Data Preprocess

Dataset description

The dataset used for this project is the **Street View House Numbers (SVHN)** dataset(http://ufldl.stanford.edu/housenumbers/), which is a real-world image dataset for developing machine learning and object recognition algorithms with minimal requirement on data preprocessing and formatting.

- **SVHN Dataset**: Contains color images of house numbers collected from Google Street View. Each image is 32x32 pixels in RGB format.
- **Contents**: The dataset includes a training set (`train_32x32.mat`) and a test set (`test_32x32.mat`), each containing images (X) and their corresponding labels (y).

Data Preprocessing Steps:

1. Loading the Data:

2. Preparing the Test Dataset:

3. Preparing the Training Dataset:

4. Determining the Size of the Dataset:

5. Setting the Size of the Validation Set:

6. Random Selection for Validation Data:

7. Splitting the Data:

```
% load datasets
trainData = load('train_32x32.mat');
testData = load('test_32x32.mat');

% prepare test datasets
X_test = double(testData.X) / 255;
y_test = categorical(testData.y);

% prepare train datasets
X_full = double(trainData.X) / 255;
y_full = categorical(trainData.y);

% Determine the total size of the dataset
total_samples = size(X_full, 4);

% Set Verification Set Size (20%)
val_size = floor(0.2 * total_samples);

% Randomly select validation data
rng(1); % For repeatability, seed the random number generator
indices = randperm(total_samples);
```

```
% Split data to validation datasets and train datasets
X_val = X_full(:,:,:,indices(1:val_size));
y_val = y_full(indices(1:val_size));
X_train = X_full(:,:,:,indices(val_size+1:end));
y_train = y_full(indices(val_size+1:end));
```

Create Layer_A

Layers_A:

- **Image Input Layer**: Receives a 3-channel image of 32x32 pixels.
- **Convolutional Layer**: Use 20 5x5 filters with "same" padding.
- **ReLU Layer**: Activation function layer, using ReLU function to increase nonlinearity.
- **Max Pooling Layer**: Use a 2x2 window and a stride of 2 to reduce the feature dimension.
- **Fully Connected Layer** : Contains 10 neurons and is used for classification.
- **Softmax Layer**: Converts the output of the fully connected layer into a probability distribution.
- **Classification Layer**: Outputs the final classification results.

```
layers_A = [
    imageInputLayer([32 32 3], 'Name', 'input')
    convolution2dLayer(5, 20, 'Padding', 'same', 'Name', 'conv1')
    reluLayer('Name', 'relu1')
    maxPooling2dLayer(2, 'Stride', 2, 'Name', 'maxpool1')
    fullyConnectedLayer(10, 'Name', 'fc')
    softmaxLayer('Name', 'softmax')
    classificationLayer('Name', 'output')
];

options = trainingOptions('sgdm', ...
    'InitialLearnRate', 0.01, ...
    'MaxEpochs', 10, ...
    'MiniBatchSize', 128, ...
    'Shuffle', 'every-epoch', ...
    'ValidationData', {X_val, y_val}, ...  % 确保使用逗号分隔这一行和下一行
    'ValidationFrequency', 30, ...
    'Verbose', true, ...
    'Plots', 'training-progress');
```

Train net_A

```
net_A = trainNetwork(X_train, y_train, layers_A, options);
```

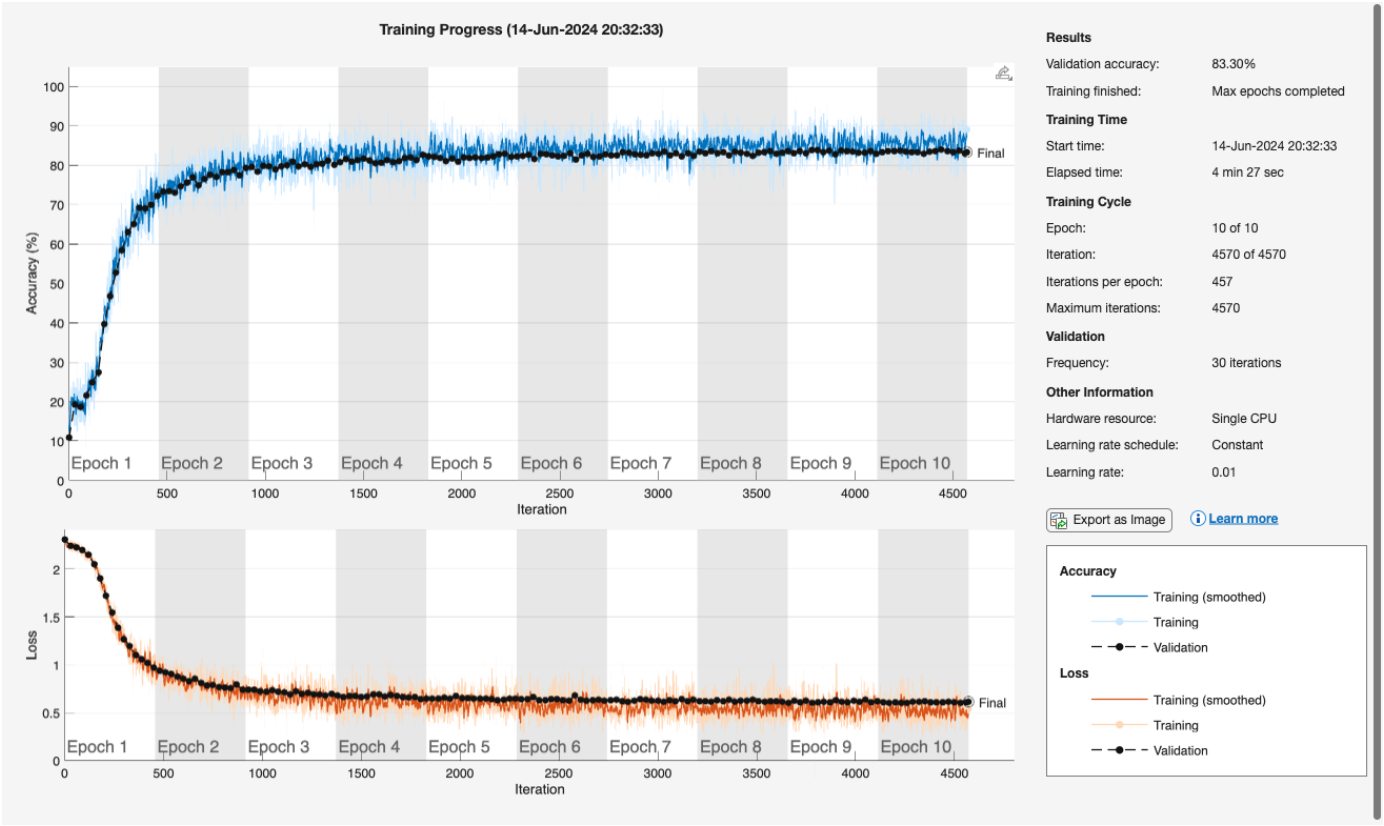
```
Training on single CPU.
Initializing input data normalization.
|=========================================================================================================
|  Epoch  |  Iteration  |  Time Elapsed  |  Mini-batch  |  Validation  |  Mini-batch  |  Validation  |  Ba
|         |             |   (hh:mm:ss)   |   Accuracy   |   Accuracy   |     Loss     |     Loss     |
|=========================================================================================================
|       1 |           1 |       00:00:01 |       12.50% |       10.81% |       2.3052 |       2.3085 |
```

