```
close all;
clear variables;
clc;
```

```
folder = "CUB_200_2011_Subset20classes";
trainingImageNames = readtable(fullfile(folder, "train.txt"),'ReadVariableNames', false);
trainingImageNames.Properties.VariableNames = {'index', 'imageName'};

validationImageNames = readtable(fullfile(folder, "validate.txt"),'ReadVariableNames', false);
validationImageNames.Properties.VariableNames = {'index', 'imageName'};

testImageNames = readtable(fullfile(folder, "test.txt"),'ReadVariableNames', false);
testImageNames.Properties.VariableNames = {'index', 'imageName'};

classNames = readtable(fullfile(folder, "classes.txt"),'ReadVariableNames', false);
classNames.Properties.VariableNames = {'index', 'className'};

imageClassLabels = readtable(fullfile(folder, "image_class_labels.txt"),'ReadVariableNames', fa
imageClassLabels.Properties.VariableNames = {'index', 'classLabel'};

folder = "CUB_200_2011_Subset20classes/";
trainingImageList = strings(height(trainingImageNames), 1);
for iI = 1:height(trainingImageNames)
    trainingImageList(iI) = string(fullfile(folder, "images/", ...
        string(cell2mat(trainingImageNames.imageName(iI)))));
end

validationImageList = strings(height(validationImageNames), 1);
for iI = 1:height(validationImageNames)
    validationImageList(iI) = string(folder + "images/" + ...
        string(cell2mat(validationImageNames.imageName(iI))));
end

testImageList = strings(height(testImageNames), 1);
for iI = 1:height(testImageNames)
    testImageList(iI) = string(folder + "images/" + ...
        string(cell2mat(testImageNames.imageName(iI))));
end

trainingImageDS = imageDatastore(trainingImageList, 'labelSource', 'foldernames', ...
    'FileExtensions', {'.jpg'});
trainingImageDS.ReadFcn = @readImagesIntoDatastore;

validationImageDS = imageDatastore(validationImageList, 'labelSource', 'foldernames', ...
    'FileExtensions', {'.jpg'});
validationImageDS.ReadFcn = @readImagesIntoDatastore;

testImageDS = imageDatastore(testImageList, 'labelSource', 'foldernames', ...
    'FileExtensions', {'.jpg'});
```

```
testImageDS.ReadFcn = @readImagesIntoDatastore;

countEachLabel(trainingImageDS)

countEachLabel(validationImageDS)

countEachLabel(testImageDS)
```

```
% target_size = [100, 100];
target_size = [224, 224];

% resizing using transform operation
training_image_datastore_resized = transform(trainingImageDS, @(image_i) imresize(image_i,targe
validation_image_datastore_resized = transform(validationImageDS, @(image_i) imresize(image_i,t
test_image_datastore_resized = transform(testImageDS, @(image_i) imresize(image_i,target_size)

% Combine transformed datastores and labels
training_labels = arrayDatastore(trainingImageDS.Labels);
training_combined_datastore = combine(training_image_datastore_resized, training_labels);

validation_labels = arrayDatastore(validationImageDS.Labels);
validation_combined_datastore = combine(validation_image_datastore_resized, validation_labels);

test_labels = arrayDatastore(testImageDS.Labels);
test_combined_datastore = combine(test_image_datastore_resized, test_labels);
```

```

% cnn architecture
number_of_layers = 6;

layers = [
    imageInputLayer([224 224 3])

    convolution2dLayer(3, 8, 'Padding', 'same')
    batchNormalizationLayer
    reluLayer
    maxPooling2dLayer(2, 'Stride', 2)

    convolution2dLayer(3, 16, 'Padding', 'same')
    batchNormalizationLayer
    reluLayer
    maxPooling2dLayer(2, 'Stride', 2)

    convolution2dLayer(3, 32, 'Padding', 'same')
    batchNormalizationLayer
    reluLayer
    maxPooling2dLayer(2, 'Stride', 2)

    convolution2dLayer(3, 64, 'Padding', 'same')
```

```
    batchNormalizationLayer
    reluLayer
    maxPooling2dLayer(2, 'Stride', 2)

    convolution2dLayer(3, 128, 'Padding', 'same')
    batchNormalizationLayer
    reluLayer
    maxPooling2dLayer(2, 'Stride', 2)

    convolution2dLayer(3, 256, 'Padding', 'same')
    batchNormalizationLayer
    reluLayer
    maxPooling2dLayer(2, 'Stride', 2)

    % Fully connected block
    fullyConnectedLayer(512)
    batchNormalizationLayer
    reluLayer
    dropoutLayer(0.5)

    fullyConnectedLayer(256)
    batchNormalizationLayer
    reluLayer
    dropoutLayer(0.5)

    fullyConnectedLayer(20)
    softmaxLayer
    classificationLayer];
```

```
if (gpuDeviceCount() > 0)
    disp('Found GPU:');
    disp(gpuDeviceTable);
    gpu_device = gpuDevice(1);
    reset(gpu_device);  % Clear previous values that might still be on the GPU
end
```

```
Found GPU:
    Index        Name        ComputeCapability    DeviceAvailable    DeviceSelected
    _____    ____________    _________________    _______________    ______________

      1      "GRID T4-8Q"          "7.5"              true               true
```

```
% learning_rate = 0.01;
learning_rate = 0.001;
% learning_rate = 0.0001;

% batch_size = 8;
batch_size = 16;
% batch_size = 32;
```

```
% epochs = 5;
% epochs = 10;
epochs = 20;

options = trainingOptions('sgdm', ...
        'InitialLearnRate', learning_rate, ...
        'MiniBatchSize', batch_size, ...
        'MaxEpochs', epochs, ...
        'Verbose', true, ...
        'Shuffle', 'every-epoch', ...
