

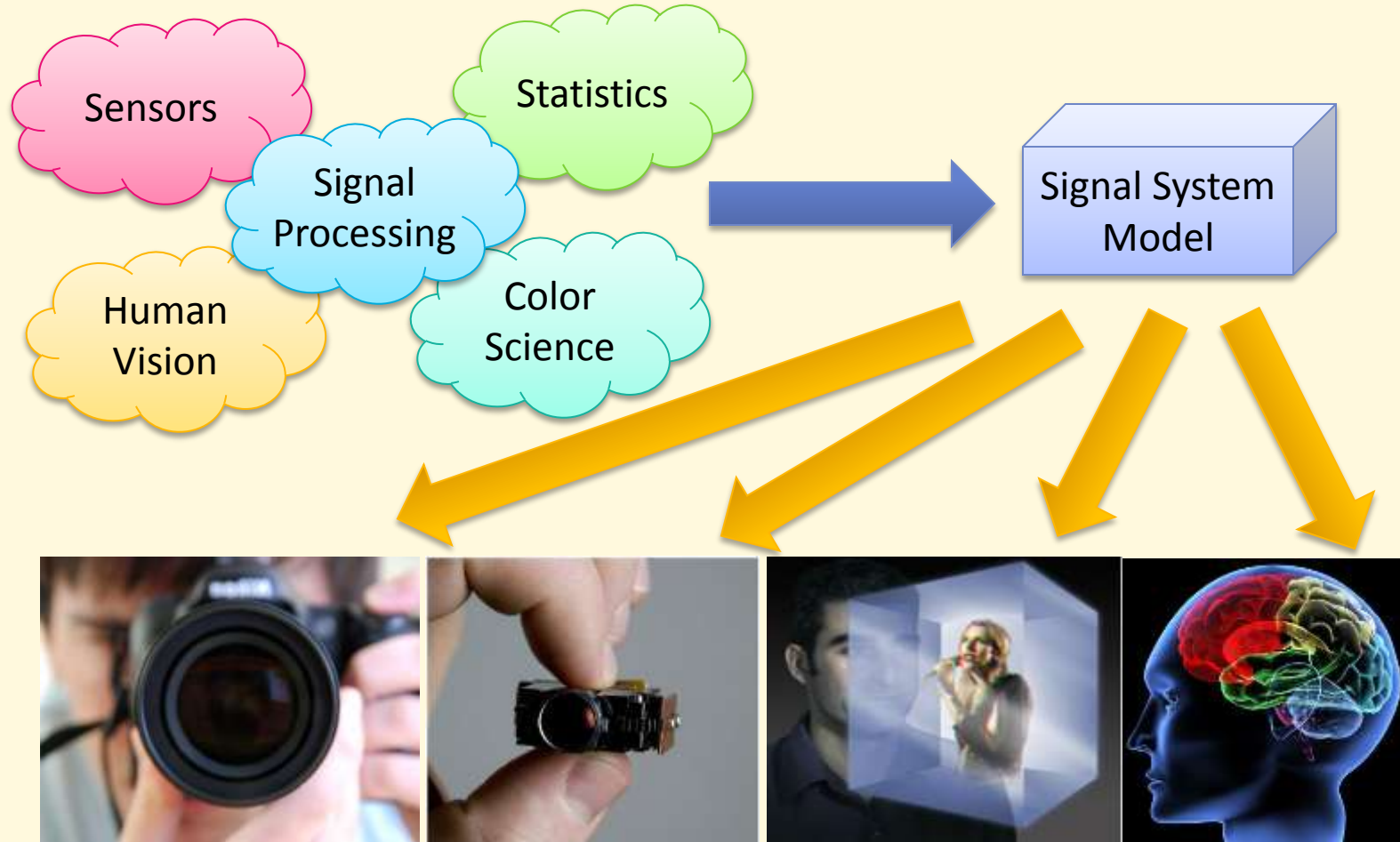
What More Can You Do With Color Image Sensors?