1	30	00:00:03	21.09%	19.24%	2.1983	2.2422
1	50	00:00:04	19.53%		2.2444	
1	60	00:00:05	16.41%	18.57%	2.2415	2.2254
1	90	00:00:07	24.22%	21.55%	2.1481	2.1981
1	100	00:00:07	25.78%		2.1484	
1	120	00:00:08	20.31%	24.92%	2.2017	2.1498
1	150	00:00:10	27.34%	27.42%	2.0406	2.0488
1	180	00:00:12	39.84%	39.72%	1.9771	1.9045
1	200	00:00:13	38.28%		1.8505	
1	210	00:00:14	42.97%	46.72%	1.7677	1.7208
1	240	00:00:15	60.16%	52.73%	1.4121	1.5445
1	250	00:00:16	63.28%		1.3334	
1	270	00:00:17	57.81%	58.42%	1.3703	1.3876
1	300	00:00:19	64.06%	63.09%	1.2931	1.2644
1	330	00:00:20	60.16%	65.07%	1.3002	1.1924
1	350	00:00:21	60.16%		1.2026	
1	360	00:00:22	64.84%	69.14%	1.2207	1.1025
1	390	00:00:24	75.00%	69.09%	0.9940	1.0572
1	400	00:00:24	73.44%		1.0257	
1	420	00:00:25	67.19%	69.94%	0.9835	1.0200
1	450	00:00:27	68.75%	72.23%	0.9307	0.9711
2	480	00:00:29	68.75%	73.28%	1.0640	0.9365
2	500	00:00:29	75.00%		0.7930	
2	510	00:00:30	71.88%	73.38%	0.9526	0.9213
2	540	00:00:32	76.56%	73.08%	0.9683	0.9059
2	550	00:00:32	75.00%		0.7443	
2	570	00:00:34	76.56%	74.69%	0.7863	0.8777
2	600	00:00:35	80.47%	75.54%	0.7659	0.8551
2	630	00:00:37	77.34%	76.90%	0.8436	0.8290
2	650	00:00:37	71.09%		0.9225	
2	660	00:00:38	77.34%	74.95%	0.7585	0.8518
2	690	00:00:40	80.47%	76.47%	0.6241	0.8082
2	700	00:00:40	78.12%		0.7695	
2	720	00:00:42	82.03%	77.63%	0.6367	0.7828
2	750	00:00:43	75.78%	77.00%	0.7349	0.7894
2	780	00:00:45	79.69%	78.20%	0.6425	0.7668
2	800	00:00:45	83.59%		0.6562	
2	810	00:00:47	79.69%	78.24%	0.8073	0.7582
2	840	00:00:48	81.25%	78.83%	0.6288	0.7534
2	850	00:00:49	75.00%		0.9248	
2	870	00:00:50	85.94%	77.48%	0.5460	0.7933
2	900	00:00:52	78.12%	79.26%	0.8652	0.7387
3	930	00:00:53	82.03%	79.63%	0.8573	0.7390
3	950	00:00:54	78.91%		0.7645	
3	960	00:00:55	85.16%	78.44%	0.5722	0.7400
3	990	00:00:57	84.38%	79.83%	0.5832	0.7237
3	1000	00:00:57	82.81%		0.6549	
3	1020	00:00:58	78.91%	79.77%	0.7945	0.7187
3	1050	00:01:00	79.69%	78.89%	0.6629	0.7328
3	1080	00:01:02	86.72%	79.69%	0.5024	0.7182
3	1100	00:01:02	81.25%		0.5404	
3	1110	00:01:03	81.25%	80.02%	0.7640	0.7142
3	1140	00:01:05	82.03%	80.92%	0.7181	0.6871
3	1150	00:01:05	78.12%		0.7140	
3	1170	00:01:07	88.28%	79.70%	0.5053	0.7251
3	1200	00:01:08	82.03%	80.31%	0.6097	0.6959
3	1230	00:01:10	76.56%	79.58%	0.7092	0.7077
3	1250	00:01:11	75.00%		0.8492	
3	1260	00:01:12	81.25%	80.29%	0.5491	0.6898
3	1290	00:01:13	78.91%	80.33%	0.7404	0.6919
3	1300	00:01:14	85.16%		0.5064	
3	1320	00:01:15	85.16%	81.20%	0.5599	0.6759
3	1350	00:01:17	83.59%	80.12%	0.4930	0.6959
4	1380	00:01:18	81.25%	80.74%	0.7887	0.6813

4	1400	00:01:19	80.47%		0.7663	
4	1410	00:01:20	85.16%	81.62%	0.5729	0.6625
4	1440	00:01:22	79.69%	80.97%	0.6972	0.6734
4	1450	00:01:22	85.16%		0.5679	
4	1470	00:01:23	81.25%	81.38%	0.6635	0.6731
4	1500	00:01:25	88.28%	81.66%	0.5719	0.6640
4	1530	00:01:27	86.72%	81.23%	0.5239	0.6702
4	1550	00:01:27	85.94%		0.7160	
4	1560	00:01:29	81.25%	80.45%	0.6482	0.6888
4	1590	00:01:30	83.59%	80.60%	0.6376	0.6868
4	1600	00:01:30	79.69%		0.7751	
4	1620	00:01:32	82.81%	81.33%	0.6164	0.6678
4	1650	00:01:33	79.69%	80.74%	0.6978	0.6865
4	1680	00:01:35	82.81%	81.02%	0.6176	0.6740
4	1700	00:01:36	82.03%		0.5918	
4	1710	00:01:37	86.72%	81.81%	0.5344	0.6598
4	1740	00:01:38	78.91%	81.95%	0.7644	0.6548
4	1750	00:01:39	79.69%		0.7226	
4	1770	00:01:40	83.59%	81.33%	0.7010	0.6637
4	1800	00:01:42	83.59%	82.59%	0.5466	0.6377
5	1830	00:01:44	79.69%	82.22%	0.7588	0.6459
5	1850	00:01:44	82.81%		0.5222	
5	1860	00:01:45	83.59%	82.13%	0.5408	0.6430
5	1890	00:01:47	85.16%	81.84%	0.5908	0.6460
5	1900	00:01:47	80.47%		0.6802	
5	1920	00:01:49	78.12%	81.01%	0.7717	0.6589
5	1950	00:01:51	85.94%	81.76%	0.5096	0.6449
5	1980	00:01:52	83.59%	80.96%	0.5567	0.6711
5	2000	00:01:53	87.50%		0.5707	
5	2010	00:01:54	76.56%	81.93%	0.8524	0.6507
5	2040	00:01:56	85.94%	81.80%	0.4570	0.6531
5	2050	00:01:56	80.47%		0.7110	
5	2070	00:01:57	75.00%	81.93%	0.7716	0.6439
5	2100	00:01:59	87.50%	81.89%	0.4978	0.6434
5	2130	00:02:01	85.16%	81.99%	0.5163	0.6475
5	2150	00:02:01	85.94%		0.5088	
5	2160	00:02:02	82.03%	82.21%	0.6378	0.6417
5	2190	00:02:04	77.34%	82.84%	0.7652	0.6273
5	2200	00:02:04	83.59%		0.5888	
5	2220	00:02:06	86.72%	82.90%	0.4526	0.6329
5	2250	00:02:07	78.91%	82.08%	0.6598	0.6463
5	2280	00:02:09	80.47%	82.28%	0.7867	0.6481
6	2300	00:02:10	85.94%		0.4180	
6	2310	00:02:11	85.94%	82.43%	0.4397	0.6405
6	2340	00:02:13	81.25%	82.60%	0.6915	0.6394
6	2350	00:02:13	85.94%		0.5092	
6	2370	00:02:14	82.81%	81.58%	0.5870	0.6597
6	2400	00:02:16	73.44%	82.85%	0.7394	0.6312
6	2430	00:02:18	82.03%	82.80%	0.6351	0.6291
6	2450	00:02:19	84.38%		0.4632	
6	2460	00:02:20	83.59%	82.55%	0.4920	0.6401
6	2490	00:02:22	83.59%	82.26%	0.5517	0.6384
6	2500	00:02:22	81.25%		0.7872	
6	2520	00:02:23	78.91%	82.39%	0.8200	0.6308
6	2550	00:02:25	85.94%	83.02%	0.5165	0.6246
6	2580	00:02:27	83.59%	81.40%	0.7242	0.6799
6	2600	00:02:27	81.25%		0.5917	
6	2610	00:02:28	89.06%	82.45%	0.5216	0.6373
6	2640	00:02:30	86.72%	82.92%	0.6261	0.6241
6	2650	00:02:31	82.81%		0.4716	
6	2670	00:02:32	82.03%	82.12%	0.6583	0.6309
6	2700	00:02:34	85.94%	82.19%	0.4844	0.6358
6	2730	00:02:35	80.47%	82.74%	0.6005	0.6216
7	2750	00:02:36	80.47%		0.5412	

