cnn_feed_forward

February 22, 2019

0.1 Importing Packages

```
In [1]: import numpy as np
        import matplotlib.pyplot as plt
        from scipy.misc import imread
```

0.2 Defining Activation Functions

```
In [2]: def sigmoid(x):
            return 1/(1 + np.exp(-x))

        def relu(x):
            x[x < 0] = 0
            return x

        def tanh(x):
            return np.tanh(x)

        def softmax(x):
            return np.exp(x) / np.sum(np.exp(x))
```

0.3 2D convolution Function

```
In [3]: def conv2d(image,filters, kernel, stride, activation, padding = 'valid'):
            # kernel size to work for both 2d and 3d input
            filter_shape = kernel
            if(len(image.shape) > 2):
                filter_shape = kernel + (image.shape[2],)

            #initializing parameters
            weights = np.random.normal(size = ((filters,) + filter_shape))
            bias = np.random.rand(filters)
            out = []

            #iterating over number of kernels
            for i in range(filters):
                if( i == 0):
                    output = np.zeros((((image.shape[0] - kernel[0])/stride[0]) + 1 ,((image.s
```

```
        #taking care of padding
        if(padding == 'same' and i == 0):
            output = np.zeros(image.shape[0:2])
            #finding number of rows and cols to pad
            temp = ((image.shape[0] - 1)* stride[0]) + kernel[0] - image.shape[0]
            pad_size_rows = temp + temp%2
            temp = ((image.shape[1] - 1)* stride[1]) + kernel[1] - image.shape[1]
            pad_size_cols = temp + temp%2
            #padding the input
            if(len(image.shape) > 2):
                image = np.pad(image, ((pad_size_rows/2,),(pad_size_cols/2,),(0,)), 'co
            else:
                image = np.pad(image, ((pad_size_rows/2,),(pad_size_cols/2,)), 'constan
        #to moniter the current positions of output and the input
        img_cur_row = 0
        out_cur_row = 0
        while(img_cur_row + kernel[0] <= image.shape[0] - 1):
            img_cur_col = 0
            out_cur_col = 0
            while(img_cur_col + kernel[1] <= image.shape[1] - 1):
                # convolution function
                if(len(image.shape) > 2):
                    output[out_cur_row , out_cur_col] = np.sum(np.multiply(image[img_cu
                else:
                    output[out_cur_row , out_cur_col] = np.sum(np.multiply(image[img_cu
                img_cur_col = img_cur_col + stride[1]
                out_cur_col = out_cur_col + 1
            img_cur_row = img_cur_row + stride[0]
            out_cur_row = out_cur_row + 1
        #applying the correesponding activation functions
        if(activation == 'sigmoid'):
            output = sigmoid(output)
        elif(activation == 'relu'):
            output = relu(output)
        elif(activation == 'tanh'):
            output = tanh(output)
        out.append(output)
    out = np.array(out)
    #making the input as channel last
    out = np.moveaxis(out, 0,2)
    return out , weights, bias
```

0.4 Pooling Function

In [4]:

```
def pooling(image, kernel, stride, pool_func = 'max'):
    if(len(image.shape) > 2):
        output = np.zeros((((image.shape[0] - kernel[0])/stride[0]) + 1 ,((image.shape
    else:
```

```
        output = np.zeros((((image.shape[0] - kernel[0])/stride[0]) + 1 ,((image.shape
    img_cur_row = 0
    out_cur_row = 0
    while(img_cur_row + kernel[0] <= image.shape[0] - 1):
        img_cur_col = 0
        out_cur_col = 0
        while(img_cur_col + kernel[1] <= image.shape[1] - 1):
            #applying corresponding pooling
            if(pool_func == 'max'):
                output[out_cur_row , out_cur_col] = np.amax(np.amax(image[img_cur_row:
            elif(pool_func == 'min'):
                output[out_cur_row , out_cur_col] = np.amin(np.amin(image[img_cur_row:
            elif(pool_func == 'average'):
                output[out_cur_row , out_cur_col] = np.mean(np.mean(image[img_cur_row:
            img_cur_col = img_cur_col + stride[1]
            out_cur_col = out_cur_col + 1
        img_cur_row = img_cur_row + stride[0]
        out_cur_row = out_cur_row + 1
    return output
```

