fire-detection-jetson-save-ca

February 12, 2018

In [1]:
```
from sklearn.datasets import load_files
from keras.utils import np_utils
import numpy as np
from glob import glob
import cv2
import matplotlib.pyplot as plt
from keras.applications.resnet50 import preprocess_input, decode_predictions
#from keras.applications.xception import Xception, preprocess_input
#from keras.applications.inception_v3 import InceptionV3, preprocess_input
#from keras.applications.vgg16 import VGG16, preprocess_input
#from keras.applications.vgg19 import VGG19, preprocess_input
```

```
/usr/local/lib/python2.7/dist-packages/h5py/__init__.py:36: FutureWarning: Conversion of the sec
  from ._conv import register_converters as _register_converters
Using TensorFlow backend.
```

In [2]:
```
### Work around GPU memory issuesimport tensorflow as tfimport keras.backend.tensorflow_
#import tensorflow as tf
#import keras.backend.tensorflow_backend as ktf

#def get_session(gpu_fraction=0.6):
#    gpu_options = tf.GPUOptions(per_process_gpu_memory_fraction=gpu_fraction,
#                                allow_growth=True)
#    return tf.Session(config=tf.ConfigProto(gpu_options=gpu_options))

#ktf.set_session(get_session())
```

In [3]:
```
img_width, img_height = 224, 224 # change based on the shape/structure of your images

# define function to load train, test, and validation datasets
def load_dataset(path):
    data = load_files(path)
    fire_files = np.array(data['filenames'])
    fire_targets = np_utils.to_categorical(np.array(data['target']), 133)
    return fire_files, fire_targets

# load train, test, and validation datasets
```

```
        train_files, train_targets = load_dataset('fireImages/train')
        valid_files, valid_targets = load_dataset('fireImages/valid')
        test_files, test_targets = load_dataset('fireImages/test')

        # load list of fire classes
        class_names = [item[21:-1] for item in sorted(glob("fireImages/train/*/"))]

        # print statistics about the dataset
        print('There are %d total fire categories.' % len(class_names))
        print('There are %s total fire images.\n' % len(np.hstack([train_files, valid_files, tes
        print('There are %d training fire images.' % len(train_files))
        print('There are %d validation fire images.' % len(valid_files))
        print('There are %d test fire images.'% len(test_files))
```

```
There are 3 total fire categories.
There are 319 total fire images.

There are 166 training fire images.
There are 89 validation fire images.
There are 64 test fire images.
```

```
In [4]: class_names
```

```
Out[4]: ['Fire', 'Smoke', 'Safe']
```

```
In [5]: from keras.preprocessing import image
        from tqdm import tqdm

        def path_to_tensor(img_path):
            # loads RGB image as PIL.Image.Image type
            img = image.load_img(img_path, target_size=(img_width, img_height))
            # convert PIL.Image.Image type to 3D tensor with shape (224, 224, 3)
            x = image.img_to_array(img)
            # convert 3D tensor to 4D tensor with shape (1, 224, 224, 3) and return 4D tensor
            return np.expand_dims(x, axis=0)

        def paths_to_tensor(img_paths):
            list_of_tensors = [path_to_tensor(img_path) for img_path in tqdm(img_paths)]
            return np.vstack(list_of_tensors)
```

```
In [6]: from PIL import ImageFile
        from PIL import Image
        ImageFile.LOAD_TRUNCATED_IMAGES = True

        # pre-process the data for Keras
        train_tensors = preprocess_input( paths_to_tensor(train_files) )
        valid_tensors = preprocess_input( paths_to_tensor(valid_files) )
        test_tensors  = preprocess_input( paths_to_tensor(test_files) )
```

```
100%|| 166/166 [00:01<00:00, 144.13it/s]
100%|| 89/89 [00:00<00:00, 175.68it/s]
100%|| 64/64 [00:00<00:00, 225.55it/s]
```

0.0.1 Detect fire with the most accurate model

```
In [7]: ### Define the architecture.
        from keras.layers import Conv2D, MaxPooling2D, GlobalAveragePooling2D
        from keras.layers import Dropout, Flatten, Dense
        from keras.models import Sequential
        from keras import applications

        from keras.applications.resnet50 import preprocess_input, decode_predictions
        VGG16_model       = applications.VGG16(input_shape=(img_width, img_height, 3), weights =
        InceptionV3_model = applications.InceptionV3(input_shape=(img_width, img_height, 3), wei
        Xception_model    = applications.Xception(input_shape=(img_width, img_height, 3), weight
        ResNet50_model    = applications.ResNet50(input_shape=(img_width, img_height, 3), weight
        VGG19_model       = applications.VGG19(input_shape=(img_width, img_height, 3), weights =
```

0.0.2 Pick the most accurate model for this application

```
In [8]: #base_model = InceptionV3_model
        #base_model = Xception_model
        base_model = ResNet50_model
        #base_model = VGG16_model
        #base_model = VGG19_model
```

0.0.3 Transfer learning (freeze base model layers)

```
In [9]: # Freeze the layers which you don't want to train.
        for layer in base_model.layers:
            layer.trainable = False

        # Here I am freezing the first 5 layers.
        # for layer in model.layers[:5]:
        #    layer.trainable = False
```

```
In [10]: # add a global spatial average pooling layer
         x = base_model.output
         x = GlobalAveragePooling2D()(x)
         x = Dropout(0.45)(x)
         # and a logistic layer we have 133 classes
         predictions = Dense(133, activation='softmax')(x)
```

```
In [11]: from keras.models import Model
         # this is the model we will train
         model = Model(inputs=base_model.input, outputs=predictions)
```

```
In [12]: # compile the model (should be done *after* setting layers to non-trainable)
         model.compile(optimizer='rmsprop', loss='categorical_crossentropy', metrics=['accuracy'
         #model.compile(loss='categorical_crossentropy', optimizer='adadelta', metrics=['accurac

In [13]: model.summary()
```

