IEEE-SA P2020

The IEEE P2020 working group on automotive image quality

Optical quality of windscreens moving into focus

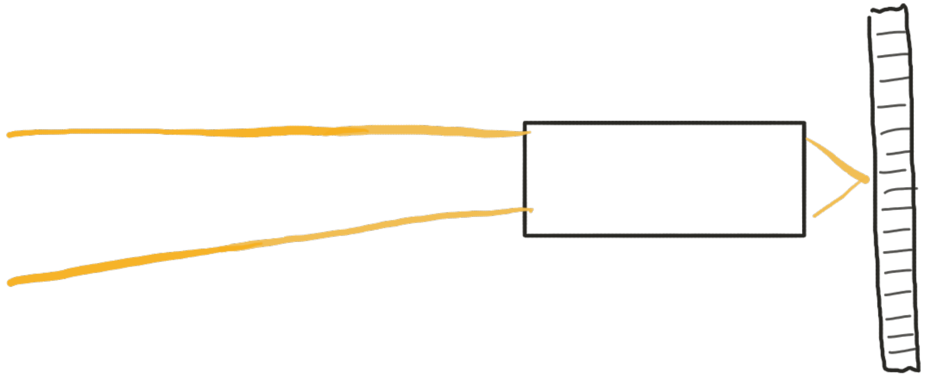
October 29, 2019

Prof. Dr. Alexander Braun
University of Applied Sciences Düsseldorf
On behalf IEEE P2020 Working Group

P2020 - Defining Image Quality

How does this…

… influence this?



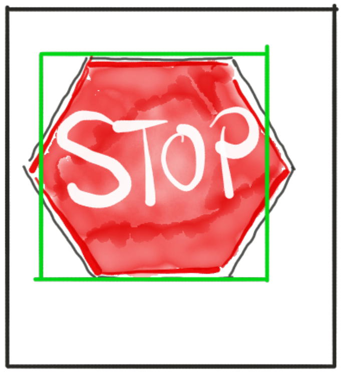


Image Quality (IQ)

Algorithmic Performance (AP)

Optical Quality of Windscreens

How does this… … influence this?

Optical Quality (OQ)

Algorithm Performance (AP)

