Adaptive Monte Carlo Retinex Method for Illumination and Reflectance Separation and Color Image Enhancement

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Motivation

Photo correction

Biometrics

Surveillance

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Retinex Theory

Image
(I)

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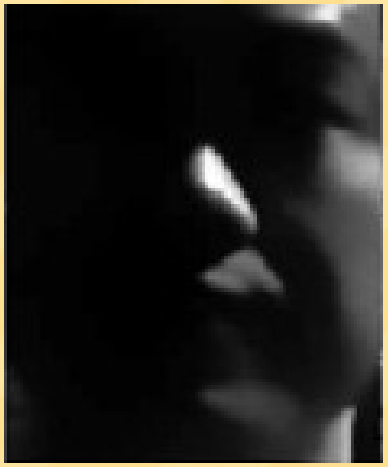
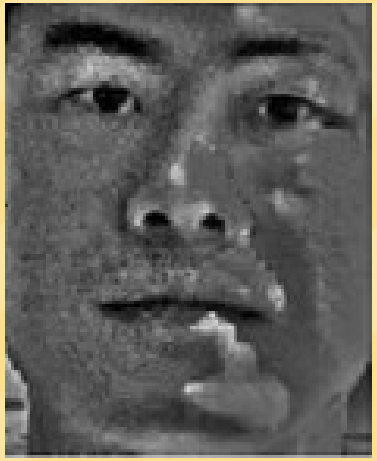


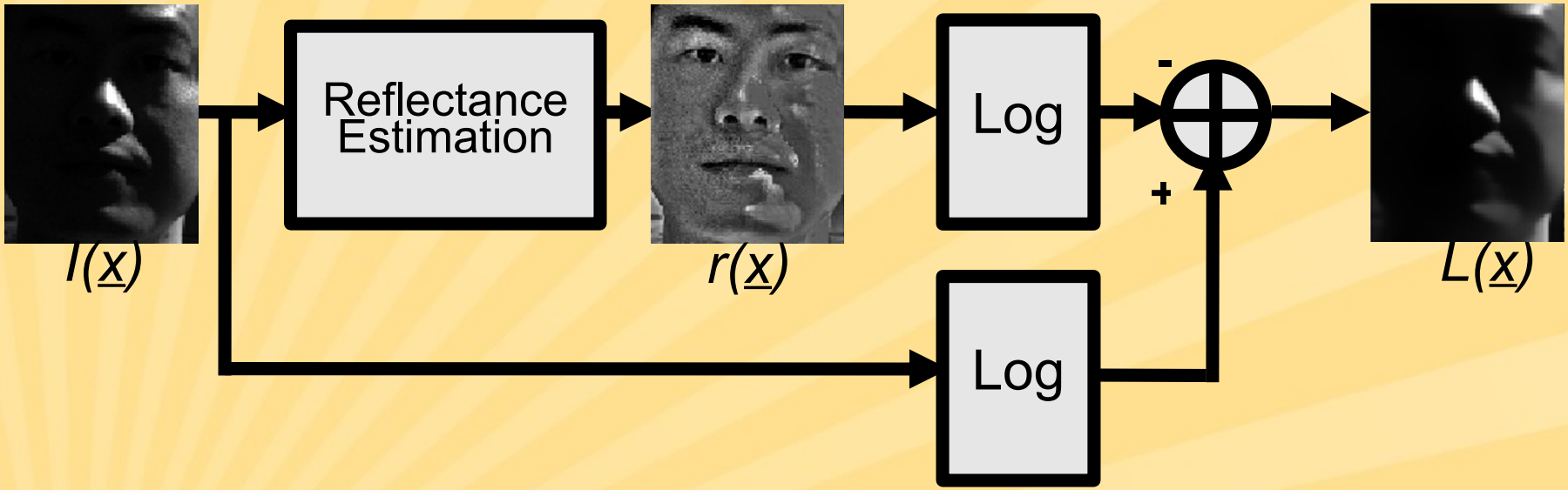
Illumination
(L)

