

```
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];
```

```
target_size = [227, 227];
```

```
% 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);
```

```
% alex net
```

```
net = alexnet;
```

```
analyzeNetwork(net);
```

```
disp(net.Layers(1).InputSize);
```

```
227 227 3
```

```
% replace last 3 layers
```

```
fullnetwork = [
```

```
    net.Layers(1:end-3)
```

```
    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, fullnetwork, 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	00:00:15	6.25%	4.50%	7.3396	4.3582	0.001
1	2	00:00:17	6.25%		6.9450		0.001
1	3	00:00:17	12.50%		4.9394		0.001
1	4	00:00:18	0.00%		4.3873		0.001
1	5	00:00:19	12.50%		3.5754		0.001
1	6	00:00:19	6.25%		4.2893		0.001
1	7	00:00:20	0.00%		4.4383		0.001
1	8	00:00:20	0.00%		4.0233		0.001
1	9	00:00:21	18.75%		2.7982		0.001
1	10	00:00:22	18.75%		3.3752		0.001
1	11	00:00:22	6.25%		3.2727		0.001
1	12	00:00:23	18.75%		3.2662		0.001
1	13	00:00:24	31.25%		2.4300		0.001
1	14	00:00:24	18.75%		2.9432		0.001
1	15	00:00:25	6.25%		2.9381		0.001
1	16	00:00:25	6.25%		2.9450		0.001

1	17	00:00:26	6.25%		3.6129		0.00
1	18	00:00:27	0.00%		2.9674		0.00
1	19	00:00:28	12.50%		3.1299		0.00
1	20	00:00:28	12.50%		2.9686		0.00
1	21	00:00:29	12.50%		3.0667		0.00
1	22	00:00:30	18.75%		2.7699		0.00
1	23	00:00:31	0.00%		3.4351		0.00
1	24	00:00:31	25.00%		2.9671		0.00
1	25	00:00:32	12.50%		2.8399		0.00
1	26	00:00:33	18.75%		2.5103		0.00
1	27	00:00:34	6.25%		2.9434		0.00
1	28	00:00:34	18.75%		2.6216		0.00
1	29	00:00:35	12.50%		2.6468		0.00
1	30	00:00:36	18.75%		2.7181		0.00
1	31	00:00:37	6.25%		3.0246		0.00
1	32	00:00:37	18.75%		2.3711		0.00
1	33	00:00:38	18.75%		2.6979		0.00
1	34	00:00:39	12.50%		2.6536		0.00
1	35	00:00:39	25.00%		2.6850		0.00
1	36	00:00:40	31.25%		2.5256		0.00
1	37	00:00:41	25.00%		2.8786		0.00
1	38	00:00:42	31.25%		2.3215		0.00
1	39	00:00:42	31.25%		2.6148		0.00
1	40	00:00:43	25.00%		2.4112		0.00
1	41	00:00:43	18.75%		2.9439		0.00
2	42	00:00:44	12.50%		2.5545		0.00
2	43	00:00:45	25.00%		2.4002		0.00
2	44	00:00:45	37.50%		2.4445		0.00
2	45	00:00:46	25.00%		2.1846		0.00
2	46	00:00:47	6.25%		3.2476		0.00
2	47	00:00:47	18.75%		2.5808		0.00
2	48	00:00:48	37.50%		2.2749		0.00