7	2760	00:02:37	84.38%	82.56%	0.4903	0.6318
7	2790	00:02:39	78.91%	82.45%	0.6295	0.6336
7	2800	00:02:39	84.38%		0.4888	
7	2820	00:02:41	89.84%	83.35%	0.4371	0.6169
7	2850	00:02:43	82.03%	83.21%	0.6471	0.6151
7	2880	00:02:45	86.72%	82.75%	0.3995	0.6264
7	2900	00:02:45	79.69%		0.5080	
7	2910	00:02:46	85.94%	82.66%	0.5413	0.6408
7	2940	00:02:48	82.81%	82.45%	0.5489	0.6367
7	2950	00:02:49	86.72%		0.4919	
7	2970	00:02:50	85.94%	83.00%	0.5037	0.6214
7	3000	00:02:52	81.25%	82.98%	0.6547	0.6240
7	3030	00:02:54	84.38%	83.47%	0.5125	0.6127
7	3050	00:02:55	89.84%		0.3818	
7	3060	00:02:56	87.50%	82.49%	0.4735	0.6273
7	3090	00:02:58	85.94%	83.11%	0.5571	0.6178
7	3100	00:02:59	84.38%		0.4624	
7	3120	00:03:00	83.59%	82.23%	0.5238	0.6381
7	3150	00:03:02	89.06%	83.01%	0.4576	0.6169
7	3180	00:03:04	85.94%	82.38%	0.4863	0.6343
8	3200	00:03:05	84.38%		0.6332	
8	3210	00:03:06	88.28%	83.41%	0.3966	0.6163
8	3240	00:03:08	86.72%	83.03%	0.4549	0.6172
8	3250	00:03:08	82.81%		0.6735	
8	3270	00:03:10	82.81%	83.52%	0.5042	0.6104
8	3300	00:03:11	85.16%	83.02%	0.5092	0.6271
8	3330	00:03:13	81.25%	83.37%	0.5178	0.6193
8	3350	00:03:14	90.62%		0.3636	
8	3360	00:03:15	79.69%	82.53%	0.6834	0.6330
8	3390	00:03:16	84.38%	83.40%	0.4692	0.6149
8	3400	00:03:17	87.50%		0.4012	
8	3420	00:03:18	82.81%	83.12%	0.5613	0.6226
8	3450	00:03:20	84.38%	82.95%	0.6606	0.6238
8	3480	00:03:22	83.59%	82.34%	0.5980	0.6349
8	3500	00:03:22	85.94%		0.4819	
8	3510	00:03:23	84.38%	83.19%	0.5679	0.6155
8	3540	00:03:25	82.03%	83.32%	0.6515	0.6124
8	3550	00:03:25	86.72%		0.4455	
8	3570	00:03:27	85.94%	83.61%	0.4898	0.6161
8	3600	00:03:29	88.28%	82.89%	0.4632	0.6198
8	3630	00:03:30	81.25%	83.24%	0.6764	0.6117
8	3650	00:03:31	82.81%		0.4175	
9	3660	00:03:32	85.94%	83.61%	0.4895	0.6036
9	3690	00:03:34	89.06%	83.11%	0.4658	0.6210
9	3700	00:03:34	86.72%		0.4950	
9	3720	00:03:35	86.72%	83.58%	0.3862	0.6081
9	3750	00:03:37	89.06%	83.05%	0.4458	0.6256
9	3780	00:03:39	91.41%	83.86%	0.3063	0.6020
9	3800	00:03:39	85.16%		0.6457	
9	3810	00:03:41	79.69%	83.86%	0.6989	0.6045
9	3840	00:03:42	84.38%	83.33%	0.5017	0.6141
9	3850	00:03:43	83.59%		0.5662	
9	3870	00:03:44	78.91%	83.75%	0.6855	0.6076
9	3900	00:03:46	82.81%	82.79%	0.5528	0.6268
9	3930	00:03:47	84.38%	83.67%	0.5865	0.6116
9	3950	00:03:48	82.03%		0.5218	
9	3960	00:03:49	90.62%	83.52%	0.3717	0.6054
9	3990	00:03:51	84.38%	83.39%	0.5167	0.6237
9	4000	00:03:51	84.38%		0.5883	
9	4020	00:03:53	82.81%	83.18%	0.5581	0.6133
9	4050	00:03:54	89.06%	83.20%	0.4824	0.6320
9	4080	00:03:56	85.16%	83.62%	0.4169	0.6069
9	4100	00:03:56	83.59%		0.5362	
9	4110	00:03:58	83.59%	82.92%	0.6201	0.6182

```
|      10 |        4140 |       00:03:59 |       84.38% |       83.38% |       0.6041 |       0.6084 |
|      10 |        4150 |       00:04:00 |       89.06% |              |       0.4067 |              |
|      10 |        4170 |       00:04:01 |       85.16% |       83.63% |       0.4624 |       0.6038 |
|      10 |        4200 |       00:04:03 |       85.94% |       83.56% |       0.5097 |       0.6059 |
|      10 |        4230 |       00:04:05 |       81.25% |       83.69% |       0.8542 |       0.5999 |
|      10 |        4250 |       00:04:05 |       79.69% |              |       0.7460 |              |
|      10 |        4260 |       00:04:07 |       83.59% |       83.52% |       0.4999 |       0.6027 |
|      10 |        4290 |       00:04:08 |       85.94% |       83.33% |       0.5032 |       0.6110 |
|      10 |        4300 |       00:04:09 |       82.81% |              |       0.6316 |              |
|      10 |        4320 |       00:04:10 |       86.72% |       83.35% |       0.4072 |       0.6138 |
|      10 |        4350 |       00:04:12 |       83.59% |       82.97% |       0.6366 |       0.6194 |
|      10 |        4380 |       00:04:14 |       85.16% |       83.44% |       0.4754 |       0.6067 |
|      10 |        4400 |       00:04:14 |       88.28% |              |       0.4459 |              |
|      10 |        4410 |       00:04:15 |       88.28% |       83.65% |       0.3747 |       0.6074 |
|      10 |        4440 |       00:04:17 |       85.16% |       83.95% |       0.4895 |       0.6085 |
|      10 |        4450 |       00:04:18 |       85.94% |              |       0.5059 |              |
|      10 |        4470 |       00:04:19 |       80.47% |       83.61% |       0.8061 |       0.6113 |
|      10 |        4500 |       00:04:21 |       84.38% |       83.37% |       0.4858 |       0.6075 |
|      10 |        4530 |       00:04:23 |       86.72% |       83.69% |       0.7227 |       0.6025 |
|      10 |        4550 |       00:04:23 |       85.16% |              |       0.5047 |              |
|      10 |        4560 |       00:04:25 |       84.38% |       83.09% |       0.5656 |       0.6093 |
|      10 |        4570 |       00:04:26 |       89.06% |       83.30% |       0.5343 |       0.6117 |
|=========|=============|================|==============|==============|==============|==============|
Training finished: Max epochs completed.
```



Evaluate net_A

```
YPred = classify(net_A, X_test);
accuracy = sum(YPred == y_test) / numel(y_test);
disp(['Test Accuracy for net_A: ', num2str(accuracy)]);
```

```
Test Accuracy for net_A: 0.81999
```

Create Layer_B

Layers_B:(Add more convolutional layers and filters)

- **Image Input Layer**: Same as configuration A.
- **First Convolutional Layer**: Use 32 5x5 filters with "same" padding.
- **ReLU Layer**: Same as configuration A.
- **Max Pooling Layer** : Same as configuration A.
- **Second Convolutional Layer**: Use 64 5x5 filters with "same" padding.
- **ReLU Layer**: Same as above.
- **Second Max Pooling Layer** : Same as the first layer.
- **Fully Connected Layer** : Same as configuration A.
- **Softmax Layer**: Same as configuration A.
- **Classification Layer**: Same as configuration A.

```
layers_B = [
    imageInputLayer([32 32 3], 'Name', 'input')
    convolution2dLayer(5, 32, 'Padding', 'same', 'Name', 'conv1')
    reluLayer('Name', 'relu1')
    maxPooling2dLayer(2, 'Stride', 2, 'Name', 'maxpool1')
    convolution2dLayer(5, 64, 'Padding', 'same', 'Name', 'conv2')
    reluLayer('Name', 'relu2')
    maxPooling2dLayer(2, 'Stride', 2, 'Name', 'maxpool2')
    fullyConnectedLayer(10, 'Name', 'fc')
    softmaxLayer('Name', 'softmax')
    classificationLayer('Name', 'output')
];
```

Train & Evaluate net_B

```
net_B = trainNetwork(X_train, y_train, layers_B, options);
```

