Optimize Performance:

Start your algorithm development with the imaging subsystem

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twisthink

Twisthink – Booth #109

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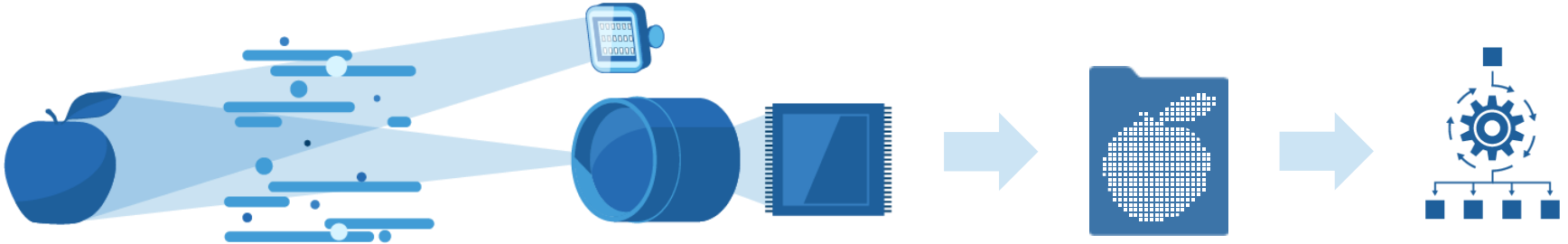
Human Centered Design | Embedded Vision | AI | Connectivity | Internet of Things | UI / UX

Vision-based Detection System

Start your algorithm development with the imaging subsystem



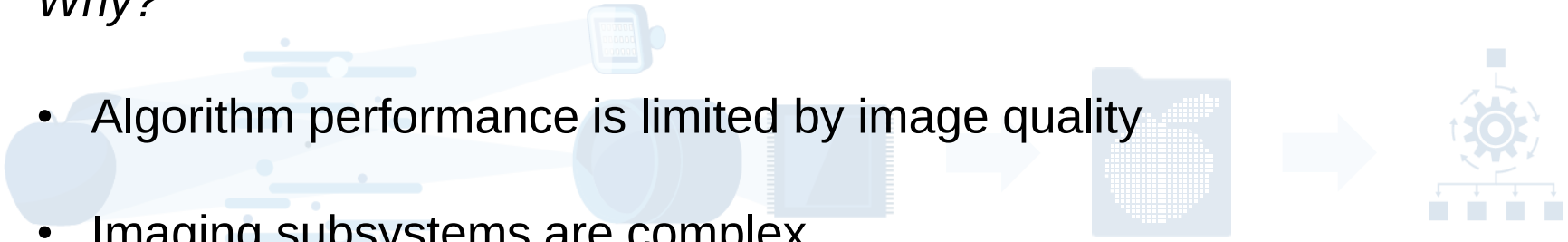
Object of Interest | Environment | Imaging Subsystem | Captured Object | Detection Algorithm

Vision-based Detection System

Start your algorithm development with the imaging subsystem

Why?

- Algorithm performance is limited by image quality
- Imaging subsystems are complex