Keigo Hirakawa, University of Dayton

<http://academic.udayton.edu/hirakawa>

Intelligent Signal Systems Laboratory

Intelligent Signal Systems Laboratory, Keigo Hirakawa, <http://academic.udayton.edu/hirakawa>



Research at ISSL is aimed at understanding the increasingly large role that signal systems play in the real-world. We connect the applied design efforts with the first principle ideas of mathematics and statistics to enable new capabilities in image processing, computer vision, and sensor exploitation.

Signal System Models

Intelligent Signal Systems Laboratory, Keigo Hirakawa, <http://academic.udayton.edu/hirakawa>



Natural Scene
Statistics

data generating model



Acquisition
Hardware

discretization, noise



Signal & Image
Processing

estimation, enhancement,
analysis, processing



Human
Vision



Display
Hardware

subjective analysis

Signal System Models

Intelligent Signal Systems Laboratory, Keigo Hirakawa, <http://academic.udayton.edu/hirakawa>



Natural Scene
Statistics



Acquisition
Hardware



Signal & Image
Processing



Display
Hardware

DATA LOST HERE!



impose limits on DSP

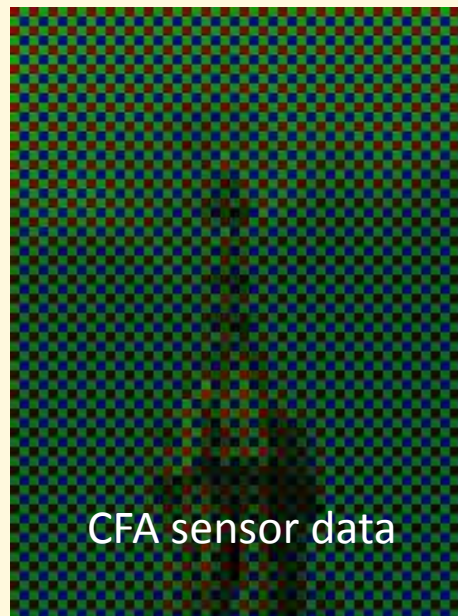
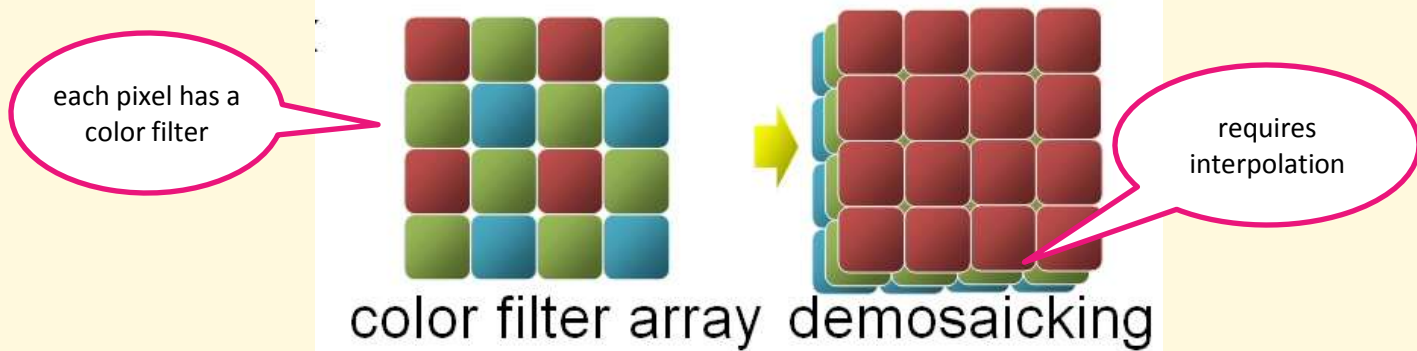
DATA LOST HERE!



impose limits on vision

Color Filter Array

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Color image sensor has color filter array. Demosaicking recovers full color image.