Layer (type)	Output Shape	Param #	Connected to
input_4 (InputLayer)	(None, 224, 224, 3)	0	
conv1 (Conv2D)	(None, 112, 112, 64)	9472	input_4[0][0]
bn_conv1 (BatchNormalization)	(None, 112, 112, 64)	256	conv1[0][0]
activation_95 (Activation)	(None, 112, 112, 64)	0	bn_conv1[0][0]
max_pooling2d_5 (MaxPooling2D)	(None, 55, 55, 64)	0	activation_95[0][0]
res2a_branch2a (Conv2D)	(None, 55, 55, 64)	4160	max_pooling2d_5[0][0]
bn2a_branch2a (BatchNormalizati	(None, 55, 55, 64)	256	res2a_branch2a[0][0]
activation_96 (Activation)	(None, 55, 55, 64)	0	bn2a_branch2a[0][0]
res2a_branch2b (Conv2D)	(None, 55, 55, 64)	36928	activation_96[0][0]
bn2a_branch2b (BatchNormalizati	(None, 55, 55, 64)	256	res2a_branch2b[0][0]
activation_97 (Activation)	(None, 55, 55, 64)	0	bn2a_branch2b[0][0]
res2a_branch2c (Conv2D)	(None, 55, 55, 256)	16640	activation_97[0][0]
res2a_branch1 (Conv2D)	(None, 55, 55, 256)	16640	max_pooling2d_5[0][0]
bn2a_branch2c (BatchNormalizati	(None, 55, 55, 256)	1024	res2a_branch2c[0][0]
bn2a_branch1 (BatchNormalizatio	(None, 55, 55, 256)	1024	res2a_branch1[0][0]
add_13 (Add)	(None, 55, 55, 256)	0	bn2a_branch2c[0][0] bn2a_branch1[0][0]
activation_98 (Activation)	(None, 55, 55, 256)	0	add_13[0][0]
res2b_branch2a (Conv2D)	(None, 55, 55, 64)	16448	activation_98[0][0]
bn2b_branch2a (BatchNormalizati	(None, 55, 55, 64)	256	res2b_branch2a[0][0]

```
activation_99 (Activation)      (None, 55, 55, 64)   0           bn2b_branch2a[0][0]
--------------------------------------------------------------------------------------------------
res2b_branch2b (Conv2D)         (None, 55, 55, 64)   36928       activation_99[0][0]
--------------------------------------------------------------------------------------------------
bn2b_branch2b (BatchNormalizati (None, 55, 55, 64)   256         res2b_branch2b[0][0]
--------------------------------------------------------------------------------------------------
activation_100 (Activation)     (None, 55, 55, 64)   0           bn2b_branch2b[0][0]
--------------------------------------------------------------------------------------------------
res2b_branch2c (Conv2D)         (None, 55, 55, 256)  16640       activation_100[0][0]
--------------------------------------------------------------------------------------------------
bn2b_branch2c (BatchNormalizati (None, 55, 55, 256)  1024        res2b_branch2c[0][0]
--------------------------------------------------------------------------------------------------
add_14 (Add)                    (None, 55, 55, 256)  0           bn2b_branch2c[0][0]
                                                                 activation_98[0][0]
--------------------------------------------------------------------------------------------------
activation_101 (Activation)     (None, 55, 55, 256)  0           add_14[0][0]
--------------------------------------------------------------------------------------------------
res2c_branch2a (Conv2D)         (None, 55, 55, 64)   16448       activation_101[0][0]
--------------------------------------------------------------------------------------------------
bn2c_branch2a (BatchNormalizati (None, 55, 55, 64)   256         res2c_branch2a[0][0]
--------------------------------------------------------------------------------------------------
activation_102 (Activation)     (None, 55, 55, 64)   0           bn2c_branch2a[0][0]
--------------------------------------------------------------------------------------------------
res2c_branch2b (Conv2D)         (None, 55, 55, 64)   36928       activation_102[0][0]
--------------------------------------------------------------------------------------------------
bn2c_branch2b (BatchNormalizati (None, 55, 55, 64)   256         res2c_branch2b[0][0]
--------------------------------------------------------------------------------------------------
activation_103 (Activation)     (None, 55, 55, 64)   0           bn2c_branch2b[0][0]
--------------------------------------------------------------------------------------------------
res2c_branch2c (Conv2D)         (None, 55, 55, 256)  16640       activation_103[0][0]
--------------------------------------------------------------------------------------------------
bn2c_branch2c (BatchNormalizati (None, 55, 55, 256)  1024        res2c_branch2c[0][0]
--------------------------------------------------------------------------------------------------
add_15 (Add)                    (None, 55, 55, 256)  0           bn2c_branch2c[0][0]
                                                                 activation_101[0][0]
--------------------------------------------------------------------------------------------------
activation_104 (Activation)     (None, 55, 55, 256)  0           add_15[0][0]
--------------------------------------------------------------------------------------------------
res3a_branch2a (Conv2D)         (None, 28, 28, 128)  32896       activation_104[0][0]
--------------------------------------------------------------------------------------------------
bn3a_branch2a (BatchNormalizati (None, 28, 28, 128)  512         res3a_branch2a[0][0]
--------------------------------------------------------------------------------------------------
activation_105 (Activation)     (None, 28, 28, 128)  0           bn3a_branch2a[0][0]
--------------------------------------------------------------------------------------------------
res3a_branch2b (Conv2D)         (None, 28, 28, 128)  147584      activation_105[0][0]
--------------------------------------------------------------------------------------------------
bn3a_branch2b (BatchNormalizati (None, 28, 28, 128)  512         res3a_branch2b[0][0]
--------------------------------------------------------------------------------------------------
```

```
activation_106 (Activation)     (None, 28, 28, 128)  0           bn3a_branch2b[0][0]
--------------------------------------------------------------------------------------------------
res3a_branch2c (Conv2D)         (None, 28, 28, 512)  66048       activation_106[0][0]
--------------------------------------------------------------------------------------------------
res3a_branch1 (Conv2D)          (None, 28, 28, 512)  131584      activation_104[0][0]
--------------------------------------------------------------------------------------------------
bn3a_branch2c (BatchNormalizati (None, 28, 28, 512)  2048        res3a_branch2c[0][0]
--------------------------------------------------------------------------------------------------
bn3a_branch1 (BatchNormalizatio (None, 28, 28, 512)  2048        res3a_branch1[0][0]
--------------------------------------------------------------------------------------------------
add_16 (Add)                    (None, 28, 28, 512)  0           bn3a_branch2c[0][0]
                                                                 bn3a_branch1[0][0]
--------------------------------------------------------------------------------------------------
activation_107 (Activation)     (None, 28, 28, 512)  0           add_16[0][0]
--------------------------------------------------------------------------------------------------
res3b_branch2a (Conv2D)         (None, 28, 28, 128)  65664       activation_107[0][0]
--------------------------------------------------------------------------------------------------
bn3b_branch2a (BatchNormalizati (None, 28, 28, 128)  512         res3b_branch2a[0][0]
--------------------------------------------------------------------------------------------------
activation_108 (Activation)     (None, 28, 28, 128)  0           bn3b_branch2a[0][0]
--------------------------------------------------------------------------------------------------
res3b_branch2b (Conv2D)         (None, 28, 28, 128)  147584      activation_108[0][0]
--------------------------------------------------------------------------------------------------
bn3b_branch2b (BatchNormalizati (None, 28, 28, 128)  512         res3b_branch2b[0][0]
--------------------------------------------------------------------------------------------------
activation_109 (Activation)     (None, 28, 28, 128)  0           bn3b_branch2b[0][0]
--------------------------------------------------------------------------------------------------
res3b_branch2c (Conv2D)         (None, 28, 28, 512)  66048       activation_109[0][0]
--------------------------------------------------------------------------------------------------
bn3b_branch2c (BatchNormalizati (None, 28, 28, 512)  2048        res3b_branch2c[0][0]
--------------------------------------------------------------------------------------------------
add_17 (Add)                    (None, 28, 28, 512)  0           bn3b_branch2c[0][0]
                                                                 activation_107[0][0]
--------------------------------------------------------------------------------------------------
activation_110 (Activation)     (None, 28, 28, 512)  0           add_17[0][0]
--------------------------------------------------------------------------------------------------
res3c_branch2a (Conv2D)         (None, 28, 28, 128)  65664       activation_110[0][0]
--------------------------------------------------------------------------------------------------
bn3c_branch2a (BatchNormalizati (None, 28, 28, 128)  512         res3c_branch2a[0][0]
--------------------------------------------------------------------------------------------------
activation_111 (Activation)     (None, 28, 28, 128)  0           bn3c_branch2a[0][0]
--------------------------------------------------------------------------------------------------
res3c_branch2b (Conv2D)         (None, 28, 28, 128)  147584      activation_111[0][0]
--------------------------------------------------------------------------------------------------
bn3c_branch2b (BatchNormalizati (None, 28, 28, 128)  512         res3c_branch2b[0][0]
--------------------------------------------------------------------------------------------------
activation_112 (Activation)     (None, 28, 28, 128)  0           bn3c_branch2b[0][0]
--------------------------------------------------------------------------------------------------
```

```
res3c_branch2c (Conv2D)         (None, 28, 28, 512)  66048       activation_112[0][0]
--------------------------------------------------------------------------------------------------
bn3c_branch2c (BatchNormalizati (None, 28, 28, 512)  2048        res3c_branch2c[0][0]
--------------------------------------------------------------------------------------------------
add_18 (Add)                    (None, 28, 28, 512)  0           bn3c_branch2c[0][0]
                                                                 activation_110[0][0]
--------------------------------------------------------------------------------------------------
activation_113 (Activation)     (None, 28, 28, 512)  0           add_18[0][0]
--------------------------------------------------------------------------------------------------
res3d_branch2a (Conv2D)         (None, 28, 28, 128)  65664       activation_113[0][0]
--------------------------------------------------------------------------------------------------
bn3d_branch2a (BatchNormalizati (None, 28, 28, 128)  512         res3d_branch2a[0][0]
--------------------------------------------------------------------------------------------------
activation_114 (Activation)     (None, 28, 28, 128)  0           bn3d_branch2a[0][0]
--------------------------------------------------------------------------------------------------
res3d_branch2b (Conv2D)         (None, 28, 28, 128)  147584      activation_114[0][0]
--------------------------------------------------------------------------------------------------
bn3d_branch2b (BatchNormalizati (None, 28, 28, 128)  512         res3d_branch2b[0][0]
--------------------------------------------------------------------------------------------------
activation_115 (Activation)     (None, 28, 28, 128)  0           bn3d_branch2b[0][0]
--------------------------------------------------------------------------------------------------
res3d_branch2c (Conv2D)         (None, 28, 28, 512)  66048       activation_115[0][0]
--------------------------------------------------------------------------------------------------
bn3d_branch2c (BatchNormalizati (None, 28, 28, 512)  2048        res3d_branch2c[0][0]
--------------------------------------------------------------------------------------------------
add_19 (Add)                    (None, 28, 28, 512)  0           bn3d_branch2c[0][0]
                                                                 activation_113[0][0]
--------------------------------------------------------------------------------------------------
activation_116 (Activation)     (None, 28, 28, 512)  0           add_19[0][0]
--------------------------------------------------------------------------------------------------
res4a_branch2a (Conv2D)         (None, 14, 14, 256)  131328      activation_116[0][0]
--------------------------------------------------------------------------------------------------
bn4a_branch2a (BatchNormalizati (None, 14, 14, 256)  1024        res4a_branch2a[0][0]
--------------------------------------------------------------------------------------------------
activation_117 (Activation)     (None, 14, 14, 256)  0           bn4a_branch2a[0][0]
--------------------------------------------------------------------------------------------------
res4a_branch2b (Conv2D)         (None, 14, 14, 256)  590080      activation_117[0][0]
--------------------------------------------------------------------------------------------------
bn4a_branch2b (BatchNormalizati (None, 14, 14, 256)  1024        res4a_branch2b[0][0]
--------------------------------------------------------------------------------------------------
activation_118 (Activation)     (None, 14, 14, 256)  0           bn4a_branch2b[0][0]
--------------------------------------------------------------------------------------------------
res4a_branch2c (Conv2D)         (None, 14, 14, 1024) 263168      activation_118[0][0]
--------------------------------------------------------------------------------------------------
res4a_branch1 (Conv2D)          (None, 14, 14, 1024) 525312      activation_116[0][0]
--------------------------------------------------------------------------------------------------
bn4a_branch2c (BatchNormalizati (None, 14, 14, 1024) 4096        res4a_branch2c[0][0]
--------------------------------------------------------------------------------------------------
```

```
bn4a_branch1 (BatchNormalizatio (None, 14, 14, 1024) 4096        res4a_branch1[0][0]
--------------------------------------------------------------------------------------------------
add_20 (Add)                    (None, 14, 14, 1024) 0           bn4a_branch2c[0][0]
                                                                 bn4a_branch1[0][0]
--------------------------------------------------------------------------------------------------