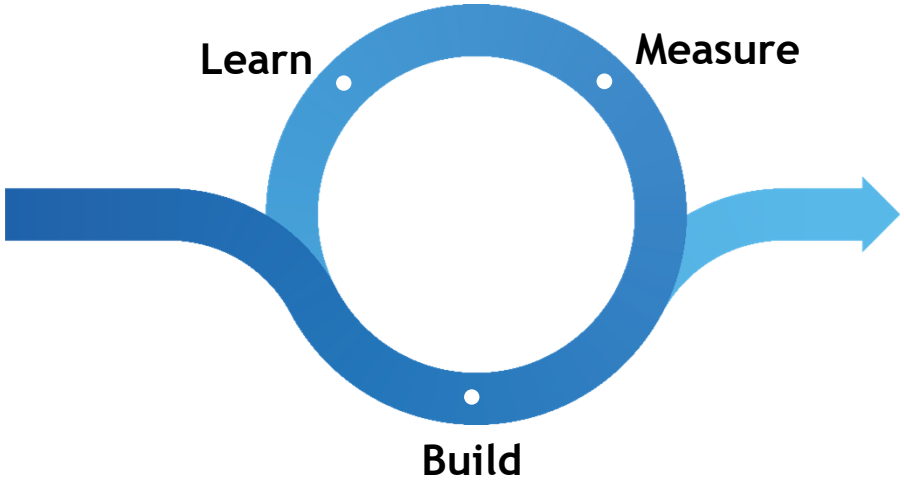


Outline

Start your algorithm development with the imaging subsystem

- Iteration
- Sampling and Sharpness
- Evaluation

Iterative Approach



Build-Measure-Learn: A flexible framework for focused learning

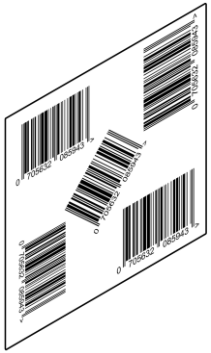
Iteration leads to an optimized solution

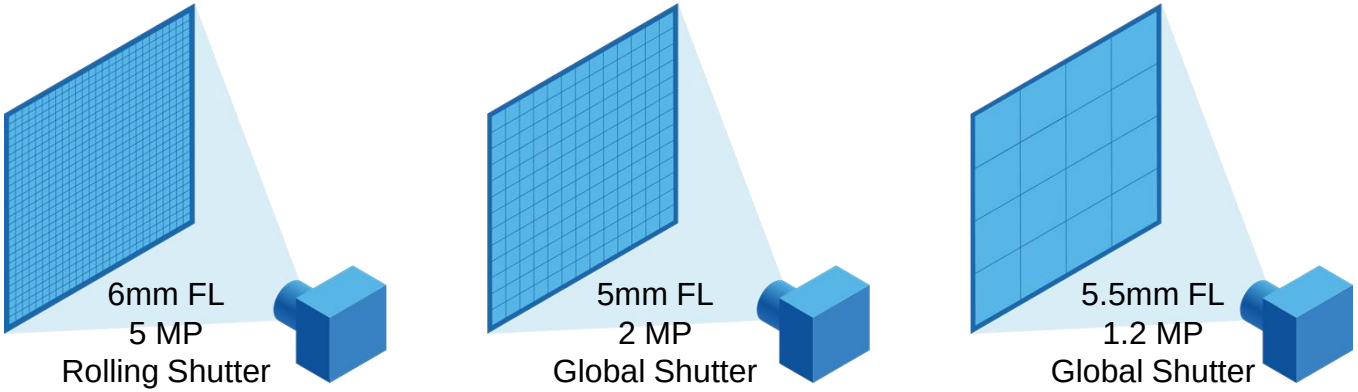
Linear Barcode Reader Example

Iteration: 1 → 2 → 3

Learning Focus:

