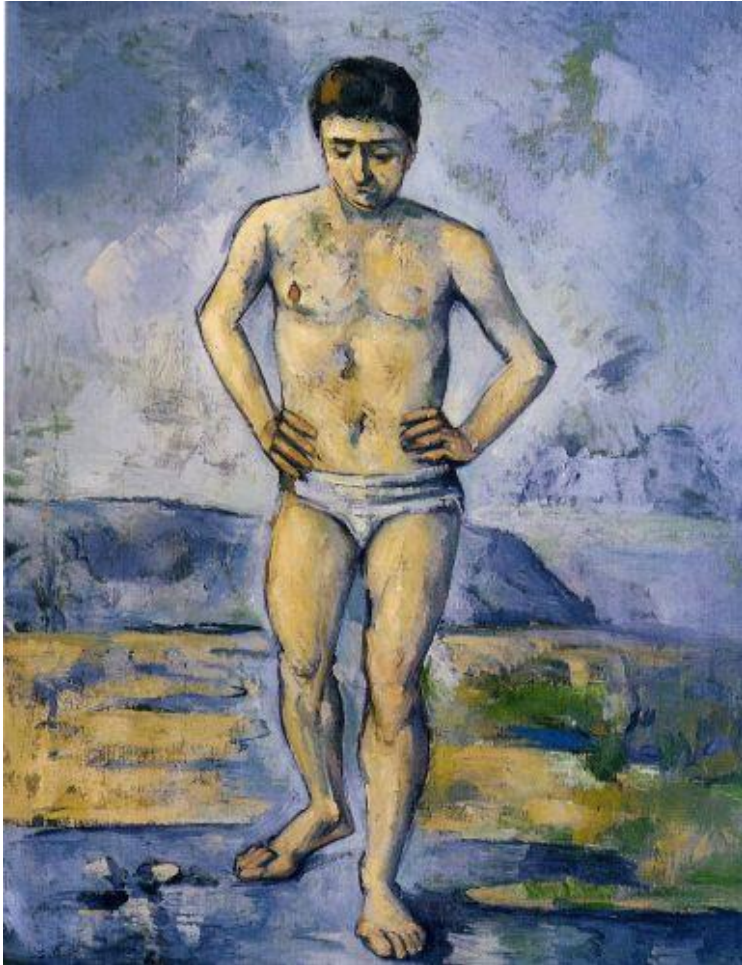


Eulerian Video Magnification



Paul Cézanne, "The Bather"

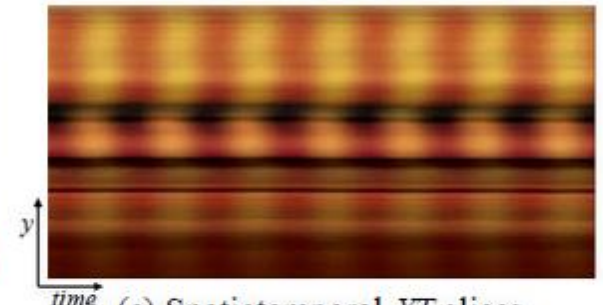
Eulerian Video Magnification for Revealing Subtle Changes in the World

Hao-Yu Wu¹[Michael Rubinstein¹](#)[Eugene Shih²](#)[John Guttag¹](#)[Frédéric Durand¹](#)[William T. Freeman¹](#)¹[MIT CSAIL](#)²[Quanta Research Cambridge, Inc.](#)

(a) Input



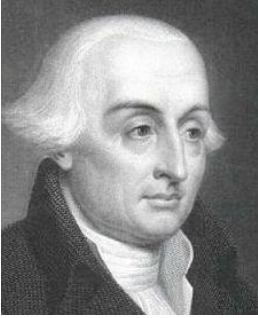
(b) Magnified



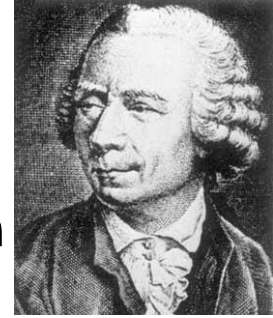
(c) Spatiotemporal YT slices

An example of using our Eulerian Video Magnification framework for visualizing the human pulse. (a) Four frames from the original video sequence. (b) The same four frames with the subject's pulse signal amplified. (c) A vertical scan line from the input (top) and output (bottom) videos plotted over time shows how our method amplifies the periodic color variation. In the input sequence the signal is imperceptible, but in the magnified sequence the variation is clear.