X

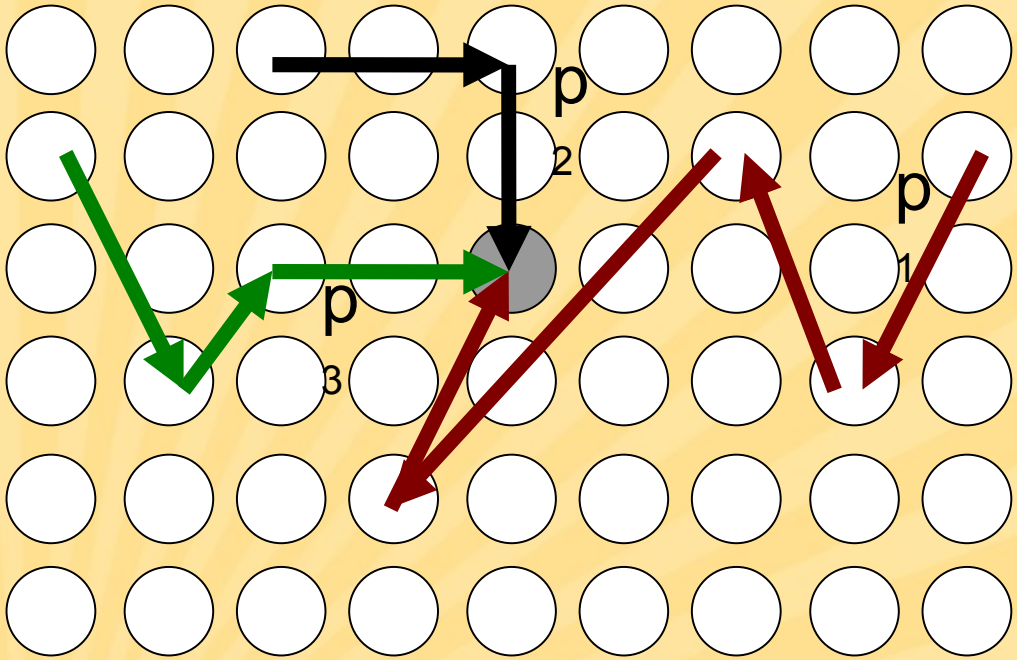


Reflectance
(R)

Global Retinex approach



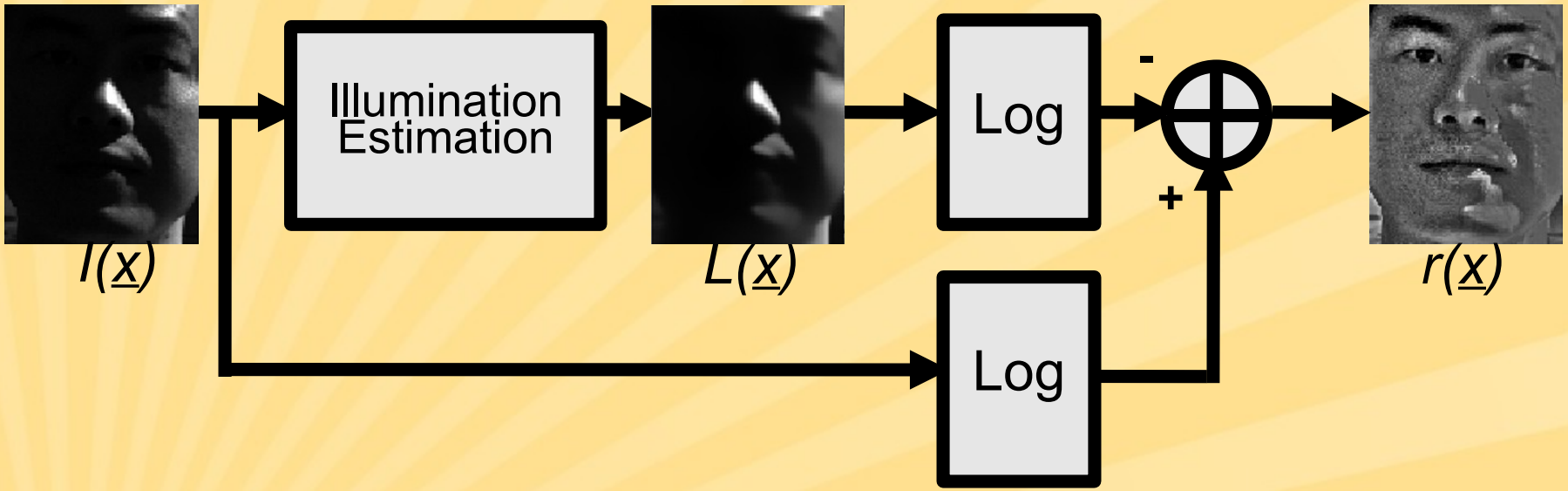
Global Retinex approach



$$\hat{R}(\underline{x}) = \frac{1}{M} \sum_{i=1}^{M} \frac{I(\underline{x})}{I(\underline{h}_i)}$$