activation_119 (Activation)     (None, 14, 14, 1024) 0           add_20[0][0]
--------------------------------------------------------------------------------------------------
res4b_branch2a (Conv2D)         (None, 14, 14, 256)  262400      activation_119[0][0]
--------------------------------------------------------------------------------------------------
bn4b_branch2a (BatchNormalizati (None, 14, 14, 256)  1024        res4b_branch2a[0][0]
--------------------------------------------------------------------------------------------------
activation_120 (Activation)     (None, 14, 14, 256)  0           bn4b_branch2a[0][0]
--------------------------------------------------------------------------------------------------
res4b_branch2b (Conv2D)         (None, 14, 14, 256)  590080      activation_120[0][0]
--------------------------------------------------------------------------------------------------
bn4b_branch2b (BatchNormalizati (None, 14, 14, 256)  1024        res4b_branch2b[0][0]
--------------------------------------------------------------------------------------------------
activation_121 (Activation)     (None, 14, 14, 256)  0           bn4b_branch2b[0][0]
--------------------------------------------------------------------------------------------------
res4b_branch2c (Conv2D)         (None, 14, 14, 1024) 263168      activation_121[0][0]
--------------------------------------------------------------------------------------------------
bn4b_branch2c (BatchNormalizati (None, 14, 14, 1024) 4096        res4b_branch2c[0][0]
--------------------------------------------------------------------------------------------------
add_21 (Add)                    (None, 14, 14, 1024) 0           bn4b_branch2c[0][0]
                                                                 activation_119[0][0]
--------------------------------------------------------------------------------------------------
activation_122 (Activation)     (None, 14, 14, 1024) 0           add_21[0][0]
--------------------------------------------------------------------------------------------------
res4c_branch2a (Conv2D)         (None, 14, 14, 256)  262400      activation_122[0][0]
--------------------------------------------------------------------------------------------------
bn4c_branch2a (BatchNormalizati (None, 14, 14, 256)  1024        res4c_branch2a[0][0]
--------------------------------------------------------------------------------------------------
activation_123 (Activation)     (None, 14, 14, 256)  0           bn4c_branch2a[0][0]
--------------------------------------------------------------------------------------------------
res4c_branch2b (Conv2D)         (None, 14, 14, 256)  590080      activation_123[0][0]
--------------------------------------------------------------------------------------------------
bn4c_branch2b (BatchNormalizati (None, 14, 14, 256)  1024        res4c_branch2b[0][0]
--------------------------------------------------------------------------------------------------
activation_124 (Activation)     (None, 14, 14, 256)  0           bn4c_branch2b[0][0]
--------------------------------------------------------------------------------------------------
res4c_branch2c (Conv2D)         (None, 14, 14, 1024) 263168      activation_124[0][0]
--------------------------------------------------------------------------------------------------
bn4c_branch2c (BatchNormalizati (None, 14, 14, 1024) 4096        res4c_branch2c[0][0]
--------------------------------------------------------------------------------------------------
add_22 (Add)                    (None, 14, 14, 1024) 0           bn4c_branch2c[0][0]
                                                                 activation_122[0][0]
--------------------------------------------------------------------------------------------------
activation_125 (Activation)     (None, 14, 14, 1024) 0           add_22[0][0]
```

```
res4d_branch2a (Conv2D)         (None, 14, 14, 256)  262400      activation_125[0][0]
bn4d_branch2a (BatchNormalizati (None, 14, 14, 256)  1024        res4d_branch2a[0][0]
activation_126 (Activation)     (None, 14, 14, 256)  0           bn4d_branch2a[0][0]
res4d_branch2b (Conv2D)         (None, 14, 14, 256)  590080      activation_126[0][0]
bn4d_branch2b (BatchNormalizati (None, 14, 14, 256)  1024        res4d_branch2b[0][0]
activation_127 (Activation)     (None, 14, 14, 256)  0           bn4d_branch2b[0][0]
res4d_branch2c (Conv2D)         (None, 14, 14, 1024) 263168      activation_127[0][0]
bn4d_branch2c (BatchNormalizati (None, 14, 14, 1024) 4096        res4d_branch2c[0][0]
add_23 (Add)                    (None, 14, 14, 1024) 0           bn4d_branch2c[0][0]
                                                                 activation_125[0][0]
activation_128 (Activation)     (None, 14, 14, 1024) 0           add_23[0][0]
res4e_branch2a (Conv2D)         (None, 14, 14, 256)  262400      activation_128[0][0]
bn4e_branch2a (BatchNormalizati (None, 14, 14, 256)  1024        res4e_branch2a[0][0]
activation_129 (Activation)     (None, 14, 14, 256)  0           bn4e_branch2a[0][0]
res4e_branch2b (Conv2D)         (None, 14, 14, 256)  590080      activation_129[0][0]
bn4e_branch2b (BatchNormalizati (None, 14, 14, 256)  1024        res4e_branch2b[0][0]
activation_130 (Activation)     (None, 14, 14, 256)  0           bn4e_branch2b[0][0]
res4e_branch2c (Conv2D)         (None, 14, 14, 1024) 263168      activation_130[0][0]
bn4e_branch2c (BatchNormalizati (None, 14, 14, 1024) 4096        res4e_branch2c[0][0]
add_24 (Add)                    (None, 14, 14, 1024) 0           bn4e_branch2c[0][0]
                                                                 activation_128[0][0]
activation_131 (Activation)     (None, 14, 14, 1024) 0           add_24[0][0]
res4f_branch2a (Conv2D)         (None, 14, 14, 256)  262400      activation_131[0][0]
bn4f_branch2a (BatchNormalizati (None, 14, 14, 256)  1024        res4f_branch2a[0][0]
activation_132 (Activation)     (None, 14, 14, 256)  0           bn4f_branch2a[0][0]
```

```
res4f_branch2b (Conv2D)         (None, 14, 14, 256)  590080      activation_132[0][0]
bn4f_branch2b (BatchNormalizati (None, 14, 14, 256)  1024        res4f_branch2b[0][0]
activation_133 (Activation)     (None, 14, 14, 256)  0           bn4f_branch2b[0][0]
res4f_branch2c (Conv2D)         (None, 14, 14, 1024) 263168      activation_133[0][0]
bn4f_branch2c (BatchNormalizati (None, 14, 14, 1024) 4096        res4f_branch2c[0][0]
add_25 (Add)                    (None, 14, 14, 1024) 0           bn4f_branch2c[0][0]
                                                                 activation_131[0][0]
activation_134 (Activation)     (None, 14, 14, 1024) 0           add_25[0][0]
res5a_branch2a (Conv2D)         (None, 7, 7, 512)    524800      activation_134[0][0]
bn5a_branch2a (BatchNormalizati (None, 7, 7, 512)    2048        res5a_branch2a[0][0]
activation_135 (Activation)     (None, 7, 7, 512)    0           bn5a_branch2a[0][0]
res5a_branch2b (Conv2D)         (None, 7, 7, 512)    2359808     activation_135[0][0]
bn5a_branch2b (BatchNormalizati (None, 7, 7, 512)    2048        res5a_branch2b[0][0]
activation_136 (Activation)     (None, 7, 7, 512)    0           bn5a_branch2b[0][0]
res5a_branch2c (Conv2D)         (None, 7, 7, 2048)   1050624     activation_136[0][0]
res5a_branch1 (Conv2D)          (None, 7, 7, 2048)   2099200     activation_134[0][0]
bn5a_branch2c (BatchNormalizati (None, 7, 7, 2048)   8192        res5a_branch2c[0][0]
bn5a_branch1 (BatchNormalizatio (None, 7, 7, 2048)   8192        res5a_branch1[0][0]
add_26 (Add)                    (None, 7, 7, 2048)   0           bn5a_branch2c[0][0]
                                                                 bn5a_branch1[0][0]
activation_137 (Activation)     (None, 7, 7, 2048)   0           add_26[0][0]
res5b_branch2a (Conv2D)         (None, 7, 7, 512)    1049088     activation_137[0][0]
bn5b_branch2a (BatchNormalizati (None, 7, 7, 512)    2048        res5b_branch2a[0][0]
activation_138 (Activation)     (None, 7, 7, 512)    0           bn5b_branch2a[0][0]
res5b_branch2b (Conv2D)         (None, 7, 7, 512)    2359808     activation_138[0][0]
```

```
bn5b_branch2b (BatchNormalizati (None, 7, 7, 512)    2048        res5b_branch2b[0][0]
activation_139 (Activation)     (None, 7, 7, 512)    0           bn5b_branch2b[0][0]
res5b_branch2c (Conv2D)         (None, 7, 7, 2048)   1050624     activation_139[0][0]
bn5b_branch2c (BatchNormalizati (None, 7, 7, 2048)   8192        res5b_branch2c[0][0]
add_27 (Add)                    (None, 7, 7, 2048)   0           bn5b_branch2c[0][0]
                                                                 activation_137[0][0]
activation_140 (Activation)     (None, 7, 7, 2048)   0           add_27[0][0]
res5c_branch2a (Conv2D)         (None, 7, 7, 512)    1049088     activation_140[0][0]
bn5c_branch2a (BatchNormalizati (None, 7, 7, 512)    2048        res5c_branch2a[0][0]
activation_141 (Activation)     (None, 7, 7, 512)    0           bn5c_branch2a[0][0]
res5c_branch2b (Conv2D)         (None, 7, 7, 512)    2359808     activation_141[0][0]
bn5c_branch2b (BatchNormalizati (None, 7, 7, 512)    2048        res5c_branch2b[0][0]
activation_142 (Activation)     (None, 7, 7, 512)    0           bn5c_branch2b[0][0]
res5c_branch2c (Conv2D)         (None, 7, 7, 2048)   1050624     activation_142[0][0]
bn5c_branch2c (BatchNormalizati (None, 7, 7, 2048)   8192        res5c_branch2c[0][0]
add_28 (Add)                    (None, 7, 7, 2048)   0           bn5c_branch2c[0][0]
                                                                 activation_140[0][0]
activation_143 (Activation)     (None, 7, 7, 2048)   0           add_28[0][0]
avg_pool (AveragePooling2D)     (None, 1, 1, 2048)   0           activation_143[0][0]
global_average_pooling2d_1 (Glo (None, 2048)         0           avg_pool[0][0]
dropout_1 (Dropout)             (None, 2048)         0           global_average_pooling2d_1[0][0
dense_1 (Dense)                 (None, 133)          272517      dropout_1[0][0]
==================================================================================================
Total params: 23,860,229
Trainable params: 272,517
Non-trainable params: 23,587,712
```

```
In [14]: from keras.callbacks import ModelCheckpoint

         import keras.backend.tensorflow_backend as K

         # train the model
         checkpointer = ModelCheckpoint(filepath='firemodel.weights.best.hdf5', verbose=3, save_
         hist = model.fit(train_tensors, train_targets, batch_size=64, epochs=20,
               validation_data=(valid_tensors, valid_targets), callbacks=[checkpointer],
               verbose=2)  #, shuffle=True)

Train on 166 samples, validate on 89 samples
Epoch 1/20
Epoch 00001: val_loss improved from inf to 1.03734, saving model to firemodel.weights.best.hdf5
 - 8s - loss: 2.8977 - acc: 0.2771 - val_loss: 1.0373 - val_acc: 0.6067
Epoch 2/20
Epoch 00002: val_loss did not improve
 - 2s - loss: 1.0408 - acc: 0.6747 - val_loss: 1.2893 - val_acc: 0.4270
Epoch 3/20
Epoch 00003: val_loss improved from 1.03734 to 0.50274, saving model to firemodel.weights.best.h
 - 2s - loss: 0.6339 - acc: 0.7651 - val_loss: 0.5027 - val_acc: 0.8427
Epoch 4/20
Epoch 00004: val_loss did not improve
 - 1s - loss: 0.5194 - acc: 0.7892 - val_loss: 0.8153 - val_acc: 0.6742
Epoch 5/20
Epoch 00005: val_loss did not improve
 - 2s - loss: 0.5115 - acc: 0.7892 - val_loss: 0.6549 - val_acc: 0.7191
Epoch 6/20
Epoch 00006: val_loss did not improve
 - 1s - loss: 0.3806 - acc: 0.8494 - val_loss: 0.6902 - val_acc: 0.7079
Epoch 7/20
Epoch 00007: val_loss did not improve
 - 2s - loss: 0.3509 - acc: 0.8494 - val_loss: 0.6417 - val_acc: 0.7191
Epoch 8/20
Epoch 00008: val_loss improved from 0.50274 to 0.47800, saving model to firemodel.weights.best.h
 - 2s - loss: 0.3082 - acc: 0.8916 - val_loss: 0.4780 - val_acc: 0.7978
Epoch 9/20
Epoch 00009: val_loss did not improve
 - 1s - loss: 0.2771 - acc: 0.8976 - val_loss: 0.5283 - val_acc: 0.7753
Epoch 10/20
Epoch 00010: val_loss did not improve
 - 2s - loss: 0.2380 - acc: 0.9157 - val_loss: 0.5711 - val_acc: 0.7753
Epoch 11/20
Epoch 00011: val_loss did not improve
 - 2s - loss: 0.1938 - acc: 0.9337 - val_loss: 0.5963 - val_acc: 0.7528
Epoch 12/20
Epoch 00012: val_loss did not improve
 - 2s - loss: 0.1709 - acc: 0.9518 - val_loss: 0.5298 - val_acc: 0.7865
Epoch 13/20
```

```
Epoch 00013: val_loss did not improve
 - 1s - loss: 0.1899 - acc: 0.9398 - val_loss: 0.6626 - val_acc: 0.7753
Epoch 14/20
Epoch 00014: val_loss improved from 0.47800 to 0.45734, saving model to firemodel.weights.best.h
 - 2s - loss: 0.2633 - acc: 0.8735 - val_loss: 0.4573 - val_acc: 0.8090
Epoch 15/20
Epoch 00015: val_loss did not improve
 - 2s - loss: 0.1447 - acc: 0.9639 - val_loss: 0.4655 - val_acc: 0.8427
Epoch 16/20
Epoch 00016: val_loss did not improve
 - 2s - loss: 0.1438 - acc: 0.9458 - val_loss: 0.5490 - val_acc: 0.8090
Epoch 17/20
Epoch 00017: val_loss improved from 0.45734 to 0.37763, saving model to firemodel.weights.best.h
 - 2s - loss: 0.1614 - acc: 0.9157 - val_loss: 0.3776 - val_acc: 0.8652
Epoch 18/20
Epoch 00018: val_loss did not improve
 - 1s - loss: 0.1596 - acc: 0.9096 - val_loss: 0.4238 - val_acc: 0.8315
Epoch 19/20
Epoch 00019: val_loss did not improve
 - 2s - loss: 0.1334 - acc: 0.9518 - val_loss: 0.4901 - val_acc: 0.8764
Epoch 20/20
Epoch 00020: val_loss did not improve
 - 1s - loss: 0.1268 - acc: 0.9518 - val_loss: 0.4281 - val_acc: 0.8764
```

```
In [15]: for i, layer in enumerate(base_model.layers):
             print(i, layer.name)
```

```
(0, 'input_4')
(1, 'conv1')
(2, 'bn_conv1')
(3, 'activation_95')
(4, 'max_pooling2d_5')
(5, 'res2a_branch2a')
(6, 'bn2a_branch2a')
(7, 'activation_96')
(8, 'res2a_branch2b')
(9, 'bn2a_branch2b')
(10, 'activation_97')
(11, 'res2a_branch2c')
(12, 'res2a_branch1')
(13, 'bn2a_branch2c')
(14, 'bn2a_branch1')
(15, 'add_13')
(16, 'activation_98')
(17, 'res2b_branch2a')
(18, 'bn2b_branch2a')
(19, 'activation_99')
```

```
(20, 'res2b_branch2b')
(21, 'bn2b_branch2b')
(22, 'activation_100')
(23, 'res2b_branch2c')
(24, 'bn2b_branch2c')
(25, 'add_14')
(26, 'activation_101')
(27, 'res2c_branch2a')
(28, 'bn2c_branch2a')
(29, 'activation_102')
(30, 'res2c_branch2b')
(31, 'bn2c_branch2b')
(32, 'activation_103')
(33, 'res2c_branch2c')
(34, 'bn2c_branch2c')
(35, 'add_15')
(36, 'activation_104')
(37, 'res3a_branch2a')
(38, 'bn3a_branch2a')
(39, 'activation_105')
(40, 'res3a_branch2b')
(41, 'bn3a_branch2b')
(42, 'activation_106')
(43, 'res3a_branch2c')
(44, 'res3a_branch1')
(45, 'bn3a_branch2c')
(46, 'bn3a_branch1')
(47, 'add_16')
(48, 'activation_107')
(49, 'res3b_branch2a')
(50, 'bn3b_branch2a')
(51, 'activation_108')
(52, 'res3b_branch2b')
(53, 'bn3b_branch2b')
(54, 'activation_109')
(55, 'res3b_branch2c')
(56, 'bn3b_branch2c')
(57, 'add_17')
(58, 'activation_110')
(59, 'res3c_branch2a')
(60, 'bn3c_branch2a')
(61, 'activation_111')
(62, 'res3c_branch2b')
(63, 'bn3c_branch2b')
(64, 'activation_112')
(65, 'res3c_branch2c')
(66, 'bn3c_branch2c')
(67, 'add_18')
```