2	49	00:00:48	25.00%		2.3665		0.00
2	50	00:00:56	43.75%	27.03%	1.9142	2.3476	0.00
2	51	00:00:57	25.00%		2.2765		0.00
2	52	00:00:58	37.50%		2.4006		0.00
2	53	00:00:58	6.25%		2.5978		0.00
2	54	00:00:59	6.25%		2.4859		0.00
2	55	00:01:00	31.25%		2.2830		0.00
2	56	00:01:00	43.75%		1.7461		0.00
2	57	00:01:01	31.25%		2.0384		0.00
2	58	00:01:01	25.00%		2.1611		0.00
2	59	00:01:02	37.50%		2.0167		0.00
2	60	00:01:03	50.00%		2.0076		0.00
2	61	00:01:03	43.75%		2.2200		0.00
2	62	00:01:04	18.75%		2.3680		0.00
2	63	00:01:05	56.25%		1.2604		0.00
2	64	00:01:05	43.75%		1.7044		0.00
2	65	00:01:06	43.75%		1.9129		0.00
2	66	00:01:07	31.25%		2.0499		0.00
2	67	00:01:07	37.50%		2.2922		0.00
2	68	00:01:08	31.25%		2.1615		0.00
2	69	00:01:09	43.75%		1.9634		0.00
2	70	00:01:09	43.75%		2.0550		0.00
2	71	00:01:10	50.00%		1.7028		0.00
2	72	00:01:11	50.00%		1.6336		0.00
2	73	00:01:11	50.00%		1.2396		0.00
2	74	00:01:12	31.25%		1.8780		0.00
2	75	00:01:13	37.50%		1.6421		0.00
2	76	00:01:13	43.75%		1.4895		0.00
2	77	00:01:14	43.75%		2.1408		0.00
2	78	00:01:14	37.50%		2.0596		0.00
2	79	00:01:15	37.50%		1.8422		0.00
2	80	00:01:16	37.50%		1.7108		0.00

2	81	00:01:16	37.50%		1.7553		0.00
2	82	00:01:16	50.00%		1.6810		0.00
3	83	00:01:18	56.25%		1.1936		0.00
3	84	00:01:18	75.00%		1.1400		0.00
3	85	00:01:19	43.75%		1.5679		0.00
3	86	00:01:19	43.75%		2.0903		0.00
3	87	00:01:20	56.25%		1.4398		0.00
3	88	00:01:20	56.25%		1.8109		0.00
3	89	00:01:21	43.75%		1.5263		0.00
3	90	00:01:21	25.00%		2.1300		0.00
3	91	00:01:22	56.25%		1.2412		0.00
3	92	00:01:23	56.25%		1.7399		0.00
3	93	00:01:24	31.25%		1.9659		0.00
3	94	00:01:24	37.50%		1.8281		0.00
3	95	00:01:25	56.25%		1.1386		0.00
3	96	00:01:26	75.00%		0.9719		0.00
3	97	00:01:26	43.75%		1.2897		0.00
3	98	00:01:27	43.75%		1.5033		0.00
3	99	00:01:28	50.00%		1.5255		0.00
3	100	00:01:37	68.75%	52.25%	1.2351	1.4623	0.00
3	101	00:01:38	37.50%		1.8055		0.00
3	102	00:01:38	37.50%		1.7111		0.00
3	103	00:01:39	75.00%		0.9294		0.00
3	104	00:01:39	56.25%		1.0385		0.00
3	105	00:01:40	56.25%		1.1292		0.00
3	106	00:01:41	68.75%		1.1804		0.00
3	107	00:01:41	75.00%		0.8348		0.00
3	108	00:01:42	75.00%		0.9566		0.00
3	109	00:01:42	56.25%		1.1739		0.00
3	110	00:01:43	50.00%		1.4377		0.00
3	111	00:01:44	75.00%		0.7455		0.00