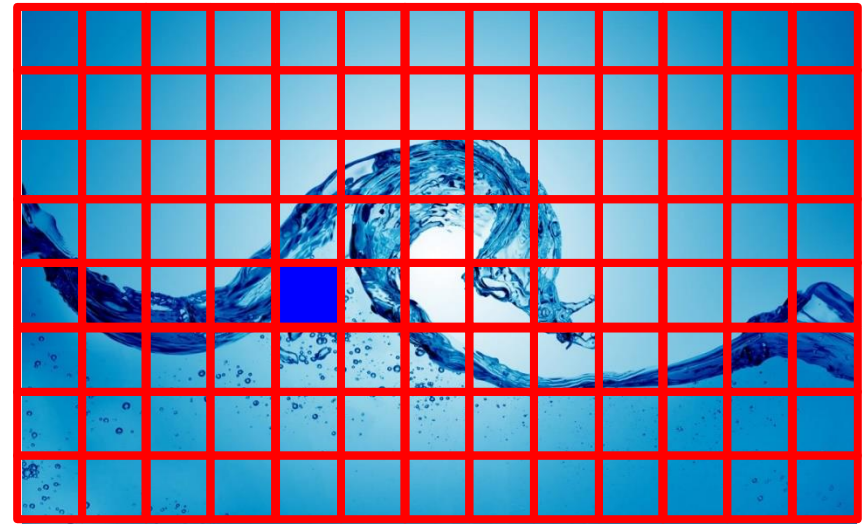
Aside: Lagrangian and Eulerian Perspectives in Fluid Dynamics



Lagrangian

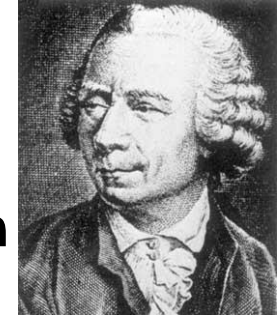


Eulerian

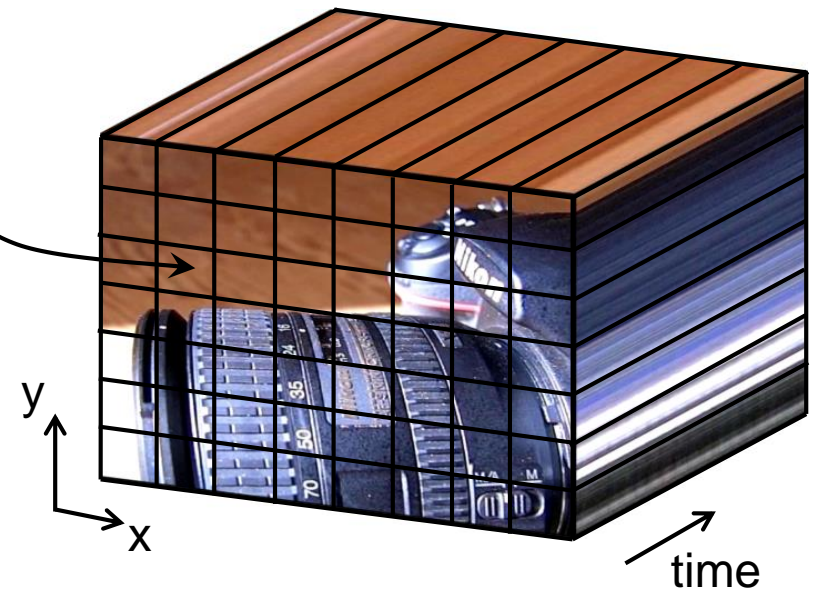
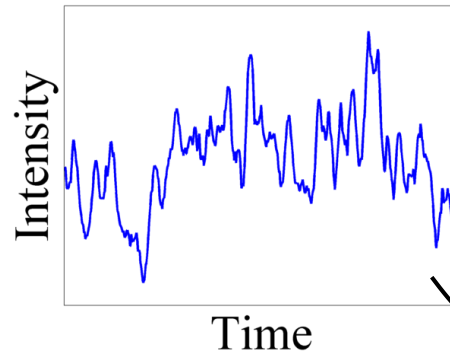


