

```
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', false);
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, target_size));
```

```
validation_image_datastore_resized = transform(validationImageDS, @(image_i) imresize(image_i, target_size));
```

```
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 (hh:mm:ss)	Mini-batch Accuracy	Validation Accuracy	Mini-batch Loss	Validation Loss	Base Learning Rate
1	1	00:00:17	12.50%	4.05%	3.2906	3.4662	0.001
1	2	00:00:18	0.00%		4.2655		0.001
1	3	00:00:19	0.00%		4.3847		0.001
1	4	00:00:19	6.25%		3.6725		0.001
1	5	00:00:20	6.25%		4.4591		0.001
1	6	00:00:21	6.25%		3.3919		0.001
1	7	00:00:21	6.25%		3.4850		0.001
1	8	00:00:22	0.00%		3.6325		0.001
1	9	00:00:22	0.00%		3.9105		0.001
1	10	00:00:23	0.00%		3.9444		0.001
1	11	00:00:24	0.00%		3.8588		0.001
1	12	00:00:25	6.25%		3.3650		0.001
1	13	00:00:25	18.75%		3.6809		0.001
1	14	00:00:26	6.25%		3.8612		0.001
1	15	00:00:27	12.50%		3.3442		0.001
1	16	00:00:27	0.00%		4.0934		0.001
1	17	00:00:28	6.25%		3.7296		0.001
1	18	00:00:29	12.50%		3.4437		0.001
1	19	00:00:30	6.25%		3.4471		0.001
1	20	00:00:30	18.75%		3.6098		0.001
1	21	00:00:31	0.00%		3.8964		0.001
1	22	00:00:32	6.25%		3.9558		0.001
1	23	00:00:32	0.00%		3.0675		0.001
1	24	00:00:33	12.50%		3.3935		0.001
1	25	00:00:34	0.00%		3.7423		0.001
1	26	00:00:34	12.50%		3.5657		0.001
1	27	00:00:35	6.25%		3.2106		0.001
1	28	00:00:36	0.00%		3.4059		0.001
1	29	00:00:36	0.00%		3.6377		0.001
1	30	00:00:37	12.50%		2.7218		0.001
1	31	00:00:38	6.25%		3.5248		0.001
1	32	00:00:38	0.00%		3.3528		0.001
1	33	00:00:39	12.50%		3.3870		0.001
1	34	00:00:40	6.25%		3.5953		0.001
1	35	00:00:40	25.00%		3.1033		0.001
1	36	00:00:41	0.00%		4.1376		0.001
1	37	00:00:42	6.25%		3.1230		0.001

1	38	00:00:42	0.00%		3.9309		0.00
1	39	00:00:43	0.00%		3.6107		0.00
1	40	00:00:43	0.00%		3.2074		0.00
1	41	00:00:43	6.25%		3.8616		0.00
2	42	00:00:45	0.00%		3.4697		0.00
2	43	00:00:45	12.50%		3.2899		0.00
2	44	00:00:46	12.50%		3.5998		0.00
2	45	00:00:46	6.25%		3.2676		0.00
2	46	00:00:47	6.25%		3.6124		0.00
2	47	00:00:47	12.50%		2.9026		0.00
2	48	00:00:48	18.75%		3.3654		0.00
2	49	00:00:49	12.50%		3.4402		0.00
2	50	00:00:56	12.50%	10.36%	3.4439	3.0181	0.00
2	51	00:00:57	0.00%		3.6041		0.00
2	52	00:00:58	6.25%		3.4631		0.00
2	53	00:00:58	18.75%		3.0407		0.00
2	54	00:00:59	6.25%		3.2651		0.00
2	55	00:01:00	6.25%		3.3670		0.00
2	56	00:01:00	6.25%		3.2436		0.00
2	57	00:01:01	6.25%		3.5831		0.00
2	58	00:01:02	6.25%		3.2493		0.00
2	59	00:01:02	0.00%		2.9464		0.00
2	60	00:01:03	25.00%		2.8661		0.00
2	61	00:01:03	12.50%		2.6636		0.00
2	62	00:01:04	6.25%		3.2001		0.00