3	112	00:01:44	62.50%		1.4833		0.00
3	113	00:01:45	50.00%		1.6934		0.00
3	114	00:01:45	31.25%		2.3558		0.00
3	115	00:01:46	50.00%		1.8215		0.00
3	116	00:01:46	50.00%		1.2591		0.00
3	117	00:01:47	68.75%		1.1837		0.00
3	118	00:01:47	87.50%		0.5861		0.00
3	119	00:01:48	56.25%		1.1680		0.00
3	120	00:01:49	43.75%		1.8538		0.00
3	121	00:01:49	56.25%		1.2622		0.00
3	122	00:01:50	62.50%		1.0853		0.00
3	123	00:01:50	50.00%		1.4173		0.00
4	124	00:01:51	87.50%		0.6856		0.00
4	125	00:01:52	50.00%		1.5647		0.00
4	126	00:01:52	75.00%		0.8761		0.00
4	127	00:01:53	87.50%		0.6659		0.00
4	128	00:01:53	87.50%		0.6514		0.00
4	129	00:01:54	81.25%		0.4947		0.00
4	130	00:01:54	68.75%		0.8742		0.00
4	131	00:01:55	75.00%		0.6360		0.00
4	132	00:01:55	68.75%		0.8395		0.00
4	133	00:01:56	87.50%		0.4062		0.00
4	134	00:01:56	62.50%		0.8811		0.00
4	135	00:01:57	68.75%		0.8989		0.00
4	136	00:01:57	93.75%		0.3176		0.00
4	137	00:01:58	75.00%		0.8771		0.00
4	138	00:01:58	56.25%		1.0679		0.00
4	139	00:01:59	68.75%		0.7884		0.00
4	140	00:01:59	81.25%		0.7602		0.00
4	141	00:02:00	68.75%		1.1319		0.00
4	142	00:02:01	68.75%		0.5447		0.00
4	143	00:02:01	81.25%		0.5872		0.00
4	144	00:02:02	62.50%		1.0691		0.00

4	145	00:02:02	68.75%		0.9861		0.00
4	146	00:02:03	81.25%		0.7454		0.00
4	147	00:02:04	81.25%		0.6363		0.00
4	148	00:02:04	68.75%		1.0188		0.00
4	149	00:02:05	93.75%		0.5149		0.00
4	150	00:02:13	62.50%	59.91%	1.3723	1.2077	0.00
4	151	00:02:13	68.75%		1.1993		0.00
4	152	00:02:14	75.00%		1.0551		0.00
4	153	00:02:15	81.25%		0.5473		0.00
4	154	00:02:15	56.25%		1.2792		0.00
4	155	00:02:16	62.50%		1.2312		0.00
4	156	00:02:17	62.50%		0.8669		0.00
4	157	00:02:18	68.75%		0.8918		0.00
4	158	00:02:18	68.75%		1.2533		0.00
4	159	00:02:19	75.00%		0.7894		0.00
4	160	00:02:20	68.75%		1.0639		0.00
4	161	00:02:21	87.50%		0.4500		0.00
4	162	00:02:22	75.00%		0.7475		0.00
4	163	00:02:22	75.00%		0.6459		0.00
4	164	00:02:22	56.25%		1.4605		0.00
5	165	00:02:24	62.50%		0.8518		0.00
5	166	00:02:25	93.75%		0.1574		0.00
5	167	00:02:26	81.25%		0.6617		0.00
5	168	00:02:27	81.25%		0.4252		0.00
5	169	00:02:27	81.25%		0.5766		0.00
5	170	00:02:28	87.50%		0.3479		0.00
5	171	00:02:29	81.25%		0.3278		0.00
5	172	00:02:30	87.50%		0.4555		0.00
