



# Optimized Image Processing for Automotive Image Sensors with Novel Color Filter Arrays

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# Today's contents

- Nextchip: Vision Professional
- Challenge for Both Human & Machine Vision
- Nextchip's ISP Topology
- Test Results of Nextchip's Image Processing for Each CFA
- Sophisticated methodology for design and tuning

# Nextchip: Vision Professional

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# Nextchip overview

## Market Proven Technology

- 420million shipping units
- 51+ MP car models

## Listed on the KOSDAQ

- Went public in July 2022

## Automotive reliability

- AEC-Q100 Gr.2/CMMI Lv.-3/ISO26262/A-Spice process

## Advanced ADAS technology

- Edge processor /w hard-wired ML algorithms
- ADAS SoCs with CNN capability
- Tuning capability human & machine vision

## World-class ISP (ASIC/IP/Tuning)

- Developing image signal processing tech. for 26 years
- Open architecture with various imagers

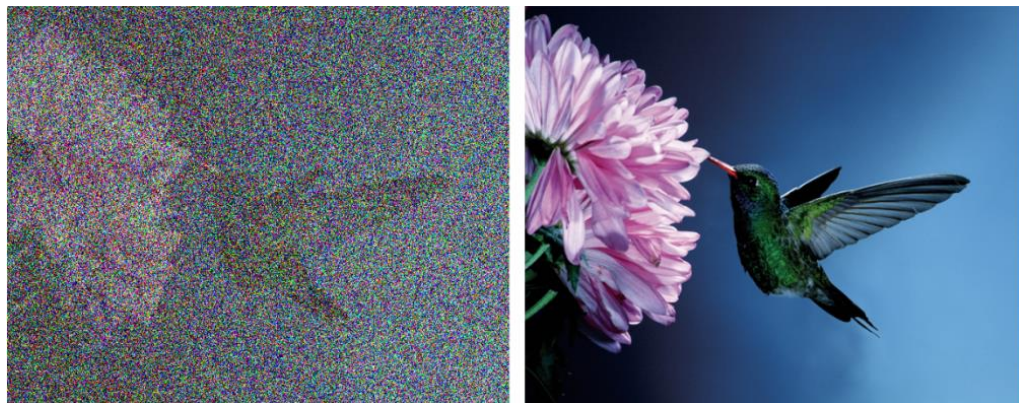
## Customer support

- Know-how in tuning against various customers' criteria

# Challenge for both Human & Machine Vision

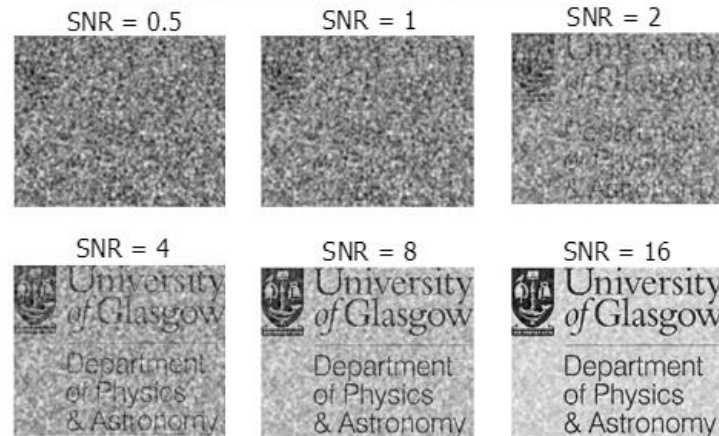
# Key factor of machine vision

- High sensitivity is the key factor of machine vision for achieving a quality video image with low image noise even in poor lighting conditions.
- The higher the signal-to-noise ratio, the better the object can be detected.
- Sensitivity is more important than color in machine vision.



<Ref. Basler "High-Sensitivity Image Processing Cameras">

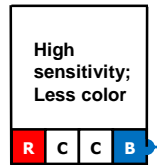
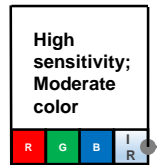
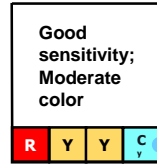
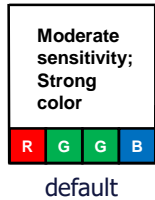
## The effect of signal-to-noise ratio



