Display Lab: Competences & Selected Projects since 2020

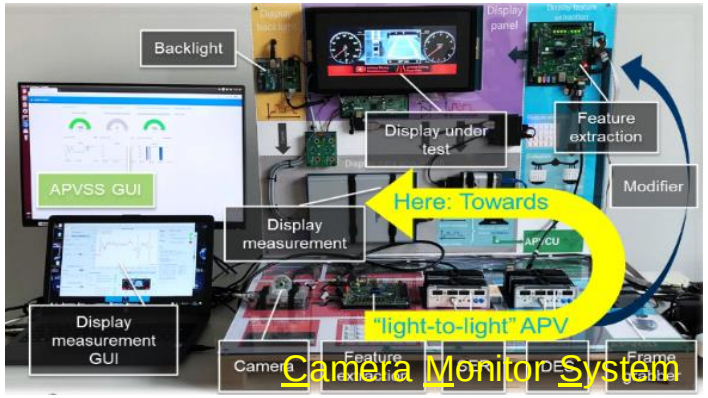
- **Optical metrology for displays and LEDs:**
  Photometric measurements (spot and imager), response time, spectrum …
- **Electronics:** Micro-controllers, display interfaces, LED drivers …
- **Software:** Dedicated test patterns, image enhancement, uniformity algorithms …
- **Systems design:** New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

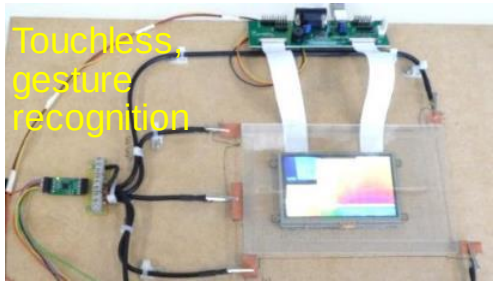
- **We prototype and/or evaluate your display, LED system, HMI or idea!**
- **Info: www.displaylab.org**
- **Contact: kb@displaylabor.de**

Karlheinz Blankenbach

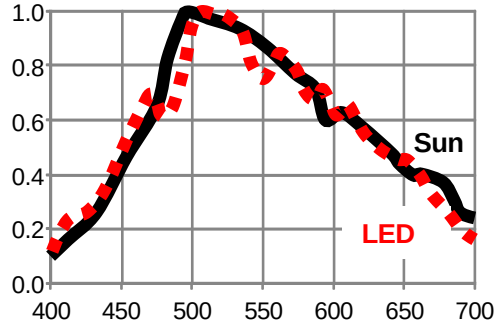
- 30 years proven expertise in displays …
- Full professor @ Pforzheim University
- Society for Information Display (www.sid.org)
  - "Automotive Displays & HMI"
  - Display metrology (ICDM)
- Honorary president DFF (www.displayforum.de)
- Chairman electronicdisplays Conference
- Member of ELED automotive interior lighting

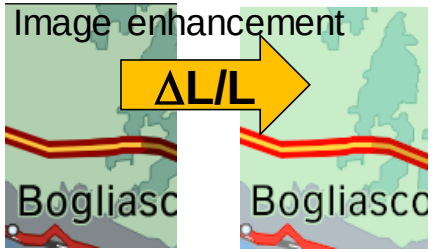
Examples of Projects





Measurements & simulations





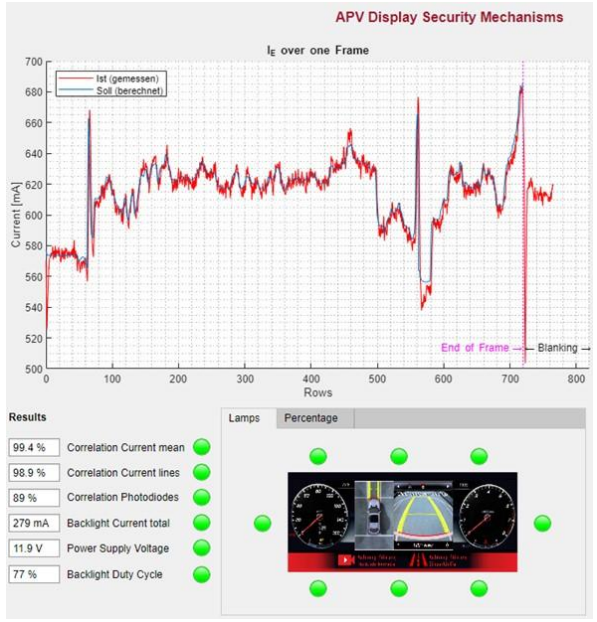
Complete product development: wearable OLED signs