Binning Pixels

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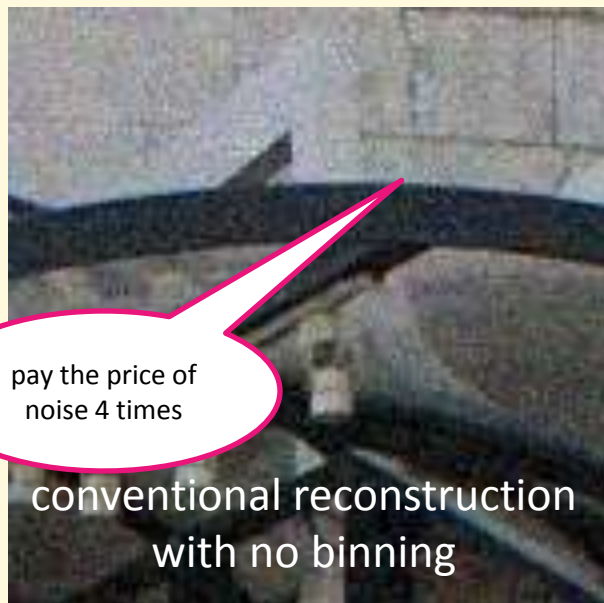
no binning

high resolution,
high noise



Kodak Pixelux

low noise,
but aliased



Example sensor data processing. Binning reduces noise but introduces aliasing artifacts.

Denoising And Interpolation

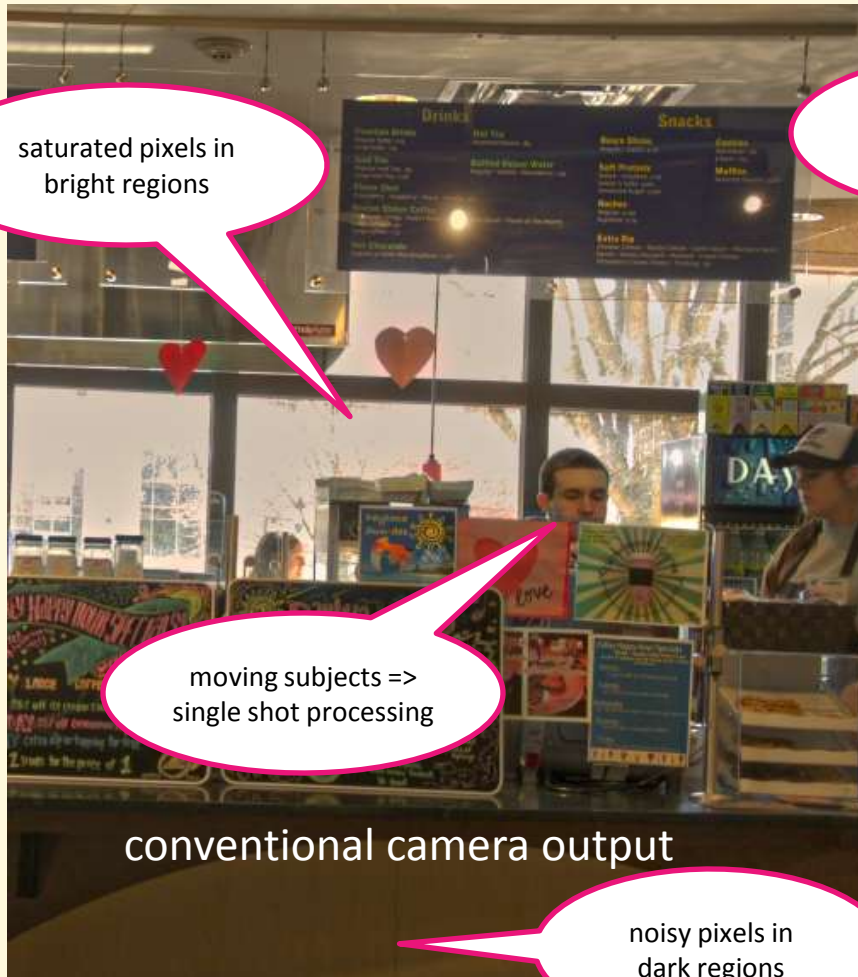
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Example camera processing. Same sensor observation but increased robustness to noise.

