



shaping the future of optics

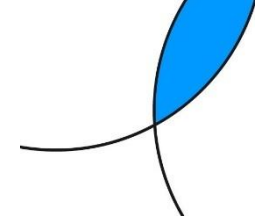
Optotune

How voice-coil based mirrors and pixel-shifters enable new applications in security

EPIC Meeting Disruptive Optics for Security and Beyond
At THALES, 8-9 April 2025, Paris

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- Optotune in a nutshell
- FOV expansion for surveillance
- Mirrors for optical free-space communication
- Pixel-shifters for thermal imaging

Purpose: Make optical innovation happen

Established in 2008

Leader in light controlling components

212 employees

- 105 in Switzerland
- 12 in sales offices
- 95 in Slovakia

Highly innovative

- 48% of staff with Master, 20% with PhD degree
- 28% of revenue spent on R&D
- >200 patents filed, >60 granted

Key markets

- Medical
- Consumer
- Industrial
- Automotive

Privately owned



[SIQT Innovations Award 2020 & 2024 >](#)

[InVision Top Innovations 2017 >](#)

[Vision Systems Innovator Award 2016 >](#)

[Swiss Economic Award 2014 >](#)

[No. 1 Startup in Switzerland 2011 >](#)

[Prism Award 2011 >](#)

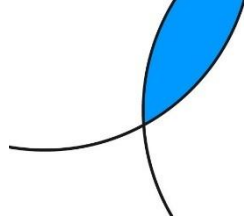
[Swiss Technology Award 2010 >](#)

[Winner of Venture 2008 >](#)

[ETH Spin-off 2008 >](#)



We combine optics and actuators to provide unique solutions



Optics

- Lenses
- Mirrors
- Prisms
- Diffusers
- Windows



Actuators

- Voice coils
- Reluctance force
- Shape memory alloys

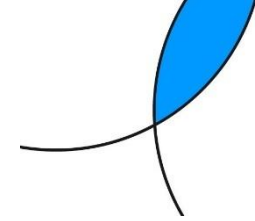
☑ **Compact designs**

☑ **Flexibility**

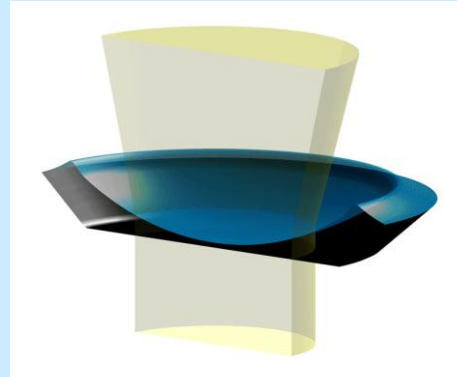
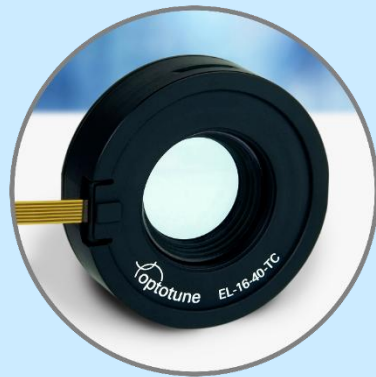
☑ **High speed / throughput**

☑ **Long lifetime**

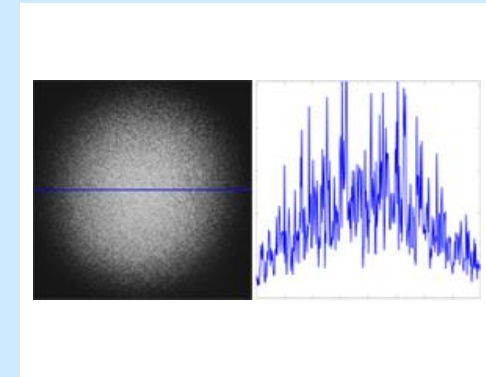
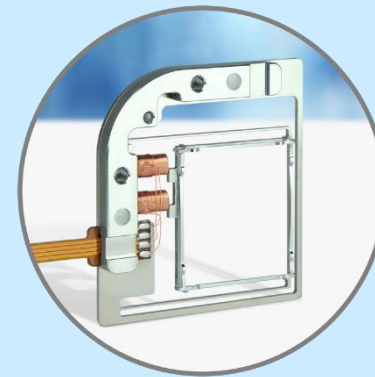
Optotune provides four core product lines



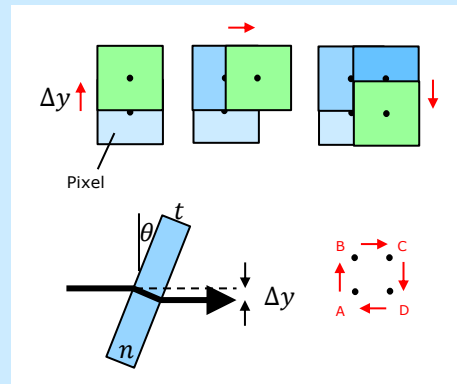
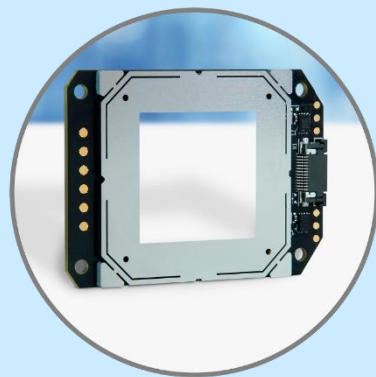
Focus tunable liquid lenses



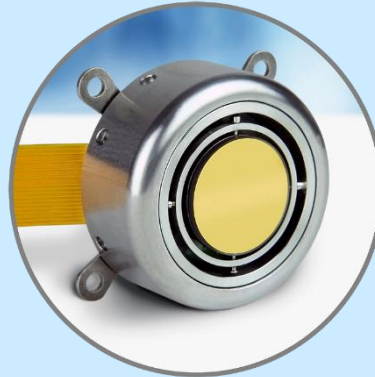
Laser speckle reducers

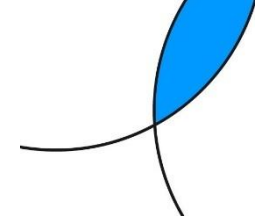


Beam shifting devices



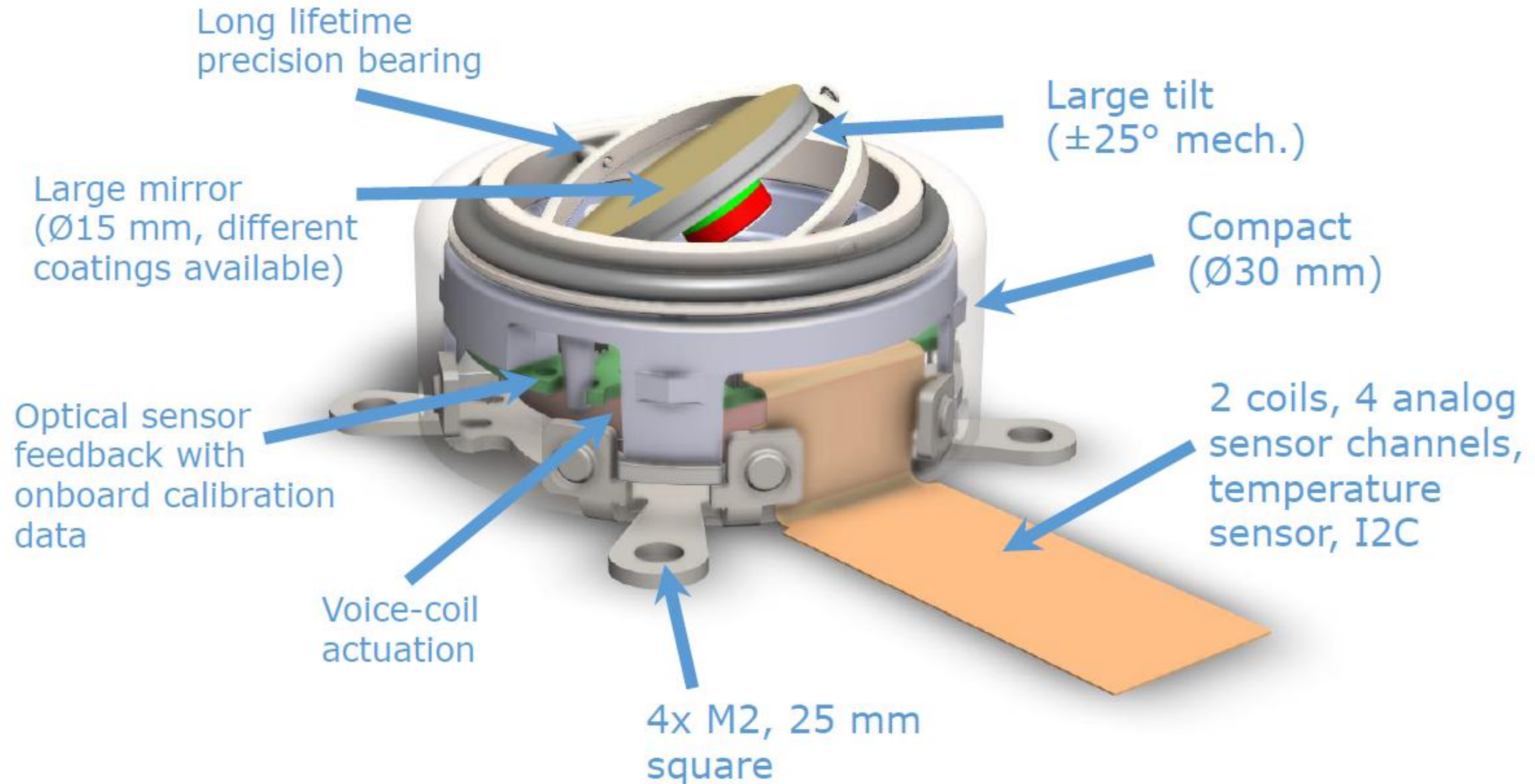
Beam steering devices (2D mirrors)