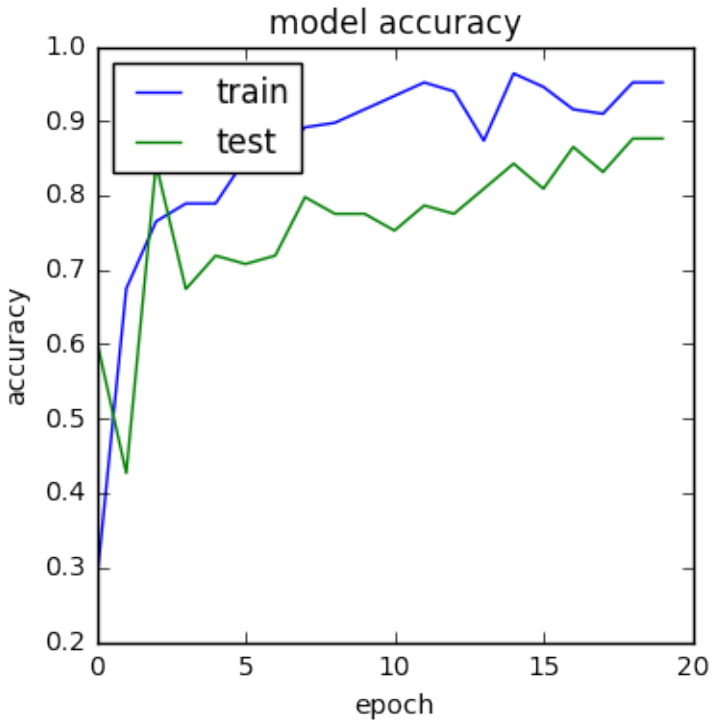
```
(68, 'activation_113')
(69, 'res3d_branch2a')
(70, 'bn3d_branch2a')
(71, 'activation_114')
(72, 'res3d_branch2b')
(73, 'bn3d_branch2b')
(74, 'activation_115')
(75, 'res3d_branch2c')
(76, 'bn3d_branch2c')
(77, 'add_19')
(78, 'activation_116')
(79, 'res4a_branch2a')
(80, 'bn4a_branch2a')
(81, 'activation_117')
(82, 'res4a_branch2b')
(83, 'bn4a_branch2b')
(84, 'activation_118')
(85, 'res4a_branch2c')
(86, 'res4a_branch1')
(87, 'bn4a_branch2c')
(88, 'bn4a_branch1')
(89, 'add_20')
(90, 'activation_119')
(91, 'res4b_branch2a')
(92, 'bn4b_branch2a')
(93, 'activation_120')
(94, 'res4b_branch2b')
(95, 'bn4b_branch2b')
(96, 'activation_121')
(97, 'res4b_branch2c')
(98, 'bn4b_branch2c')
(99, 'add_21')
(100, 'activation_122')
(101, 'res4c_branch2a')
(102, 'bn4c_branch2a')
(103, 'activation_123')
(104, 'res4c_branch2b')
(105, 'bn4c_branch2b')
(106, 'activation_124')
(107, 'res4c_branch2c')
(108, 'bn4c_branch2c')
(109, 'add_22')
(110, 'activation_125')
(111, 'res4d_branch2a')
(112, 'bn4d_branch2a')
(113, 'activation_126')
(114, 'res4d_branch2b')
(115, 'bn4d_branch2b')
```

```
(116, 'activation_127')
(117, 'res4d_branch2c')
(118, 'bn4d_branch2c')
(119, 'add_23')
(120, 'activation_128')
(121, 'res4e_branch2a')
(122, 'bn4e_branch2a')
(123, 'activation_129')
(124, 'res4e_branch2b')
(125, 'bn4e_branch2b')
(126, 'activation_130')
(127, 'res4e_branch2c')
(128, 'bn4e_branch2c')
(129, 'add_24')
(130, 'activation_131')
(131, 'res4f_branch2a')
(132, 'bn4f_branch2a')
(133, 'activation_132')
(134, 'res4f_branch2b')
(135, 'bn4f_branch2b')
(136, 'activation_133')
(137, 'res4f_branch2c')
(138, 'bn4f_branch2c')
(139, 'add_25')
(140, 'activation_134')
(141, 'res5a_branch2a')
(142, 'bn5a_branch2a')
(143, 'activation_135')
(144, 'res5a_branch2b')
(145, 'bn5a_branch2b')
(146, 'activation_136')
(147, 'res5a_branch2c')
(148, 'res5a_branch1')
(149, 'bn5a_branch2c')
(150, 'bn5a_branch1')
(151, 'add_26')
(152, 'activation_137')
(153, 'res5b_branch2a')
(154, 'bn5b_branch2a')
(155, 'activation_138')
(156, 'res5b_branch2b')
(157, 'bn5b_branch2b')
(158, 'activation_139')
(159, 'res5b_branch2c')
(160, 'bn5b_branch2c')
(161, 'add_27')
(162, 'activation_140')
(163, 'res5c_branch2a')
```

```
(164, 'bn5c_branch2a')
(165, 'activation_141')
(166, 'res5c_branch2b')
(167, 'bn5c_branch2b')
(168, 'activation_142')
(169, 'res5c_branch2c')
(170, 'bn5c_branch2c')
(171, 'add_28')
(172, 'activation_143')
(173, 'avg_pool')
```

