

CSE4020: MACHINE LEARNING

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PEOPLE & VEHICLE DETECTION

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# OBJECTIVE

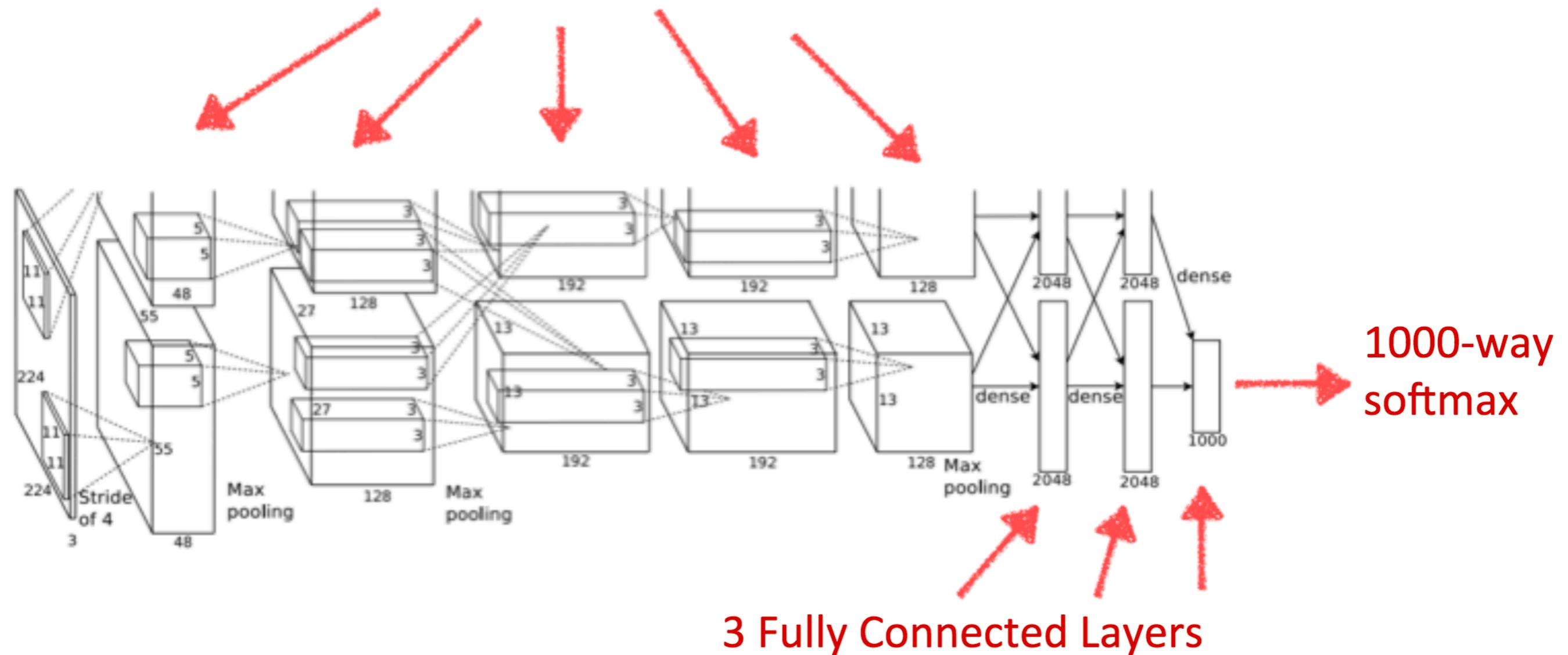
- ▶ To be able to identify people and name them
- ▶ To be able to identify specific model of vehicles
- ▶ Done using transfer learning on the ImageNet model with Tensorflow

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# TRANSFER LEARNING

- ▶ Transfer learning is a technique that shortcuts a lot of this work by taking a fully-trained model for a set of categories like ImageNet, and retrains from the existing weights for new classes.
- ▶ The first phase analyses all the images on disk and calculates the bottleneck values for each of them. 'Bottleneck' is an informal term we often use for the layer just before the final output layer that actually does the classification. This penultimate layer has been trained to output a set of values that's good enough for the classifier to use to distinguish between all the classes it's been asked to recognize.
- ▶ Once the bottlenecks are complete, the actual training of the top layer of the network begins.

