High-speed Transmission of Overlay Coding for Road-to-Vehicle Visible Light Communication Using LED Array and High-Speed Camera

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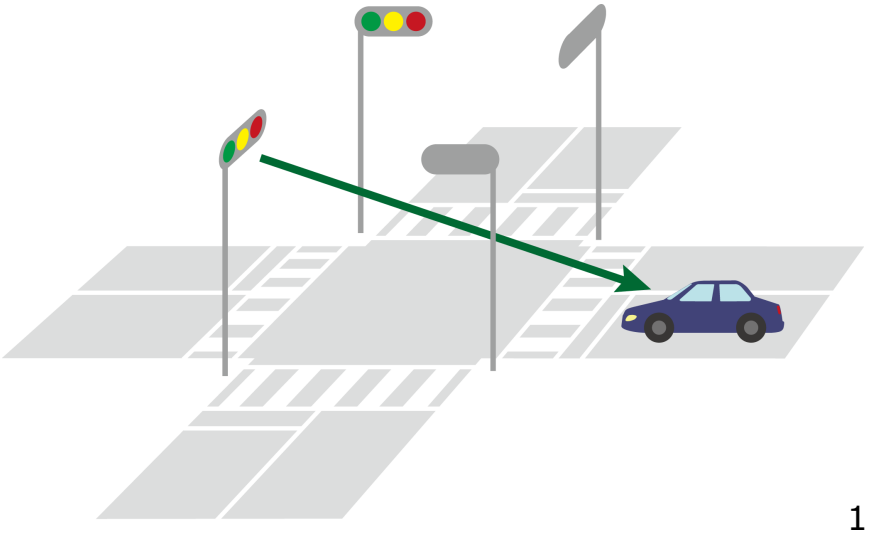
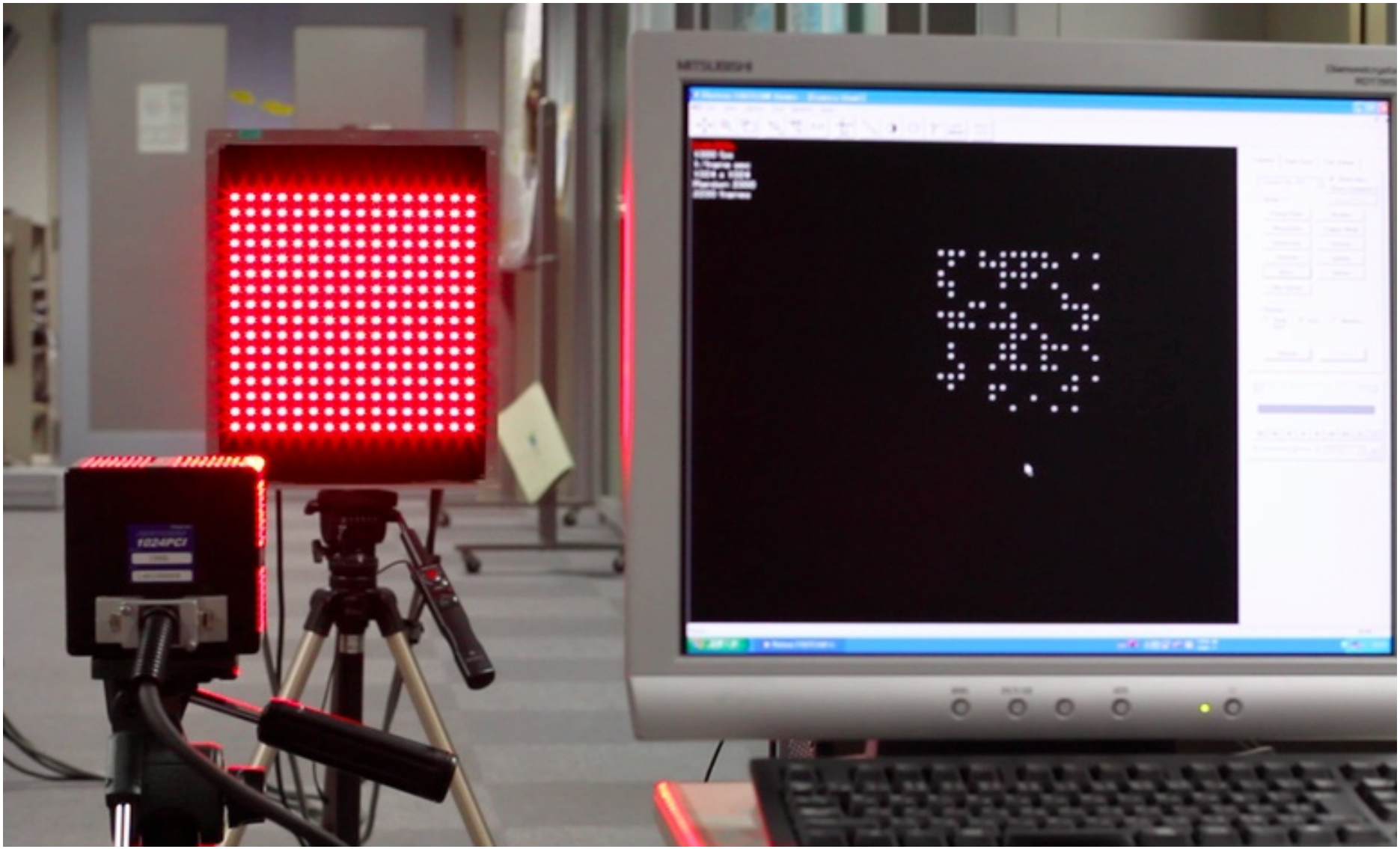
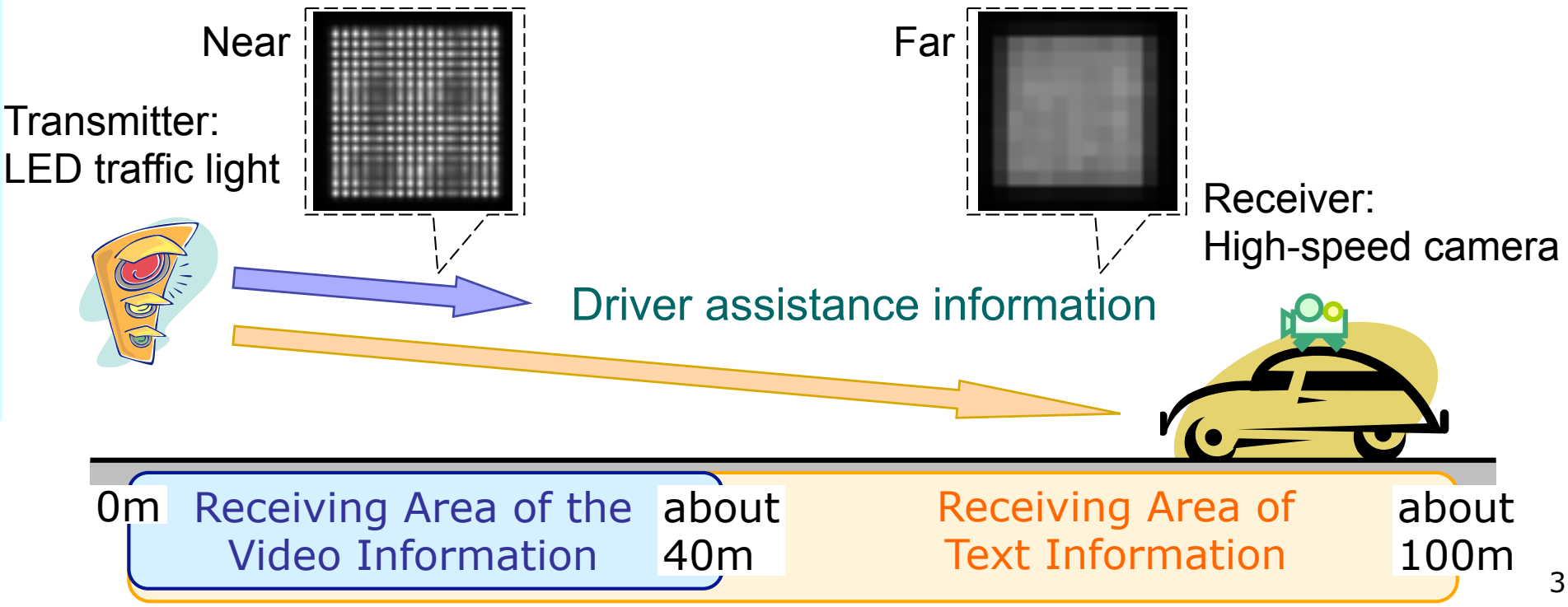


