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MEASUREMENT OF THE THRESHOLD INCREMENT (TI) IN ROAD LIGHTING BASED ON USING ILMD

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Agenda

- Motivation
  - Introducing the ‘Colight‘ project
  - Technical review of a glare value
  - Typically used values for disability glare in outdoor

- Solutions for the application
  - Evaluation of geometrical data
  - Applying a virtual viewing direction
  - Ideas for qualifying glare sources

- Introducing the software
  - Dynamic measuring of road luminances
  - Static high dynamic measuring of TI

Introducing the 'Colight' project

- **Joint project:** „Intelligent and energy-efficient lighting systems for LED“ (3,5 Mill. Euro, 2010-2012)
- **Task (All):** development of a pilot LED road luminaire that can change its light distribution and light colour during operation
- **Subtask (TUIL):** the influence of the distribution and colour on the user acceptance in road lighting
- **Method:** visibility tests with subjetcs on a test road
- **Request:** TI (Lv) measurement for objective in-situ measurements of the luminance difference threshold
- **Experimental results (wet road):** the higher Uo and CCT, the better the visibility

Motivation

Solutions for the Application

Introducing the software

Technical review of a glare value

Glare values does classify 'glaring' light sources L_S depending from its position $P_S(\vartheta,\phi)$ and the solid angle Ω_S proportionally to the adaptation level e. g. the adaptation luminance L_{adapt}.:

$$glare\_value\ X = f\left(L_S;\Omega_S;P_S(\varphi;\vartheta);L_{adapt}\right)$$

L_S = glaring luminance / source

L_{adapt} = background luminance (adaptation level)

Ω_S = solid angle (as can be seen)

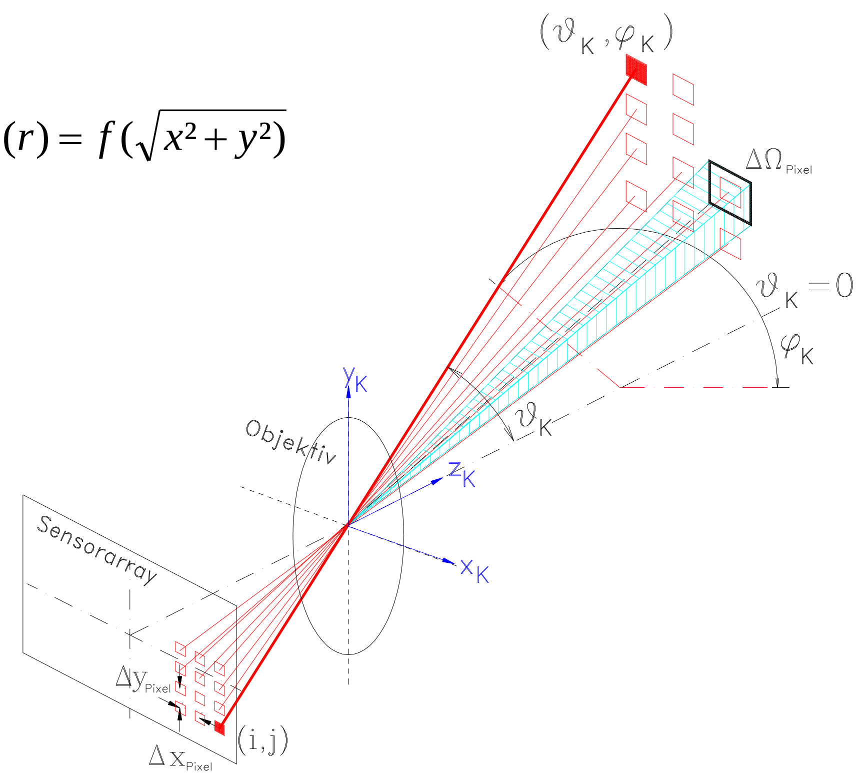
P_S = angular position of source (ϑ,ϕ = 0° → *viewing direction)*

Evaluation of geometrical data (principle)

