

Display Lab: Competences & Selected Projects since 2020

- **Optical metrology for displays and LEDs:**
Photometric measurements (spot and imager), response time, spectrum ...
- **Electronics:** Micro controllers, display interfaces, LED drivers ...
- **Software:** Dedicated test patterns, image enhancement, uniformity algorithms ...
- **Systems design:** New concepts, prototypes, user interfaces, evaluation and validation ...
- **Evaluations and assessments:** User studies incl. comparison to measurements ...
- **Consultancy, workshops ...**



- We prototype and/or evaluate your display, LED system, HMI or idea!
- Info: www.displaylab.org
- Contact: kb@displaylabor.de

Karlheinz Blankenbach



- 30 years proven expertise in displays ...
- Full professor @ Pforzheim University
- Society for Information Display (www.sid.org)
 - "Automotive Displays & HMI"
 - Display metrology (ICDM)



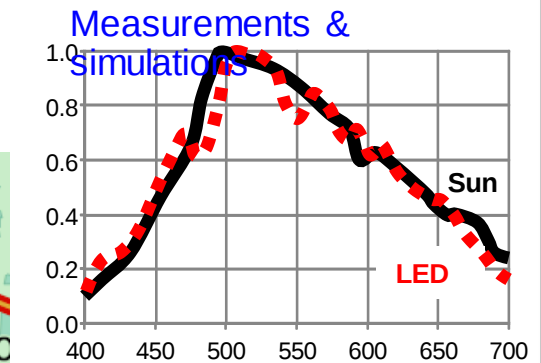
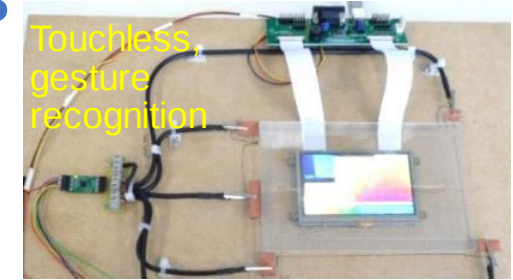
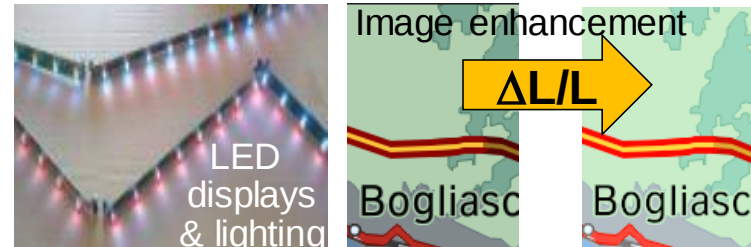
- Honorary president DFF (www.displayforum.de)



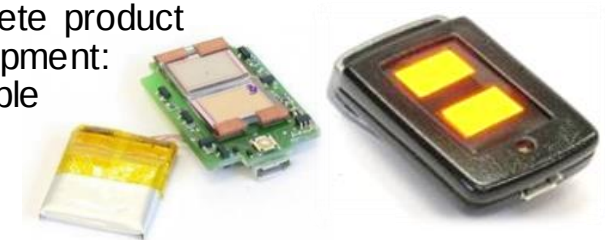
- Chairman  **ed electronic displays** Conference