Single Shot High Dynamic Range

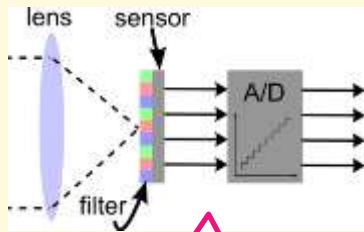
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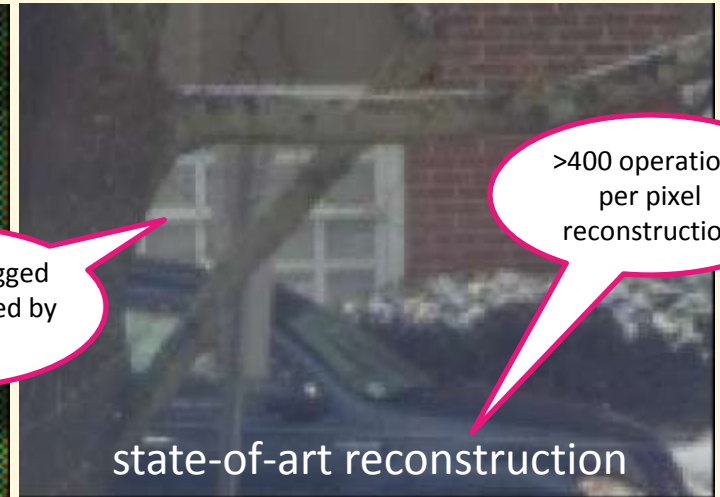
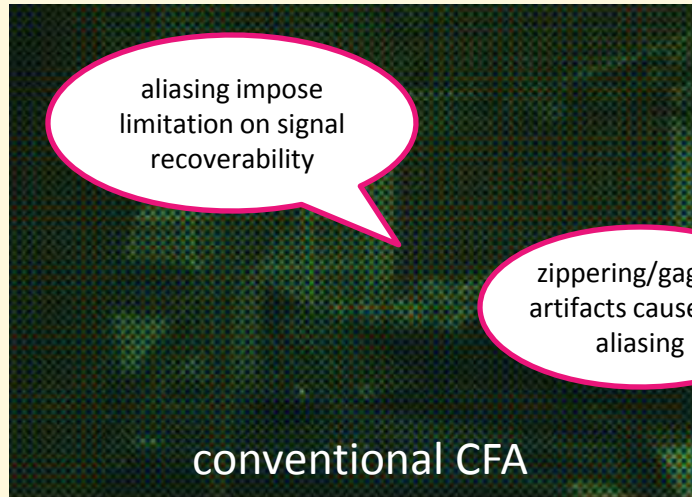
Example single shot HDR using conventional hardware. Captures moving subjects or video.

Color Image Sensor

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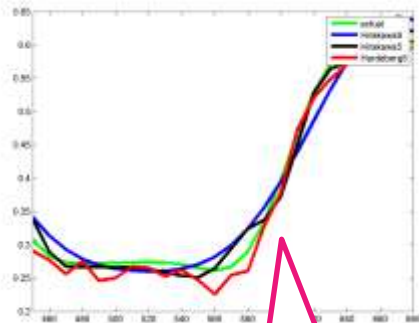
color filter array
(spatio-color
multiplexing)



Example image sensor design. Same number of pixels, but increased spatial resolution.

