A New Optical Imaging Approach for Detecting Drowsy Drivers

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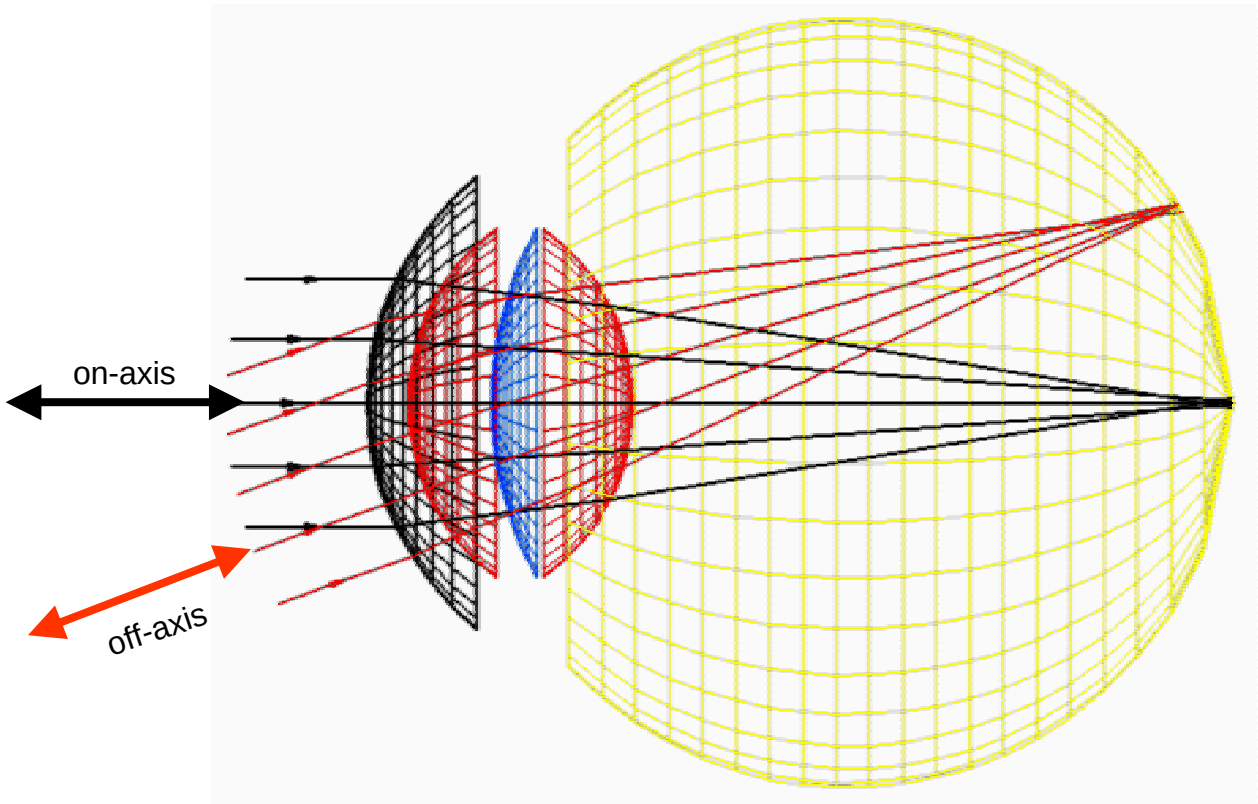
6 Oct., 2004