Eulerian Perspective: Videos

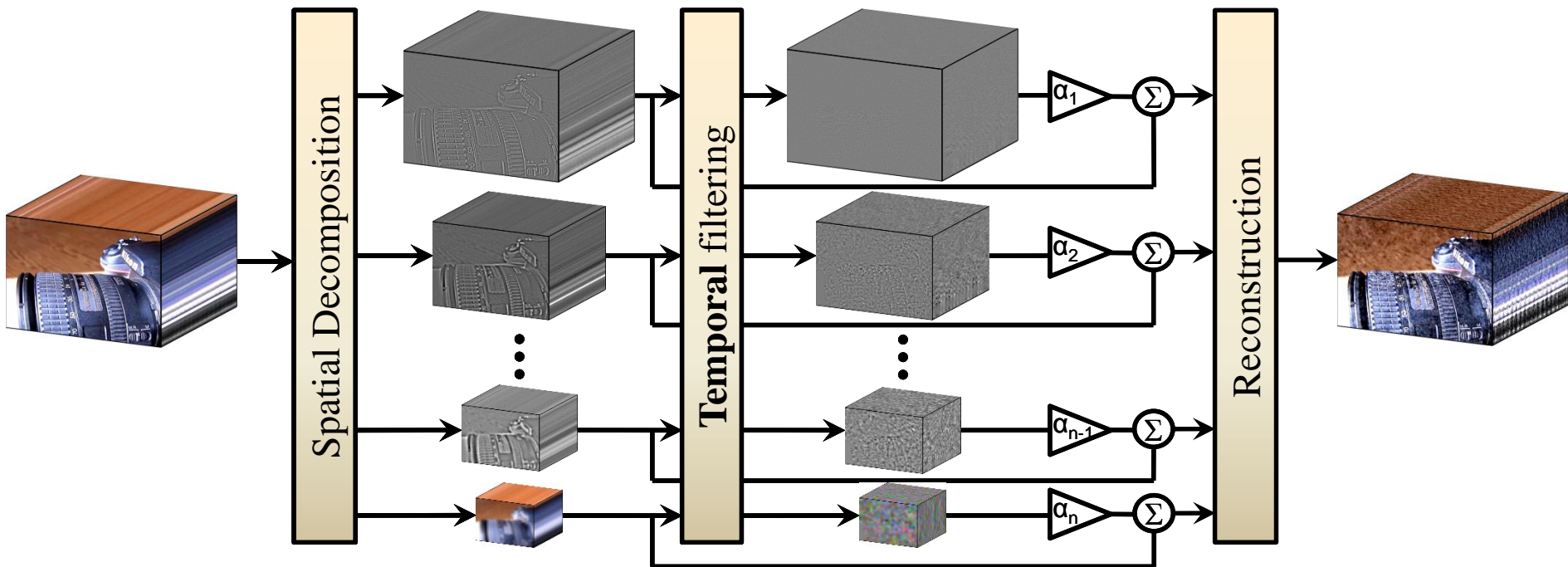
- Each pixel is processed independently
- Treat each pixel as a time series and apply signal processing to it