0.5 Function to flatten or unravel the input

```
In [5]: def flatten(inp, output_length = -1):
            #flattening the input
            inp = inp.flatten()
            #output_length = 1 , implies output desired is same as length of flattened input
            if(output_length != -1):
                # initializing matrix with corresponding size
                mat = np.random.uniform(size = (output_length, len(inp)))
                #matrix multiplying to get the desired output shape
                out = np.matmul(mat, inp)
                return out
            else:
                return inp
```

0.6 Fully Connected (Dense) layer

```
In [6]: def fully_connected(inp, nodes, activation):
            inp = np.asarray(inp).reshape(len(inp),1)
            inp = np.vstack((np.array(inp),1))
            #initiazing weights
            weights = np.asmatrix(np.random.rand(nodes, len(inp)))
            output_raw = np.matmul(weights, inp)
            #normalizing the output to ensure no overflow in exp
            output_raw = output_raw/np.max(output_raw)
            #applying activation function
            if(activation == 'sigmoid'):
                output = sigmoid(output_raw)
```

```
        elif(activation == 'relu'):
            output = relu(output_raw)
        elif(activation == 'tanh'):
            output = tanh(output_raw)
        elif(activation == 'softmax'):
            output = softmax(output_raw)
        #making the output vector as column matrix
        if(output.shape[0] == 1):
            output = np.moveaxis(output, 0,1)
            output_raw = np.moveaxis(output_raw, 0,1)
        return output, output_raw, weights
```

0.7 Function to build the model architecture and feed forward

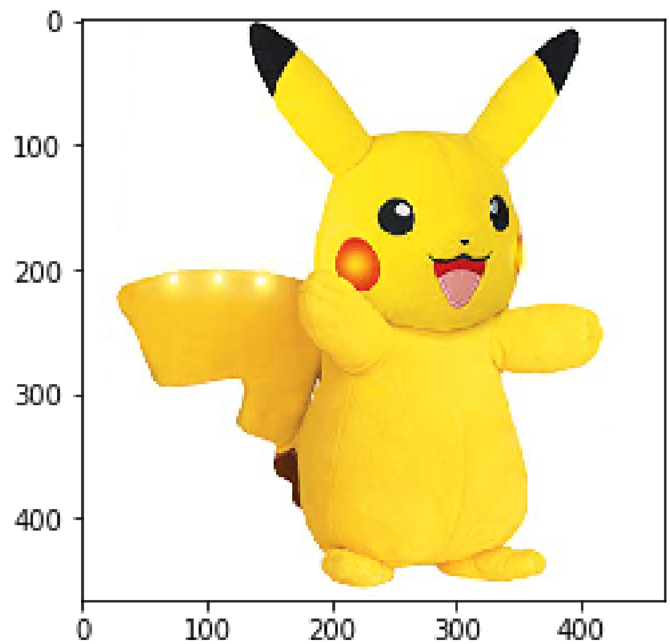
```
In [7]: def feed_forward(feed_dict):
            final_out = []
            #input
            inp = feed_dict['input']
            #architecture
            layers = feed_dict['layers']

            for i in range(len(layers)):
                #convolution layer
                if(layers[i]['type'] == 'conv'):
                    output, weights, bias = conv2d(inp, filters = layers[i]['filters'], kernel
                    #saving the outputs, layer type, weights in a dictionary
                    out_dict = {'layer_number': i , 'type': 'conv', 'output': output, 'weights
                    #appending the dict into a list of dict outputs
                    final_out.append(out_dict)
                #pooling layer
                elif(layers[i]['type'] == 'pool'):
                    output= pooling(inp, kernel = layers[i]['kernel'] , stride = layers[i]['st
                    out_dict = {'layer_number': i , 'type': 'pool', 'output': output}
                    final_out.append(out_dict)
                #fully connected layer
                elif(layers[i]['type'] == 'fc'):
                    output, output_raw ,weights = fully_connected(inp, nodes = layers[i]['node
                    out_dict = {'layer_number': i , 'type': 'fc', 'output': output,'weights':
                    final_out.append(out_dict)
                #Flattening or unravel layer
                elif(layers[i]['type'] == 'flat'):
                    output = flatten(inp, output_length = layers[i]['output_length'])
                    out_dict = {'layer_number': i , 'type': 'flat', 'output': output}
                    final_out.append(out_dict)
                inp = output
            return final_out
```

