489
100%|      | 646/646 [00:55<00:00, 11.73it/s]
Epoch 33/50, Train Loss: 0.095, Train Accuracy: 98.677
100%|      | 646/646 [01:03<00:00, 10.15it/s]
Epoch 34/50, Train Loss: 0.089, Train Accuracy: 98.832
```

```
100%|      | 646/646 [01:06<00:00,  9.65it/s]
Epoch 35/50, Train Loss: 0.086, Train Accuracy: 98.853
100%|      | 646/646 [01:13<00:00,  8.74it/s]
Epoch 36/50, Train Loss: 0.074, Train Accuracy: 99.112
100%|      | 646/646 [00:57<00:00, 11.23it/s]
Epoch 37/50, Train Loss: 0.070, Train Accuracy: 99.188
100%|      | 646/646 [01:04<00:00, 10.05it/s]
Epoch 38/50, Train Loss: 0.064, Train Accuracy: 99.324
100%|      | 646/646 [00:44<00:00, 14.60it/s]
Epoch 39/50, Train Loss: 0.061, Train Accuracy: 99.356
100%|      | 646/646 [00:54<00:00, 11.91it/s]
Epoch 40/50, Train Loss: 0.058, Train Accuracy: 99.373
100%|      | 646/646 [00:54<00:00, 11.96it/s]
Epoch 41/50, Train Loss: 0.054, Train Accuracy: 99.467
100%|      | 646/646 [01:24<00:00,  7.61it/s]
Epoch 42/50, Train Loss: 0.057, Train Accuracy: 99.422
100%|      | 646/646 [00:40<00:00, 16.13it/s]
Epoch 43/50, Train Loss: 0.044, Train Accuracy: 99.667
100%|      | 646/646 [00:31<00:00, 20.53it/s]
Epoch 44/50, Train Loss: 0.043, Train Accuracy: 99.686
100%|      | 646/646 [00:42<00:00, 15.25it/s]
Epoch 45/50, Train Loss: 0.041, Train Accuracy: 99.682
100%|      | 646/646 [00:49<00:00, 13.02it/s]
Epoch 46/50, Train Loss: 0.035, Train Accuracy: 99.817
100%|      | 646/646 [01:02<00:00, 10.30it/s]
Epoch 47/50, Train Loss: 0.032, Train Accuracy: 99.867
100%|      | 646/646 [01:37<00:00,  6.61it/s]
Epoch 48/50, Train Loss: 0.033, Train Accuracy: 99.815
100%|      | 646/646 [01:03<00:00, 10.17it/s]
Epoch 49/50, Train Loss: 0.036, Train Accuracy: 99.718
100%|      | 646/646 [01:25<00:00,  7.57it/s]
```

```
Epoch 50/50, Train Loss: 0.026, Train Accuracy: 99.912

 Training complete. Model saved to 'train_logs/window_10\model.pth', stats saved
to 'train_logs/window_10\train_stats.csv'

100%|      | 132/132 [00:20<00:00,  6.50it/s]
c:\Users\Ward\anaconda3\envs\multibench\Lib\site-
packages\sklearn\metrics\_classification.py:2480: UserWarning: y_pred contains
classes not in y_true
  warnings.warn("y_pred contains classes not in y_true")


 Evaluation Results:
Top-1 Accuracy: 86.16%
Top-5 Accuracy: 97.29%
Balanced Accuracy: 67.52%

 Classification Report:
                                                    precision    recall  f1-score
support

                                SYSTEM_CONFIRM       0.89      0.79      0.84
1113
                                SYSTEM_GOODBYE       0.91      0.93      0.92
1331
                                 SYSTEM_INFORM       0.93      0.91      0.92
719
            SYSTEM_INFORM|SYSTEM_NOTIFY_SUCCESS       0.92      0.85      0.89
310
 SYSTEM_INFORM|SYSTEM_OFFER|SYSTEM_NOTIFY_FAILURE       0.60      0.18      0.27
17
          SYSTEM_NOTIFY_FAILURE|SYSTEM_REQ_MORE       0.68      0.34      0.45
79
                          SYSTEM_NOTIFY_SUCCESS       0.90      0.86      0.88
499
                                   SYSTEM_OFFER       0.82      0.92      0.86
806
                            SYSTEM_OFFER_INTENT       0.75      0.97      0.85
383
              SYSTEM_OFFER|SYSTEM_INFORM_COUNT       0.87      0.91      0.89
608
            SYSTEM_OFFER|SYSTEM_NOTIFY_FAILURE       1.00      0.29      0.44
14
                                SYSTEM_REQUEST       0.94      0.93      0.93
1961
                              SYSTEM_REQ_MORE       0.87      0.91      0.89
585
                                   USER_AFFIRM       0.90      0.78      0.84
572
```