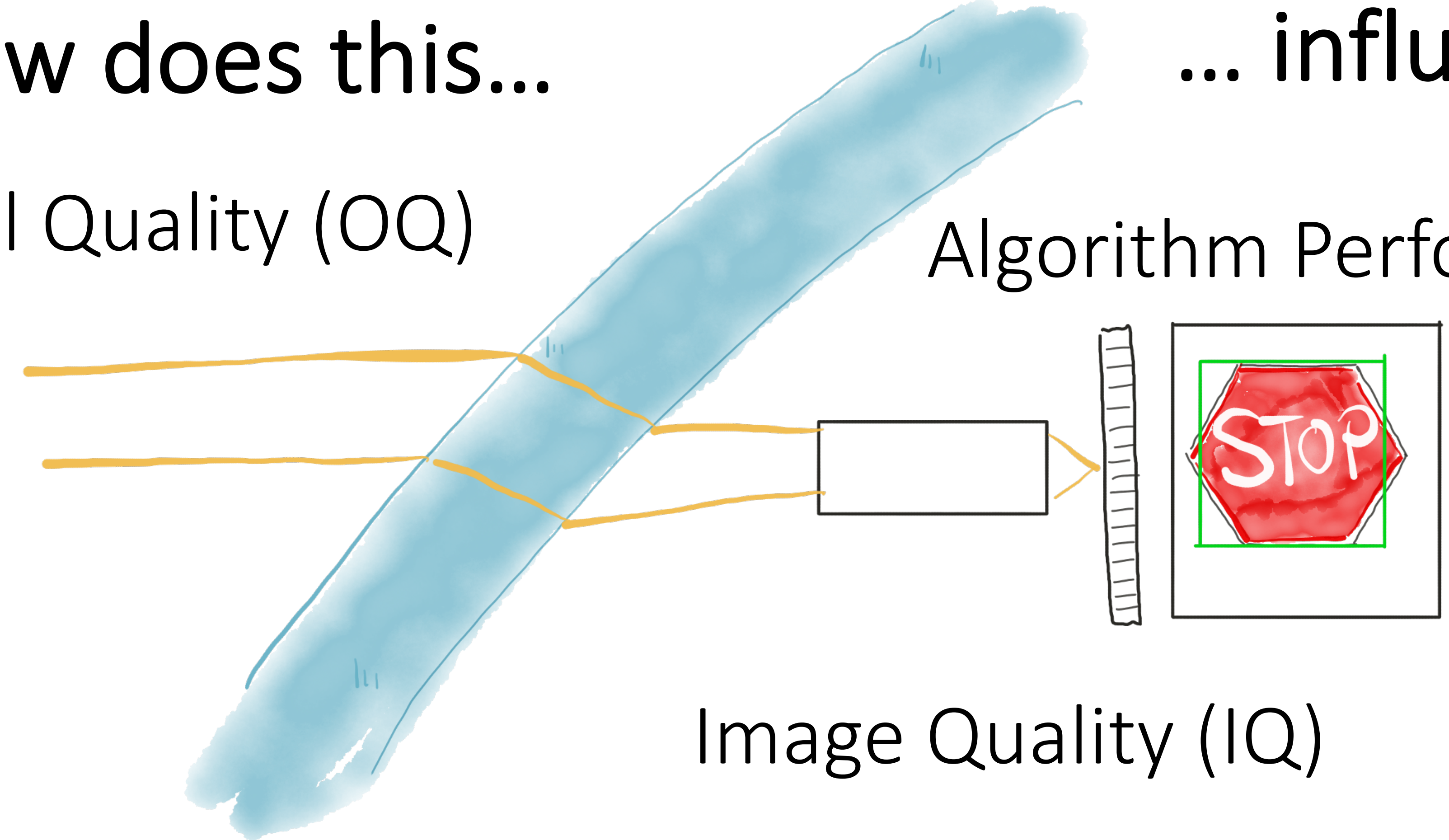
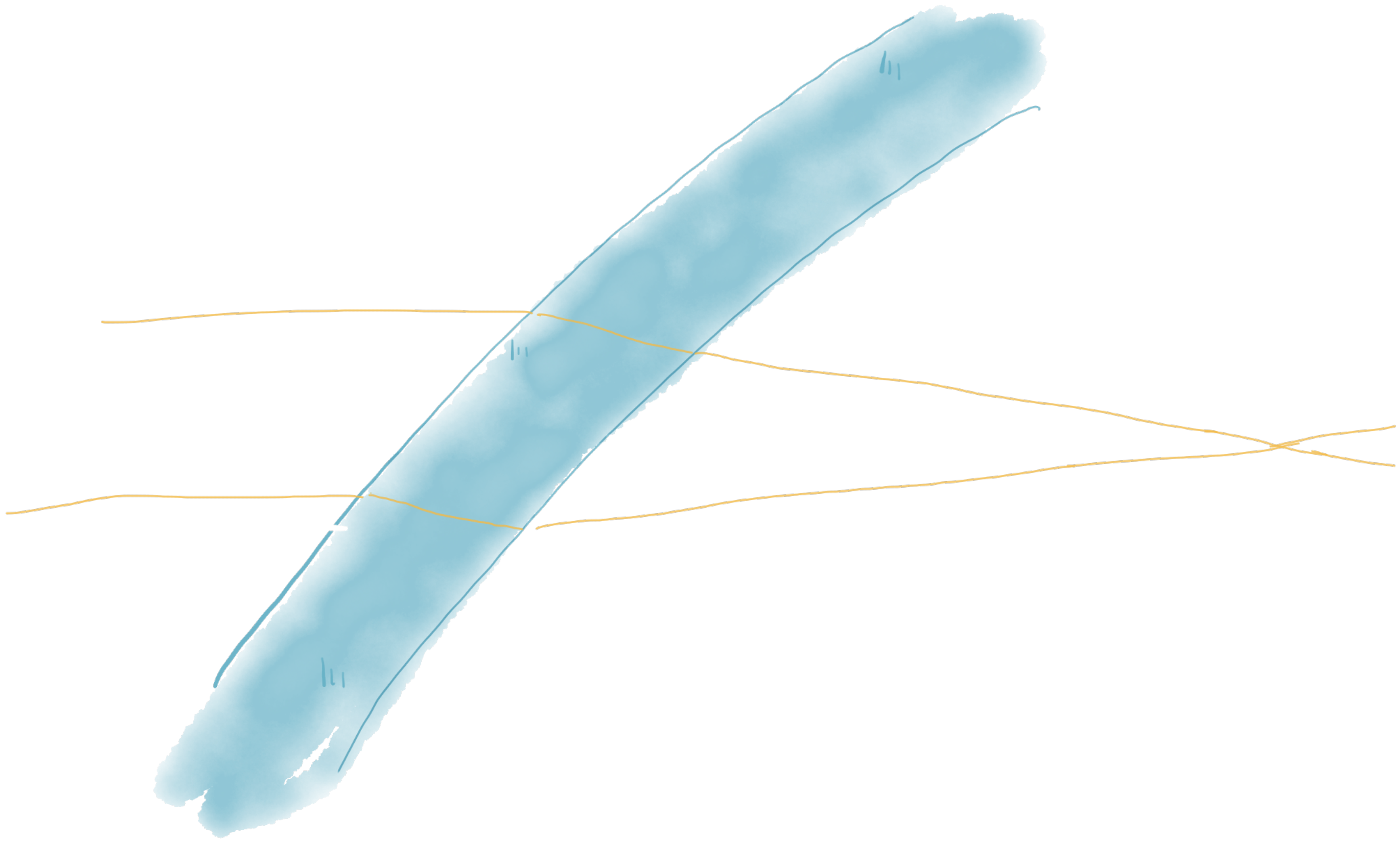
