future lighting

event voor kennis & innovatie

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Adaptive Luminaires for Smart Museum Lighting

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Fixed lighting systems

+ Optimized *fixed* lighting conditions
- Fixed light distribution for the rest of the system's lifetime

What if the lighting conditions change?

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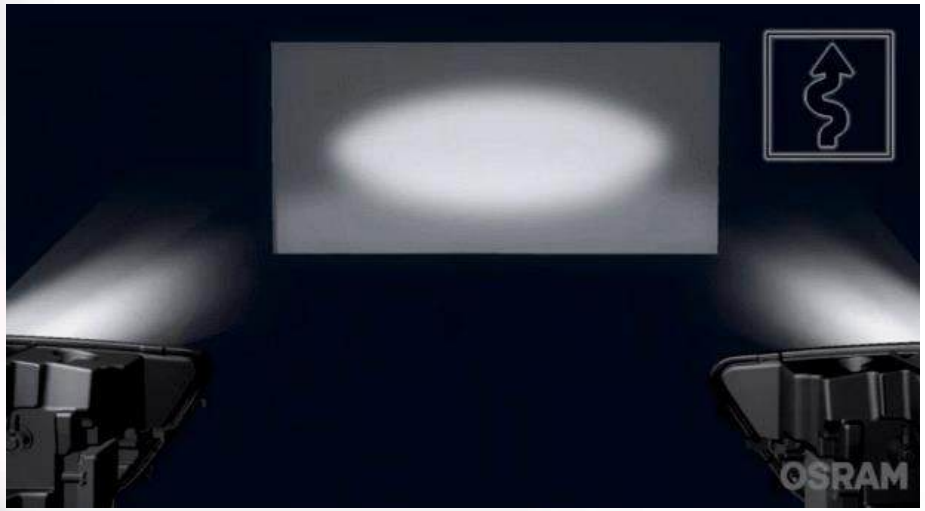
Adaptive illumination components

Adaptive illumination via either

a) Adaptive light sources

b) Adaptive optical systems



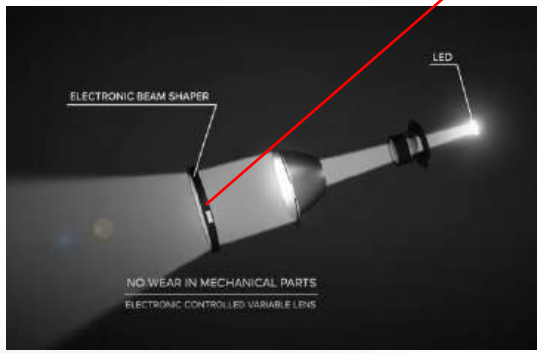
Adaptive illumination components

By using adaptive components in the fixture, adaptive illumination can be realized

1. Tunable diffuser (variable spot size)
2. Rotation of fixture (like a spotlight) generally quite bulky

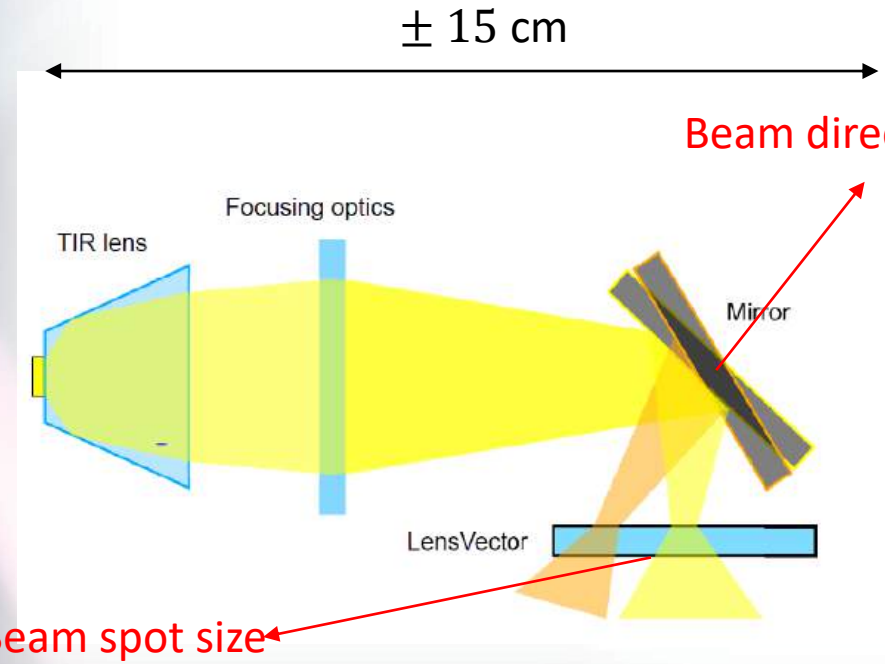
Generally, only one of these functionalities