        'VerboseFrequency', 1, ...
        'ValidationData', validation_combined_datastore, ...
        'Plots','training-progress');

myCNN = trainNetwork(training_combined_datastore, layers, options);
```

```
Training on single GPU.
Initializing input data normalization.
|=========================================================================================================================
|  Epoch  |  Iteration  |  Time Elapsed  |  Mini-batch  |  Validation  |  Mini-batch  |  Validation  |  Base Learnin
|         |             |   (hh:mm:ss)   |   Accuracy   |   Accuracy   |     Loss     |     Loss     |      Rate
|=========================================================================================================================
|       1 |           1 |       00:00:14 |        6.25% |        5.41% |       4.1432 |       3.3965 |          0.00
|       1 |           2 |       00:00:15 |        6.25% |              |       4.1879 |              |          0.00
|       1 |           3 |       00:00:16 |        6.25% |              |       4.5379 |              |          0.00
|       1 |           4 |       00:00:16 |        0.00% |              |       4.1687 |              |          0.00
|       1 |           5 |       00:00:17 |        0.00% |              |       3.7155 |              |          0.00
|       1 |           6 |       00:00:17 |       12.50% |              |       3.8702 |              |          0.00
|       1 |           7 |       00:00:18 |        6.25% |              |       3.5132 |              |          0.00
|       1 |           8 |       00:00:19 |        0.00% |              |       3.7503 |              |          0.00
|       1 |           9 |       00:00:19 |        0.00% |              |       3.9184 |              |          0.00
|       1 |          10 |       00:00:20 |        0.00% |              |       3.7098 |              |          0.00
|       1 |          11 |       00:00:21 |       18.75% |              |       3.2973 |              |          0.00
|       1 |          12 |       00:00:21 |        0.00% |              |       3.3342 |              |          0.00
|       1 |          13 |       00:00:22 |       12.50% |              |       3.5429 |              |          0.00
|       1 |          14 |       00:00:22 |       12.50% |              |       3.6561 |              |          0.00
|       1 |          15 |       00:00:23 |       12.50% |              |       3.2350 |              |          0.00
|       1 |          16 |       00:00:24 |        0.00% |              |       3.4638 |              |          0.00
|       1 |          17 |       00:00:25 |        0.00% |              |       4.1792 |              |          0.00
|       1 |          18 |       00:00:25 |        6.25% |              |       3.7506 |              |          0.00
|       1 |          19 |       00:00:26 |        0.00% |              |       3.7093 |              |          0.00
|       1 |          20 |       00:00:26 |       18.75% |              |       3.5409 |              |          0.00
|       1 |          21 |       00:00:27 |        6.25% |              |       3.3011 |              |          0.00
|       1 |          22 |       00:00:28 |        6.25% |              |       3.6997 |              |          0.00
|       1 |          23 |       00:00:28 |        6.25% |              |       3.3601 |              |          0.00
|       1 |          24 |       00:00:29 |       18.75% |              |       2.8213 |              |          0.00
|       1 |          25 |       00:00:30 |        0.00% |              |       3.9294 |              |          0.00