- Member of  **ELED** automotive interior lighting

Examples of Projects



Complete product development: wearable OLED signs

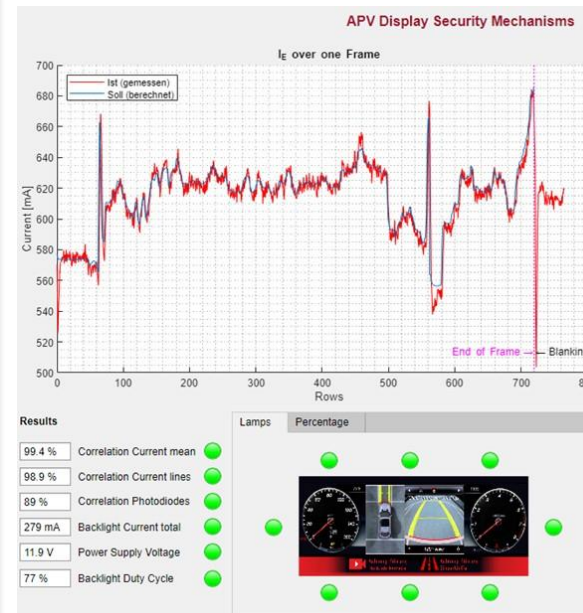


„Light-to-Light“ Safety for Camera Monitor Systems

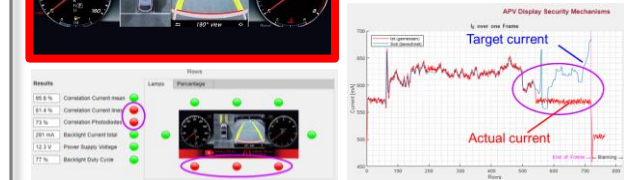
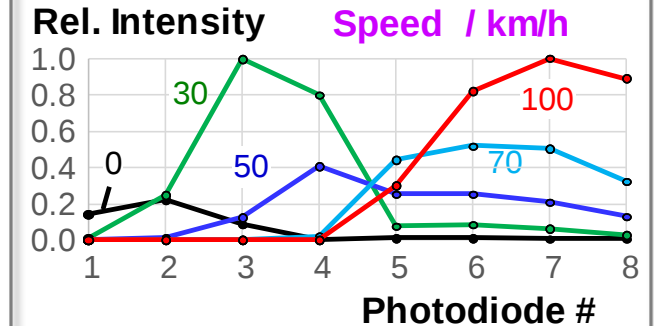
- **Today:** Only digital interface data supervised, no light of display
- **Here:** Optical supervision of display output by photodiodes and camera
- **Methods:**
 - ~10 photodiodes & line current
 - Camera incl. AI (best for remote)
- **Results:**
 - Validation of both methods ✓
 - “Detection” of essential failures ✓
 - Image compression for remote operator okay with AI ✓

JSID 2020/1 <https://doi.org/10.1002/jsid.909>,
<https://doi.org/10.1002/jsid.1079>

Demonstrator



Examples



Advanced CMS safety

Single Pixel Measurement Method for Halo on OLED and FALD LCD

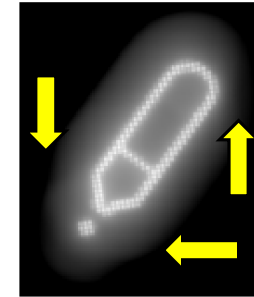
- **Background:** Halo is judged as caused by low quality display (in social media). It is mostly noticed at FALD LCDs. No “good” measurement method exists.
- **Our work:** Find and evaluate an advanced method to access single pixel halo
- **Method:**
 - 5 step procedure with imager
 - Macro lens and simulation of fits
- **Result:**
 - Single pixel halo can be measured
 - FALD LCD halo = 10x of OLED

SID 2022, session 35.1

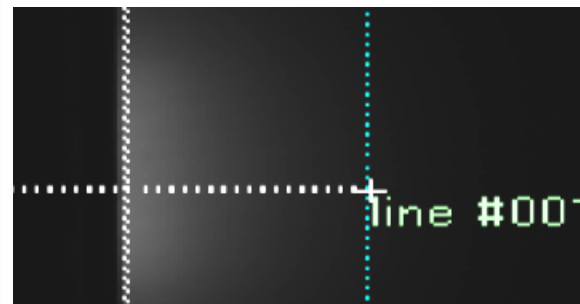
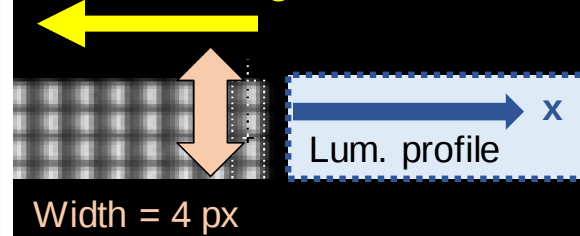
Halo & Method