5	173	00:02:31	93.75%		0.2906		0.00
5	174	00:02:31	87.50%		0.4496		0.00
5	175	00:02:32	87.50%		0.3614		0.00
5	176	00:02:33	81.25%		0.4835		0.00
5	177	00:02:34	68.75%		0.6912		0.00
5	178	00:02:34	93.75%		0.3052		0.00
5	179	00:02:35	87.50%		0.6538		0.00
5	180	00:02:36	75.00%		0.7205		0.00
5	181	00:02:37	87.50%		0.3781		0.00
5	182	00:02:37	87.50%		0.4147		0.00
5	183	00:02:38	87.50%		0.2869		0.00
5	184	00:02:39	87.50%		0.5038		0.00
5	185	00:02:40	81.25%		0.3984		0.00
5	186	00:02:41	75.00%		0.6659		0.00
5	187	00:02:41	93.75%		0.1958		0.00
5	188	00:02:42	93.75%		0.2858		0.00
5	189	00:02:43	93.75%		0.3220		0.00
5	190	00:02:44	75.00%		0.7737		0.00
5	191	00:02:45	81.25%		0.4108		0.00
5	192	00:02:45	81.25%		0.7623		0.00
5	193	00:02:46	93.75%		0.2563		0.00
5	194	00:02:47	81.25%		0.4961		0.00
5	195	00:02:48	93.75%		0.1383		0.00
5	196	00:02:49	93.75%		0.3773		0.00
5	197	00:02:49	93.75%		0.2097		0.00
5	198	00:02:50	93.75%		0.2217		0.00
5	199	00:02:51	81.25%		0.5364		0.00
5	200	00:03:00	93.75%	66.22%	0.1780	1.1690	0.00
5	201	00:03:01	75.00%		0.6366		0.00
5	202	00:03:02	75.00%		0.4932		0.00
5	203	00:03:03	87.50%		0.2083		0.00
5	204	00:03:03	93.75%		0.2173		0.00
5	205	00:03:03	75.00%		0.8551		0.00
6	206	00:03:05	93.75%		0.1808		0.00
6	207	00:03:06	100.00%		0.1065		0.00
6	208	00:03:06	87.50%		0.3094		0.00

6	209	00:03:07	81.25%		0.5323		0.00
6	210	00:03:07	87.50%		0.3170		0.00
6	211	00:03:08	93.75%		0.1619		0.00
6	212	00:03:09	81.25%		0.3662		0.00
6	213	00:03:10	93.75%		0.2706		0.00
6	214	00:03:10	87.50%		0.5829		0.00
6	215	00:03:11	100.00%		0.1298		0.00
6	216	00:03:12	100.00%		0.1975		0.00
6	217	00:03:12	87.50%		0.4775		0.00
6	218	00:03:13	93.75%		0.3094		0.00
6	219	00:03:13	81.25%		0.8139		0.00
6	220	00:03:14	81.25%		0.3754		0.00
6	221	00:03:15	93.75%		0.2503		0.00
6	222	00:03:15	81.25%		0.3847		0.00
6	223	00:03:16	81.25%		0.6435		0.00
6	224	00:03:17	81.25%		0.4212		0.00
6	225	00:03:17	100.00%		0.0952		0.00
6	226	00:03:18	100.00%		0.0833		0.00
6	227	00:03:19	75.00%		0.6269		0.00
6	228	00:03:20	68.75%		0.9856		0.00
6	229	00:03:20	93.75%		0.2296		0.00
6	230	00:03:21	87.50%		0.2081		0.00
6	231	00:03:22	93.75%		0.2450		0.00
6	232	00:03:22	93.75%		0.1268		0.00
6	233	00:03:23	93.75%		0.1627		0.00
