CaffeLink

ImageNet example

Requirements and Initialization

This example shows how to use CaffeLink to test AlexNet and visualize its features. It relies on examples from Caffe, which can be found here. Trained model can be obtained from Caffe Model Zoo. This document is only concerned with CaffeLink, so for details regarding net design please refer to Caffe.

Caffe is a command line tool and it would be inefficient to somehow transmit all its output to *Mathematica*. So it is highly recommended to launch *Mathematica* session with terminal. CaffeLink also relies on stoud.

Initialize CaffeLink

The first think to do is load CaffeLink module and initialize it with path to `caffe.proto` protobuffer definition of all parameters Caffe uses.

```
caffeDir = "...";
```

```
Needs["CaffeLink`",FileNameJoin[{NotebookDirectory[],"../caffeLink.m"}]];
initCaffeLinkModule[FileNameJoin[{caffeDir,"src/caffe/proto/caffe.proto"}]];
```

Before training, testing etc. CaffeLink library must be initialized. That is: choose data type (double or float), computing mode (GPU or CPU) and device ID for GPU mode.

```
initCaffeLink["UseDouble"→True,"UseGPU"→True,"GPUDevice"→0]
```

```
True
```

Mode can be switched later, data type not.

Net

Testing

Net testing requires a net and net parameters, referred by Caffe as deploy proto. The main difference between deploy and training proto is in input definition, the rest can be the same.

Deploy

```
netDeployParam = ReadString[FileNameJoin[
    {caffeDir,"models/bvlc_reference_caffenet/deploy.prototxt"}]
    ];
```

Test

- Tested net must be prepared at first. Caffe allocates memory and creates net topology based on given deploy proto. Preparation is done either from string with `prepareNetString` or from file path using `prepareNetFile`.

```
prepareNetString[netDeployParam]
```

Net info can be printed (to console) with `printNetInfo`.

```
printNetInfo[]
```

- After preparation, any net data with the same topology can be loaded.

```
loadNet[FileNameJoin[
    {caffeDir,"models/bvlc_reference_caffenet/bvlc_reference_caffenet.caffemodel"}]
    ]
```

That also allows extracting learned parameters (weights, filters, etc.).

- Caffe provide one testing image, so lets use it.

```
testImg = Import[FileNameJoin[{caffeDir,"examples/images/cat.jpg"}]];
```

Deploy defines 10 input images with size 227x227.

```
h = 227; w = 227;
If[ImageDimensions[testImg][[1]]>ImageDimensions[testImg][[2]],
    testImg = ImageRotate[testImg];
    testImg = ImageResize[testImg,w];
    testImg = ImageRotate[testImg,-90 Degree];
    ,
    testImg=ImageResize[testImg,w];
];

inputImgs={};
AppendTo[inputImgs,ImageCrop[testImg,{w,h},{Right,Top}]];
AppendTo[inputImgs,ImageCrop[testImg,{w,h},{Left,Top}]];
AppendTo[inputImgs,ImageCrop[testImg,{w,h},{Right,Bottom}]];
AppendTo[inputImgs,ImageCrop[testImg,{w,h},{Left,Bottom}]];
AppendTo[inputImgs,ImageCrop[testImg,{w,h}]];
testImg=ImageReflect[testImg,Left→Right];
AppendTo[inputImgs,ImageCrop[testImg,{w,h},{Right,Top}]];
AppendTo[inputImgs,ImageCrop[testImg,{w,h},{Left,Top}]];
AppendTo[inputImgs,ImageCrop[testImg,{w,h},{Right,Bottom}]];
AppendTo[inputImgs,ImageCrop[testImg,{w,h},{Left,Bottom}]];
AppendTo[inputImgs,ImageCrop[testImg,{w,h}]]
```

{, , , , ,
, , , , }

Caffe requires channels separated.

```
input={};
For[i=1,i<=10,i++,
 chs=ColorSeparate[inputImgs[[i]]];
 AppendTo[input,ImageData[chs[[3]]]];
 AppendTo[input,ImageData[chs[[2]]]];
 AppendTo[input,ImageData[chs[[1]]]];
 ];
{Image[input[[28]]],Image[input[[29]]],Image[input[[30]]]}
```

