

Proposal of MAC concept for VL-ISC (Visible Light Image Sensor Communication)

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VLCC

Contents

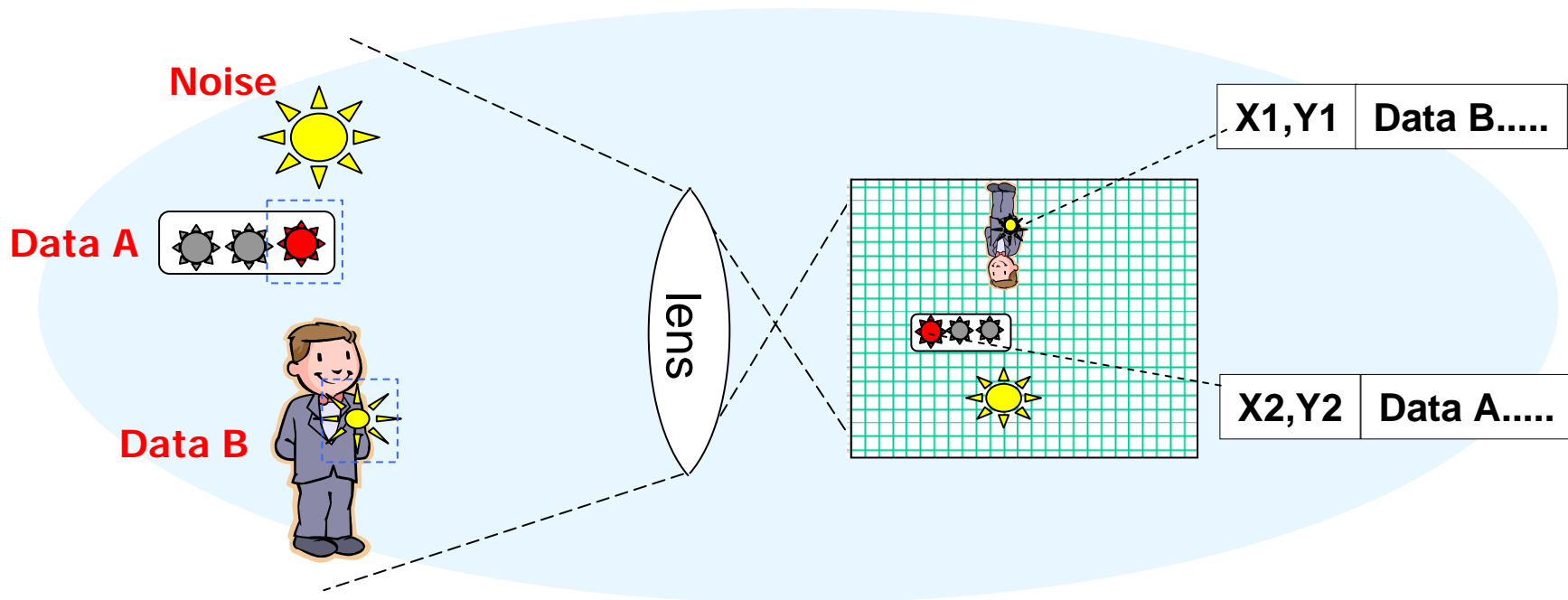
- Characteristics of ISC
- New MAC concept of ISC
- The example of CASIO's ISC
- Conclusion

Next....

- Characteristics of ISC
- New MAC concept of ISC
- The example implementation of CASIO
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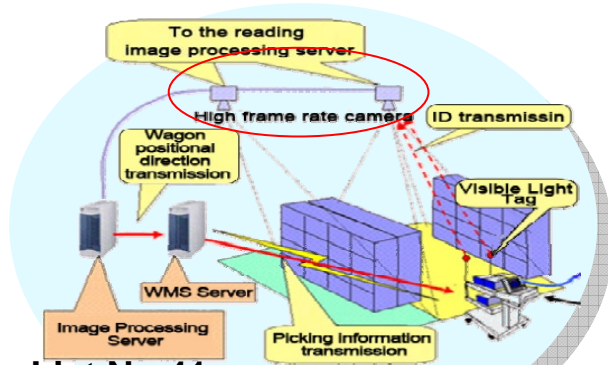
Image Sensor Communication (ISC)

- Spatial separation capability
 - Brightness–Distance invariant law
 - Providing “Data” simultaneous with “Spatial position”
- (Assumption: MAC mode is broadcast / Multi-pt to pt communication)



About VLC using Arrayed PD / Image sensor doc.: IEEE 802.15-<09-0502-00-10 July 2009 0007 >

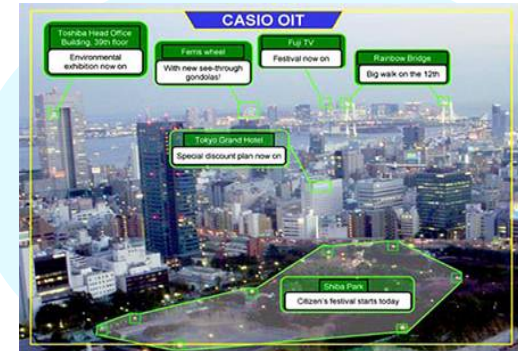
Many applications of ISC



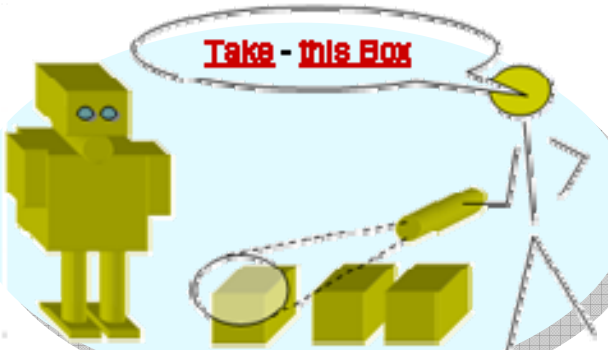
List No.41
Positional measurement at
Factory and warehouse



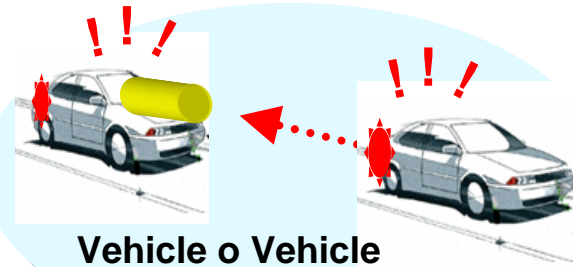
List No. 47
ITS Navigation



List No. 46
Guiding in spectacle outdoor

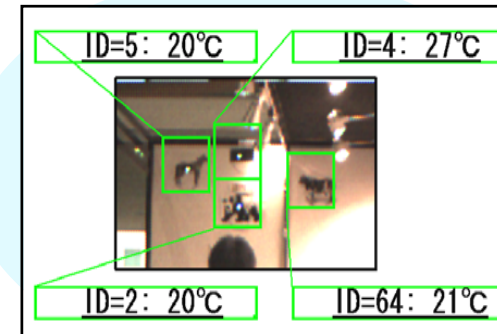


List No.43
Robotics (Indicate and command)



Vehicle to Vehicle
Pre crash safety

Using spatial property in
communication



List No.40
Positional sensor net

Application summary list: doc.: 15-09-0125-08-0007-vlc-application-definitions-and-summary.xls

Motivation of ISC based on Visible Light characteristics

ISC utilizes

Visible Light advantages that should be considered

1. The short wavelength provides high spatial resolution
 - It is not only for “High data rate” or “many channels”
2. Image formation lens is usable
 - It provides “Imaging” capability.