1	2	3
Baseline camera	Motion Blur	Performance in Real-world Environment

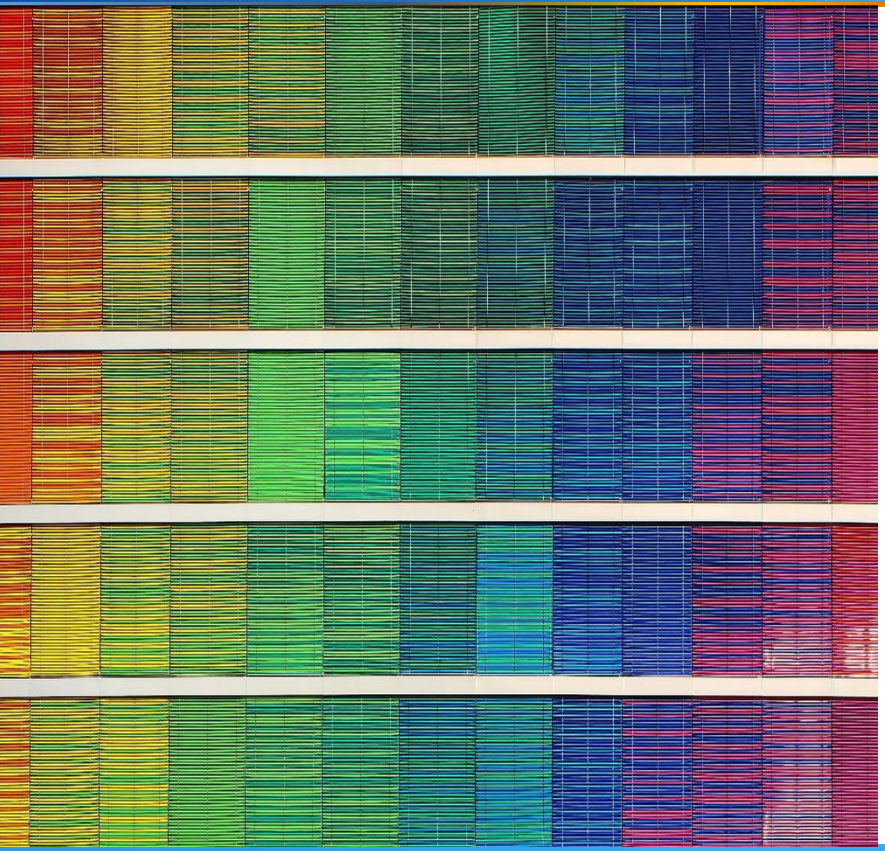




Key Takeaways:

Baseline cost Reduce sampling Motion blur	Global shutter Further sampling reduction

Outline



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Sampling

Sampling is pixel count over a given area (e.g. pixels per inch)

Insufficient sampling reduces discriminating detail

Sampling Requirements:

- Physical size of distinguishing features
- Max detection distance
- Start with 4-5 pixels across key features

Sampling: Image Subsystem Parameters

Use a camera model to quickly evaluate sampling

	Inputs				
Image Sensor					
Horizontal Pixel Count	2592	Horizontal Dimension (mm)	5.70	Sensor Spatial Resolution (lp/mm)	227.27
Vertical Pixel Count	1944	Vertical Dimension (mm)	4.28		
Pixel Size (um)	2.2	Diagonal Dimension (mm)	7.13		
		Optical Format (in)	0.42		
Lens					
Focal Length (mm)	2.2	Horizontal FOV (degrees)	104.69	*Note: FOV as focused at infinity*	
F/#	2	Vertical FOV (degrees)	88.37		
Circle of Confusion (mm)	0.00334	Diagnonal FOV (degrees)	116.63	Near Sampling (px per mm)	6.137013
Focus Distance (mm)	213.25	Hyperfocal Distance (mm)	726.75	Far Sampling (px per mm)	3.347883
		Near DOF (mm)	165.15	Near Magnification	0.013501
		Far DOF (mm)	300.90	Far Magnification	0.007365
		DOF Working Distance (mm)	135.75		

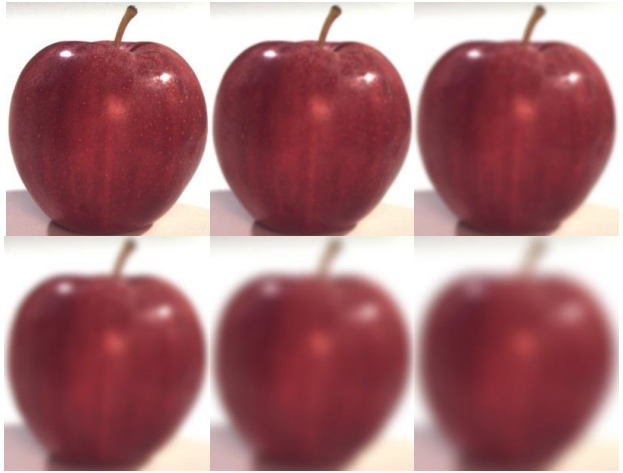
Download Twisthink worksheet at: www.twisthink.com/embedded-vision-summit

