



FIRE DETECTION IN COLOR VIDEO

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at Utah State University



Objective: detect fire in video

Steps:

- 1) Identify moving pixels or regions
- 2) Check colors of moving regions to see if they're fire-colored"
- 3) Wavelet Analysis in the Temporal Domain
- 4) Wavelet Analysis in the Spatial Domain
- 5) Decide if it is a fire

Step 1: Identify moving pixels or regions

- Estimate Background

$$B_{n+1}[k, l] = \begin{cases} aB_n[k, l] + (1 - a)x_n[k, l] & \text{if } [k, l] \text{ is non-moving} \\ B_n[k, l] & \text{if } [k, l] \text{ is moving,} \end{cases}$$

- Find moving regions

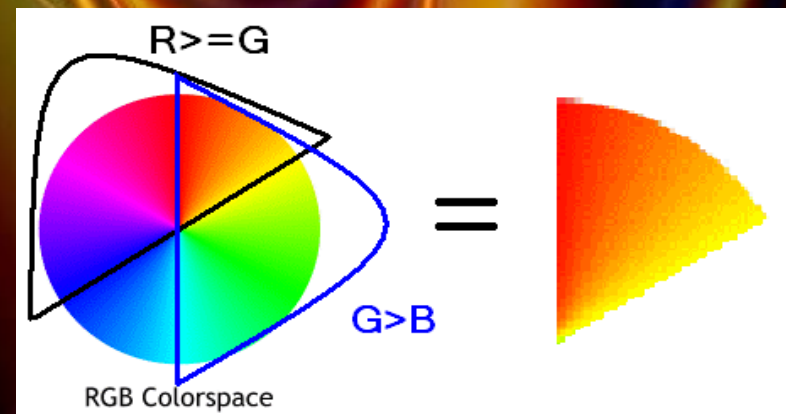
- If it's significantly different from the background, it's moving.

- Moving pixels are grouped into connected regions

- Binary map created: 1 for moving, 0 for not

Step 2: Check colors of moving regions to see if they're "fire-colored"

- New, simpler approach.
- Red value greater than 180
- Red \geq Green $>$ Blue (red \rightarrow yellow colorspace)



- Saturation $>80\%$ or $<20\%$

- Intensity $>40\%$

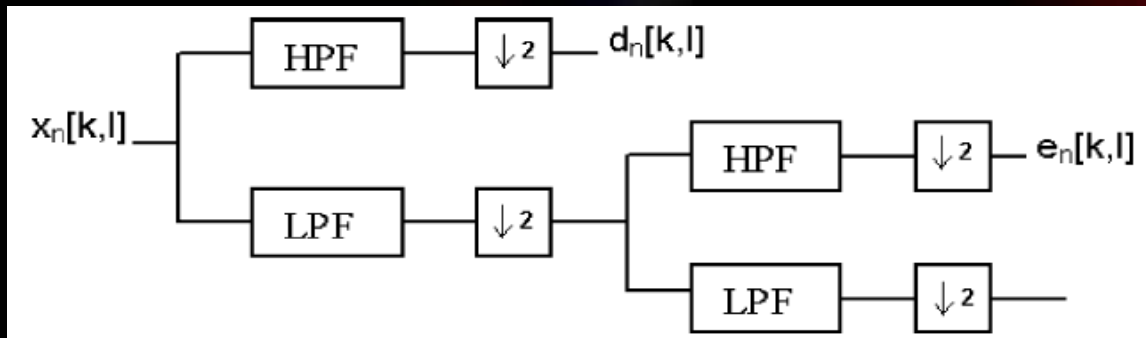


- Binary map "fire-colored" created; the intersection of this with the moving regions binary map creates a binary mask called "fire".