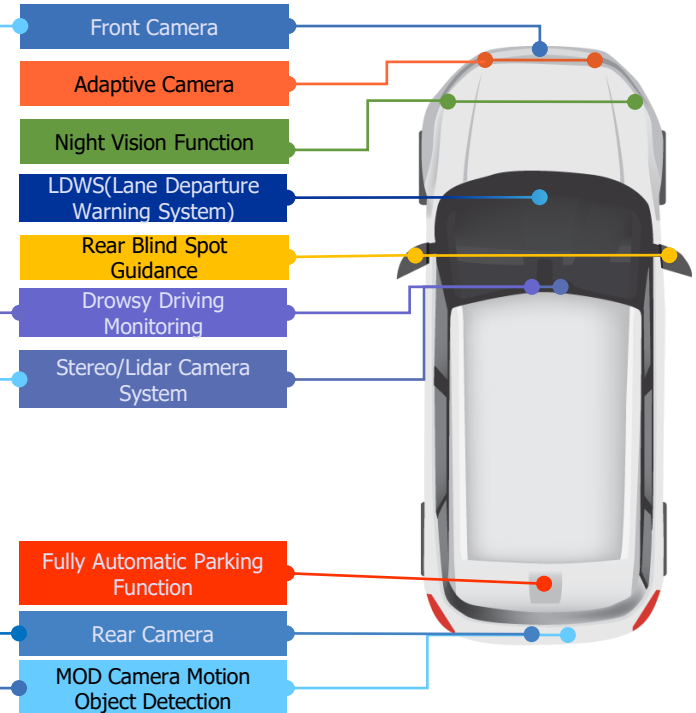
<Ref. gla.ac.uk "Sensitivity and noise">

# How to get higher sensitivity

## Diverse bayer pattern with pixels



- Special CFAs have popped in a variety of scenarios depending on how the camera is used.
- All about the color & sensitivity for human & machine vision.
- HOWEVER, newly proposed CFAs have an issue in color reproduction.



< Ref1. MCNEX official website >



# What is the difference between human vision & machine vision?



it are





# Issues when color reproduction fails



- Hard to distinguish red light. And, it is directly linked to malfunction in autonomous driving.
- Even for sensing application, color reproduction is required at the very least.

< Ref3. Non-RGB color filter options and traffic signal detection capabilities >

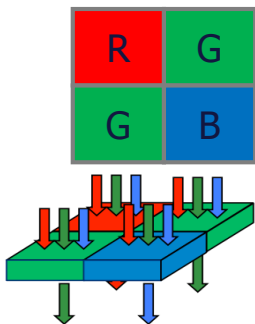
# Nextchip's ISP Topology

Attempts to get sensitivity and color at the same time

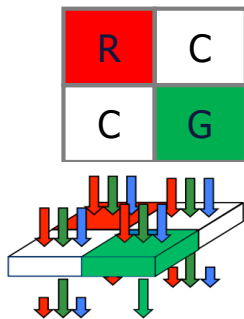
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# What is special?

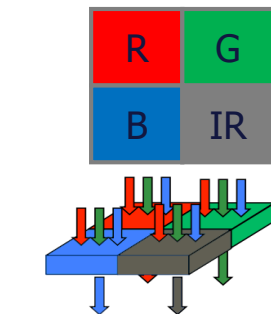
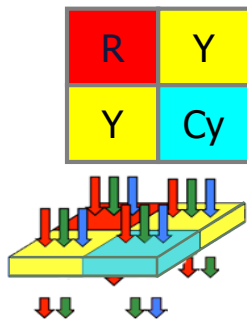
- There is a trend to change color filter array from RGB to others. It is based on applications like RGB-IR for in-cabin camera system, RCCG and RYYCy for exterior cameras in automotive market.



**General Purpose**



**Front Sensing  
With Higher Resolution**



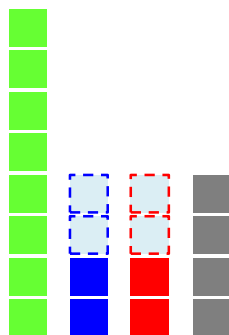
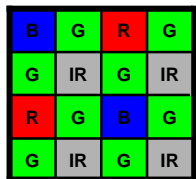
**In-cabin sensing  
for Occupant Monitoring**

<Ref4. Image Sensor World>

- While maintaining Red, **RCCG** gets more color than RGGB.
- **RYYCy** subtracts varying degrees of red, green, and blue from white light to produce a full spectrum of colors.
- **RGBIR** uses IR to get higher sensitivity under the dark cabin environment.