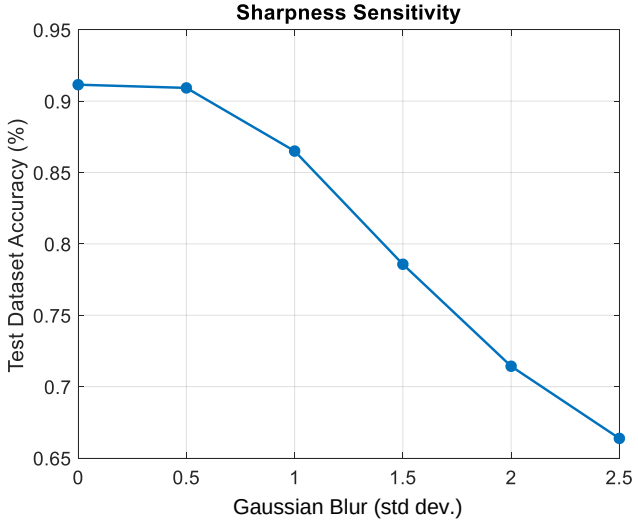
Sharpness

Sharpness is a measure of spatial frequency

Blur reduces high-frequency content and discriminating detail

Use a sensitivity study to understand sharpness requirements



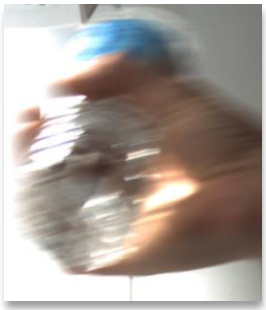


Sharpness: Image Subsystem Parameters

Static

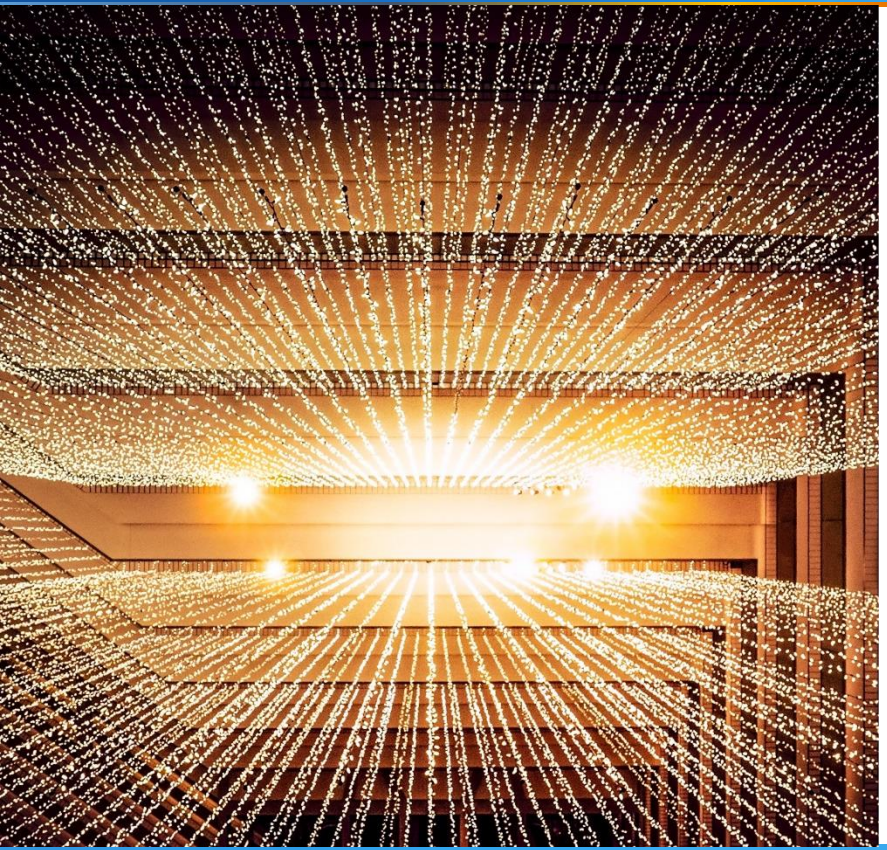
Environment	Fog, particulate, lens surface contaminate, ...
Lens	Temperature, mfg. variation, …
Image Sensor	Varies with wavelength

