Coded Computational Imaging

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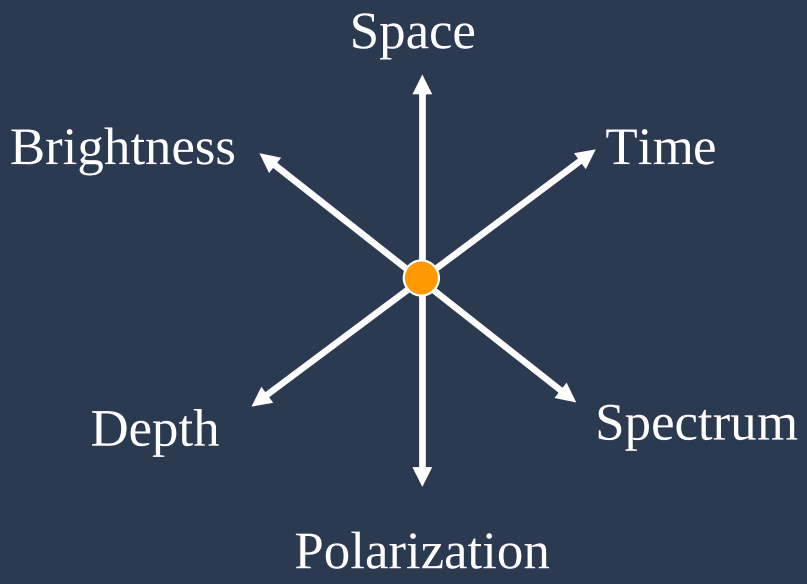
Course WebPage :
http://www.umiacs.umd.edu/~aagrawal/CVPR10Tutorial/index.html

Schedule

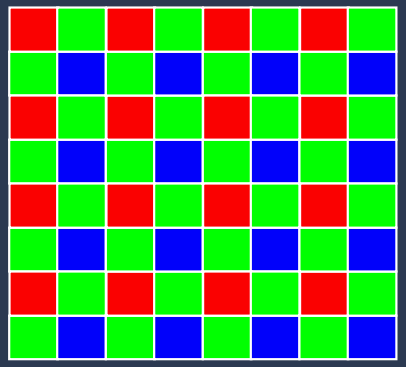
Introduction	Narasimhan, 10 mins
Assorted Pixels	Narasimhan, 20 mins
Coding and Modulation in Cameras	Agrawal, 45 mins
Break	10 min
Light Fields and Applications	Mohan, 60 mins
Break	10 min
Computational Illumination	Narasimhan, 45 mins
Future Trends	Agrawal, 15 mins
Discussion	

Dimensions of Imaging



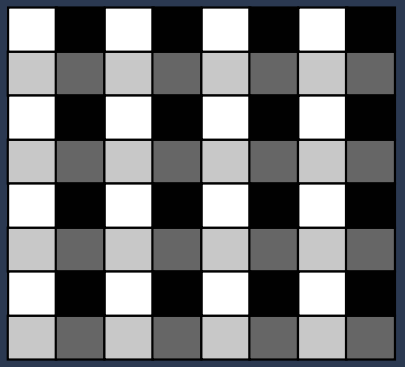
How can we capture information in multiple dimensions using only a two-dimensional array of pixels ?

Assorted Pixels: Multi-Sampled Images



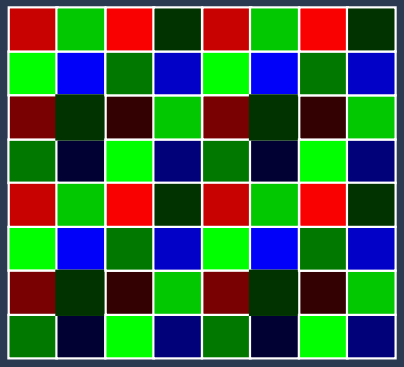
Base Pattern

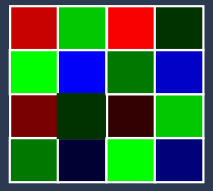
SVC : Spatially Varying Color
(Bayer Pattern)



Base Pattern

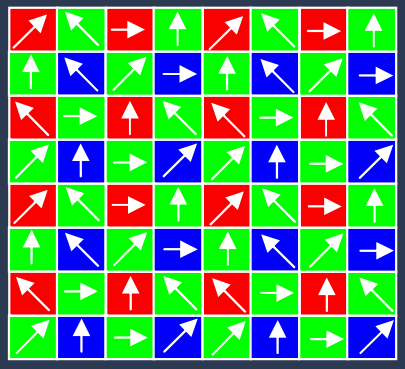
SVE : Spatially Varying Exposure
(Nayar et. al., 00)

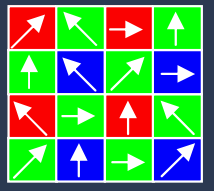




Base Pattern

SVEC : Spatially Varying Color
& Exposure (Narasimhan et al 02)



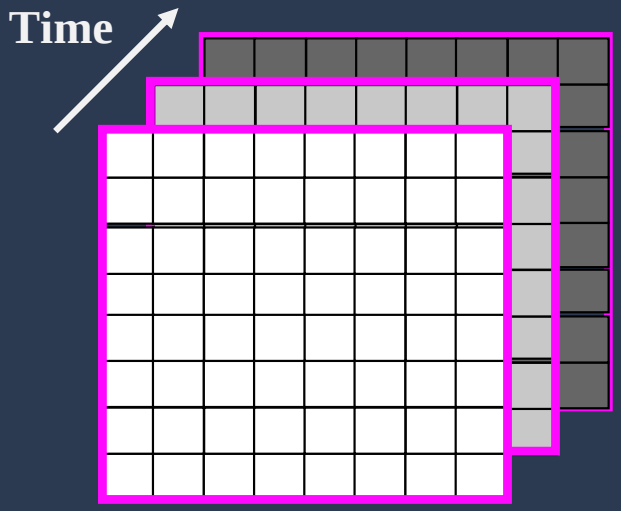


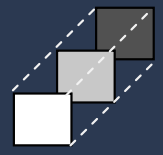
Base Pattern

SVCP : Spatially Varying Color
and Polarization (Ben Ezra et al)