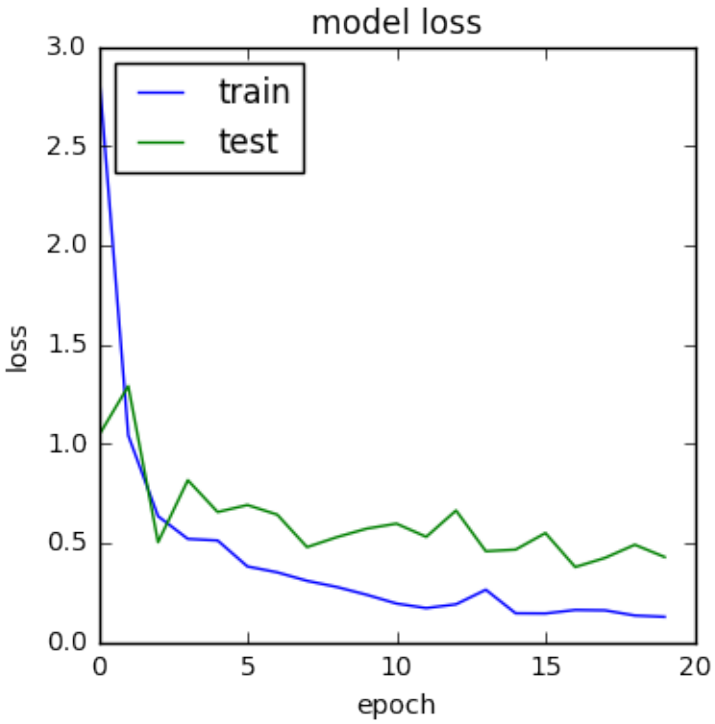
In [16]:
```
import cv2
import matplotlib.pyplot as plt

# summarize history for accuracy
plt.figure(figsize=(4,4), dpi=100 )
plt.plot(hist.history['acc'])
plt.plot(hist.history['val_acc'])
plt.title('model accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
plt.show()
plt.savefig('training1.png', dpi=300)
```



```
<matplotlib.figure.Figure at 0x7f93044e7e50>
```

```
In [17]: # summarize history for loss
         plt.figure(figsize=(4,4), dpi=100 )
         plt.plot(hist.history['loss'])
         plt.plot(hist.history['val_loss'])
         plt.title('model loss')
         plt.ylabel('loss')
         plt.xlabel('epoch')
         plt.legend(['train', 'test'], loc='upper left')
         plt.show()
```