|       1 |          26 |       00:00:31 |       18.75% |              |       3.5562 |              |          0.00
|       1 |          27 |       00:00:32 |        6.25% |              |       3.4726 |              |          0.00
|       1 |          28 |       00:00:32 |        0.00% |              |       3.6207 |              |          0.00
|       1 |          29 |       00:00:33 |        0.00% |              |       3.6124 |              |          0.00
|       1 |          30 |       00:00:34 |        6.25% |              |       3.0855 |              |          0.00
|       1 |          31 |       00:00:34 |       25.00% |              |       3.0025 |              |          0.00
|       1 |          32 |       00:00:35 |        6.25% |              |       3.1796 |              |          0.00
|       1 |          33 |       00:00:36 |        0.00% |              |       3.5782 |              |          0.00
|       1 |          34 |       00:00:36 |        6.25% |              |       3.6569 |              |          0.00
|       1 |          35 |       00:00:37 |        6.25% |              |       3.4265 |              |          0.00
|       1 |          36 |       00:00:38 |        0.00% |              |       4.0276 |              |          0.00
|       1 |          37 |       00:00:38 |        6.25% |              |       3.5925 |              |          0.00
```

1	38	00:00:39	0.00%		3.4520		0.00
1	39	00:00:40	18.75%		2.9187		0.00
1	40	00:00:40	6.25%		3.6161		0.00
1	41	00:00:40	0.00%		3.7329		0.00
2	42	00:00:42	6.25%		3.5151		0.00
2	43	00:00:42	6.25%		3.1366		0.00
2	44	00:00:43	12.50%		3.1016		0.00
2	45	00:00:43	18.75%		2.7245		0.00
2	46	00:00:44	6.25%		3.1829		0.00
2	47	00:00:44	18.75%		3.0534		0.00
2	48	00:00:45	6.25%		3.4296		0.00
2	49	00:00:45	12.50%		2.8736		0.00
2	50	00:00:53	6.25%	9.46%	3.4148	3.1320	0.00
2	51	00:00:53	25.00%		2.7682		0.00
2	52	00:00:54	6.25%		3.5170		0.00
2	53	00:00:54	6.25%		3.2467		0.00
2	54	00:00:55	6.25%		3.6187		0.00
2	55	00:00:56	25.00%		3.1981		0.00
2	56	00:00:56	0.00%		3.0712		0.00
2	57	00:00:57	18.75%		2.8393		0.00
2	58	00:00:58	12.50%		3.1475		0.00
2	59	00:00:58	12.50%		3.1838		0.00
2	60	00:00:59	6.25%		3.7294		0.00
2	61	00:01:00	6.25%		3.3789		0.00
2	62	00:01:00	6.25%		3.7900		0.00
2	63	00:01:01	6.25%		3.5552		0.00
2	64	00:01:02	6.25%		2.8442		0.00
2	65	00:01:02	0.00%		3.9662		0.00
2	66	00:01:03	25.00%		3.1186		0.00
2	67	00:01:04	25.00%		2.9458		0.00
2	68	00:01:04	18.75%		3.4652		0.00
2	69	00:01:05	0.00%		3.0254		0.00
2	70	00:01:06	6.25%		3.0965		0.00
2	71	00:01:06	12.50%		2.6667		0.00
2	72	00:01:07	0.00%		3.2758		0.00
2	73	00:01:08	25.00%		2.9522		0.00
2	74	00:01:08	6.25%		3.2224		0.00
2	75	00:01:09	31.25%		2.6983		0.00
2	76	00:01:10	0.00%		3.7977		0.00
2	77	00:01:10	6.25%		3.1721		0.00
2	78	00:01:11	6.25%		3.0105		0.00
2	79	00:01:11	6.25%		3.5090		0.00
2	80	00:01:12	18.75%		3.3549		0.00
2	81	00:01:12	6.25%		2.9155		0.00
2	82	00:01:12	6.25%		3.0649		0.00
3	83	00:01:14	0.00%		3.3742		0.00
3	84	00:01:15	18.75%		2.9299		0.00
3	85	00:01:15	25.00%		2.4724		0.00
3	86	00:01:16	12.50%		3.1428		0.00
3	87	00:01:16	31.25%		2.6872		0.00
3	88	00:01:17	12.50%		2.9849		0.00
3	89	00:01:17	0.00%		3.2388		0.00
3	90	00:01:18	6.25%		2.6754		0.00
3	91	00:01:18	0.00%		3.2494		0.00
3	92	00:01:19	12.50%		3.1971		0.00
3	93	00:01:20	12.50%		3.0719		0.00
3	94	00:01:20	12.50%		3.1324		0.00
3	95	00:01:21	6.25%		3.4012		0.00
3	96	00:01:21	25.00%		3.0864		0.00
3	97	00:01:22	37.50%		2.2048		0.00
3	98	00:01:23	12.50%		2.9743		0.00
3	99	00:01:23	18.75%		2.7631		0.00
3	100	00:01:31	6.25%	16.22%	3.2271	2.7678	0.00
3	101	00:01:31	0.00%		3.6286		0.00

3	102	00:01:32	12.50%		3.0332		0.00
3	103	00:01:33	18.75%		2.5036		0.00