2	63	00:01:05	25.00%		2.9586		0.00
2	64	00:01:05	12.50%		3.0655		0.00
2	65	00:01:06	12.50%		3.2731		0.00
2	66	00:01:06	0.00%		3.2935		0.00
2	67	00:01:07	12.50%		3.5507		0.00
2	68	00:01:08	12.50%		2.9713		0.00
2	69	00:01:08	18.75%		2.7291		0.00
2	70	00:01:09	12.50%		2.9265		0.00
2	71	00:01:09	6.25%		3.5448		0.00
2	72	00:01:10	6.25%		3.4943		0.00
2	73	00:01:11	0.00%		3.2149		0.00
2	74	00:01:11	6.25%		3.6451		0.00
2	75	00:01:12	12.50%		3.1130		0.00
2	76	00:01:13	12.50%		3.3659		0.00
2	77	00:01:13	25.00%		2.6519		0.00
2	78	00:01:14	6.25%		3.5468		0.00
2	79	00:01:15	6.25%		3.4504		0.00
2	80	00:01:15	6.25%		3.0726		0.00
2	81	00:01:16	18.75%		2.9724		0.00
2	82	00:01:16	0.00%		3.1368		0.00
3	83	00:01:17	6.25%		2.9057		0.00
3	84	00:01:18	37.50%		2.7031		0.00
3	85	00:01:18	18.75%		2.6289		0.00
3	86	00:01:19	18.75%		3.1781		0.00
3	87	00:01:19	25.00%		2.8438		0.00
3	88	00:01:20	18.75%		2.8034		0.00
3	89	00:01:20	0.00%		3.5098		0.00
3	90	00:01:21	0.00%		3.0321		0.00
3	91	00:01:21	18.75%		2.8841		0.00
3	92	00:01:22	18.75%		2.9655		0.00
3	93	00:01:23	12.50%		3.3037		0.00
3	94	00:01:23	6.25%		3.3666		0.00
3	95	00:01:24	6.25%		3.0630		0.00
3	96	00:01:24	6.25%		3.1943		0.00
3	97	00:01:25	12.50%		2.9524		0.00
3	98	00:01:26	18.75%		2.6169		0.00
3	99	00:01:26	12.50%		2.8049		0.00
3	100	00:01:34	6.25%	18.02%	2.9885	2.7736	0.00
3	101	00:01:35	6.25%		3.1440		0.00

3	102	00:01:35	18.75%		2.9110		0.00
3	103	00:01:36	6.25%		3.0812		0.00
3	104	00:01:36	12.50%		3.4245		0.00
3	105	00:01:37	31.25%		2.9862		0.00
3	106	00:01:38	18.75%		2.6316		0.00
3	107	00:01:38	6.25%		3.3834		0.00
3	108	00:01:39	12.50%		3.1169		0.00
3	109	00:01:40	12.50%		2.9423		0.00
3	110	00:01:40	0.00%		3.0142		0.00
3	111	00:01:41	12.50%		2.7154		0.00
3	112	00:01:41	31.25%		2.5064		0.00
3	113	00:01:42	6.25%		3.0767		0.00
3	114	00:01:43	6.25%		3.1441		0.00
3	115	00:01:43	6.25%		3.0723		0.00
3	116	00:01:44	18.75%		2.7944		0.00
3	117	00:01:44	12.50%		3.0849		0.00
3	118	00:01:45	25.00%		2.4063		0.00
3	119	00:01:46	0.00%		3.1094		0.00
3	120	00:01:46	31.25%		3.4767		0.00
3	121	00:01:47	6.25%		3.2678		0.00
3	122	00:01:47	6.25%		3.7332		0.00
3	123	00:01:48	12.50%		3.0911		0.00
4	124	00:01:49	12.50%		2.4680		0.00
4	125	00:01:49	18.75%		3.0144		0.00
4	126	00:01:50	25.00%		2.4703		0.00
4	127	00:01:51	6.25%		3.5548		0.00
4	128	00:01:51	18.75%		3.1064		0.00
4	129	00:01:52	6.25%		2.9845		0.00
4	130	00:01:52	25.00%		2.6462		0.00
4	131	00:01:53	18.75%		2.9242		0.00
4	132	00:01:53	18.75%		2.8349		0.00
4	133	00:01:54	12.50%		2.7203		0.00
4	134	00:01:55	12.50%		2.7280		0.00
4	135	00:01:55	18.75%		3.0861		0.00
4	136	00:01:56	25.00%		3.0171		0.00