Simultaneous Sampling along Multiple Dimensions

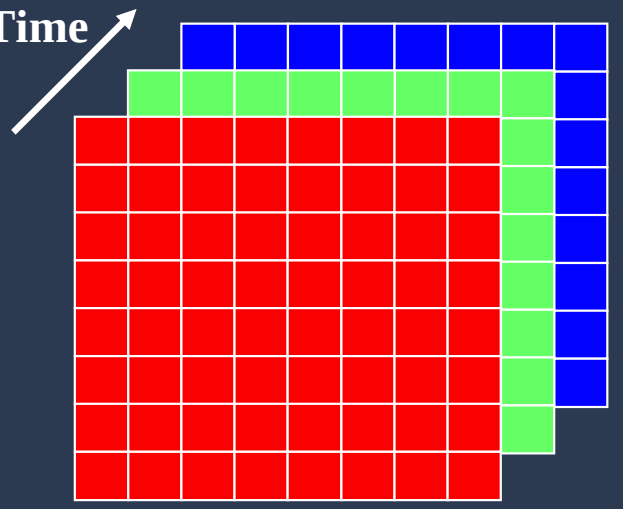
Assorted Voxels: Multi-Sampled Video





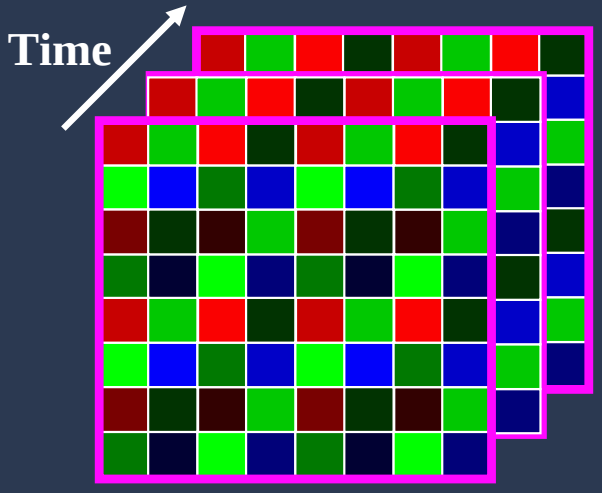
Base Pattern

Sequential Exposure Changes

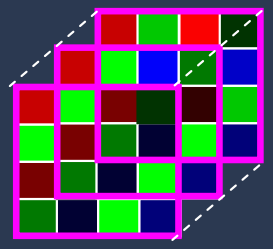


Base Pattern

Sequential Color Changes



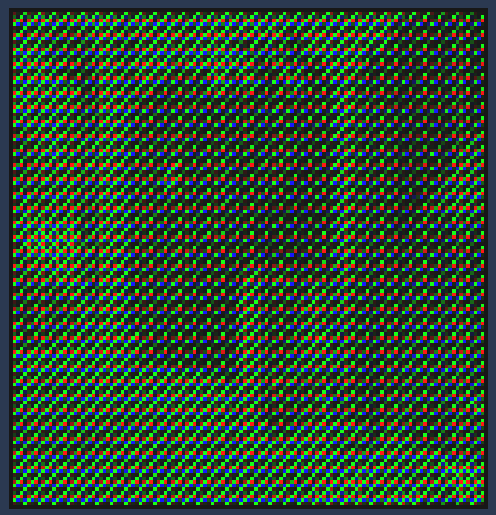
SVEC Video



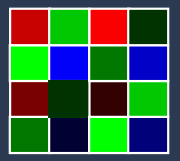
Base Pattern

[Narasimhan and Nayar, 2005]