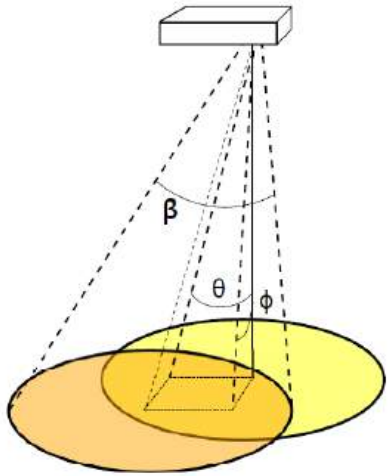
Tunable diffuser

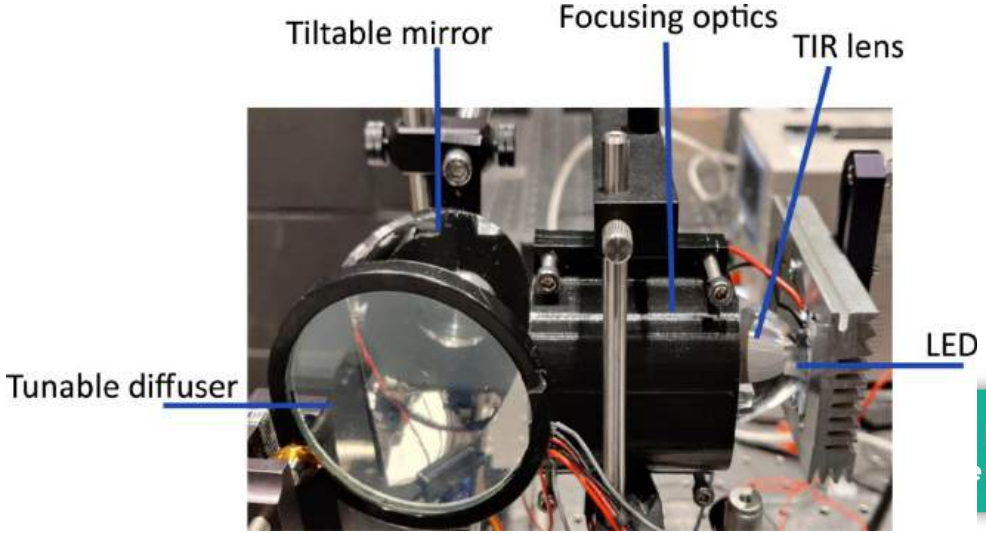


Optical system

- Using a rotateable mirror ⟶ more compactness
- Combine with optics + tunable diffuser