4	137	00:01:57	25.00%		2.5218		0.00
4	138	00:01:57	25.00%		2.5447		0.00
4	139	00:01:58	12.50%		2.9544		0.00
4	140	00:01:59	18.75%		3.1681		0.00
4	141	00:01:59	6.25%		3.0206		0.00
4	142	00:02:00	31.25%		2.7332		0.00
4	143	00:02:01	25.00%		2.9710		0.00
4	144	00:02:01	18.75%		3.3680		0.00
4	145	00:02:02	6.25%		3.0128		0.00
4	146	00:02:03	25.00%		2.7119		0.00
4	147	00:02:03	18.75%		3.0004		0.00
4	148	00:02:04	12.50%		3.0605		0.00
4	149	00:02:04	0.00%		3.5025		0.00
4	150	00:02:12	6.25%	18.02%	3.5664	2.8080	0.00
4	151	00:02:12	18.75%		2.5460		0.00
4	152	00:02:13	25.00%		2.5978		0.00
4	153	00:02:14	31.25%		2.1320		0.00
4	154	00:02:14	12.50%		2.9513		0.00
4	155	00:02:15	18.75%		2.5044		0.00
4	156	00:02:16	18.75%		2.8279		0.00
4	157	00:02:16	18.75%		2.9565		0.00
4	158	00:02:17	37.50%		2.7057		0.00
4	159	00:02:18	6.25%		3.4429		0.00
4	160	00:02:18	18.75%		2.9205		0.00
4	161	00:02:19	18.75%		2.7448		0.00
4	162	00:02:19	6.25%		3.2698		0.00
4	163	00:02:20	12.50%		3.0147		0.00
4	164	00:02:20	12.50%		3.0949		0.00
5	165	00:02:22	37.50%		2.6005		0.00

5	166	00:02:22	0.00%		3.1848		0.00
5	167	00:02:23	18.75%		2.7901		0.00
5	168	00:02:23	31.25%		2.1835		0.00
5	169	00:02:24	18.75%		2.6086		0.00
5	170	00:02:25	0.00%		3.4733		0.00
5	171	00:02:25	12.50%		2.8138		0.00
5	172	00:02:26	6.25%		2.7533		0.00
5	173	00:02:26	12.50%		3.1296		0.00
5	174	00:02:27	0.00%		3.1795		0.00
5	175	00:02:28	43.75%		2.1077		0.00
5	176	00:02:28	18.75%		2.8381		0.00
5	177	00:02:29	25.00%		2.9513		0.00
5	178	00:02:30	12.50%		2.3486		0.00
5	179	00:02:30	12.50%		2.8619		0.00
5	180	00:02:31	25.00%		2.7002		0.00
5	181	00:02:32	6.25%		3.1157		0.00
5	182	00:02:33	12.50%		3.0060		0.00
5	183	00:02:33	12.50%		2.9667		0.00
5	184	00:02:34	25.00%		2.5929		0.00
5	185	00:02:35	12.50%		2.4893		0.00
5	186	00:02:35	25.00%		2.5634		0.00
5	187	00:02:36	6.25%		3.0900		0.00
5	188	00:02:36	25.00%		2.7746		0.00
5	189	00:02:37	6.25%		2.9643		0.00
5	190	00:02:38	25.00%		3.1202		0.00
5	191	00:02:39	25.00%		2.6167		0.00
5	192	00:02:39	25.00%		2.6995		0.00
5	193	00:02:40	6.25%		3.1424		0.00
5	194	00:02:40	43.75%		2.5113		0.00
5	195	00:02:41	12.50%		2.9232		0.00
5	196	00:02:42	18.75%		2.7566		0.00
5	197	00:02:42	18.75%		2.9368		0.00
5	198	00:02:43	18.75%		3.1628		0.00
5	199	00:02:44	12.50%		2.7561		0.00
5	200	00:02:51	25.00%	22.07%	2.7254	2.6388	0.00
5	201	00:02:52	12.50%		2.6288		0.00
5	202	00:02:52	12.50%		2.9095		0.00
5	203	00:02:53	18.75%		2.6676		0.00
5	204	00:02:53	18.75%		2.6673		0.00
5	205	00:02:53	18.75%		2.3771		0.00
6	206	00:02:55	25.00%		2.7869		0.00
6	207	00:02:55	6.25%		2.9432		0.00
6	208	00:02:56	31.25%		2.4578		0.00