Dynamic



Motion speed	Limit speed, limit exposure
Exposure duration	Affects image brightness, lighting intensity, …

Outline



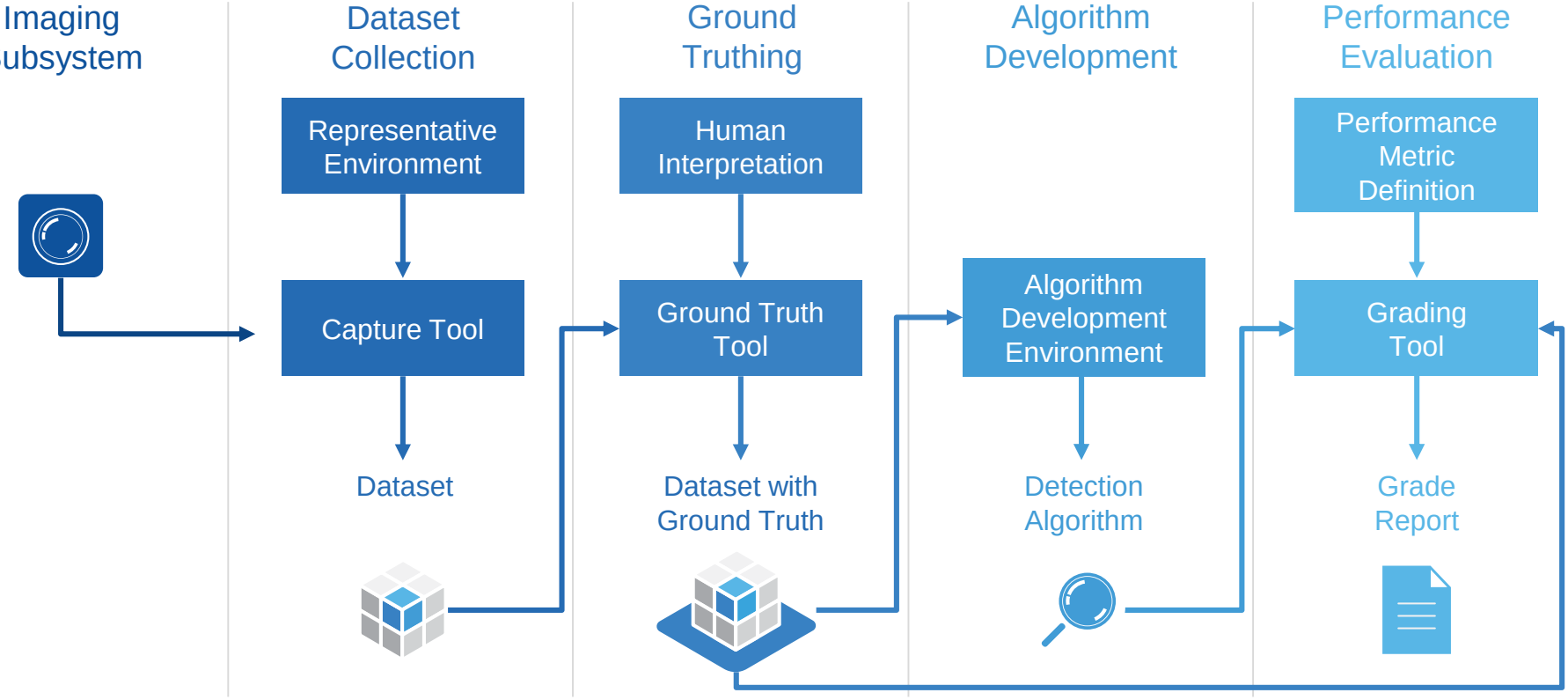
Start your algorithm development with the imaging subsystem