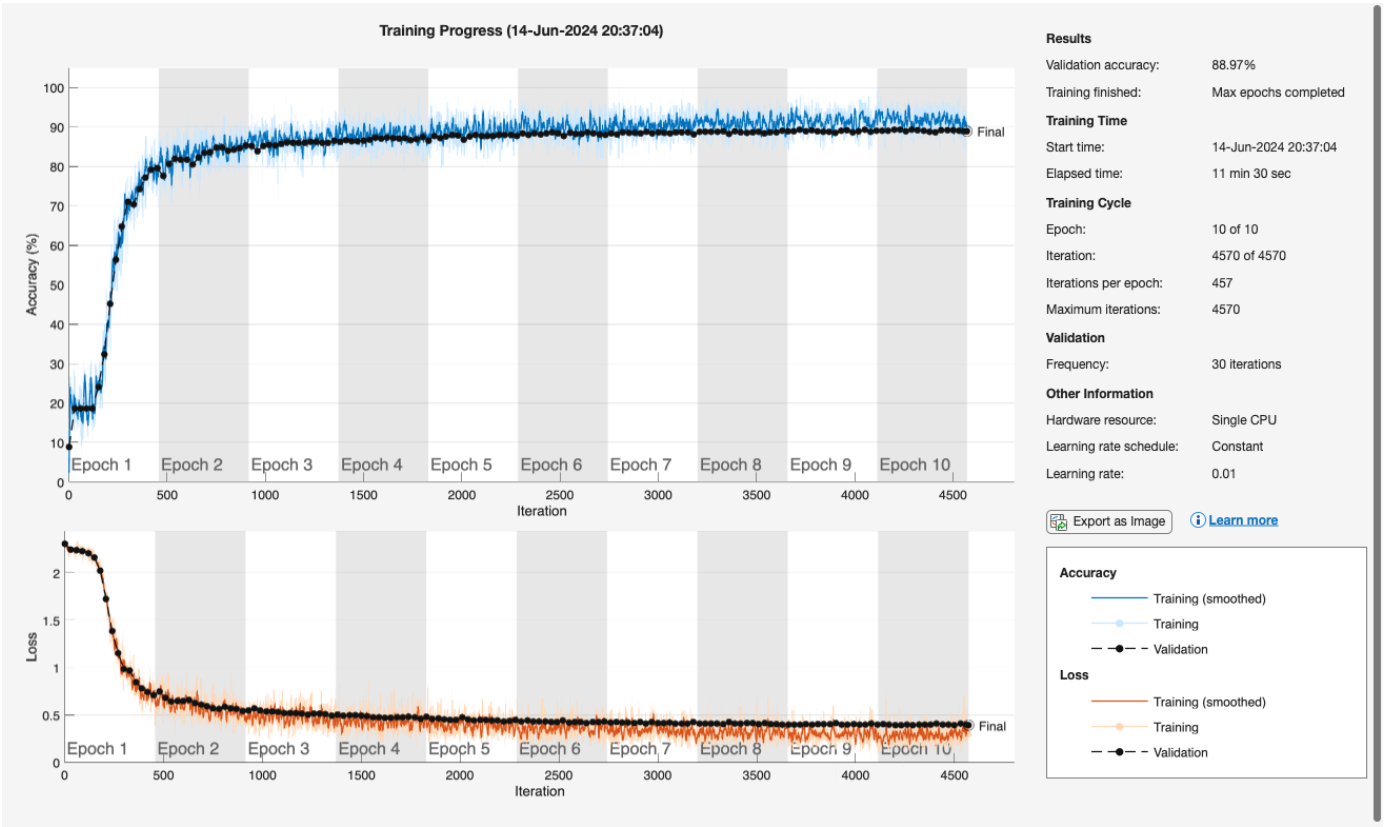
```
Training on single CPU.
Initializing input data normalization.
|=========================================================================================================
|  Epoch  |  Iteration  |  Time Elapsed  |  Mini-batch  |  Validation  |  Mini-batch  |  Validation  |  Ba
|         |             |   (hh:mm:ss)   |   Accuracy   |   Accuracy   |     Loss     |     Loss     |
|=========================================================================================================
|       1 |           1 |       00:00:03 |        2.34% |        8.87% |       2.3103 |       2.3055 |
|       1 |          30 |       00:00:07 |       14.84% |       18.56% |       2.2528 |       2.2479 |
|       1 |          50 |       00:00:09 |       21.88% |              |       2.1961 |              |
|       1 |          60 |       00:00:12 |       18.75% |       18.58% |       2.2135 |       2.2388 |
|       1 |          90 |       00:00:17 |       15.62% |       18.56% |       2.2294 |       2.2296 |
|       1 |         100 |       00:00:18 |       17.19% |              |       2.2387 |              |
|       1 |         120 |       00:00:22 |       15.62% |       18.57% |       2.2289 |       2.2083 |
|       1 |         150 |       00:00:26 |       25.00% |       24.07% |       2.1480 |       2.1610 |
|       1 |         180 |       00:00:31 |       35.16% |       32.31% |       2.0081 |       2.0225 |
|       1 |         200 |       00:00:33 |       42.19% |              |       1.8291 |              |
|       1 |         210 |       00:00:36 |       42.19% |       45.14% |       1.7439 |       1.7241 |
|       1 |         240 |       00:00:41 |       57.81% |       56.34% |       1.3971 |       1.3860 |
```

1	250	00:00:41	66.41%		1.1448	
1	270	00:00:45	66.41%	64.83%	1.0505	1.1518
1	300	00:00:50	69.53%	71.01%	1.0555	0.9853
1	330	00:00:55	66.41%	70.43%	0.9799	0.9669
1	350	00:00:57	76.56%		0.8867	
1	360	00:01:00	71.09%	74.28%	0.8944	0.8466
1	390	00:01:05	69.53%	77.22%	0.8941	0.7804
1	400	00:01:05	80.47%		0.6583	
1	420	00:01:09	84.38%	79.18%	0.5976	0.7403
1	450	00:01:14	80.47%	79.54%	0.7238	0.7093
2	480	00:01:19	78.12%	77.61%	0.7303	0.7489
2	500	00:01:20	78.91%		0.7844	
2	510	00:01:23	81.25%	80.65%	0.5802	0.6783
2	540	00:01:28	85.94%	82.00%	0.5387	0.6427
2	550	00:01:29	82.03%		0.6220	
2	570	00:01:32	78.91%	81.75%	0.6957	0.6477
2	600	00:01:37	79.69%	81.78%	0.6864	0.6450
2	630	00:01:42	85.16%	80.54%	0.5498	0.6610
2	650	00:01:43	85.94%		0.5939	
2	660	00:01:46	80.47%	82.23%	0.6890	0.6262
2	690	00:01:51	79.69%	83.39%	0.8842	0.6074
2	700	00:01:52	85.94%		0.4647	
2	720	00:01:55	78.12%	83.56%	0.6896	0.5917
2	750	00:02:00	87.50%	84.77%	0.4773	0.5712
2	780	00:02:04	84.38%	84.79%	0.5611	0.5664
2	800	00:02:06	83.59%		0.4809	
2	810	00:02:09	83.59%	83.93%	0.6865	0.5842
2	840	00:02:13	82.81%	84.19%	0.4846	0.5668
2	850	00:02:14	86.72%		0.5579	
2	870	00:02:17	89.84%	84.69%	0.3672	0.5615
2	900	00:02:22	89.84%	85.28%	0.4112	0.5409
3	930	00:02:26	82.03%	85.12%	0.6405	0.5462
3	950	00:02:27	90.62%		0.3762	
3	960	00:02:30	91.41%	83.84%	0.2949	0.5712
3	990	00:02:35	90.62%	85.25%	0.3504	0.5494
3	1000	00:02:35	91.41%		0.3493	
3	1020	00:02:39	83.59%	85.45%	0.5138	0.5357
3	1050	00:02:43	87.50%	85.32%	0.4350	0.5356
3	1080	00:02:48	85.94%	85.72%	0.5652	0.5297
3	1100	00:02:49	87.50%		0.7502	
3	1110	00:02:53	89.84%	86.10%	0.3873	0.5173
3	1140	00:02:57	85.16%	85.99%	0.5479	0.5205
3	1150	00:02:58	86.72%		0.4500	
3	1170	00:03:01	84.38%	85.94%	0.5874	0.5215
3	1200	00:03:06	92.97%	86.03%	0.4578	0.5115
3	1230	00:03:10	89.06%	86.31%	0.4134	0.5035
3	1250	00:03:11	82.81%		0.7352	
3	1260	00:03:14	91.41%	86.23%	0.5057	0.5134
3	1290	00:03:18	84.38%	86.04%	0.5424	0.5116
3	1300	00:03:19	84.38%		0.3851	
3	1320	00:03:23	85.16%	85.96%	0.4446	0.5065
3	1350	00:03:27	87.50%	86.54%	0.4647	0.4934
4	1380	00:03:32	82.81%	86.24%	0.6137	0.5021
4	1400	00:03:33	91.41%		0.3255	
4	1410	00:03:36	91.41%	86.62%	0.3199	0.4938
4	1440	00:03:40	90.62%	86.33%	0.3455	0.4976
4	1450	00:03:41	88.28%		0.3359	
4	1470	00:03:45	90.62%	86.39%	0.2957	0.4969
4	1500	00:03:50	92.19%	86.57%	0.3045	0.4914
4	1530	00:03:54	91.41%	86.83%	0.3592	0.4857
4	1550	00:03:56	89.84%		0.3121	
4	1560	00:03:59	85.94%	87.38%	0.4368	0.4750
4	1590	00:04:03	87.50%	87.02%	0.4010	0.4746
4	1600	00:04:04	93.75%		0.3247	