6	209	00:02:56	12.50%		2.8061		0.00
6	210	00:02:57	25.00%		2.6356		0.00
6	211	00:02:58	12.50%		2.6681		0.00
6	212	00:02:58	43.75%		2.1888		0.00
6	213	00:02:59	0.00%		2.5003		0.00
6	214	00:02:59	37.50%		2.2740		0.00
6	215	00:03:00	25.00%		2.7784		0.00
6	216	00:03:01	37.50%		2.2330		0.00
6	217	00:03:01	31.25%		2.6255		0.00
6	218	00:03:02	6.25%		2.9983		0.00
6	219	00:03:03	18.75%		2.7550		0.00
6	220	00:03:03	43.75%		1.9471		0.00
6	221	00:03:04	31.25%		2.1933		0.00
6	222	00:03:05	25.00%		2.3994		0.00
6	223	00:03:05	12.50%		2.8683		0.00
6	224	00:03:06	6.25%		2.8665		0.00
6	225	00:03:07	31.25%		2.2656		0.00
6	226	00:03:08	37.50%		2.2364		0.00
6	227	00:03:09	12.50%		2.9641		0.00
6	228	00:03:09	12.50%		2.9038		0.00
6	229	00:03:10	25.00%		2.2193		0.00

6	230	00:03:11	18.75%		2.5410		0.00
6	231	00:03:12	43.75%		2.4619		0.00
6	232	00:03:12	0.00%		3.2336		0.00
6	233	00:03:13	18.75%		2.7111		0.00
6	234	00:03:14	25.00%		2.5199		0.00
6	235	00:03:15	18.75%		2.5651		0.00
6	236	00:03:16	18.75%		2.8249		0.00
6	237	00:03:17	25.00%		2.7222		0.00
6	238	00:03:17	12.50%		2.7189		0.00
6	239	00:03:18	18.75%		3.0304		0.00
6	240	00:03:19	18.75%		3.0005		0.00
6	241	00:03:20	18.75%		2.4042		0.00
6	242	00:03:21	18.75%		2.5118		0.00
6	243	00:03:21	25.00%		2.9339		0.00
6	244	00:03:22	37.50%		2.6517		0.00
6	245	00:03:23	12.50%		2.6664		0.00
6	246	00:03:23	37.50%		2.3584		0.00
7	247	00:03:25	31.25%		2.6489		0.00
7	248	00:03:25	12.50%		2.9673		0.00
7	249	00:03:26	56.25%		1.6171		0.00
7	250	00:03:35	18.75%	20.27%	2.5223	2.5823	0.00
7	251	00:03:35	37.50%		2.4206		0.00
7	252	00:03:36	31.25%		2.5306		0.00
7	253	00:03:36	50.00%		2.0092		0.00
7	254	00:03:37	43.75%		2.1599		0.00
7	255	00:03:38	25.00%		2.3768		0.00
7	256	00:03:38	25.00%		2.1101		0.00
7	257	00:03:39	18.75%		2.5403		0.00
7	258	00:03:39	12.50%		2.8805		0.00
7	259	00:03:40	25.00%		2.8211		0.00
7	260	00:03:41	18.75%		2.4602		0.00
7	261	00:03:41	31.25%		2.1572		0.00
7	262	00:03:42	25.00%		2.7452		0.00
7	263	00:03:43	12.50%		3.1783		0.00
7	264	00:03:43	18.75%		2.7196		0.00
7	265	00:03:44	31.25%		2.6984		0.00
7	266	00:03:45	18.75%		2.5431		0.00
7	267	00:03:45	37.50%		2.5763		0.00
7	268	00:03:46	12.50%		2.6084		0.00
7	269	00:03:47	25.00%		2.8710		0.00
7	270	00:03:47	25.00%		2.1241		0.00
7	271	00:03:48	37.50%		2.1175		0.00
7	272	00:03:49	31.25%		2.5123		0.00
7	273	00:03:50	12.50%		2.3905		0.00
7	274	00:03:51	25.00%		2.3279		0.00
7	275	00:03:51	31.25%		2.3785		0.00
7	276	00:03:52	37.50%		2.0925		0.00
7	277	00:03:53	31.25%		2.3119		0.00
7	278	00:03:54	25.00%		3.2284		0.00
7	279	00:03:54	43.75%		2.2394		0.00
7	280	00:03:55	43.75%		1.9949		0.00