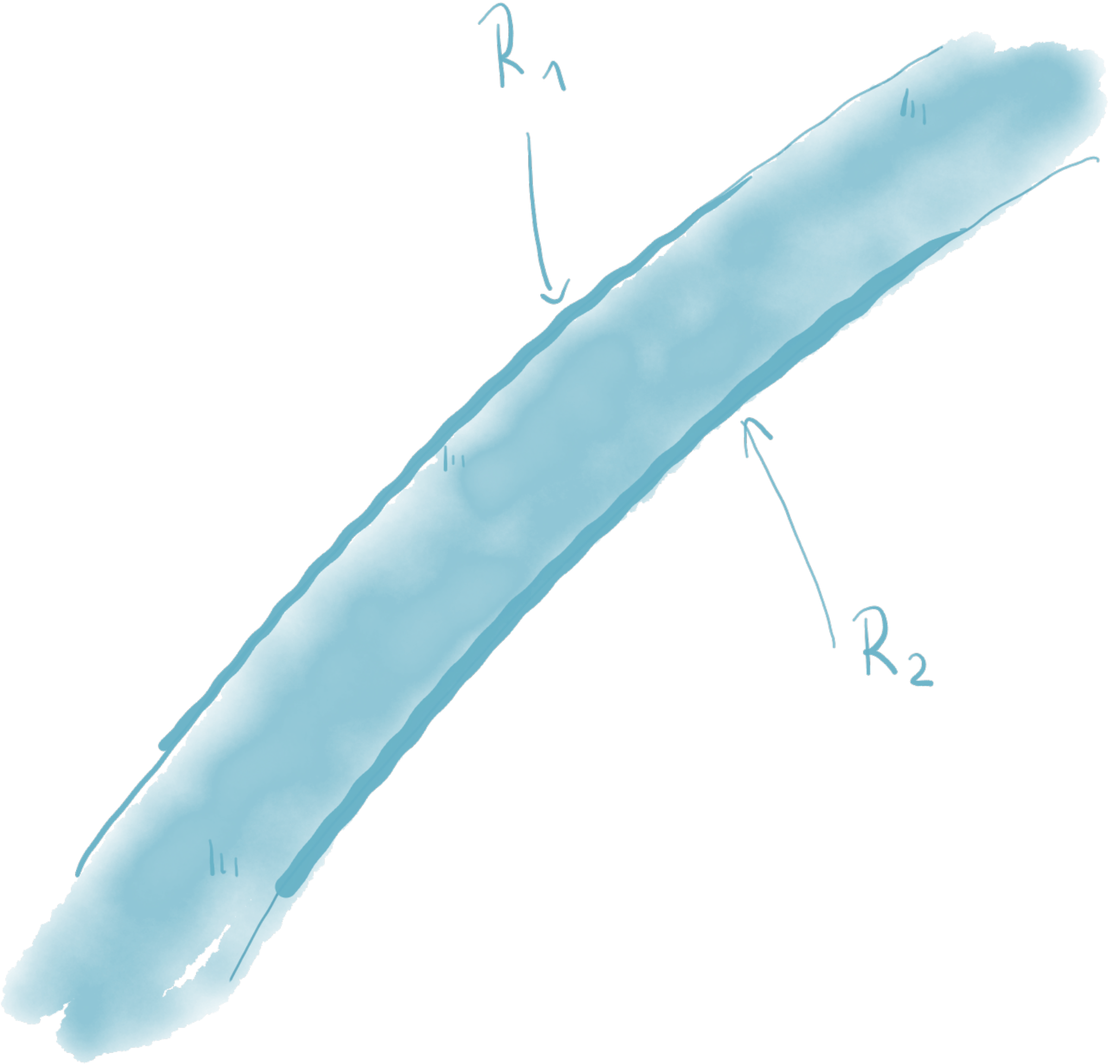
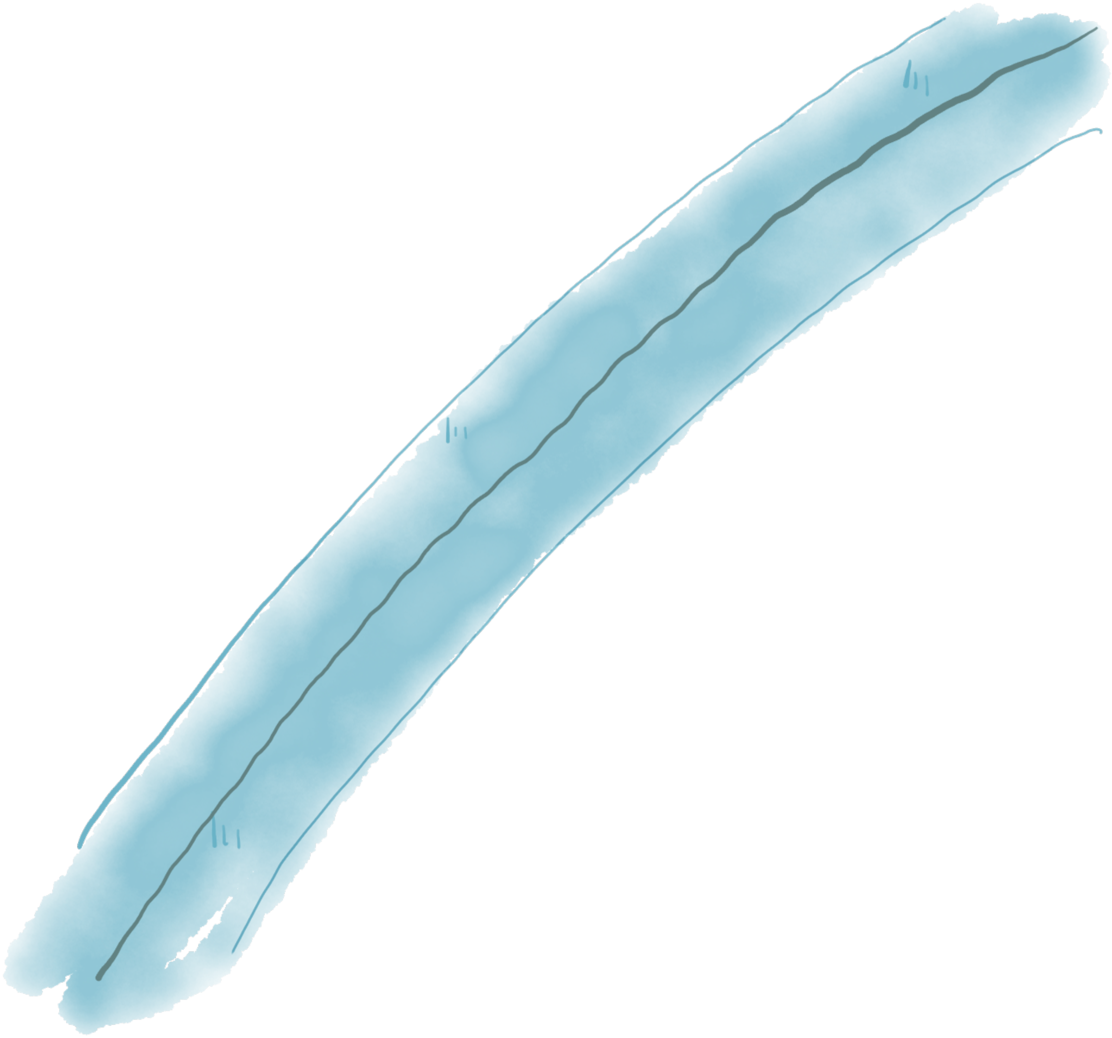