5 Convolutional Layers



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- ▶ Identifying the various objects in the image
  - ▶ Imagenet



giant panda, panda, panda bear, coon bear, *Ailuropoda melanoleuca* (score = 0.89107)

indri, indris, *Indri indri*, *Indri brevicaudatus* (score = 0.00779)

lesser panda, red panda, panda, bear cat, cat bear, *Ailurus fulgens* (score = 0.00296)

custard apple (score = 0.00147)

earthstar (score = 0.00117)

- 
- ▶ If humans are present, we classify the image in the following 4 classes:

- ▶ Narendra Modi
- ▶ Rahul Gandhi
- ▶ Arvind Kejriwal
- ▶ Donald Trump



- ▶ If the image has any vehicle we feed the image to our second model which can classify the image into the following 4 categories:
- ▶ Hyundai i20
- ▶ Maruti Swift
- ▶ BMW M3
- ▶ Ford Endeavour



# BOTTLENECK GENERATION

```
tensorflow — Python tensorflow/examples/image_retraining/retrain.py --image_dir ~/politicians/BW --output_labels ~/politicians/label.txt --output_graph ~/politicians/graph.pb — 136x39
~ — jupyter-notebook • Python ... ..._dir ~/politicians/BW --output_labels ~/politicians/label.txt --output_graph ~/politicians/graph.pb +
```

```
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_324.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_495.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_481.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_654.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_132.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_126.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_668.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_683.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_682.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_696.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_669.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_641.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_655.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_133.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_480.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_494.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_325.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_331.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_457.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_286.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_279.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_537.jpg_inception_v3.txt
INFO:tensorflow:700 bottleneck files created.
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_251.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_245.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_523.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_090.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_084.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_709.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_053.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_721.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_047.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_738.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_062.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_704.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_076.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_089.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_248.jpg_inception_v3.txt
INFO:tensorflow:Creating bottleneck at /tmp/bottleneck/narendra_modi/narendra_modi_506.jpg_inception_v3.txt
```