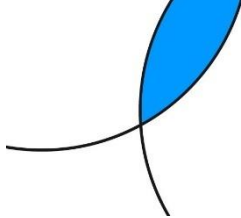


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- Mirrors for optical free-space communication
- Pixel-shifters for thermal imaging

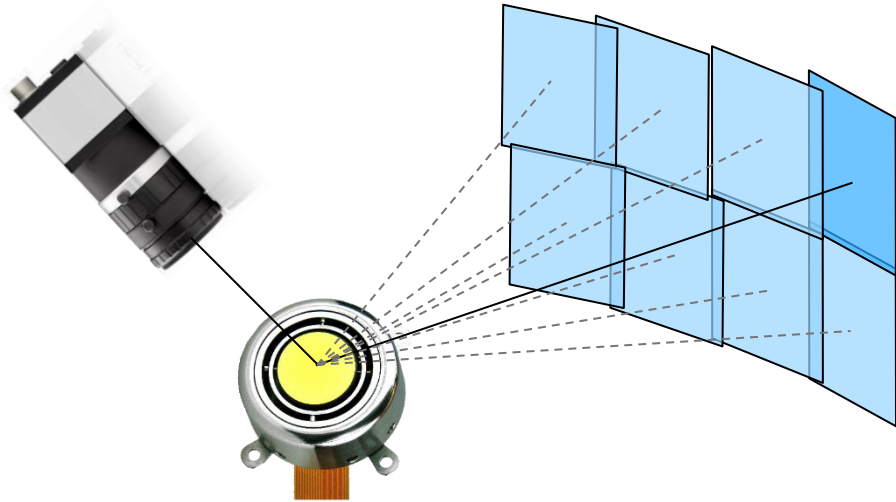
Working principle of fast-steering mirror



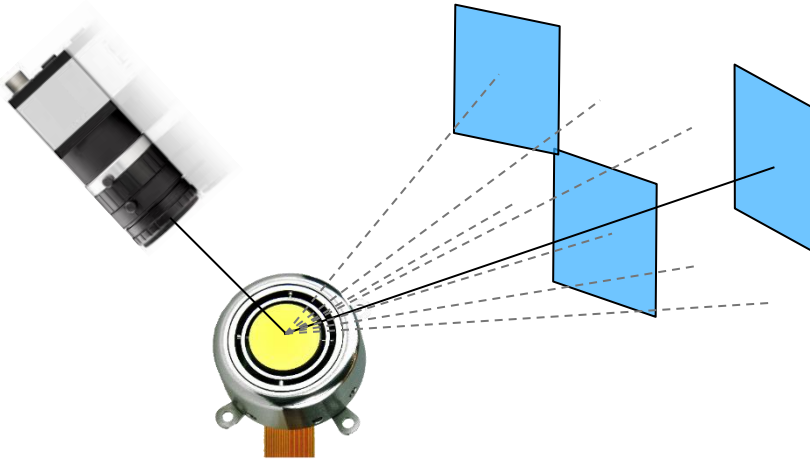
FOV Expansion allows for Gigapixel Imaging or for Area of Interest (AOI) selection



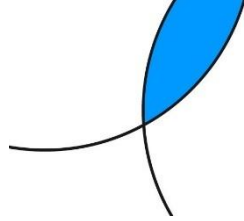
Gigapixel Imaging



Area of interest (AOI) selection



FOV expansion / face recognition devkit



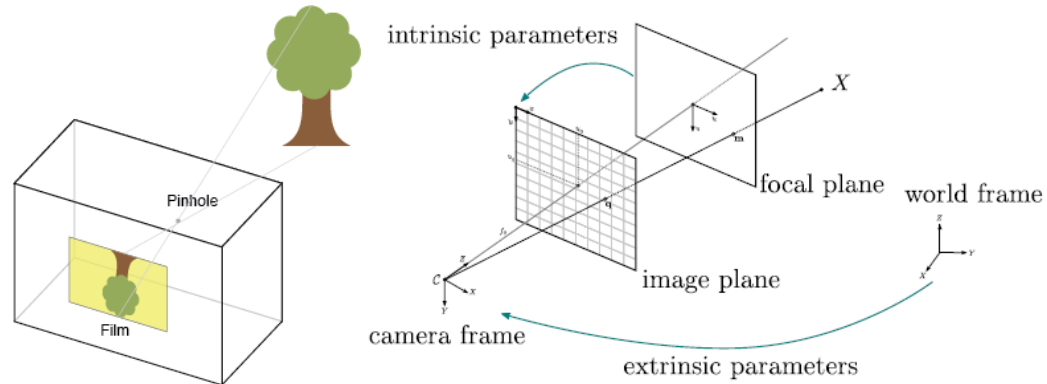
- Applications:

- Surveillance and face-tracking in airports and other public spaces.
- Traffic surveillance (License plate recognition)

Focal length of wide-angle lens	4	mm
f/# of wide-angle lens	f/2.0	
Wide-angle FOV (H x V)	67 x 84	°
Focal length of narrow-angle lens	50 or 75	mm
f/# of narrow-angle lens	f/2.8 (50mm) f/2.8 (75mm)	
Narrow-angle FOV (H x V)	8.2 x 6.1 (50 mm lens) 5.5 x 4.1 (75 mm lens)	°

Step-by-step FOV expansion & face recognition

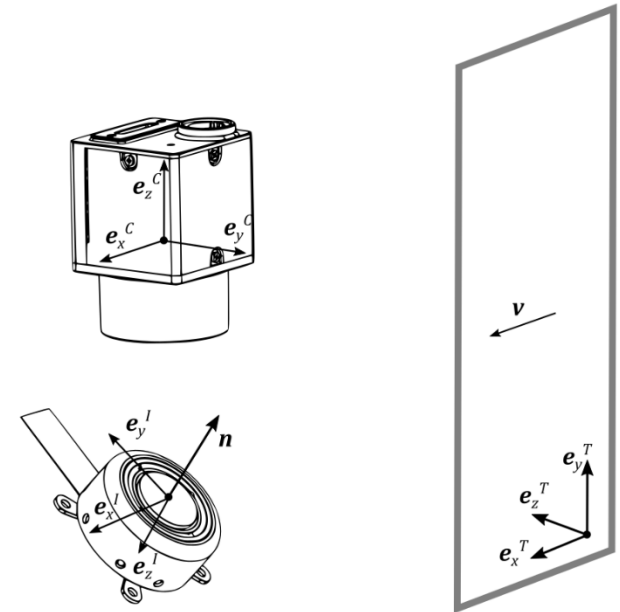
Step 1: Wide angle camera calibration with the «checkerboard method»