Image Quality (IQ)




R_1
R_2



Optical Quality of Windscreens

- What are state-of-the-art measurements techniques and KPIs?
- What optical properties are currently being measured in real production lines?
- What properties are not measured?
- Are all these optical properties ready for simulation?
- Ageing, Dirt, Replacement?

The P2020

P2020 - Overview & Long Term Objectives

- The next generation of cars will be **multi-sensor, multi-modal, multi-camera, AI platforms**. The key driver for this dramatic evolution in our vehicles is to increase safety.
- While cameras are crucial for a vehicle to sense and perceive its surroundings, to date there had **not been a consistent approach in the automotive industry** to measure image quality.
- **Existing standards are not covering the needs of automotive imaging**:
  - IEEE-SA P1858 Camera Phone Image Quality (CPIQ) working group
  - EMVA1288
  - ISO12233
- **Automotive imaging imposes unique challenges** due to its varied and distinct landscape of different setups (fisheye, multi-camera, HDR, temperature range, …), which are not adequately addressed in the existing standards.
- Therefore, the IEEE-SA P2020 working group has set the **goal of defining the relevant metrics and KPIs for automotive image quality**, enabling customers and suppliers to efficiently define, measure and communicate image quality of their systems.

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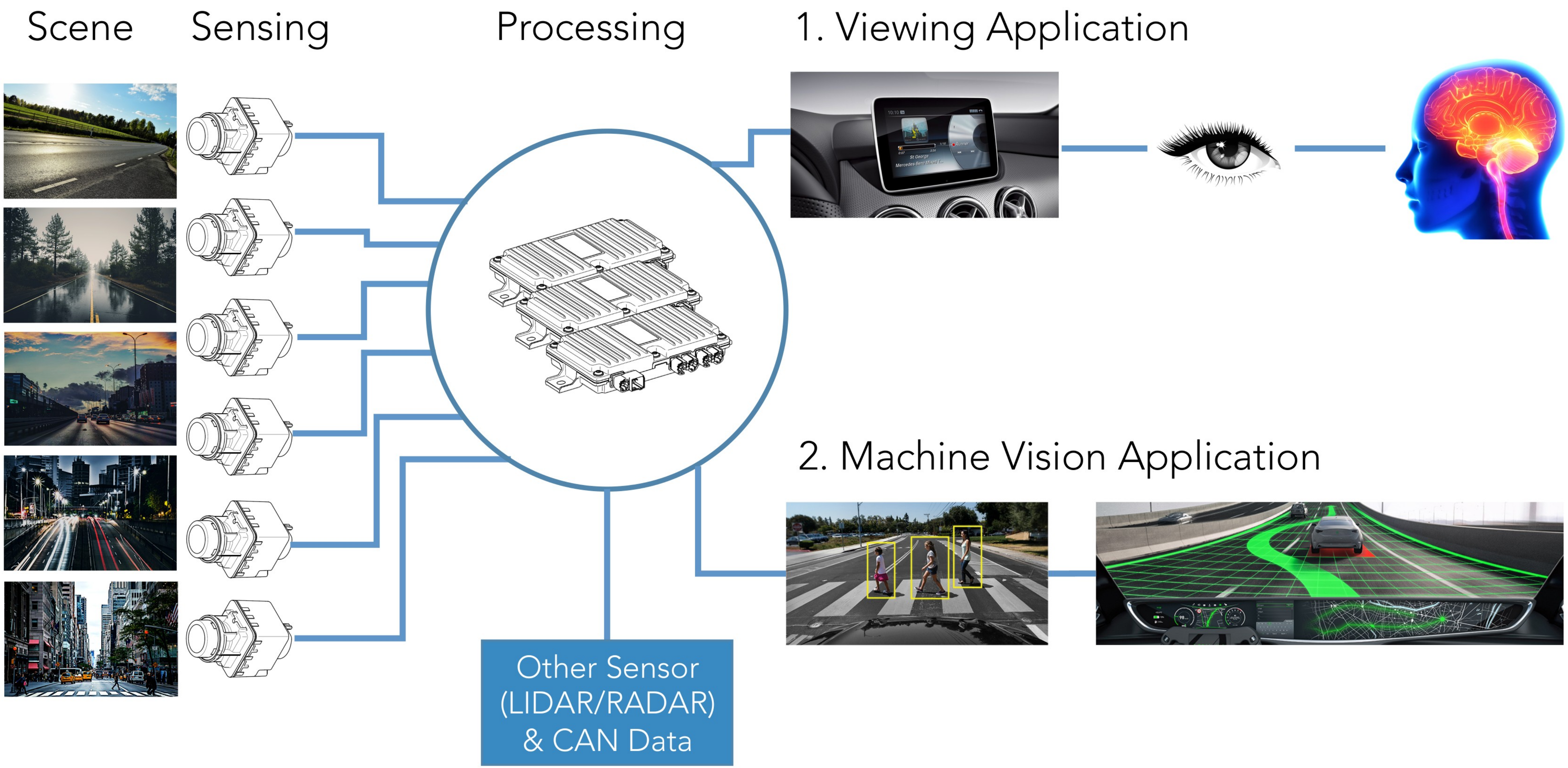
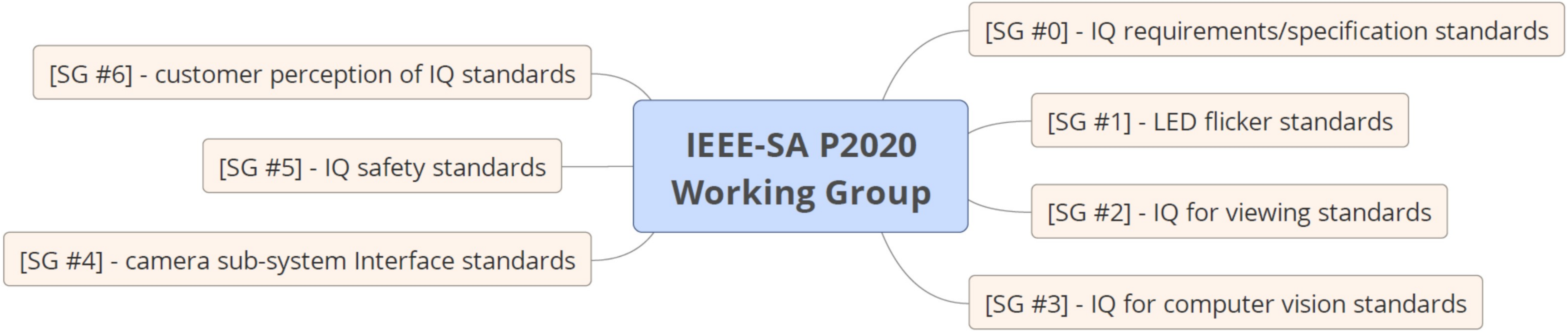
Automotive Image Quality



IEEE P2020 Sub Groups



SENSE MEDIA
GM
Labsphere
Image Engineering
FotoNation®
Panasonic® Automotive
Valeo
IEEE®
RENESAS
Fastree 3D imagers
VOLKSWAGEN GROUP OF AMERICA
DAIMLER
DXO SIMPLY BETTER IMAGES
Ford
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TEXAS INSTRUMENTS
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videantis
passion for video
life.augmented
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codeplay®
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SONY
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Continental
HITACHI
Inspire the Next
IBM
LG Electronics
GENTEX CORPORATION
A Smarter Vision®
smr
Samvardhana Motherson Reflectec
NISSAN
MITSUBISHI ELECTRIC
RESEARCH LABORATORIES
PSA PEUGEOT CITROËN