Advantage: Good tone preservation

Local Retinex approach



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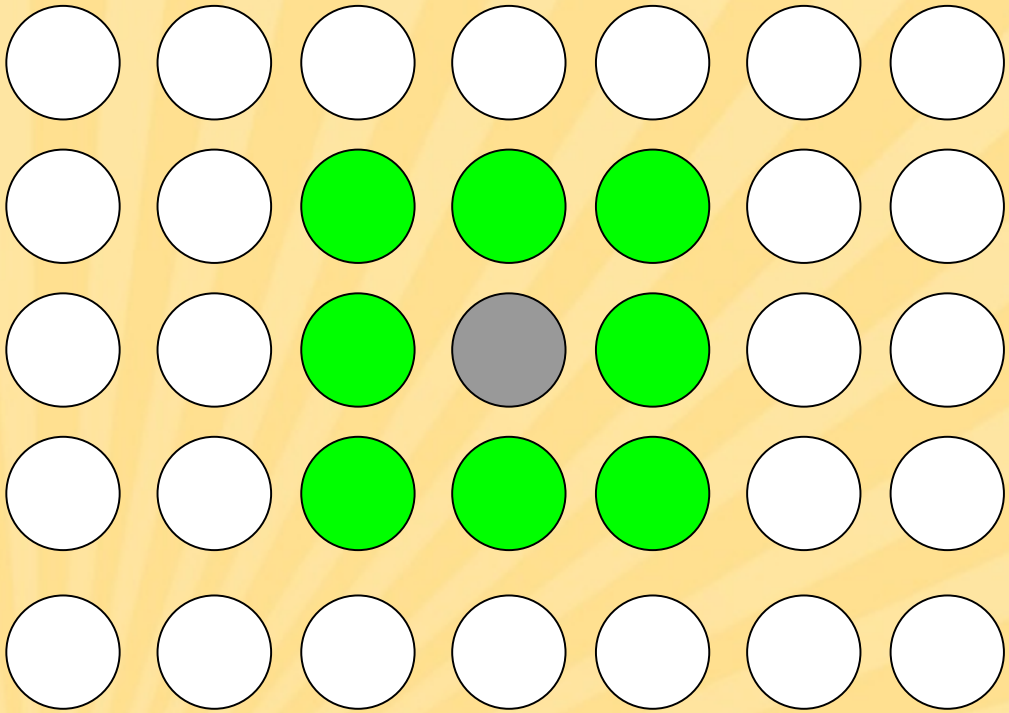
Local Retinex approach

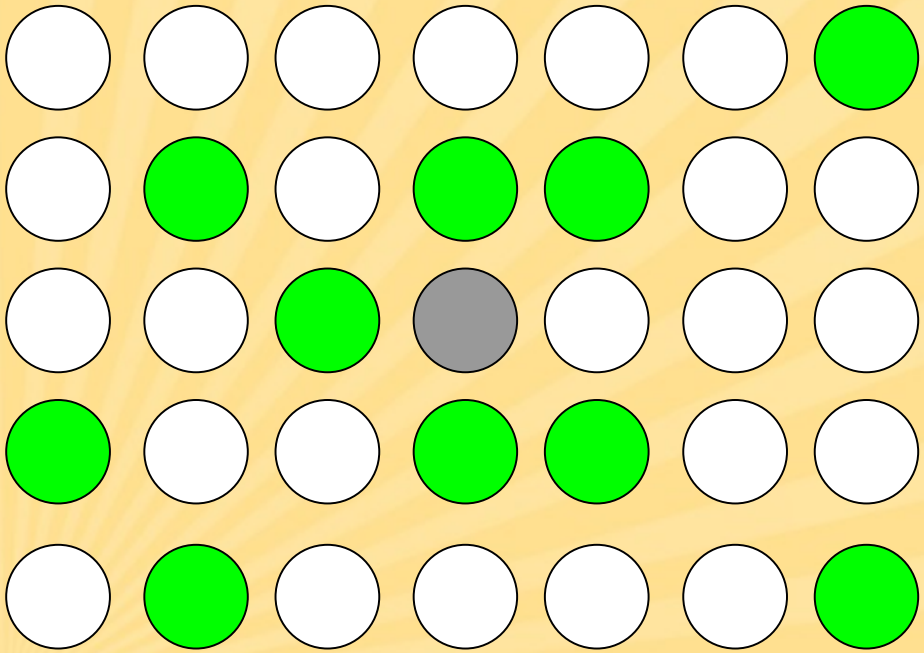


$$\hat{L}(\underline{x}) = \sum_{q \in \aleph} w(\underline{q}, \underline{x}) I(\underline{q})$$

Advantage: Good detail recovery, particularly in dark regions

Local + Global = Hybrid?