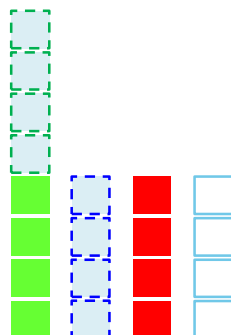
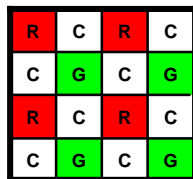
# The key is how to fill the lack of pixel information

## Color Reproduction



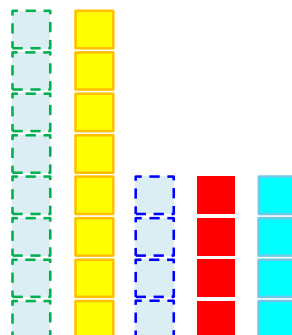
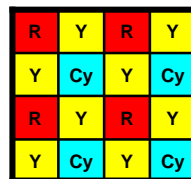
G:8 B:2 R:2 IR:4

## Edge Enhancer



G:4 B:0 R:4 C:4

## Noise Reduction

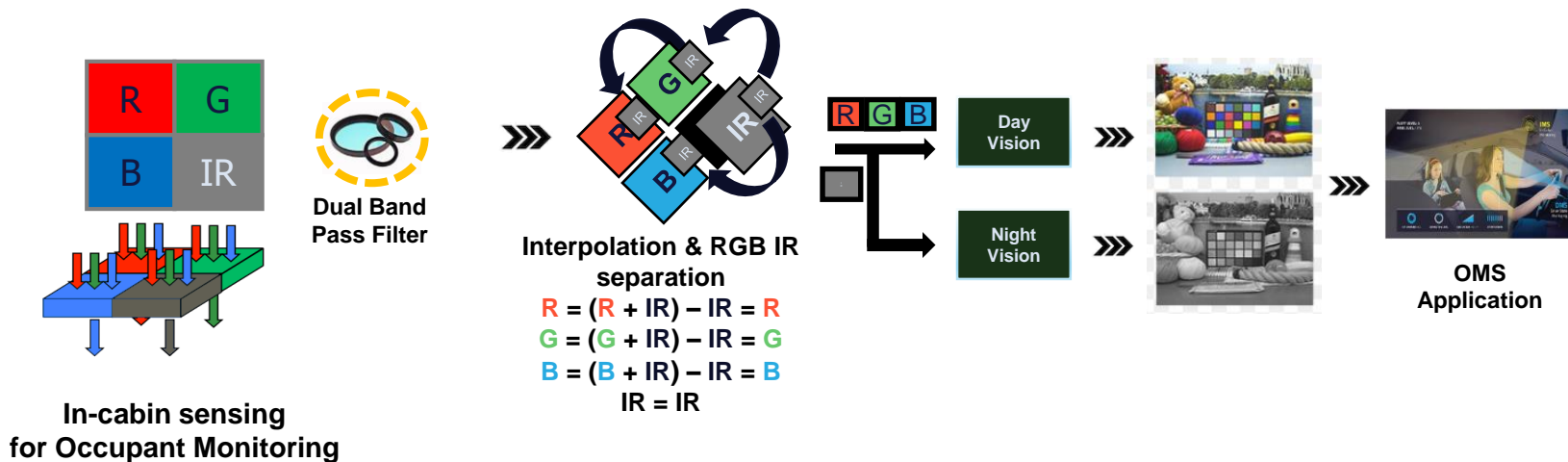


G:0 Y:8 B:0 R:4 Cy:4

- Since several pixels had been converted to another pixels compared to RGGB, the key is how to handle and improve the color and edge characteristics given the lack of pixel information.
- With specialty in image signal processing technology as the fundamental vision technology of Nextchip, it provides the differentiated image quality for embedded systems.v

# In RGB-IR case

- RGB-IR is the most complicated case because it needs to extract IR from each pixels.
- Dedicated processing block for extracting IR is required.



# Test Results of Nextchip's Image Processing for Each CFA

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# RGBIR image

- Despite the lack of pixel information, the Nextchip ISP is able to reproduce color at the same level as RGGB.
- If you want both RAW and YUV, you can get 2 separate image streams.
- They can be used for both human vision and machine vision.