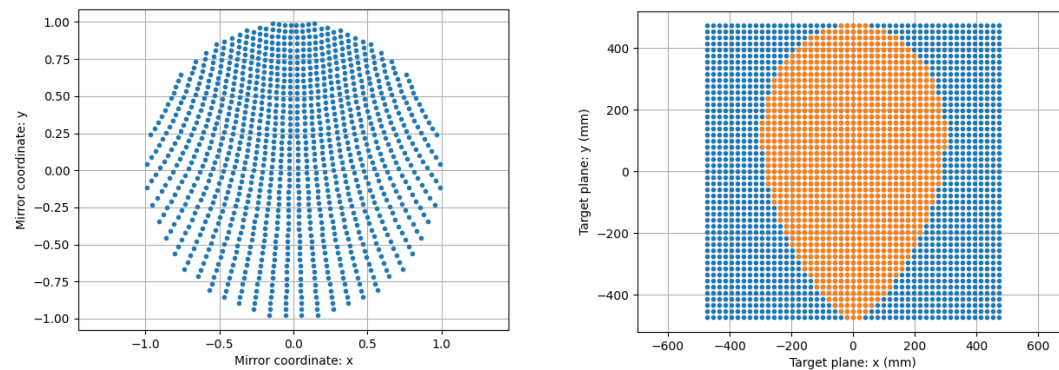
Correct pincushion and barrel distortion



Step 2: Transformation between different Cartesian projection coordinates

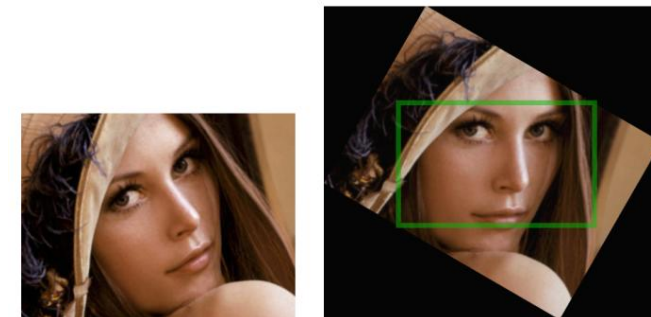


Step 3: Choice of mirror positions



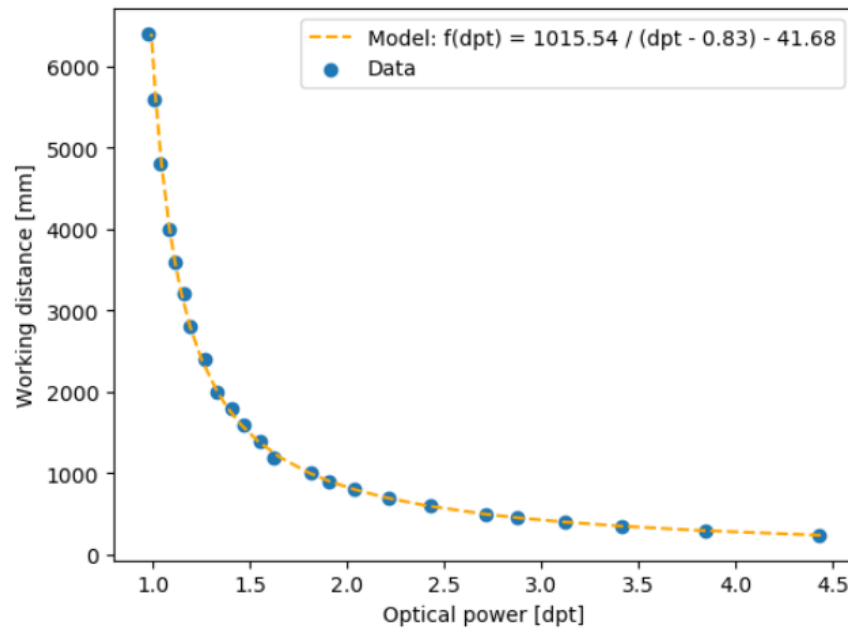
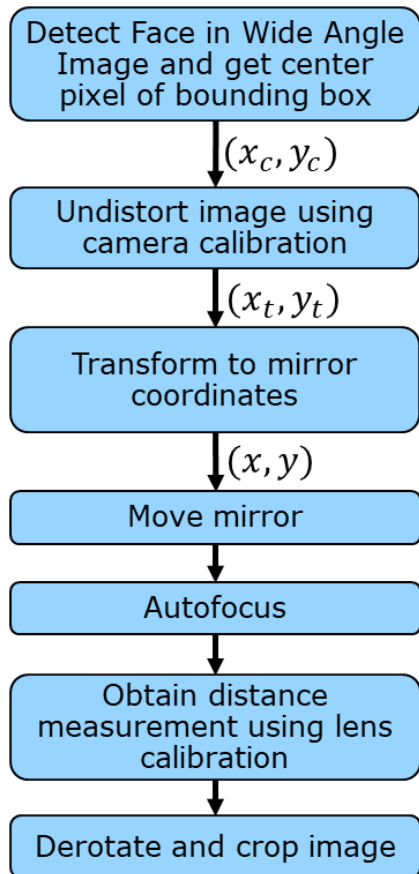
A specific set of non-equally spaced mirror positions (left) results in equally spaced target plane coordinates (right, marked orange).

Step 4: Rotating individual camera frames



Step-by-step FOV expansion & face recognition

Step 5a: Face detection



Flowchart of the face detection demo program in Optotune Cockpit (left) and example of a distance-from-focus calibration (right).

Step 5b: Image stitching based on free Hugin Software



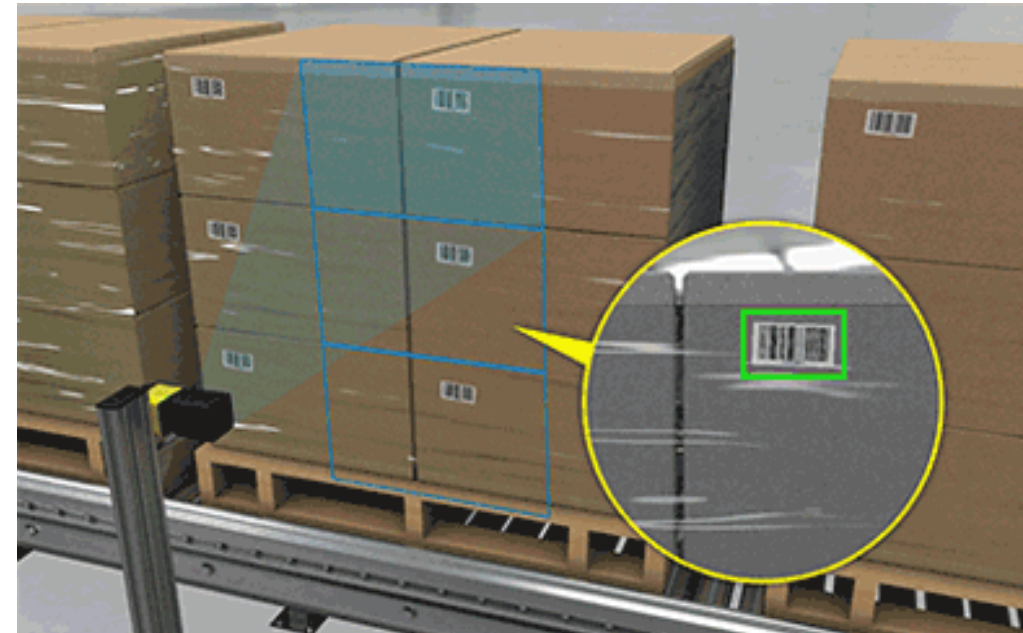
Example of stitched image with gigapixel resolution

Zurich with 1 gigapixel



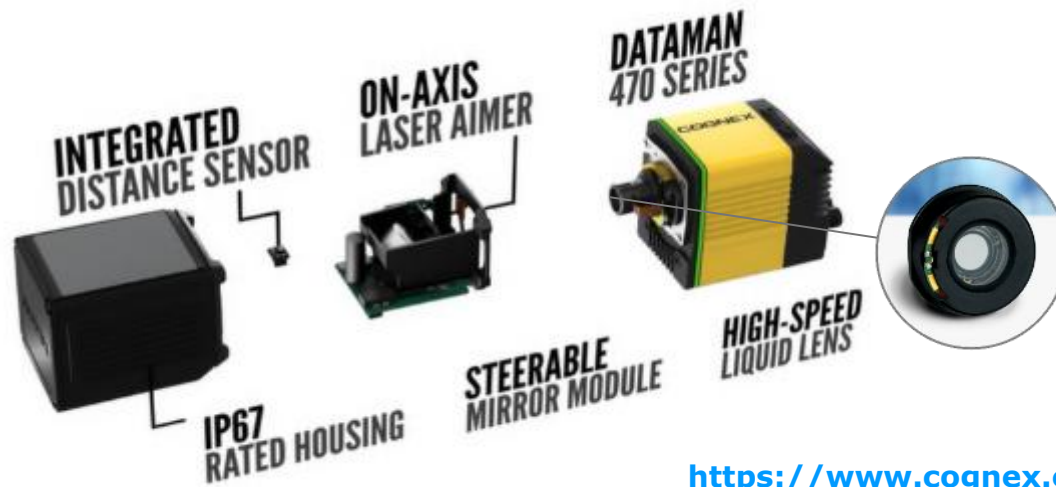
Try out and visit <https://www.optotune.com/gigapixel-image>