# TRAINING

```
tensorflow — Python tensorflow/examples/image_retraining/retrain.py --image_dir ~/politicians/BW --output_labels ~/politicians/label.txt --output_graph ~/politicians/graph.pb — 136x41
INFO:tensorflow:2018-02-28 10:45:33.858514: Step 0: Train accuracy = 33.0%
INFO:tensorflow:2018-02-28 10:45:33.858740: Step 0: Cross entropy = 1.312757
INFO:tensorflow:2018-02-28 10:45:35.100549: Step 0: Validation accuracy = 24.0% (N=100)
INFO:tensorflow:2018-02-28 10:45:36.663299: Step 10: Train accuracy = 57.0%
INFO:tensorflow:2018-02-28 10:45:36.663458: Step 10: Cross entropy = 1.181625
INFO:tensorflow:2018-02-28 10:45:36.806311: Step 10: Validation accuracy = 56.0% (N=100)
INFO:tensorflow:2018-02-28 10:45:38.173514: Step 20: Train accuracy = 69.0%
INFO:tensorflow:2018-02-28 10:45:38.173665: Step 20: Cross entropy = 1.089581
INFO:tensorflow:2018-02-28 10:45:38.309249: Step 20: Validation accuracy = 64.0% (N=100)
INFO:tensorflow:2018-02-28 10:45:39.611818: Step 30: Train accuracy = 75.0%
INFO:tensorflow:2018-02-28 10:45:39.612043: Step 30: Cross entropy = 0.885439
INFO:tensorflow:2018-02-28 10:45:39.745178: Step 30: Validation accuracy = 71.0% (N=100)
INFO:tensorflow:2018-02-28 10:45:41.003083: Step 40: Train accuracy = 78.0%
INFO:tensorflow:2018-02-28 10:45:41.003234: Step 40: Cross entropy = 0.859938
INFO:tensorflow:2018-02-28 10:45:41.138385: Step 40: Validation accuracy = 59.0% (N=100)
INFO:tensorflow:2018-02-28 10:45:42.382668: Step 50: Train accuracy = 85.0%
INFO:tensorflow:2018-02-28 10:45:42.382811: Step 50: Cross entropy = 0.813622
INFO:tensorflow:2018-02-28 10:45:42.523960: Step 50: Validation accuracy = 60.0% (N=100)
INFO:tensorflow:2018-02-28 10:45:43.766352: Step 60: Train accuracy = 76.0%
INFO:tensorflow:2018-02-28 10:45:43.766497: Step 60: Cross entropy = 0.802048
INFO:tensorflow:2018-02-28 10:45:43.894169: Step 60: Validation accuracy = 65.0% (N=100)
INFO:tensorflow:2018-02-28 10:45:45.073527: Step 70: Train accuracy = 72.0%
INFO:tensorflow:2018-02-28 10:45:45.073665: Step 70: Cross entropy = 0.836458
INFO:tensorflow:2018-02-28 10:45:45.202852: Step 70: Validation accuracy = 65.0% (N=100)
INFO:tensorflow:2018-02-28 10:45:46.541432: Step 80: Train accuracy = 79.0%
INFO:tensorflow:2018-02-28 10:45:46.541585: Step 80: Cross entropy = 0.742156
INFO:tensorflow:2018-02-28 10:45:46.671687: Step 80: Validation accuracy = 67.0% (N=100)
INFO:tensorflow:2018-02-28 10:45:47.834506: Step 90: Train accuracy = 85.0%
INFO:tensorflow:2018-02-28 10:45:47.834658: Step 90: Cross entropy = 0.725817
INFO:tensorflow:2018-02-28 10:45:47.957805: Step 90: Validation accuracy = 65.0% (N=100)
INFO:tensorflow:2018-02-28 10:45:49.113063: Step 100: Train accuracy = 82.0%
INFO:tensorflow:2018-02-28 10:45:49.113199: Step 100: Cross entropy = 0.685051
INFO:tensorflow:2018-02-28 10:45:49.236022: Step 100: Validation accuracy = 68.0% (N=100)
INFO:tensorflow:2018-02-28 10:45:50.390216: Step 110: Train accuracy = 81.0%
INFO:tensorflow:2018-02-28 10:45:50.390355: Step 110: Cross entropy = 0.693680
INFO:tensorflow:2018-02-28 10:45:50.513149: Step 110: Validation accuracy = 67.0% (N=100)
INFO:tensorflow:2018-02-28 10:45:51.754942: Step 120: Train accuracy = 79.0%
INFO:tensorflow:2018-02-28 10:45:51.755115: Step 120: Cross entropy = 0.716006
INFO:tensorflow:2018-02-28 10:45:51.887341: Step 120: Validation accuracy = 69.0% (N=100)
INFO:tensorflow:2018-02-28 10:45:53.221642: Step 130: Train accuracy = 86.0%
INFO:tensorflow:2018-02-28 10:45:53.221870: Step 130: Cross entropy = 0.632002
```