0.8 importing the image

```
In [8]: img = imread("10.jpg")
        print img.shape
        plt.imshow(img)
        plt.show()
```

```
/home/legion/.local/lib/python2.7/site-packages/ipykernel_launcher.py:1: DeprecationWarning: `i
`imread` is deprecated in SciPy 1.0.0, and will be removed in 1.2.0.
Use ``imageio.imread`` instead.
  """Entry point for launching an IPython kernel.
```

```
(466, 466, 3)
```



0.9 Defining the model architecture

0.9.1 Guidelines to define model architecture

- The feed forward network accepts a dictiontionay with input and layers as keys
- Store the input image or activation map in 'input' key of the dict
- key 'layers' is a list of dictionaries where each dict represents a layer and in the same as they are in the list
- each dict in layers should have a 'type' key which defines the type of the layer
- It supports four types of layers :
  - conv : Convolutional layer 2d

- pool : Pooling layer
- flat : flattening or unravell layer
- fc : fully connected or dense layer #### Attributes for each layer

- conv:
  - filters (int) : Number of kernels
  - kernal (int, int): kernel size, first value corresponds to row
  - stride (int, int): Stride size
  - padding ('same' or 'valid):
    * 'same': the output shape will be same as input
    * 'valid': no padding will be done to the input
  - activation ('sigmoid' or 'relu' or 'tanh'): corresponding activation functions will be applied
- pool:
  - kernal (int, int): kernel size, first value corresponds to row
  - stride (int, int): Stride size
  - pool_func ('max' or 'average' or 'min'): corresponding pooling functions will be applied
- flat:
  - output_length (int) : output vector length
- fc:
  - nodes (int) : no of nodes in the corresponding layer
  - activation ('sigmoid' or 'relu' or 'tanh' or 'softmax'): corresponding activation functions will be applied

```
In [9]: feed_dict = {}
        feed_dict['input'] = img
        feed_dict['layers'] = [{'type': 'conv', 'filters': 4 , 'kernel': (3,3) , 'stride': (2,2
                               {'type': 'conv', 'filters': 4 , 'kernel': (3,3) , 'stride': (2,2
                               {'type': 'pool', 'kernel': (2,2) , 'stride': (1,1),  'pool_func
                               {'type': 'conv', 'filters': 8 , 'kernel': (2,2) , 'stride': (1,1
                               {'type': 'conv', 'filters': 8 , 'kernel': (2,2) , 'stride': (1,1
                               {'type': 'pool', 'kernel': (2,2) , 'stride': (2,2),  'pool_func
                               {'type': 'flat', 'output_length': 2048},
                               {'type': 'fc',  'nodes': 1024, 'activation' : 'sigmoid'},
                               {'type': 'fc',  'nodes': 1024, 'activation' : 'sigmoid'},
                               {'type': 'fc',  'nodes': 10, 'activation' : 'sigmoid'}]
```

0.10 buliding the model and fed forward the input

```
In [10]: output = feed_forward(feed_dict)

         print 'layer \t type \t output shape\n'
         #printing the output layers with corresponding shape
         for i in range(len(output)):
             print str(output[i]['layer_number']) + '\t' + str(output[i]['type']) + '\t' + str
```