Cognex implemented fast code reading across large field of view



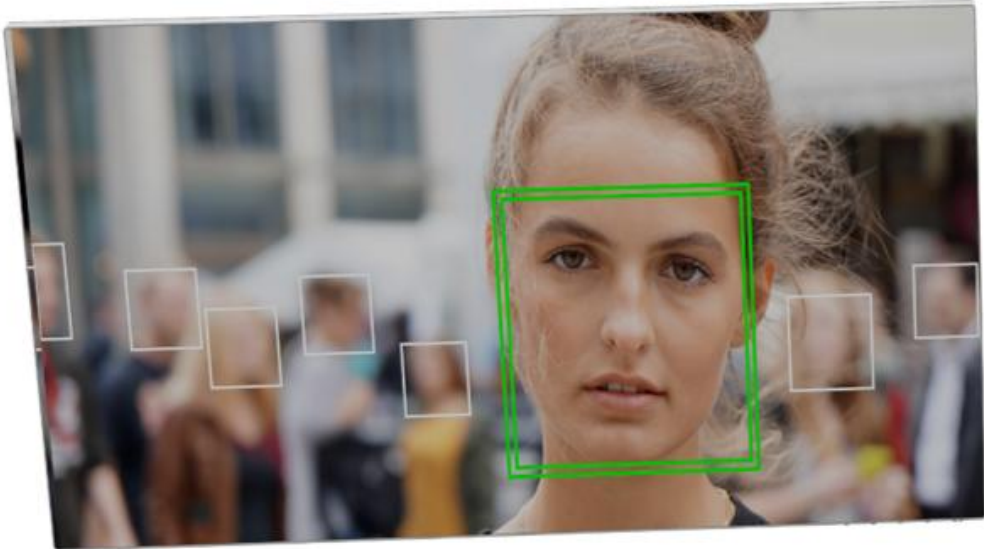
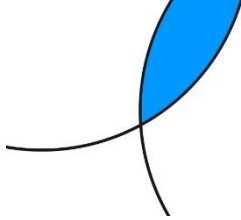
10X larger field of view

Focus from 10cm to infinity



<https://www.cognex.com/products/leading-technology/high-speed-steerable-mirror>

FOV expansion overcomes the traditional resolution limit and allows to “zoom-in” on an object from a large distance

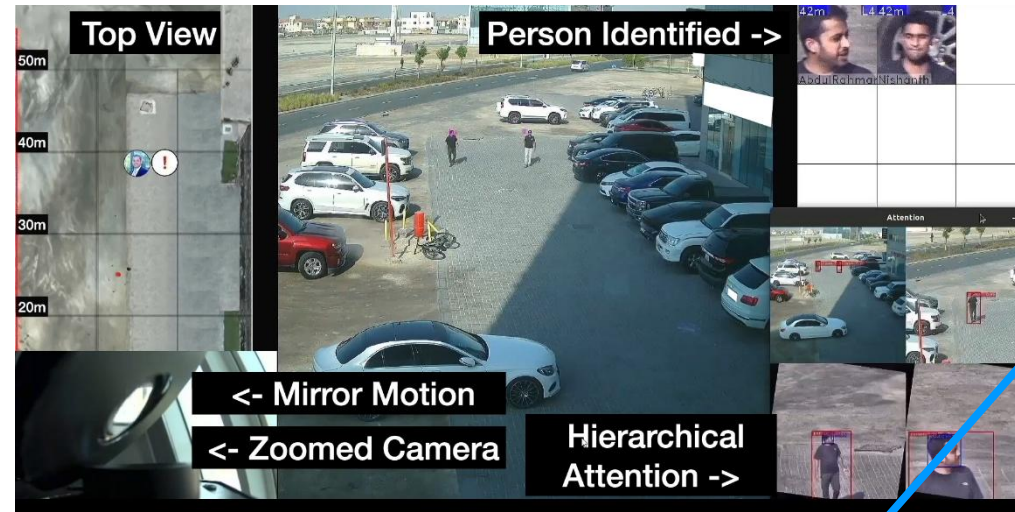


Camera with narrow angle objective

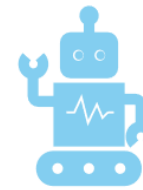
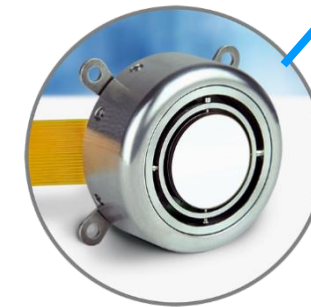
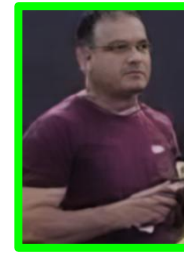
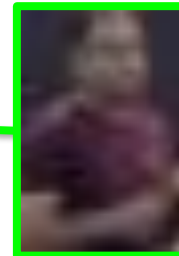


Camera with wide angle objective

Wamda.ai has successfully implemented FOV expansion for security



Sharp Vision Camera
IP67- GCC
Specification

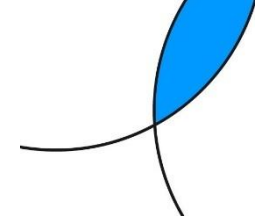


Functionally equivalent to more than 100 FHD cameras (for Face ID coverage of 50 x 50 meters)

* Concept Illustration

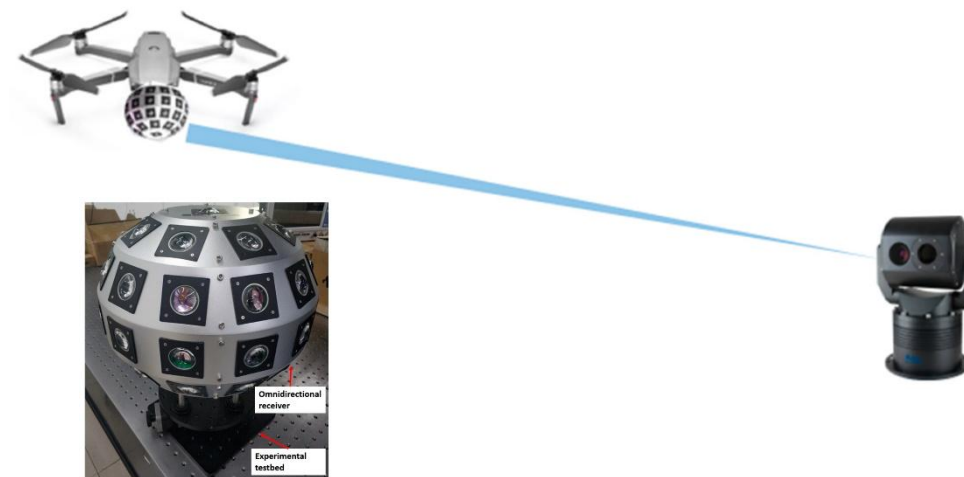
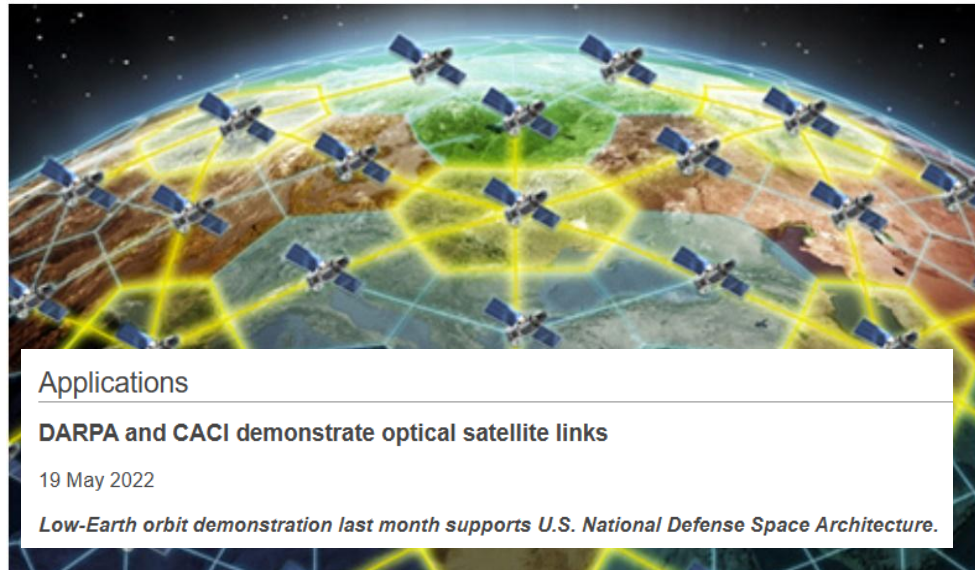
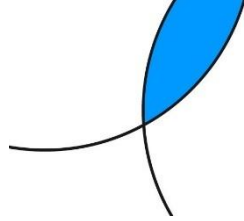
IP cameras

