The Frequency-Domain Effects of Stochastic Image Foveation in Superpixelating Cameras

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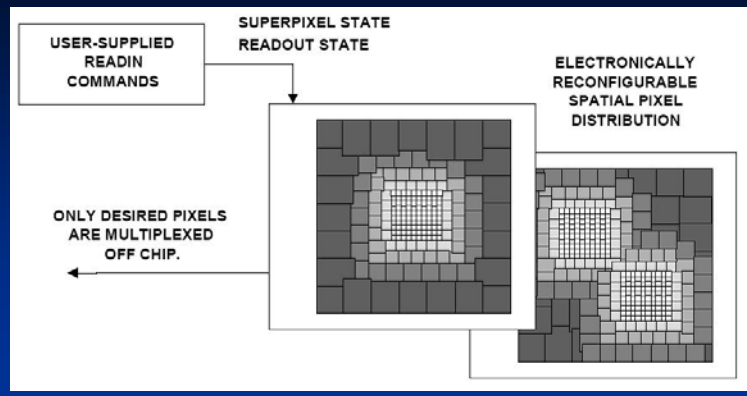
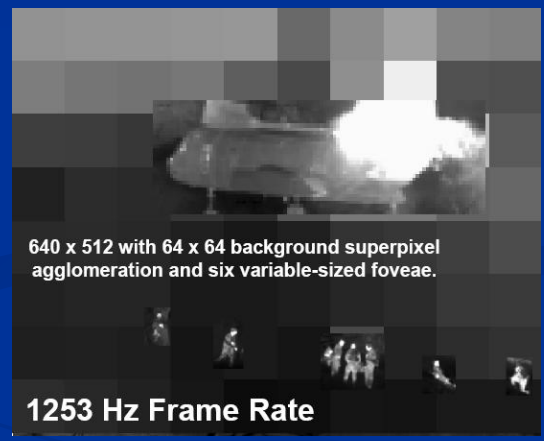
EE381K-14
March 10, 2005

Introduction and Motivation

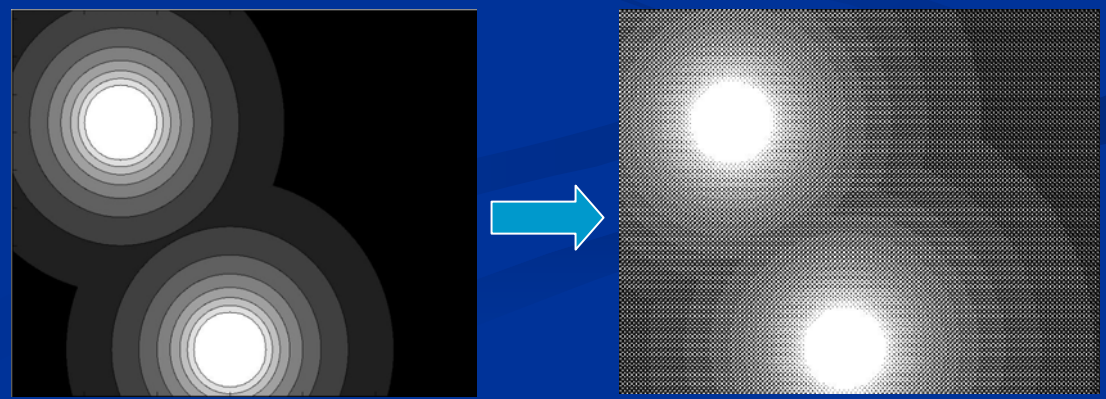
- Superpixellating cameras
  [McCarley et al, 2004]
  - Images foveated directly on sensing plane by sharing pixel charges
  - Desired resolution function must be translated to binary share/no-share control signal
  - Can achieve ≥ 1000 fr/sec





- Translation of control signal is similar to halftoning

- Which halftoning method would give the best ATR performance?



Halftoning by Classical Screening

- The first widely used method
- A point operation (very efficient)
- Pixel gray levels are thresholded against a periodic dithering matrix
  - Clustered dot matrices for printing
  - Dispersed dot matrices for human consumption
- The periodic dithering matrix can introduce unpleasant visual artifacts
- Standard dithering matrices were introduced in [Bayer, 1973]

	20	9	11	20
1/16 *	13	1	3	15
	20	7	5	20

Clustered, 9 gray levels

	9	6	4	9
1/9 *	7	1	8	2
	9	5	3	9

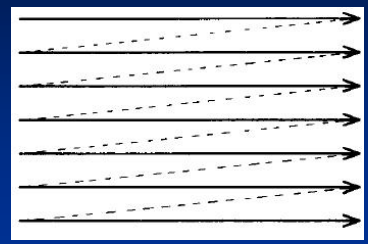
Unclustered, 9 gray levels

Dithered 'Lena' (dispersed dot)