3	104	00:01:34	25.00%		2.6963		0.00
3	105	00:01:35	25.00%		2.6224		0.00
3	106	00:01:36	18.75%		2.8386		0.00
3	107	00:01:36	18.75%		2.9329		0.00
3	108	00:01:37	12.50%		2.4503		0.00
3	109	00:01:38	25.00%		3.1653		0.00
3	110	00:01:39	12.50%		2.8676		0.00
3	111	00:01:40	12.50%		3.3531		0.00
3	112	00:01:40	12.50%		2.7648		0.00
3	113	00:01:41	6.25%		3.1361		0.00
3	114	00:01:42	12.50%		2.7772		0.00
3	115	00:01:42	6.25%		2.6539		0.00
3	116	00:01:43	12.50%		2.9972		0.00
3	117	00:01:44	6.25%		3.0757		0.00
3	118	00:01:44	12.50%		3.3965		0.00
3	119	00:01:45	18.75%		3.0377		0.00
3	120	00:01:46	25.00%		2.7151		0.00
3	121	00:01:46	12.50%		3.0413		0.00
3	122	00:01:47	12.50%		3.3156		0.00
3	123	00:01:47	12.50%		3.2269		0.00
4	124	00:01:48	18.75%		2.8133		0.00
4	125	00:01:49	31.25%		2.6128		0.00
4	126	00:01:50	12.50%		3.4490		0.00
4	127	00:01:50	6.25%		2.7998		0.00
4	128	00:01:51	18.75%		2.7922		0.00
4	129	00:01:52	25.00%		2.9035		0.00
4	130	00:01:53	6.25%		3.3667		0.00
4	131	00:01:53	25.00%		2.5088		0.00
4	132	00:01:54	6.25%		2.8474		0.00
4	133	00:01:54	18.75%		2.4964		0.00
4	134	00:01:55	12.50%		2.7697		0.00
4	135	00:01:56	25.00%		2.2981		0.00
4	136	00:01:56	25.00%		2.7148		0.00
4	137	00:01:57	18.75%		2.7522		0.00
4	138	00:01:58	25.00%		2.7614		0.00
4	139	00:01:58	25.00%		2.8425		0.00
4	140	00:01:59	12.50%		2.7004		0.00
4	141	00:01:59	12.50%		2.9247		0.00
4	142	00:02:00	31.25%		2.4147		0.00
4	143	00:02:01	12.50%		2.5094		0.00
4	144	00:02:01	12.50%		2.7983		0.00
4	145	00:02:02	18.75%		2.3438		0.00
4	146	00:02:03	31.25%		2.2849		0.00
4	147	00:02:03	6.25%		2.7009		0.00
4	148	00:02:04	6.25%		3.0493		0.00
4	149	00:02:05	6.25%		3.0738		0.00
4	150	00:02:12	25.00%	20.27%	2.7388	2.6435	0.00
4	151	00:02:13	18.75%		2.4036		0.00
4	152	00:02:14	25.00%		2.5791		0.00
4	153	00:02:14	25.00%		2.2561		0.00
4	154	00:02:15	25.00%		2.9241		0.00
4	155	00:02:16	37.50%		2.3456		0.00
4	156	00:02:17	25.00%		2.8616		0.00
4	157	00:02:17	12.50%		3.1546		0.00
4	158	00:02:18	25.00%		2.7926		0.00
4	159	00:02:19	25.00%		2.4127		0.00
4	160	00:02:20	0.00%		3.4883		0.00
4	161	00:02:20	25.00%		2.7855		0.00
4	162	00:02:21	12.50%		3.1454		0.00
4	163	00:02:22	12.50%		3.0074		0.00
4	164	00:02:22	31.25%		2.1109		0.00
5	165	00:02:24	37.50%		2.2638		0.00

5	166	00:02:24	6.25%		3.1231			0.00
5	167	00:02:25	37.50%		2.4944			0.00
5	168	00:02:25	12.50%		3.0250			0.00
5	169	00:02:26	31.25%		2.5321			0.00
5	170	00:02:26	37.50%		2.2911			0.00
5	171	00:02:27	25.00%		2.3902			0.00
5	172	00:02:28	12.50%		2.7322			0.00
5	173	00:02:28	18.75%		2.8669			0.00
5	174	00:02:29	37.50%		2.5592			0.00
5	175	00:02:29	0.00%		2.8589			0.00
5	176	00:02:30	43.75%		1.8824			0.00
5	177	00:02:31	6.25%		2.8018			0.00
5	178	00:02:31	37.50%		2.4747			0.00
5	179	00:02:32	18.75%		2.3883			0.00
5	180	00:02:33	25.00%		2.4431			0.00
5	181	00:02:34	25.00%		2.5580			0.00
5	182	00:02:36	31.25%		2.5520			0.00
5	183	00:02:36	18.75%		2.2815			0.00
5	184	00:02:37	25.00%		2.8709			0.00
5	185	00:02:38	31.25%		2.1349			0.00
5	186	00:02:39	31.25%		2.5607			0.00
5	187	00:02:40	25.00%		2.4690			0.00
5	188	00:02:41	31.25%		2.1363			0.00
5	189	00:02:41	0.00%		3.1423			0.00
5	190	00:02:42	12.50%		2.7754			0.00
5	191	00:02:43	18.75%		2.6999			0.00
5	192	00:02:43	18.75%		2.8399			0.00
5	193	00:02:44	31.25%		2.5409			0.00
5	194	00:02:44	12.50%		2.6268			0.00
5	195	00:02:45	31.25%		2.4910			0.00
5	196	00:02:45	6.25%		3.1143			0.00
5	197	00:02:46	25.00%		2.2122			0.00
5	198	00:02:47	43.75%		2.3444			0.00
5	199	00:02:47	6.25%		2.5866			0.00
5	200	00:02:56	12.50%	23.87%	2.8103	2.5230		0.00
5	201	00:02:57	6.25%		2.7497			0.00
5	202	00:02:57	18.75%		2.4406			0.00
5	203	00:02:58	6.25%		3.4730			0.00
5	204	00:02:59	18.75%		2.5811			0.00