Sharp Vision cameras

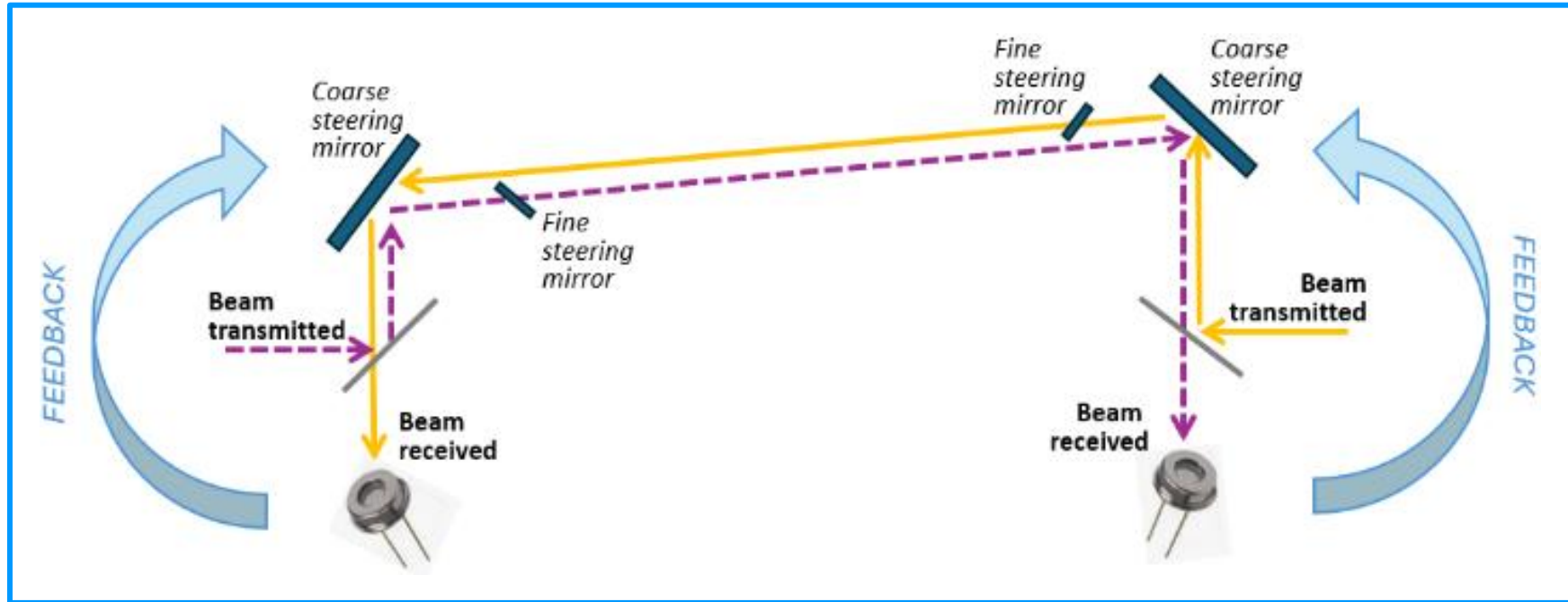
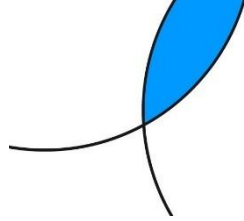


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Free-space optical comms is secure and has high bandwidth

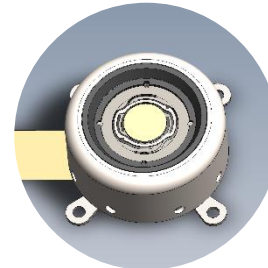
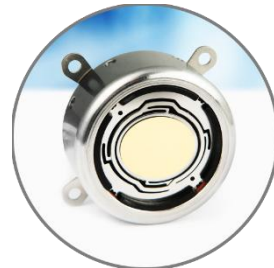


Optotune provides fine & fast steering mirrors for optical comms

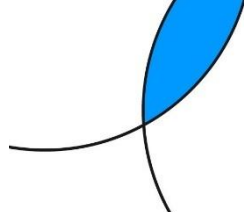


Our mirrors excel at

- lower frequencies (compensation of mechanical vibrations)
- wide angles
- small size
- light weight



Potential of Optotune's mirrors to enhance security

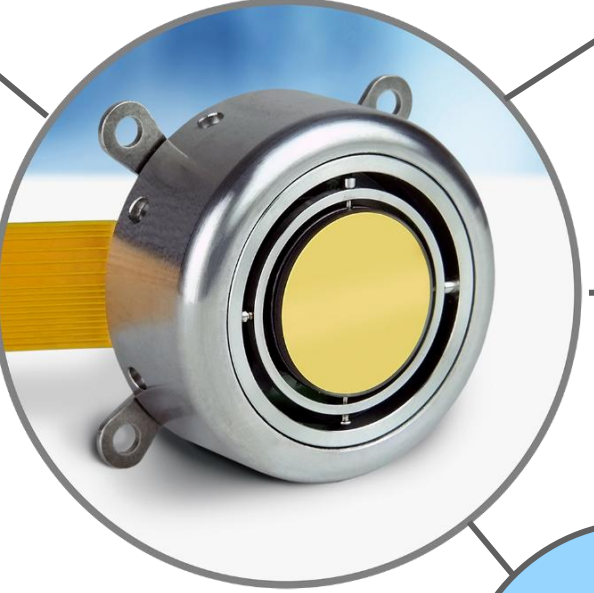


Drone detecting camera system

Drone detecting LiDAR



Laser dazzling

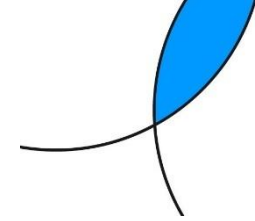


Face tracking in public spaces



Optical Free Space Comms





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Motivation: Beam Shifting Windows increase Resolution

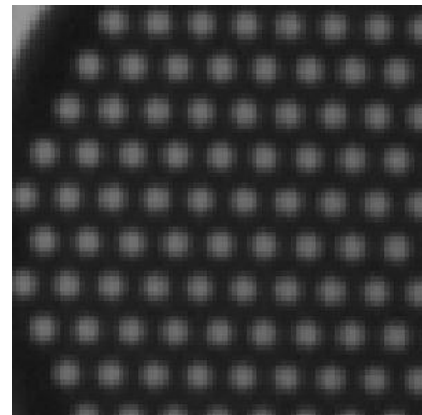
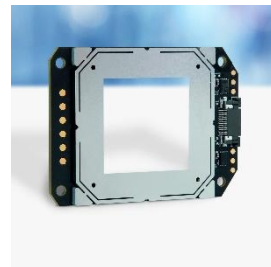
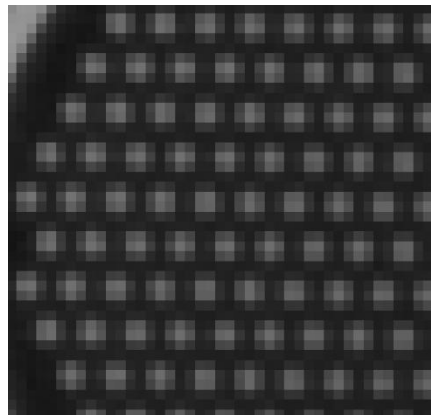
- **Pain point:**

Thermal cameras have large pixels (12-17 μm) that limit spatial resolution.