Drowsy driver detection

Falling asleep at the wheel causes

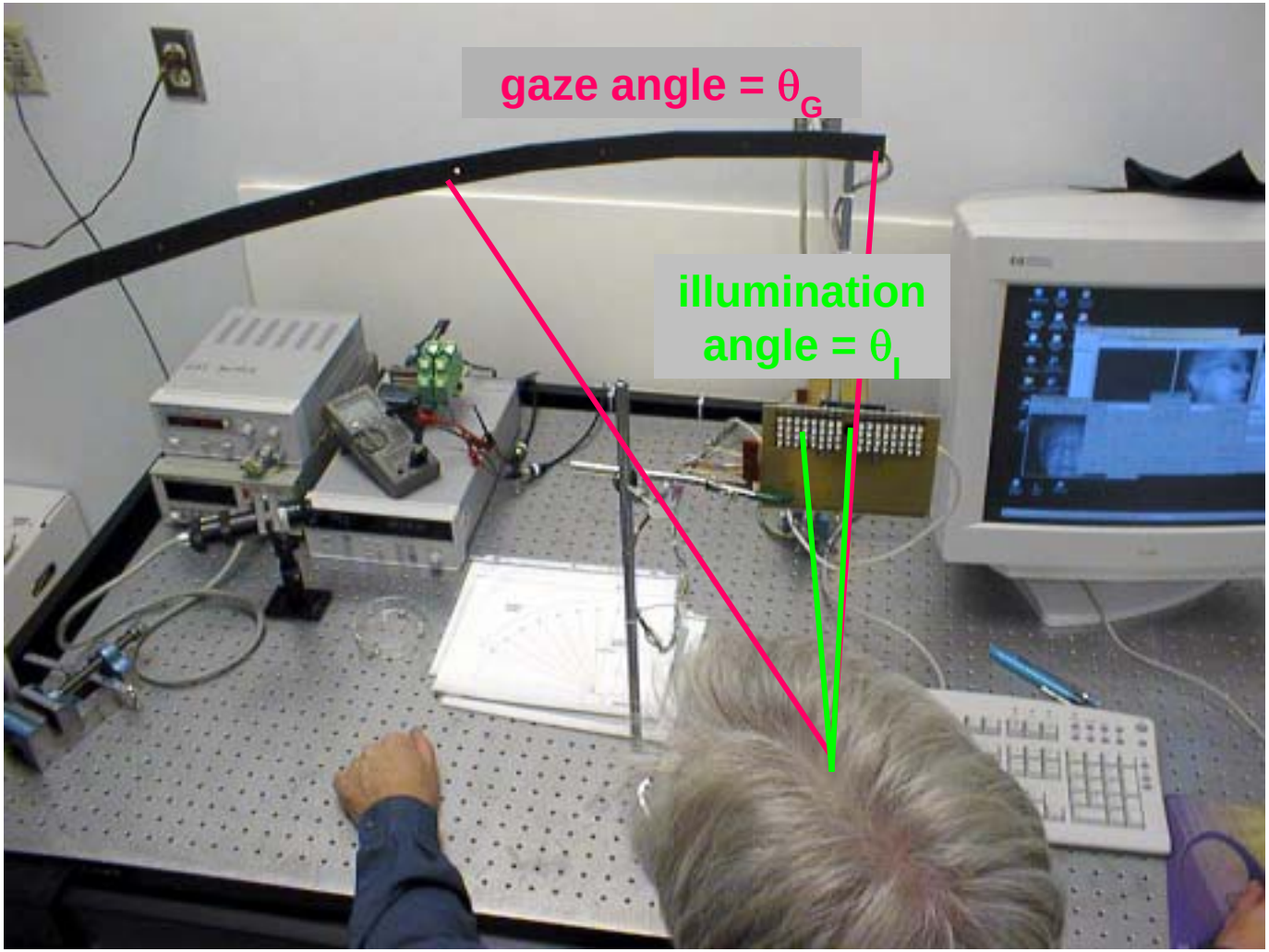
- 100,000 accidents per year in US
- 1,550 deaths (out of 38,000) (may be low - Dement)
- 24% of motorway fatalities in Germany (German Insurance Inst.)
- $15.5B losses per year in US (NHTSA)
- Tax break legislation for DDD equip. pending in US