5	205	00:02:59	37.50%		2.3857			0.00
6	206	00:03:01	12.50%		3.1576			0.00
6	207	00:03:01	6.25%		2.9154			0.00
6	208	00:03:02	6.25%		2.9903			0.00
6	209	00:03:02	25.00%		2.2355			0.00
6	210	00:03:03	31.25%		2.4542			0.00
6	211	00:03:04	31.25%		2.4443			0.00
6	212	00:03:04	18.75%		2.9763			0.00
6	213	00:03:05	25.00%		2.0879			0.00
6	214	00:03:06	18.75%		2.4793			0.00
6	215	00:03:06	37.50%		2.2872			0.00
6	216	00:03:07	18.75%		2.9265			0.00
6	217	00:03:08	12.50%		2.9821			0.00
6	218	00:03:08	31.25%		2.0445			0.00
6	219	00:03:09	12.50%		2.6622			0.00
6	220	00:03:09	18.75%		2.6328			0.00
6	221	00:03:10	18.75%		2.5824			0.00
6	222	00:03:11	18.75%		2.8635			0.00
6	223	00:03:11	18.75%		2.8181			0.00
6	224	00:03:12	18.75%		2.6790			0.00
6	225	00:03:13	37.50%		2.4167			0.00
6	226	00:03:13	12.50%		2.5329			0.00
6	227	00:03:14	31.25%		2.1717			0.00
6	228	00:03:14	12.50%		2.8392			0.00
6	229	00:03:15	25.00%		2.3521			0.00

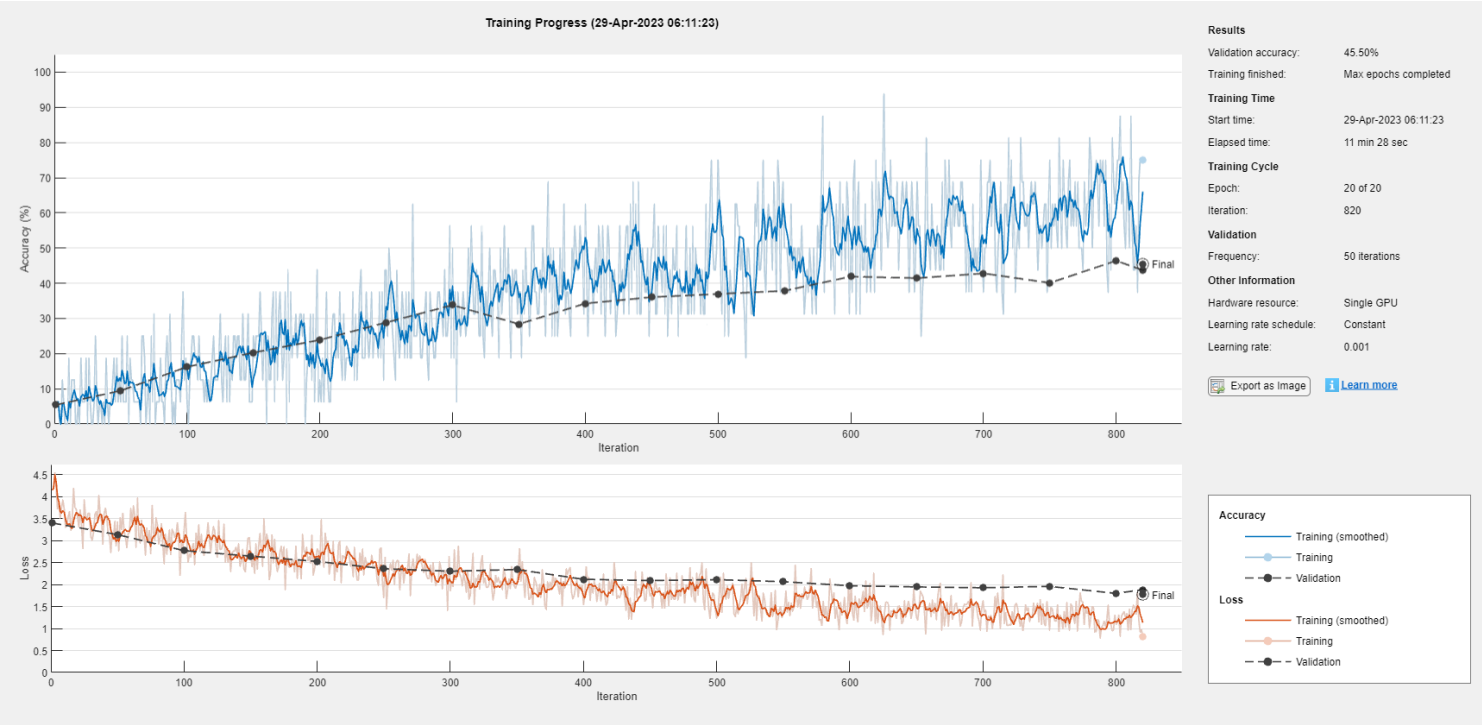
6	230	00:03:16	37.50%		2.1000		0.00
6	231	00:03:16	43.75%		2.1020		0.00
6	232	00:03:17	18.75%		2.7193		0.00
6	233	00:03:18	18.75%		2.4253		0.00
6	234	00:03:18	18.75%		2.8003		0.00
6	235	00:03:19	37.50%		2.2183		0.00
6	236	00:03:19	25.00%		2.6096		0.00
6	237	00:03:20	18.75%		2.4976		0.00
6	238	00:03:21	25.00%		2.3985		0.00
6	239	00:03:21	37.50%		2.4391		0.00
6	240	00:03:22	18.75%		2.4480		0.00
6	241	00:03:22	25.00%		2.6633		0.00
6	242	00:03:23	25.00%		2.3696		0.00
6	243	00:03:24	25.00%		2.3901		0.00
6	244	00:03:25	18.75%		2.4428		0.00
6	245	00:03:25	37.50%		2.1003		0.00
6	246	00:03:25	18.75%		1.9786		0.00
7	247	00:03:26	37.50%		2.7957		0.00
7	248	00:03:27	12.50%		2.8325		0.00
7	249	00:03:27	43.75%		2.0537		0.00
7	250	00:03:35	43.75%	28.83%	1.6940	2.3569	0.00
7	251	00:03:36	25.00%		2.6192		0.00
7	252	00:03:36	50.00%		1.4501		0.00
7	253	00:03:37	43.75%		1.9838		0.00
7	254	00:03:38	31.25%		2.3143		0.00
7	255	00:03:38	25.00%		2.4718		0.00
7	256	00:03:39	18.75%		2.3266		0.00
7	257	00:03:40	12.50%		2.5532		0.00
7	258	00:03:40	43.75%		2.0000		0.00
7	259	00:03:41	25.00%		2.4702		0.00
7	260	00:03:42	18.75%		2.5455		0.00
7	261	00:03:42	25.00%		2.5337		0.00
7	262	00:03:43	37.50%		1.8739		0.00
7	263	00:03:44	31.25%		2.2849		0.00
7	264	00:03:44	18.75%		2.4416		0.00
7	265	00:03:45	37.50%		2.0332		0.00
7	266	00:03:46	18.75%		2.2835		0.00
7	267	00:03:46	37.50%		2.2420		0.00
7	268	00:03:47	18.75%		2.3925		0.00
7	269	00:03:48	18.75%		2.6939		0.00
7	270	00:03:49	62.50%		1.7426		0.00
7	271	00:03:49	25.00%		2.3780		0.00
7	272	00:03:50	25.00%		2.5825		0.00
7	273	00:03:51	25.00%		2.3162		0.00
7	274	00:03:52	31.25%		2.3069		0.00
7	275	00:03:53	31.25%		2.6806		0.00
7	276	00:03:54	18.75%		2.5108		0.00
7	277	00:03:55	18.75%		2.6504		0.00
7	278	00:03:56	25.00%		2.5231		0.00
7	279	00:03:57	31.25%		2.4012		0.00
7	280	00:03:57	37.50%		2.2733		0.00
7	281	00:03:58	18.75%		2.5719		0.00
7	282	00:03:59	12.50%		2.2137		0.00
7	283	00:03:59	37.50%		2.1353		0.00
7	284	00:04:00	31.25%		2.1348		0.00
7	285	00:04:01	25.00%		2.4321		0.00
7	286	00:04:01	18.75%		2.0524		0.00
7	287	00:04:01	18.75%		2.5012		0.00
8	288	00:04:03	31.25%		2.1785		0.00
8	289	00:04:03	37.50%		1.9749		0.00
8	290	00:04:04	37.50%		2.0681		0.00
8	291	00:04:04	31.25%		2.1010		0.00
8	292	00:04:05	31.25%		2.5101		0.00
8	293	00:04:06	25.00%		2.3602		0.00

8	294	00:04:06	43.75%		1.9057		0.00
8	295	00:04:07	25.00%		2.2715		0.00
8	296	00:04:08	25.00%		2.3198		0.00
8	297	00:04:08	31.25%		2.1768		0.00
8	298	00:04:09	56.25%		1.4138		0.00
8	299	00:04:10	18.75%		2.6374		0.00
8	300	00:04:17	50.00%	33.78%	1.8637	2.3008	0.00
8	301	00:04:18	18.75%		2.0665		0.00
8	302	00:04:18	37.50%		1.9506		0.00
8	303	00:04:19	6.25%		2.7843		0.00
8	304	00:04:20	37.50%		2.1088		0.00