Halo is spreading of light from bright content into dark surrounding

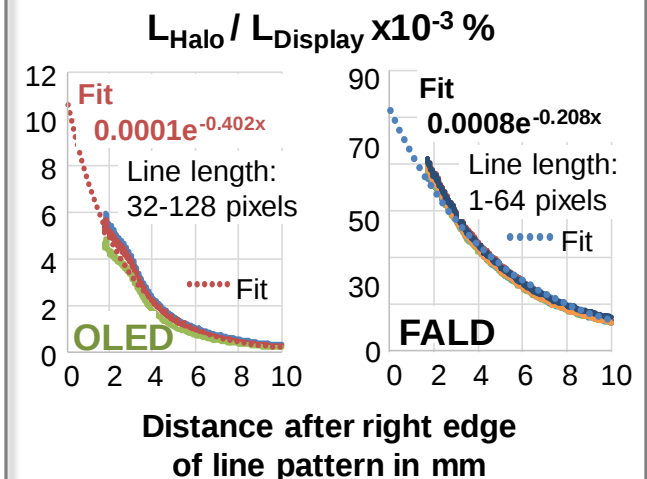
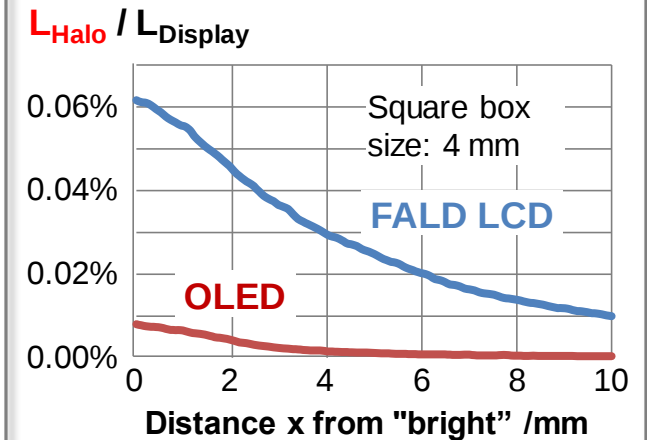
“Uneven” halo (↑) of FALD LCD →