6	234	00:03:24	93.75%		0.2769		0.00
6	235	00:03:25	87.50%		0.5074		0.00
6	236	00:03:25	93.75%		0.1163		0.00
6	237	00:03:26	87.50%		0.2271		0.00
6	238	00:03:27	68.75%		0.6559		0.00
6	239	00:03:27	87.50%		0.3827		0.00
6	240	00:03:28	81.25%		0.5199		0.00
6	241	00:03:29	75.00%		0.7378		0.00
6	242	00:03:30	68.75%		0.7105		0.00
6	243	00:03:31	87.50%		0.3202		0.00
6	244	00:03:32	93.75%		0.3192		0.00
6	245	00:03:32	93.75%		0.2729		0.00
6	246	00:03:32	93.75%		0.2074		0.00
7	247	00:03:34	100.00%		0.1461		0.00
7	248	00:03:34	87.50%		0.3265		0.00
7	249	00:03:35	93.75%		0.2866		0.00
7	250	00:03:42	81.25%	59.46%	0.2583	1.2363	0.00
7	251	00:03:42	87.50%		0.3034		0.00
7	252	00:03:43	100.00%		0.0659		0.00
7	253	00:03:43	100.00%		0.0431		0.00
7	254	00:03:44	87.50%		0.6061		0.00
7	255	00:03:45	93.75%		0.3090		0.00
7	256	00:03:45	87.50%		0.2953		0.00
7	257	00:03:46	93.75%		0.1364		0.00
7	258	00:03:46	93.75%		0.1154		0.00
7	259	00:03:47	87.50%		0.3162		0.00
7	260	00:03:48	87.50%		0.3132		0.00
7	261	00:03:48	100.00%		0.0707		0.00
7	262	00:03:49	93.75%		0.2844		0.00
7	263	00:03:49	100.00%		0.1162		0.00
7	264	00:03:50	81.25%		0.3186		0.00
7	265	00:03:51	100.00%		0.0683		0.00
7	266	00:03:52	87.50%		0.4150		0.00
7	267	00:03:52	100.00%		0.0685		0.00
7	268	00:03:53	81.25%		0.4179		0.00
7	269	00:03:53	81.25%		0.3673		0.00
7	270	00:03:54	100.00%		0.0152		0.00
7	271	00:03:55	100.00%		0.0202		0.00
7	272	00:03:55	93.75%		0.1095		0.00

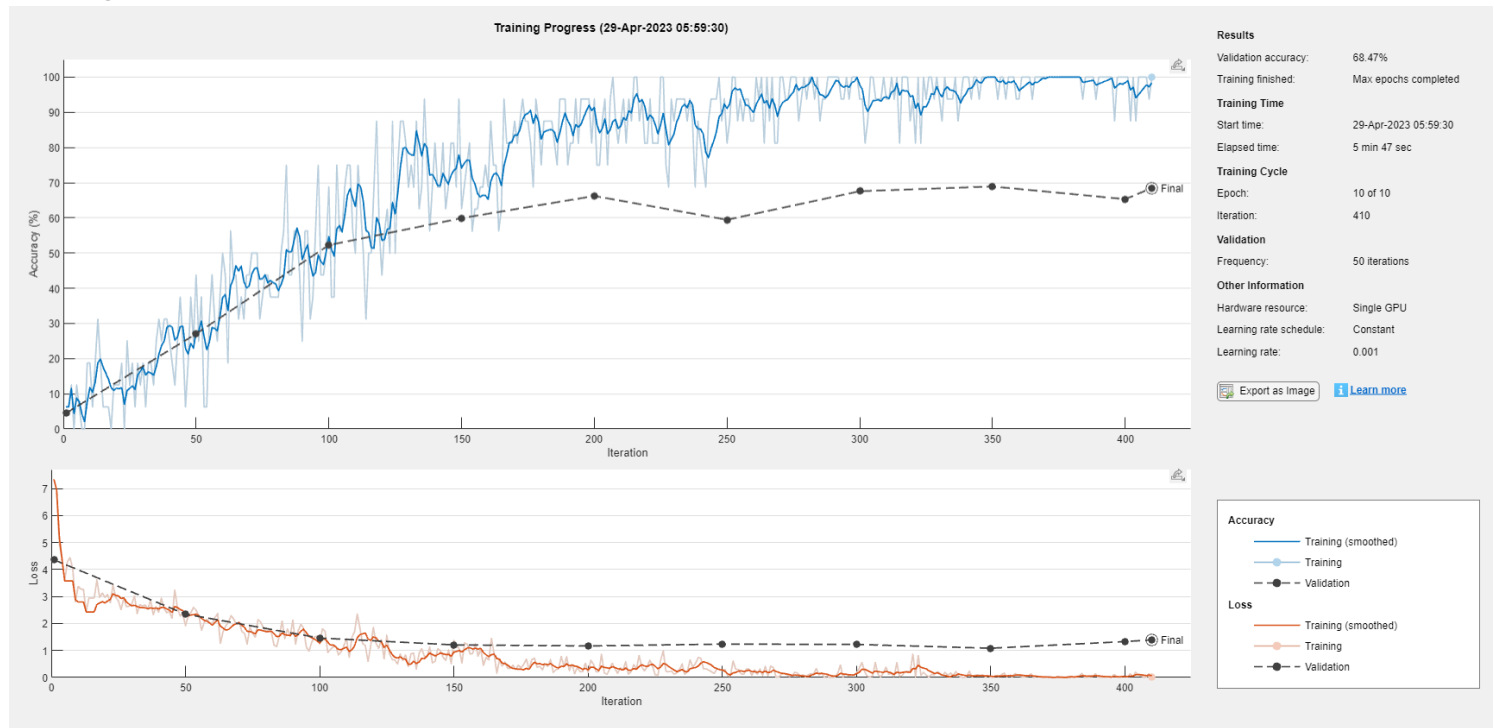
7	273	00:03:56	93.75%		0.1744		0.00
7	274	00:03:57	100.00%		0.0975		0.00
7	275	00:03:57	100.00%		0.0376		0.00
7	276	00:03:58	100.00%		0.0729		0.00
7	277	00:03:59	87.50%		0.1924		0.00
7	278	00:03:59	93.75%		0.1656		0.00
7	279	00:04:00	100.00%		0.0380		0.00
7	280	00:04:01	93.75%		0.1004		0.00
7	281	00:04:01	100.00%		0.0154		0.00
7	282	00:04:02	100.00%		0.0878		0.00
7	283	00:04:03	93.75%		0.1461		0.00
7	284	00:04:03	100.00%		0.1234		0.00
7	285	00:04:04	87.50%		0.3379		0.00
7	286	00:04:04	93.75%		0.0925		0.00
7	287	00:04:04	93.75%		0.1610		0.00
8	288	00:04:06	100.00%		0.0134		0.00
8	289	00:04:07	100.00%		0.0615		0.00
8	290	00:04:07	100.00%		0.0013		0.00
8	291	00:04:08	100.00%		0.0074		0.00
8	292	00:04:08	100.00%		0.0261		0.00
8	293	00:04:08	93.75%		0.1475		0.00