ISC solves

Visible Light environment issue that should support

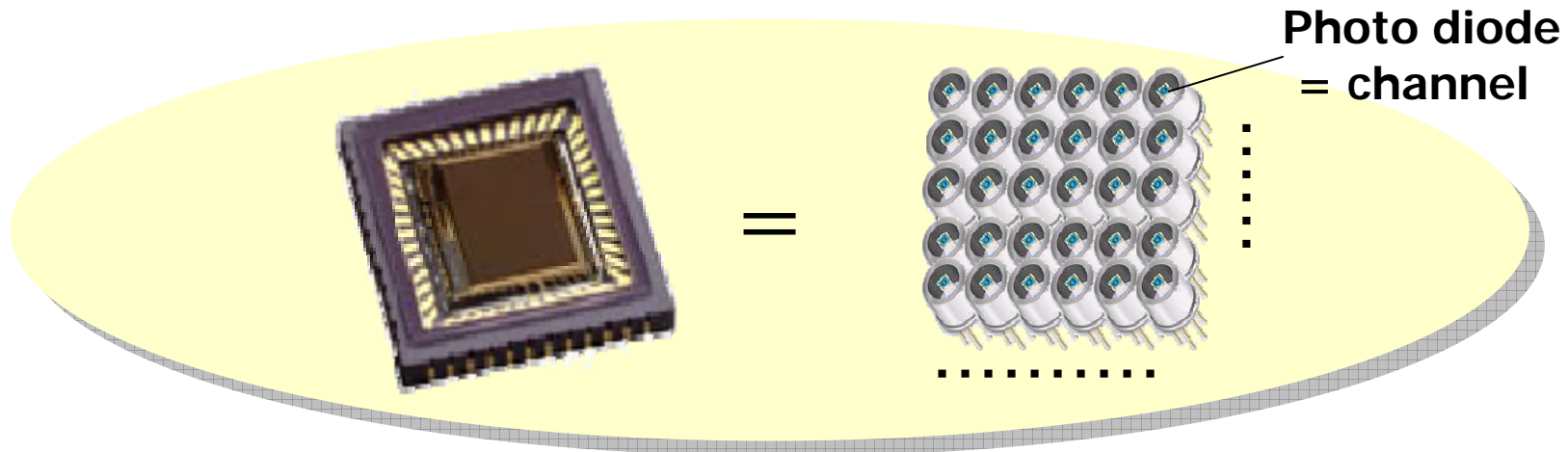
- A lot of strong ambient light noise/ interference
 - Sun light is severe DC noise in outdoor.
 - Indoor fluorescent lamp has 30–500kHz noise.

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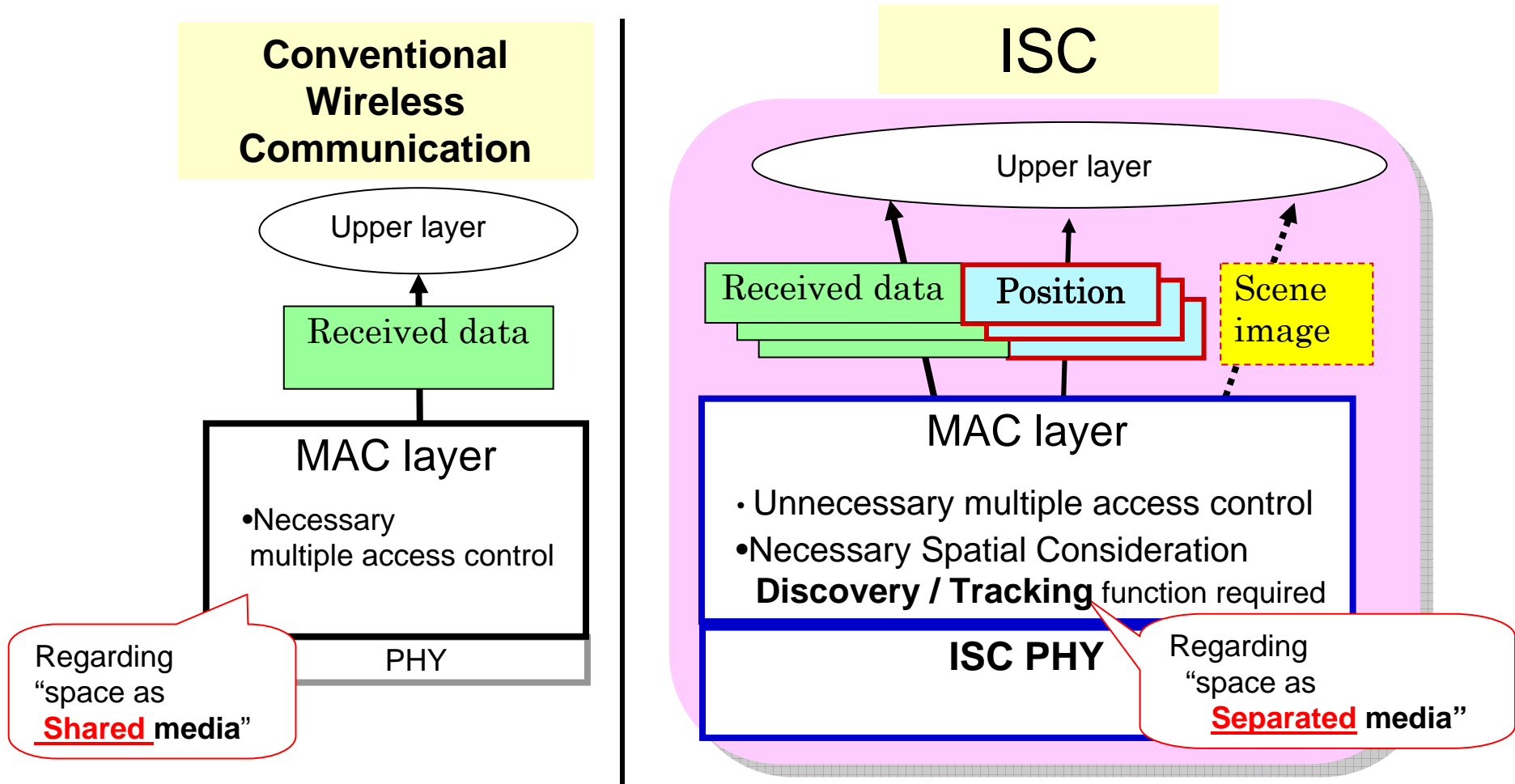
In a reductive point of view

The structure is arrayed photo diode...



- Is it the merely arrayed channels?
We think “No It brings a qualitative change”
- Does it need the consideration for standard?
We think “Yes we should consider it”

A new MAC concept of ISC



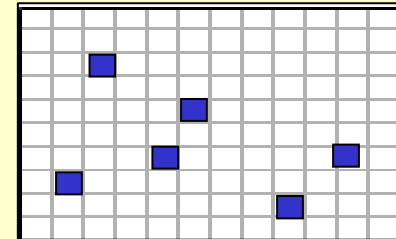
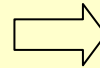
For the new effect / new issue, we should consider it

Discovery and Tracking required function of ISC

- **Discovery**

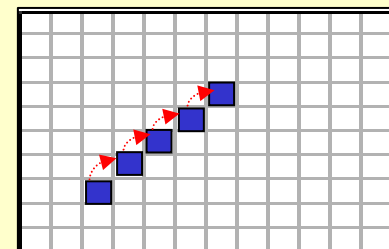
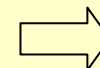
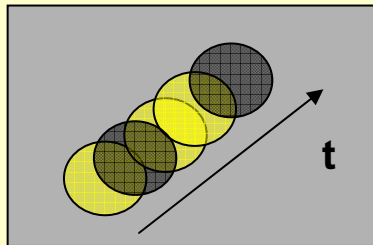
- It is Channel (s) selection from many channels in the array.