8	305	00:04:20	31.25%		2.2511		0.00
8	306	00:04:21	25.00%		2.8669		0.00
8	307	00:04:22	31.25%		2.2324		0.00
8	308	00:04:23	37.50%		2.1570		0.00
8	309	00:04:23	31.25%		1.9655		0.00
8	310	00:04:24	25.00%		2.2484		0.00
8	311	00:04:25	31.25%		2.0807		0.00
8	312	00:04:26	50.00%		1.8162		0.00
8	313	00:04:26	37.50%		2.3174		0.00
8	314	00:04:27	56.25%		1.6716		0.00
8	315	00:04:28	43.75%		1.7479		0.00
8	316	00:04:28	31.25%		2.2430		0.00
8	317	00:04:29	31.25%		2.7016		0.00
8	318	00:04:29	43.75%		1.5501		0.00
8	319	00:04:30	37.50%		2.1330		0.00
8	320	00:04:31	25.00%		2.0795		0.00
8	321	00:04:32	25.00%		2.2198		0.00
8	322	00:04:33	56.25%		1.8913		0.00
8	323	00:04:34	25.00%		2.5028		0.00
8	324	00:04:34	18.75%		2.6506		0.00
8	325	00:04:35	37.50%		2.0276		0.00
8	326	00:04:36	31.25%		2.1515		0.00
8	327	00:04:36	37.50%		1.9363		0.00
8	328	00:04:36	50.00%		1.9324		0.00
9	329	00:04:38	31.25%		1.9782		0.00
9	330	00:04:38	25.00%		2.4669		0.00
9	331	00:04:39	43.75%		1.9701		0.00
9	332	00:04:40	43.75%		1.6474		0.00
9	333	00:04:40	37.50%		1.8196		0.00
9	334	00:04:41	37.50%		2.2054		0.00
9	335	00:04:41	18.75%		2.0544		0.00
9	336	00:04:42	50.00%		2.1565		0.00
9	337	00:04:43	31.25%		2.0281		0.00
9	338	00:04:43	37.50%		2.0744		0.00
9	339	00:04:44	56.25%		1.8833		0.00
9	340	00:04:45	37.50%		2.3735		0.00
9	341	00:04:45	37.50%		2.2304		0.00
9	342	00:04:46	50.00%		1.6744		0.00
9	343	00:04:46	31.25%		1.8703		0.00
9	344	00:04:47	18.75%		2.1249		0.00
9	345	00:04:47	43.75%		1.9083		0.00
9	346	00:04:48	37.50%		2.4083		0.00
9	347	00:04:48	43.75%		2.0881		0.00
9	348	00:04:49	43.75%		1.9652		0.00
9	349	00:04:50	31.25%		1.9128		0.00
9	350	00:04:57	37.50%	28.38%	2.0285	2.3390	0.00
9	351	00:04:59	37.50%		2.3214		0.00
9	352	00:04:59	18.75%		2.8152		0.00
9	353	00:05:00	43.75%		2.0765		0.00
9	354	00:05:01	31.25%		2.5213		0.00
9	355	00:05:01	50.00%		2.0775		0.00
9	356	00:05:02	37.50%		1.6982		0.00
9	357	00:05:02	37.50%		2.3203		0.00

9	358	00:05:03	25.00%		2.0585		0.00
9	359	00:05:03	37.50%		1.6544		0.00
9	360	00:05:04	56.25%		1.6801		0.00
9	361	00:05:05	56.25%		1.8682		0.00
9	362	00:05:06	37.50%		1.5376		0.00
9	363	00:05:07	37.50%		2.1578		0.00
9	364	00:05:07	31.25%		2.0806		0.00
9	365	00:05:08	31.25%		1.9408		0.00
9	366	00:05:09	43.75%		1.7312		0.00
9	367	00:05:10	37.50%		1.9942		0.00
9	368	00:05:10	50.00%		1.7080		0.00
9	369	00:05:10	43.75%		2.3305		0.00
10	370	00:05:12	25.00%		2.0715		0.00
10	371	00:05:13	50.00%		1.5112		0.00
10	372	00:05:14	68.75%		1.4347		0.00
10	373	00:05:14	37.50%		2.0575		0.00
10	374	00:05:15	50.00%		1.9280		0.00
10	375	00:05:15	25.00%		2.0530		0.00
10	376	00:05:16	50.00%		1.8810		0.00
10	377	00:05:17	25.00%		2.2348		0.00
10	378	00:05:17	43.75%		2.0210		0.00
10	379	00:05:18	25.00%		2.1415		0.00
10	380	00:05:18	31.25%		2.0935		0.00
10	381	00:05:19	50.00%		1.9483		0.00
10	382	00:05:19	37.50%		1.7832		0.00
10	383	00:05:20	43.75%		2.1415		0.00
10	384	00:05:20	62.50%		1.5036		0.00
10	385	00:05:21	31.25%		2.0706		0.00
10	386	00:05:22	37.50%		1.9229		0.00
10	387	00:05:22	37.50%		2.3501		0.00
10	388	00:05:23	31.25%		2.2342		0.00
10	389	00:05:23	25.00%		2.3395		0.00
10	390	00:05:24	50.00%		2.3875		0.00
10	391	00:05:25	43.75%		1.8281		0.00
10	392	00:05:25	56.25%		1.6699		0.00
10	393	00:05:26	50.00%		1.7533		0.00
10	394	00:05:27	43.75%		1.9361		0.00
10	395	00:05:28	43.75%		2.0998		0.00
10	396	00:05:29	56.25%		1.7144		0.00
10	397	00:05:30	50.00%		1.9853		0.00
10	398	00:05:32	50.00%		1.8763		0.00
10	399	00:05:34	31.25%		1.9757		0.00
10	400	00:05:43	62.50%	34.23%	1.5370	2.1169	0.00
10	401	00:05:44	43.75%		1.7995		0.00
10	402	00:05:45	25.00%		2.4019		0.00
10	403	00:05:46	43.75%		2.0846		0.00
10	404	00:05:46	43.75%		2.1617		0.00
10	405	00:05:47	43.75%		1.6316		0.00
