Optical smoke detection with fire tower cameras

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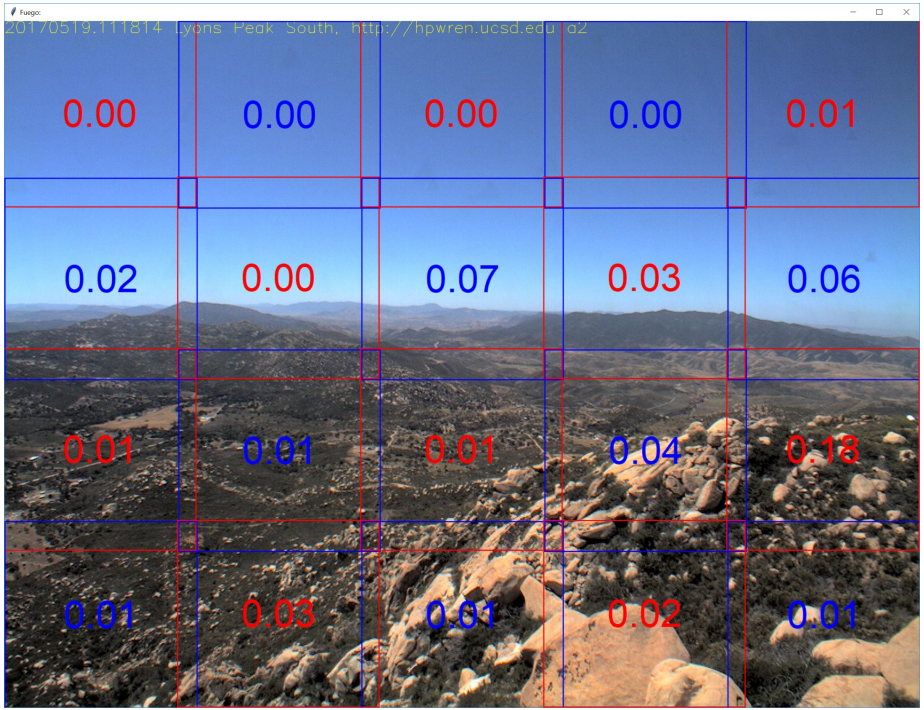
Overview

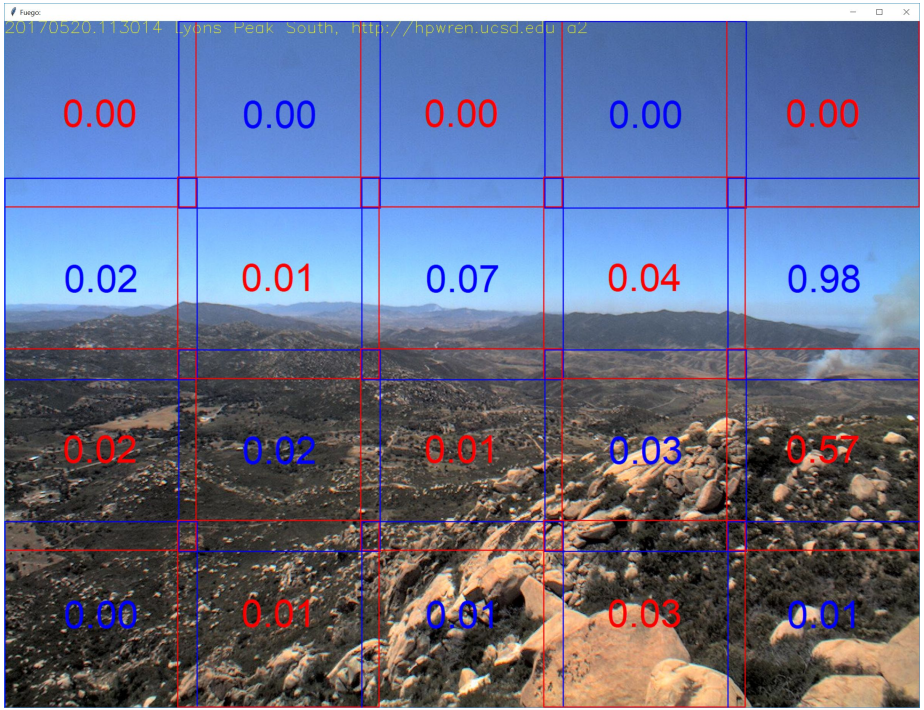
- Grounded (real and literal)
  - Exists today and already capable of detecting fires
- ~200 existing webcams on fire towers
  - Multiple organizations: HPWREN, AlertWildfire, and USGS
  - Some 24hrs, others daylight only
  - Fixed (good for detecting new fires) vs. PTZ (good for monitoring known fires)
  - Range up to tens of miles from good vantage points
  - Expanding network
- Machine Learning based smoke detection
  - Recently rebuilt to improve accuracy -- preliminary results