- A hybrid method with the advantages of both approaches is desired
- One possible solution: Integrate random sampling aspect of global approach into local approach



$$\hat{L}(\underline{x}) = \sum_{i=1}^{N} w(\underline{q}_i, \underline{x}) I(\underline{q}_i)$$

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Problems with Hybrid Solution 1

- If we use existing local Retinex convention, spatial locality is enforced on a pixel basis
- This is based on assumption that illumination varies slowly
- However, this assumption can be violated in situations where there is sharp illumination (e.g., strong shadows)
- Results in false discontinuities in estimated reflectance

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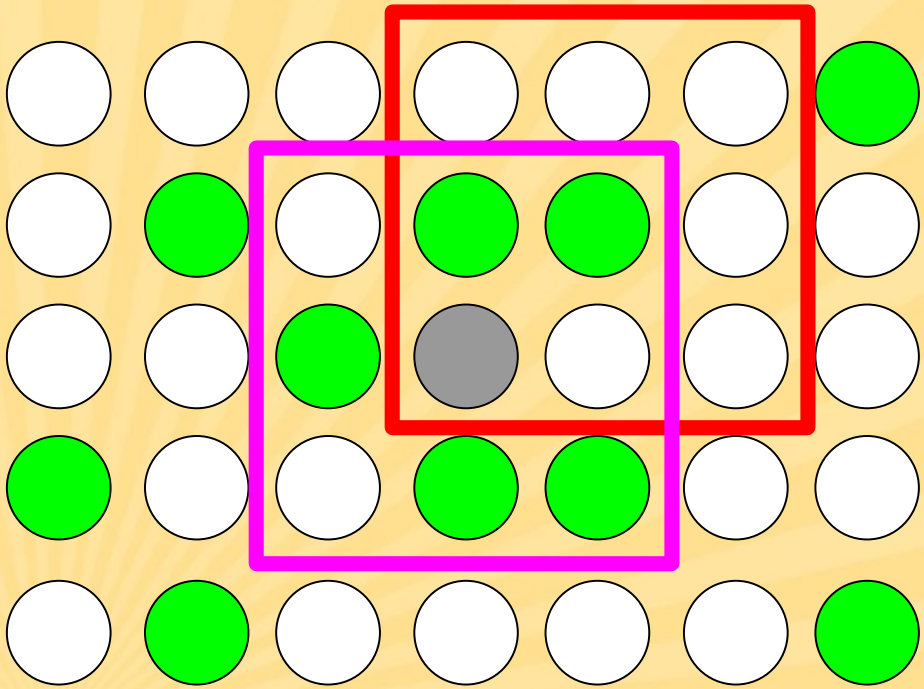
Hybrid Solution 2

- Instead of determining the weight solely on spatial distance between the sample and the pixel being estimated, we base it on the accumulated error between their local neighborhoods



$$w(\aleph_{\underline{q}_i}, \aleph_{\underline{x}_c}) = \exp\left[\frac{-\Phi(\aleph_{\underline{q}_i}, \aleph_{\underline{x}_c})}{d}\right]$$

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Advantages of Hybrid Solution 2

- By removing the spatial locality constraint between the samples and the pixel being estimated, the assumption of slow illumination variation is no longer made
  - discontinuities due to sharp illumination changes is well preserved in the estimated illumination of the image.
- By determining the weight on local neighbors instead of individual points, the detail recovery performance of the local Retinex approach is retained.

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Experiments

- Experiment 1:
  - Illumination and reflectance separation on monochromatic face image test sets from Yale Face Database B
- Experiment 2:
  - Color image enhancement using two low-contrast chromatic images
- Tested against:
    - Single scale Retinex (SSR) [Jobson et al., 1997]
    - Multi scale Retinex (MSR) [Jobson et al., 1997b]
    - Bilateral filter Retinex (BSR) [Elad, 2005]