Eulerian



Method Overview



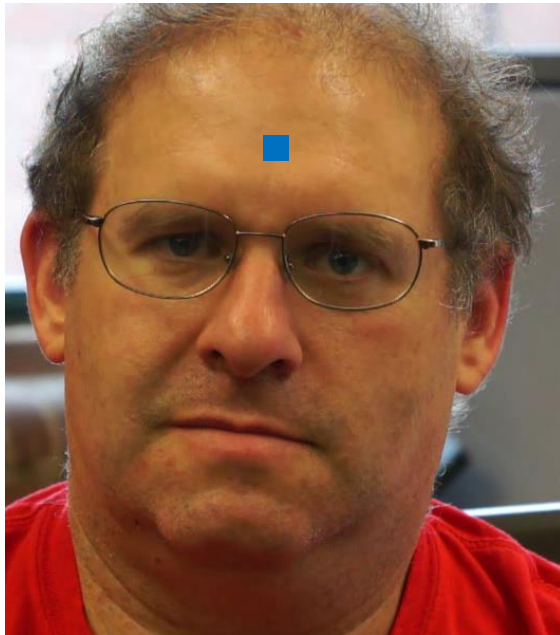
Laplacian
Pyramid

Bandpass filter
intensity at each
pixel over time

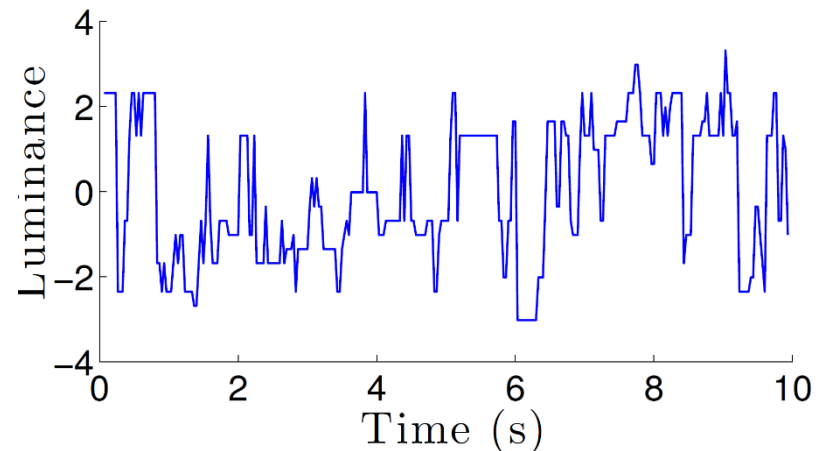
Amplify
bandpassed
signal and add
back to original

Subtle Color Variations

- The face gets slightly redder when blood flows
- Unfortunately usually below the per pixel noise level



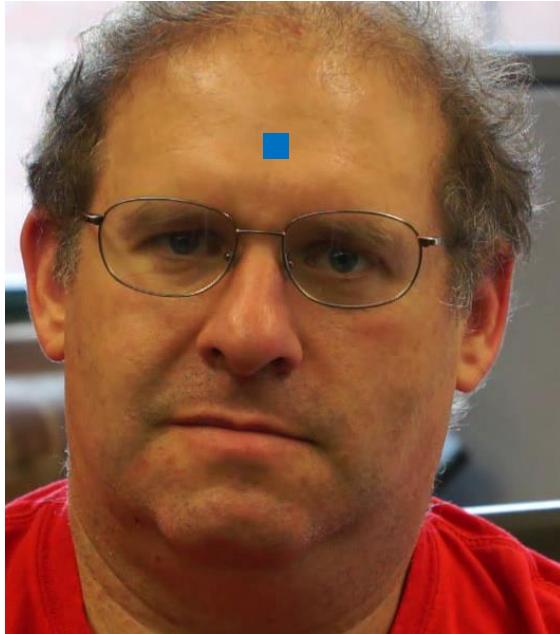
Input frame



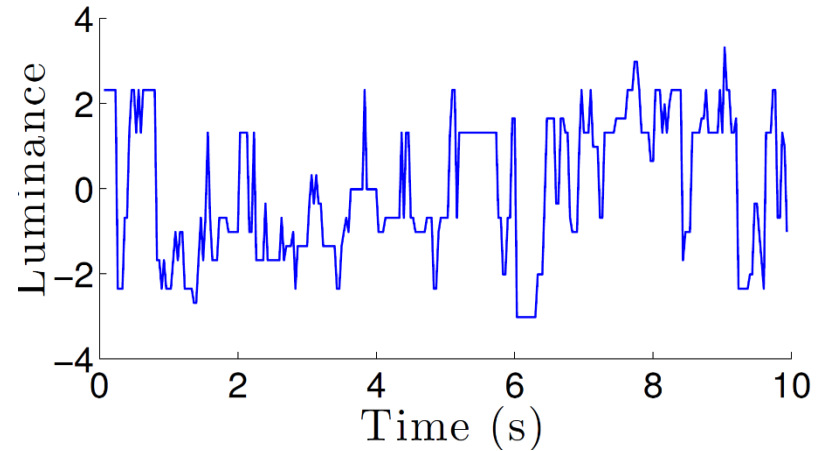
Luminance trace (zero mean)