0.0.4 Load the Model with the Best Validation Loss

```
In [18]: ### Load the model weights with the best validation loss.
         model.load_weights('firemodel.weights.best.hdf5')
```

0.0.5 Test the Fire detection Model

```
In [19]: ### Calculate classification accuracy on the test dataset.
```

```
        # get index of predicted fire class for each image in test se
        predictions = [np.argmax(model.predict(np.expand_dims(feature, axis=0))) for feature in
```

```
In [20]: # report test accuracy
         test_accuracy = 100*np.sum ( np.array( predictions)==np.argmax(test_targets, axis=1) )
         print('Test accuracy: %.4f%%' % test_accuracy)
```

```
Test accuracy: 93.0000%
```

```
In [21]: # test validation accuracy
         predictions = [np.argmax(model.predict(np.expand_dims(feature, axis=0))) for feature in
         valid_accuracy = 100*np.sum ( np.array( predictions)==np.argmax(valid_targets, axis=1)
         print('Validation accuracy: %.4f%%' % valid_accuracy)
```

```
Validation accuracy: 86.0000%
```

```
In [22]: def detect_fire(img_path):
             predicted_vector = model.predict(preprocess_input(path_to_tensor(img_path)))
             return class_names[np.argmax(predicted_vector)]
```

```
In [23]: import glob
         from PIL import Image
         from IPython import display

         path = "test_images/*"
         for fname in glob.glob(path):
             fire_detection = detect_fire( fname )
             display.display(plt.gcf())
             print('_____
             print('')
             if (fire_detection=='Fire'):
                 print ('\033[1m'+'\033[91m'+'ALARM: Detected '+fire_detection.replace("_", ""))
             elif (fire_detection=='Smoke'):
                 print ('\033[1m'+'\033[91m'+'ALARM: Detected '+fire_detection.replace("_", ""))
             else:
                 print ('\033[1m'+'\033[92m'+'Looking good: ' +fire_detection.replace("_", ""))
             plt.imshow(Image.open(fname))
             #raw_input()
```