Step 3: Wavelet Analysis in the Temporal Domain

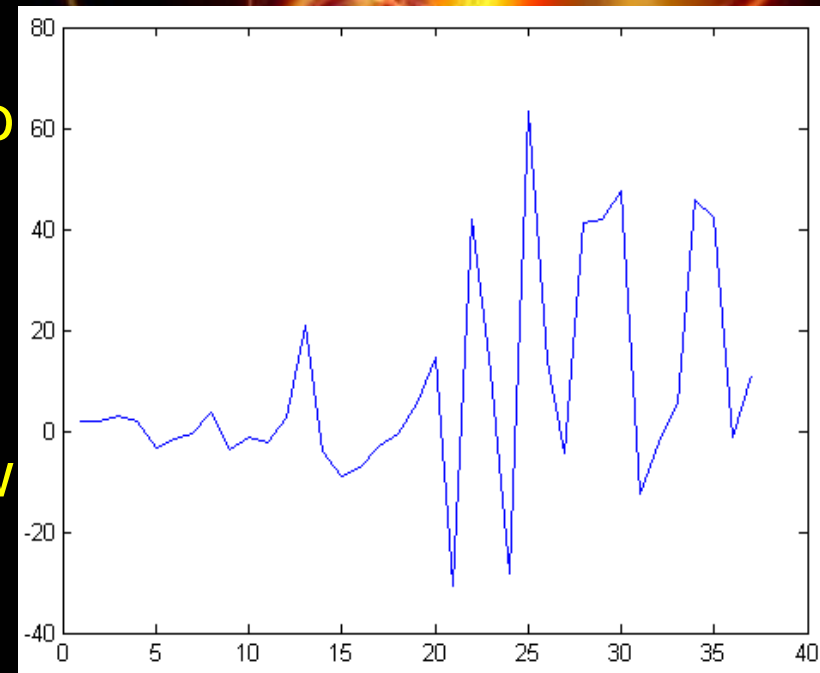
This step checks for flicker. Fire flickers; little Joey in a fire-colored shirt doesn't.



- Binary mask “fire” fed through filter bank

No fire: subsignal values very low to zero

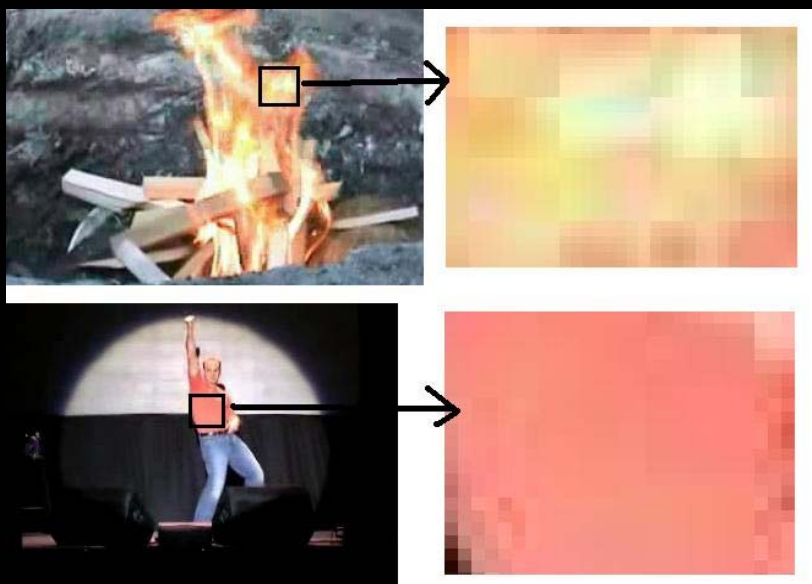
- Flame boundary: several spikes per second
- Number of midpoint (within a std. Deviation of half of the highest peak) crossings in the subband signals in a few seconds determines if it's flame or not.



Step 4: Wavelet Analysis in the Spatial Domain

In an image of fire, the variations in color will be great. In a fire-colored object, such as creepy charlie's shirt, there is not much variation. They used this formula to decide the level of variation:

$$v_4 = \frac{1}{M \times N} \sum_{k,l} |x_{lh}[k, l]|^2 + |x_{hl}[k, l]|^2 + |x_{hh}[k, l]|^2,$$



Step 5: Decide if it is a fire

A binary mask for each step is created. Each step only considers the pixels identified as potential fire by the binary mask created in the previous step.

A combined mask for all stages and frames, called the “mastermask”, is created and updated with every step.

If a pixel is not eliminated as fire by any of the steps, it is determined to be fire. If there are more than a set number of “fire” pixels in a video's mastermask, the video contains fire and an alarm is issued.



Experimental Results

<i>Sequence</i>	<i>Length</i>	<i>Frames with fire</i>	<i>Fire detected ?</i>	<i>Description</i>
Movie 1	41	0	yes	Lit fountain at night
Movie 2	37	0	no	White birds taking off
Movie 3	618	401	yes	Tan couch on fire
Movie 4	49	49	yes	People holding candles
Movie 5	48	0	no	Street intersection
Movie 6	98	98	yes	Campfire in the day
Movie 7	108	108	yes	Cardboard fire at night
Movie 8	93	93	yes	Campfire at night
Movie 9	32	0	no	American flag waving
Movie 10	33	0	no	Cars on an icy road
Movie 11	48	0	no	Swinging light bulb
Movie 12	66	66	yes	Armchair on fire
Movie 13	142	142	yes	Another armchair, fire
Movie 14	104	104	yes	3 dog houses burning

Future Work

Possible improvements for the current system include:

- ***Increasing the efficiency, real-time***
- ***Further work to eliminate current false positives***
- ***Use the final binary mask to determine location of the fire for automatic extinction***

Questions?



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