**Many Signals
and
Many Interference**



- **Tracking** optional function based on discovery

- It is like a hand-over method of mobile phone system.

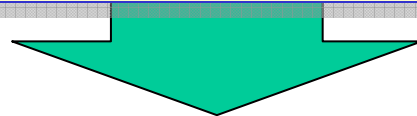


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A realization of ISC-MAC

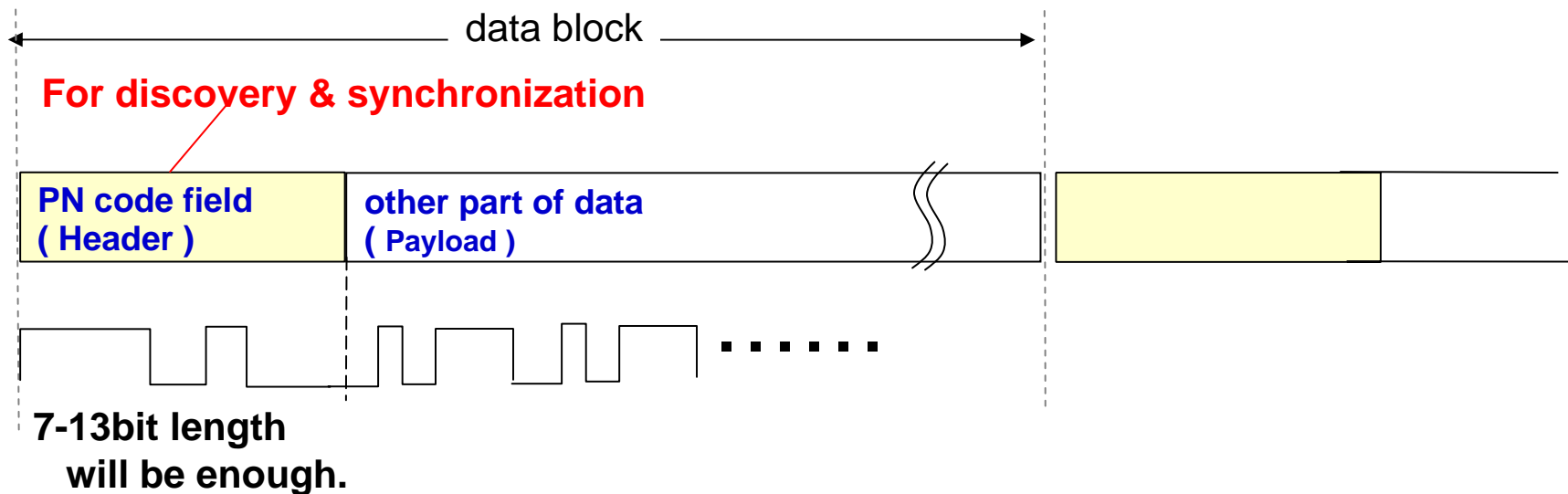
- Policy :
 - Simple architecture, available device
 - Performance of “discovery” have to be……
 - Stabilized in any environment.
 - Wide range of scalability in data rate
 - ultra low data rate (100bps) to low data rate (5K bps)



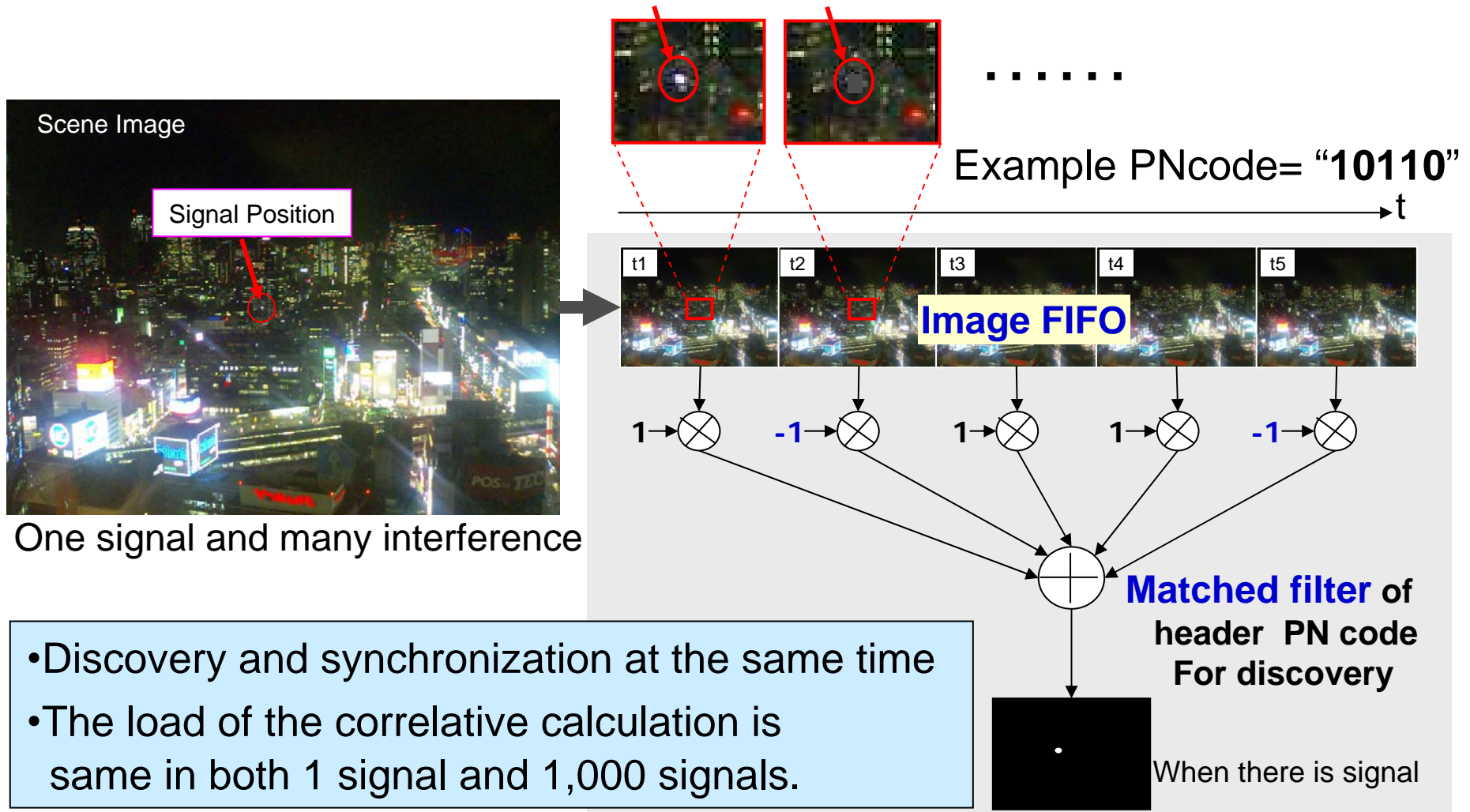
- Suitable method for “discovery” :
 - Consider about sending data for ISC.
 - Receiving devise use a **expansion of sending out data.**

Data format with ISC expansion

- Add specific PN (Pseudo Noise) code field in a data block.
- The PN-code is a **key of discovery**.
 - “Every natural brightness fluctuation” and the PN-code do not have a correlation each other.
 - “Other part of the block” and the PN-code also do not have a correlation each other.

