Rectilinear Optics Reduce Compute Burden in Edge Machine Learning

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Theia® TECHNOLOGIES

Wide angle machine vision application

Inspection with Machine Learning

- Semi-automated wire crimping inspection
- One camera
- Edge AI
- Areas of interest
  - Wide angle to find object (hand-held)

Image from Hexicurity

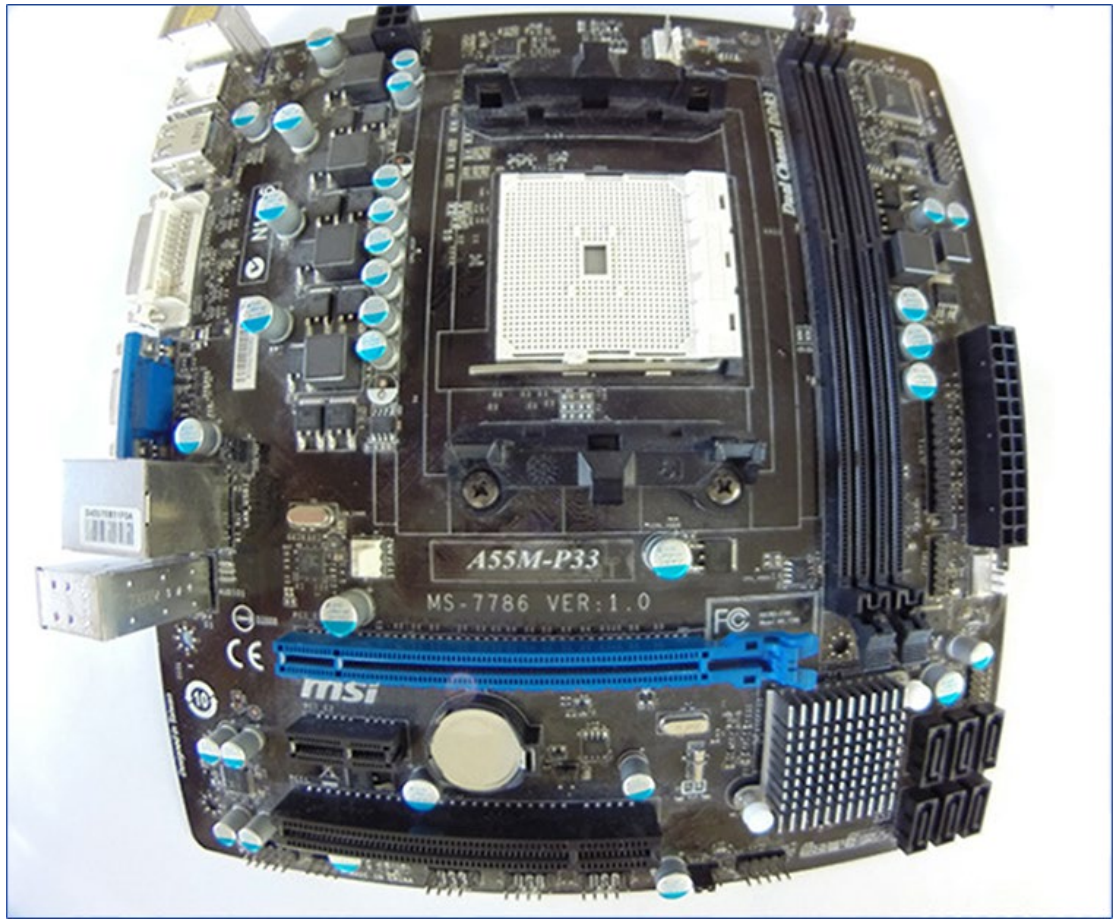
Inspection with Machine Learning

- Semi-automated wire crimping inspection
- One camera
- Edge AI
- Areas of interest
  - Wide angle to find object (hand-held)
  - Narrow angle for inspection
- Limited processor power