Transformation of cartesian image coordinates $x, y \Leftrightarrow \vartheta, \varphi$ to angular coordinate system:

$$\varphi = \arctan \frac{y}{x} \qquad \vartheta = f(r) = f(\sqrt{x^2 + y^2})$$

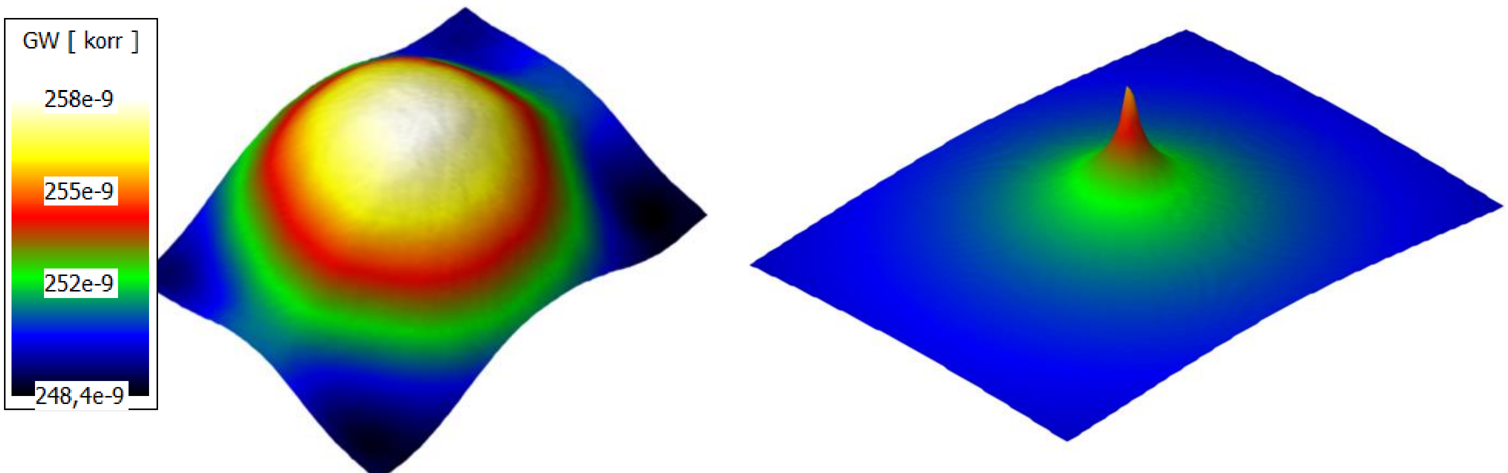
$$\Delta\Omega = \Delta\vartheta \cdot \Delta\varphi \cdot \sin\vartheta$$



Evaluation of geometrical data (principle)

Calculation of synthetic functional images (Weighting images):

- E.g. pixel-wise solid angle increment or the Stiles-Holladay equation for the equivalent veiling luminance



$$E_{vert} = \sum_{i,j} L(i,j) \cdot \Delta\Omega(i,j) \cdot \cos\vartheta(i,j)$$

$$for\ \forall(i,j) \in lightsource$$

$$L_V = k \cdot \frac{E_{vert}}{\vartheta^2}$$

Evaluation of geometrical data (measuring cones)

According to EN 13201-3, the luminance meter shall use a restricted total angle of the measurement cone to at least 0,03° in the vertical plane and at least 0,3° in the horizontal plane.:

Lens type (focal length)	Measuring cone of the luminance image	Measuring cone of one squared pixel (average values)	Averaging cone adjacent pixel (3(H) x 3(V))	Measuring average road luminance	Measuring vertical illuminance
8 mm	63°(H) x 45°(V)	0,0452°/px	0,1356°	-	x
12 mm	43°(H) x 31°(V)	0,0313°/px	0,0939°	-	x
16 mm	32°(H) x 23°(V)	0,0232°/px	0,0696°	?	?
25 mm	20°(H) x 14°(V)	0,0148°/px	0,0444°	?	?
50 mm	10°(H) x 7,4°(V)	0,0074°/px	0,0222°	x	-

Table 1 – Red question marks does remark possible configuration under investigation. E. g. the averaging cone for the 25 or 16 mm focal length could also be 10(H) x 2(V) adjacent pixel and would now meet the requirements.