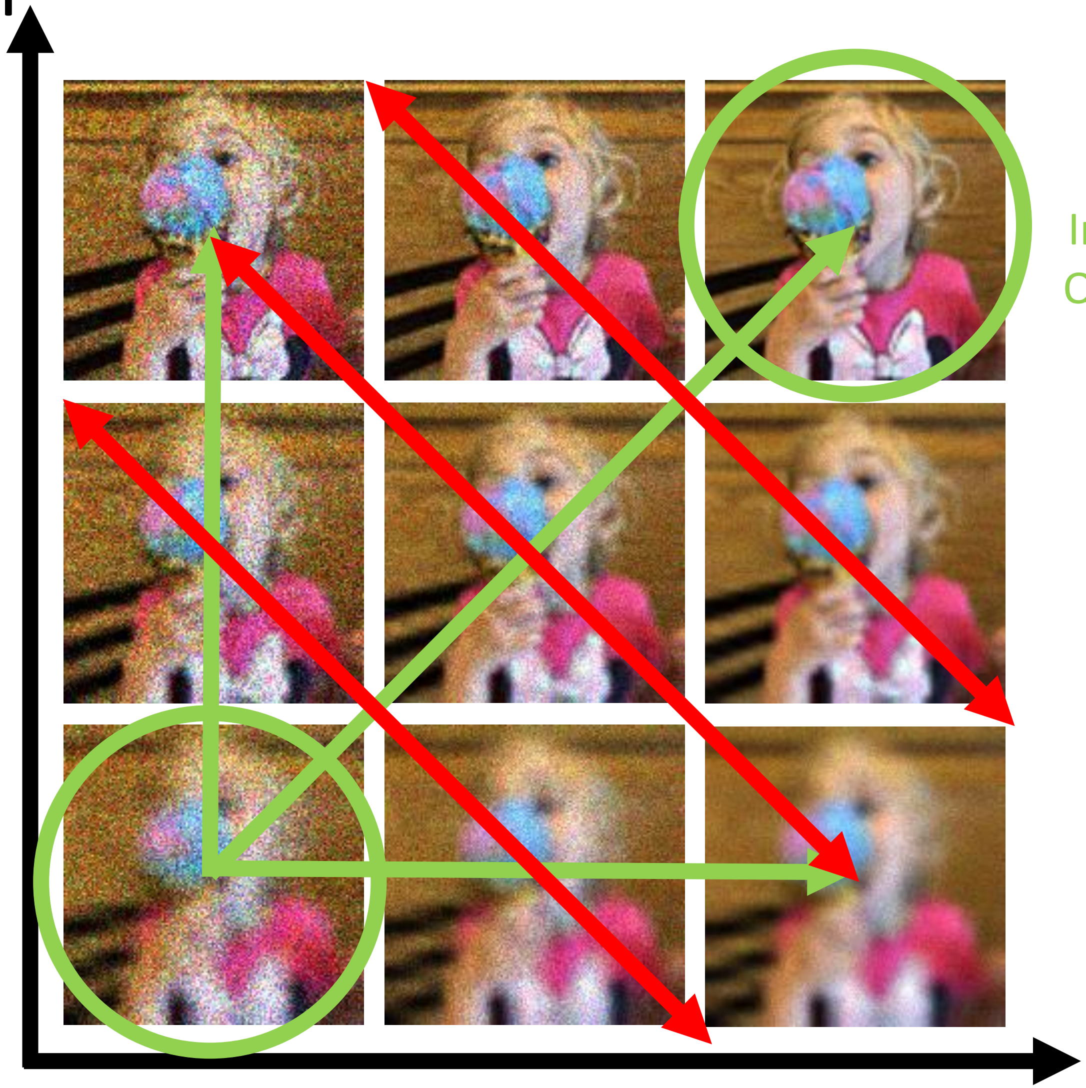
Why is P2020 important?

Reality
Constrained
Size or Cost or Processing
Dual Tasks

Trade one KPI for another
Cannot move in just
one direction
e.g Fixed Sensor Size

More Subtle

Well defined, clean,
objective metrics
- Repeatable
- Adapted for automotive,
  e.g. LED flicker
- Largely orthogonal in
  Hyper-dimensional space



Idealized
Represents
Unconstrained Development
Bigger Size
Increased Cost
More Processing

Effects fairly obvious

Subgroup #0
Image quality requirements and specification standards
(Terms and Definitions)

Subgroup #0 - Image quality requirements and specification standards

- Coordinates topics relevant to all other subgroups
- List of (actual) Camera Samples
- Camera Matrix
- List of Use-Cases
- List of Automotive Spectra