```
                                USER_AFFIRM_INTENT       0.79      0.82      0.81
139
                     USER_AFFIRM_INTENT|USER_INFORM       0.79      0.75      0.77
103
                                     USER_INFORM       0.97      0.92      0.94
1961
                                USER_INFORM_INTENT       0.95      0.90      0.92
658
             USER_INFORM_INTENT|USER_NEGATE_INTENT       0.00      0.00      0.00
0
                    USER_INFORM_INTENT|USER_SELECT       0.62      0.75      0.68
167
                 USER_INFORM_INTENT|USER_THANK_YOU       0.00      0.00      0.00
12
                    USER_INFORM|USER_INFORM_INTENT       0.91      0.94      0.92
772
USER_INFORM|USER_INFORM_INTENT|USER_NEGATE_INTENT       0.00      0.00      0.00
0
       USER_INFORM|USER_INFORM_INTENT|USER_SELECT       0.43      0.39      0.41
117
    USER_INFORM|USER_INFORM_INTENT|USER_THANK_YOU       0.00      0.00      0.00
14
                          USER_INFORM|USER_NEGATE       0.72      0.67      0.70
216
                    USER_INFORM|USER_REQUEST_ALTS       0.56      0.77      0.65
184
                                     USER_NEGATE       0.50      0.14      0.22
7
                                USER_NEGATE_INTENT       0.46      0.58      0.51
69
                   USER_NEGATE_INTENT|USER_GOODBYE       0.56      0.50      0.53
72
                         USER_NEGATE|USER_GOODBYE       0.00      0.00      0.00
9
                      USER_NEGATE|USER_THANK_YOU       0.95      0.93      0.94
587
                                     USER_REQUEST       0.93      0.84      0.88
719
                                USER_REQUEST_ALTS       0.74      0.86      0.80
152
                         USER_REQUEST|USER_AFFIRM       0.83      0.82      0.83
340
                                     USER_SELECT       0.67      0.87      0.76
515
                         USER_SELECT|USER_GOODBYE       0.67      0.50      0.57
279
                                    USER_THANK_YOU       0.80      0.63      0.71
377
```

```
                    USER_THANK_YOU|USER_GOODBYE       0.59      0.84      0.69
384

                                       accuracy                           0.86
16850
                                      macro avg       0.68      0.64      0.64
16850
                                   weighted avg       0.87      0.86      0.86
16850


Ablation study completed! Results saved to 'ablation_window_size_results.csv'
```

Visualize the results of the different window sizes:

[ ]:
```
import pandas as pd
import matplotlib.pyplot as plt

# Load the CSV file
df = pd.read_csv("ablation_window_size_results.csv")

# Sort by window_size just to be safe
df = df.sort_values("window_size")

# Create a color-mapped table using pandas styling
styled_table = df.style.background_gradient(
    subset=["accuracy", "top5_accuracy", "balanced_accuracy"],
    cmap="Blues"
).format({
    "accuracy": "{:.2f}",
    "top5_accuracy": "{:.2f}",
    "balanced_accuracy": "{:.2f}",
    "dataset_creation_time_sec": "{:.2f}",
    "train_time_sec": "{:.2f}"
}).set_caption("Ablation Study: Window Size vs Performance")

styled_table
```

[ ]:
```
<pandas.io.formats.style.Styler at 0x1bad1322c60>
```

[23]:
```
import pandas as pd
import matplotlib.pyplot as plt

# Load CSV
df = pd.read_csv("ablation_window_size_results.csv")

# Set style
plt.style.use("seaborn-v0_8-whitegrid")
```

```
fig, axs = plt.subplots(1, 2, figsize=(15, 6))

# Plot accuracy curves
axs[0].plot(df["window_size"], df["accuracy"], label="Accuracy", marker='o')
axs[0].plot(df["window_size"], df["top5_accuracy"], label="Top-5 Accuracy",␣
 ↪marker='^')
axs[0].plot(df["window_size"], df["balanced_accuracy"], label="Balanced␣
 ↪Accuracy", marker='s')
axs[0].set_xlabel("Window Size")
axs[0].set_ylabel("Accuracy (%)")
axs[0].set_title("Performance vs. Window Size")
axs[0].legend()

# Plot time curves
axs[1].plot(df["window_size"], df["dataset_creation_time_sec"], label="Dataset␣
 ↪Creation Time", marker='o')
axs[1].plot(df["window_size"], df["train_time_sec"], label="Train Time",␣
 ↪marker='x')
axs[1].set_xlabel("Window Size")
axs[1].set_ylabel("Time (seconds)")
axs[1].set_title("Time vs. Window Size")
axs[1].legend()

plt.tight_layout()
plt.show()
fig.savefig("ablation_study_results.png", dpi=300)
```