Evaluation of geometrical data (field of view - FOV)

Any glare source above a screening plane of 20° to the horizontal, and which passes through the observer's eye, and which intersects the road in a transverse direction, shall be excluded from the calculation.:

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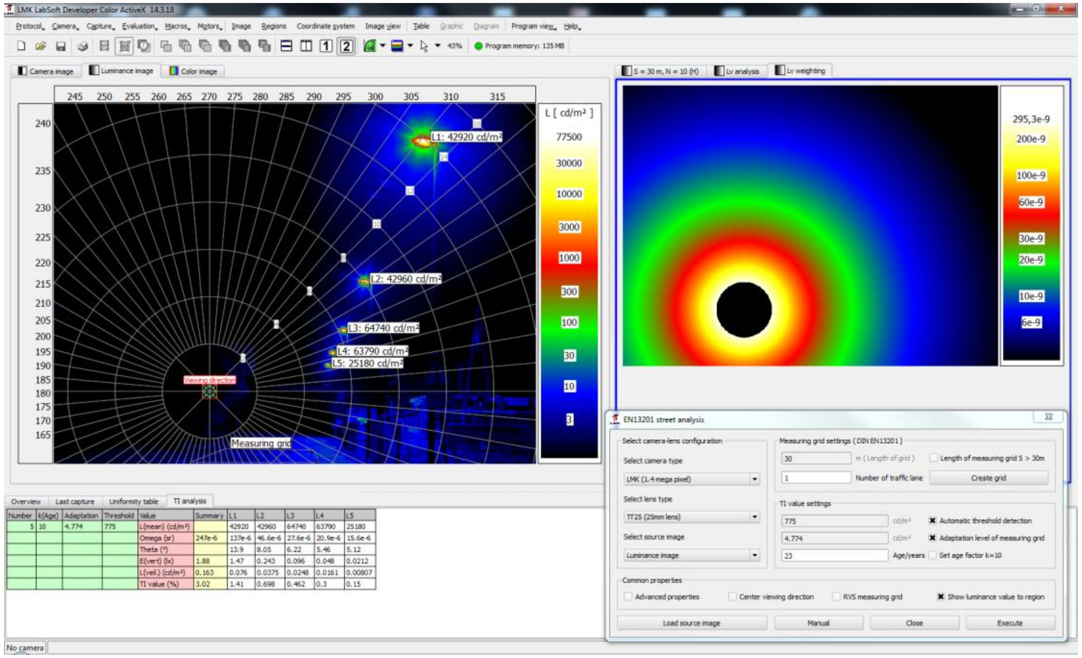
Applying a virtual viewing direction

Calculation of synthetic functional images (Weighting images):

- Implementing a real-time calculation for the glare angle analysis enables a virtual replacement of the Viewing direction



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Ideas for qualifying glare sources

Using statistic tools it is possible to classify objects when using a luminance threshold:

- Generally ambient ≤ 100 cd/m² (fix threshold)
- Ambient ≤ 1% of maximum luminance (adaptiv threshold)
- Average luminance of an area of interest or whole image

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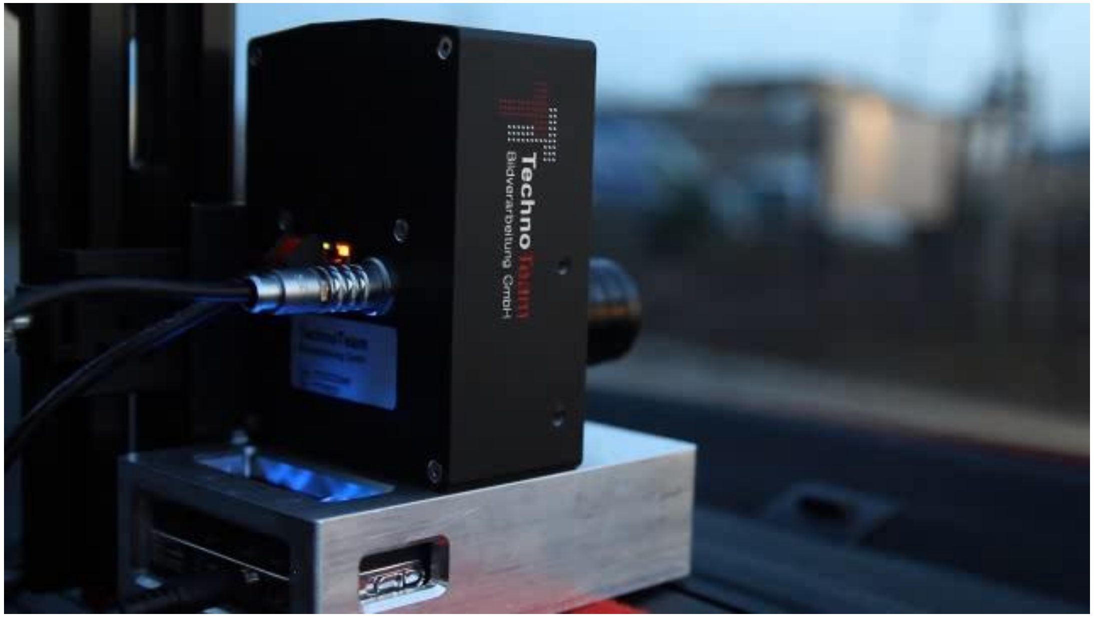
Dynamic measuring of road luminances