Multi-Sampled Image Reconstruction



Multi-Sampled SVEC Image



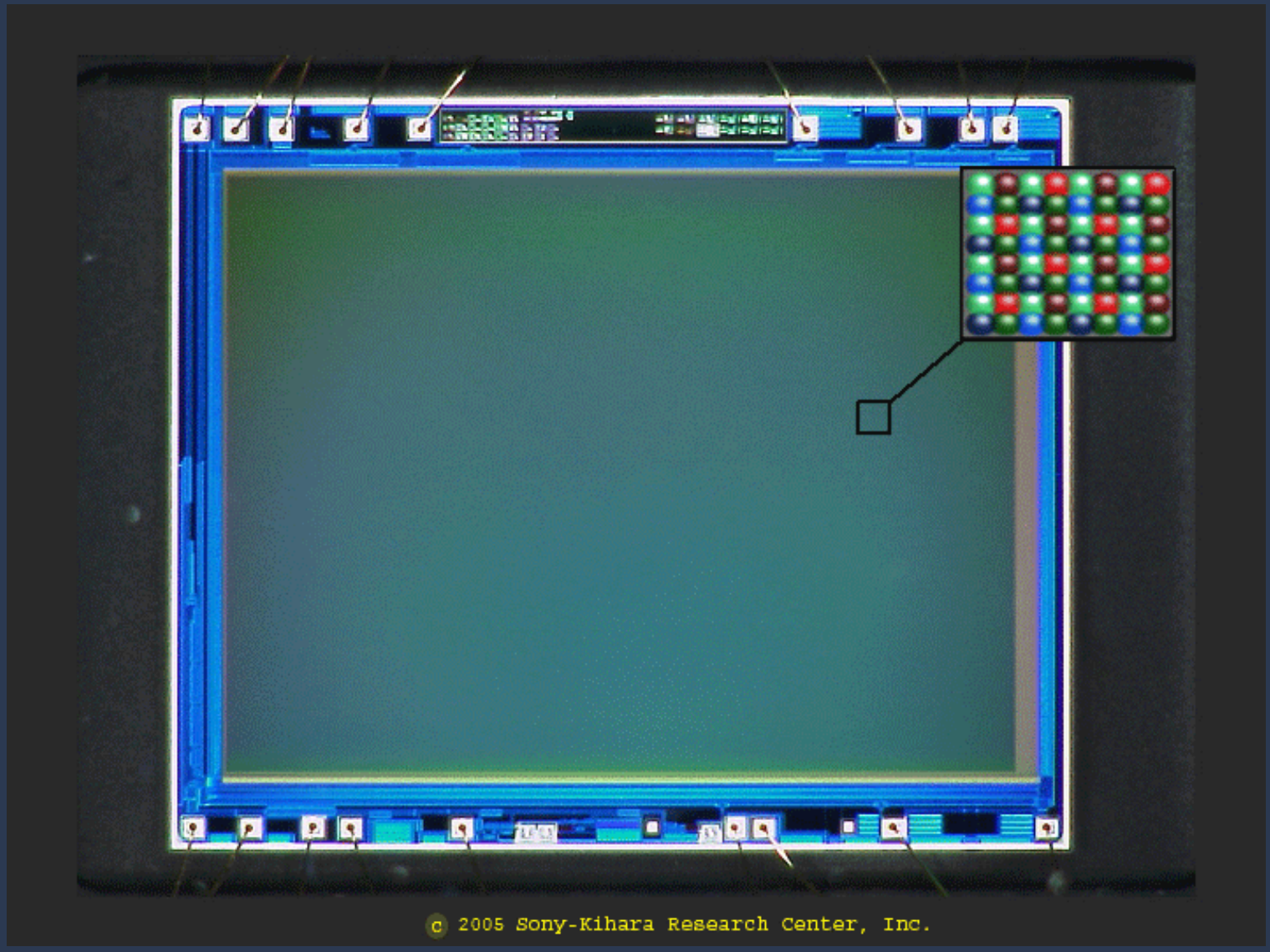
SVEC Pattern

Original Scene

- Can we do better than interpolating separately along different imaging dimensions?
- Can we beat a reconstruction method that is limited by Nyquist's sampling rate?

Assorted-Pixel Camera Prototype

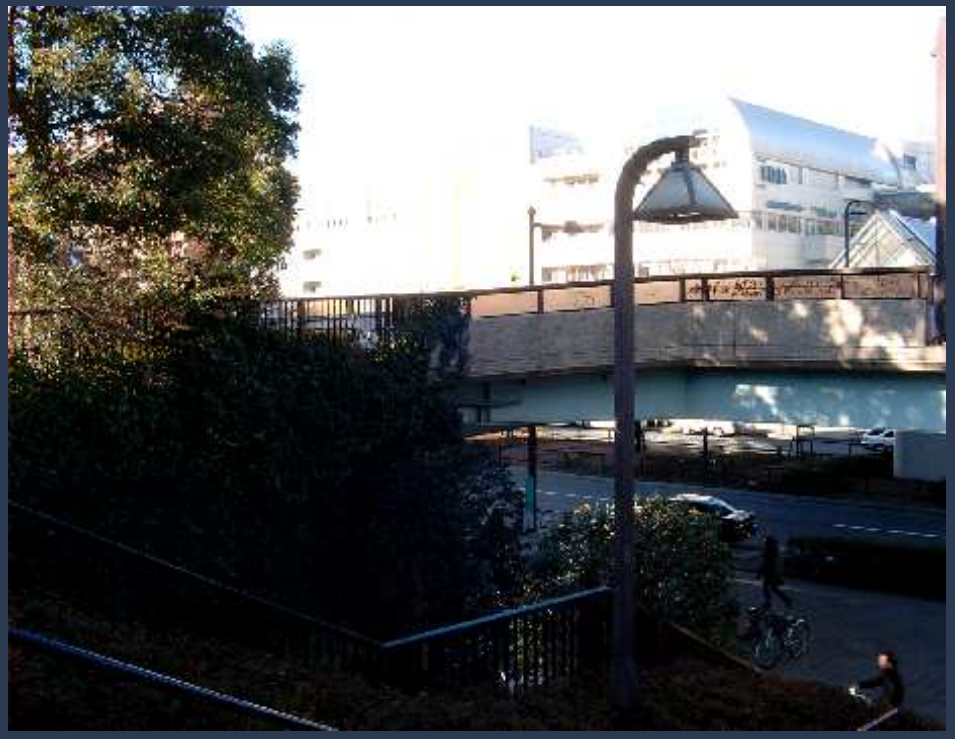
(Courtesy : Sony Kihara Research Lab)



Assorted-Pixel Camera Prototype

(Courtesy : Sony Kihara Research Lab)