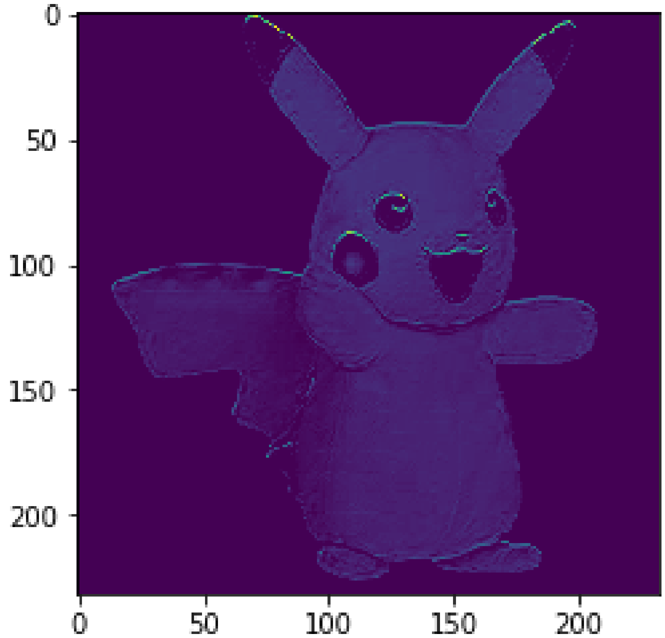
```
layer          type          output shape

0        conv        (232, 232, 4)
1        conv        (115, 115, 4)
2        pool        (114, 114, 4)
3        conv        (113, 113, 8)
4        conv        (112, 112, 8)
5        pool        (56, 56, 8)
6        flat        (2048,)
7        fc        (1024, 1)
8        fc        (1024, 1)
9        fc        (10, 1)
```

In [11]:
```python
#printing the last output
print output[len(output) - 1]['output']
```

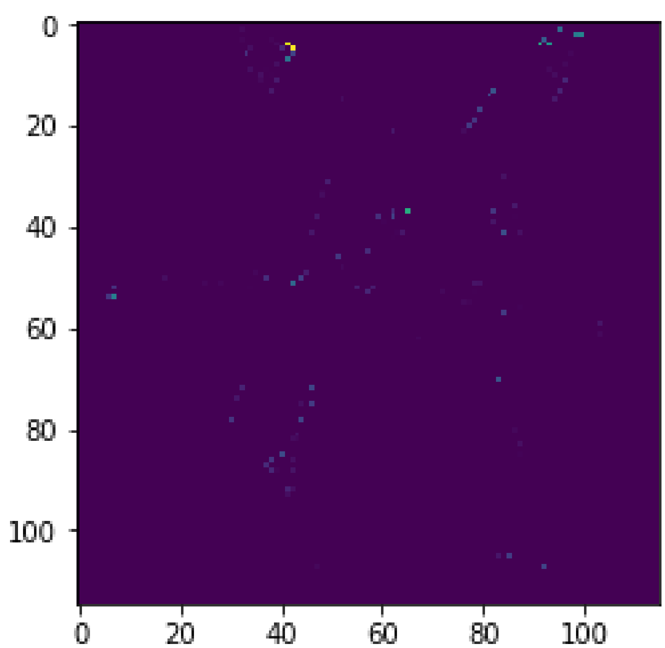
```
[[0.72467933]
 [0.72360681]
 [0.72577901]
 [0.73060894]
 [0.72494787]
 [0.73105858]
 [0.72715446]
 [0.72128104]
 [0.72138725]
 [0.72092858]]
```

In [12]:
```python
for i in range(len(output)):
    if(output[i]['type'] == 'conv' or output[i]['type'] == 'pool'):
        print str(output[i]['layer_number']) + '\t' + str(output[i]['type'])
        plt.imshow(output[i]['output'][:,:,0])
        plt.show()
```