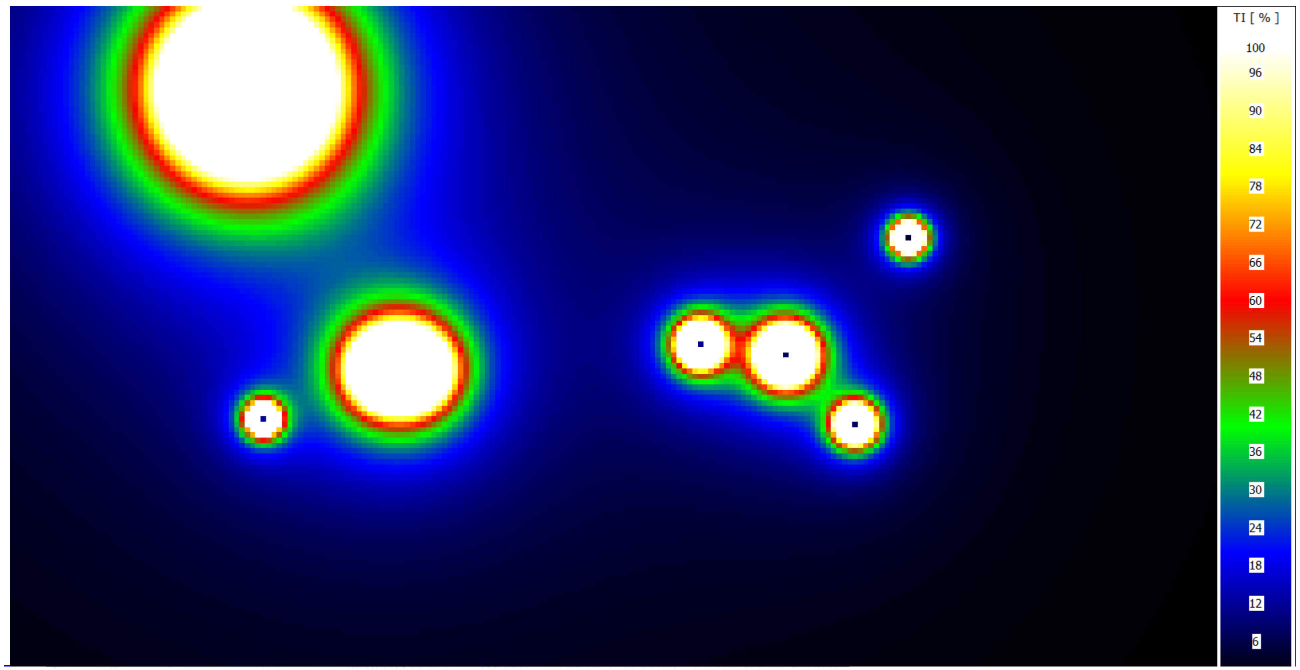
Using the single capture algorithm at an exposure time range of 20 – 70 msec. will allow an average speed of 50-80 km/h for dynamic measurements:

- Frame rate: 1 image per 2 sec.
- Measuring street luminances below 4 cd/m²



Static high dynamic measuring of TI

Using the high dynamic capturing algorithm for measuring luminances of ambient and glare sources in one image



Thank you for your attention!

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