{, , }

```
setInput[Flatten[input]*255]
```

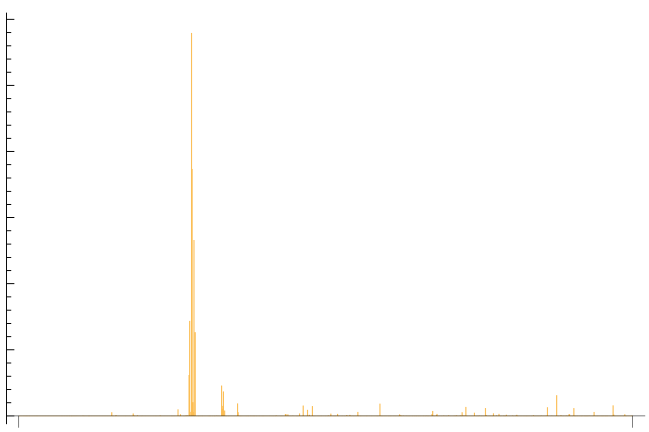
- This runs the test.

```
evaluateNet[]
```

Result can be obtained from top blob of the last layer.

```
result = getTopBlob["prob"];
```

```
res = ArrayReshape[result,{10,1000}];
BarChart[res[[1]]] (* probabilities of the first image *)
```



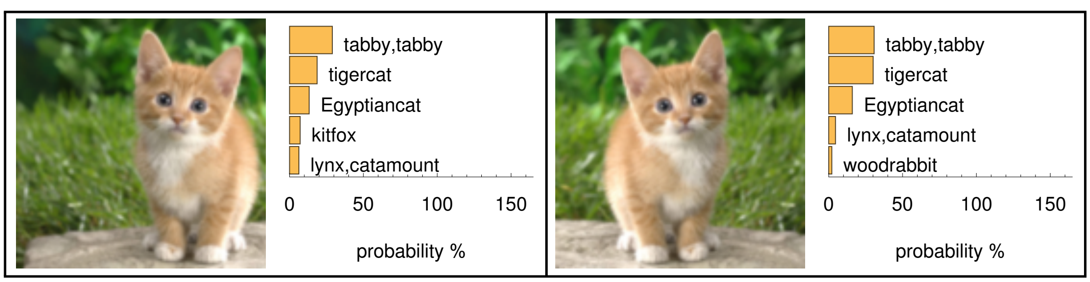
In order to visualize image classification we have to import class names:

```
classes = Module[{raw,noId},
    raw = Import[FileNameJoin[{caffeDir, "data/ilsvrc12/synset_words.txt"}], {"Text", "Li
    noId = StringSplit[#][[2 ;;]] & /@ raw;
    StringTrim[StringJoin[#[[;;Min[Length[#],2]]]],","]& /@ noId
];
```

This shows five most probable classes for image 1 and 10.

```
classifyBestFive[probs_]:=
Module[{pairs, best},
    pairs = Transpose[{probs, classes}];
    best = Transpose[Reverse[Reverse[SortBy[pairs, First]][[;;5]]]];
    BarChart[best[[1]]*100.0,
        BarOrigin→Left,
        ChartLabels→Placed[best[[2]],After],
        Frame→{True,False,False,False},
        PlotRange -> {{0, 100},Automatic},
        PlotRangePadding→{{0,65},0},
        FrameLabel→"probability %",
        BaseStyle→{FontSize→10},
        ImageSize→130
    ]
]

selected = {1,10};
Grid[Partition[MapThread[Grid[{{ImageResize[#1,130],classifyBestFive[#2]}}]&,
    {inputImgs[[selected]],res[[selected]]}],2],Frame→All]
```



Extractingfeatures

Functions `getParamBlob`, `getTopBlob` and `getBottomBlob` allow inspection of all blobs in net. In combination with `setParamBlob` weights can be easily copied to another layer or to completely different net.