“Red-eye” effect



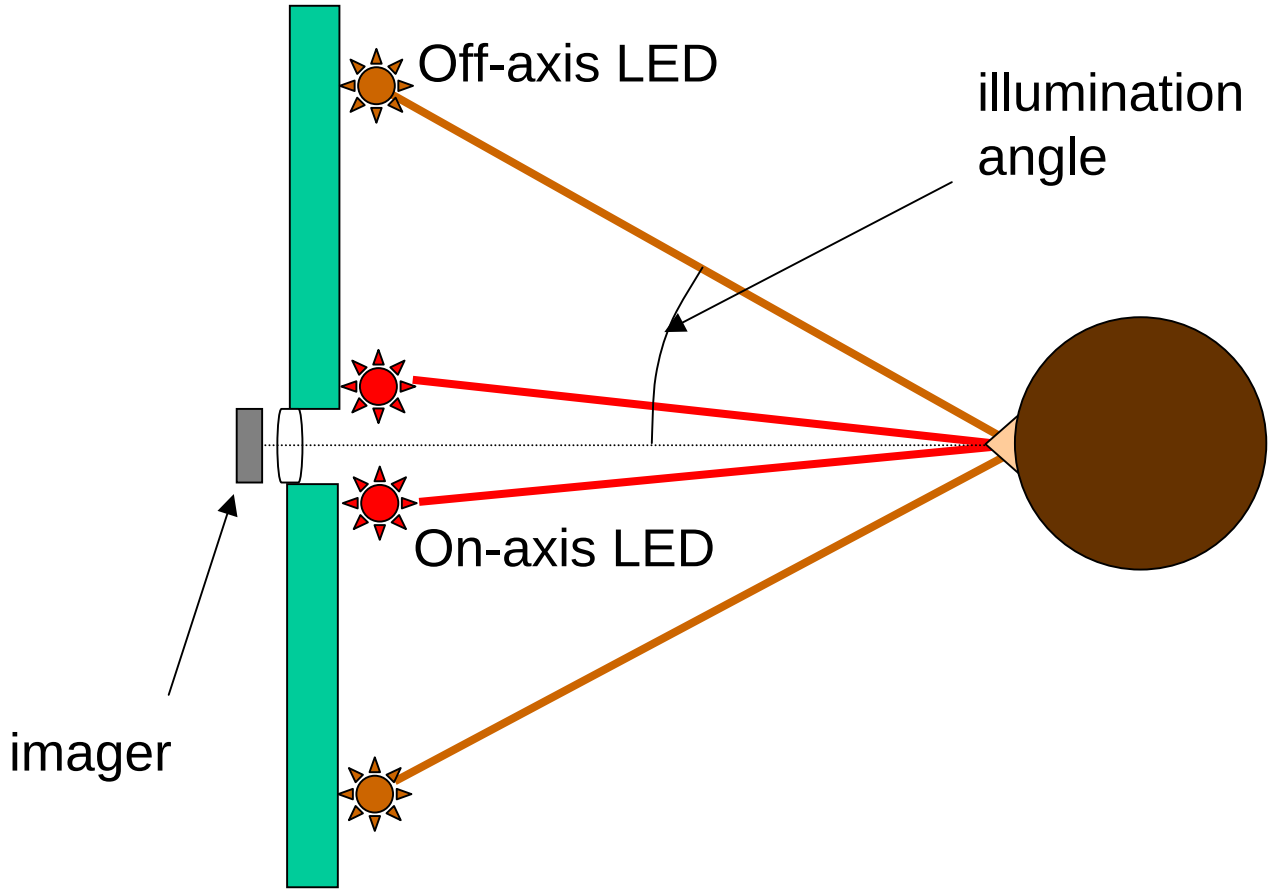
The eye reflects light back to the source.