10	406	00:05:48	31.25%		2.0147		0.00
10	407	00:05:49	43.75%		1.8068		0.00
10	408	00:05:49	50.00%		2.0667		0.00
10	409	00:05:50	37.50%		1.9398		0.00
10	410	00:05:50	56.25%		1.6134		0.00
11	411	00:05:52	50.00%		1.8117		0.00
11	412	00:05:52	31.25%		2.0276		0.00
11	413	00:05:53	56.25%		1.6270		0.00
11	414	00:05:53	43.75%		1.8316		0.00
11	415	00:05:54	25.00%		2.2384		0.00
11	416	00:05:54	43.75%		1.7446		0.00
11	417	00:05:55	56.25%		1.5315		0.00
11	418	00:05:56	50.00%		1.5849		0.00
11	419	00:05:56	31.25%		2.1025		0.00
11	420	00:05:57	43.75%		1.8710		0.00
11	421	00:05:57	37.50%		2.1105		0.00

11	422	00:05:58	43.75%		1.7543		0.00
11	423	00:05:58	25.00%		2.4994		0.00
11	424	00:05:59	31.25%		2.1624		0.00
11	425	00:05:59	37.50%		1.6776		0.00
11	426	00:06:00	56.25%		1.7435		0.00
11	427	00:06:01	37.50%		1.6963		0.00
11	428	00:06:02	43.75%		1.7588		0.00
11	429	00:06:03	31.25%		1.9980		0.00
11	430	00:06:04	50.00%		1.9308		0.00
11	431	00:06:04	56.25%		1.6611		0.00
11	432	00:06:05	56.25%		1.4132		0.00
11	433	00:06:06	31.25%		1.9464		0.00
11	434	00:06:07	62.50%		1.2169		0.00
11	435	00:06:08	37.50%		1.6829		0.00
11	436	00:06:09	68.75%		1.2154		0.00
11	437	00:06:09	43.75%		1.5807		0.00
11	438	00:06:10	62.50%		1.3625		0.00
11	439	00:06:11	31.25%		2.2942		0.00
11	440	00:06:12	68.75%		1.6964		0.00
11	441	00:06:13	31.25%		1.9056		0.00
11	442	00:06:13	31.25%		1.8649		0.00
11	443	00:06:14	50.00%		1.7492		0.00
11	444	00:06:15	43.75%		2.2837		0.00
11	445	00:06:16	37.50%		1.9464		0.00
11	446	00:06:17	37.50%		1.6191		0.00
11	447	00:06:17	50.00%		1.6501		0.00
11	448	00:06:18	25.00%		2.1553		0.00
11	449	00:06:19	43.75%		1.9341		0.00
11	450	00:06:27	50.00%	36.04%	1.7360	2.0888	0.00
11	451	00:06:27	50.00%		1.8007		0.00
12	452	00:06:29	62.50%		1.4628		0.00
12	453	00:06:29	31.25%		1.8974		0.00
12	454	00:06:30	31.25%		2.0532		0.00
12	455	00:06:31	56.25%		1.8924		0.00
12	456	00:06:31	43.75%		1.8714		0.00
12	457	00:06:32	43.75%		1.9259		0.00
12	458	00:06:33	37.50%		1.7419		0.00
12	459	00:06:33	56.25%		1.4624		0.00
12	460	00:06:34	31.25%		1.8070		0.00
12	461	00:06:35	56.25%		1.4609		0.00
12	462	00:06:36	25.00%		2.2332		0.00
12	463	00:06:36	37.50%		1.9524		0.00
12	464	00:06:37	43.75%		1.5255		0.00
12	465	00:06:38	31.25%		2.1507		0.00
12	466	00:06:38	50.00%		1.6654		0.00
12	467	00:06:39	43.75%		1.7676		0.00
12	468	00:06:40	43.75%		1.6570		0.00
12	469	00:06:40	56.25%		1.6674		0.00
12	470	00:06:41	25.00%		2.2525		0.00
12	471	00:06:42	43.75%		1.6503		0.00
12	472	00:06:43	31.25%		1.8486		0.00
12	473	00:06:43	37.50%		1.7359		0.00
12	474	00:06:44	37.50%		2.1975		0.00
12	475	00:06:45	37.50%		1.9171		0.00
12	476	00:06:46	56.25%		1.5782		0.00
12	477	00:06:47	31.25%		1.9950		0.00
12	478	00:06:48	31.25%		1.9457		0.00
12	479	00:06:48	50.00%		1.8834		0.00
12	480	00:06:49	31.25%		2.3852		0.00
12	481	00:06:50	56.25%		1.7211		0.00
12	482	00:06:51	31.25%		2.1530		0.00
12	483	00:06:51	50.00%		1.6660		0.00
12	484	00:06:52	43.75%		1.6025		0.00
12	485	00:06:53	37.50%		2.2626		0.00

```
|      12 |         486 |       00:06:53 |       43.75% |            |       1.7624 |            |          0.00
|      12 |         487 |       00:06:54 |       31.25% |            |       2.2039 |            |          0.00
|      12 |         488 |       00:06:54 |       43.75% |            |       2.2535 |            |          0.00
|      12 |         489 |       00:06:55 |       31.25% |            |       2.4906 |            |          0.00
|      12 |         490 |       00:06:56 |       31.25% |            |       1.6440 |            |          0.00
|      12 |         491 |       00:06:56 |       62.50% |            |       1.4230 |            |          0.00
|      12 |         492 |       00:06:56 |...