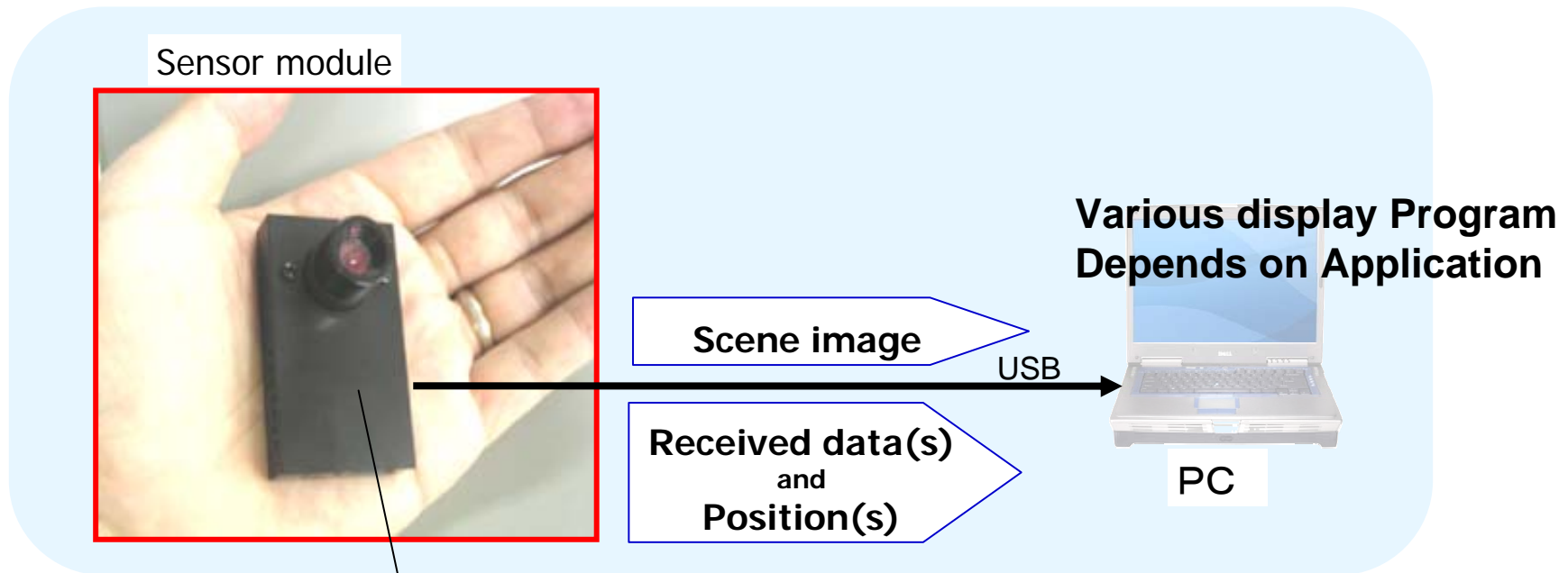


ISC expansion : receive side process



- Discovery and synchronization at the same time
- The load of the correlative calculation is same in both 1 signal and 1,000 signals.

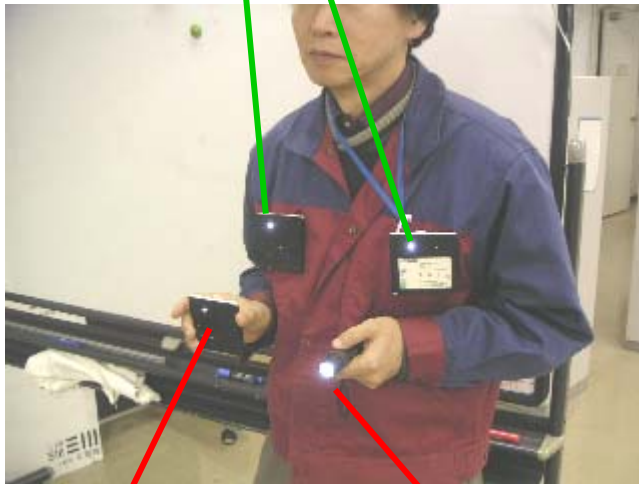
ISC Prototype of CASIO



Fast COMS Image Sensor + ISC processor
(fps-windowing controllable, Almost normal structure)

Confirmation experiment about eliminating interference

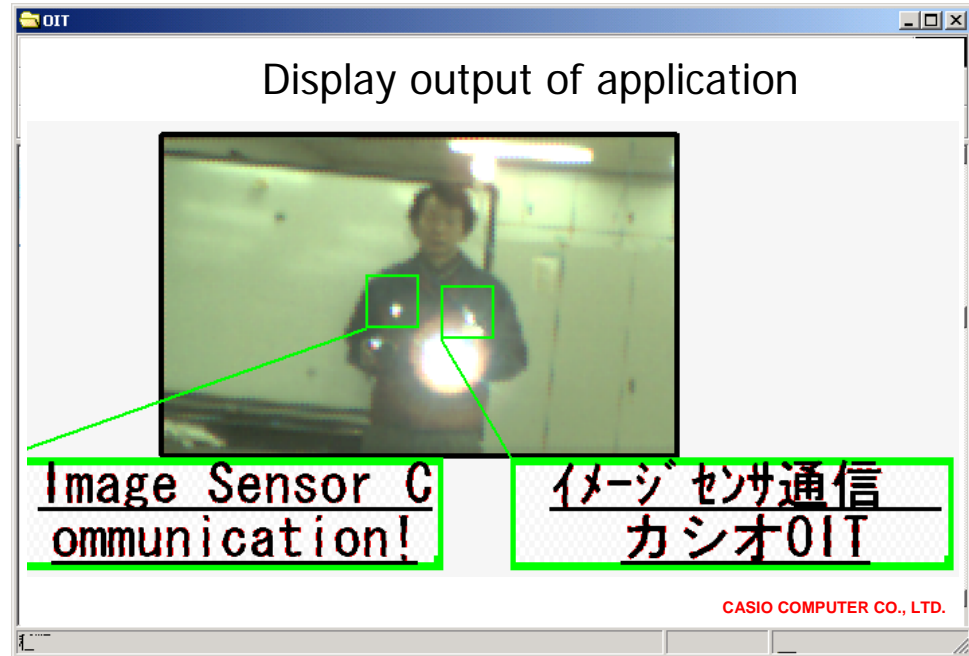
VLC data signal
300Hz mod. Freq.



300Hz freq. Signal
That has no
PN-code

Handy light
(intense DC)

Interferences



There is not the influence of interfering.

A demo movie

Discovery and Tracking using proposed data format



CASIO 2009.Sep. 2minutes.

The list of ISC examples

Image sensor	Application conscious	↔	Performance conscious
use existing sensor	CASIO (VLCC)	TOSHIBA (VLCC) NEC (VLCC)	
Make special hardware	SONY (VLCC)		KEIO Univ. (VLCC) Shizuoka Univ. NAIST ...etc

These examples have “discovery” function.