Illumination angle vs. gaze angle

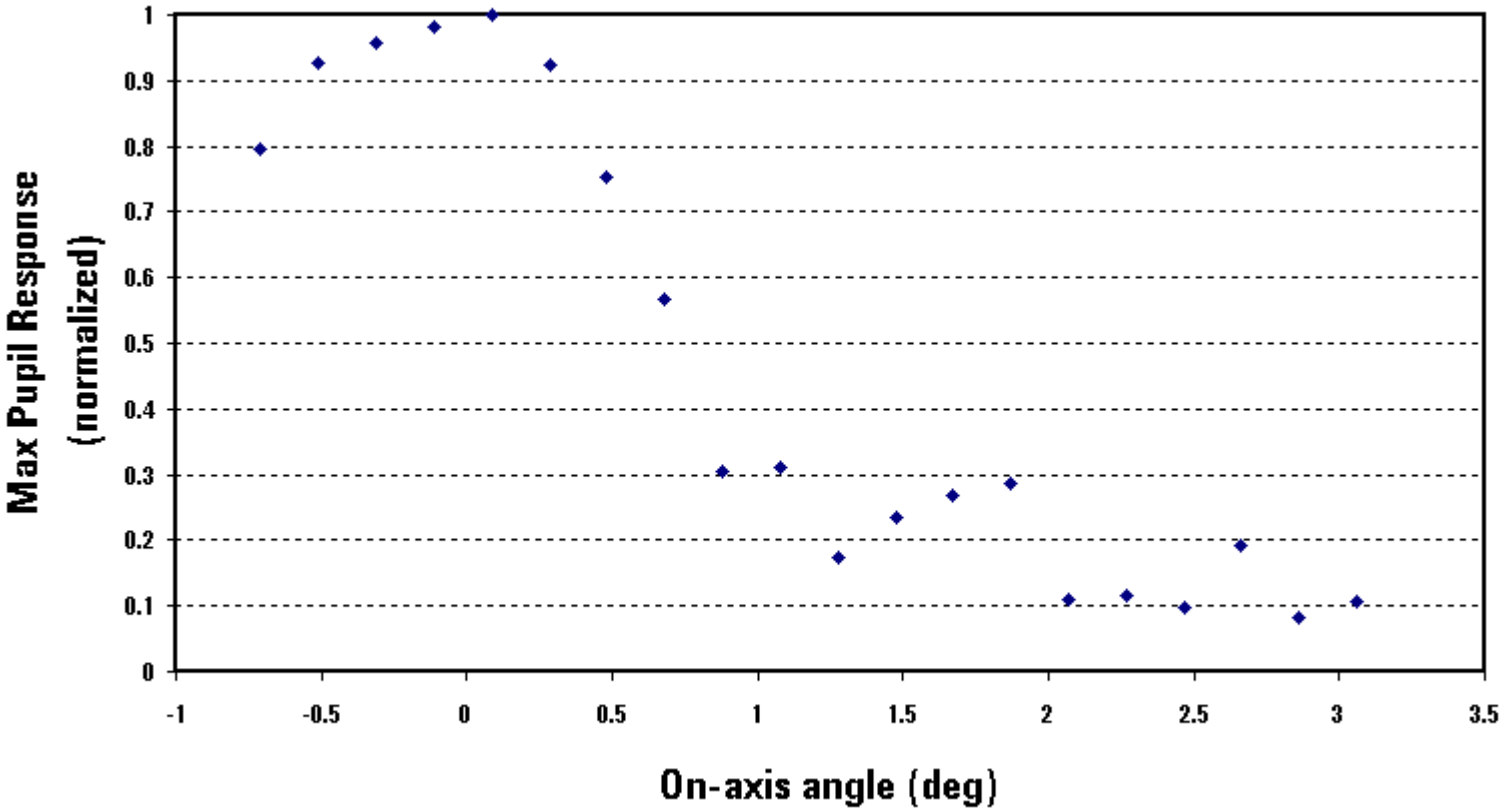


Differential angle illumination