Image from Hexicurity

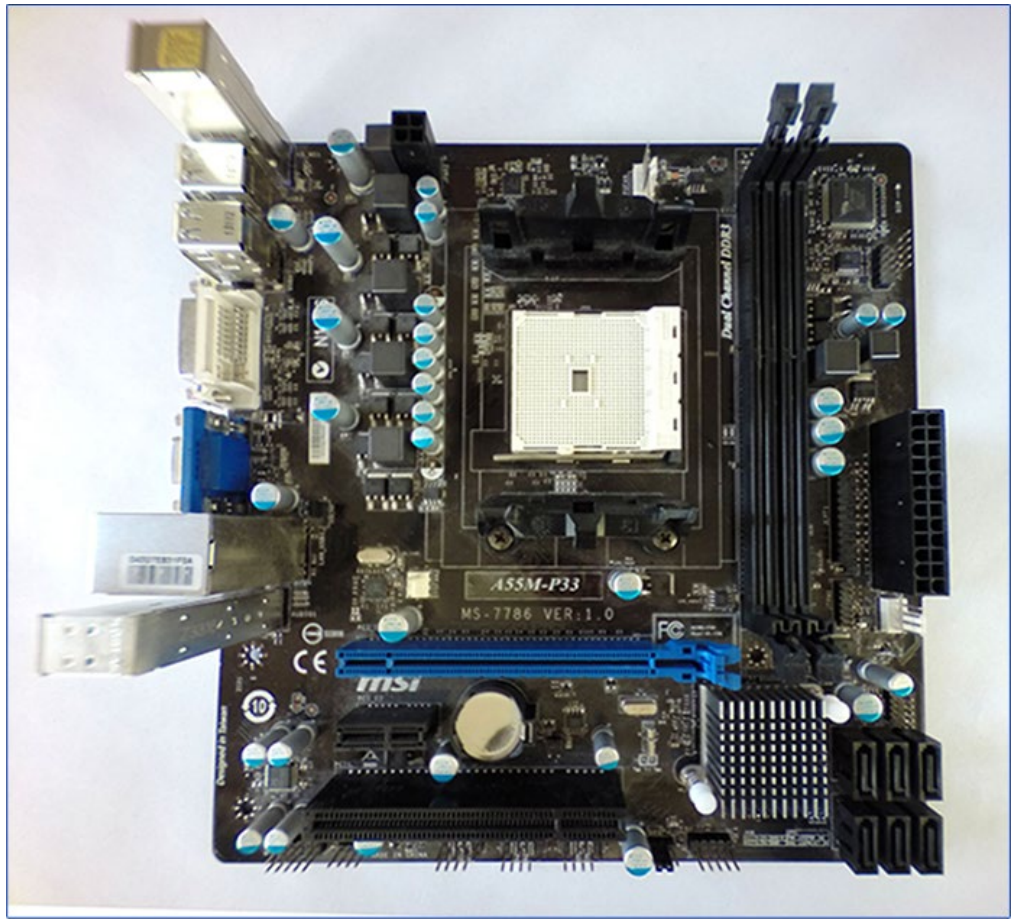
Processing a wide field of view

- Typical wide FOV with distortion
- Larger training set required
- Processor power/memory for dewarping
  - Challenging for edge AI systems



Rectilinear optical solution

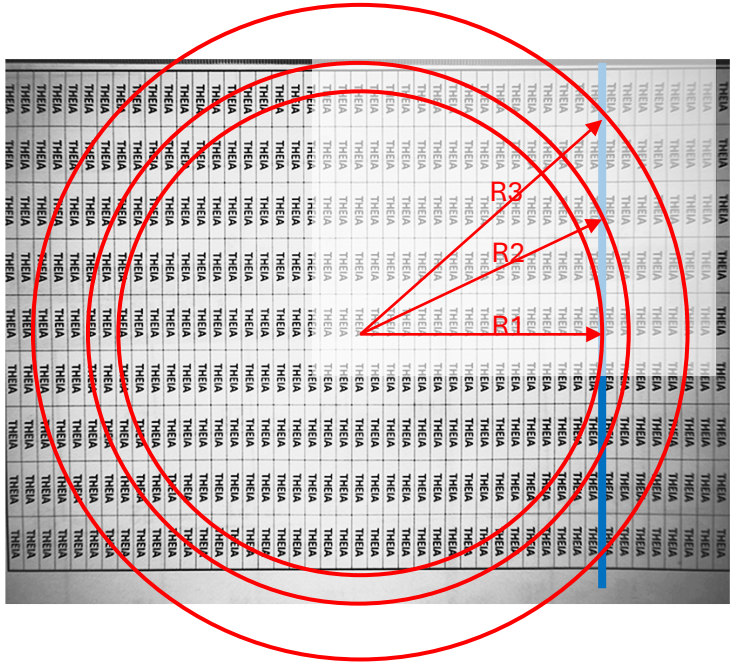
- Remove barrel distortion in optics
  - Consistent geometry
  - Higher edge resolution
  - No latency