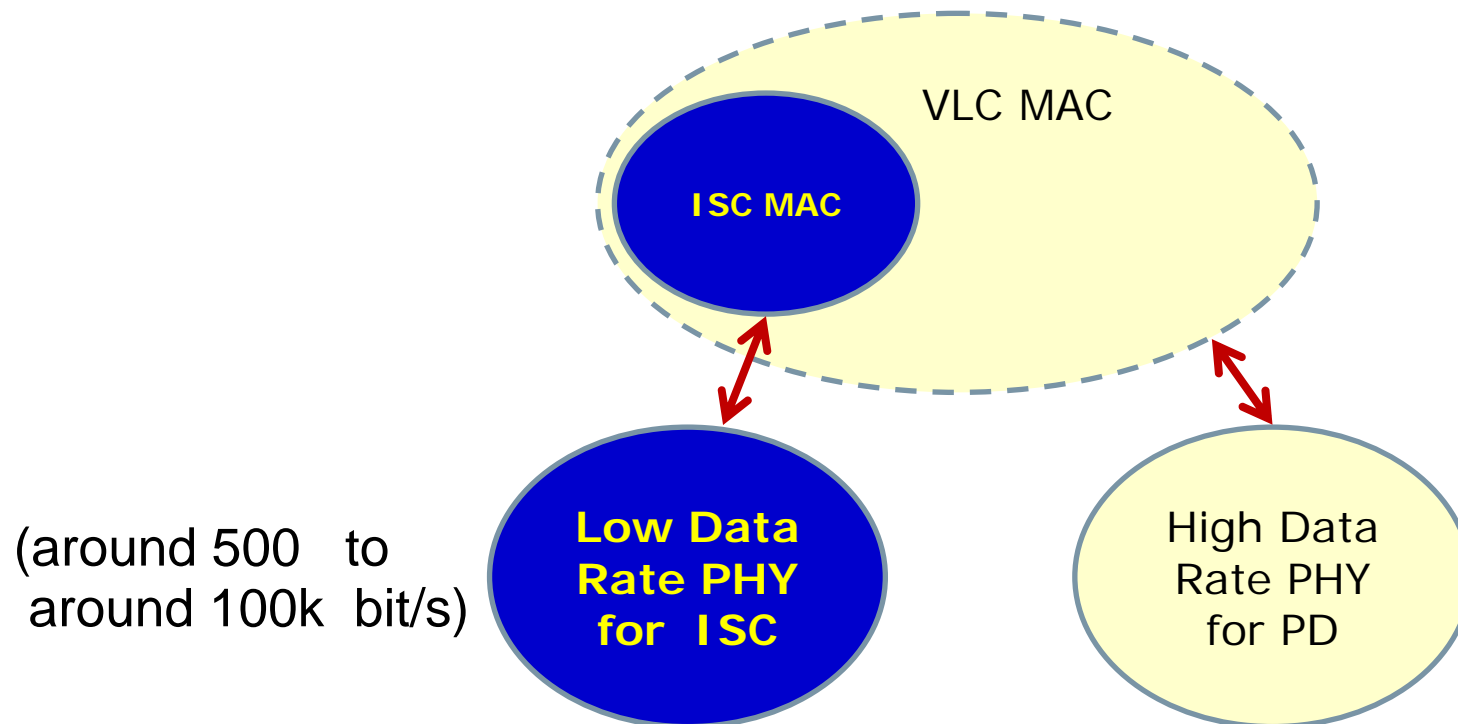
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VLC MAC/PHY logical diagram

- ISC includes a new concept of MAC, but it may be possible by expansion of conventional MAC.
- From the viewpoint of “time-to-market”, the standardization of ISC should begin examination by the PHY of the low data rate.



Conclusion

- New MAC concept was proposed and explained that “spatial consideration” is mandatory.
 - Especially “discover” is essential.

- An effective method for “discovery” was explained.

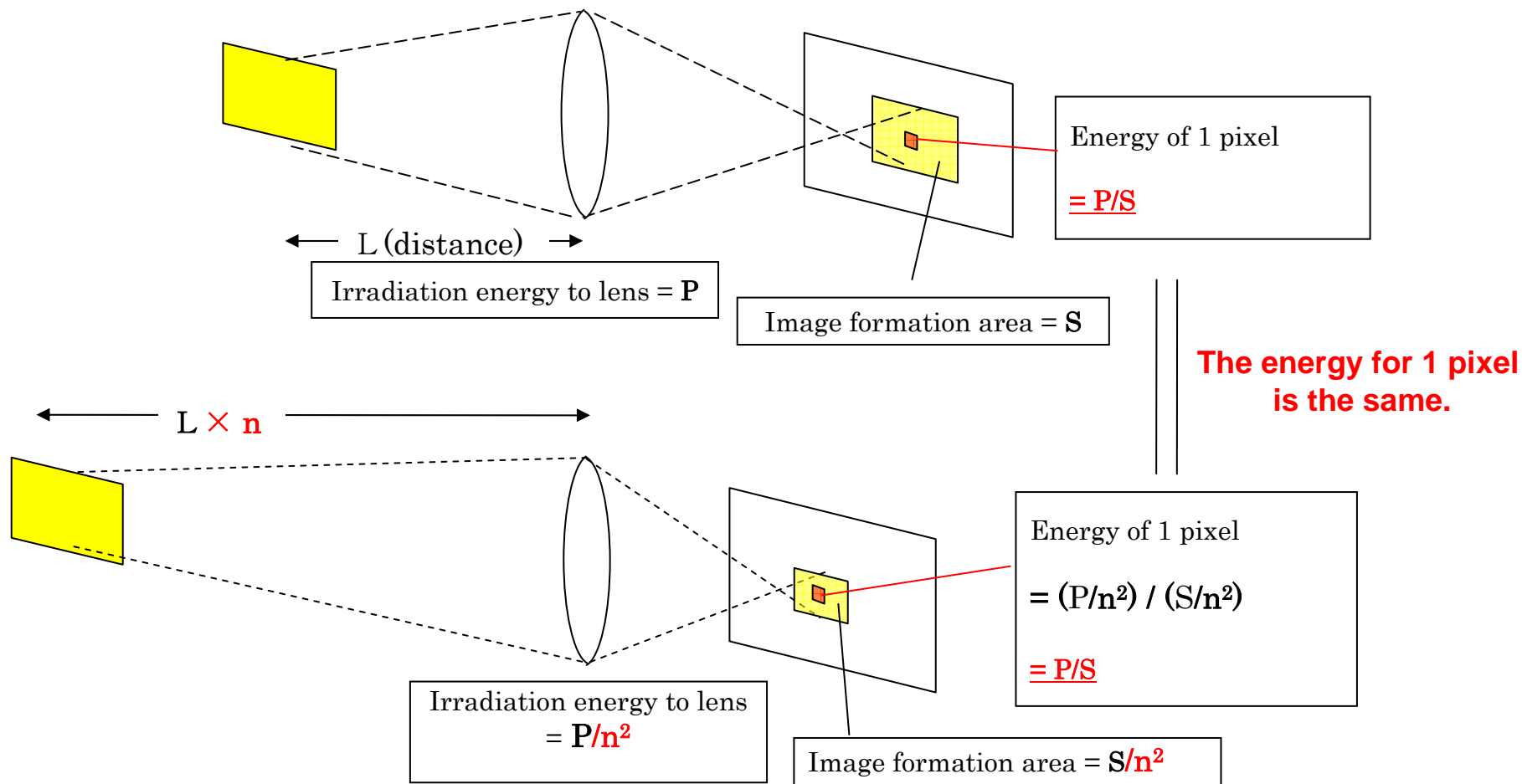
- As ISC point of view, PHY modulation frequency should be considered in low data rate at first.

- ISC is one of the fundamental technology, and not just implementation matter.
Spatial consideration for ISC should be discussed in TG7.