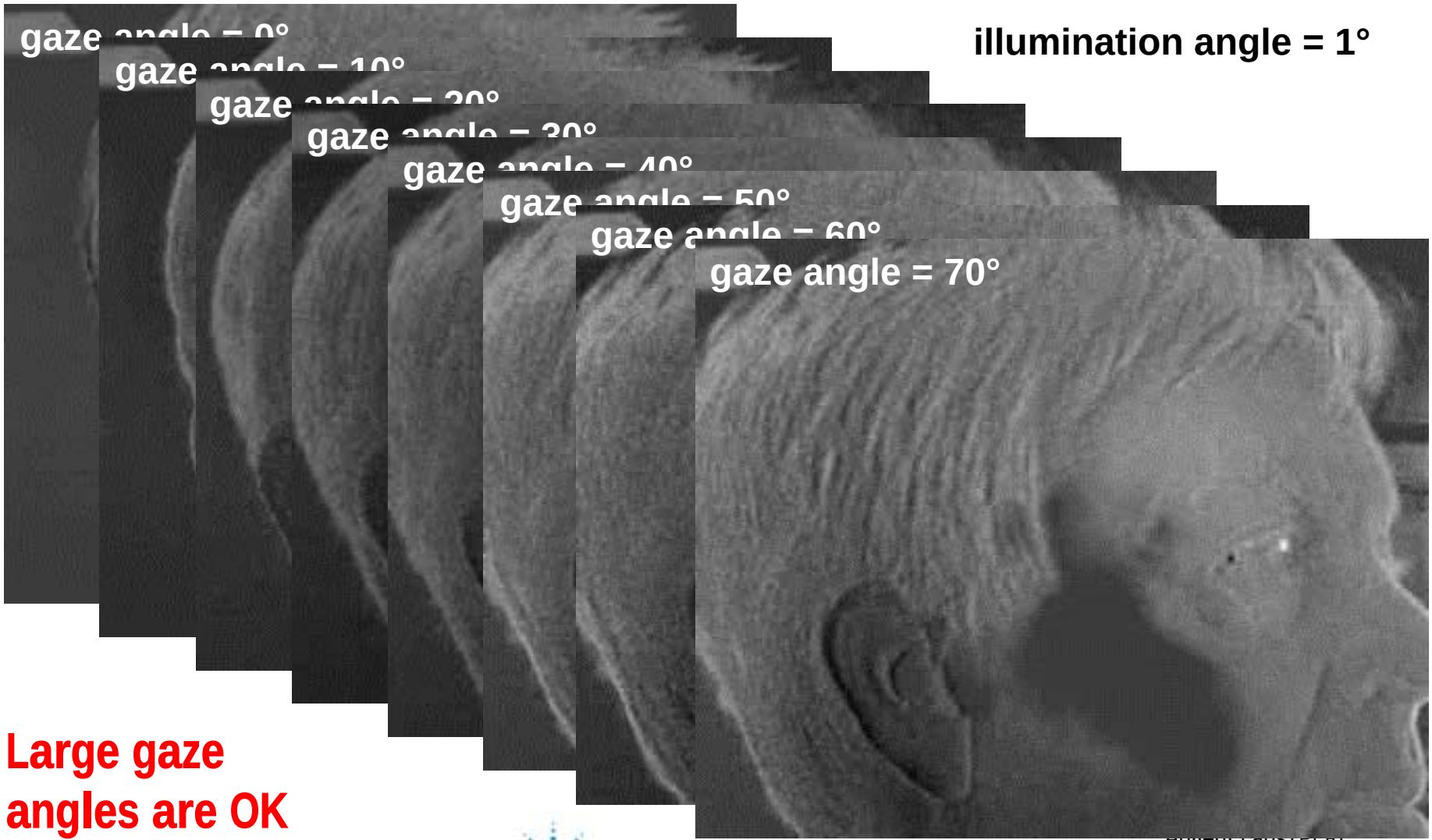
(On-axis image – off-axis image) difference highlights pupils