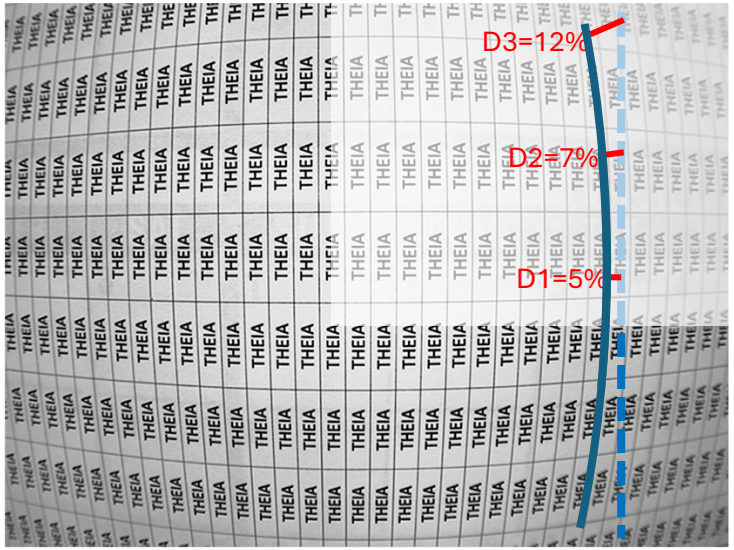


Rectilinear lens background

Barrel distortion

- Object with straight lines
- Straight lines appear curved in the image
- Distortion is a function of radius