Iteration

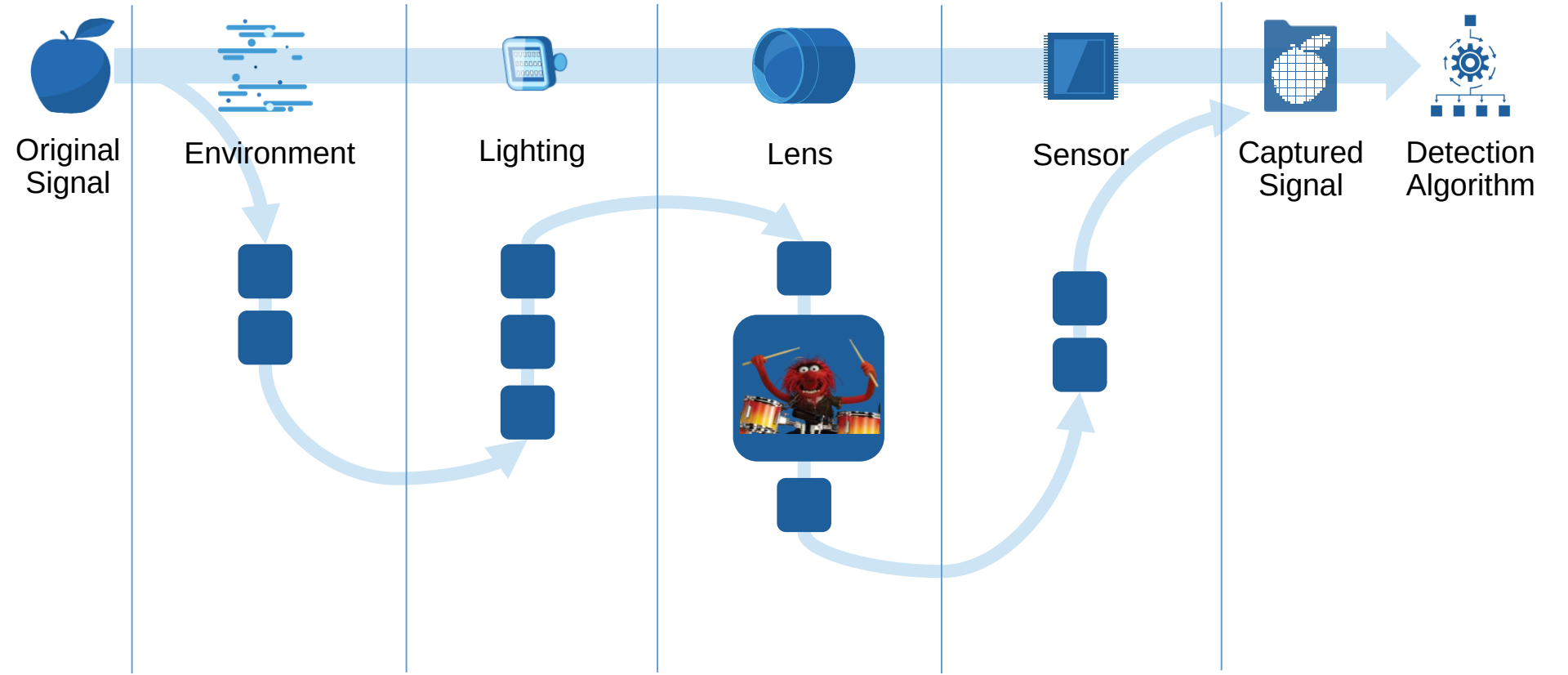
Sampling and Sharpness

Evaluation

Algorithm Development Framework



Modeling Signal Path



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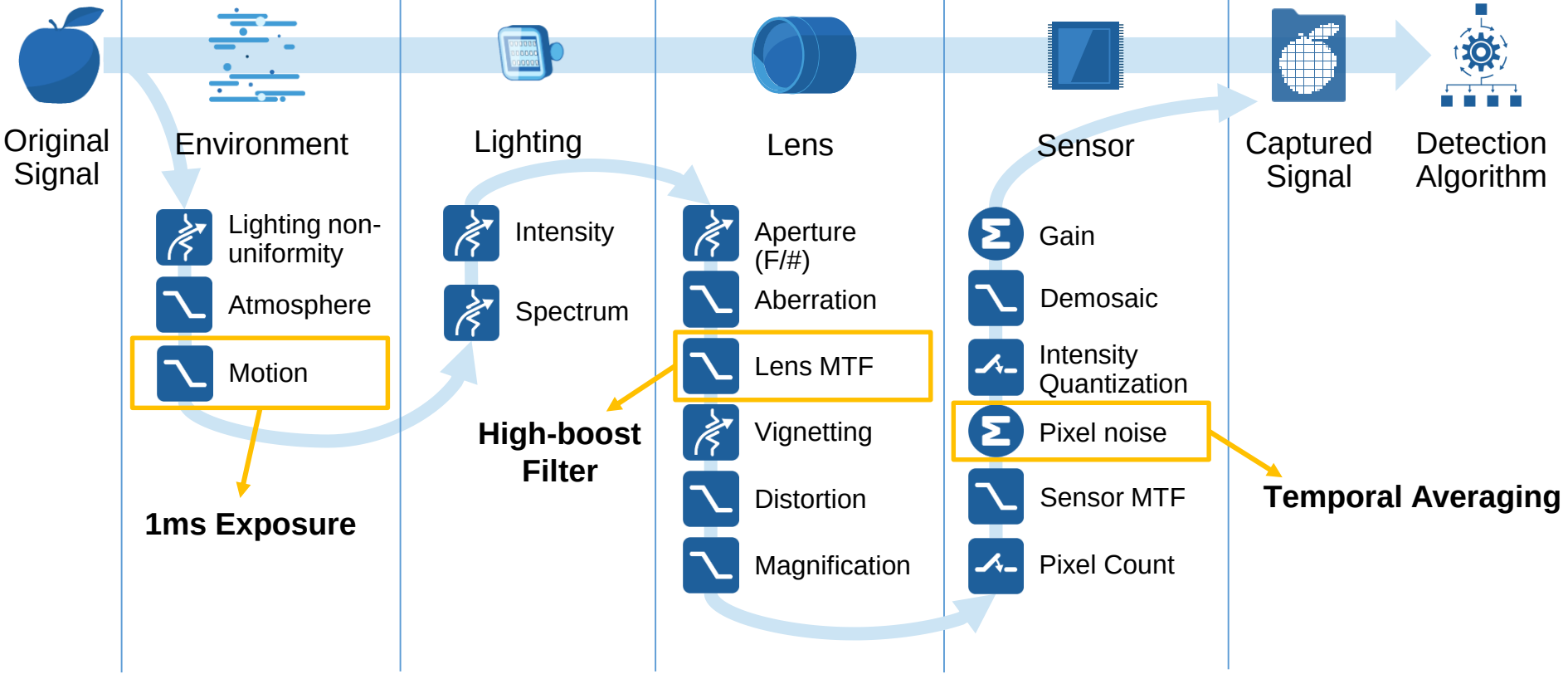


Conclusions

Start your algorithm development with the imaging subsystem

Iteration	Be focused and intentional Find the right solution
Sampling and Sharpness	High-impact image quality factors Focus here first
Evaluation	Use datasets and modeling Evaluate often

Resources

Edmund Optics MTF Intro

Measuring Sharpness

Slanted Edge: International Standard ISO 12233:2000(E)

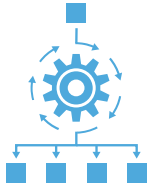
www.twisthink.com/embedded-vision-summit