# TRAINING

```
tensorflow — bash — 136x41  
INFO:tensorflow:2018-02-28 10:54:00.965156: Step 3880: Cross entropy = 0.242860  
INFO:tensorflow:2018-02-28 10:54:01.089097: Step 3880: Validation accuracy = 82.0% (N=100)  
INFO:tensorflow:2018-02-28 10:54:02.244920: Step 3890: Train accuracy = 97.0%  
INFO:tensorflow:2018-02-28 10:54:02.245070: Step 3890: Cross entropy = 0.215802  
INFO:tensorflow:2018-02-28 10:54:02.372639: Step 3890: Validation accuracy = 76.0% (N=100)  
INFO:tensorflow:2018-02-28 10:54:03.538788: Step 3900: Train accuracy = 99.0%  
INFO:tensorflow:2018-02-28 10:54:03.538929: Step 3900: Cross entropy = 0.188179  
INFO:tensorflow:2018-02-28 10:54:03.668549: Step 3900: Validation accuracy = 74.0% (N=100)  
INFO:tensorflow:2018-02-28 10:54:04.814625: Step 3910: Train accuracy = 97.0%  
INFO:tensorflow:2018-02-28 10:54:04.814782: Step 3910: Cross entropy = 0.226833  
INFO:tensorflow:2018-02-28 10:54:04.937959: Step 3910: Validation accuracy = 78.0% (N=100)  
INFO:tensorflow:2018-02-28 10:54:06.087348: Step 3920: Train accuracy = 95.0%  
INFO:tensorflow:2018-02-28 10:54:06.087505: Step 3920: Cross entropy = 0.242469  
INFO:tensorflow:2018-02-28 10:54:06.212245: Step 3920: Validation accuracy = 78.0% (N=100)  
INFO:tensorflow:2018-02-28 10:54:07.365886: Step 3930: Train accuracy = 100.0%  
INFO:tensorflow:2018-02-28 10:54:07.366025: Step 3930: Cross entropy = 0.167015  
INFO:tensorflow:2018-02-28 10:54:07.489197: Step 3930: Validation accuracy = 76.0% (N=100)  
INFO:tensorflow:2018-02-28 10:54:08.631797: Step 3940: Train accuracy = 96.0%  
INFO:tensorflow:2018-02-28 10:54:08.631958: Step 3940: Cross entropy = 0.189798  
INFO:tensorflow:2018-02-28 10:54:08.759170: Step 3940: Validation accuracy = 77.0% (N=100)  
INFO:tensorflow:2018-02-28 10:54:09.902707: Step 3950: Train accuracy = 98.0%  
INFO:tensorflow:2018-02-28 10:54:09.902858: Step 3950: Cross entropy = 0.182522  
INFO:tensorflow:2018-02-28 10:54:10.025506: Step 3950: Validation accuracy = 74.0% (N=100)  
INFO:tensorflow:2018-02-28 10:54:11.167819: Step 3960: Train accuracy = 93.0%  
INFO:tensorflow:2018-02-28 10:54:11.167971: Step 3960: Cross entropy = 0.225387  
INFO:tensorflow:2018-02-28 10:54:11.300396: Step 3960: Validation accuracy = 80.0% (N=100)  
INFO:tensorflow:2018-02-28 10:54:12.458338: Step 3970: Train accuracy = 99.0%  
INFO:tensorflow:2018-02-28 10:54:12.458489: Step 3970: Cross entropy = 0.156520  
INFO:tensorflow:2018-02-28 10:54:12.581256: Step 3970: Validation accuracy = 80.0% (N=100)  
INFO:tensorflow:2018-02-28 10:54:13.739292: Step 3980: Train accuracy = 96.0%  
INFO:tensorflow:2018-02-28 10:54:13.739444: Step 3980: Cross entropy = 0.203587  
INFO:tensorflow:2018-02-28 10:54:13.863439: Step 3980: Validation accuracy = 77.0% (N=100)  
INFO:tensorflow:2018-02-28 10:54:15.010846: Step 3990: Train accuracy = 97.0%  
INFO:tensorflow:2018-02-28 10:54:15.010998: Step 3990: Cross entropy = 0.189162  
INFO:tensorflow:2018-02-28 10:54:15.134058: Step 3990: Validation accuracy = 75.0% (N=100)  
INFO:tensorflow:2018-02-28 10:54:16.187281: Step 3999: Train accuracy = 95.0%  
INFO:tensorflow:2018-02-28 10:54:16.187439: Step 3999: Cross entropy = 0.198602  
INFO:tensorflow:2018-02-28 10:54:16.313497: Step 3999: Validation accuracy = 74.0% (N=100)  
INFO:tensorflow:Final test accuracy = 77.4% (N=234)  
INFO:tensorflow:Froze 2 variables.  
Converted 2 variables to const ops.
```