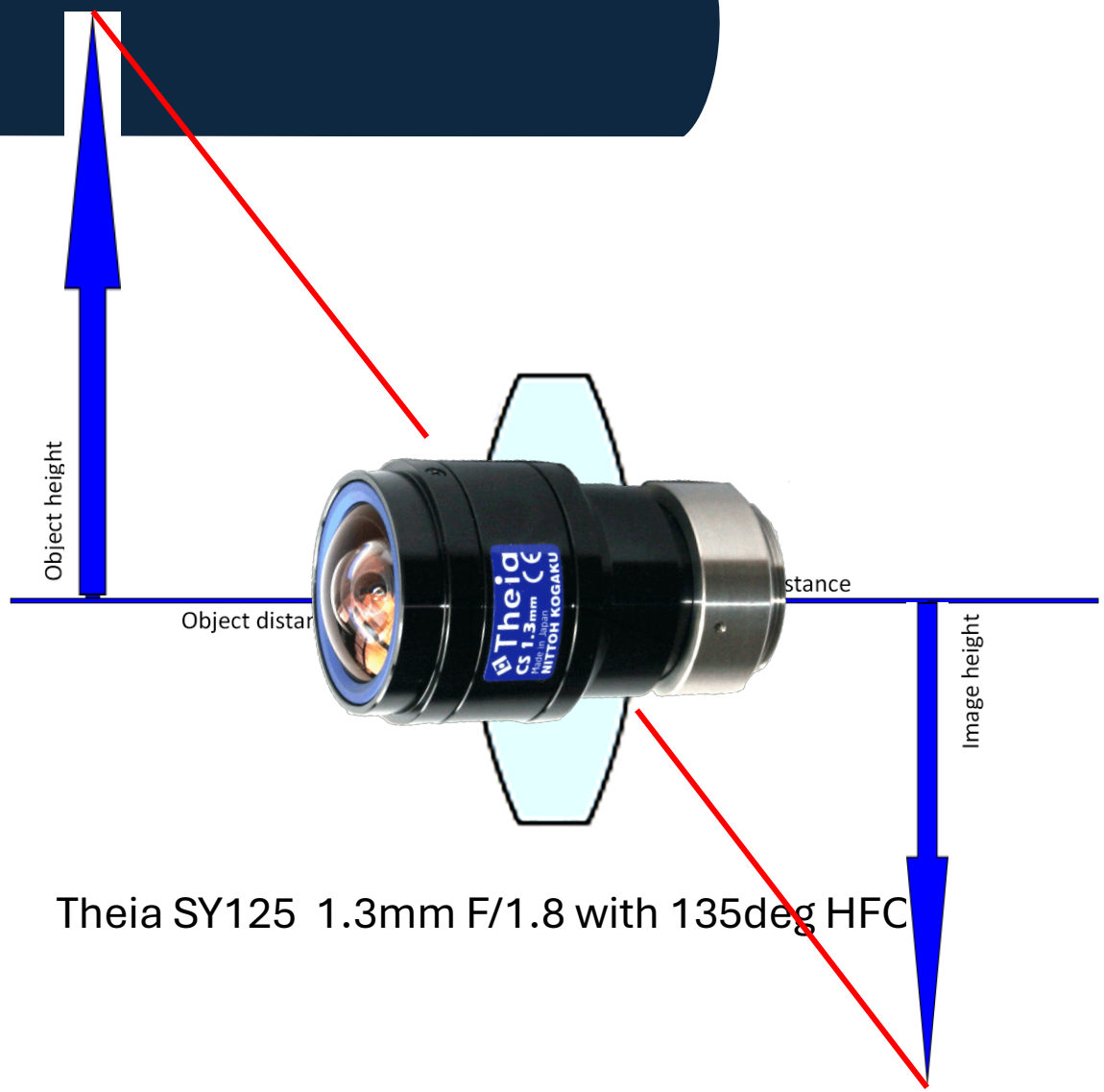




$$Distortion = \frac{Actual - Predicted}{Predicted}$$

Rectilinear lens

- Straight lines are straight in the image
- Simple lens equation
- Rectilinear lenses require more lens elements and aspheric elements
- Wider angle lenses, > 90° are more difficult to correct for distortion



Theia SY125 1.3mm F/1.8 with 135deg HFC

Rectilinear Lens Technology

- Ultra wide fields of view from 90deg to ~140deg
- All-optical distortion correction
  - No software correction