Sub Group 0 – Image quality requirements and specification standards

Gap Analysis

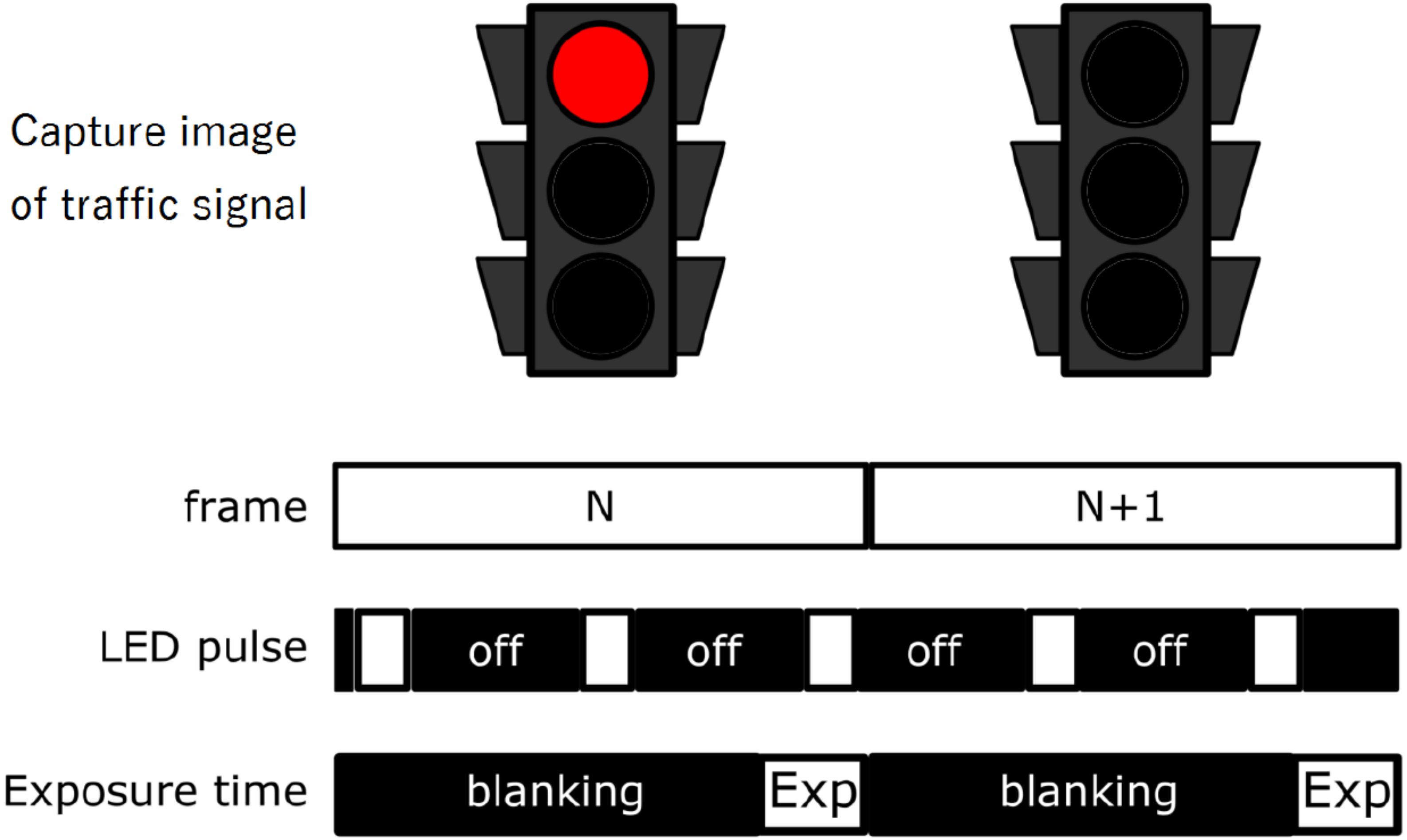
Table 1 Gap analysis

Technical category	Item	Existing industry standards	Original use case of existing standard, or comments	Gap to automotive particular needs	Correlated Item, comments	Cat.
Tonal response	**Dynamic range**	ISO 15739: 2017 [14], EMVA 1288 [6]	Evaluation on monotonical response input image. Given as the ratio of the signal saturation to the absolute sensitivity threshold	Dynamic range definition on multi-exposure type of sensor; dynamic range of displayed imaged with adaptive tone mapping; dynamic range considering a minimum SNR required over its defined range. (A minimum SNR required to perform intended operation, e.g., distinguishing an object.)	Window glare, optics flare, sensor intrinsic dynamic range and quantization, compression I/F	Sensor
	Contrast Detection Probability (Dynamic range that meets specific CDP)	New approach in IEEE P2020	—	Gap to close: Define the dynamic range and other dependencies, where the signal allows the detection of a certain Object Category (feature: Contrast) for the targeted application. For more details, see literature [13]. For example, guarantee detection even if SNR drops are present in multi-capture systems.	—	System and Compon ent Level
	Sensitivity	ISO 12232 [7], Speed; EMVA 1288 [6], QE	Digital Still Camera, Visual spectrum	Definition extend to IR spectrum.	—	Sensor
	Low light performance	ISO 19093 [15] (in development)	Smartphone camera evaluation is main focus of this standard	Low light performance on actual use condition, definition considering trade-off operation according to application (2D, 3D NR operation dependence on scene brightness, ...).	SNR, Temperature dependency, NR operation	Sensor
	SNR 1/5/10	—	Illuminance in lux that delivers image with at least the defined SNR value equal to 1, 5, or 10 for a neutral grey patch.	Alternative to low light performance.	—	Sensor
	Tonal shading	ISO 17957 [16]	Metrics defined using a flat target chart	Needs adaptation to wide view angle application.	Optical, CRA	Sensor
	Chroma shading	ISO 17957 [16]	Metrics defined using a flat target chart	Needs adaptation to wide view angle application.	Optical, opto-device, device cross-talk	Sensor
	OECF	ISO 14524 [17]	OECF (Evaluation on monotonical response input image)	Evaluation on adaptive tone mapping operation.	—	Sensor

Subgroup #1
LED-Flicker

Sub Group 1 – LED Flicker

Sub-Group 1



Capture image
of traffic signal
frame
N
N+1
LED pulse
off
off
off
off
Exposure time
blanking
Exp
blanking
Exp

Sub Group 1 – Tutorial Paper

- Deegan, B., LED flicker: Root cause, impact and measurement for automotive imaging applications, Electronic Imaging Symposium 2018, Autonomous Vehicles and Machines Conference 2018, Society for Imaging Science and Technology,
  DOI: https://doi.org/10.2352/ISSN.2470-1173.2018.17.AVM-146

https://doi.org/10.2352/ISSN.2470-1173.2018.17.AVM-146

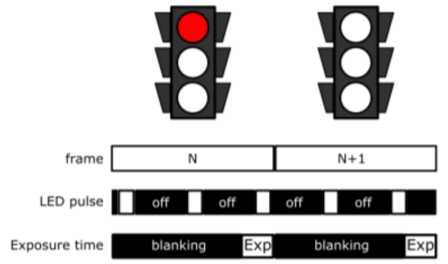
LED flicker: Root cause, impact and measurement for automotive imaging applications

Brian Deegan; Valeo Vision Systems, Tuam, Galway, Ireland

Abstract
In recent years, the use of LED lighting has become widespread in the automotive environment, largely because of their high energy efficiency, reliability, and low maintenance costs. There has also been a concurrent increase in the use and complexity of automotive camera systems. To a large extent, LED lighting and automotive camera technology evolved separately and independently. As the use of both technologies has increased, it has become clear that LED lighting poses significant challenges for automotive imaging i.e. so-called "LED flicker". LED flicker is an artifact observed in digital imaging where an imaged light source appears to flicker, even though the light source appears constant to a human observer. This paper defines the root cause and manifestations of LED flicker. It defines the use cases where LED flicker occurs, and related consequences. It further defines a test methodology and metrics for evaluating an imaging systems susceptibility to LED flicker.

Introduction
In recent years, the use of Pulse Width Modulation (PWM) driven LED lighting has become widespread in the automotive environment. Vehicle designers have taken advantage of the flexibility of LED headlamps to devise innovative styling designs, which have now become a key brand differentiator. LED lighting is also increasingly used in road signage and advertising, because of their high energy efficiency, reliability, and low maintenance costs. There has also been a concurrent increase in the use of cameras in the automotive industry. Automotive cameras have evolved from simple backup cameras to advanced surround view systems, mirror replacement systems, and machine vision cameras that enable Advanced Driver Assistance Systems (ADAS)

varying duty cycle (i.e. the fraction of one period when the light is active) in order to adjust their apparent brightness. At frequencies greater than 90Hz, the light will usually appear to be constant to most human observers [1, 2]. However, a camera imaging the light source may require a very short exposure time to capture a scene correctly, particularly in bright conditions. An illustrative example is shown in Figure 1. In frame N, the camera exposure time coincides with a pulse from the PWM driven LED traffic light. Therefore, for frame N, the red traffic light will be captured by the camera. However, in frame N+1, the camera exposure time and LED pulse do not coincide. In this case, the red light will not be captured. Over the course of consecutive video frames, the traffic light will appear to flicker on and off, depending on whether or not the cameras exposure time coincides with the LED light pulses.