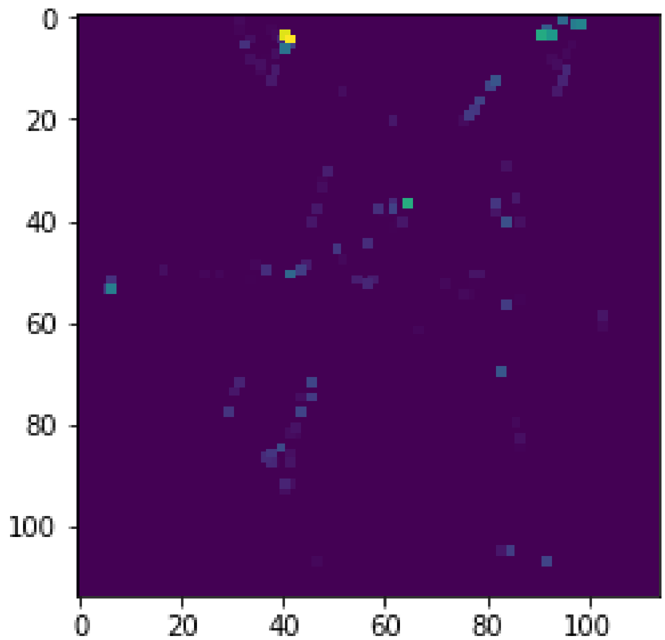
```
0        conv
```



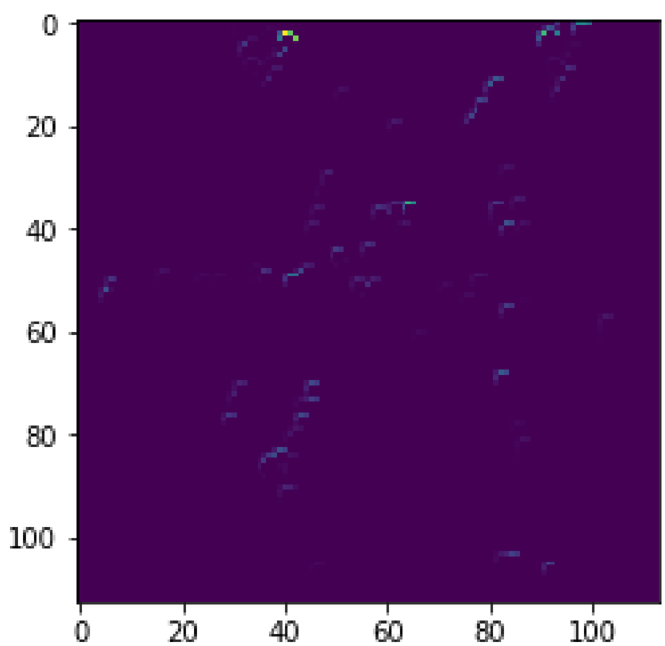
1 conv



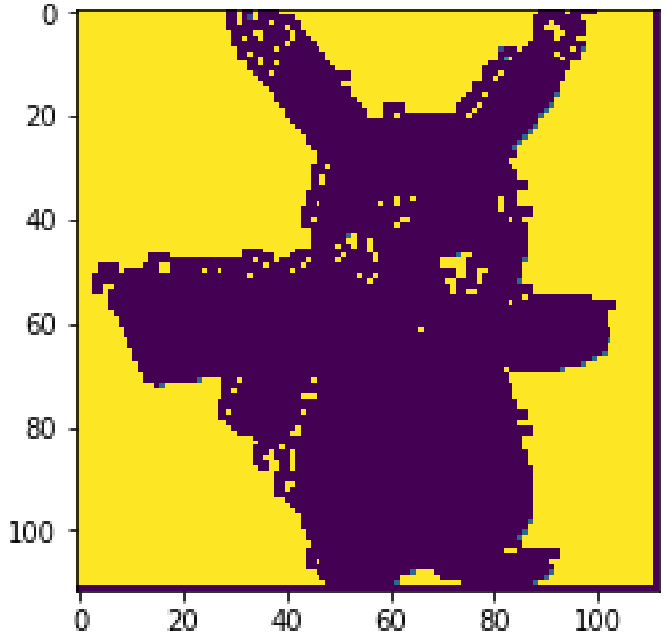
2 pool



3 conv



4 conv



5 pool