Digital Still Camera

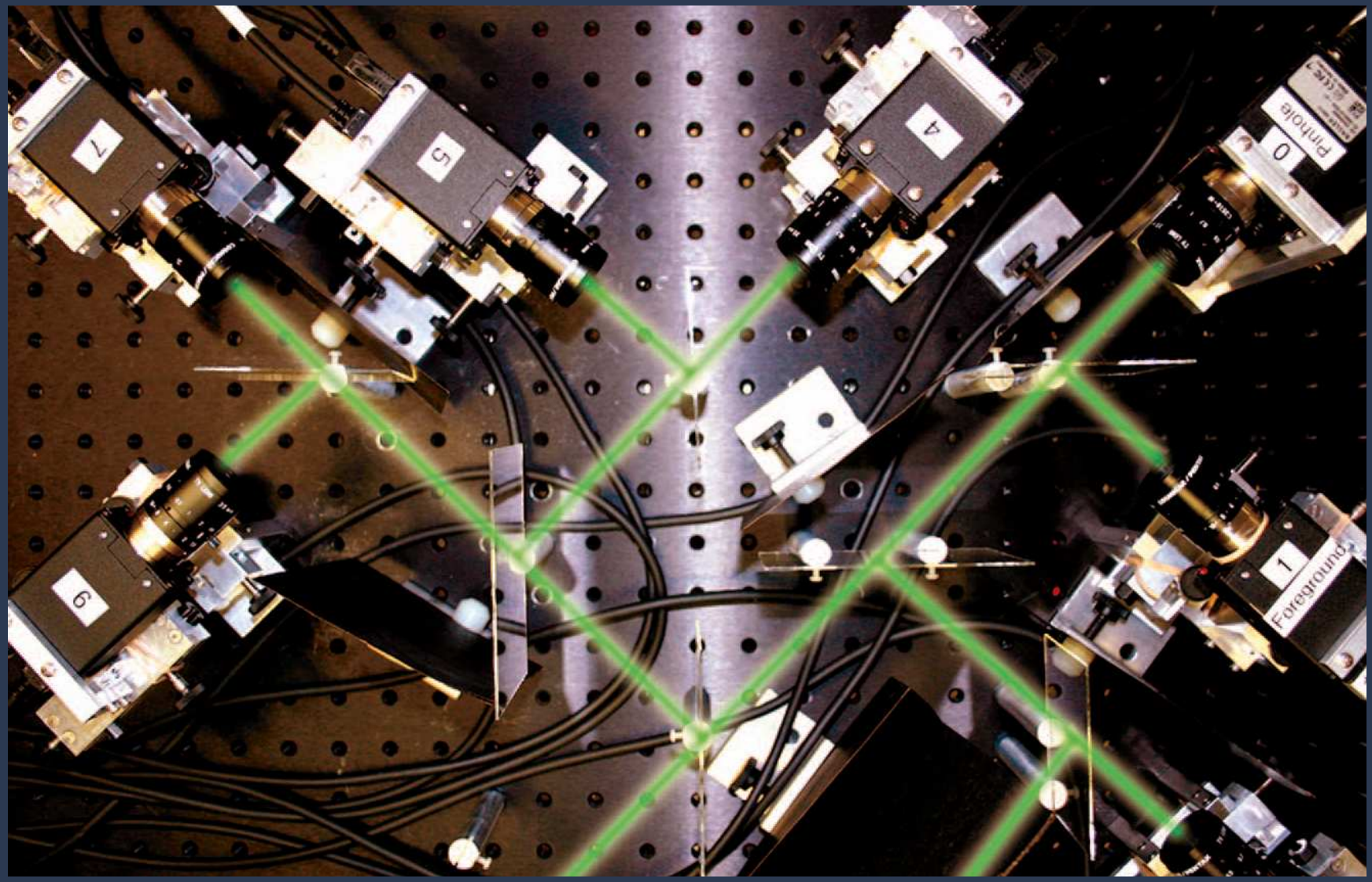


Camera with Assorted Pixels

Normal Camera

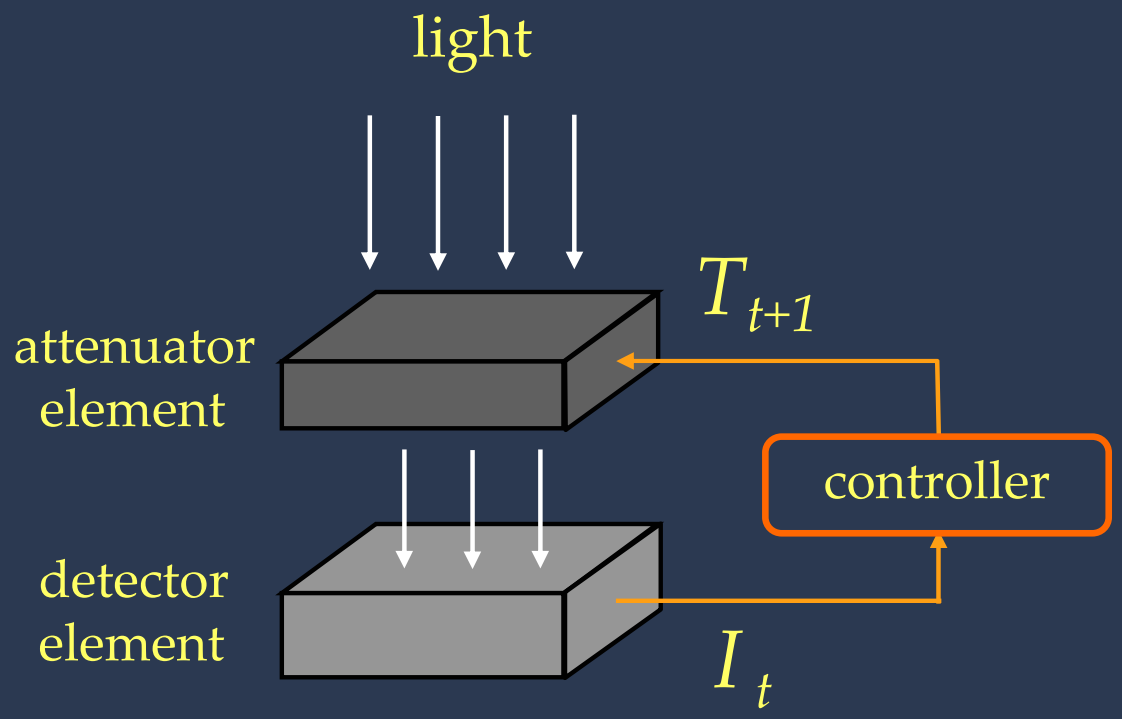
Assorted Pixel Camera

Optical Beam Splitting with Multiple Sensors



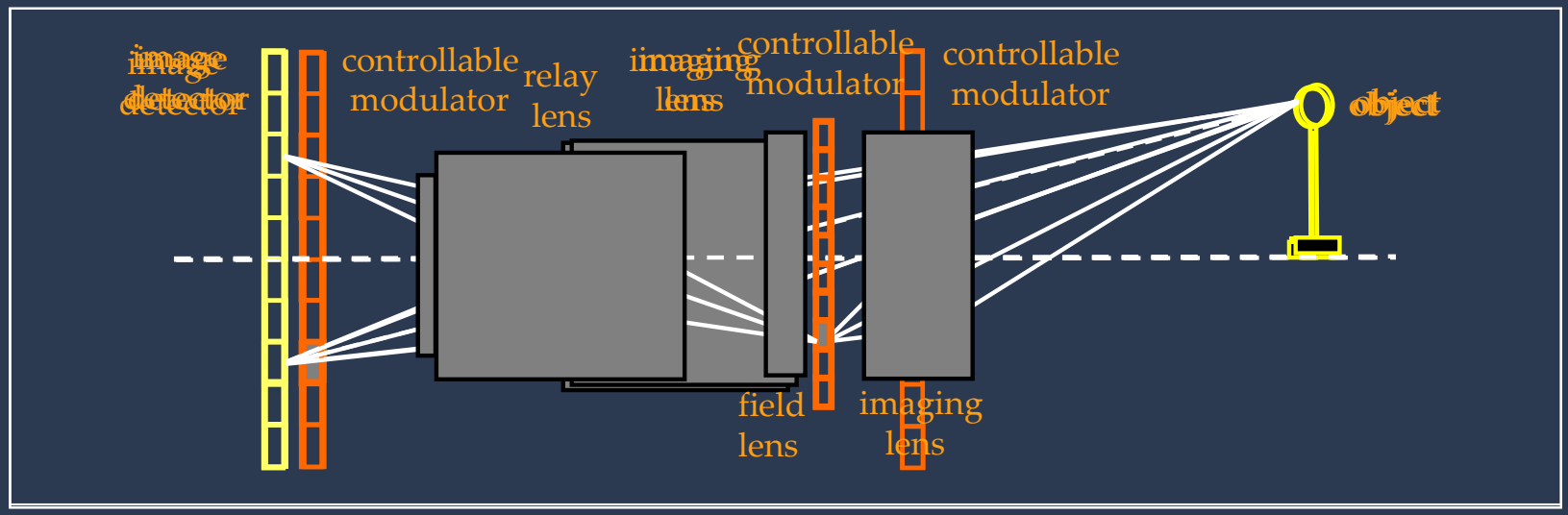
McGuire et al 07

Pixel with Adaptive Exposure Control



[Nayar et al, 03, 04]