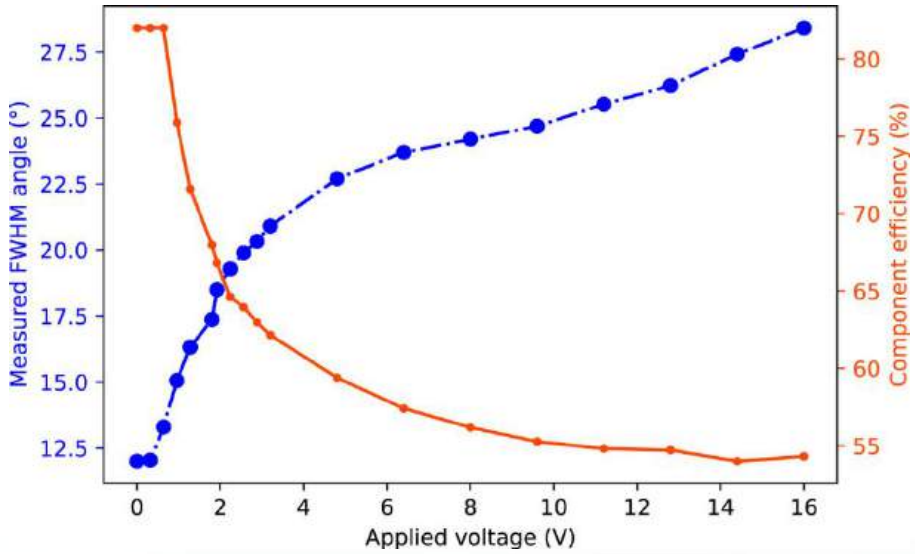






Tunable diffuser

- Tunable diffuser (exit apt. 65.1 mm) – characterized in advance
- Applying different voltages ⟶ changing beam FWHM



Adaptive illumination

- Now we have a compact, adaptive luminaire
- Still requires human expertise for adjusting the light distribution
  - Costs time and money

- Solution: automation
- An AI which
  1. Detects objects
  2. And then illuminates them

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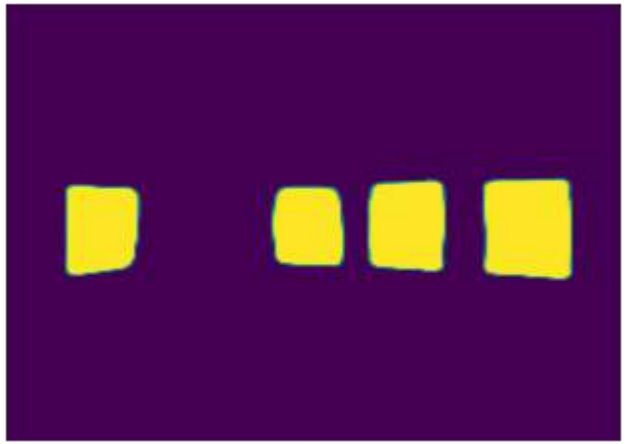
Adaptive illumination - automation

- How to apply such system?
  - E.g., in a museum environment

Microprocessor + camera



Advanced vision

Adaptive illumination

Advanced computer vision

Typical, low-cost vision relies on simplified methods

Low-level vision *(edge detection, …)*

Machine learning *(CNNs, ViTs)*

Machine vision for paintings

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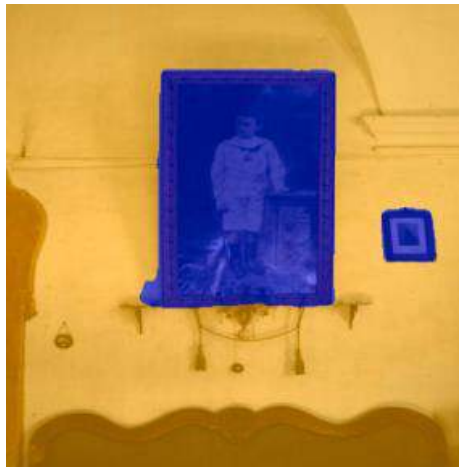
- We can *train* a neural network to detect paintings
- Give a bunch of images with paintings
  - And show it where the paintings are located
  - Given enough different images, it can learn to robustly detect paintings

Training images



New image

Full system integration

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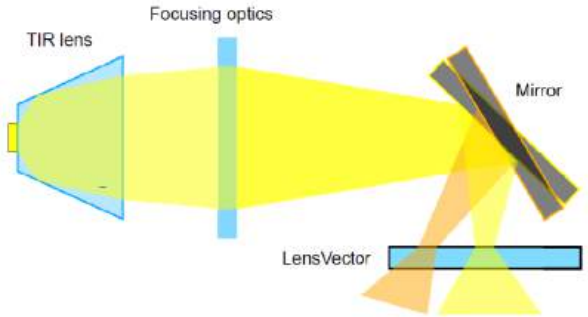
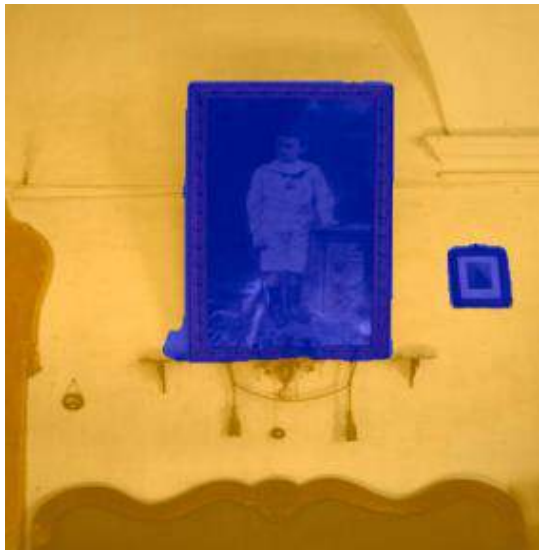
- Now we have
  - An adaptive optical system
  - A microprocessor with camera, detecting paintings