Large sensors require large imaging optics that are expensive -> not cost-effective

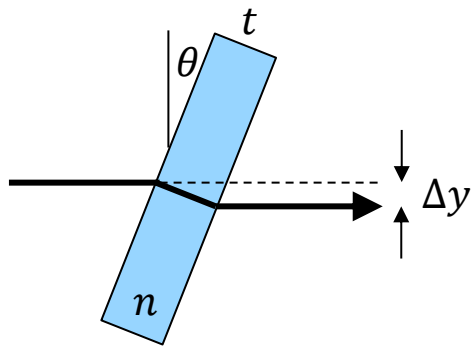
- **Solution:**

Optotune's Beam Shifting windows shift the image across the sensor on a sub-pixel level to increase the resolution



Pixel shifting concept

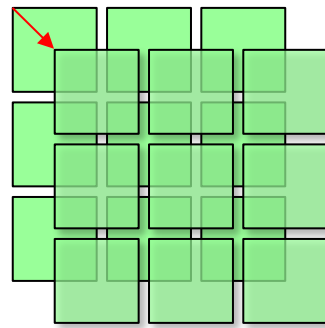
Tilting a window leads to lateral shift of an optical beam



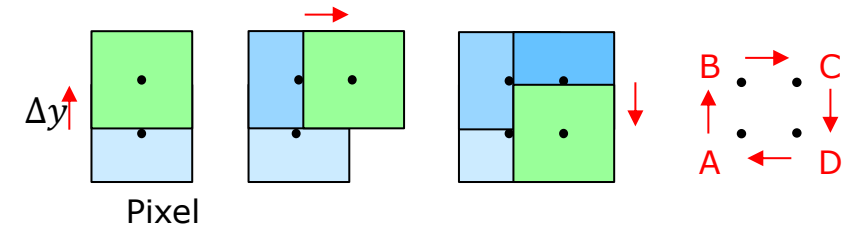
$$\Delta y = t \sin\theta \left(1 - \sqrt{\frac{1 - \sin^2\theta}{n^2 - \sin^2\theta}} \right)$$

Example: A 1 mm thick Germanium window tilted by 1° achieves a shift of $13 \mu\text{m}$

Diagonal 2-position operation

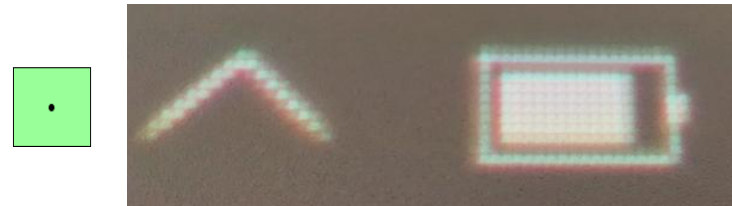


4-position operation

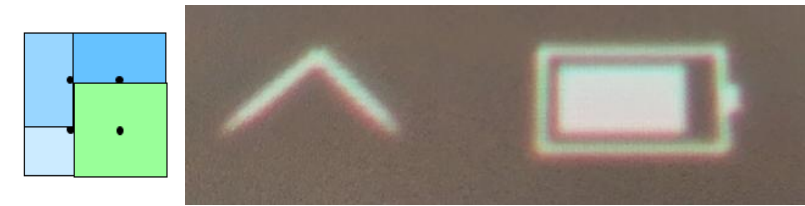


DLP projector example: Resolution increase from 1080p to 4K

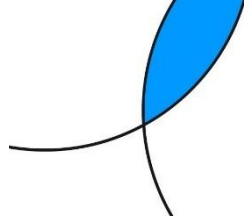
Pixel shifter OFF:



Pixel shifter ON:



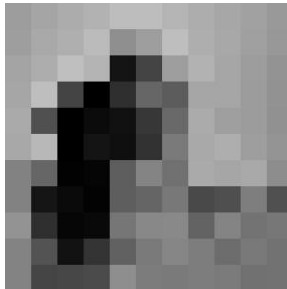
Imaging example: Achieving higher resolution



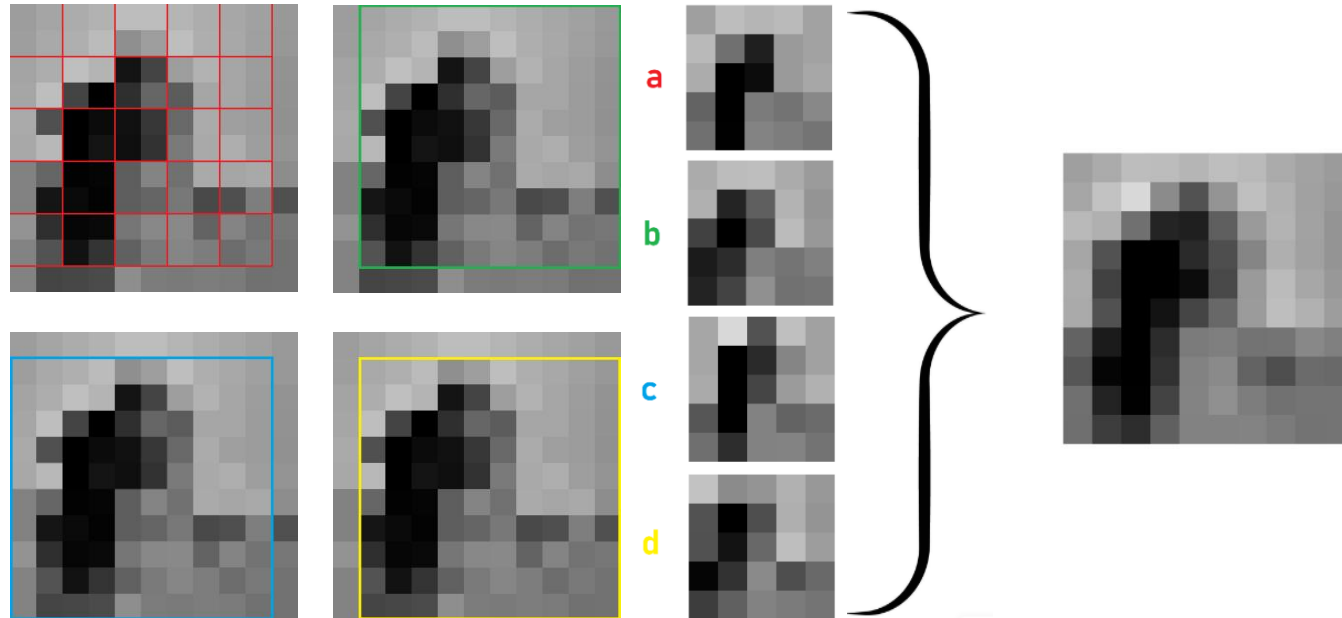
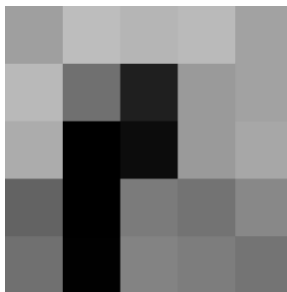
Ground truth



Downsampled to 11x11 pixels



Native camera resolution 5x5 pixels



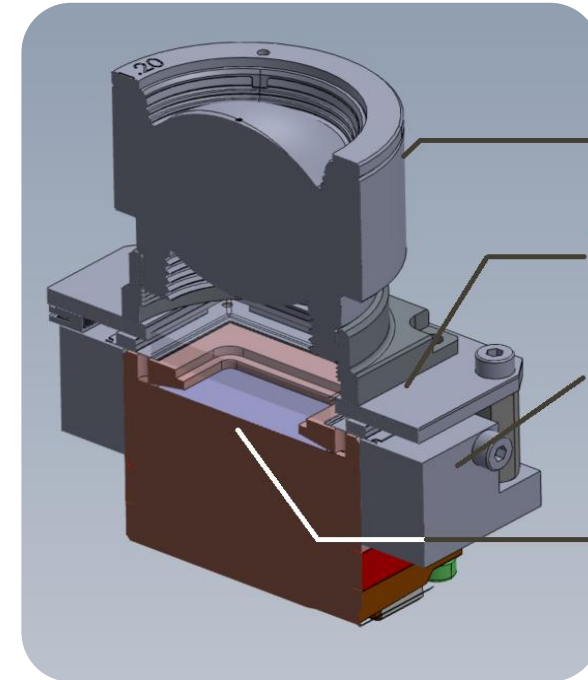
Acquire 4 sequential subframes:

- Native resolution
- Shifted by $\frac{1}{2}$ pixel
- Standard frame rate
- Low noise thanks to large pixels

- Higher resolution image from combined subframes
- Updated with every new subframe at standard frame rate

Camera module

- Camera:
 - SmartIR640 from Photonis
 - Resolution : 640 x 480 (VGA)
 - Operation: uncooled, shutterless
 - Sensitivity: 30mK
 - Pixel pitch: 17 μm
- Lens:
 - Umicore GASIR®
 - Focal length: 25mm
 - F#: f/1.2
- Optotune BSW-20
 - 20 x 20 mm clear aperture
 - 1.3 ms transition time
 - Germanium window (2 mm thick, AR coated)