7	281	00:03:56	18.75%		2.5908		0.00
7	282	00:03:57	25.00%		2.7172		0.00
7	283	00:03:57	31.25%		2.0360		0.00
7	284	00:03:58	18.75%		2.3684		0.00
7	285	00:03:59	18.75%		2.6893		0.00
7	286	00:03:59	31.25%		2.6566		0.00
7	287	00:03:59	18.75%		2.5615		0.00
8	288	00:04:01	18.75%		2.6551		0.00
8	289	00:04:01	31.25%		2.0964		0.00
8	290	00:04:02	37.50%		2.0887		0.00
8	291	00:04:02	37.50%		1.9513		0.00
8	292	00:04:02	25.00%		2.7661		0.00
8	293	00:04:03	43.75%		2.2002		0.00

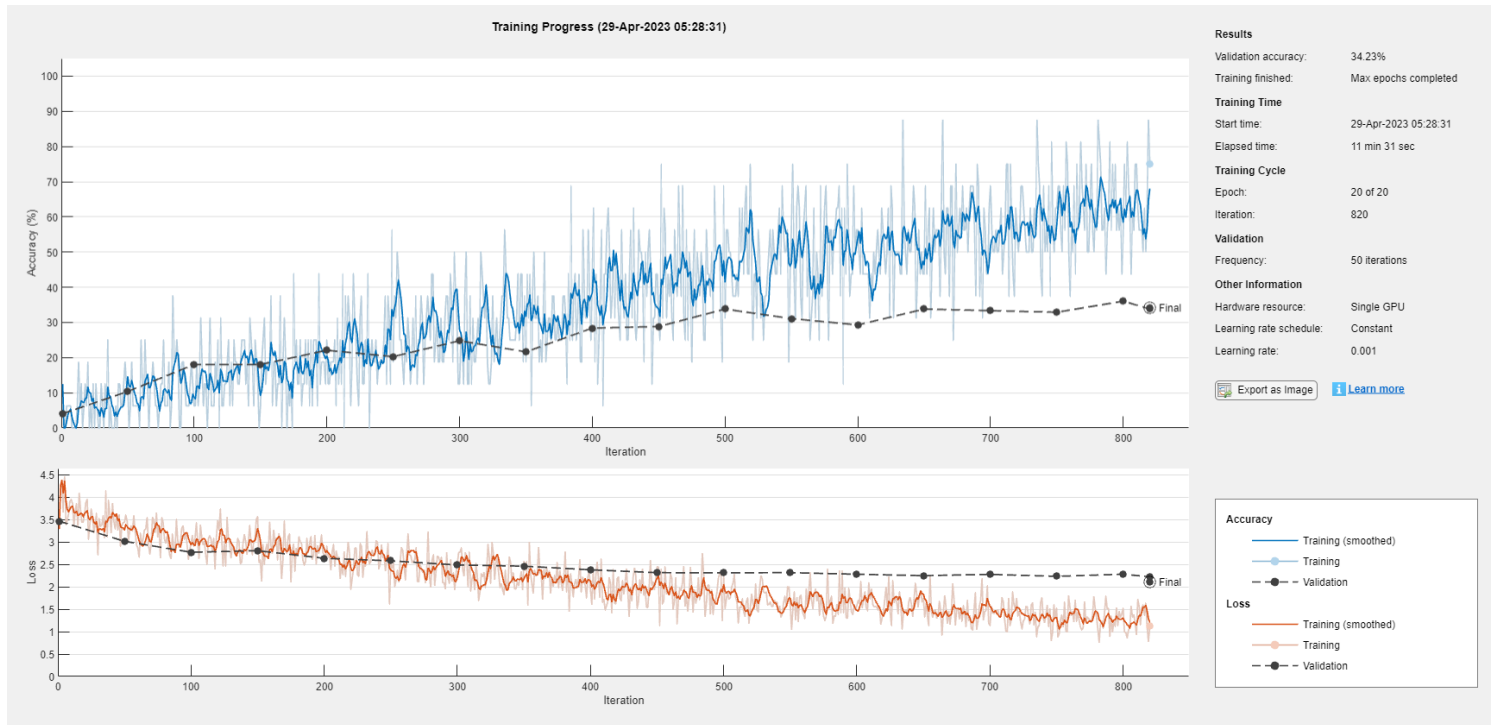


8	294	00:04:04	37.50%		2.0796		0.00
8	295	00:04:04	18.75%		2.6066		0.00
8	296	00:04:05	50.00%		2.1270		0.00
8	297	00:04:05	37.50%		2.3168		0.00
8	298	00:04:06	31.25%		1.9402		0.00
8	299	00:04:07	12.50%		2.3028		0.00
8	300	00:04:14	12.50%	24.77%	2.5256	2.4888	0.00
8	301	00:04:15	25.00%		2.7654		0.00
8	302	00:04:15	25.00%		2.7772		0.00
8	303	00:04:16	12.50%		2.8728		0.00
8	304	00:04:16	37.50%		2.3947		0.00
8	305	00:04:17	50.00%		2.2462		0.00
8	306	00:04:18	12.50%		2.7652		0.00
8	307	00:04:19	12.50%		2.6604		0.00
8	308	00:04:19	37.50%		2.0020		0.00
8	309	00:04:20	12.50%		2.7709		0.00
8	310	00:04:21	31.25%		1.9089		0.00
8	311	00:04:21	18.75%		2.1786		0.00
8	312	00:04:22	18.75%		2.2742		0.00
8	313	00:04:23	25.00%		1.9433		0.00
8	314	00:04:24	31.25%		2.5197		0.00
8	315	00:04:24	25.00%		2.2407		0.00
8	316	00:04:25	50.00%		1.6930		0.00
8	317	00:04:25	43.75%		1.8997		0.00
8	318	00:04:26	37.50%		2.2902		0.00
8	319	00:04:27	31.25%		2.2240		0.00
8	320	00:04:28	37.50%		2.3261		0.00
8	321	00:04:29	18.75%		1.9896		0.00
8	322	00:04:30	12.50%		2.3574		0.00
8	323	00:04:31	12.50%		2.9474		0.00
8	324	00:04:32	18.75%		2.6500		0.00
8	325	00:04:32	37.50%		2.0824		0.00
8	326	00:04:33	18.75%		2.9923		0.00
8	327	00:04:34	25.00%		2.7510		0.00
8	328	00:04:34	31.25%		2.1661		0.00
9	329	00:04:35	18.75%		2.5426		0.00
9	330	00:04:36	25.00%		2.6303		0.00
9	331	00:04:36	31.25%		2.3178		0.00
9	332	00:04:37	37.50%		1.9899		0.00
9	333	00:04:37	37.50%		2.0702		0.00
9	334	00:04:38	56.25%		1.9310		0.00
9	335	00:04:39	43.75%		1.8293		0.00
9	336	00:04:39	31.25%		2.3722		0.00
9	337	00:04:40	31.25%		1.9462		0.00
9	338	00:04:40	25.00%		2.0489		0.00
9	339	00:04:41	25.00%		2.6699		0.00
9	340	00:04:41	25.00%		2.5429		0.00
9	341	00:04:42	25.00%		2.1002		0.00
9	342	00:04:42	25.00%		2.3102		0.00
9	343	00:04:43	31.25%		1.9523		0.00
9	344	00:04:43	43.75%		1.9582		0.00
9	345	00:04:44	25.00%		2.1161		0.00
9	346	00:04:45	43.75%		2.0264		0.00
9	347	00:04:45	43.75%		2.1787		0.00
9	348	00:04:46	18.75%		2.3309		0.00
9	349	00:04:46	37.50%		1.9345		0.00
9	350	00:04:54	18.75%	21.62%	2.5736	2.4627	0.00
9	351	00:04:55	43.75%		2.3692		0.00