Line extending to left



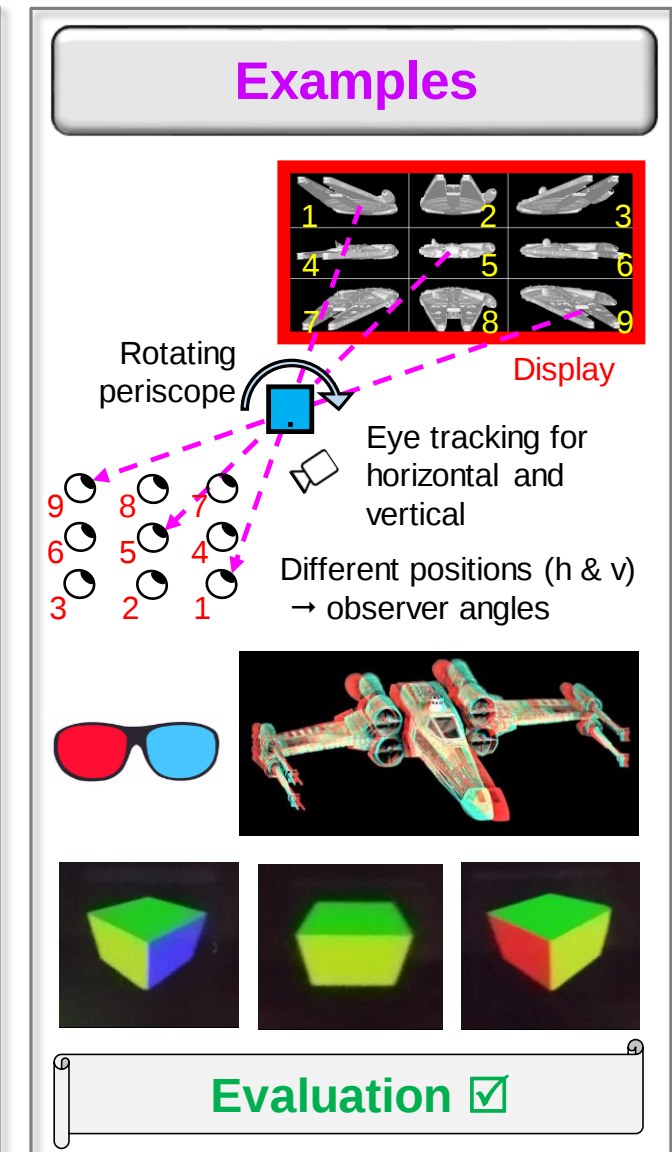
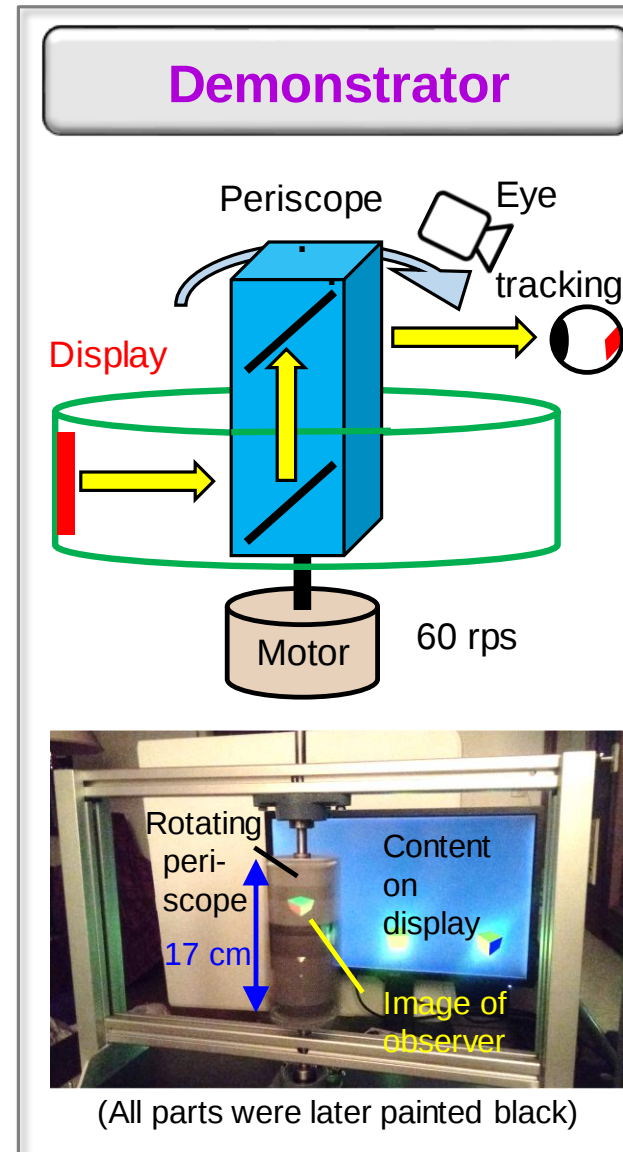
Examples



3D Multi-View Display

- **Today:** 3D image is the same for all observers → no perspective view
- **Here:** Development and evaluation of a 3D display for up to three observers with dedicated perspective
- **Methods:**
 - Rotating periscope visualizes images of large display
 - Dynamic perspective by eye tracking
- **Results:**
 - Multi-view (different 3D perspectives), see mark in green
 - Surprising effect → Science museums ...
 - Limits: Relatively small and dark images are less suitable