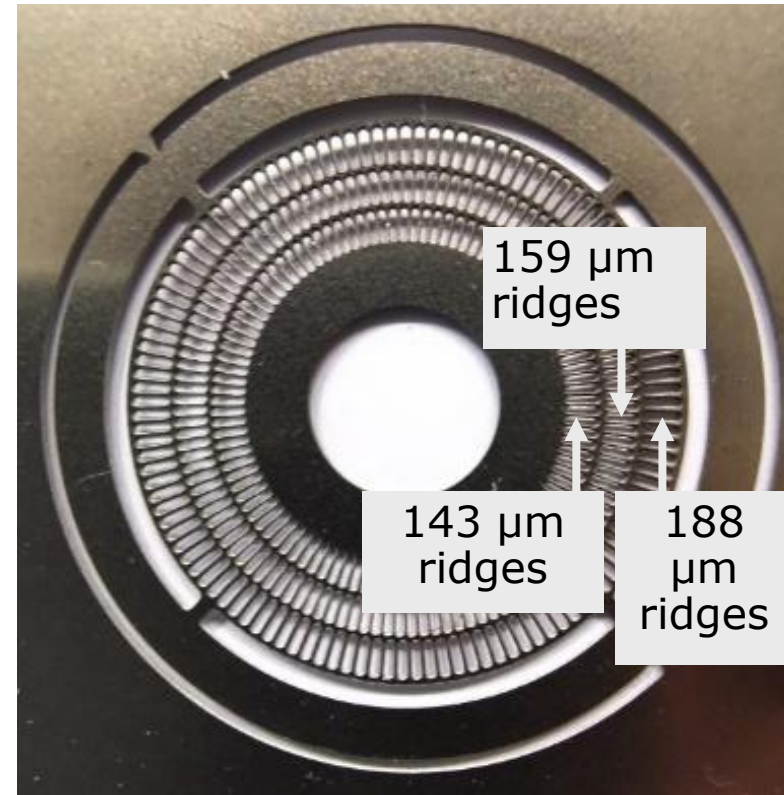
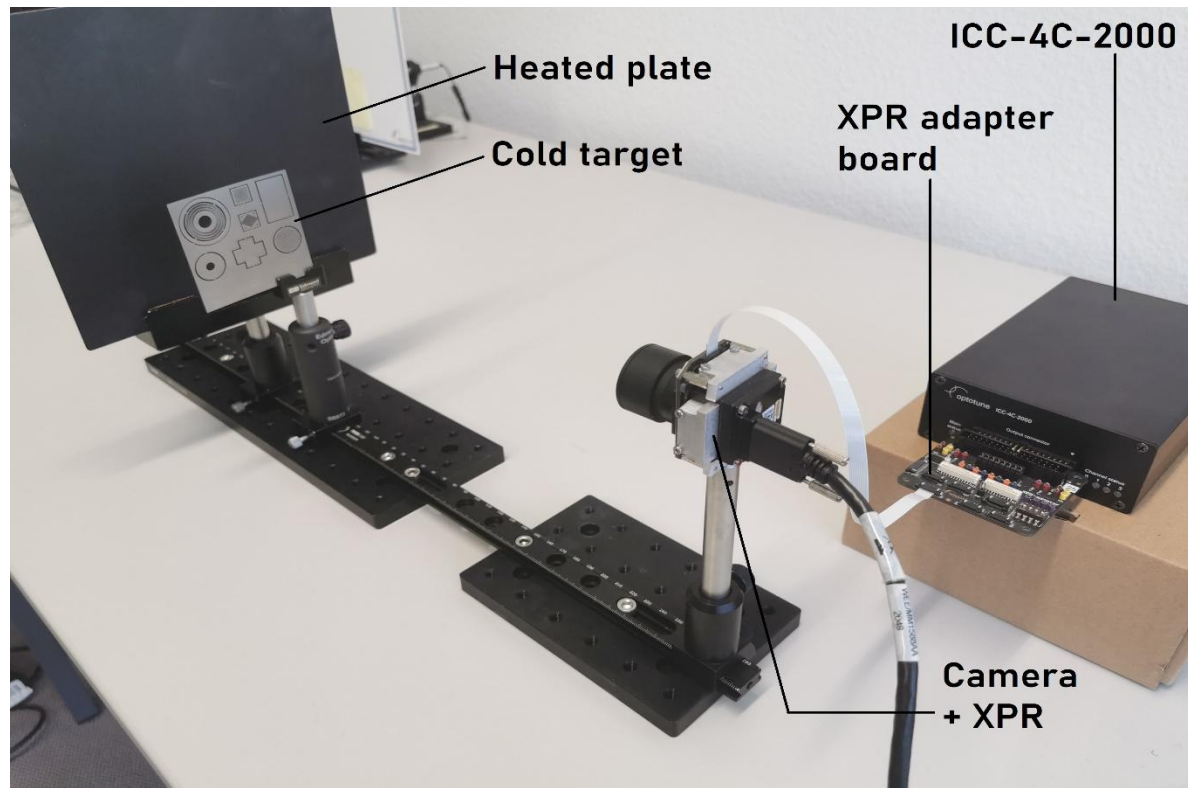
Lens
BSW-20
Mount
Sensor



BSW-20

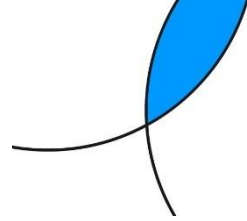
Setup

- XPR-20 imaging a target at 30 cm distance, magnification factor 0.091
- Heated plate behind the target acts as a blackbody

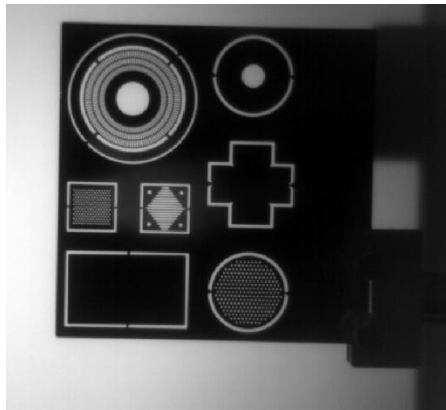


Aluminum plate with alternating ridge/hole pattern of decreasing width

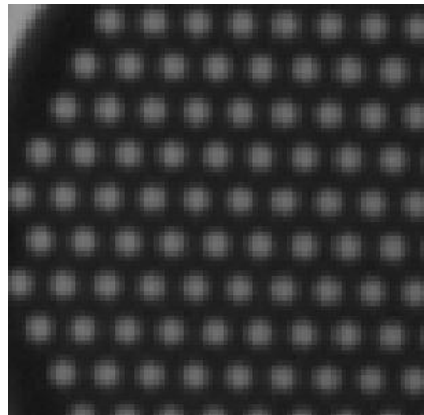
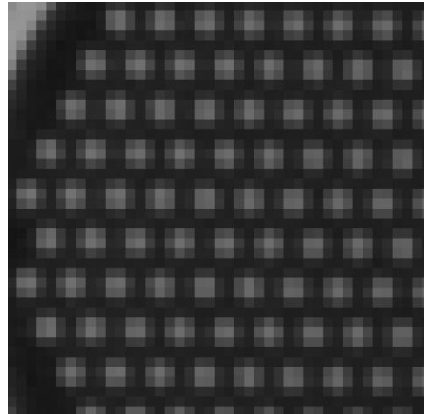
Number of pixels effectively doubled



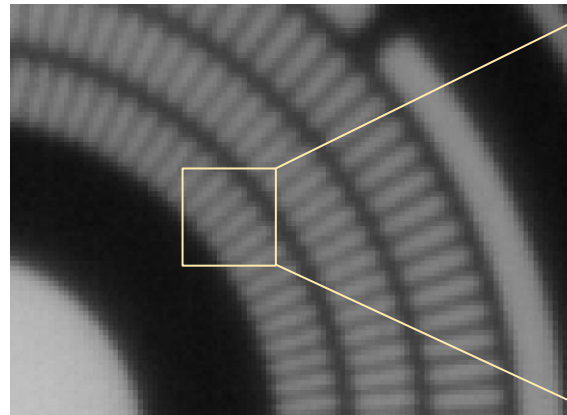
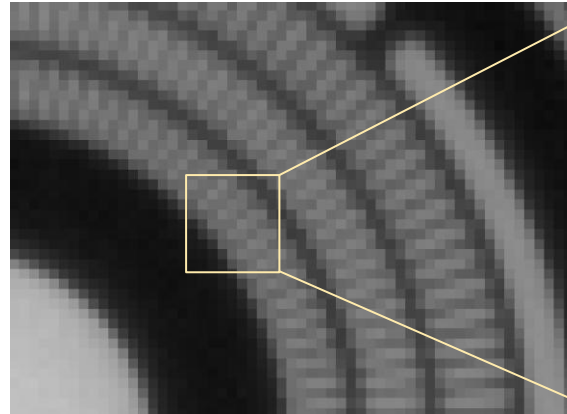
Hot black body illuminating a mask with different patterns