  - No processing latency
  - No processing power usage
- Multi-megapixel optical designs

Typical wide angle lens

Rectilinear lens

Rectilinear lens wire crimping application

Wire crimping application

- 5MP optical system
- Sony IMX335
  - Wide field for detection
  - Narrow field for inspection
- 30fps, Inference in every frame
- STM32N6 processor
  - Edge AI engine
  - Smaller than Nvidia system

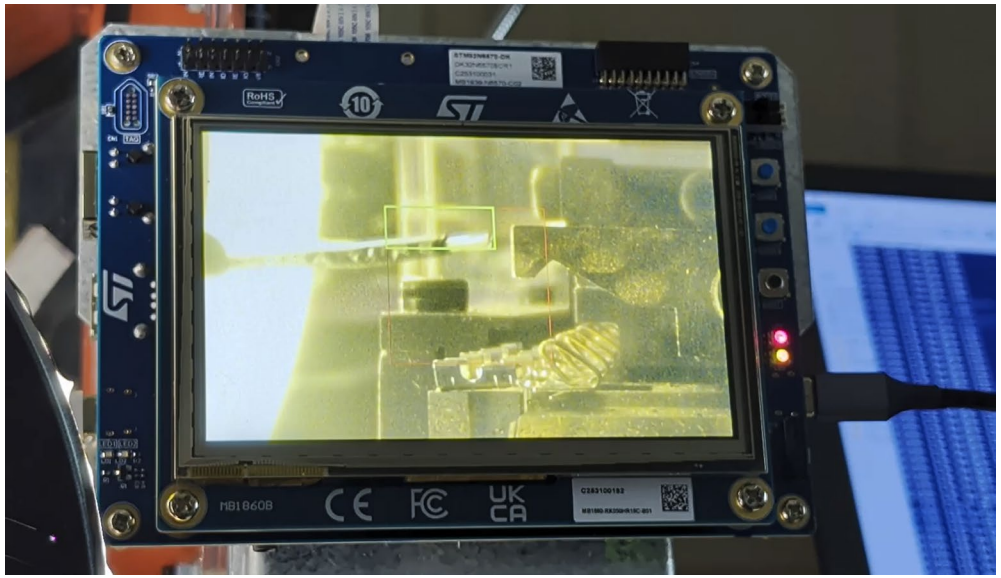
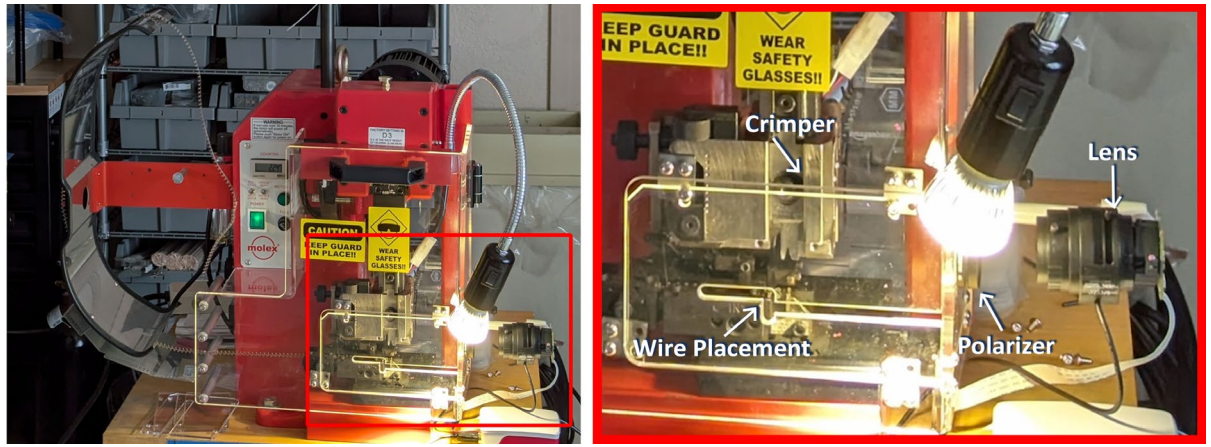