4	1620	00:04:08	89.06%	87.37%	0.4827	0.4721
4	1650	00:04:12	89.84%	87.17%	0.3787	0.4720
4	1680	00:04:17	87.50%	87.05%	0.5514	0.4774
4	1700	00:04:18	85.94%		0.4060	
4	1710	00:04:21	88.28%	87.15%	0.6039	0.4752
4	1740	00:04:26	92.97%	86.71%	0.2911	0.4797
4	1750	00:04:27	89.84%		0.3117	
4	1770	00:04:30	83.59%	86.92%	0.4491	0.4746
4	1800	00:04:35	81.25%	87.41%	0.6471	0.4584
5	1830	00:04:39	89.06%	86.54%	0.3324	0.4817
5	1850	00:04:40	86.72%		0.3742	
5	1860	00:04:43	85.94%	87.78%	0.4937	0.4587
5	1890	00:04:48	85.16%	87.17%	0.5315	0.4665
5	1900	00:04:49	85.16%		0.4091	
5	1920	00:04:52	89.06%	87.63%	0.3896	0.4509
5	1950	00:04:57	92.19%	88.03%	0.2880	0.4492
5	1980	00:05:02	93.75%	87.91%	0.2903	0.4499
5	2000	00:05:03	83.59%		0.5031	
5	2010	00:05:06	93.75%	86.80%	0.3336	0.4740
5	2040	00:05:11	91.41%	87.58%	0.2642	0.4524
5	2050	00:05:11	90.62%		0.4931	
5	2070	00:05:15	94.53%	88.03%	0.2289	0.4412
5	2100	00:05:20	92.19%	87.75%	0.2384	0.4468
5	2130	00:05:24	84.38%	87.71%	0.5005	0.4470
5	2150	00:05:26	89.84%		0.2996	
5	2160	00:05:29	85.16%	87.76%	0.5092	0.4440
5	2190	00:05:33	87.50%	87.94%	0.4400	0.4434
5	2200	00:05:34	88.28%		0.3324	
5	2220	00:05:38	86.72%	88.01%	0.4153	0.4330
5	2250	00:05:42	92.19%	88.05%	0.3399	0.4380
5	2280	00:05:46	89.06%	87.76%	0.3640	0.4481
6	2300	00:05:48	92.97%		0.2825	
6	2310	00:05:51	89.84%	88.41%	0.3246	0.4284
6	2340	00:05:56	87.50%	88.02%	0.3683	0.4399
6	2350	00:05:56	90.62%		0.3035	
6	2370	00:06:00	87.50%	88.44%	0.4661	0.4309
6	2400	00:06:05	92.97%	88.16%	0.2780	0.4324
6	2430	00:06:09	86.72%	88.42%	0.4028	0.4300
6	2450	00:06:11	84.38%		0.3655	
6	2460	00:06:13	90.62%	88.59%	0.3552	0.4237
6	2490	00:06:18	90.62%	88.39%	0.3022	0.4271
6	2500	00:06:19	88.28%		0.3690	
6	2520	00:06:22	86.72%	87.78%	0.3720	0.4413
6	2550	00:06:26	88.28%	88.46%	0.3346	0.4190
6	2580	00:06:31	85.16%	88.24%	0.4306	0.4267
6	2600	00:06:32	87.50%		0.3497	
6	2610	00:06:35	89.06%	88.31%	0.3185	0.4263
6	2640	00:06:39	88.28%	88.64%	0.2577	0.4160
6	2650	00:06:40	90.62%		0.2605	
6	2670	00:06:44	89.84%	88.36%	0.3132	0.4251
6	2700	00:06:48	95.31%	88.11%	0.2037	0.4272
6	2730	00:06:52	90.62%	87.99%	0.3068	0.4308
7	2750	00:06:54	94.53%		0.3426	
7	2760	00:06:57	89.84%	88.40%	0.3181	0.4184
7	2790	00:07:01	91.41%	88.10%	0.4036	0.4273
7	2800	00:07:02	87.50%		0.4017	
7	2820	00:07:06	92.97%	88.62%	0.2273	0.4182
7	2850	00:07:10	91.41%	88.52%	0.2793	0.4173
7	2880	00:07:14	91.41%	88.55%	0.3153	0.4123
7	2900	00:07:16	87.50%		0.3503	
7	2910	00:07:19	92.97%	88.34%	0.2812	0.4251
7	2940	00:07:23	94.53%	88.74%	0.2423	0.4105
7	2950	00:07:24	91.41%		0.2722	
7	2970	00:07:28	92.97%	88.35%	0.2681	0.4235

7	3000	00:07:32	88.28%	88.68%	0.3041	0.4142
7	3030	00:07:36	85.94%	88.50%	0.5035	0.4142
7	3050	00:07:38	92.97%		0.2744	
7	3060	00:07:41	94.53%	88.37%	0.2394	0.4189
7	3090	00:07:45	89.06%	88.62%	0.3723	0.4100
7	3100	00:07:46	89.84%		0.2870	
7	3120	00:07:49	89.84%	88.70%	0.2874	0.4077
7	3150	00:07:54	89.06%	88.69%	0.3645	0.4098
7	3180	00:07:58	88.28%	88.06%	0.3610	0.4230
8	3200	00:07:59	90.62%		0.2661	
8	3210	00:08:02	92.97%	88.72%	0.3613	0.4107
8	3240	00:08:07	86.72%	88.85%	0.4459	0.4100
8	3250	00:08:07	92.19%		0.2062	
8	3270	00:08:11	93.75%	88.84%	0.2229	0.4080
8	3300	00:08:15	95.31%	88.83%	0.2491	0.4099
8	3330	00:08:20	90.62%	88.96%	0.2785	0.4035
8	3350	00:08:21	87.50%		0.4681	
8	3360	00:08:24	92.97%	88.27%	0.2473	0.4271
8	3390	00:08:28	88.28%	88.95%	0.3076	0.4075
8	3400	00:08:29	90.62%		0.2856	
8	3420	00:08:33	89.84%	88.64%	0.4817	0.4095
8	3450	00:08:37	96.09%	88.55%	0.2950	0.4142
8	3480	00:08:41	92.97%	88.61%	0.2875	0.4134
8	3500	00:08:43	92.97%		0.3221	
8	3510	00:08:46	95.31%	88.79%	0.2111	0.4036
8	3540	00:08:50	90.62%	88.42%	0.3594	0.4161
8	3550	00:08:51	93.75%		0.2287	
8	3570	00:08:55	96.09%	88.70%	0.2251	0.4037
8	3600	00:08:59	90.62%	88.67%	0.2746	0.4047
8	3630	00:09:03	91.41%	89.02%	0.2603	0.3995
8	3650	00:09:05	91.41%		0.3801	
9	3660	00:09:08	90.62%	88.98%	0.3340	0.3956
9	3690	00:09:12	93.75%	88.89%	0.2236	0.4001
9	3700	00:09:13	94.53%		0.2491	
9	3720	00:09:16	92.19%	89.28%	0.2449	0.3973
9	3750	00:09:21	92.97%	88.98%	0.2466	0.4042
9	3780	00:09:25	88.28%	89.22%	0.3804	0.3948
9	3800	00:09:27	91.41%		0.3266	
9	3810	00:09:30	92.97%	88.96%	0.2278	0.4008
9	3840	00:09:35	91.41%	88.85%	0.2862	0.4041
9	3850	00:09:36	92.97%		0.2303	
9	3870	00:09:40	91.41%	88.75%	0.4054	0.4046
9	3900	00:09:44	91.41%	88.59%	0.2992	0.4148
9	3930	00:09:48	94.53%	89.00%	0.3050	0.3994
9	3950	00:09:50	93.75%		0.2403	
9	3960	00:09:53	91.41%	89.15%	0.4221	0.3965
9	3990	00:09:57	89.84%	88.67%	0.3377	0.4051
9	4000	00:09:58	94.53%		0.1489	
9	4020	00:10:02	89.84%	88.98%	0.3718	0.3983
9	4050	00:10:07	90.62%	89.33%	0.2586	0.3954
9	4080	00:10:12	89.06%	88.82%	0.3326	0.4072
9	4100	00:10:13	92.19%		0.3145	
9	4110	00:10:16	91.41%	89.03%	0.3856	0.3994
10	4140	00:10:21	94.53%	88.99%	0.1823	0.4045
10	4150	00:10:21	91.41%		0.3070	
10	4170	00:10:25	93.75%	89.05%	0.1978	0.3969
10	4200	00:10:30	89.84%	89.27%	0.2853	0.3911
10	4230	00:10:35	90.62%	89.30%	0.3143	0.3902
10	4250	00:10:36	92.97%		0.2908	
10	4260	00:10:39	87.50%	88.89%	0.3485	0.3967
10	4290	00:10:44	92.97%	89.30%	0.2194	0.3915
10	4300	00:10:45	92.19%		0.1949	
10	4320	00:10:48	94.53%	89.17%	0.2270	0.3985
10	4350	00:10:53	91.41%	89.06%	0.2493	0.3964

```
|      10 |        4380 |       00:10:57 |       92.19% |       88.74% |       0.2544 |       0.3966 |
|      10 |        4400 |       00:10:59 |       91.41% |              |       0.3224 |              |
|      10 |        4410 |       00:11:02 |       93.75% |       88.64% |       0.1979 |       0.4076 |
|      10 |        4440 |       00:11:06 |       89.84% |       89.24% |       0.2446 |       0.3981 |
|      10 |        4450 |       00:11:07 |       89.06% |              |       0.3228 |              |
|      10 |        4470 |       00:11:11 |       91.41% |       89.22% |       0.2432 |       0.3968 |
|      10 |        4500 |       00:11:16 |       95.31% |       89.19% |       0.1824 |       0.3927 |
|      10 |        4530 |       00:11:20 |       92.19% |       89.02% |       0.2032 |       0.4068 |
|      10 |        4550 |       00:11:22 |       92.97% |              |       0.2648 |              |
|      10 |        4560 |       00:11:25 |       84.38% |       88.95% |       0.5502 |       0.3968 |
|      10 |        4570 |       00:11:28 |       89.84% |       88.97% |       0.2957 |       0.3910 |
|=========================================================================================================================|
Training finished: Max epochs completed.
```




```
YPred = classify(net_B, X_test);
accuracy = sum(YPred == y_test) / numel(y_test);
disp(['Test Accuracy for net_B: ', num2str(accuracy)]);
```

```
Test Accuracy for net_B: 0.87711
```