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

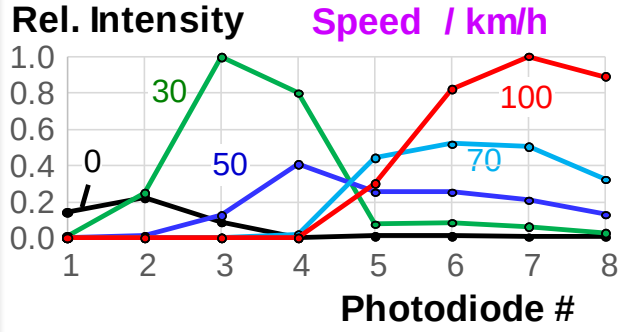
- **Today:** Only digital interface data supervised, no light of display
- **Here:** Optical supervision of display output by photodiodes and camera
- **Methods:**
  - ~10 photodiodes & line current
  - Camera incl. AI (best for remote)
- **Results:**
  - Validation of both methods ☑
  - “Detection”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

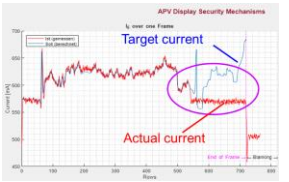
JSID 2020 https://doi.org/10.1002/jsid.909,
JSID 2021 https://doi.org/10.1002/jsid.1079

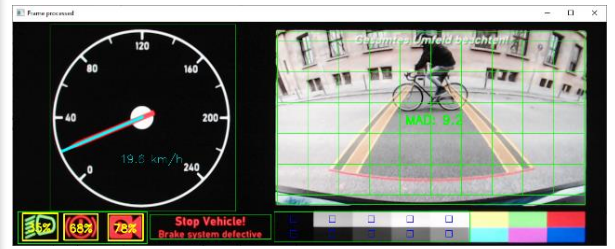
Demonstrator



Examples







Advanced CMS safety

Single Pixel Measurement Method for Halo on OLED and FALD LCD

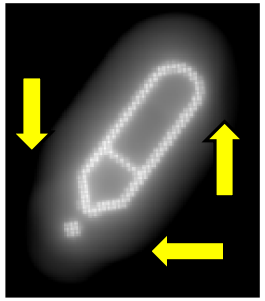
- **Background:** Halo is judged as caused by low quality display (in social media). It is mostly noticed at FALD LCDs. No “good” measurement method exists.
- **Our work:** Find and evaluate an advanced method to access single pixel halo
- **Method:**
  - 5 step procedure with imager
  - Macro lens and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

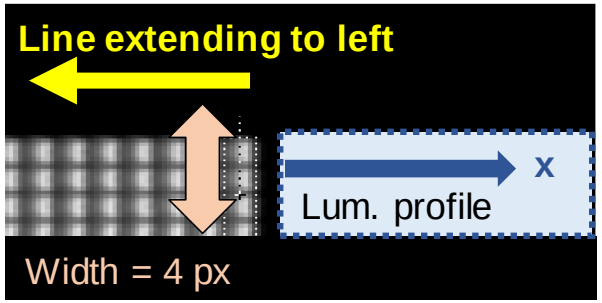
SID 2022 https://doi.org/10.1002/sdtp.15512