Machine Learning Details

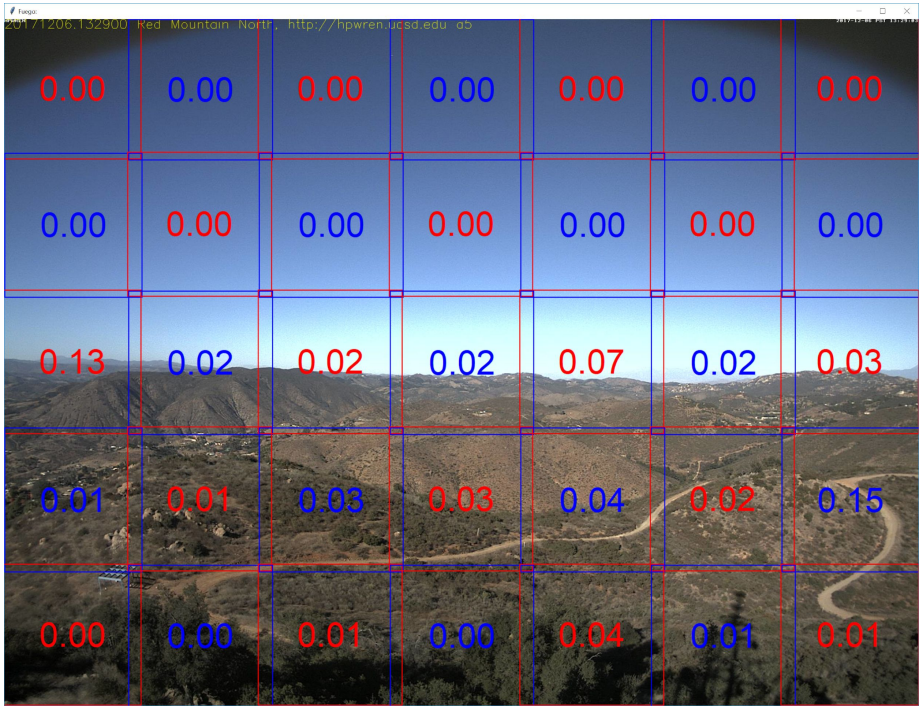
- Supervised training with two classes: smoke and not-smoke
  - Retrain last layer of Google Tensorflow Inception v3 model with ~10000 images
  - Training full deep network would be more accurate, but requires millions of labeled images
- Inception v3 expects 299x299 pixel images (images are resized)
  - Large images with small amount of smoke get shrunk too much to detect smoke
  - Automatically segment images into approximately 300x300 pixel squares
- Training data for smoke
  - Match Calfire's historical fire data with camera locations to search archived images
  - Manually crop smoke sections
- Training data for not-smoke
  - Take pictures one day before fire start, and auto segment

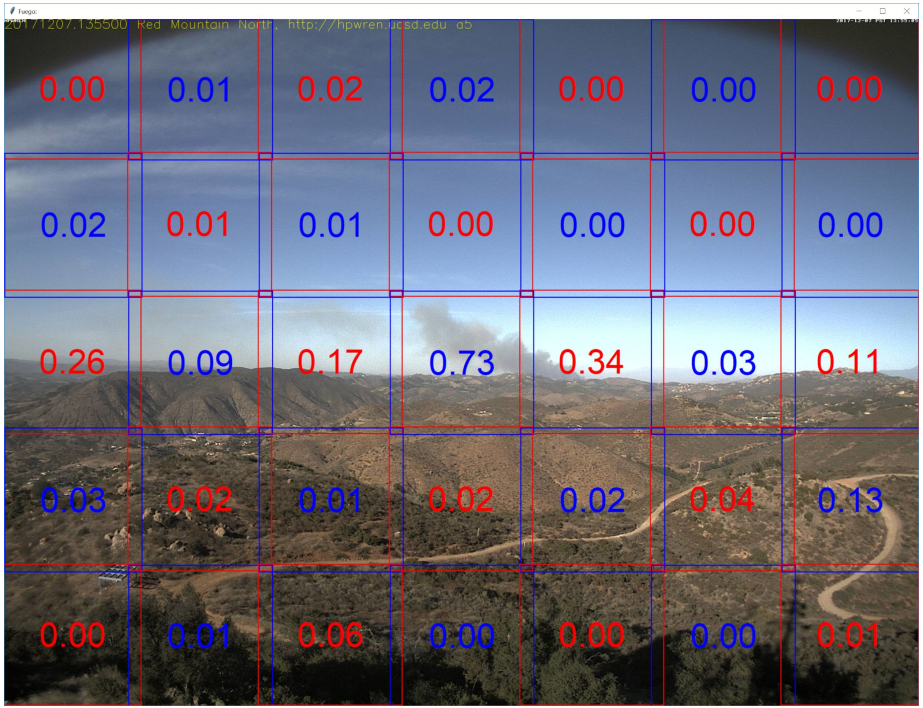
Sample results (before and after)