Appendix

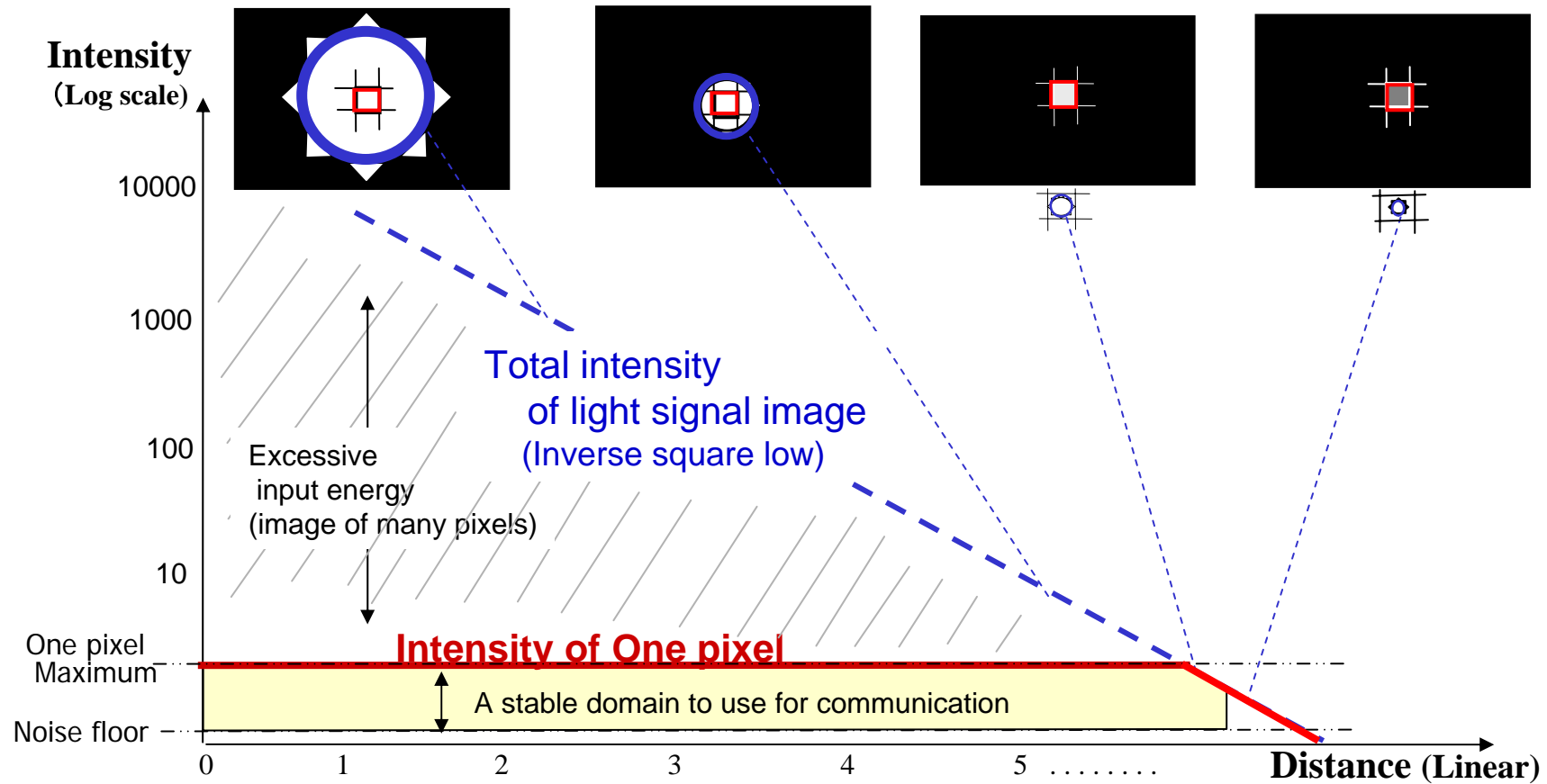
“Brightness – Distance” Invariable Characteristics

"Brightness doesn't depend on the distance" is a fundamental law in optics.

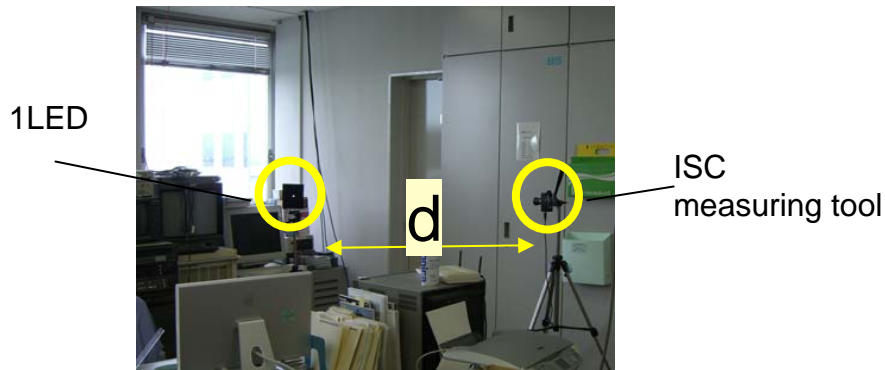
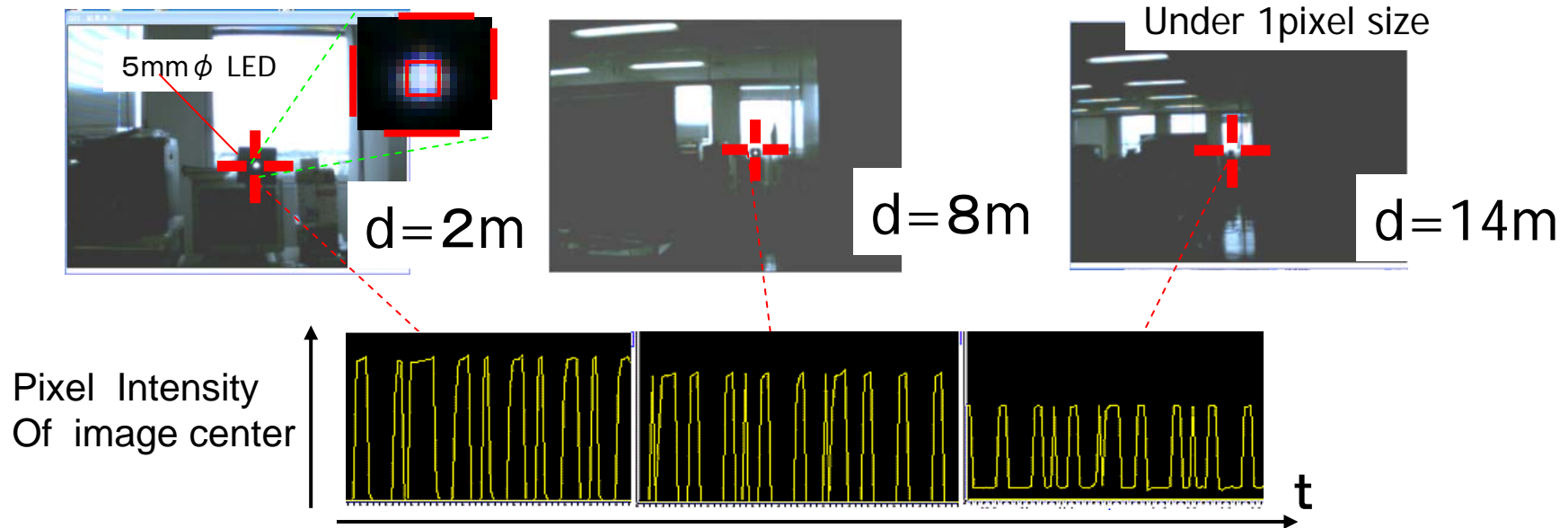


Stable decoding by one pixel selection

According to “Brightness–Distance invariable low”,
 One Pixel Selection provides “easy gain control” and “wide range distance”.