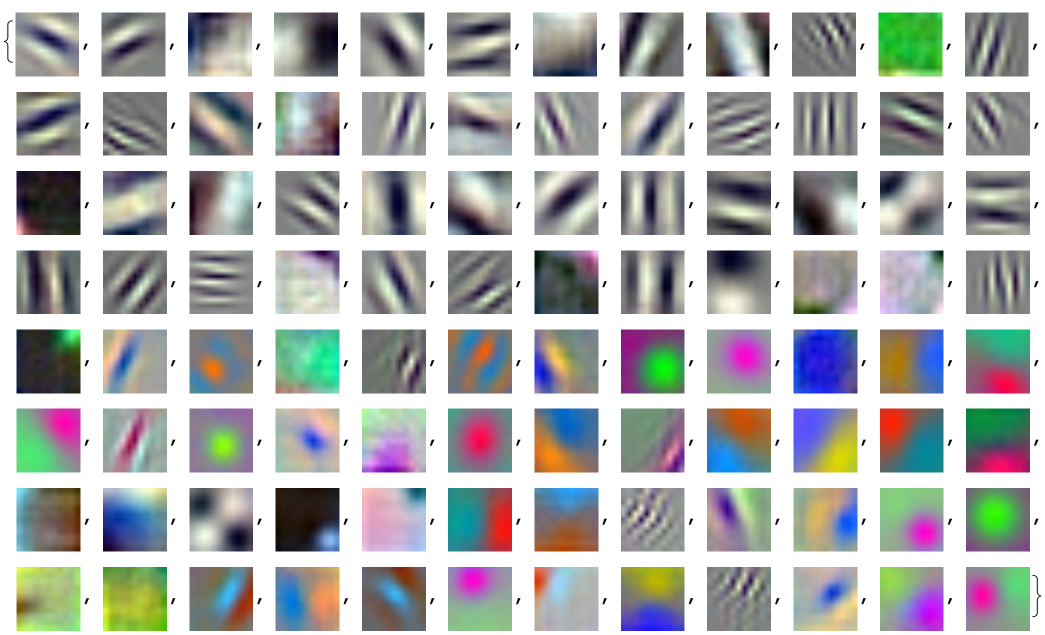
Visualization

In short: get parameters, separate and reshape them and then render.

- Layer `conv1` - filters

```
par = getParamBlob["conv1"]; (* 0th layer: conv1, 0th par. blob - filters *)
```

```
fn = 96;
filters = ArrayReshape[par,{96,3,11,11}]; (* conv1 has 96 filters, 11x11 *)
filters = Map[Rescale,filters];
fImgs = {};
f = Map[Image[#]&,filters,{2}];
For[i = 1,i ≤ fn,i++,
    AppendTo[fImgs,ColorCombine[{f[[i,3]],f[[i,2]],f[[i,1]]},"RGB"]];
];
fImgs
```



- Layer `conv1` - features

```
in = getBottomBlob["conv1"];
out = getTopBlob["conv1"];
```

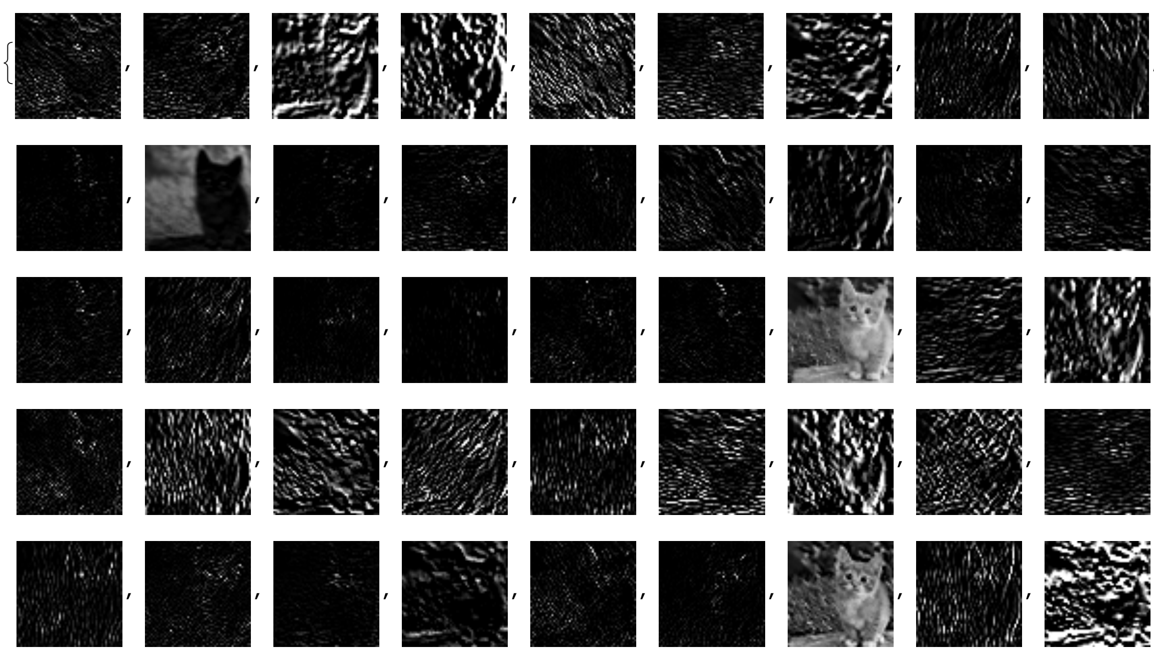
This shows one input image and result after convolution (20 filters).