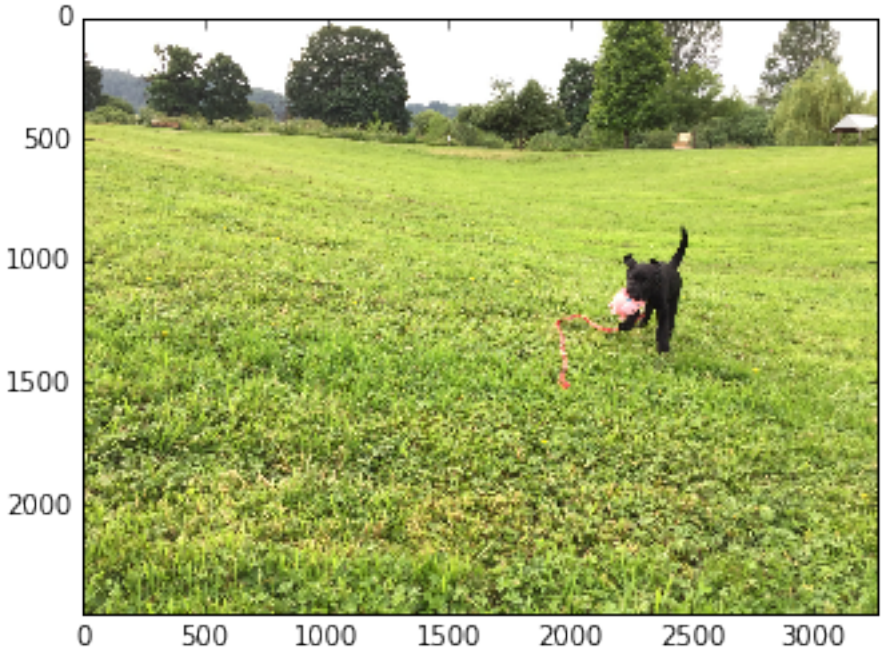
```
<matplotlib.figure.Figure at 0x7f93044adf90>
```

```
-----------------------------------------------------------------------------------------------
```