Multispectral Image Sensor

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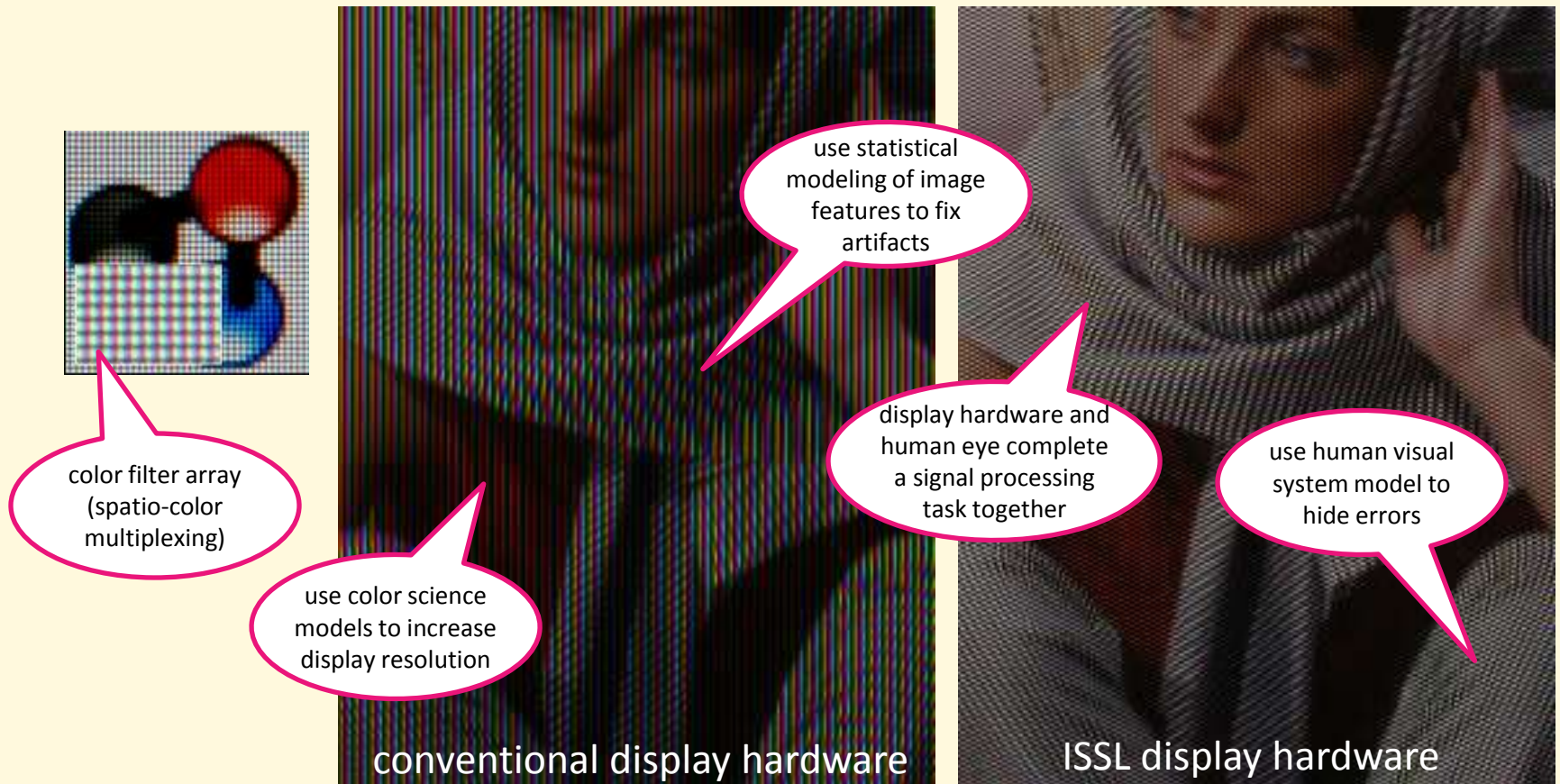
comparable spectral accuracy



Example image sensor design. Same number of pixels, but increased spatial resolution.

Image Display Device Design


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Example display design. Same number of pixels, but increased spatial and color resolution.

Color Image Processing


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color scientists
have long ignored
spatial information


not robust to
dominant colors

conventional white balance



aesthetically
pleasing but
inaccurate

manual color balance
by photographer



statistical
modeling of
color images

spatio-color
modeling

ISSL white balance

Example white balance. Statistical and signal processing approach to color science.