Subtle Color Variations

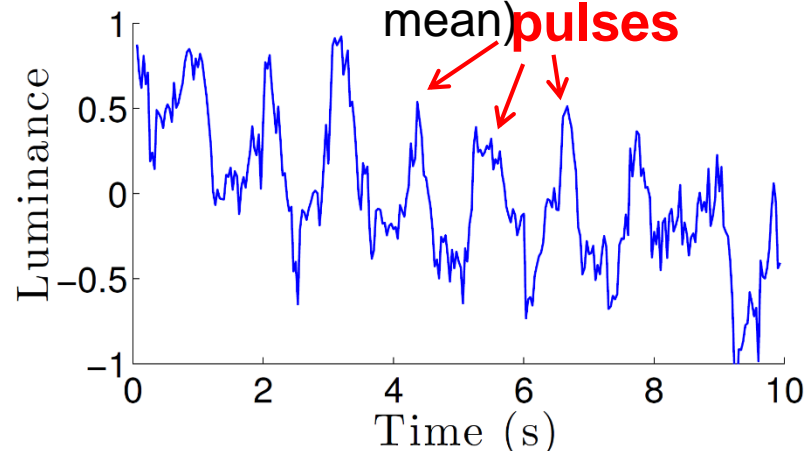
1. Average spatially to overcome sensor and quantization noise



Input frame



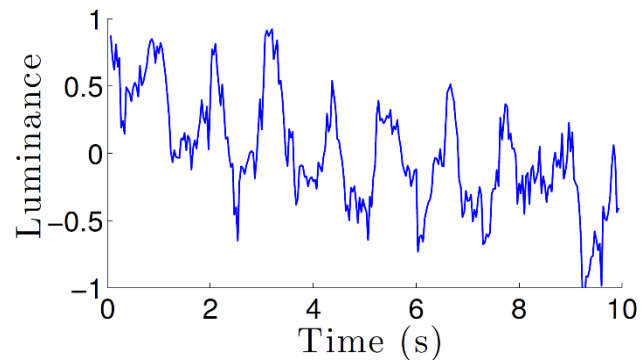
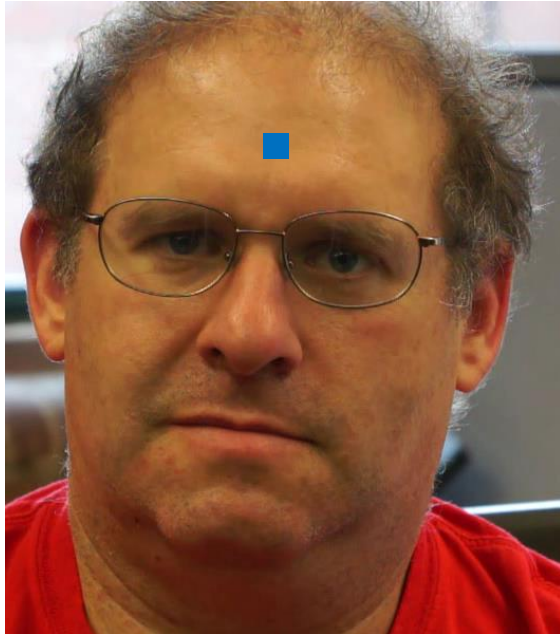
Luminance trace (zero mean)