SPIE 2021 <https://doi.org/10.1117/12.2576972>

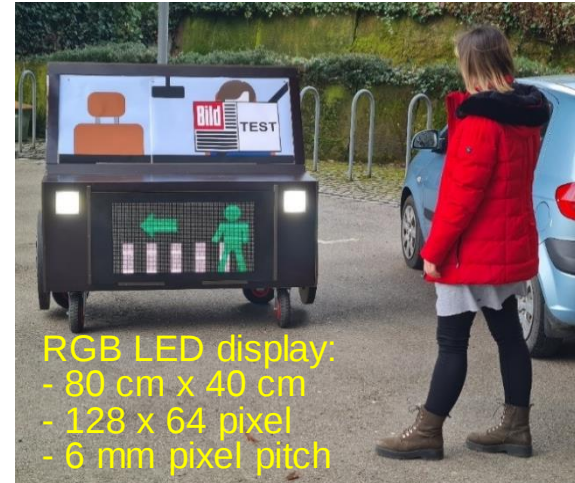


Exterior Displays for Autonomous Cars Raise Safety

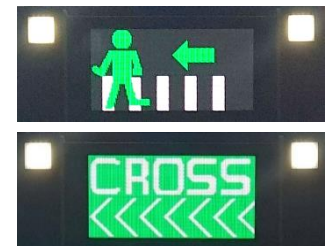
- **Visual communication since ~1900:**
Break light, traffic light, turn indicator ...
- **Here:** Graphic displays can provide more such as warnings, pedestrians
- **Mock-Up:** Simulation of use cases
Pedestrian, oncoming and following cars, autonomous driving mode ...
- **Results:**
 - Size > 30 cm x 30 cm, 6+ mm pixel
 - Text: 10 cm readable from 40+ m
 - Signs: 30+ cm for 50+ m
 - Pedestrians feel safe to cross

SPIE 2022 <https://doi.org/10.1117/12.2606887>,
SID 2022 51.4 & ICDT 2022

Mock-Up



Test Image Examples



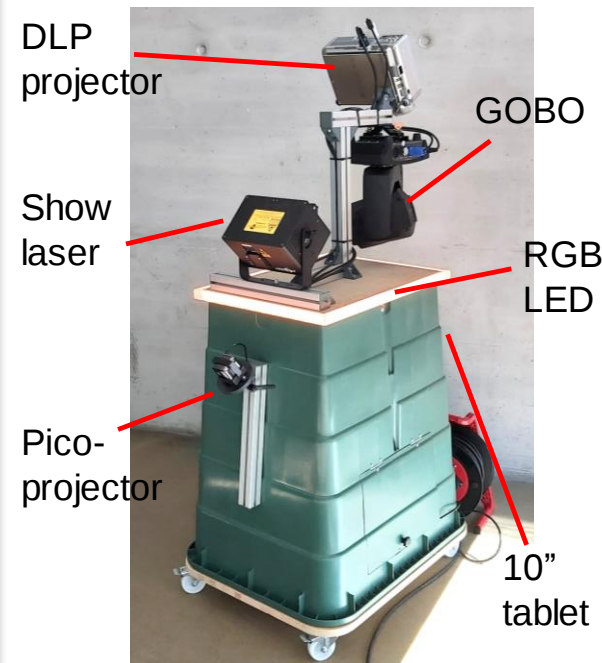
Height of 40 cm 👍

Human Robot Interaction (HRI) for Autonomous (Cleaning) Robots

- **Today:** Discomfort of subjects as no or only blue light visualization
- **Here:** Measurements and evaluation of various display technologies
- **Methods:**
 - Mock-up with different visualizations
 - Measurements, legibility acc. CIELUV
- **Results:**
 - Pico projector is best incl. integration
 - LED stripe for attention grabbing
 - Show laser, tablet, large projector are less suitable

SID 2021 <https://doi.org/10.1002/sdtp.14749>, BMBF "RobotKoop"

Demonstrator



Display	L_w /cd/m ²	Max. E /lx (CR = 2:1)
Pico-proj.	33	300
GOBO	1,900	17,000
Show laser	3,000	27,000
LED stripe	3,200	44,000

Examples



Trajectory reduces fear

Low Cost „HUD“ for Safety and Comfort

- „Scheibenwurzel-Display“:
as comfort function
- **Here:** Parameters for visualization
of safety (warnings ...)
- **Mock-Up:** Simulation of all features
incl. luminance, RGB ratio and perceived
brightness up to blinding sunlight
- **Results:**
 - RGB luminance ratio of **35 : 50 : 15**
 - $L_{\text{White}} \geq 3,300 \text{ cd/m}^2$ (3x L of today)
 - $L_{\text{Blue}} \geq 500 \text{ cd/m}^2$
 - **R****G****B****B** LED for white point adjustment