Image from Hexicurity

Optical system

- Lens front element 40mm from anvil
- Blue-blocking filter and CPL
- Optimized lighting
- No chromatic artifacts/ ghosts



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Inspection with Machine Learning

- 2.3mm fixed lens
- 200 lp/mm
- 5mpx camera
- 10X digital zoom for inspection

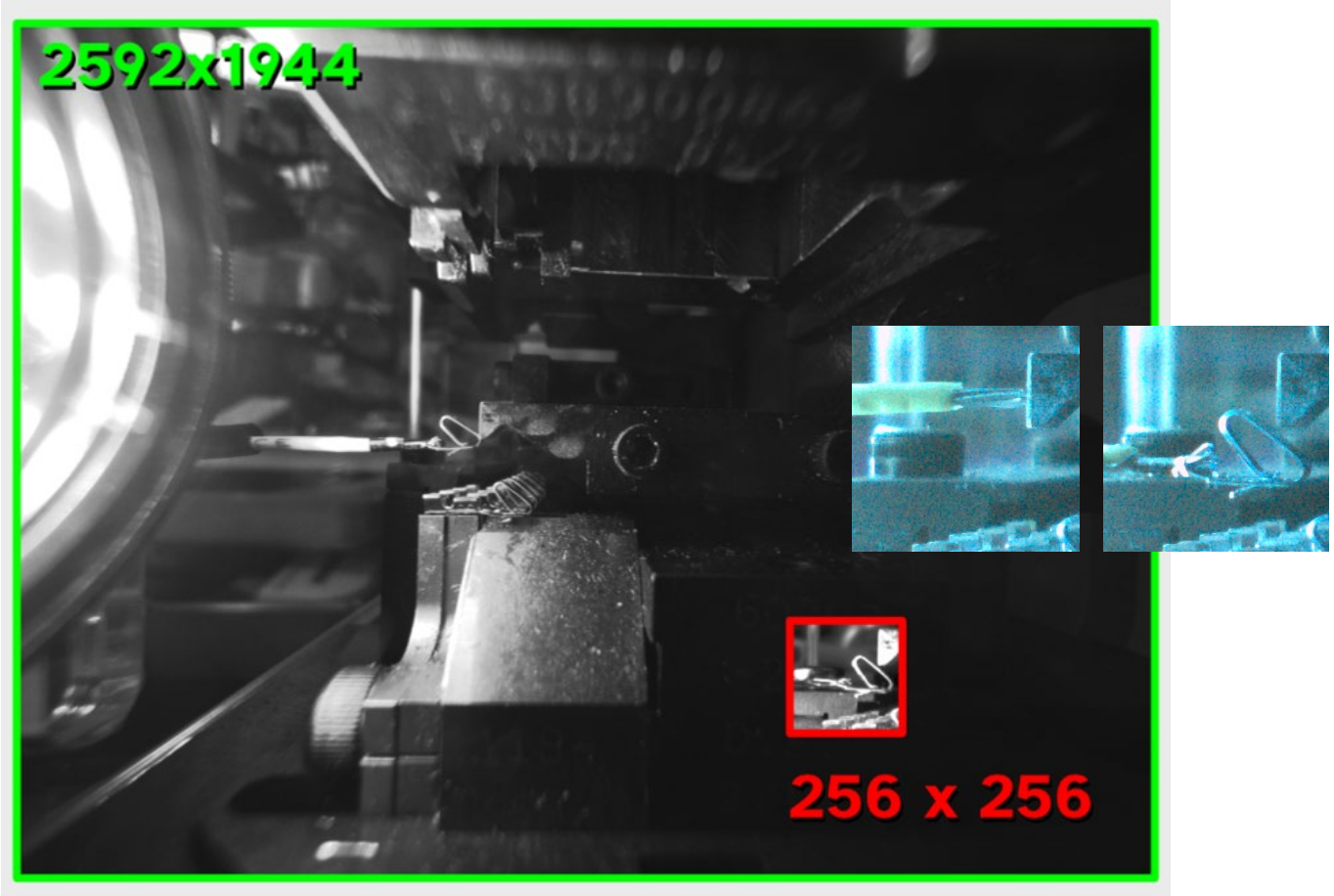


Image from Hexicurity

Benefits

- Optical distortion correction
- Lower power processor
  - 0.9W vs. 120W
  - Fewer processing steps
- No latency
  - 30fps, 100% inference
  - 256^2 inference tiles
- Less memory
- Less cooling
- Reduced system cost