A rough confirmation experiment

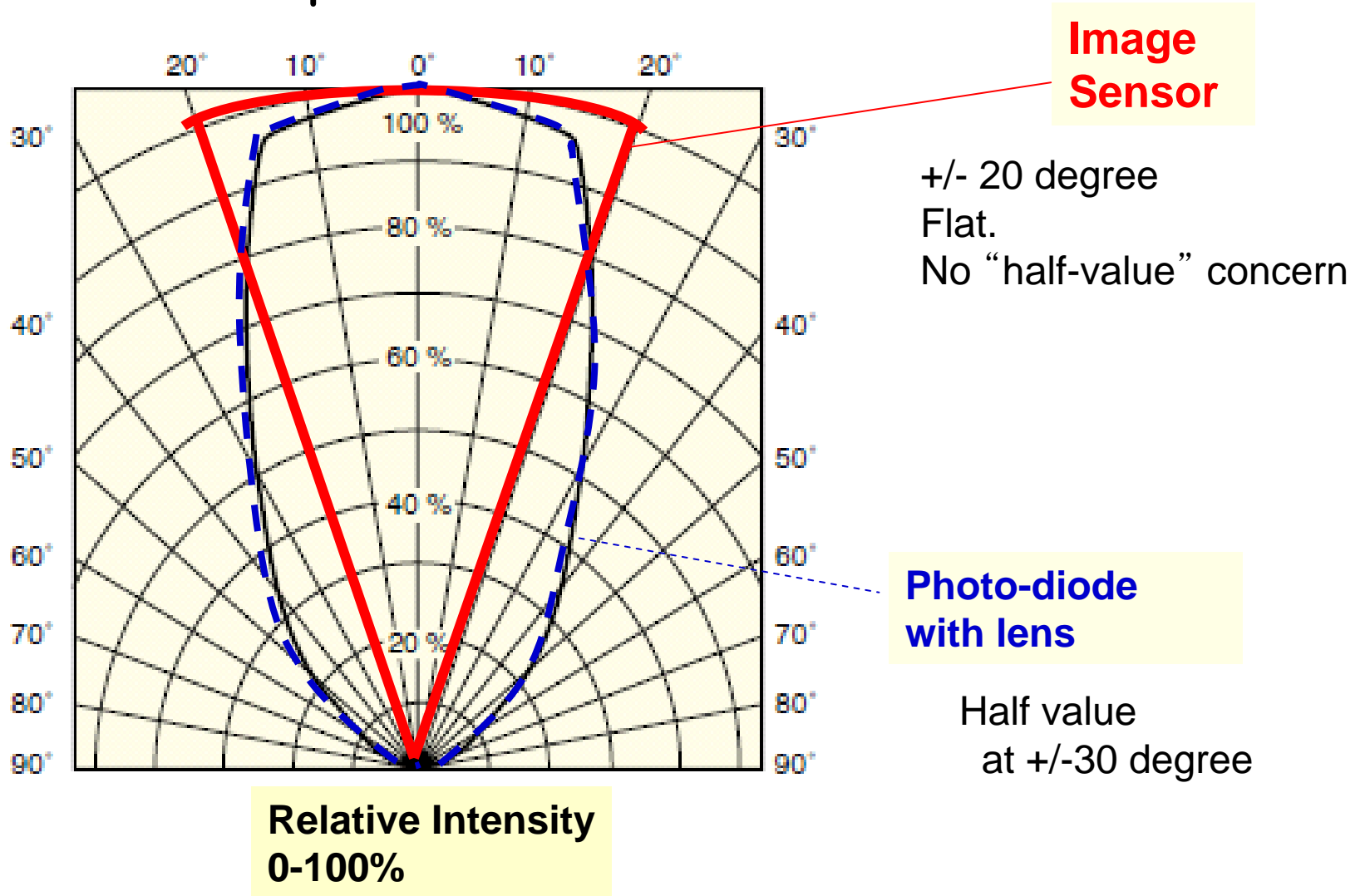


Distance: 2 \rightarrow 14 (x7)

Intensity: 1 \rightarrow 2/3

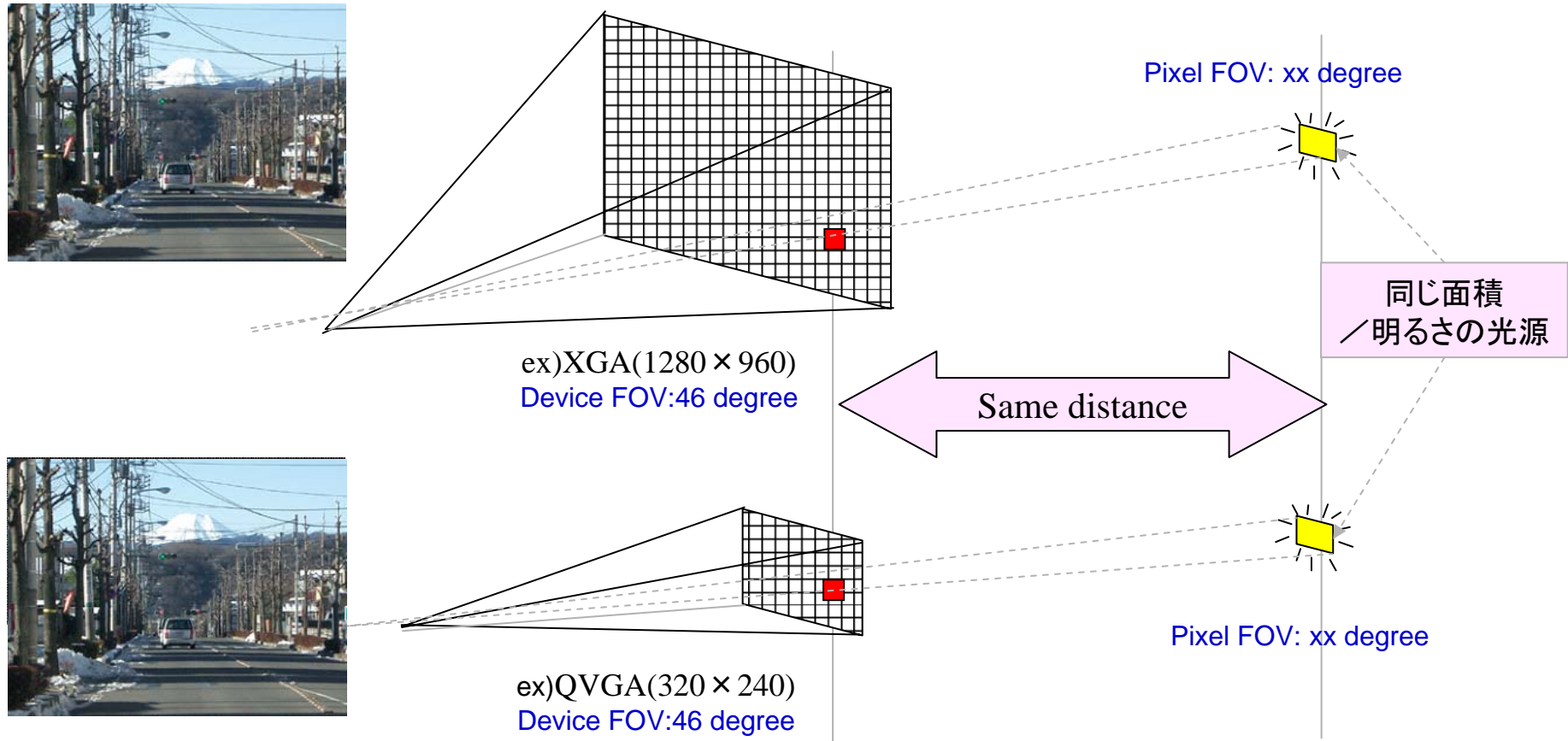
Not 1/49! (7x7=49)