Motion Blur Detection

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robust statistical model for image features using wavelets

blurred wavelet coefficients behave differently than sharp wavelet coefficients

robust to noise and assumptions

motion blur kernel has a parametric form

exploit sparsity of wavelet coefficients to estimate blur parameter

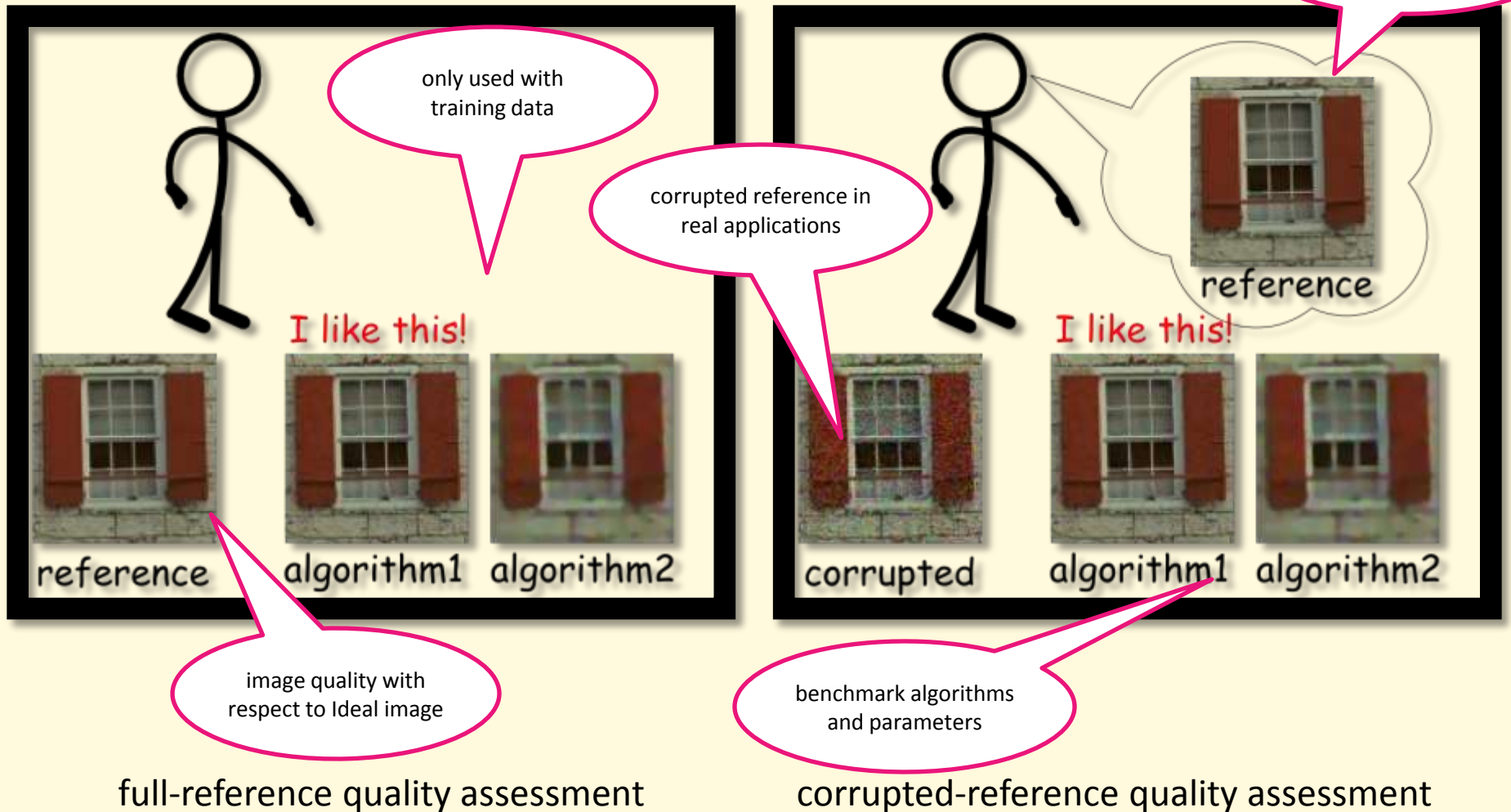
input image with motion blur

ISSL motion blur detection

Example of blur detection. Has many computer vision and surveillance applications.

Image Quality Assessment

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Example of image quality assessment with corrupted reference data.

Intelligent Signal Systems Laboratory

University of Dayton, Electrical and Computer Engineering, Keigo Hirakawa, PI

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