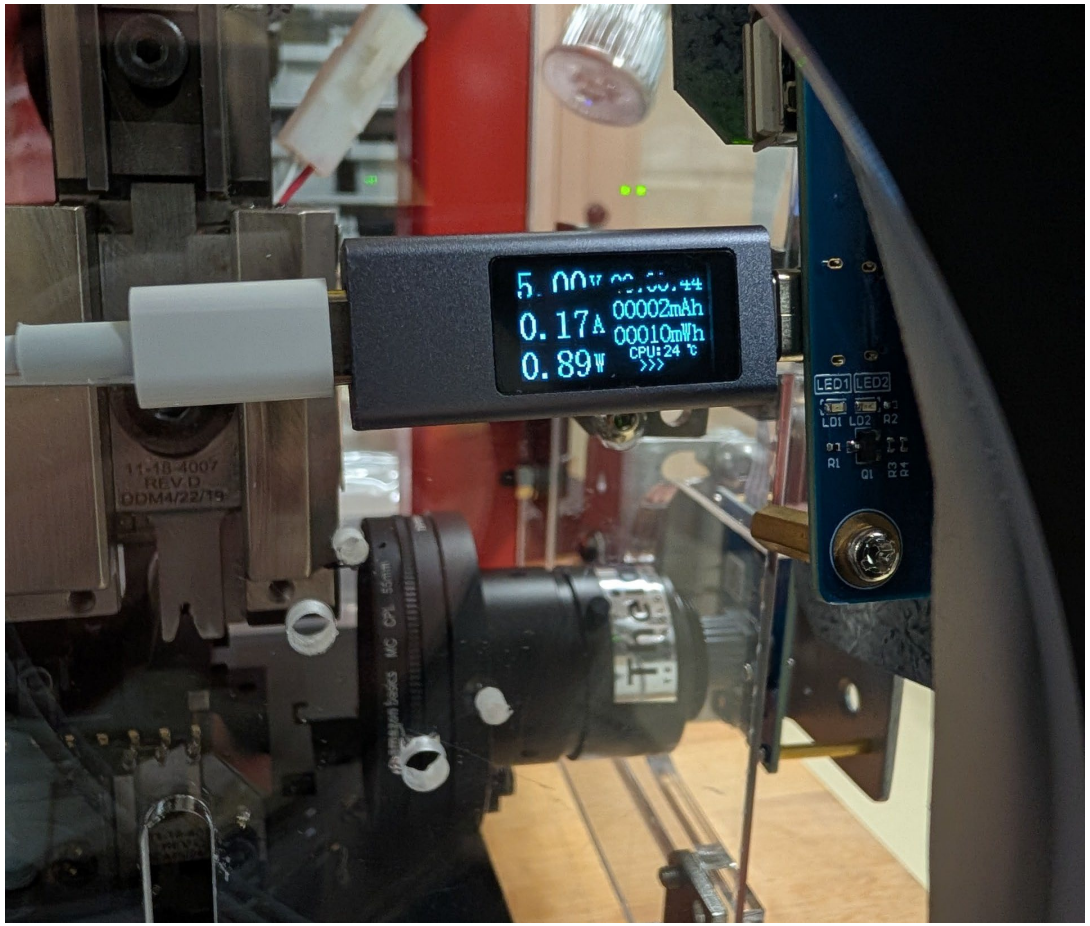
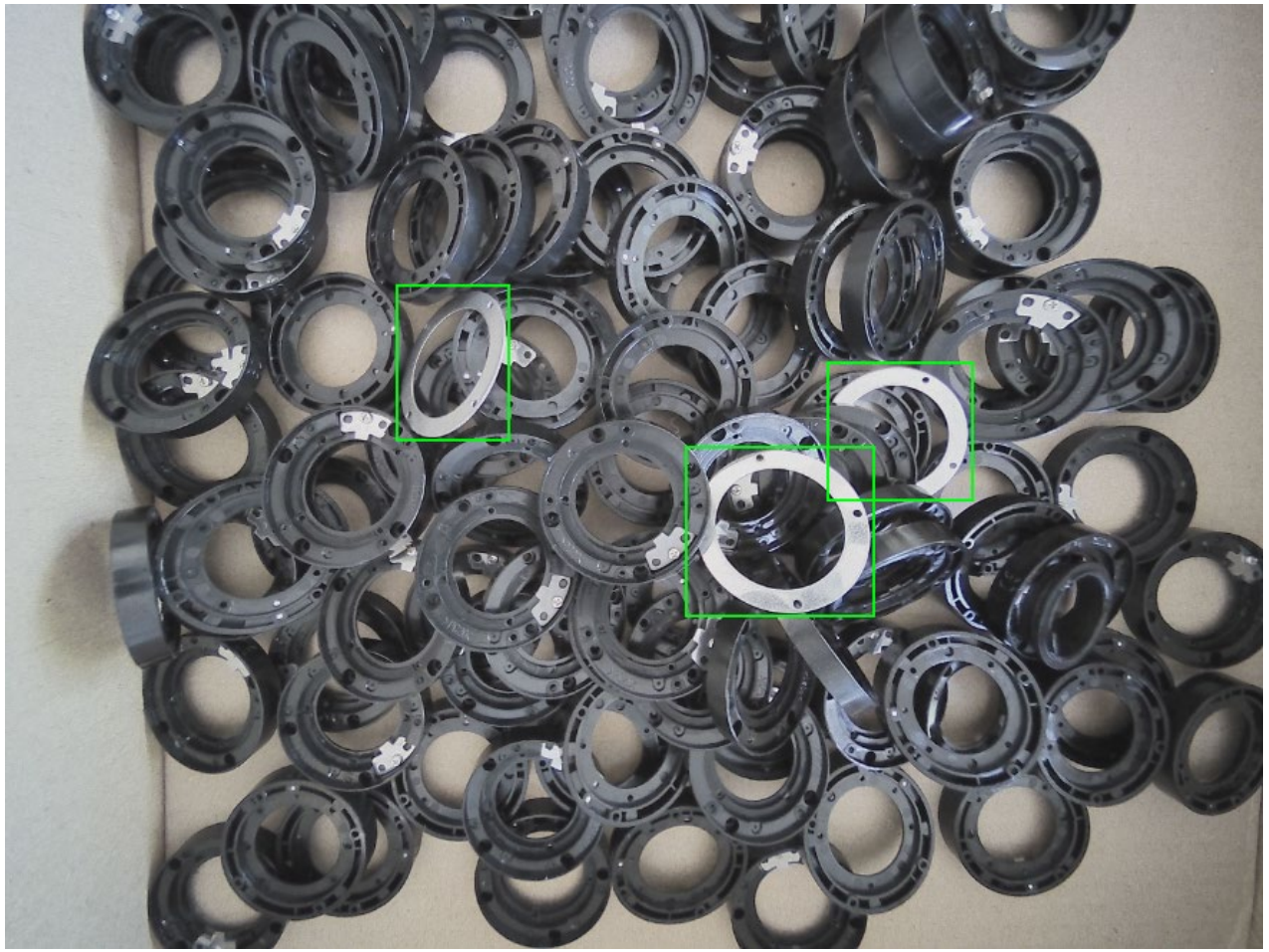