SPIE 2021 <https://doi.org/10.1117/12.2599859>

Motivation

Design Questions

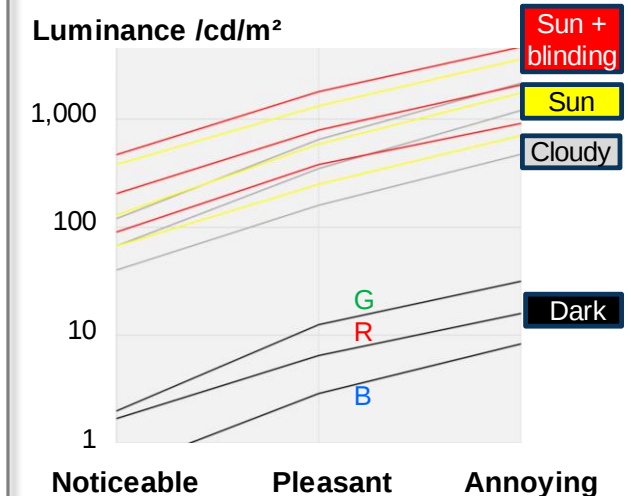
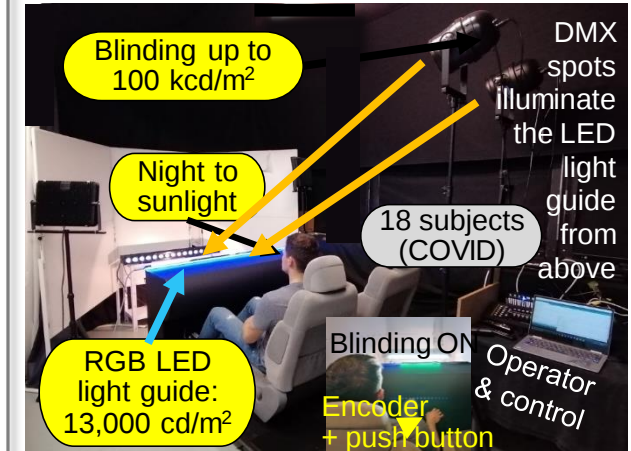
- Luminance for RGB?
- Luminance @ bright light



Augmented ADAS visualisation of pedestrian



Evaluation



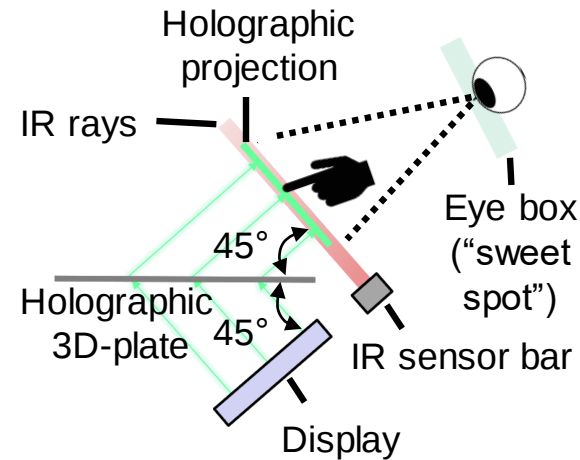
Touchless User Interface for e.g. Pandemic Situations

- **Today:** Buttons in public spaces pressed often but hygiene issue
- **Here:** Measurements and evaluation of various display technologies
- **Demonstrators:**
 - Single buttons as pedestrian crossing
 - Keypad and gesture input
- **Results:**
 - Touchless accepted for buttons
 - Numeric inputs less accepted but "great" for ATM safety

Validation ✓

ICEET 2021 DOI: 10.1109/ICEET53442.2021.9659596

Touchless Keypad



„9“ selected via IR sensor



Pedestrian Light

Default mode:
Waiting



Touchless to start



Crossing time ends



Crossing time starts

Waiting time starts



Waiting time ends



Please walk