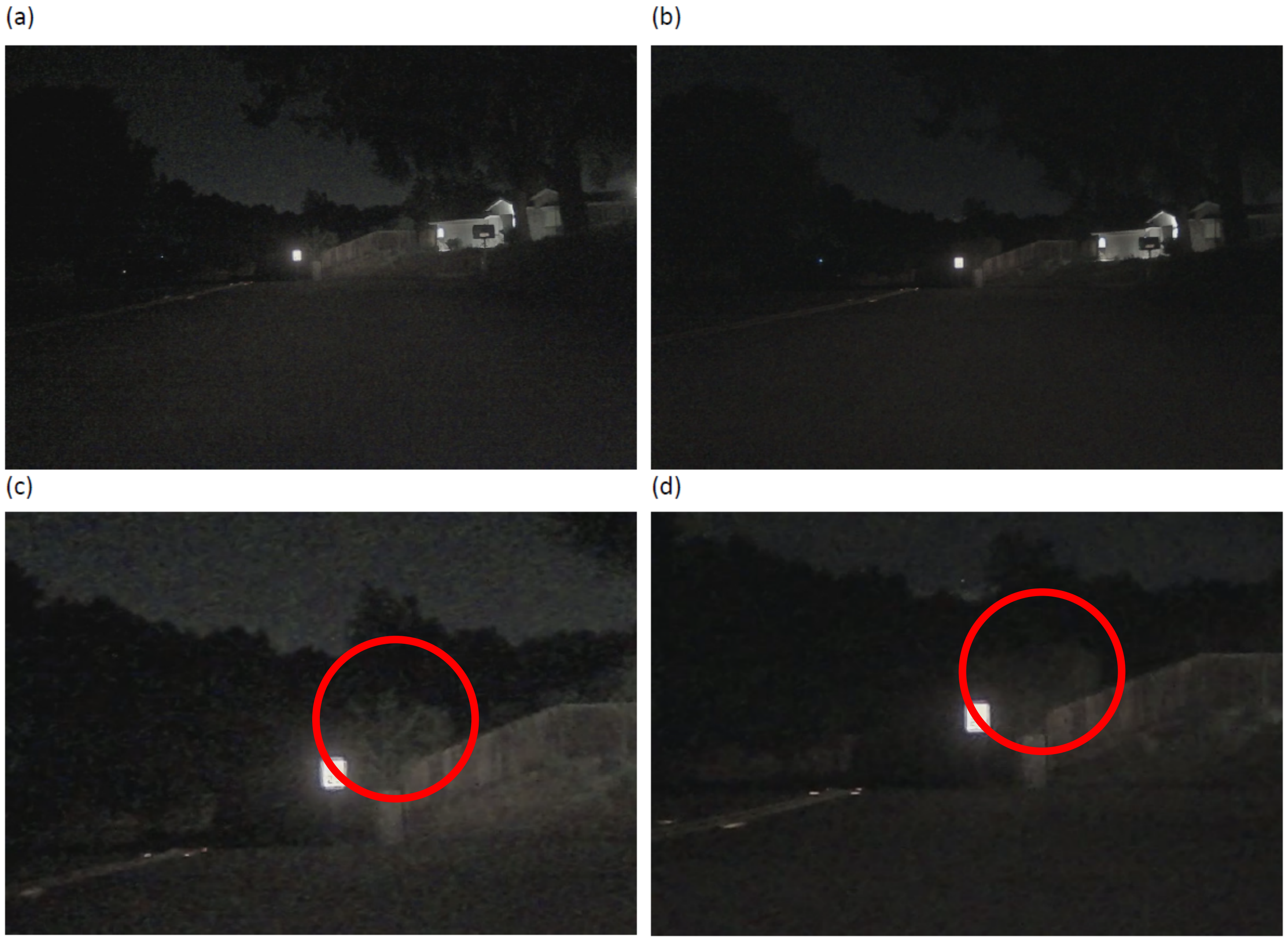


IEEE STANDARDS ASSOCIATION

Sub Group 1 – Psychovisual study

Subgroup #2
Image Quality for Viewing

Sub Group 2 – Image Quality for Viewing



Sub-Group 2 - Image Quality for Viewing

- Developing stable objective metrics initially
- Dynamic Range (Mario Heid - Omnivision)
  - Dynamic Range Extension and Lowest SNR defined for sensor level
- Noise (Orit Skorka – ON Semiconductor, Vladimir Zlokolica, Valeo)
  - Moved away from “Low light Sensitivity” at present to concentrate on noise metrics versus light level. Probably SNR based. Experimental set-up well defined.
- Glare and Flare (Andre Rieder, Gentex)
  - Well defined experimental setup and luma metric defined as extension of ISO 18844 to account for source angle. Will extend to account for chroma.
- Resolution (Uwe Artmann, Image Engineering)
  - Starting development, probably eSFR based

Subgroup #3
Image Quality for Machine Vision

Sub Group 3 – Image Quality for Machine Vision

Sub Group 3 – Paper on CDP

- Geese, Marc; Seger, Ulrich; Paolillo, Alfredo, Electronic Imaging, Autonomous Vehicles and Machines 2018, pp. 148-1-148-14(14) Electronic Imaging, Society for Imaging Science and Technology, **DOI:** https://doi.org/10.2352/ISSN.2470-1173.2018.17.AVM-148

https://doi.org/10.2352/ISSN.2470-1173.2018.17.AVM-148

Detection Probabilities: Performance Prediction for Sensors of Autonomous Vehicles

Marc Geese, Ulrich Seger and Alfredo Paolillo
Robert Bosch GmbH, Leonberg, Germany

Abstract

The recent established goal of autonomous driving cars, motivates the discussion about safety relevant performance parameters in the automotive industry. The majority of currently accepted key performance indicators (KPIs) do not allow a good prediction over the system performance along a safety relevant critical effect chain. A breakdown of the functional system down to component and sensor levels makes this KPI problem evident.