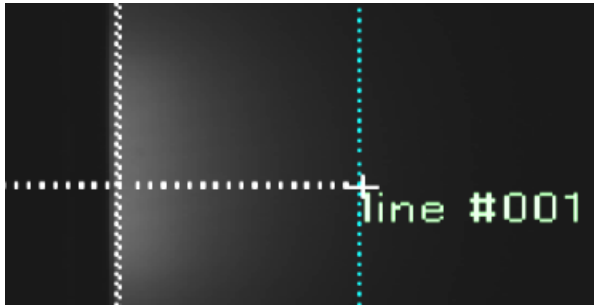
Halo & Method

Halo is spreading of light from bright content into dark surrounding

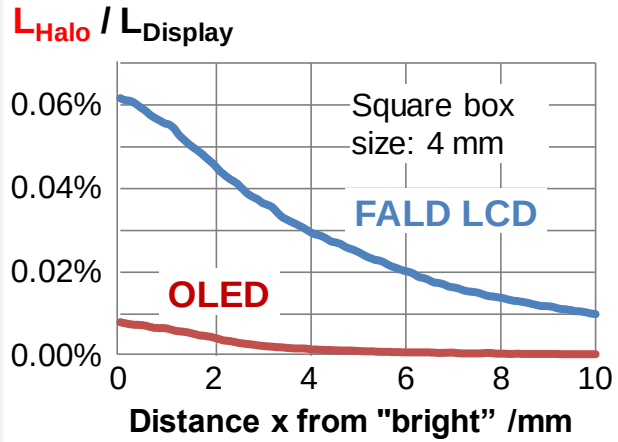
“Uneven” halo (↑) of FALD LCD ➞

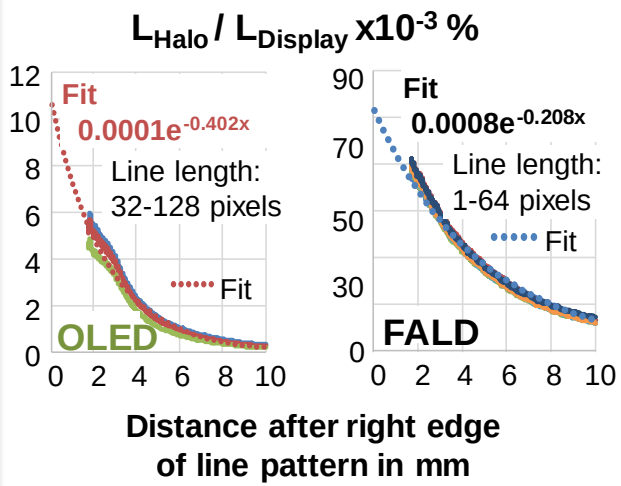






Examples



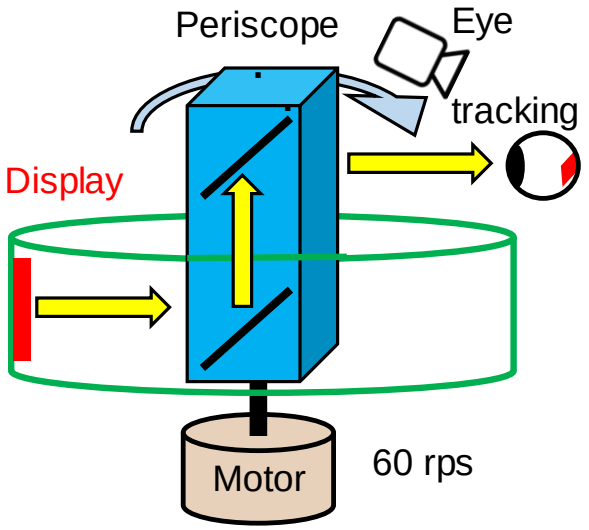


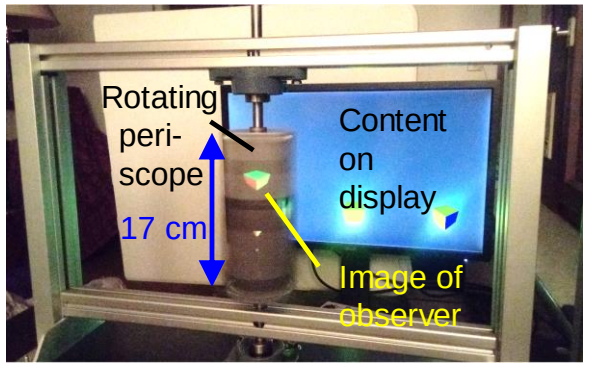
3D Multi-View Display

- **Today:** 3D image is the same for all observers → no perspective view
- **Here:** Development and evaluation of a 3D display for up to three observes 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