9	352	00:04:55	31.25%		2.5594		0.00
9	353	00:04:56	43.75%		1.5937		0.00
9	354	00:04:57	6.25%		2.9973		0.00
9	355	00:04:57	37.50%		2.2879		0.00
9	356	00:04:58	50.00%		2.0624		0.00
9	357	00:04:59	31.25%		1.8611		0.00

9	358	00:04:59	31.25%		2.3746		0.00
9	359	00:05:00	37.50%		2.2396		0.00
9	360	00:05:01	18.75%		2.2699		0.00
9	361	00:05:01	25.00%		2.8810		0.00
9	362	00:05:02	18.75%		2.3105		0.00
9	363	00:05:03	31.25%		2.2855		0.00
9	364	00:05:04	50.00%		1.7230		0.00
9	365	00:05:05	18.75%		2.3913		0.00
9	366	00:05:05	25.00%		2.1954		0.00
9	367	00:05:06	31.25%		2.4321		0.00
9	368	00:05:07	31.25%		2.2437		0.00
9	369	00:05:07	25.00%		2.3558		0.00
10	370	00:05:08	37.50%		1.8643		0.00
10	371	00:05:09	37.50%		2.2061		0.00
10	372	00:05:10	25.00%		2.0121		0.00
10	373	00:05:10	25.00%		2.2557		0.00
10	374	00:05:11	31.25%		2.1419		0.00
10	375	00:05:11	25.00%		2.5449		0.00
10	376	00:05:12	25.00%		1.9809		0.00
10	377	00:05:12	25.00%		2.3585		0.00
10	378	00:05:13	37.50%		2.0785		0.00
10	379	00:05:13	37.50%		1.9262		0.00
10	380	00:05:14	31.25%		2.2042		0.00
10	381	00:05:15	12.50%		2.7835		0.00
10	382	00:05:16	43.75%		1.8940		0.00
10	383	00:05:17	25.00%		2.3911		0.00
10	384	00:05:18	68.75%		1.4522		0.00
10	385	00:05:19	25.00%		2.2884		0.00
10	386	00:05:21	37.50%		2.0696		0.00
10	387	00:05:22	43.75%		1.7781		0.00
10	388	00:05:22	25.00%		2.0725		0.00
10	389	00:05:23	31.25%		2.1697		0.00
10	390	00:05:24	43.75%		1.9747		0.00
10	391	00:05:24	18.75%		2.1955		0.00
10	392	00:05:25	18.75%		2.6035		0.00
10	393	00:05:26	56.25%		1.8835		0.00
10	394	00:05:26	37.50%		2.2143		0.00
10	395	00:05:27	31.25%		2.1565		0.00
10	396	00:05:28	31.25%		2.0359		0.00
10	397	00:05:29	56.25%		1.7574		0.00
10	398	00:05:29	37.50%		2.2262		0.00
10	399	00:05:30	25.00%		2.3638		0.00
10	400	00:05:36	43.75%	28.38%	1.9256	2.3819	0.00
10	401	00:05:37	62.50%		1.6083		0.00
10	402	00:05:37	18.75%		2.3661		0.00
10	403	00:05:38	43.75%		1.7355		0.00
10	404	00:05:38	12.50%		2.2370		0.00
10	405	00:05:39	25.00%		2.5581		0.00
10	406	00:05:39	37.50%		2.1619		0.00
10	407	00:05:40	56.25%		1.7676		0.00
10	408	00:05:40	6.25%		2.6219		0.00
10	409	00:05:41	43.75%		1.6557		0.00
10	410	00:05:41	43.75%		1.7245		0.00
11	411	00:05:42	56.25%		1.4848		0.00
11	412	00:05:43	62.50%		1.5748		0.00
11	413	00:05:44	50.00%		1.6723		0.00
11	414	00:05:44	31.25%		2.2112		0.00
11	415	00:05:45	37.50%		2.0736		0.00
11	416	00:05:46	50.00%		1.4258		0.00
11	417	00:05:46	31.25%		2.3914		0.00
11	418	00:05:47	50.00%		1.6383		0.00
11	419	00:05:48	37.50%		1.6225		0.00
11	420	00:05:48	31.25%		2.1818		0.00
11	421	00:05:49	25.00%		2.2248		0.00