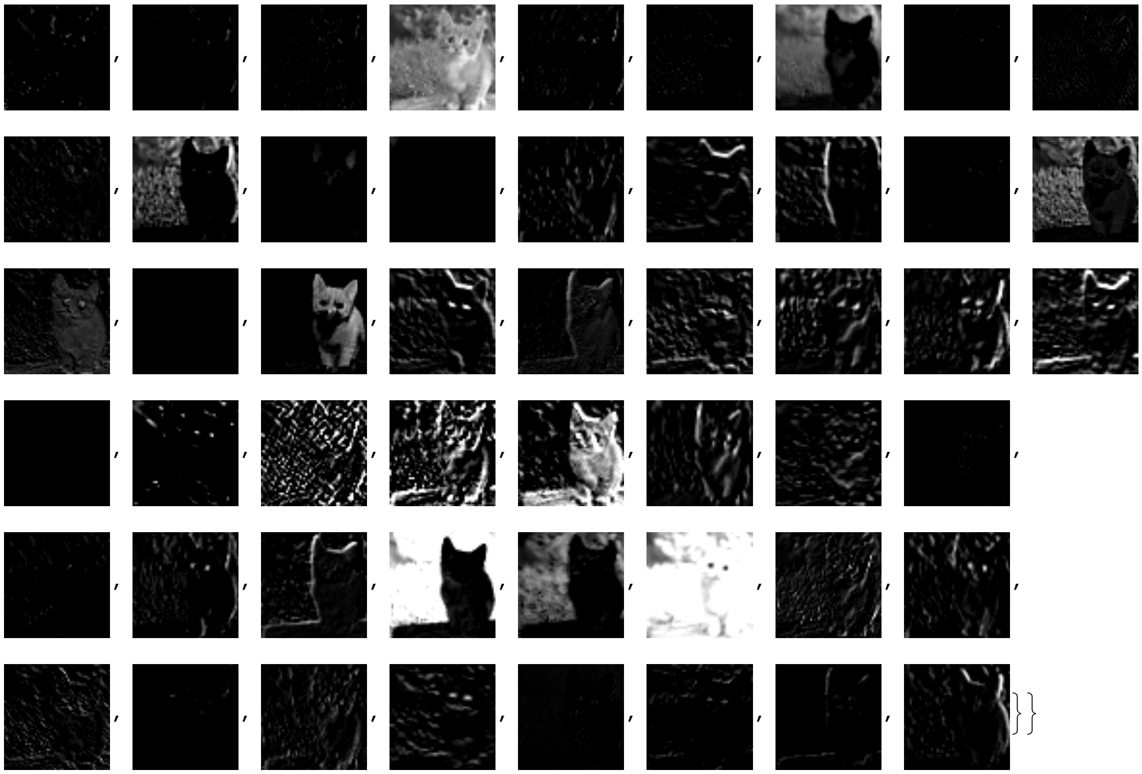
```
Map[Image[#, Magnification → 2] &, outImgs[[imgi, 1 ;; fn]], 1]
```

```
Image[outImgs[[imgi, 1]]]
```

```
imgi = 1; (* test image index, 1 - 10 *)
inImg = ArrayReshape[in,{10,3,h,w}]/255;
f = Map[Image[#]&,inImg,{2}];
inImg = ColorCombine[{f[[imgi,3]],f[[imgi,2]],f[[imgi,1]]},"RGB"];

outImgs = ArrayReshape[out/255,{10,96,55,55}][[imgi]];
{Image[inImg,Magnification→1],
Map[Image[#,Magnification→1]&,outImgs[[1;;fn]],1]}
```





The same in range 0, 1 :

```
outImgs = Map[Rescale,outImgs];
Map[Image[#,Magnification→1]&,outImgs[[1;;fn]],1]
```