# TESTING

```
tensorflow — -bash — 136x38
~/Development/tensorflow — -bash
~/Development/tensorflow — -bash +[

ary was not compiled to use: SSE4.2 AVX AVX2 FMA
2018-02-28 11:05:21.117680: W tensorflow/core/framework/op_def_util.cc:343] Op BatchNormWithGlobalNormalization is deprecated. It will c
ease to work in GraphDef version 9. Use tf.nn.batch_normalization().
narendra modi 0.9737491
arvind kejriwal 0.02122431
rahul gandhi 0.0046805926
donald trump 0.0003460652
[Ratnasambhavs-MacBook-Pro:tensorflow ratnasambhavpriyadarshi$ python3 tensorflow/examples/label_image/label_image.py --graph=/Users/ratn
asambhavpriyadarshi/politicians/graph.pb --labels=/Users/ratnasambhavpriyadarshi/politicians/label.txt --input_layer=Mul --output_layer=
final_result --image=/Users/ratnasambhavpriyadarshi/Development/MLJ/test-images/dt.jpg
/Library/Frameworks/Python.framework/Versions/3.6/lib/python3.6/site-packages/h5py/_init__.py:36: FutureWarning: Conversion of the seco
nd argument of issubdtype from `float` to `np.floating` is deprecated. In future, it will be treated as `np.float64 == np.dtype(float).t
ype`.
    from ._conv import register_converters as _register_converters
2018-02-28 11:05:44.036397: I tensorflow/core/platform/cpu_feature_guard.cc:137] Your CPU supports instructions that this TensorFlow bin
ary was not compiled to use: SSE4.2 AVX AVX2 FMA
2018-02-28 11:05:45.364459: W tensorflow/core/framework/op_def_util.cc:343] Op BatchNormWithGlobalNormalization is deprecated. It will c
ease to work in GraphDef version 9. Use tf.nn.batch_normalization().
donald trump 0.98305684
narendra modi 0.012410658
rahul gandhi 0.00433352
arvind kejriwal 0.00019899507
[Ratnasambhavs-MacBook-Pro:tensorflow ratnasambhavpriyadarshi$ python3 tensorflow/examples/label_image/label_image.py --graph=/Users/ratn
asambhavpriyadarshi/cars/graph.pb --labels=/Users/ratnasambhavpriyadarshi/cars/label.txt --input_layer=Mul --output_layer=final_result -
-image=/Users/ratnasambhavpriyadarshi/Development/MLJ/test-images/car.png
/Library/Frameworks/Python.framework/Versions/3.6/lib/python3.6/site-packages/h5py/_init__.py:36: FutureWarning: Conversion of the seco
nd argument of issubdtype from `float` to `np.floating` is deprecated. In future, it will be treated as `np.float64 == np.dtype(float).t
ype`.
    from ._conv import register_converters as _register_converters
2018-02-28 11:30:15.915618: I tensorflow/core/platform/cpu_feature_guard.cc:137] Your CPU supports instructions that this TensorFlow bin
ary was not compiled to use: SSE4.2 AVX AVX2 FMA
2018-02-28 11:30:17.324825: W tensorflow/core/framework/op_def_util.cc:343] Op BatchNormWithGlobalNormalization is deprecated. It will c
ease to work in GraphDef version 9. Use tf.nn.batch_normalization().
swift 0.9650396
i20 0.030135134
m3 0.004554852
endeavour 0.00027033265
Ratnasambhavs-MacBook-Pro:tensorflow ratnasambhavpriyadarshi$ ]
```



narendra modi: 0.9737491

arvind kejriwal: 0.02122431

rahul gandhi: 0.0046805926

donald trump: 0.0003460652



donald trump: 0.5016777

rahul gandhi: 0.40016282

narendra modi: 0.050294165

arvind kejriwal: 0.047865327



donald trump: 0.98305684

narendra modi: 0.012410658

rahul gandhi: 0.00433352

arvind kejriwal: 0.00019899507



swift 0.9650396

i20 0.030135134

m3 0.004554852

endeavour 0.00027033265



narendra modi 0.56674504

donald trump 0.4329216

rahul gandhi 0.00016799386

arvind kejriwal 0.00016533607



swift 0.90781724

i20 0.06465163

m3 0.025005655

endeavour 0.0025255012