11	422	00:05:49	56.25%		1.7561		0.00
11	423	00:05:50	37.50%		1.6871		0.00
11	424	00:05:51	31.25%		2.1452		0.00
11	425	00:05:51	43.75%		1.8382		0.00
11	426	00:05:52	25.00%		2.1124		0.00
11	427	00:05:53	25.00%		2.4047		0.00
11	428	00:05:54	43.75%		1.8948		0.00
11	429	00:05:55	56.25%		1.3457		0.00
11	430	00:05:56	31.25%		1.9858		0.00
11	431	00:05:57	62.50%		1.6822		0.00
11	432	00:05:58	31.25%		2.2227		0.00
11	433	00:05:59	25.00%		2.4203		0.00
11	434	00:06:00	31.25%		2.2549		0.00
11	435	00:06:01	56.25%		1.5203		0.00
11	436	00:06:02	50.00%		1.6736		0.00
11	437	00:06:03	50.00%		2.1566		0.00
11	438	00:06:03	43.75%		1.8693		0.00
11	439	00:06:04	18.75%		2.4012		0.00
11	440	00:06:05	50.00%		1.8141		0.00
11	441	00:06:06	37.50%		2.0221		0.00
11	442	00:06:06	50.00%		1.5516		0.00
11	443	00:06:07	56.25%		1.5374		0.00
11	444	00:06:08	43.75%		1.9575		0.00
11	445	00:06:10	12.50%		2.5912		0.00
11	446	00:06:11	31.25%		2.0321		0.00
11	447	00:06:13	31.25%		2.1146		0.00
11	448	00:06:14	43.75%		1.9354		0.00
11	449	00:06:16	43.75%		2.1668		0.00
11	450	00:06:24	31.25%	28.83%	2.4506	2.3175	0.00
11	451	00:06:24	25.00%		2.4436		0.00
12	452	00:06:26	75.00%		1.1281		0.00
12	453	00:06:27	31.25%		2.3992		0.00
12	454	00:06:27	62.50%		1.6173		0.00
12	455	00:06:28	56.25%		1.6875		0.00
12	456	00:06:28	31.25%		2.4460		0.00
12	457	00:06:29	43.75%		1.8408		0.00
12	458	00:06:30	37.50%		1.8750		0.00
12	459	00:06:30	43.75%		1.8354		0.00
12	460	00:06:31	31.25%		2.2917		0.00
12	461	00:06:31	25.00%		2.2063		0.00
12	462	00:06:32	56.25%		1.5018		0.00
12	463	00:06:32	43.75%		1.6655		0.00
12	464	00:06:33	37.50%		2.2089		0.00
12	465	00:06:34	68.75%		1.1801		0.00
12	466	00:06:34	50.00%		1.7137		0.00
12	467	00:06:35	37.50%		1.9763		0.00
12	468	00:06:35	68.75%		1.9211		0.00
12	469	00:06:36	31.25%		2.0788		0.00
12	470	00:06:37	25.00%		2.4559		0.00
12	471	00:06:37	56.25%		1.5718		0.00
12	472	00:06:38	25.00%		1.7880		0.00
12	473	00:06:39	50.00%		1.4620		0.00
12	474	00:06:39	43.75%		1.7576		0.00
12	475	00:06:40	18.75%		2.4327		0.00
12	476	00:06:40	43.75%		2.0271		0.00
12	477	00:06:41	56.25%		1.4337		0.00
12	478	00:06:42	31.25%		1.9392		0.00
12	479	00:06:42	50.00%		1.6422		0.00
12	480	00:06:43	43.75%		1.7500		0.00
12	481	00:06:44	37.50%		2.2057		0.00
12	482	00:06:44	50.00%		1.7163		0.00
12	483	00:06:45	43.75%		1.9231		0.00
12	484	00:06:46	25.00%		2.7467		0.00
12	485	00:06:46	25.00%		2.2663		0.00

12	486	00:06:47	56.25%	1.3380	0.00
12	487	00:06:47	43.75%	1.6283	0.00
12	488	00:06:48	43.75%	2.0411	0.00
12	489	00:06:48	37.50%	2.0368	0.00
12	490	00:06:49	50.00%	1.3982	0.00
12	491	00:06:49	31.25%	1.9342	0.00
12	492	00:06:50	...		