Strong dependence on illumination angle



Weak dependence on gaze angle



Large gaze angles are OK

Sequential illumination



on-axis



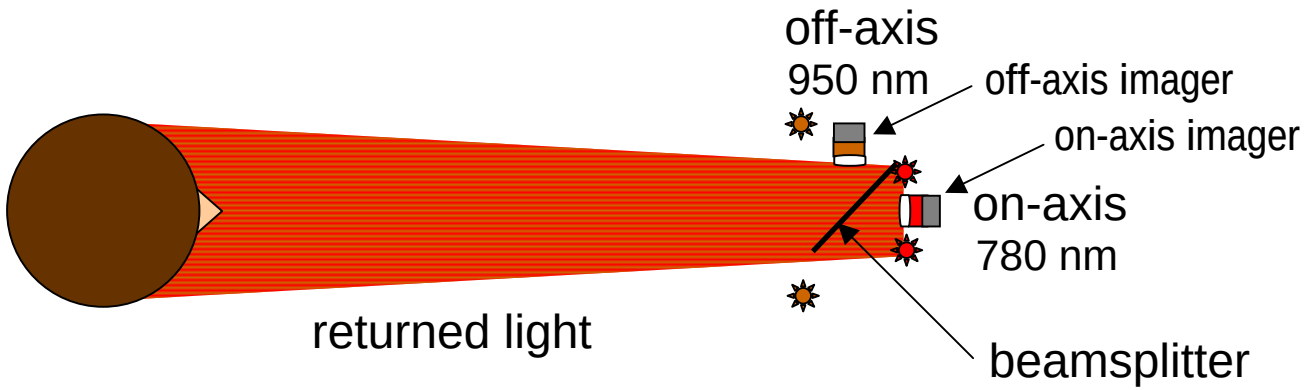
off-axis



difference

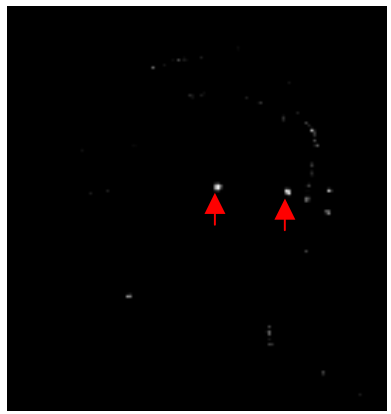
However, motion of subject in auto can eliminate pupil pixel overlap and cause artifacts at 15 fps.