Create Layer_C

Layers_C:(Add Dropout Layer)

- **Image Input Layer**: Same as configuration A.
- **Convolutional Layer**: Use 20 5x5 filters with "same" padding.

- **ReLU Layer**: Same as configuration A.
- **Max Pooling Layer** : Same as configuration A.
- **Dropout Layer**: The dropout rate is 50% to prevent overfitting.
- **Fully Connected Layer** : Same as configuration A.
- **Softmax Layer**: Same as configuration A.
- **Classification Layer**: Same as configuration A.

```
layers_C = [
    imageInputLayer([32 32 3], 'Name', 'input')
    convolution2dLayer(5, 20, 'Padding', 'same', 'Name', 'conv1')
    reluLayer('Name', 'relu1')
    maxPooling2dLayer(2, 'Stride', 2, 'Name', 'maxpool1')
    dropoutLayer(0.5, 'Name', 'dropout')
    fullyConnectedLayer(10, 'Name', 'fc')
    softmaxLayer('Name', 'softmax')
    classificationLayer('Name', 'output')
];
```

Train & Evaluate net_C

```
net_C = trainNetwork(X_train, y_train, layers_C, options);
```

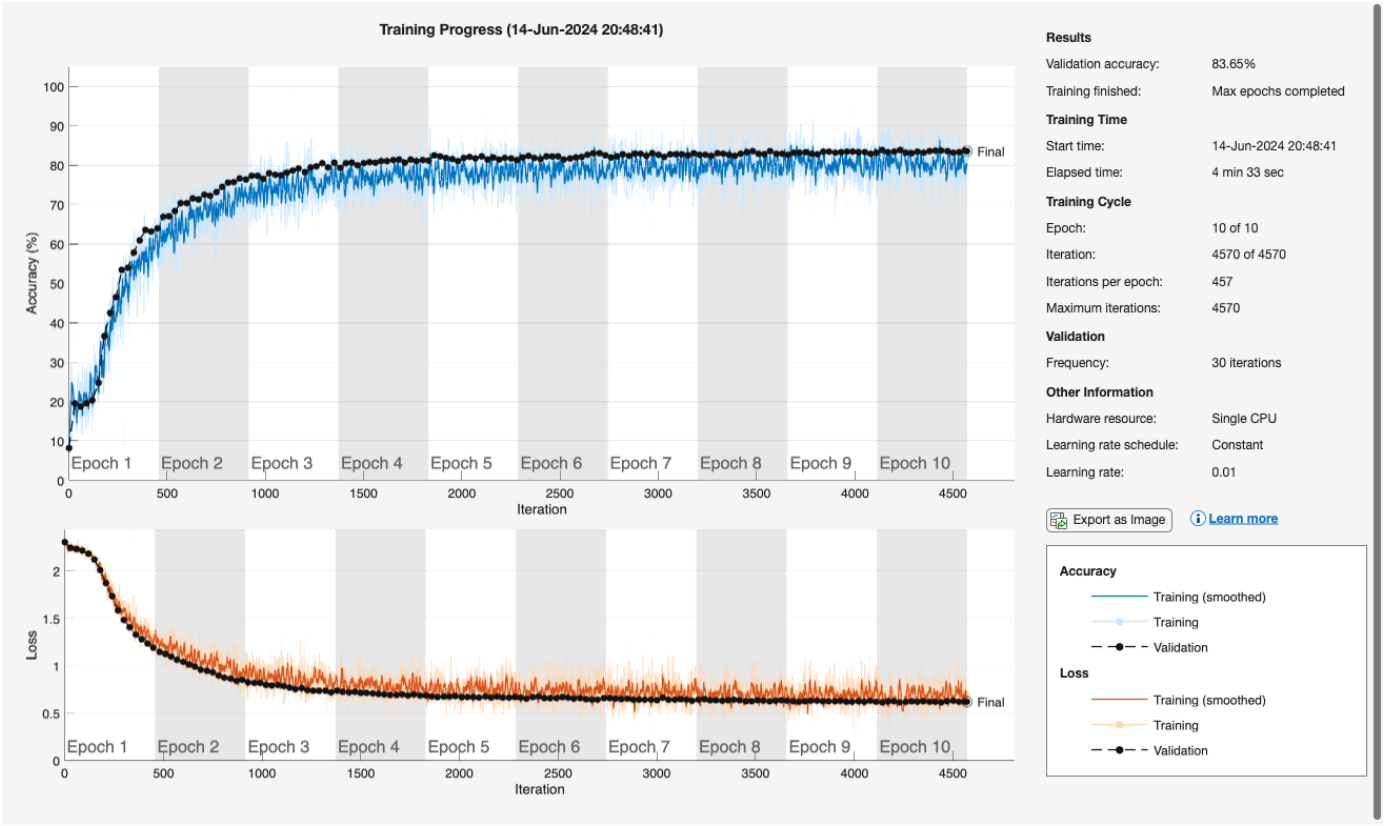
```
Training on single CPU.
Initializing input data normalization.
|=========================================================================================================================|
|  Epoch  |  Iteration  |  Time Elapsed  |  Mini-batch  |  Validation  |  Mini-batch  |  Validation  |  Ba
|         |             |   (hh:mm:ss)   |   Accuracy   |   Accuracy   |     Loss     |     Loss     |
|=========================================================================================================================|
|       1 |           1 |       00:00:01 |        7.03% |        8.19% |       2.3163 |       2.3059 |
|       1 |          30 |       00:00:03 |       26.56% |       19.58% |       2.2175 |       2.2431 |
|       1 |          50 |       00:00:04 |       21.09% |              |       2.2368 |              |
|       1 |          60 |       00:00:05 |       25.00% |       18.67% |       2.1832 |       2.2337 |
|       1 |          90 |       00:00:07 |       28.12% |       19.58% |       2.1719 |       2.2163 |
|       1 |         100 |       00:00:07 |       14.84% |              |       2.2506 |              |
|       1 |         120 |       00:00:09 |       21.09% |       20.34% |       2.1344 |       2.1807 |
|       1 |         150 |       00:00:11 |       20.31% |       24.68% |       2.1801 |       2.1199 |
|       1 |         180 |       00:00:13 |       37.50% |       36.60% |       2.0064 |       2.0109 |
|       1 |         200 |       00:00:13 |       35.16% |              |       1.9648 |              |
|       1 |         210 |       00:00:15 |       36.72% |       42.45% |       1.8978 |       1.8703 |
|       1 |         240 |       00:00:17 |       44.53% |       46.47% |       1.7788 |       1.7326 |
|       1 |         250 |       00:00:17 |       47.66% |              |       1.6286 |              |
|       1 |         270 |       00:00:18 |       48.44% |       53.39% |       1.5596 |       1.5830 |
|       1 |         300 |       00:00:20 |       46.09% |       53.92% |       1.6628 |       1.4849 |
|       1 |         330 |       00:00:22 |       46.09% |       57.84% |       1.6394 |       1.4039 |
|       1 |         350 |       00:00:23 |       56.25% |              |       1.4733 |              |
|       1 |         360 |       00:00:24 |       51.56% |       60.91% |       1.4306 |       1.3278 |
|       1 |         390 |       00:00:25 |       56.25% |       63.60% |       1.4146 |       1.2805 |
|       1 |         400 |       00:00:26 |       46.88% |              |       1.4913 |              |
|       1 |         420 |       00:00:27 |       56.25% |       63.18% |       1.3727 |       1.2337 |
|       1 |         450 |       00:00:29 |       55.47% |       64.02% |       1.3290 |       1.1889 |
|       2 |         480 |       00:00:31 |       57.81% |       66.87% |       1.1812 |       1.1460 |
|       2 |         500 |       00:00:31 |       58.59% |              |       1.3389 |              |
|       2 |         510 |       00:00:32 |       59.38% |       67.09% |       1.3380 |       1.1215 |
|       2 |         540 |       00:00:34 |       70.31% |       68.35% |       1.0721 |       1.0930 |
|       2 |         550 |       00:00:35 |       71.09% |              |       1.0547 |              |
|       2 |         570 |       00:00:36 |       57.03% |       70.43% |       1.2579 |       1.0601 |
```