- Download Presentation
- Download Twisthink Sampling Worksheet

Appendix

Finding the Right Solution

Imaging Subsystem



Detection Algorithm

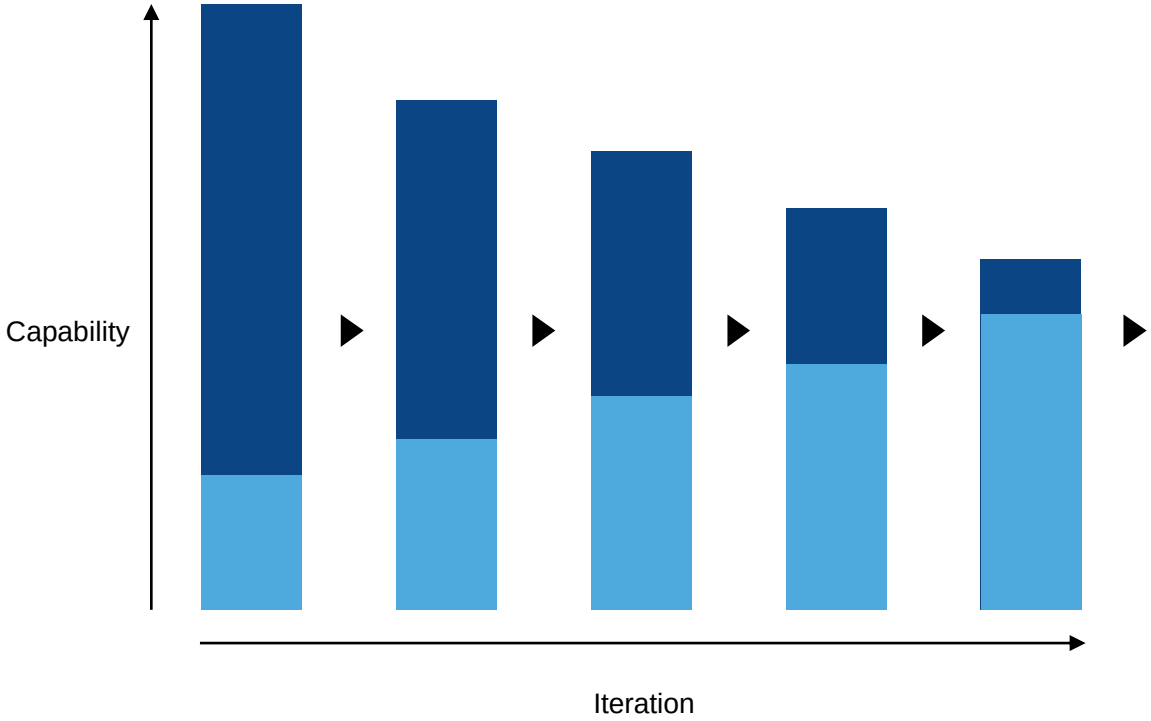


Image Subsystem “Noise Sources”

Noise Source	Image Degradation	Improvement Options
Insufficient sampling	Loss of spatial information, aliasing artifacts (Moiré patterns, staircasing)	Higher resolution sensor, increased magnification, anti-aliasing filters
Blur	Removal of high frequency content, Reduction in discriminating detail	Increased lens quality, sharpening algorithms
Low Signal Amplitude	Reduced signal-to-noise ratio (SNR)	Increased exposure time/gain, increased light source intensity, improved sensor sensitivity
Image Noise	Additive random unwanted signal, Reduced signal-to-noise ratio (SNR)	Minimize gain, filtering, temporal averaging, increased contrast, improved pixel design
False contouring (low gray-level quantization)	Dull and washed out gray look, saturated or undersaturated signal	Increased quantizer levels, high dynamic range sensor
Color Inaccuracy	Loss of discriminating color information	Auto white balance, color calibration
And others…		

Sharpness: Neglecting Effect of Temperature