Example of FOV difference



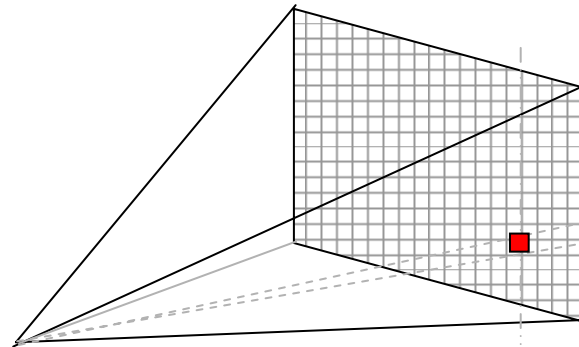
Two FOV of ISC – 1

ex1) Device FOV: different / Pixel FOV: same



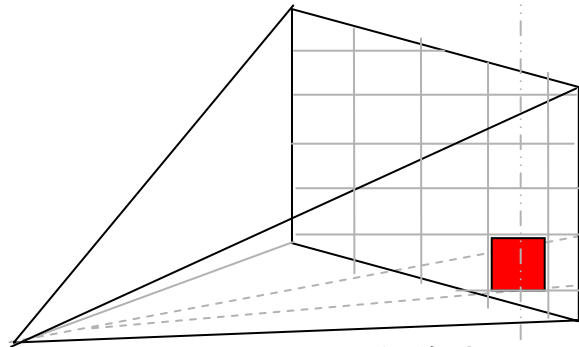
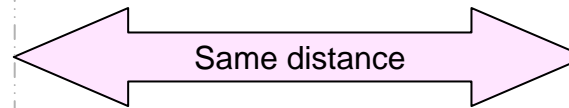
Two FOV of ISC – 2

Device FOV: same / Pixel FOV: different



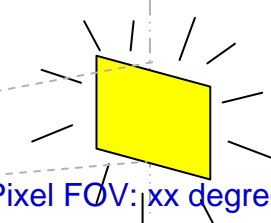
XGA(1280 × 960)
Device FOV: 46 degree

Pixel FOV: xx degree



QVGA(320 × 240) ¼解像度
Device FOV: 46 degree

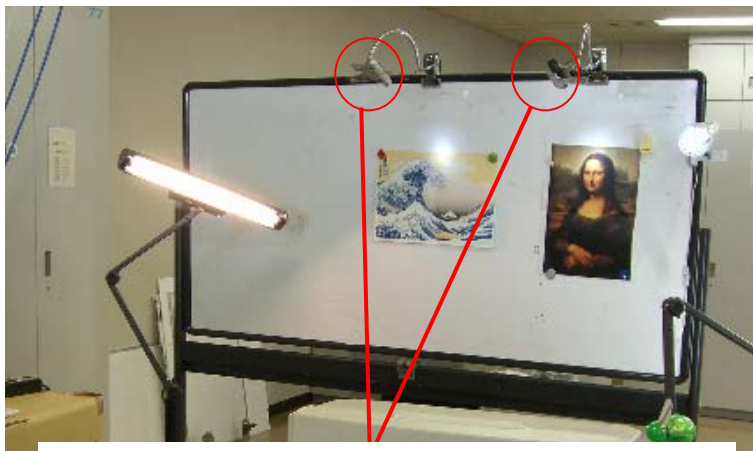
Pixel FOV: xx degree



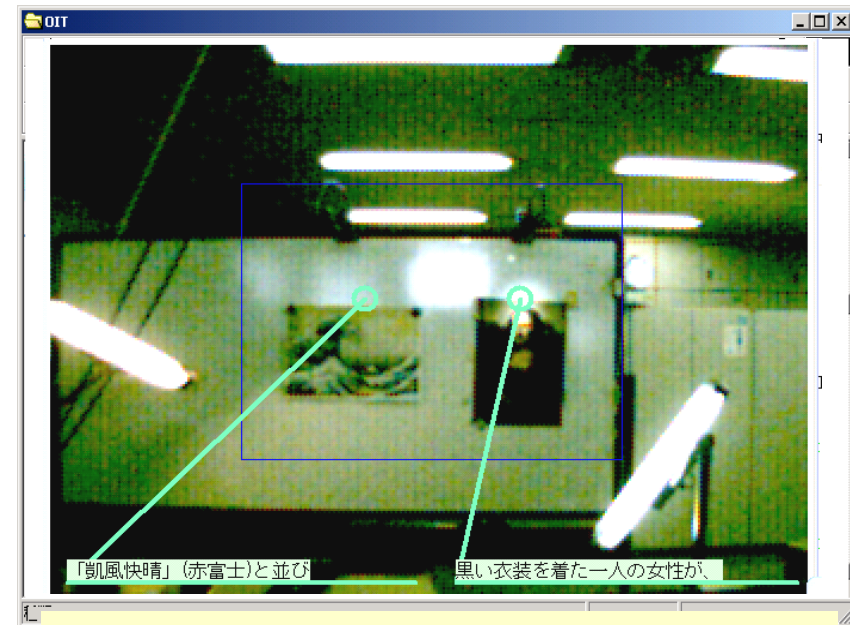
n倍のパワー

Weak indirect light and a lot of interference

- ISC can receive by the feeble signal of the reflection. (indirect light).
- "Pasting up of the information" is possible with spotlights such as Art Gallery / Museum / Store.



Spot down light

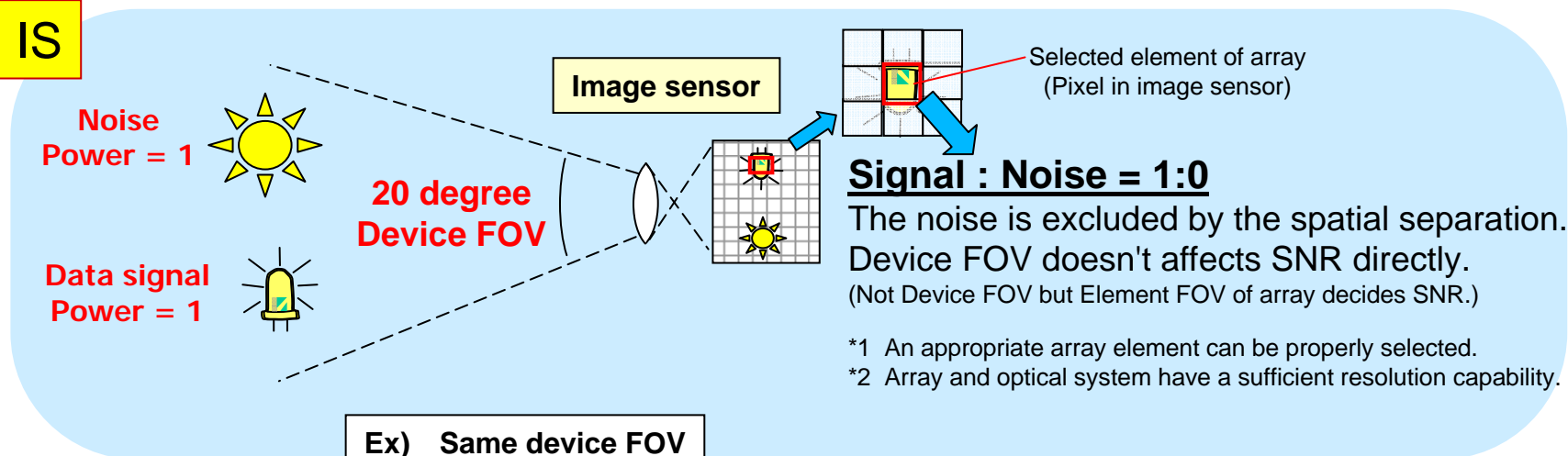


Display output of application
Information balloon in bottom of display

Image Sensor : Spatial Separation Capability

- Robustness to Ambient Light noise.
- No interference even when the Multi Point light sources are received.

Using IS



Ex) Same device FOV 20 degree

Using PD