8	294	00:04:09	93.75%		0.4637		0.00
8	295	00:04:10	100.00%		0.0101		0.00
8	296	00:04:10	93.75%		0.1428		0.00
8	297	00:04:11	100.00%		0.0588		0.00
8	298	00:04:11	100.00%		0.0848		0.00
8	299	00:04:12	100.00%		0.0896		0.00
8	300	00:04:19	93.75%	67.57%	0.1719	1.2248	0.00
8	301	00:04:20	93.75%		0.3290		0.00
8	302	00:04:20	81.25%		0.5571		0.00
8	303	00:04:21	87.50%		0.2277		0.00
8	304	00:04:22	100.00%		0.0458		0.00
8	305	00:04:22	100.00%		0.0227		0.00
8	306	00:04:23	93.75%		0.0561		0.00
8	307	00:04:23	93.75%		0.5452		0.00
8	308	00:04:24	93.75%		0.1154		0.00
8	309	00:04:25	100.00%		0.0165		0.00
8	310	00:04:26	93.75%		0.1681		0.00
8	311	00:04:26	93.75%		0.3782		0.00
8	312	00:04:27	100.00%		0.1161		0.00
8	313	00:04:28	93.75%		0.1552		0.00
8	314	00:04:28	100.00%		0.0358		0.00
8	315	00:04:29	81.25%		0.5450		0.00
8	316	00:04:30	100.00%		0.0420		0.00
8	317	00:04:30	100.00%		0.0750		0.00
8	318	00:04:31	100.00%		0.2056		0.00
8	319	00:04:32	87.50%		0.2339		0.00
8	320	00:04:33	93.75%		0.2119		0.00
8	321	00:04:33	81.25%		0.8752		0.00
8	322	00:04:34	100.00%		0.0264		0.00
8	323	00:04:35	81.25%		0.8193		0.00
8	324	00:04:35	100.00%		0.0822		0.00
8	325	00:04:36	93.75%		0.1921		0.00
8	326	00:04:36	100.00%		0.0844		0.00
8	327	00:04:37	100.00%		0.0151		0.00
8	328	00:04:37	93.75%		0.1101		0.00
9	329	00:04:39	100.00%		0.1017		0.00
9	330	00:04:39	93.75%		0.2090		0.00
9	331	00:04:40	87.50%		0.1642		0.00
9	332	00:04:40	100.00%		0.0742		0.00
9	333	00:04:41	93.75%		0.1922		0.00
9	334	00:04:42	93.75%		0.0800		0.00
9	335	00:04:42	93.75%		0.1666		0.00
9	336	00:04:43	100.00%		0.0695		0.00



9	337	00:04:43	87.50%		0.2148		0.00
9	338	00:04:44	93.75%		0.0675		0.00
9	339	00:04:45	100.00%		0.0128		0.00
9	340	00:04:45	100.00%		0.0038		0.00
9	341	00:04:46	100.00%		0.0366		0.00
9	342	00:04:46	93.75%		0.2350		0.00
9	343	00:04:47	100.00%		0.0241		0.00
9	344	00:04:48	100.00%		0.0769		0.00
9	345	00:04:48	93.75%		0.1003		0.00
9	346	00:04:49	100.00%		0.0766		0.00
9	347	00:04:49	100.00%		0.0958		0.00
9	348	00:04:50	100.00%		0.0193		0.00
9	349	00:04:51	100.00%		0.0687		0.00
9	350	00:04:58	100.00%	68.92%	0.0216	1.0845	0.00
9	351	00:04:59	100.00%		0.0147		0.00
9	352	00:04:59	93.75%		0.0673		0.00
9	353	00:05:00	100.00%		0.0337		0.00