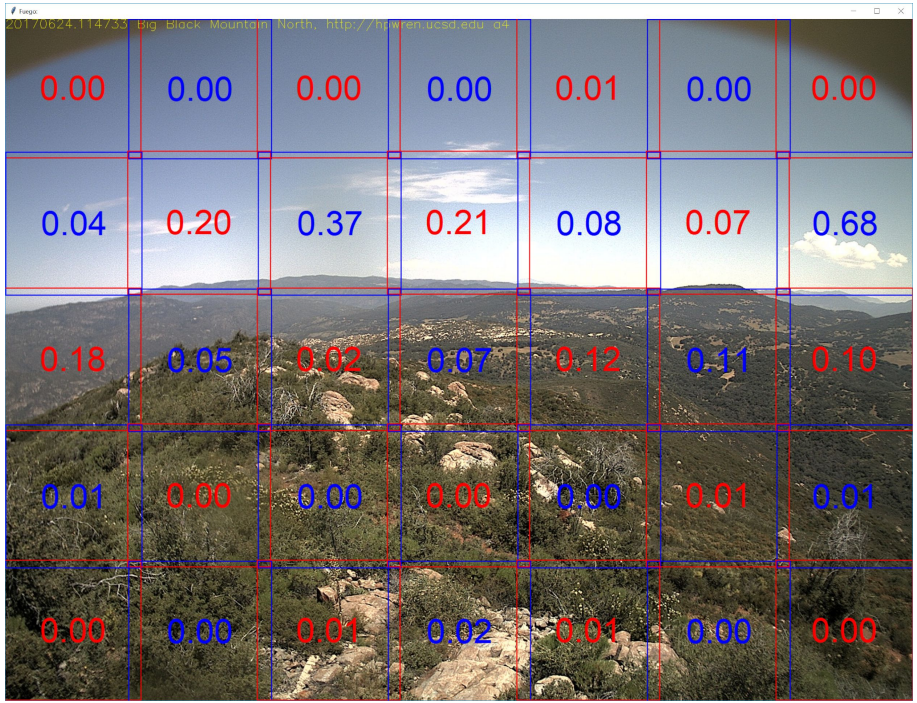


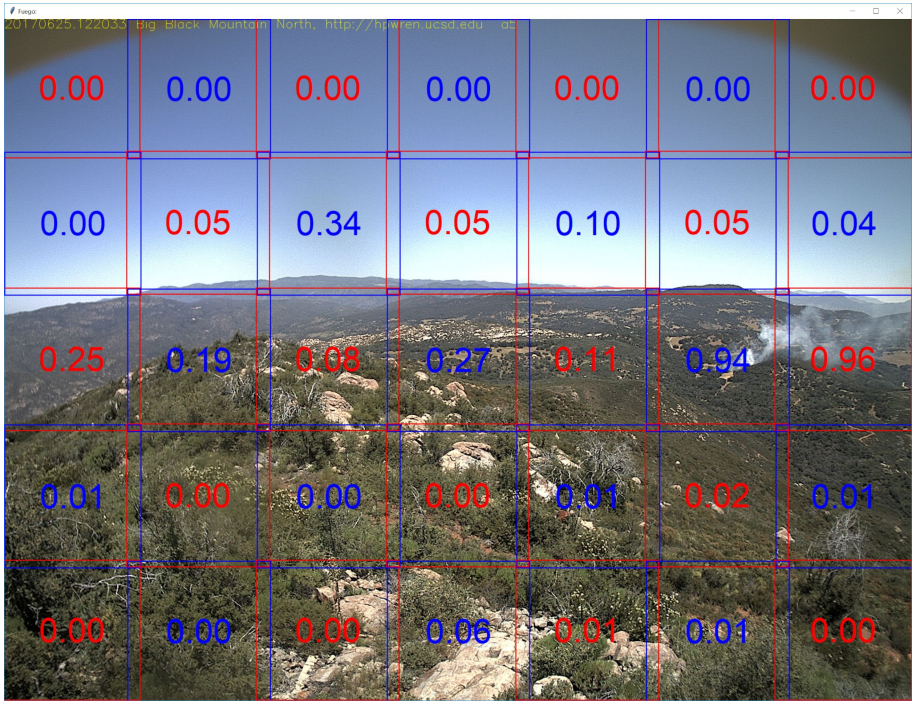
Sample results 2 (before and after)





Sample results 3 (before and after)





Improving accuracy of predictions

- Accuracy already 95%+ without significant tuning
- Reducing false positives
  - Augment not-smoke dataset with images triggering false positives
    - Clouds, fog, haze, snow, and glare
  - Post filters
    - Compare results from previous days for same segment
    - Check weather data
- Reducing false negatives
  - Variable segment size (small for top, big for bottom)
  - Augment smoke images in training set
- Test on images of historical fires to evaluate

Results and future

- Able to detect when fires within minutes if fire is within few miles
  - Range will increase over time
- Takes only 10 seconds per image on single CPU
  - Scaling will improve with code optimization and parallel processing
- Can send email alerts with location and image
  - Plan to add fire severity over time
    - Use fire spread models to predict progression of detections to determine severity
    - Fast growing and those affecting inhabited areas would be high severity
- Expanding camera network will increase coverage
- Cross cueing and data fusion with satellite imagery will make it even more useful