**RAW**



**RGBIR**



# RCCG image

- Despite the lack of pixel information, the Nextchip ISP is able to reproduce color at the same level as RGGb.
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**RAW**



**RCCG**

# RCCG image

- Despite the lack of pixel information, the Nextchip ISP is able to reproduce color at the same level as RRGB.
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- They can be used for both human vision and machine vision.



**RAW**



**RCCG**

# RYYCy image

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- If you want both RAW and YUV, you can get 2 separate image streams.
- They can be used for both human vision and machine vision.



**RAW**



**RYYCy**

**Sophisticated methodology  
for design and tuning**

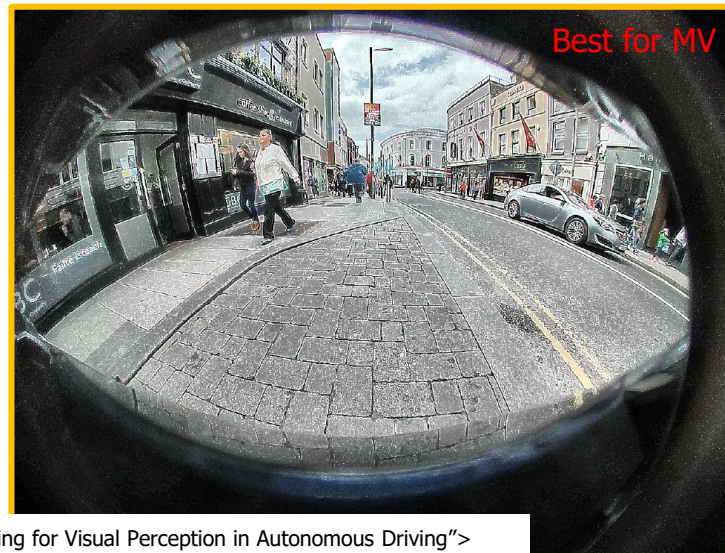
# Realtime processing through well partitioning

- Real-time constraint is one of the most common challenge found in many critical embedded applications, namely image and video processing. However, software tools and general purpose microprocessor are not suitable for deals with such as problems. The implementation method is based on Hardware/Software (HW/SW) codesign approach.
- To achieve a partition that will give us the required performance within the overall system requirements (in size, weight, power, cost, etc.)
- In addition to the advantage of easily modifying parameters to suit various environments, blocks that require fast image processing speed are designed with hardware that uses as little calculation line memory as possible, so they have the advantage of being processed in real time and displayed on the screen without delay.



# Image analysis for machine vision

- Key ISP modules which impact CV performance are MTF and Low light sensibility by sensor side, and Sharpening, HDR, Tone mapping and Color contrast by ISP side.



<Ref. "Overview and Empirical Analysis of ISP Parameter Tuning for Visual Perception in Autonomous Driving">

- ISP vendor should understand each algorithms and trys to find out ultimate setting values for better detection.

# Takeaways



# Market proven ISP technology

- ✓ ***ISP is not a one function. It is a bunch of functions.***
- ✓ ***Well-partitioned flexible ISP core technology***
- ✓ ***2 dedicated processing topologies for human vision and machine vision***
- ✓ ***Capable of analyzing the image based on understanding of HV and MV***

***High-Sensitivity Image Processing Cameras***

<https://www.baslerweb.com/en/vision-campus/camera-technology/high-sensitivity-industrial-cameras/>

***Sensitivity and noise***

[https://radio.astro.gla.ac.uk/a2\\_oa/a2oa\\_sec4.pdf](https://radio.astro.gla.ac.uk/a2_oa/a2oa_sec4.pdf)

***MCNEX AUTOMOTIVE DRIVING- RELATED TECHNOLOGY***

<https://www.mcnex.com/en/business/020201.automotive-camera>

***Robot Bionic Vision Technologies: A Review***

<https://www.mdpi.com/2076-3417/12/16/7970>

***Non-RGB color filter options and traffic signal detection capabilities***

<https://library.imaging.org/ei/articles/34/16/AVM-215>

***Aptina Explains Clarity+ Technology, Reveals 1.1um Pixel Product***

<http://image-sensors-world.blogspot.com/2013/07/aptina-explains-clarity-technology.html>

***Design of Image Signal Processor greatly reduced chip area  
by role sharing of hardware and software***

<https://koreascience.kr/article/JAKO201031559288071.pdf>

***Other images***

[www.nextchip.com/en/](http://www.nextchip.com/en/) & Nextchip's internal reports

**Please visit booth #109 and enjoy the latest image processing technologies.**