How to get the system to actually match the light distribution to this painting?

Summary of procedure

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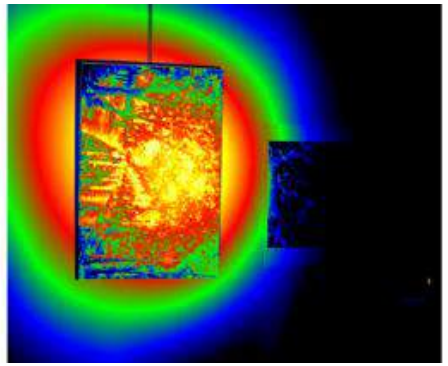
Turn on LED at widest opening angle, neutral mirror position

Determine current center spot & deviation to detected center

iterate



Demonstration

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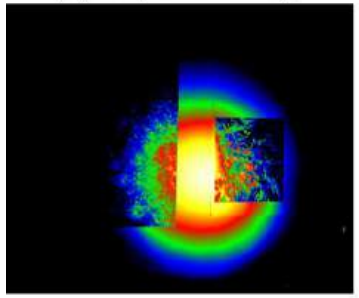
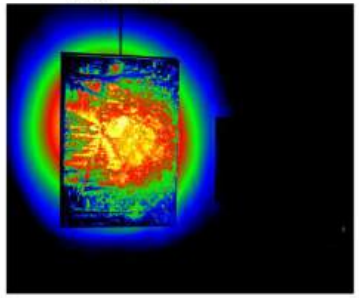
(a) Captured image

(b) Segmentation

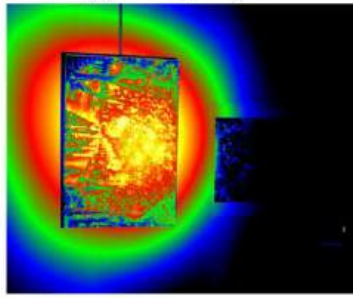
(c) Target spot



(d) Neutral mirror starting beam



(e) Beam direction adjusted



(f) Beam divergence adjusted

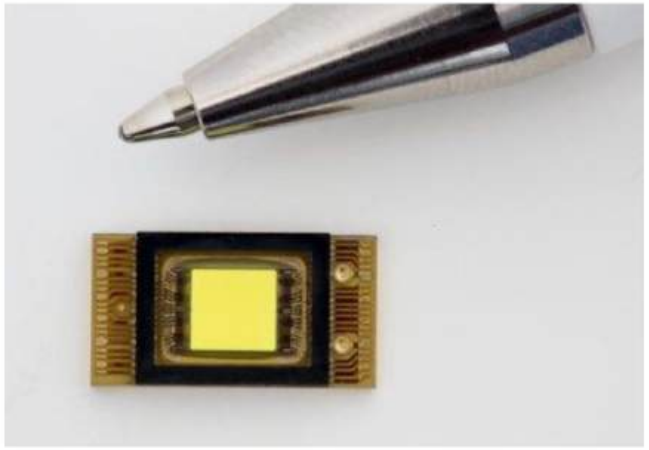
Possible downsides

- Circular spot does not *match* the rectangular painting shape
- 1 system can illuminate 1 paintings
  - Could be solved by integrating multiple luminaires with a microprocessor

- **Other adaptive lighting systems?**

LED arrays - challenges

- Projected LED arrays
- Mostly applied in automotives, with different specifications than general lighting
  - Limited color performance (CRI, Duv)
  - Low efficiency



Outlook – future vision

- But if these LED array issues are addressed..
- Use RGB LEDs -- full color control

Thank you!

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