```
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 command window
```

```
overall_accuracy = 0.3919
```

```
% 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');
```

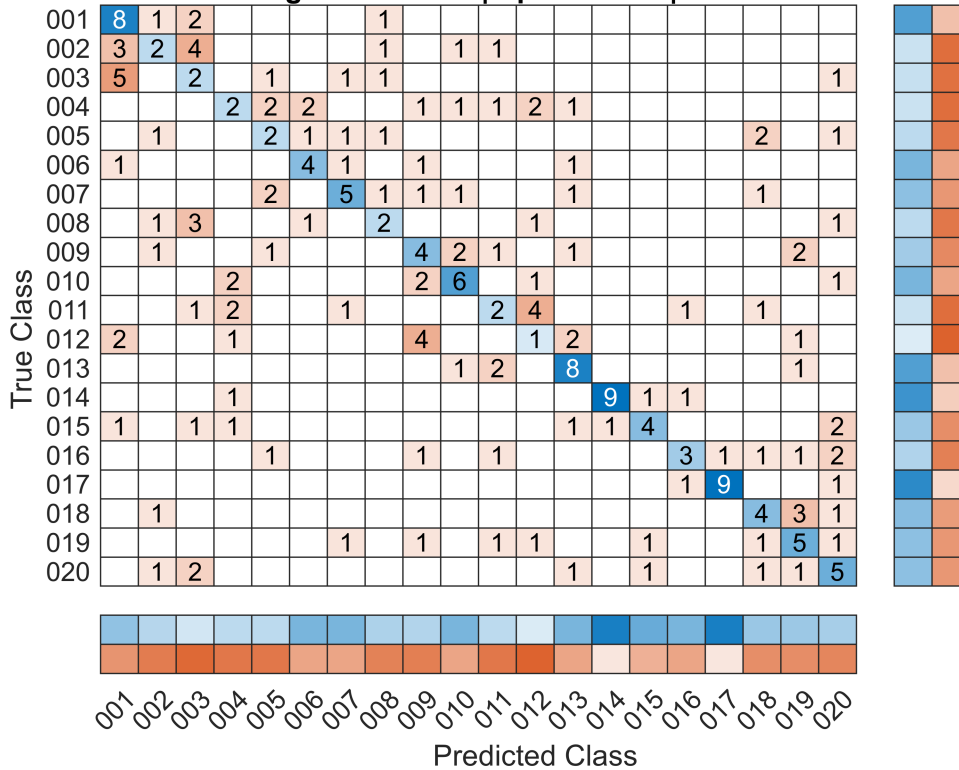
```
title({"Resnet50: Overall Accuracy " + string(round(overall_accuracy*100, 1)) + "%" + ...
```

```
    " | Image Size : " + target_size(1) + " x " + target_size(1); ...
```

```
    "Learning Rate : " + learning_rate + " | Epochs : " + epochs + " | Batch Size : " + batch_size});
```

**Resnet50: Overall Accuracy 39.2% | Image Size : 224 x 224**

**Learning Rate : 0.001 | Epochs : 20 | Batch Size : 16**



```
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 39.19%

```
disp(class_wise_recognition_rates);
```

Class Name	Correct Recognition Rate (%)
{'001.Black_footed_Albatross' }	66.7
{'002.Laysan_Albatross' }	16.7
{'003.Sooty_Albatross' }	18.2
{'004.Groove_billed_Ani' }	16.7
{'005.Crested_Auklet' }	22.2
{'006.Least_Auklet' }	50
{'007.Parakeet_Auklet' }	41.7
{'008.Rhinoceros_Auklet' }	22.2

{'009.Brewer_Blackbird' }	33.3
{'010.Red_winged_Blackbird' }	50
{'011.Rusty_Blackbird' }	16.7
{'012.Yellow_headed_Blackbird' }	9.1
{'013.Bobolink' }	66.7
{'014.Indigo_Bunting' }	75
{'015.Lazuli_Bunting' }	36.4
{'016.Painted_Bunting' }	27.3
{'017.Cardinal' }	81.8
{'018.Spotted_Catbird' }	44.4
{'019.Gray_Catbird' }	41.7
{'020.Yellow_breasted_Chat' }	41.7