9	354	00:05:01	100.00%		0.0974		0.00
9	355	00:05:01	93.75%		0.1644		0.00
9	356	00:05:02	100.00%		0.0338		0.00
9	357	00:05:03	100.00%		0.0849		0.00
9	358	00:05:04	100.00%		0.0262		0.00
9	359	00:05:04	93.75%		0.1415		0.00
9	360	00:05:05	93.75%		0.1035		0.00
9	361	00:05:06	100.00%		0.0486		0.00
9	362	00:05:06	100.00%		0.0198		0.00
9	363	00:05:07	100.00%		0.0329		0.00
9	364	00:05:08	100.00%		0.0509		0.00
9	365	00:05:08	93.75%		0.1351		0.00
9	366	00:05:09	100.00%		0.0017		0.00
9	367	00:05:10	100.00%		0.0446		0.00
9	368	00:05:10	100.00%		0.0263		0.00
9	369	00:05:10	100.00%		0.0122		0.00
10	370	00:05:12	100.00%		0.0060		0.00
10	371	00:05:12	100.00%		0.0292		0.00
10	372	00:05:13	100.00%		0.0251		0.00
10	373	00:05:13	100.00%		0.0102		0.00
10	374	00:05:14	100.00%		0.0036		0.00
10	375	00:05:15	100.00%		0.0465		0.00
10	376	00:05:15	100.00%		0.0013		0.00
10	377	00:05:16	100.00%		0.0201		0.00
10	378	00:05:16	100.00%		0.0141		0.00
10	379	00:05:17	100.00%		0.0415		0.00
10	380	00:05:17	100.00%		0.0385		0.00
10	381	00:05:18	100.00%		0.0069		0.00
10	382	00:05:18	100.00%		0.0385		0.00
10	383	00:05:19	100.00%		0.0663		0.00
10	384	00:05:20	93.75%		0.1512		0.00
10	385	00:05:20	100.00%		0.0065		0.00
10	386	00:05:21	100.00%		0.0103		0.00
10	387	00:05:21	100.00%		0.0344		0.00
10	388	00:05:22	100.00%		0.0327		0.00
10	389	00:05:23	93.75%		0.1387		0.00
10	390	00:05:23	100.00%		0.0072		0.00
10	391	00:05:24	100.00%		0.0118		0.00
10	392	00:05:25	100.00%		0.0101		0.00
10	393	00:05:25	100.00%		0.0231		0.00
10	394	00:05:26	100.00%		0.0307		0.00
10	395	00:05:27	100.00%		0.0052		0.00
10	396	00:05:27	87.50%		0.1200		0.00
10	397	00:05:28	100.00%		0.0206		0.00
10	398	00:05:29	100.00%		0.0095		0.00
10	399	00:05:29	100.00%		0.0329		0.00
10	400	00:05:36	100.00%	65.32%	0.0526	1.3297	0.00

10	401	00:05:37	100.00%		0.0217		0.00
10	402	00:05:37	87.50%		0.1364		0.00
10	403	00:05:38	100.00%		0.0425		0.00
10	404	00:05:38	87.50%		0.1978		0.00
10	405	00:05:39	100.00%		0.0911		0.00
10	406	00:05:39	100.00%		0.0586		0.00
10	407	00:05:40	100.00%		0.0053		0.00
10	408	00:05:40	100.00%		0.0216		0.00
10	409	00:05:41	93.75%		0.1471		0.00
10	410	00:05:44	100.00%	68.47%	0.0064	1.3925	0.00

Training finished: Max epochs completed.