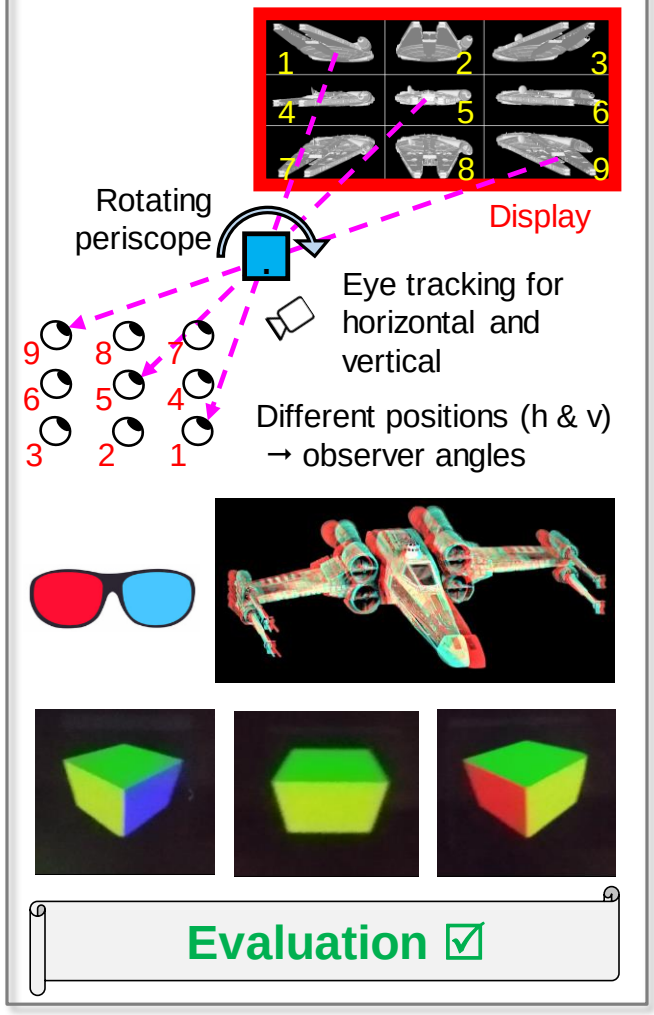
Demonstrator





(All parts were later painted black)

Examples



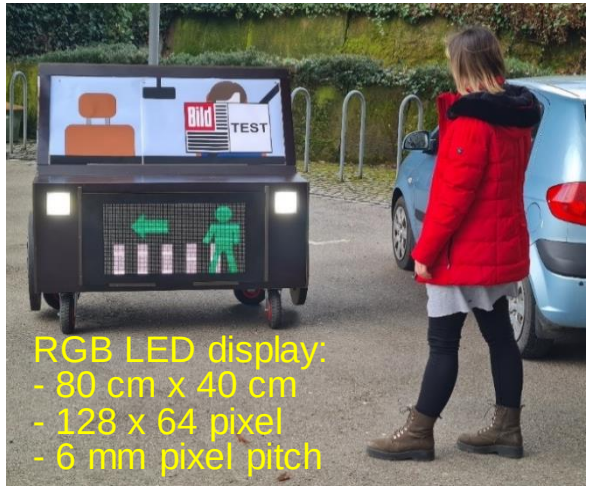
Evaluation ☑

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 https://doi.org/10.1002/sdtp.15577
ICDT 2022 https://doi.org/10.1002/sdtp.16024

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/m²	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 per-ceived brightness up to blinding sunlight
- **Results:**
  - RGB luminance ratio of 35 : 50 : 15
  - $L_{White} \geq 3{,}300$ cd/m² (3x L of today)
  - $L_{Blue} \geq 500$ cd/m²
  - RGBB LED for white point adjustment

