Image classification using Convolutional Neural Network [MATLAB]

Author: Vineet Jacob Kuruvilla, PhD

Company: MathWorks

Date: 8th March 2020

Intended audience: Beginners

Project Description

The purpose of this project is to show an example of how to use Convolutional Neural Network for image classification tasks. In this project, I have used dog and cat image dataset to classify whether the image is that of a dog or a cat. There are two way to go about this task- 1) Transfer Learning ie., to use a pretrained network and, 2) Design your own CNN. I have used the approach #2 in this project.

What you'll learn:

1. Using datastore
2. Augmenting image data for produce more training data than originally available
3. Defining a CNN architecture (here only the programmatic way is shown. I used the Deep Network Designer App to build the network. It saves a lot of time.)
4. Setting the training parameters (also enabling parallel computing option)
5. Finally, testing the accuracy of the trained network using test data

Products used

MATLAB 9.7

Deep Learning Toolbox13.0

Machine Learning and Statistics 11.6

Parallel Computing Toolbox 7.1

Code and Outputs

Load data from data folder.

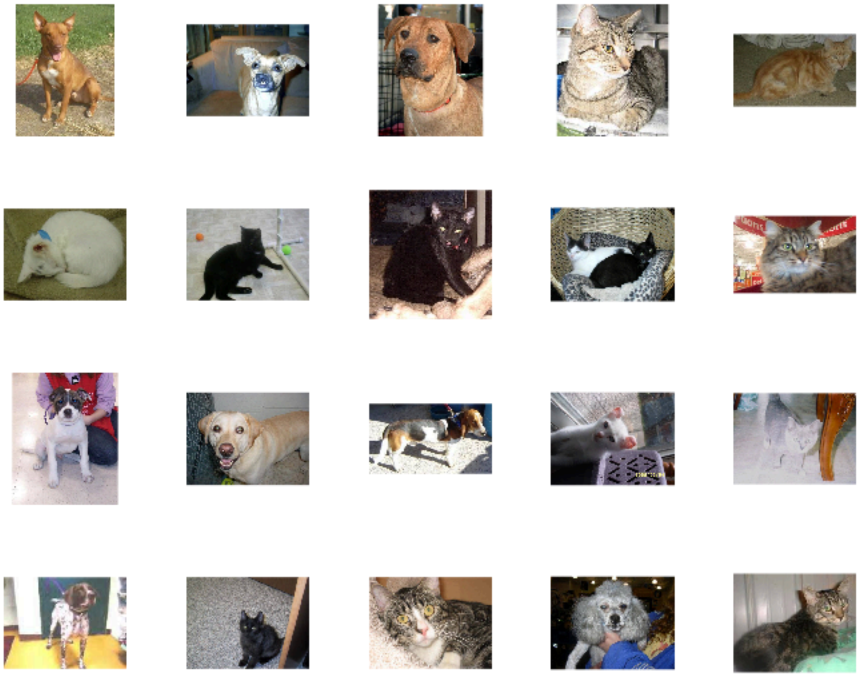
The dataset was obtained from Kaggle: https://www.kaggle.com/chetankv/dogs-cats-images

```
clear
data_loc = ".\dataset\training_set";
dt = datastore(data_loc,'IncludeSubfolders',true,"LabelSource","foldernames");
```

Read data and visualize

```
figure;
perm = randperm(8000,20);
```

```
for i = 1:20
    subplot(4,5,i);
    imshow(dt.Files{perm(i)});
end
```



Preprocessing and Data augmentation

```
labelCount = countEachLabel(dt)
```

labelCount = 2×2 table

	Label	Count
1	cats	4000
2	dogs	4000

Create variable to set the input size of the CNN. This variable will be used to resize the training and test images as well.

```
input_size = [56,56];
```

Check the test data

```
data_loc = ".\dataset\test_set";
dtest = datastore(data_loc,'IncludeSubfolders',true,"LabelSource","foldernames");
labelCount_test = countEachLabel(dtest)
labelCount_test = 2×2 table
```

	Label	Count
1	cats	1000
2	dogs	1000

Split data into train and validation

Also resize and augment the available training data.

```
numTrainFiles = 3600;
[dtrain,dValidation] = splitEachLabel(dt,numTrainFiles,'randomize');

pixelRange = [-3 3];
scaleRange = [0.9 1.1];
imageAugmenter = imageDataAugmenter( ...
    'RandRotation',[-20,20], ...
    'RandXReflection',true, ...
    'RandXTranslation',pixelRange, ...
    'RandYTranslation',pixelRange, ...
    'RandXScale',scaleRange, ...
    'RandYScale',scaleRange);

augtrain = augmentedImageDatastore(input_size,dtrain,'ColorPreprocessing','rgb2gray','DataAugme
% We don't need to augment the validation test
augValidation = augmentedImageDatastore(input_size,dValidation,'ColorPreprocessing','rgb2gray',
```