```

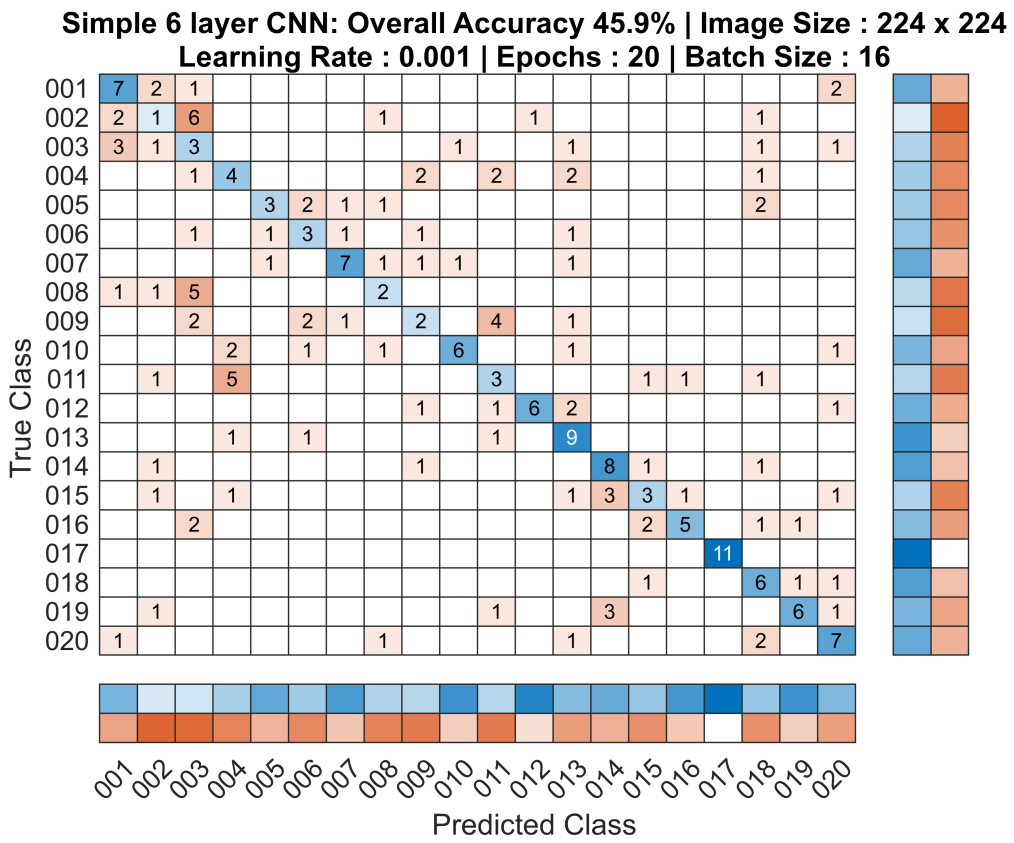



```
target_predictions = classify(myCNN, test_image_datastore_resized);
target_test = testImageDS.Labels;

% Calculate overall accuracy
overall_accuracy = sum(target_predictions == target_test)/numel(target_test) % Output on comma
```

```
overall_accuracy = 0.4595
```

```
% Show confusion matrix in figure
[matrix, order] = confusionmat(target_test, target_predictions);
figure(2);
confusion_matrix = confusionchart(matrix, order, ...
    'ColumnSummary','column-normalized', ...
    'RowSummary','row-normalized');
title({"Simple 6 layer CNN: Overall Accuracy " + string(round(overall_accuracy*100, 1)) + "%" +
    " | Image Size : " + target_size(1) + " x " + target_size(1); ...
    "Learning Rate : " + learning_rate + " | Epochs : " + epochs + " | Batch Size : " + batch_s
```




```
class_wise_correct_recognition_rates = zeros(height(order), 1);
samples_per_row = sum(matrix, 2);
for i = 1:height(order)
    class_wise_correct_recognition_rates(i) = round(100 * matrix(i, i) / samples_per_row(i), 1)
end
class_name_labels = table2array(classNames(:,2));

class_wise_recognition_rates = table(class_name_labels, ...
    class_wise_correct_recognition_rates, ...
    'VariableNames',["Class Name", "Correct Recognition Rate (%)"]);

disp("Class Weighted Average Overall Accuracy is " + string(round(overall_accuracy*100, 2)) + '
```

```
Class Weighted Average Overall Accuracy is 45.95%
```

```
disp(class_wise_recognition_rates);
```

Class Name	Correct Recognition Rate (%)
{'001.Black_footed_Albatross' }	58.3
{'002.Laysan_Albatross' }	8.3
{'003.Sooty_Albatross' }	27.3
{'004.Groove_billed_Ani' }	33.3
{'005.Crested_Auklet' }	33.3
{'006.Least_Auklet' }	37.5
{'007.Parakeet_Auklet' }	58.3
{'008.Rhinoceros_Auklet' }	22.2

```
{'009.Brewer_Blackbird'       }               16.7
{'010.Red_winged_Blackbird'   }                 50
{'011.Rusty_Blackbird'        }                 25
{'012.Yellow_headed_Blackbird'}               54.5
{'013.Bobolink'               }                 75
{'014.Indigo_Bunting'         }               66.7
{'015.Lazuli_Bunting'         }               27.3
{'016.Painted_Bunting'        }               45.5
{'017.Cardinal'               }                100
{'018.Spotted_Catbird'        }               66.7
{'019.Gray_Catbird'           }                 50
{'020.Yellow_breasted_Chat'   }               58.3
```