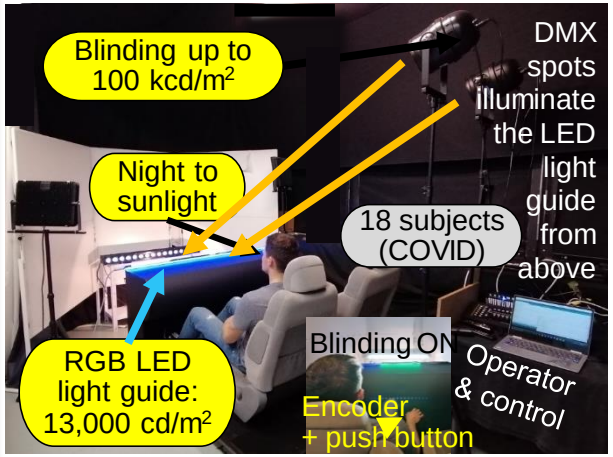
SPIE 2021 https://doi.org/10.1117/12.2599859

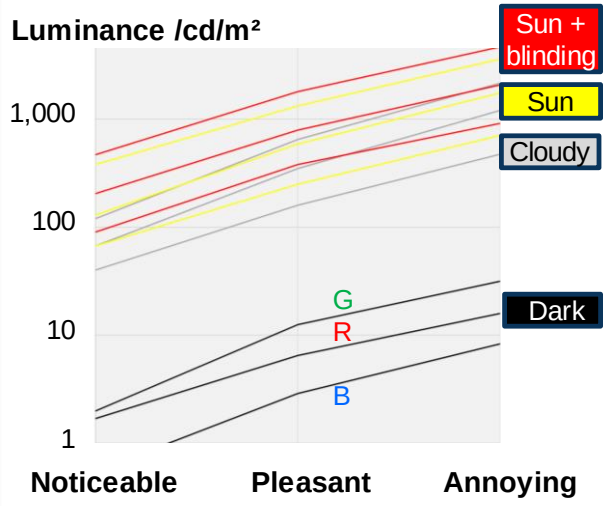
Motivation

Design Questions
- Luminance for RGB?
- Luminance @ bright light

Augmented ADAS visua-lisation of pedestrian

Evaluation





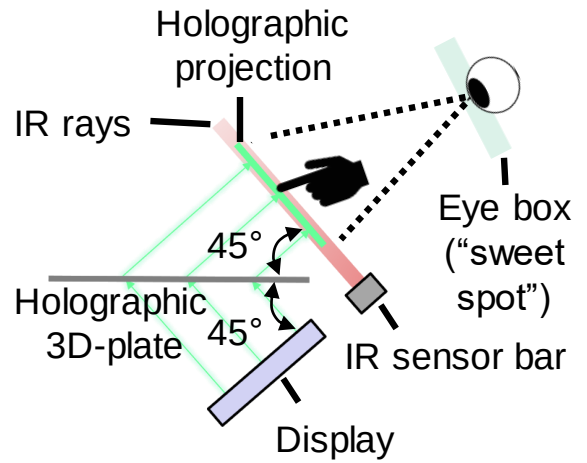
Touchless User Interface for e.g. Pandemic Situations

- **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

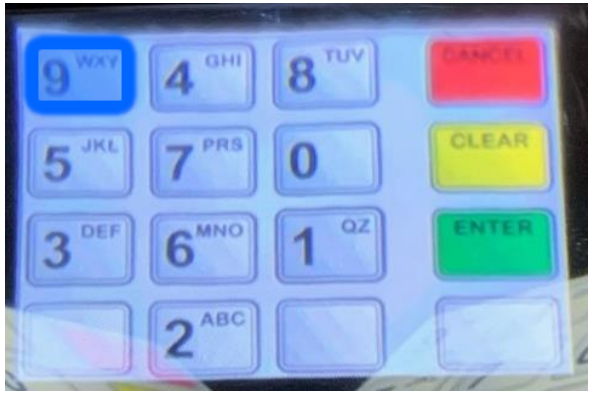
Validation ☑

ICEET 2021 DOI: 10.1109/ICEET53442.2021.9659596

Touchless Keypad



„9" selected via IR sensor



Pedestrian Light