Image from Hexicurity

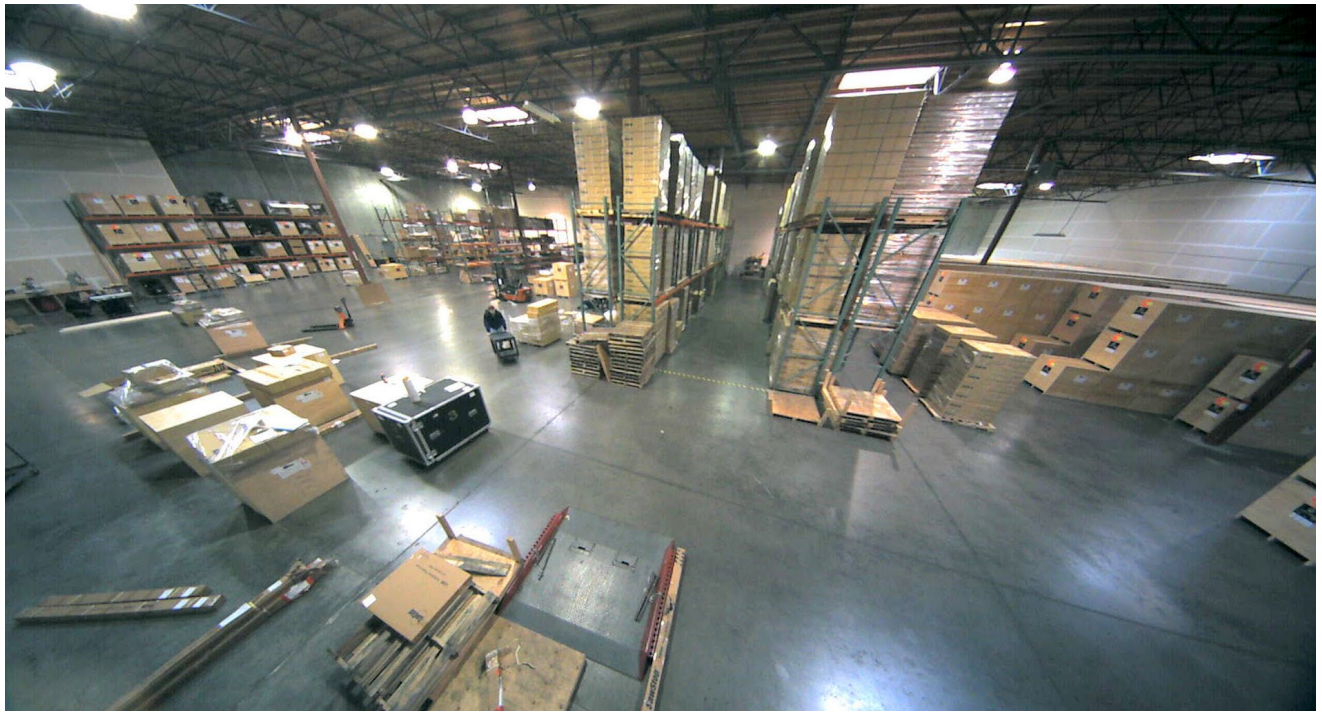
Other applications

- ✓Factory automation & inspection
- ➢Pick & Place Robots



Other applications

- ✓Factory automation & inspection
- ✓Pick & Place Robots
- ➢Logistics



Other applications

- ✓Factory automation & inspection
- ✓Pick & Place Robots
- ✓Logistics
- ➢Embedded Vision

Other applications

- ✓Factory automation & inspection
- ✓Pick & Place Robots
- ✓Logistics
- ✓Embedded Vision
- ➢Autonomous vehicles

About Theia Technologies

- Founded in 2006
- Patented, award winning Linear Optical Technology®
- Design and distribute from Wilsonville, OR, USA
  - Lenses distributed worldwide
  - OEM thin labeling
- Japanese manufacturing partner
- ISO 9001:2015 certified January 2014
- Megapixel lenses for Machine Vision, ITS, Security, Military and Consumer Electronics markets
- Custom Lens Design and Supply

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Theia Rectilinear Lenses

SY125 & MY125	SY110 & MY110	SL183 & ML183	MY23F
1.3mm fixed FL	1.7mm fixed FL	1.8 – 3.0mm varifocal	2.3mm fixed FL
135° HFOV	120° HFOV	120° to 92° HFOV	116° HFOV
7% corner distortion	2% corner distortion	0% corner distortion	<1% corner distortion
Visible or IR only	IR corrected from 440 to 940nm	IR corrected from 440 to 850nm	IR corrected from 440 to 850nm
200 lp/mm	160 lp/mm	200 lp/mm	200 lp/mm
1/2.5” sensor	1/3” sensor	1/2.3” sensor	1/1.8” sensor
0.1m MOD	0.2m MOD	0.3m MOD	0.5m MOD

Conclusion

- Rectilinear lens for optical distortion correction
- Machine learning benefits from clean geometric data
- Lower power, size, cost, complexity
- Enabling practical edge AI machine vision
- Theia offers multiple lens options

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