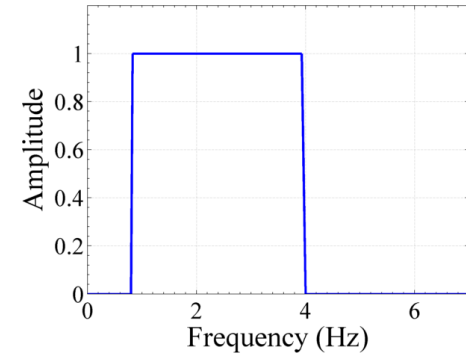
Spatially averaged luminance trace

Amplifying Subtle Color Variations

2. Filter temporally to extract the signal of interest

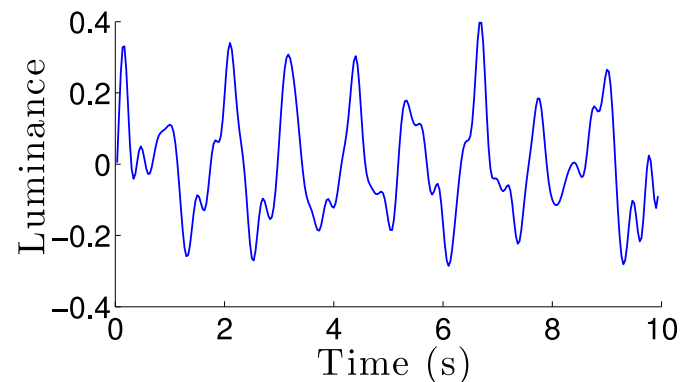


Spatially averaged luminance trace



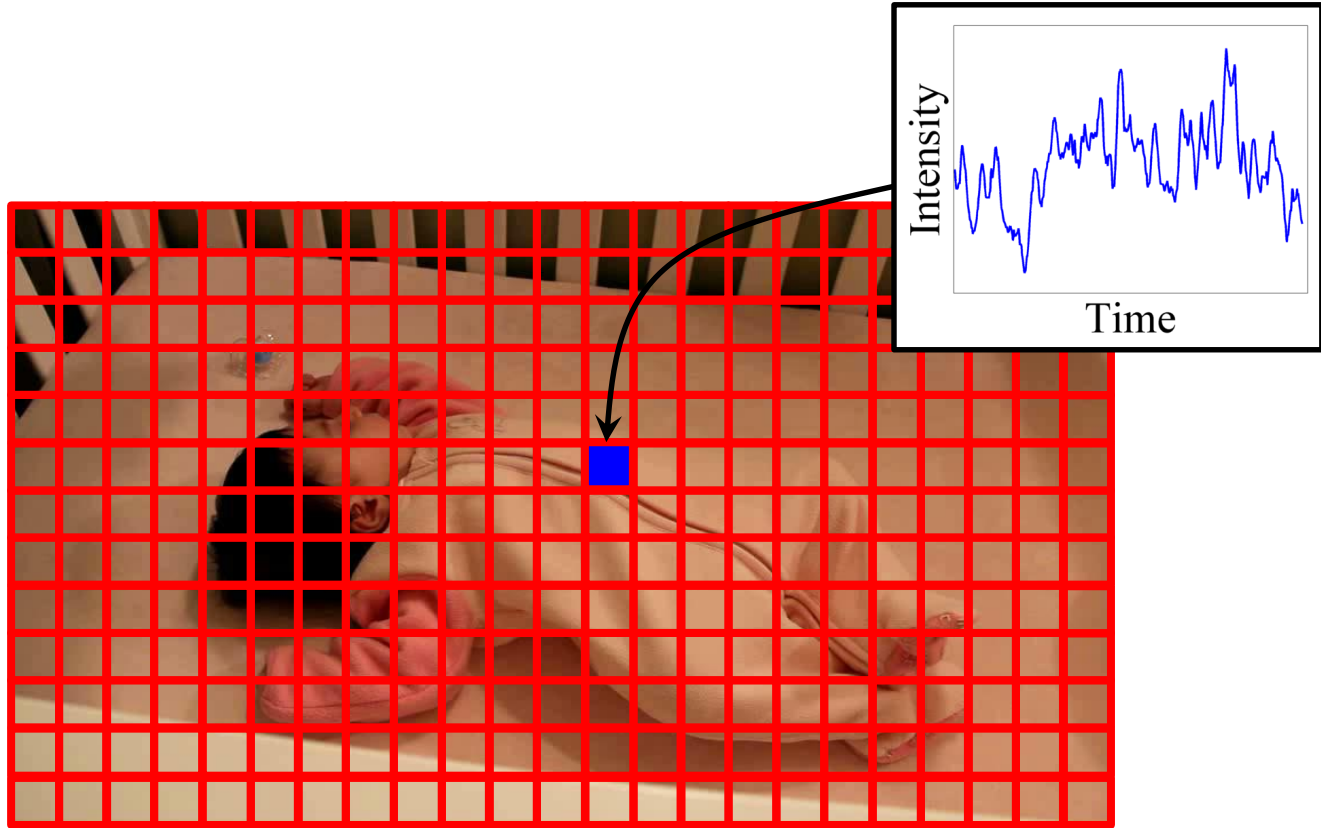
Temporal filter

=



Temporally bandpassed trace

Why It Amplifies Motion



Relating Temporal and Spatial Changes