Simultaneous illumination



on-axis



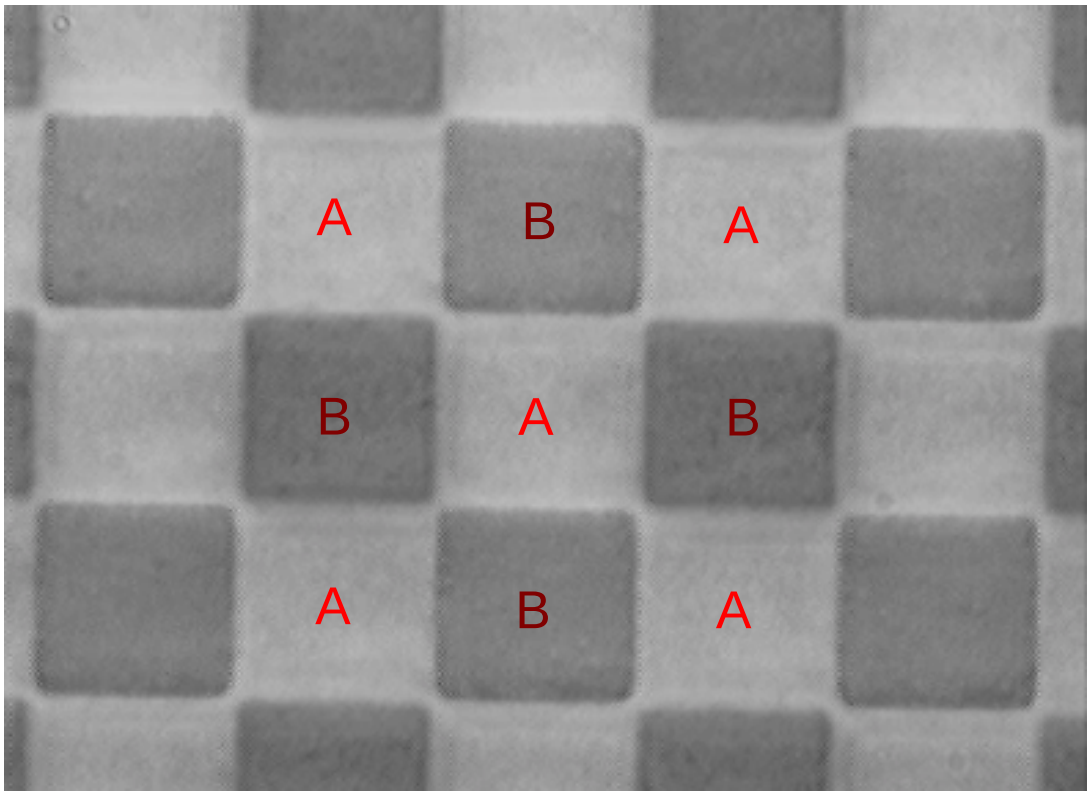


difference

Works, but

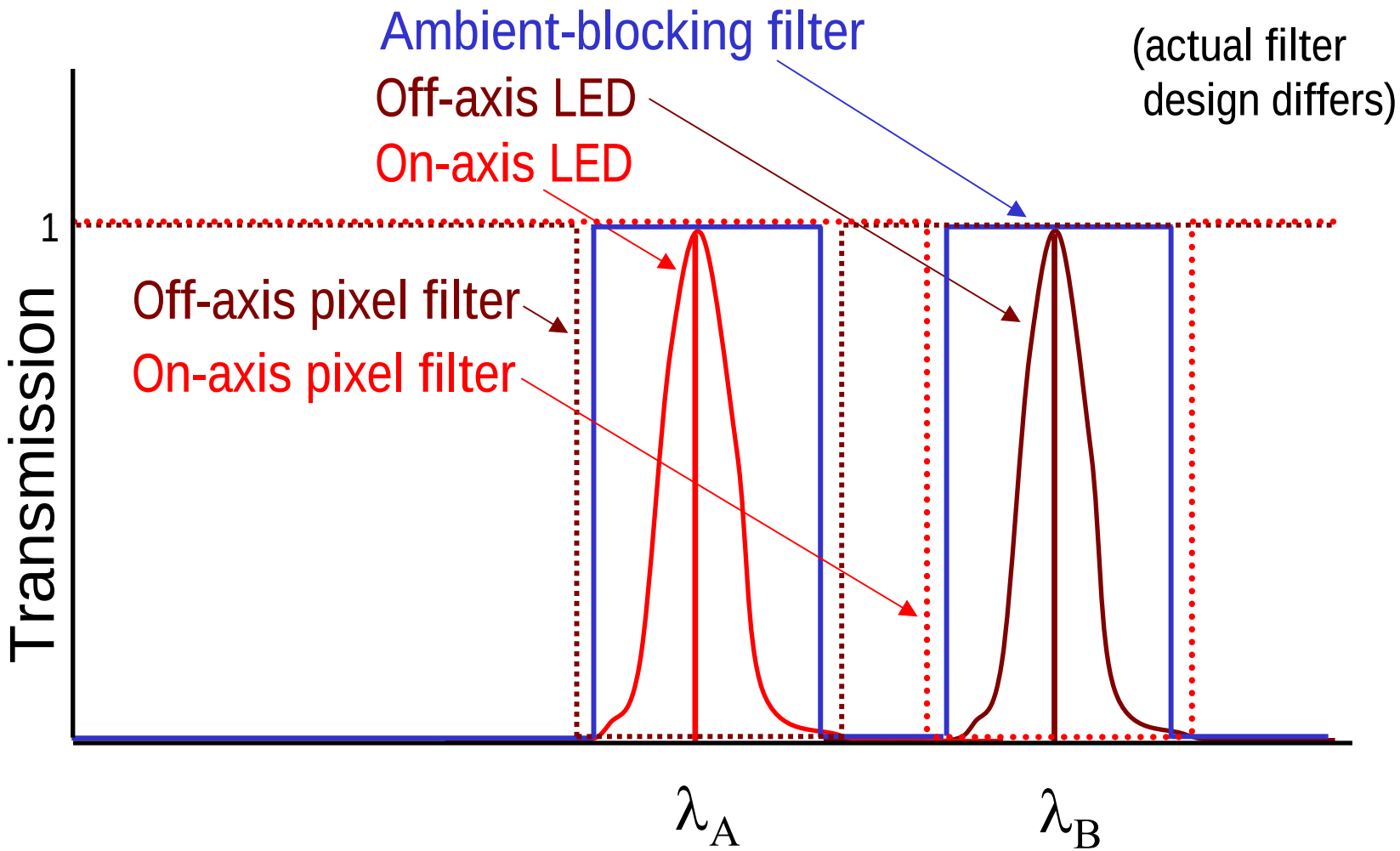
- maintaining alignment for image mapping is difficult
- packaging is more expensive