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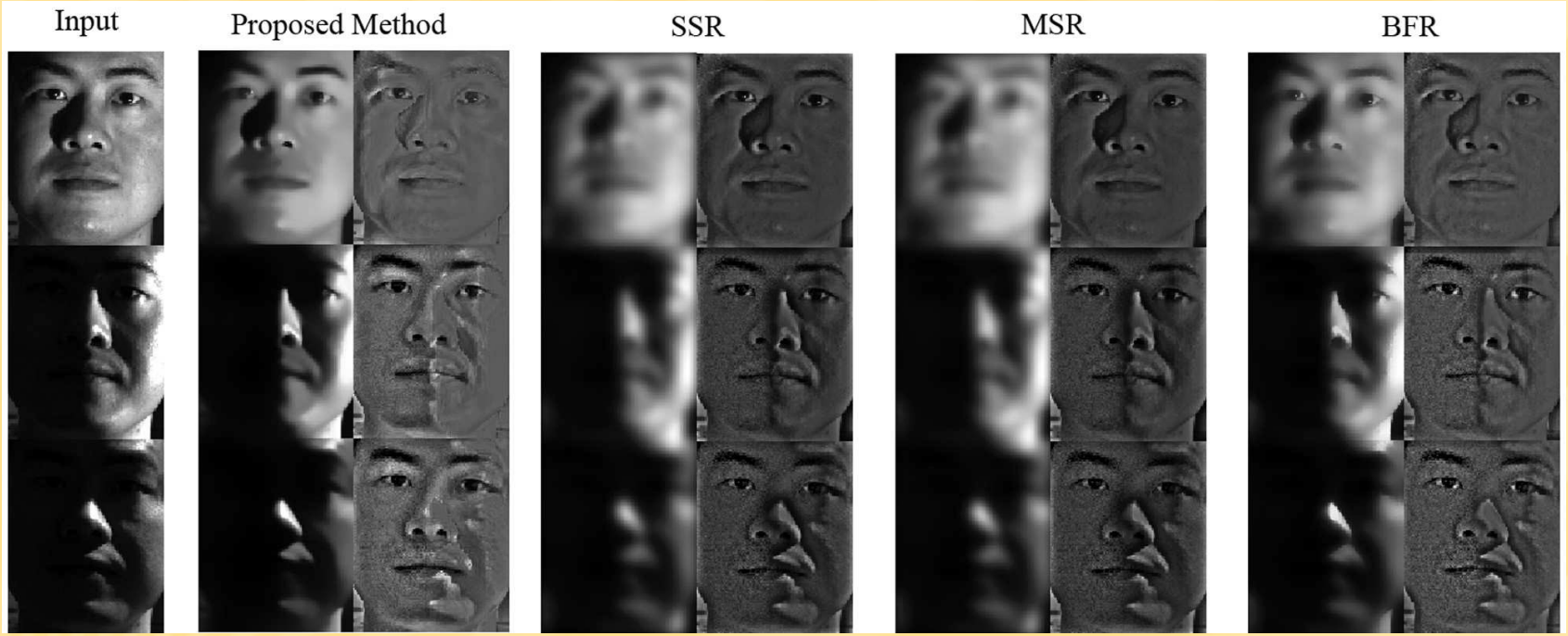
Experimental Results (Experiment 1)



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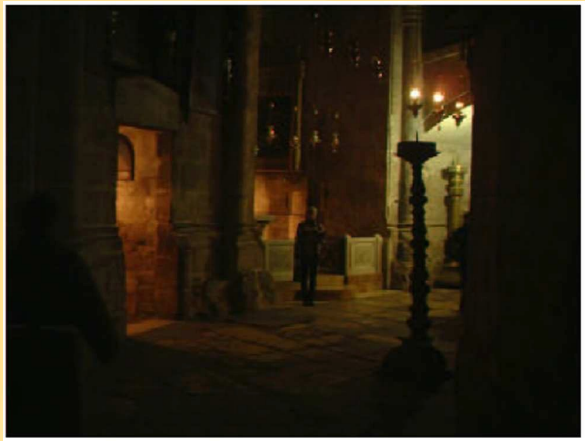
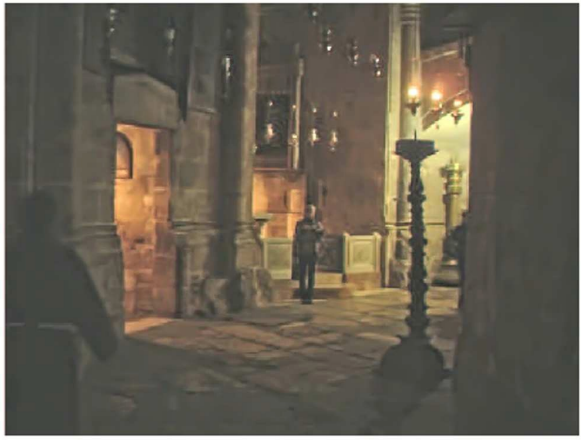
Experimental Results (Experiment 2)



Input

Histogram Equalization



Proposed Method

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Future Work

- Investigate alternative sampling and weighing schemes
- Applying proposed approach to illumination-invariant tracking

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Thank you!

- Any questions?