```
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

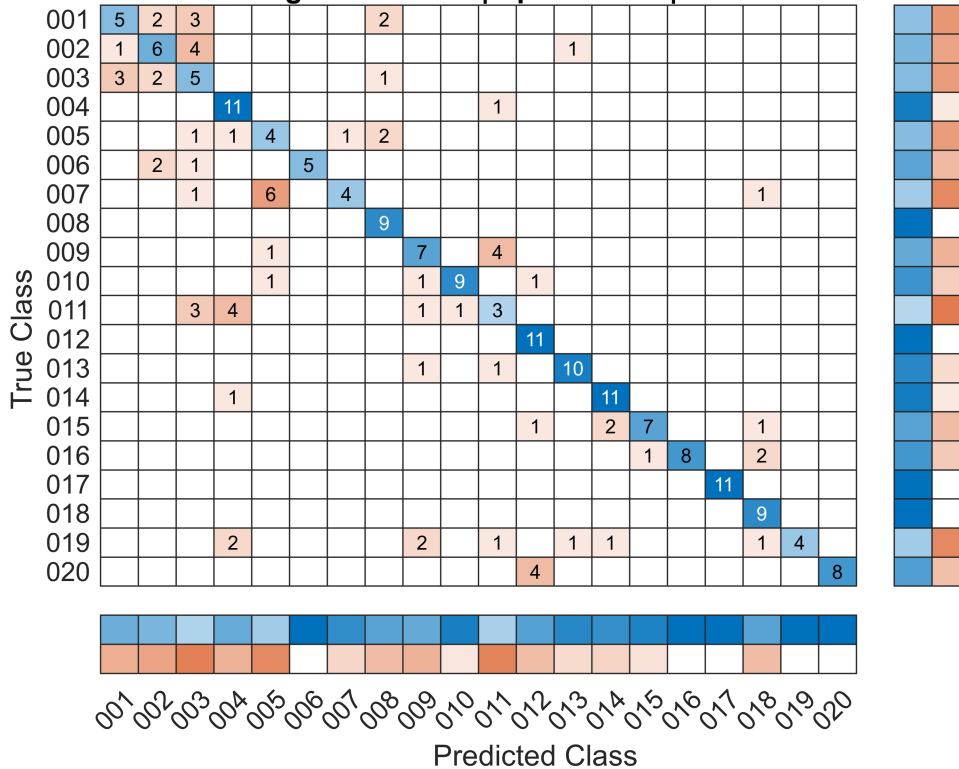
overall_accuracy = 0.6622
```

```
% 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({"Alexnet: 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

**Alexnet: Overall Accuracy 66.2% | Image Size : 227 x 227**

**Learning Rate : 0.001 | Epochs : 10 | 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 66.22%

```
disp(class_wise_recognition_rates);
```

Class Name	Correct Recognition Rate (%)
{'001.Black_footed_Albatross' }	41.7
{'002.Laysan_Albatross' }	50
{'003.Sooty_Albatross' }	45.5
{'004.Groove_billed_Ani' }	91.7
{'005.Crested_Auklet' }	44.4
{'006.Least_Auklet' }	62.5

{'007.Parakeet_Auklet' }	33.3
{'008.Rhinoceros_Auklet' }	100
{'009.Brewer_Blackbird' }	58.3
{'010.Red_winged_Blackbird' }	75
{'011.Rusty_Blackbird' }	25
{'012.Yellow_headed_Blackbird' }	100
{'013.Bobolink' }	83.3
{'014.Indigo_Bunting' }	91.7
{'015.Lazuli_Bunting' }	63.6
{'016.Painted_Bunting' }	72.7
{'017.Cardinal' }	100
{'018.Spotted_Catbird' }	100
{'019.Gray_Catbird' }	33.3
{'020.Yellow_breasted_Chat' }	66.7