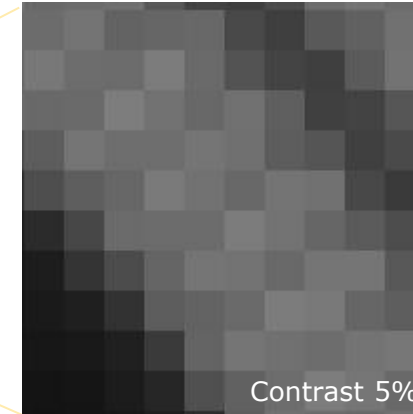
Hole pattern



Line grating



Zoom-in



Contrast 5%

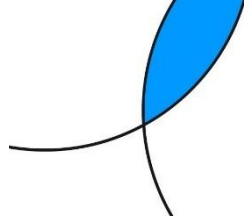
Native resolution at Nyquist limit:
29.4 lp/mm

Enhanced resolution:
41.5 lp/mm

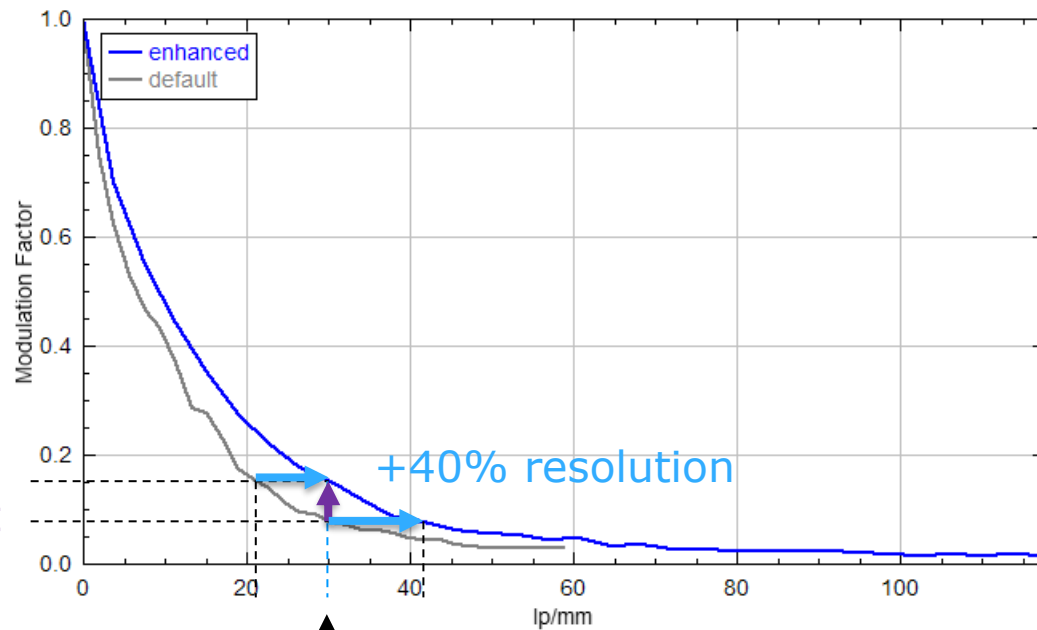
Contrast 12%

- **+40%** in lateral **resolution** (both directions) and improved image contrast
- Amounts to **2x** number of pixels (900 x 675 instead of 640 x 480)

40% increase in resolution and 2x contrast



Modulation Transfer Function



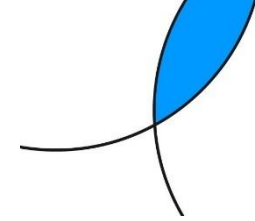
2x contrast at resolution limit

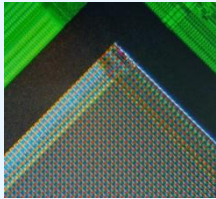

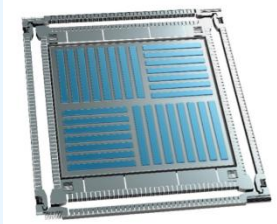
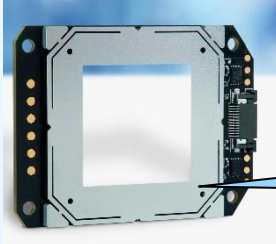
Nyquist frequency

- Resolution increases by 40%
 - From 21 lp/mm to 29.4 lp/mm at 15% contrast
 - From 29.4 lp/mm to 41.5 lp/mm at 7.5% contrast
- Contrast at Nyquist frequency doubles from 7.5% to 15%

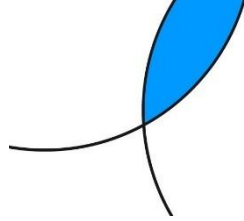
Current solutions

To increase camera resolution



	Smaller pixels	Larger sensors and optics	Sensor shift	Image shift	
				 <div data-bbox="2139 568 2386 677" style="border: 1px solid black; padding: 2px;">no moving wires</div>	
Frame rate	+	+	-	-	
Light sensitivity (signal to noise)	-	+	+	+	Larger pixels can be used
Flexibility	-	-	+	++	Can be integrated into objective or miniaturized into camera. Compatible with any sensor.
Price	\$	\$\$	\$	\$	
Price of compatible optics	\$\$	\$\$\$	\$	\$	Lens MTF does not need to extend to smaller pixels

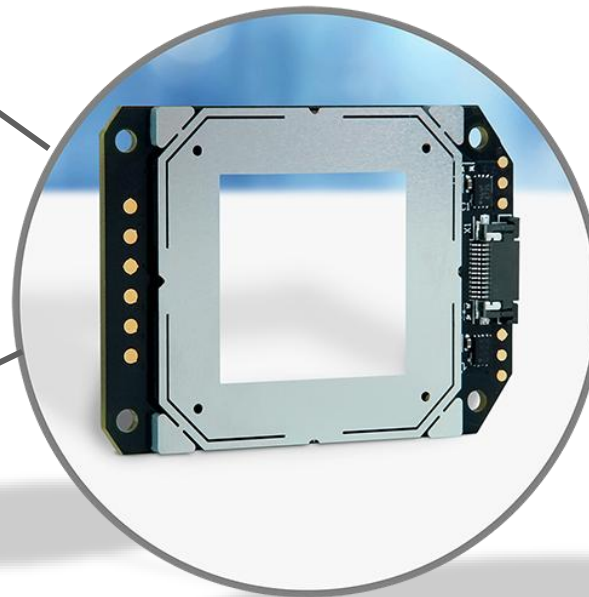
Potential of Optotune's XPRs to enhance security



High resolution drone detecting cameras

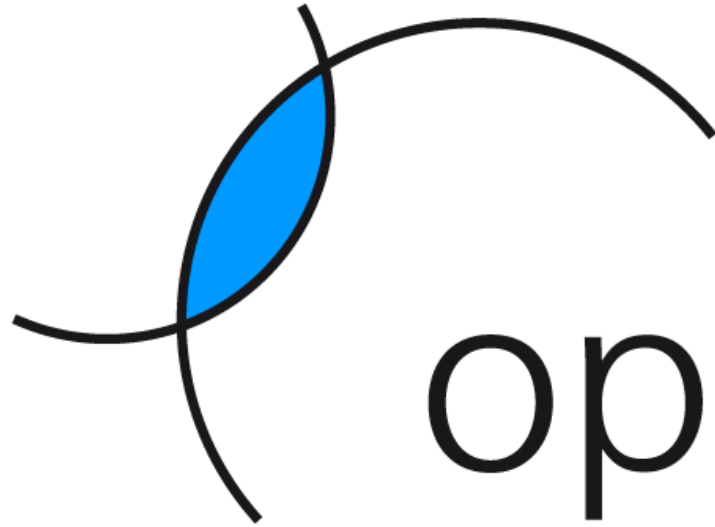


High-resolution thermal imaging



High resolution access control





optotune

shaping the future of optics