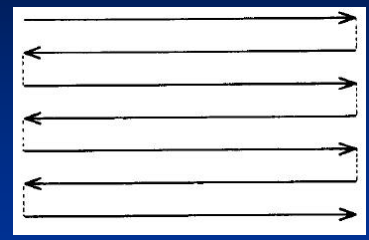
Halftoning by Error Diffusion

[Floyd & Steinberg, 1976] [some images from Ulichney, 1988]

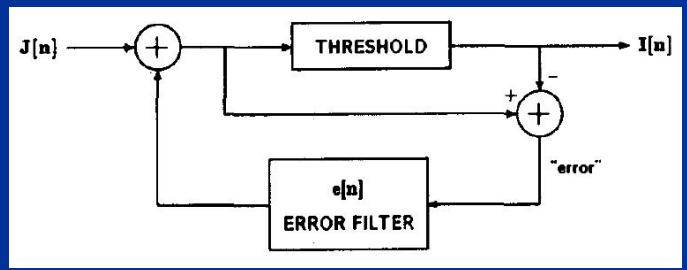
- A neighborhood operation (more computation)
- Quantization threshold fixed at 0.5
- Feedback "diffuses" quantization error by altering the gray values of neighboring pixels
- Visual quality is superior to screening



Raster scan



Serpentine scan



Feedback loop

	■	7/16
3/16	5/16	1/16

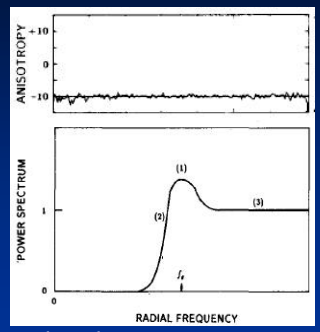
Diffusion weights

Dithered 'Lena'

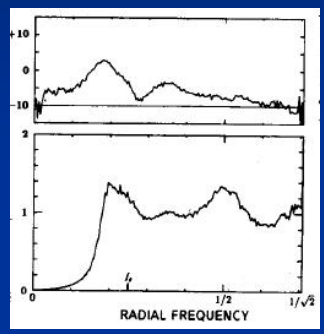
Halftoning by Dithering with Blue Noise

[Ulichney, 1988]

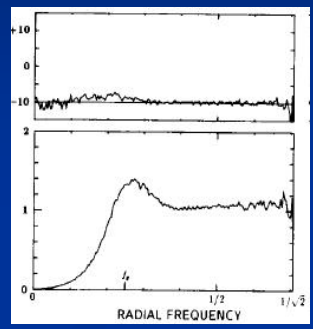
- An extension of error diffusion
- Diffusion weights and/or locations are randomly "perturbed"
- Result is isotropic high-frequency ("blue") noise in the dither pattern (which is good)
- This reduces negative visual artifacts



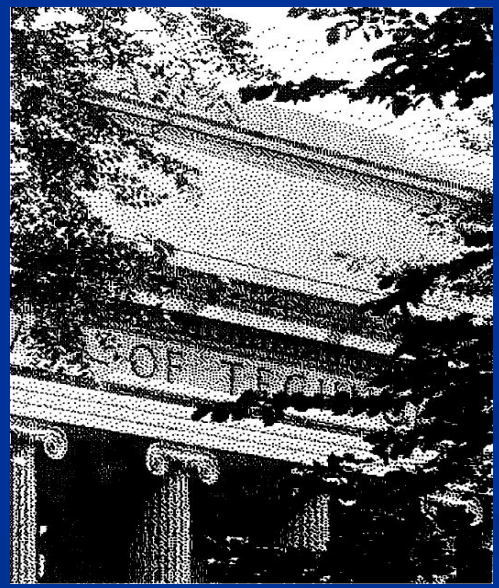
Ideal characteristics



Error diffusion



Blue noise



What I Propose To Do

- Pick some test images or video sequences
- Pick the foveation points / desired resolution by hand
- Try out a few halftoning methods for control signal translation
  - Download standard halftoning implementations [Monga et al 2002]
  - Attempt to make my own stochastic approach
- Simulate the charge sharing behavior of the camera in software
- Evaluate the quality of the foveated images via some subset of
  - MSE in frequency domain
  - SNR, PSNR, WSNR
  - Foveated Wavelet Quality Index (FWQI) [Wang et al 2001]
  - Ulichney's anisotropy and frequency metrics on power spectra

References

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