Define the network architecture

```
filter_size = [3,3];
layers = [
    imageInputLayer(input_size,"Name","imageinput","Normalization","zerocenter")

    convolution2dLayer(filter_size,8,"Name","conv_1","Padding","same")
    batchNormalizationLayer
    reluLayer("Name","relu_1")
    maxPooling2dLayer([2 2],"Name","maxpool_1","Padding","same",'Stride',2)

    convolution2dLayer(filter_size,16,"Name","conv_2","Padding","same")
    batchNormalizationLayer
    reluLayer("Name","relu_2")
    maxPooling2dLayer([2 2],"Name","maxpool_2","Padding","same",'Stride',2)

    convolution2dLayer(filter_size,32,"Name","conv_3","Padding","same")
    batchNormalizationLayer
    reluLayer("Name","relu_3")
    maxPooling2dLayer([2 2],"Name","maxpool_3","Padding","same",'Stride',2)

    convolution2dLayer(filter_size,64,"Name","conv_4","Padding","same")
    batchNormalizationLayer
    reluLayer("Name","relu_4")
    maxPooling2dLayer([2 2],"Name","maxpool_4","Padding","same",'Stride',2)
    convolution2dLayer(filter_size,128,"Name","conv_5","Padding","same")
    batchNormalizationLayer
    reluLayer("Name","relu_5")
    maxPooling2dLayer([2 2],"Name","maxpool_5","Padding","same",'Stride',2)

    convolution2dLayer(filter_size,256,"Name","conv_6","Padding","same")
    batchNormalizationLayer
    reluLayer("Name","relu_6")
    maxPooling2dLayer([2 2],"Name","maxpool_6","Padding","same",'Stride',2)

    fullyConnectedLayer(10,"Name","fc_2_2")
    reluLayer("Name","relu_5_2")

    fullyConnectedLayer(2,"Name","fc_3")
    softmaxLayer("Name","softmax")
    classificationLayer("Name","classoutput")];
```

Specify training options.

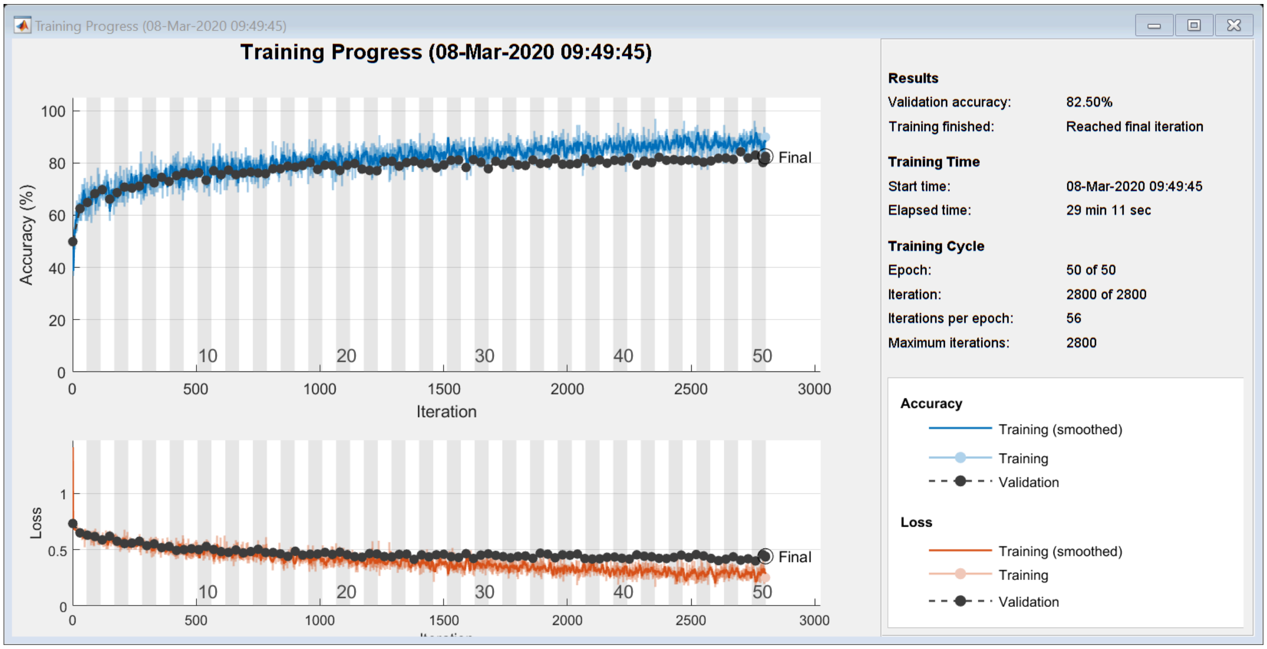
Parallel Computing Toolbox was used to accelerate the training process. It was trained on quad core Intel Core i7 8th Gen PC.

```
options = trainingOptions('sgdm','Momentum',0.85, ...
    'InitialLearnRate',0.01, ...
    'MaxEpochs',50, ...
    'Shuffle','every-epoch', ...
    'ValidationData',augValidation, ...
    'ValidationFrequency',30, ...
    'Verbose',true, ...
    'Plots','training-progress',...
    'ExecutionEnvironment',"parallel");
```

Training the neural network

```
net = trainNetwork(augtrain,layers,options);
```

```
Starting parallel pool (parpool) using the 'local' profile ...
Connected to the parallel pool (number of workers: 4).
```



Results

Validation accuracy: 82.50%
Training finished: Reached final iteration

Training Time

Start time: 08-Mar-2020 09:49:45
Elapsed time: 29 min 11 sec

Training Cycle

Epoch: 50 of 50
Iteration: 2800 of 2800
Iterations per epoch: 56
Maximum iterations: 2800

```
Training across multiple CPUs.
Initializing input data normalization.
|==========================================================================================================
|  Epoch  |  Iteration  |  Time Elapsed  |  Mini-batch  |  Validation  |  Mini-batch  |  Validation  |  Base Learnir
|         |             |   (hh:mm:ss)   |   Accuracy   |   Accuracy   |     Loss     |     Loss     |      Rate
|==========================================================================================================
```

Test the accuracy of the trained network.

Resize the test images to match the network input size and then use the trained network to predict whether the image in the test images represent a dog or a cat

```
augdtest = augmentedImageDatastore(input_size,dtest,'ColorPreprocessing','rgb2gray');
YPred = classify(net,augdtest);
Ytest = dtest.Labels;

accuracy = sum(YPred == Ytest)/numel(Ytest)
```

```
accuracy = 0.8315
```