2	600	00:00:38	61.72%	70.36%	1.1203	1.0383
2	630	00:00:40	64.84%	71.54%	1.2167	1.0108
2	650	00:00:40	64.84%		1.0207	
2	660	00:00:42	67.97%	71.35%	1.1758	0.9891
2	690	00:00:43	64.06%	72.56%	1.1945	0.9570
2	700	00:00:44	67.97%		1.0880	
2	720	00:00:45	74.22%	72.27%	0.9623	0.9459
2	750	00:00:47	70.31%	73.21%	0.9403	0.9294
2	780	00:00:49	69.53%	74.47%	1.0218	0.8963
2	800	00:00:49	72.66%		0.9466	
2	810	00:00:50	74.22%	75.53%	0.9390	0.8754
2	840	00:00:52	63.28%	75.70%	1.0115	0.8609
2	850	00:00:53	75.78%		0.7858	
2	870	00:00:54	70.31%	76.65%	0.8362	0.8386
2	900	00:00:56	68.75%	76.38%	1.0312	0.8500
3	930	00:00:58	70.31%	77.26%	1.0377	0.8255
3	950	00:00:58	66.41%		1.1407	
3	960	00:00:59	71.88%	77.35%	1.0541	0.8193
3	990	00:01:01	73.44%	76.55%	0.8723	0.8164
3	1000	00:01:01	73.44%		0.9069	
3	1020	00:01:03	82.03%	77.93%	0.7058	0.7955
3	1050	00:01:05	69.53%	77.59%	1.0282	0.7929
3	1080	00:01:07	65.62%	77.39%	1.0035	0.7942
3	1100	00:01:07	80.47%		0.8115	
3	1110	00:01:09	72.66%	78.17%	0.9361	0.7830
3	1140	00:01:11	74.22%	78.67%	0.9433	0.7674
3	1150	00:01:11	73.44%		1.0623	
3	1170	00:01:13	71.09%	79.13%	0.8382	0.7542
3	1200	00:01:14	68.75%	78.26%	1.0512	0.7649
3	1230	00:01:16	80.47%	79.48%	0.7552	0.7434
3	1250	00:01:17	80.47%		0.7776	
3	1260	00:01:18	69.53%	79.77%	0.9883	0.7369
3	1290	00:01:20	71.09%	80.45%	0.9655	0.7354
3	1300	00:01:20	79.69%		0.9371	
3	1320	00:01:22	81.25%	79.51%	0.7159	0.7356
3	1350	00:01:24	75.78%	80.60%	0.8802	0.7212
4	1380	00:01:26	79.69%	79.33%	0.6768	0.7344
4	1400	00:01:26	70.31%		0.9994	
4	1410	00:01:27	81.25%	80.49%	0.6882	0.7266
4	1440	00:01:29	77.34%	80.68%	0.7574	0.7178
4	1450	00:01:30	74.22%		0.9089	
4	1470	00:01:31	74.22%	80.02%	0.8502	0.7219
4	1500	00:01:33	78.91%	80.55%	0.7585	0.7140
4	1530	00:01:34	81.25%	80.85%	0.6477	0.7116
4	1550	00:01:35	76.56%		0.7930	
4	1560	00:01:36	81.25%	80.61%	0.6361	0.7066
4	1590	00:01:38	75.78%	81.05%	0.7274	0.6996
4	1600	00:01:38	78.91%		0.9401	
4	1620	00:01:40	74.22%	81.11%	0.8728	0.6980
4	1650	00:01:41	77.34%	81.28%	0.6995	0.6917
4	1680	00:01:43	80.47%	81.51%	0.7870	0.6889
4	1700	00:01:44	76.56%		0.7086	
4	1710	00:01:45	83.59%	80.61%	0.6717	0.6970
4	1740	00:01:47	75.00%	81.48%	0.7928	0.6838
4	1750	00:01:47	82.03%		0.6535	
4	1770	00:01:48	82.81%	81.02%	0.6182	0.6938
4	1800	00:01:50	80.47%	81.36%	0.6749	0.6834
5	1830	00:01:52	75.00%	81.18%	0.7767	0.6850
5	1850	00:01:52	78.12%		0.7275	
5	1860	00:01:54	76.56%	82.46%	0.8153	0.6759
5	1890	00:01:55	76.56%	82.29%	0.8185	0.6705
5	1900	00:01:56	78.12%		0.8313	
5	1920	00:01:57	71.88%	81.80%	0.8140	0.6742
5	1950	00:01:59	78.91%	81.63%	0.7794	0.6749