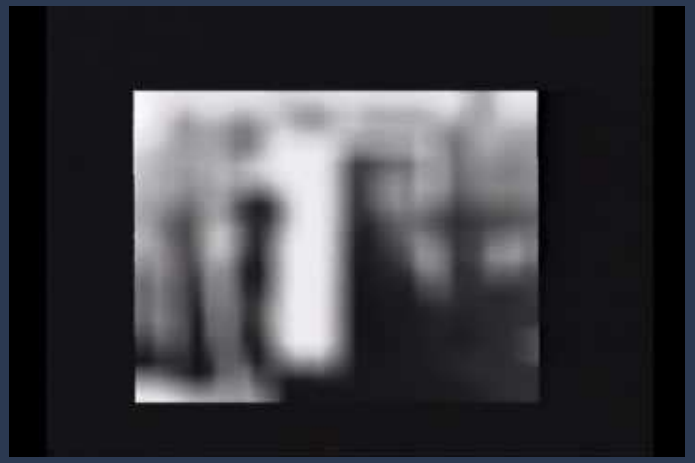
Spatial Light Modulation (SLM)



Adaptive Dynamic Range Camera (ADR)

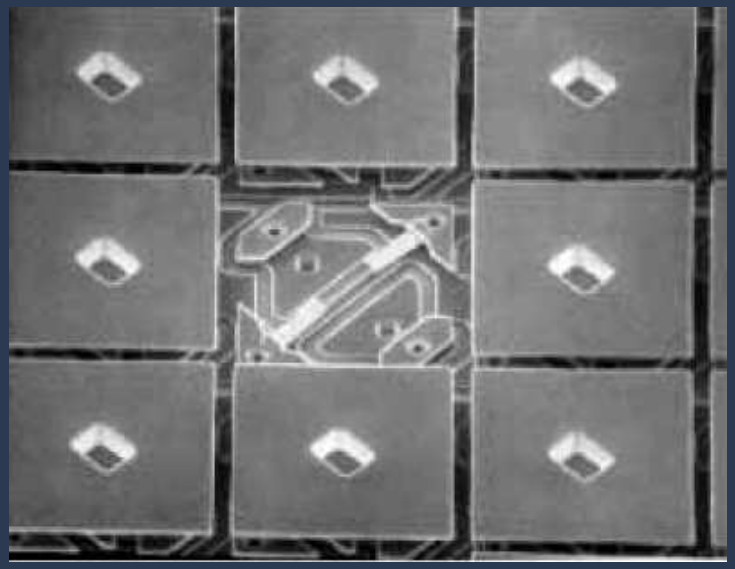
Adaptive Dynamic Range Camera (ADR)

LCD Attenuation



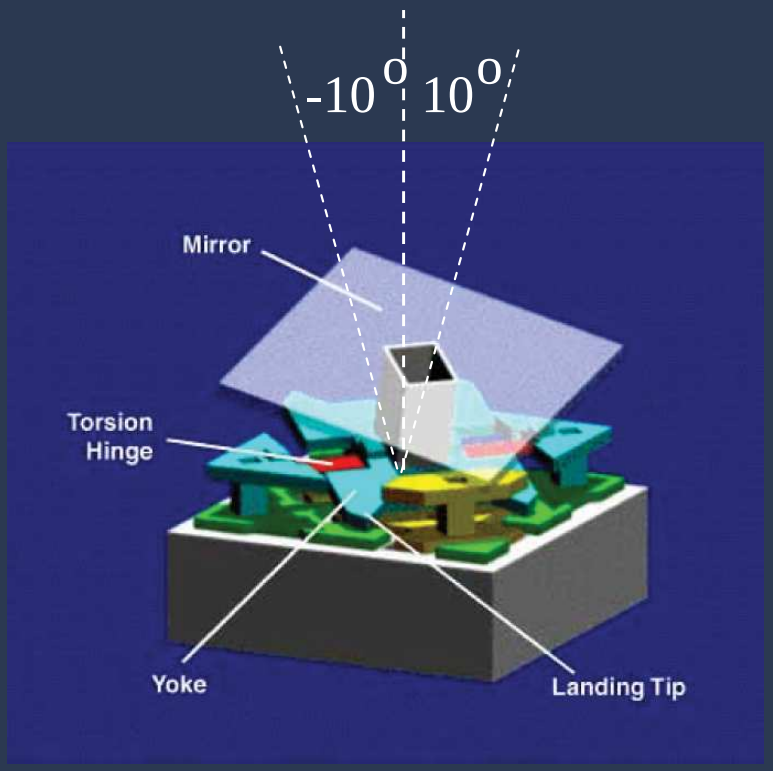
SLM using Digital Micro-mirror Arrays

DMD Array:



14 um

Micromirror Architecture:

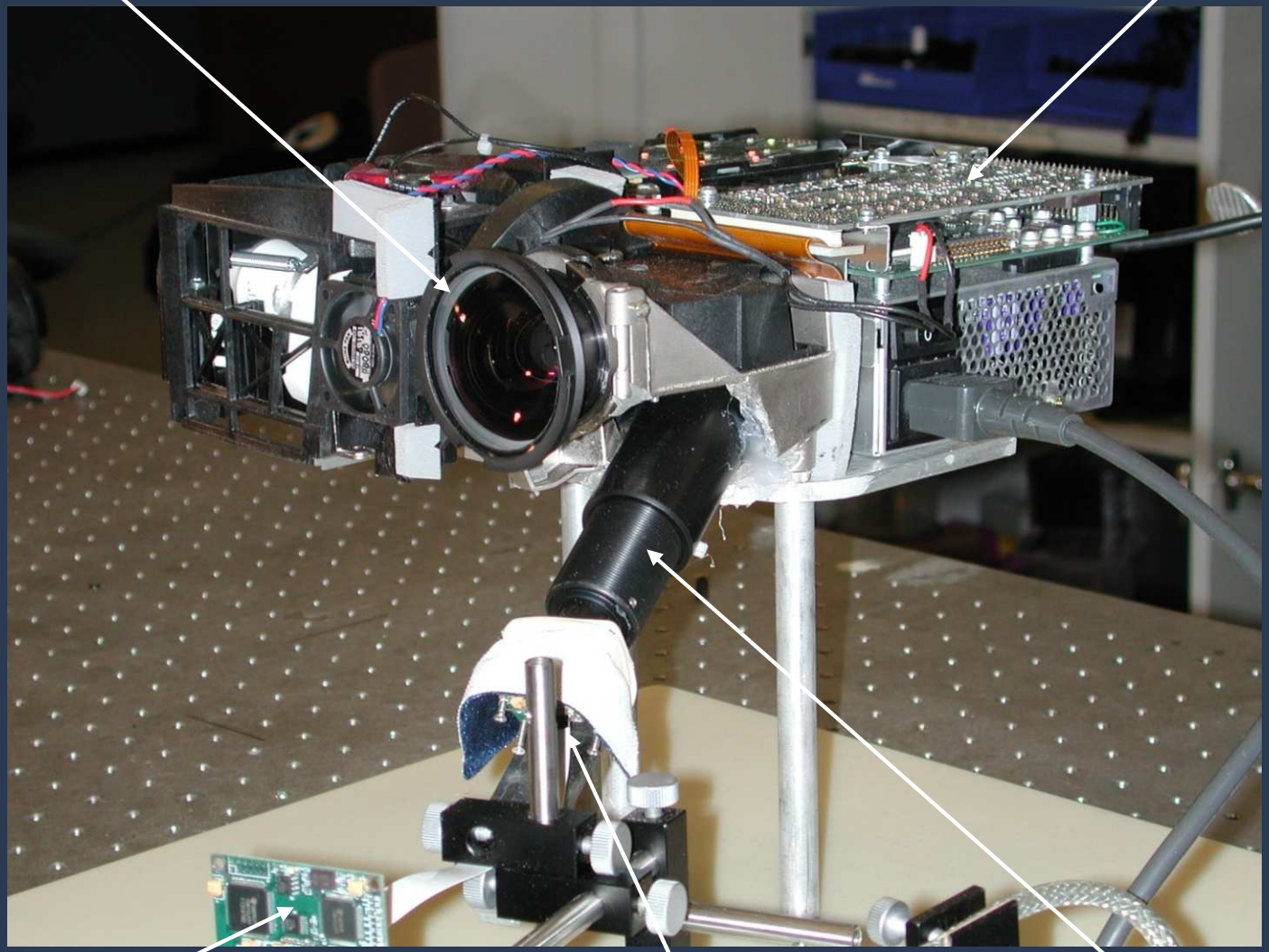


(by Texas Instruments)

DMD for Imaging:

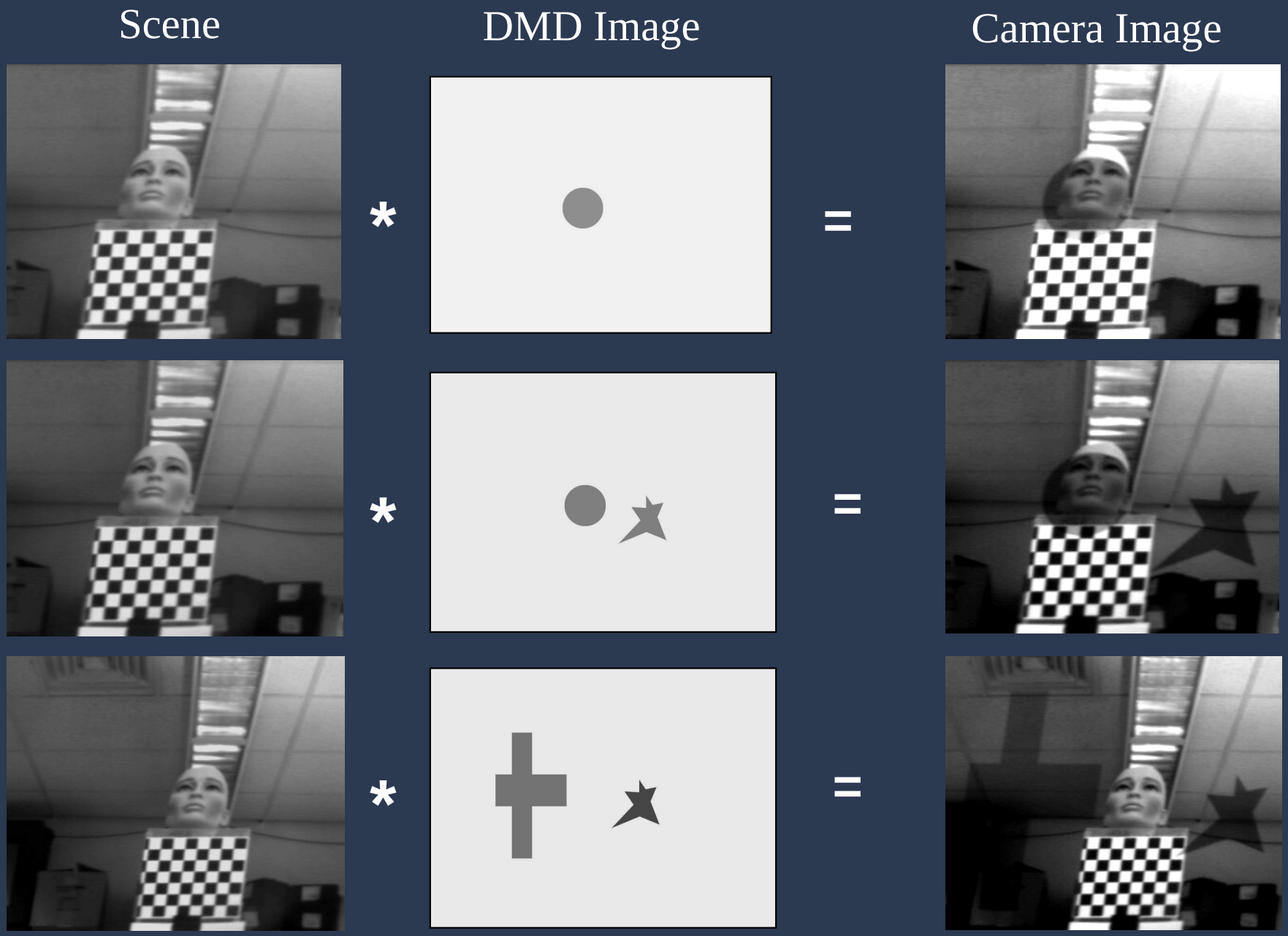
(Malbet et al. 95, Kearney et al. 98, Castracane et al. 99, Christensen et al. 02)