Pixel-based filter imager



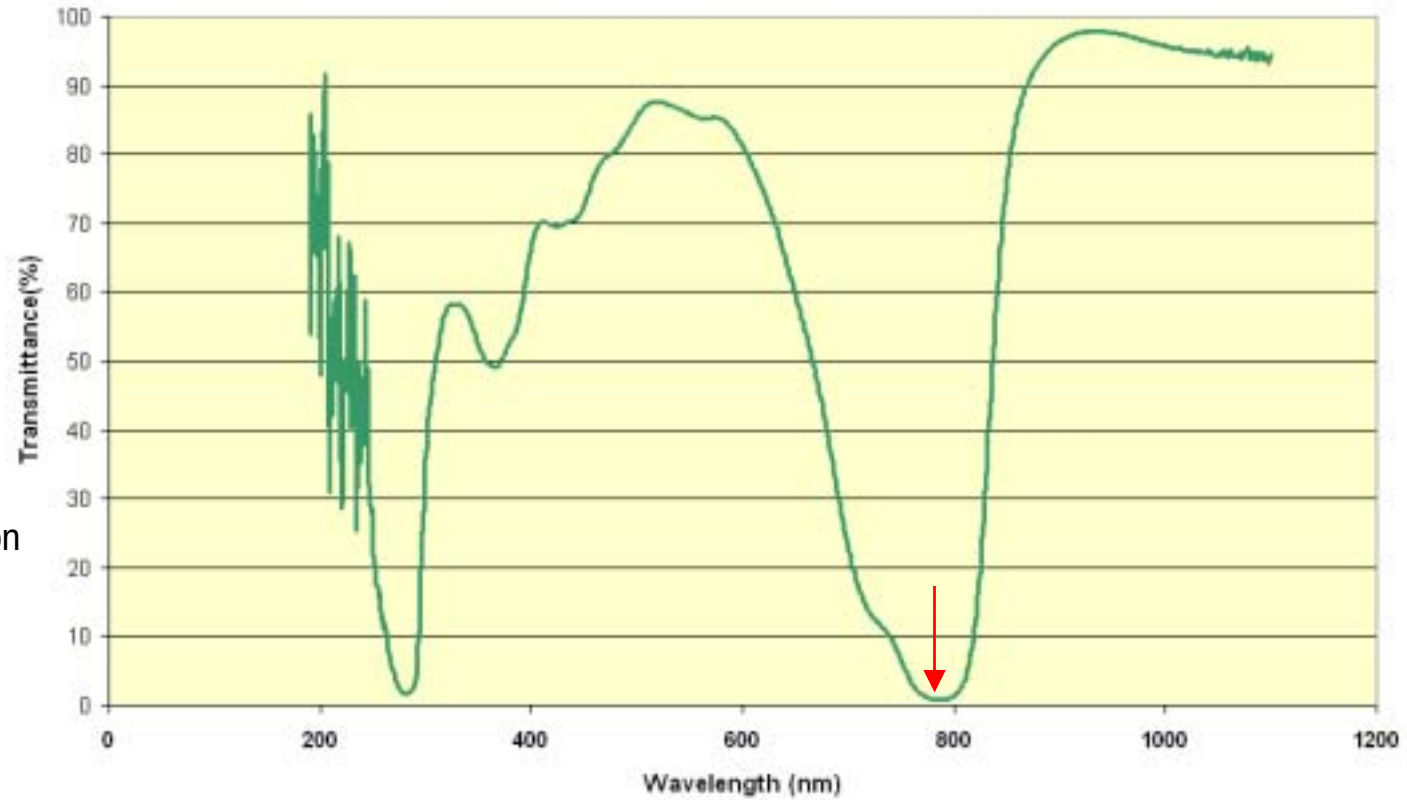
6 patents pending

Desired filter spectra



Checkerboard short λ -blocking filter

for 1 micron thickness



Custom pixel filter material blocks 780 nm = λ_A very well in bulk form

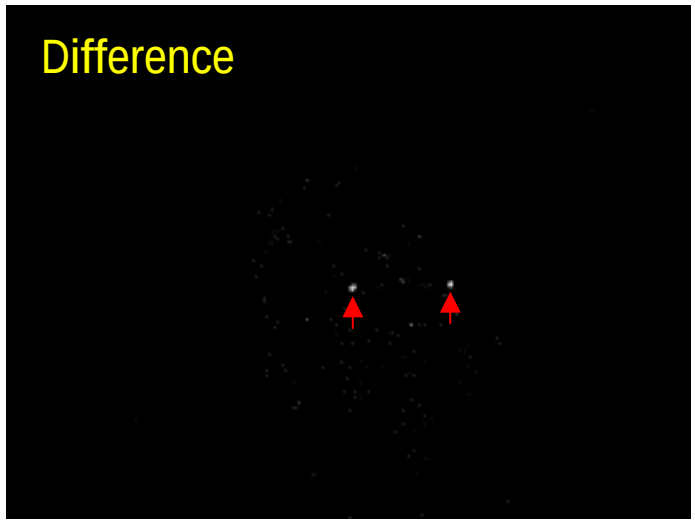
Differencing with a single imager



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highlights
pupils
w/ self-registration

Movie

Advantages of single-imager approach

Single imager

- low cost
- single lens eliminates need for registration between imagers

Resulting difference image is easy to process – in future:

- no frame memory needed
- simple ASIC implementation



With glare correction



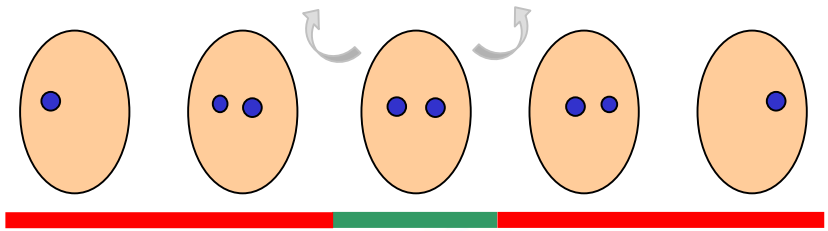
Without glare correction



Prototype measurement capabilities

- position of eyes in 2D field
- presence of human
- number of eyes
- percent closure in last n frames
- approximate distance to eyes

Future work – gaze OK/not OK



Potential applications of eye detection

Consumer-oriented products

turn off displays when nobody is watching

security

detect presence of people rather than just any moving objects

detect presence of people that are sitting still

locate eyes for camera pointing

locate eyes for iris- or retina-based identification

automotive

drowsy driver detection

approximate gaze direction detection

Strengths of Agilent's approach

- Finds everyone's eyes in the dark @ 70 cm
- Finds most people's eyes under fluorescents
- Low cost
- No beamsplitter, no need for registration
- Wide range of gaze angles
- Simple image processing
- Non-contact
- No moving parts
- Strong IP position
- Suitable for one-chip implementation

Going forward

- A major automotive manufacturer has expressed interest in this technology
- We plan to optimize technology to match this manufacturer's interests