5	1980	00:02:01	75.00%	81.03%	0.7586	0.6805
5	2000	00:02:01	82.81%		0.6972	
5	2010	00:02:02	78.12%	81.84%	0.6868	0.6688
5	2040	00:02:04	75.00%	82.06%	0.9633	0.6676
5	2050	00:02:04	75.78%		0.8958	
5	2070	00:02:06	75.00%	81.74%	0.8757	0.6702
5	2100	00:02:08	72.66%	82.23%	0.8586	0.6611
5	2130	00:02:09	82.81%	81.46%	0.6564	0.6722
5	2150	00:02:10	79.69%		0.6241	
5	2160	00:02:11	73.44%	82.01%	0.7888	0.6648
5	2190	00:02:13	75.78%	81.52%	0.8417	0.6738
5	2200	00:02:13	78.12%		0.7692	
5	2220	00:02:15	85.94%	81.86%	0.5729	0.6654
5	2250	00:02:16	70.31%	81.69%	0.9165	0.6636
5	2280	00:02:18	84.38%	81.36%	0.5510	0.6703
6	2300	00:02:19	81.25%		0.7435	
6	2310	00:02:20	81.25%	82.01%	0.6330	0.6632
6	2340	00:02:21	78.12%	82.38%	0.6033	0.6538
6	2350	00:02:22	83.59%		0.6053	
6	2370	00:02:23	82.03%	81.91%	0.7042	0.6677
6	2400	00:02:25	76.56%	81.56%	0.7474	0.6721
6	2430	00:02:27	80.47%	82.29%	0.7256	0.6556
6	2450	00:02:27	73.44%		0.9182	
6	2460	00:02:28	75.78%	82.29%	0.7960	0.6595
6	2490	00:02:30	75.78%	82.29%	1.0032	0.6564
6	2500	00:02:30	83.59%		0.6696	
6	2520	00:02:32	74.22%	81.39%	0.8923	0.6679
6	2550	00:02:33	78.12%	81.74%	0.6439	0.6607
6	2580	00:02:35	82.81%	82.01%	0.6470	0.6535
6	2600	00:02:36	78.12%		0.9566	
6	2610	00:02:37	91.41%	82.15%	0.3953	0.6591
6	2640	00:02:39	78.91%	82.62%	0.8408	0.6442
6	2650	00:02:39	82.03%		0.8981	
6	2670	00:02:40	78.91%	83.09%	0.6296	0.6416
6	2700	00:02:42	85.16%	83.06%	0.5282	0.6430
6	2730	00:02:44	77.34%	82.58%	0.6776	0.6550
7	2750	00:02:45	81.25%		0.9344	
7	2760	00:02:46	75.00%	81.94%	0.7808	0.6583
7	2790	00:02:47	75.00%	82.29%	0.8287	0.6541
7	2800	00:02:48	82.03%		0.7741	
7	2820	00:02:49	85.94%	82.79%	0.6386	0.6469
7	2850	00:02:51	75.78%	82.37%	0.8405	0.6537
7	2880	00:02:53	80.47%	82.96%	0.7934	0.6413
7	2900	00:02:53	79.69%		0.8424	
7	2910	00:02:54	75.78%	82.96%	0.7631	0.6408
7	2940	00:02:56	85.94%	82.41%	0.5965	0.6404
7	2950	00:02:56	79.69%		0.9117	
7	2970	00:02:58	85.16%	83.05%	0.5550	0.6386
7	3000	00:03:00	77.34%	82.65%	0.7833	0.6365
7	3030	00:03:01	78.12%	82.12%	0.8046	0.6629
7	3050	00:03:02	79.69%		0.7210	
7	3060	00:03:03	78.91%	82.76%	0.7458	0.6398
7	3090	00:03:05	78.91%	82.83%	0.7724	0.6384
7	3100	00:03:05	76.56%		0.8450	
7	3120	00:03:07	77.34%	82.75%	0.6539	0.6443
7	3150	00:03:08	80.47%	82.47%	0.6157	0.6421
7	3180	00:03:10	75.00%	83.01%	0.8151	0.6313
8	3200	00:03:11	80.47%		0.7366	
8	3210	00:03:12	82.03%	82.64%	0.5935	0.6425
8	3240	00:03:13	81.25%	82.72%	0.7558	0.6470
8	3250	00:03:14	79.69%		0.6882	
8	3270	00:03:15	76.56%	82.40%	0.7728	0.6382
8	3300	00:03:17	77.34%	83.11%	0.6938	0.6334
8	3330	00:03:19	78.12%	82.87%	0.8256	0.6311

8	3350	00:03:19	72.66%		0.9130	
8	3360	00:03:20	82.03%	82.60%	0.6799	0.6374
8	3390	00:03:22	81.25%	82.39%	0.7044	0.6416
8	3400	00:03:22	73.44%		0.9182	
8	3420	00:03:24	84.38%	82.92%	0.6638	0.6364
8	3450	00:03:26	86.72%	83.31%	0.6370	0.6252
8	3480	00:03:27	81.25%	83.56%	0.6716	0.6259
8	3500	00:03:28	75.78%		0.8263	
8	3510	00:03:29	82.81%	82.90%	0.5382	0.6378
8	3540	00:03:31	79.69%	82.77%	0.7022	0.6281
8	3550	00:03:31	80.47%		0.7676	
8	3570	00:03:33	78.12%	83.52%	0.7686	0.6230
8	3600	00:03:34	77.34%	82.98%	0.8119	0.6303
8	3630	00:03:36	80.47%	82.87%	0.8938	0.6351
8	3650	00:03:37	75.78%		0.8705	
9	3660	00:03:38	82.81%	82.68%	0.5353	0.6327
9	3690	00:03:40	83.59%	83.13%	0.4993	0.6266
9	3700	00:03:40	84.38%		0.5395	
9	3720	00:03:42	79.69%	83.21%	0.7485	0.6215
9	3750	00:03:43	75.78%	83.28%	1.0352	0.6257
9	3780	00:03:45	75.78%	82.89%	0.8975	0.6290
9	3800	00:03:46	72.66%		0.8756	
9	3810	00:03:47	82.81%	82.81%	0.5737	0.6313
9	3840	00:03:48	85.16%	83.39%	0.6827	0.6218
9	3850	00:03:49	84.38%		0.5448	
9	3870	00:03:50	77.34%	83.48%	0.7057	0.6242
9	3900	00:03:52	68.75%	83.15%	1.0233	0.6248
9	3930	00:03:54	81.25%	83.30%	0.6559	0.6288
9	3950	00:03:54	88.28%		0.6843	
9	3960	00:03:56	77.34%	83.43%	0.9022	0.6182
9	3990	00:03:57	78.91%	83.43%	0.6260	0.6173
9	4000	00:03:58	81.25%		0.6155	
9	4020	00:03:59	82.03%	83.26%	0.6541	0.6217
9	4050	00:04:01	81.25%	83.36%	0.7646	0.6208
9	4080	00:04:03	76.56%	82.87%	0.7112	0.6325
9	4100	00:04:03	84.38%		0.9335	
9	4110	00:04:04	76.56%	83.21%	0.9395	0.6200
10	4140	00:04:06	78.12%	83.82%	0.7084	0.6156
10	4150	00:04:06	81.25%		0.6858	
10	4170	00:04:08	89.84%	83.26%	0.3819	0.6218
10	4200	00:04:10	80.47%	83.43%	0.6464	0.6238
10	4230	00:04:11	81.25%	83.87%	0.6925	0.6155
10	4250	00:04:12	80.47%		0.7733	
10	4260	00:04:13	83.59%	83.24%	0.6001	0.6189
10	4290	00:04:15	77.34%	83.11%	0.6689	0.6258
10	4300	00:04:16	72.66%		0.9366	
10	4320	00:04:17	85.16%	83.40%	0.5149	0.6187
10	4350	00:04:19	76.56%	83.18%	0.6576	0.6271
10	4380	00:04:21	77.34%	83.55%	0.7960	0.6183
10	4400	00:04:21	81.25%		0.6485	
10	4410	00:04:23	78.12%	83.67%	0.6953	0.6210
10	4440	00:04:24	78.12%	83.71%	0.6781	0.6122
10	4450	00:04:25	85.94%		0.5642	
10	4470	00:04:26	82.03%	83.58%	0.5964	0.6233
10	4500	00:04:28	78.91%	83.15%	0.5742	0.6280
10	4530	00:04:30	78.12%	83.28%	0.7774	0.6199
10	4550	00:04:30	83.59%		0.5868	
10	4560	00:04:31	80.47%	83.65%	0.6478	0.6163
10	4570	00:04:33	82.03%	83.65%	0.6703	0.6211

Training finished: Max epochs completed.




```
YPred = classify(net_C, X_test);
accuracy = sum(YPred == y_test) / numel(y_test);
disp(['Test Accuracy for net_C: ', num2str(accuracy)]);
```

```
Test Accuracy for net_C: 0.82222
```

Conclusion

Test Accuracy for net_A: 0.81999

Test Accuracy for net_B: 0.87711

Test Accuracy for net_C: 0.82222

net_A : Test accuracy is 81.999%. This is a basic network structure with basic convolutional layers, pooling layers, and fully connected layers. This configuration provides a good baseline performance.

net_B : The test accuracy is 87.711%. This configuration significantly improves performance by increasing the number of convolutional layers and filters, as well as adding an additional convolutional and pooling layer. More convolutional layers and filters enhance the network's ability to capture complex features, which may be the main reason for its performance improvement.

net_C: The test accuracy is 82.222%. This configuration introduces a Dropout layer to reduce overfitting. Although the Dropout layer helps improve the model's generalization ability, in this case, its performance did not significantly exceed the basic configuration A.

Save the best Net

```
save('best_network.mat', 'net_B');
```

Test the Net

Testing the 'best_network.mat' in function classifyImageScript.m. I input a sample image which is the number '9', and then output the classification of the label.

Output of the command window:

Predicted Label: 9