We will present a methodology for sensor performance prediction by a probabilistic approach, on the basis of significant critical use cases. As a result the requirement engineering along the effect chain especially for safety relevant processes appears transparent and understandable. Specific examples from the field of image quality will concentrate on the proposal of a new KPI, the ***contrast detection probability (CDP)****. This proposal is currently under discussion within the P2020 work group on automotive image quality and challenges known KPIs such as SNR, especially with respect their effects on automotive use cases.*

Introduction and Overview

In the last few years the market for driver assistance systems has been emerging very fast. Starting with anti-blockage-systems (ABS) for braking, the driver assistance systems spread into other applications of the car like automatic light switching, rain sensors for wiper control and ultrasound for parking assistance. While these and other systems are meanwhile standard for new cars, the development of driver assistance system continued. connected and highly complex system is required for the introduction of systems for a fully autonomous cars. Considering the effect chain of these systems the above described functionality relies on a good signal quality of a video capturing device.

Motivation and Goal

As described, advanced driver assistance systems are based on a complex effect chain for the video signal processing. This effect chain has to make ensure that the created output signal guarantees enough information to fulfill the demanded function in all use cases. For a video based ADAS we have for example to consider the effect chain that is composed by a scene in the world, windshield of the car, camera optics, image sensor and parts of the image signal preparation. The complete chain contributes to store an image into memory that can be used by further algorithms and neural networks.

Analyzing the above mentioned effect chain makes it evident that meaningful key performance indicators (KPIs) need to be specified. In this paper we will show by example for the imaging effect chain what KPIs could look like that allow to specify the components needed for an ADAS systems. The used probabilistic approach that derives a detection probability along the chain is suited to be transferred to other ADAS systems than the imaging chain.

The Problem of Requirement Engineering ADAS

Summary and Support

- IEEE P2020 is a collaborative effort working towards identifying and creating fundamental metrics to evaluate image quality for automotive applications.
- Important work that has safety considerations.
- In addition is complex and needs collaboration across disciplines.
- **We need your participation!**
    - **Free to attend (+ meeting fee $100)**
    - **Three meetings per year (January (variable location), May (Detroit), September (Brussels))**
- We also need the support of your companies for meetings and to facilitate work
    - Trying to keep participation open and free to be inclusive as possible

Optical Quality of Windscreens

We Want You!

How does this… … influence this?

Optical Quality (OQ) Algorithm Performance (AP)

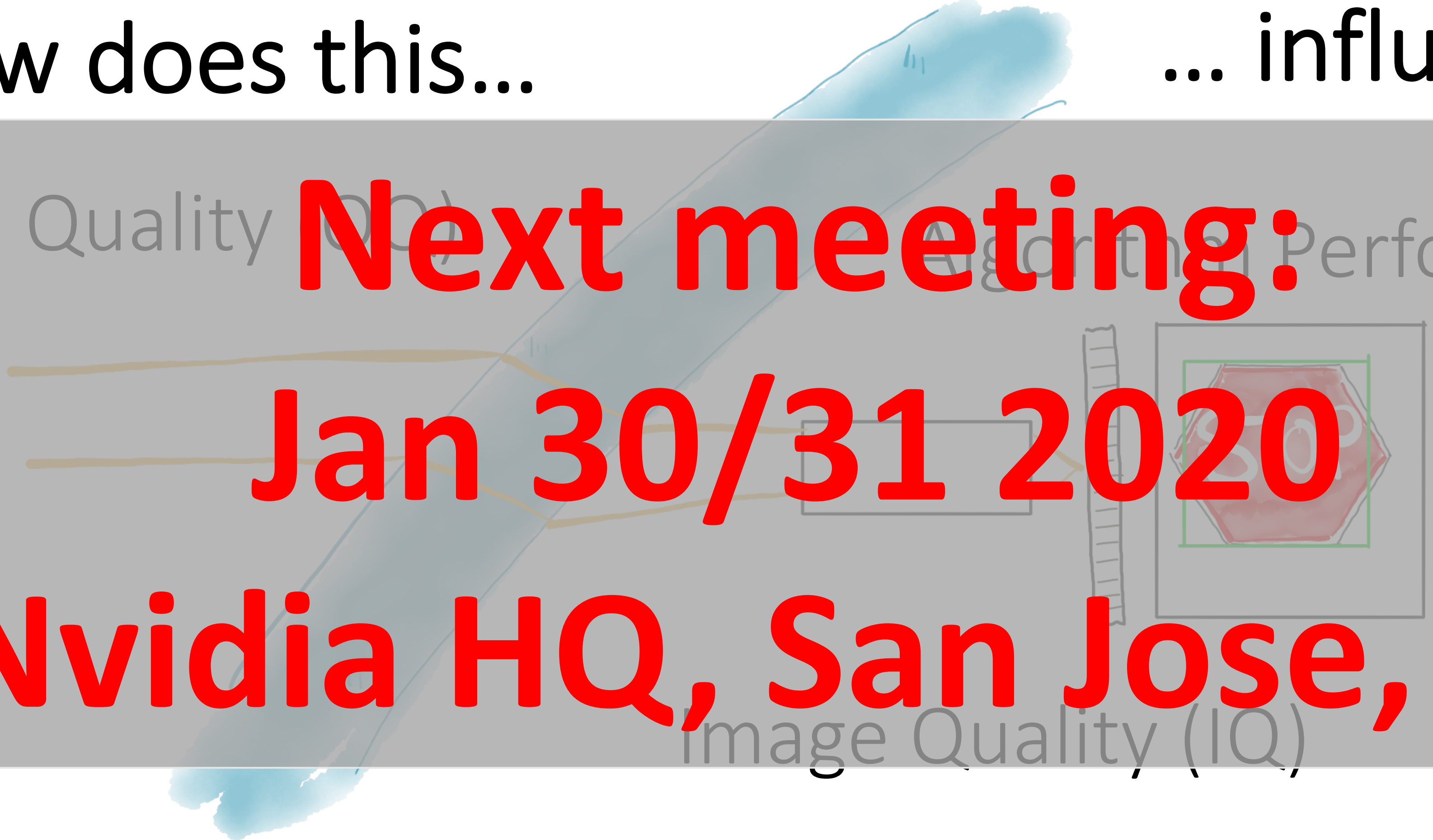


Image Quality (IQ)

Next meeting:

Jan 30/31 2020

Nvidia HQ, San Jose, CA