Programmable Imaging System



Nayar et al, CVPR 2004

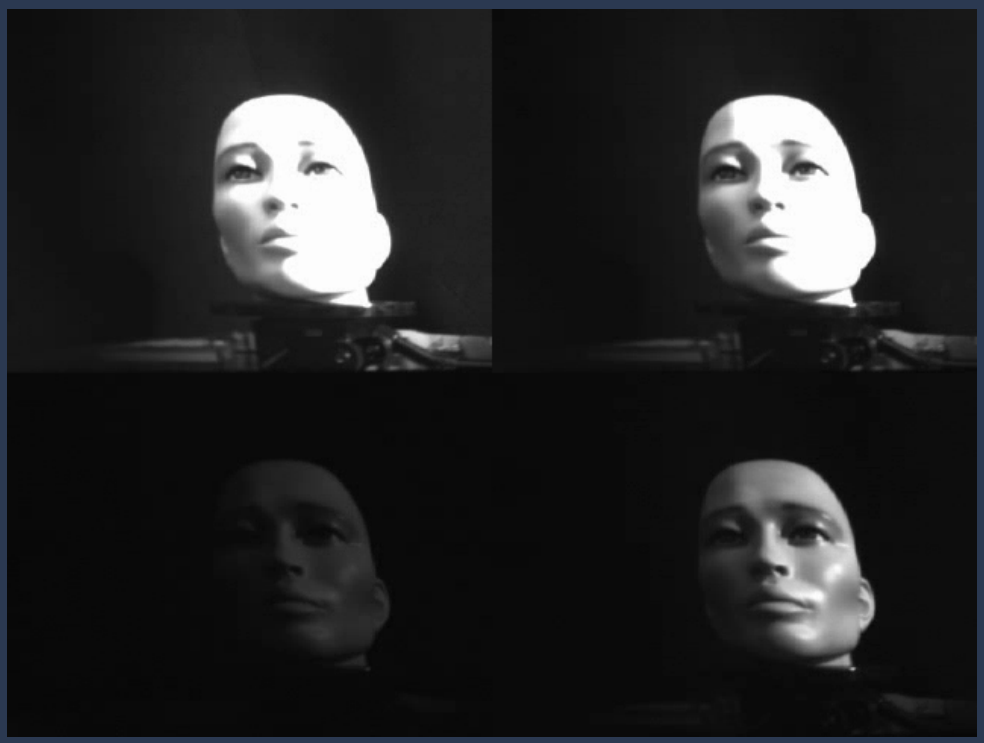
Modulation: Examples



HDR: Temporal Exposure Variation

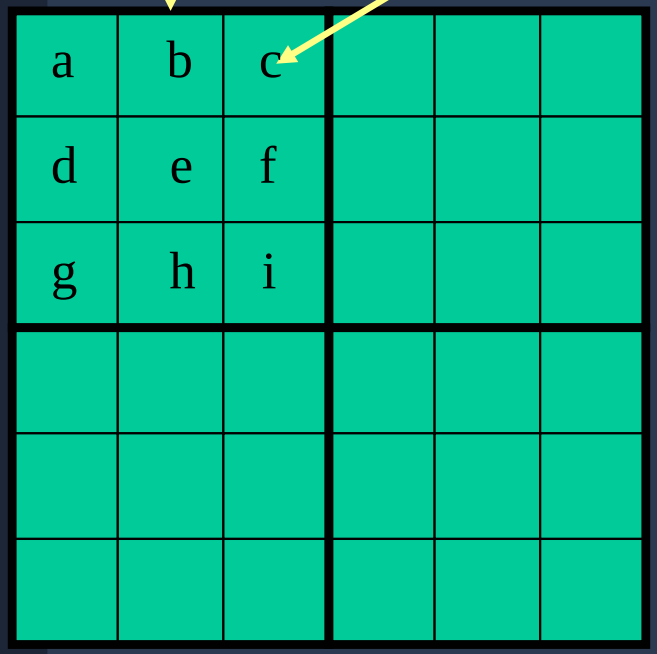
Captured Temporal Exposure Video
(4 Exposures)

Multiple Video Streams with
Different Exposures



(Ginosar et al. 92, Kang et al. 03)

Optical Intra-Pixel Feature Detection



Laplacian:

1	4	1
4	-20	4
1	4	1

=

1	4	1
4	0	4
1	4	1

−

0	0	0
0	20	0
0	0	0

Laplacian Image:

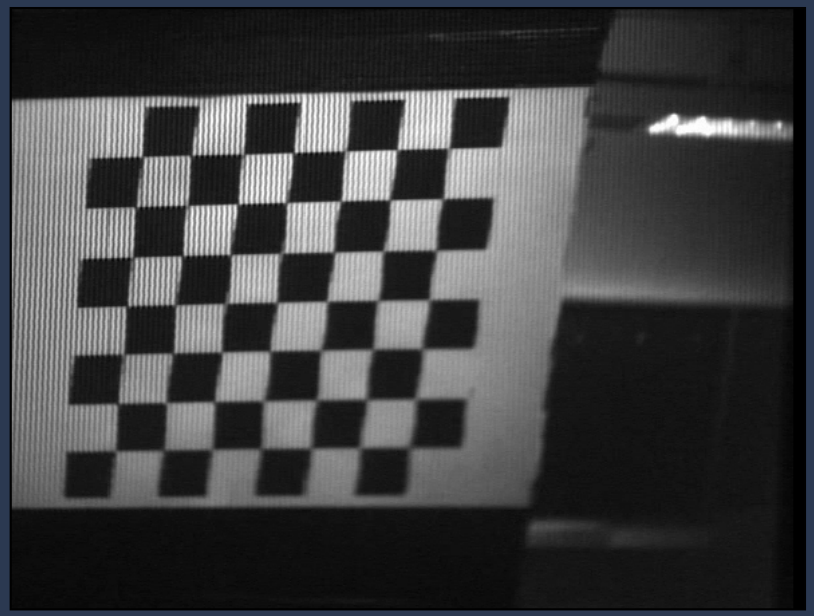
1	4	1	1	4	1
4	0	4	4	0	4
1	4	1	1	4	1
1	4	1	1	4	1
4	0	4	4	0	4
1	4	1	1	4	1

−

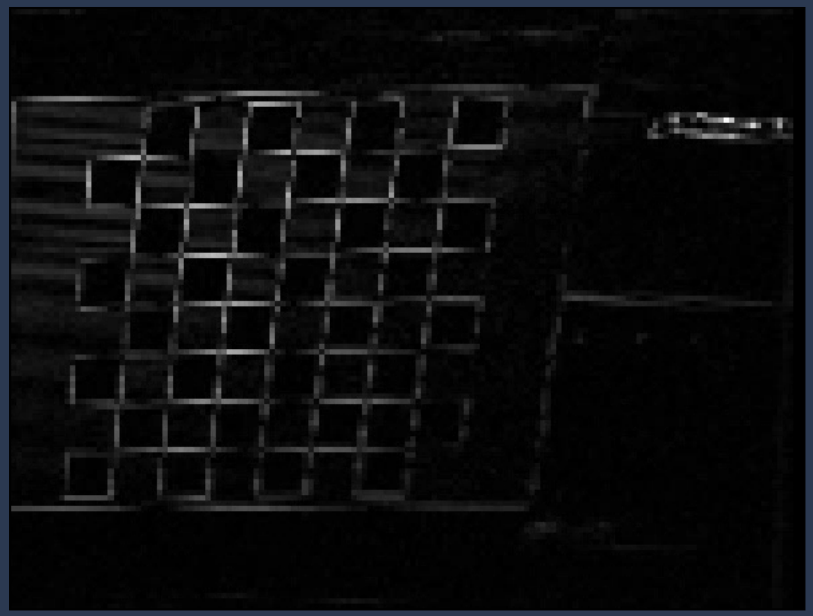
0	0	0	0	0	0
0	20	0	0	20	0
0	0	0	0	0	0
0	0	0	0	0	0
0	20	0	0	20	0
0	0	0	0	0	0

Optical Edge Detection

Scene Video



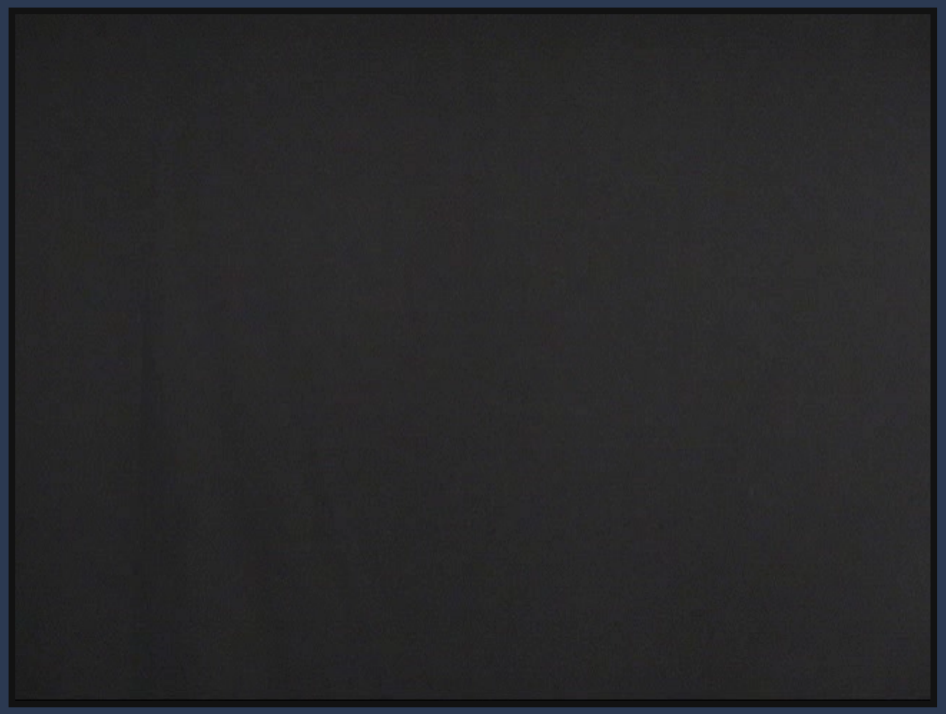
Edge Video



Nayar et al, CVPR 2004

Optical Appearance Matching

Real-Time Recognition



Nayar et al, CVPR 2004