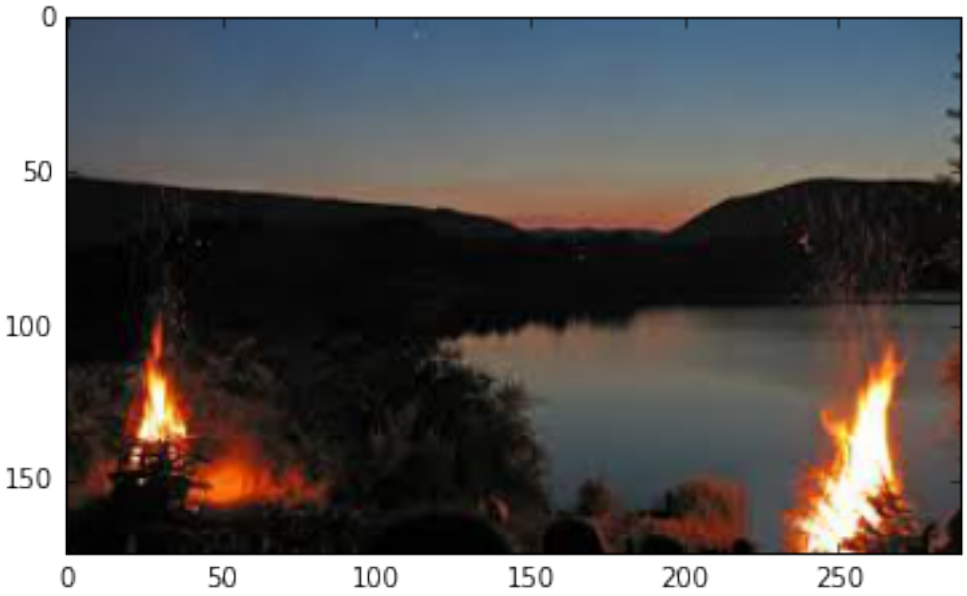
```
ALARM: Detected Smoke
```

```
ALARM: Detected Smoke
```

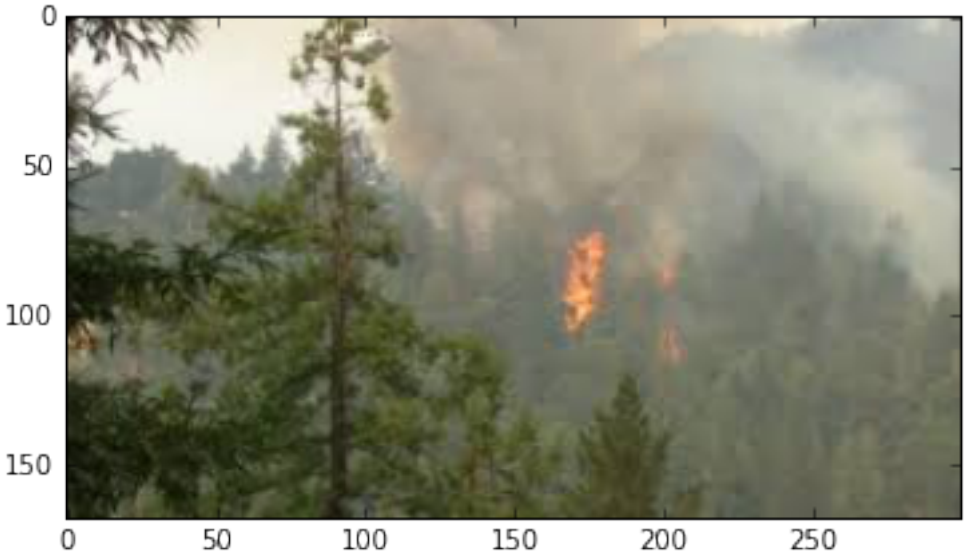
Looking good: Safe



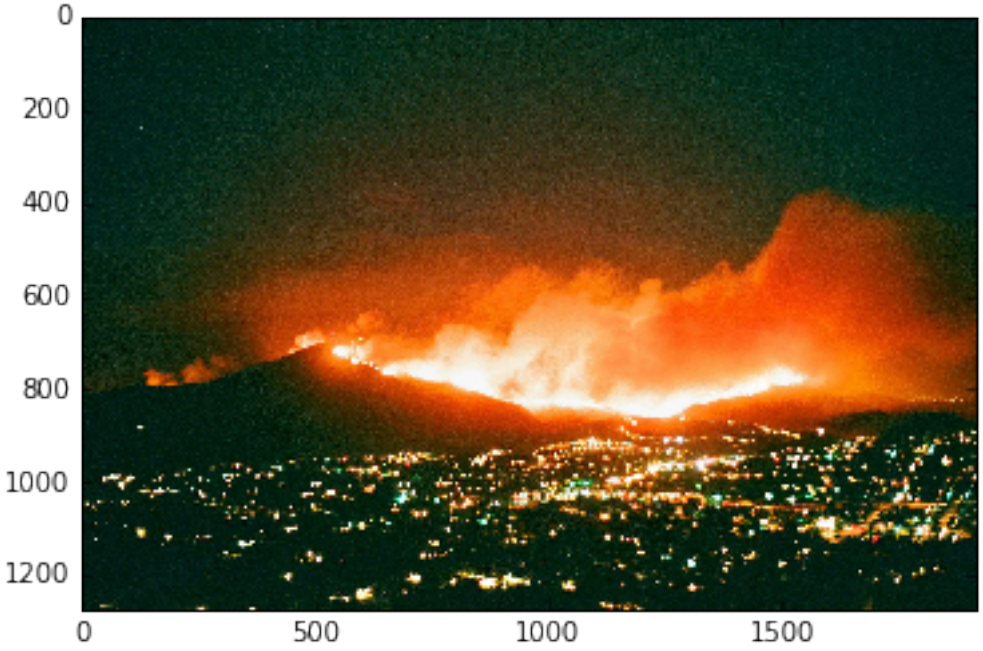
ALARM: Detected Fire



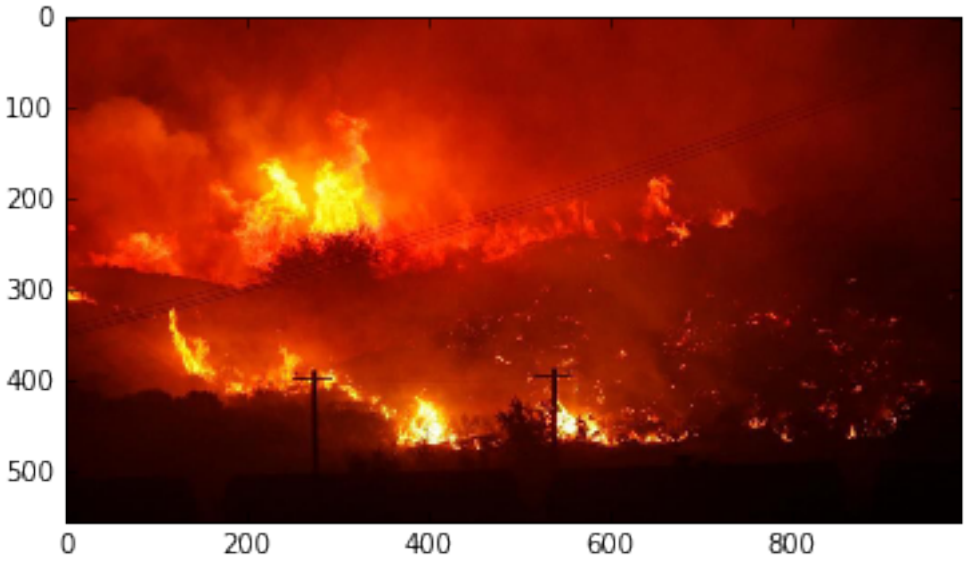
```
ALARM: Detected Fire
```



```
ALARM: Detected Fire
```



```
ALARM: Detected Fire
```



```
ALARM: Detected Fire
```

```
ALARM: Detected Fire
```