Visible light communication



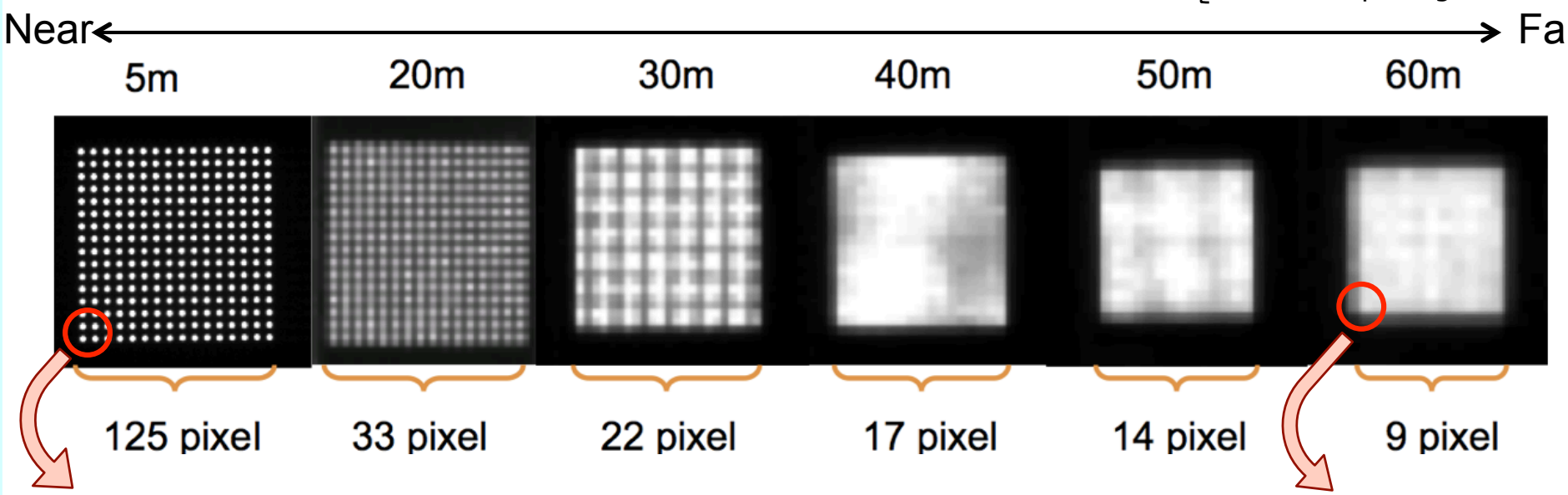
Load-to-vehicle visible light communication

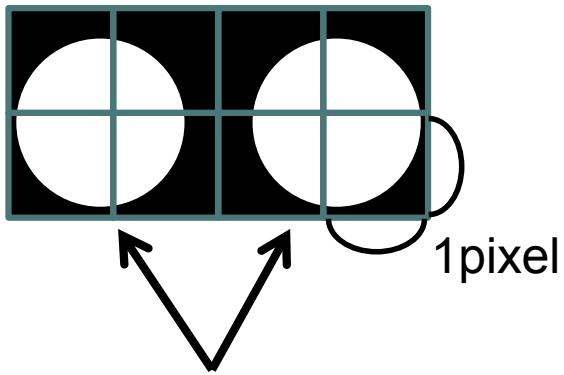
- LED traffic lights broadcast driver assistance information to vehicles with high-speed camera
  - Road-to-vehicle visible light communication
- Received images degrade depending on distance



Deterioration of received image

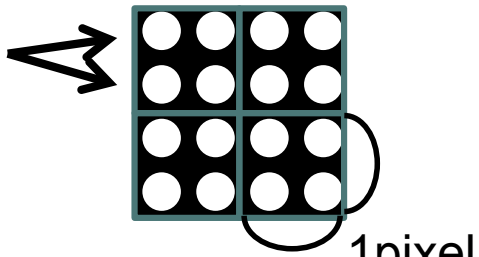
[The LED spacing: 20mm]





We can distinguish the LEDs

We cannot distinguish the LEDs



Deterioration of received image

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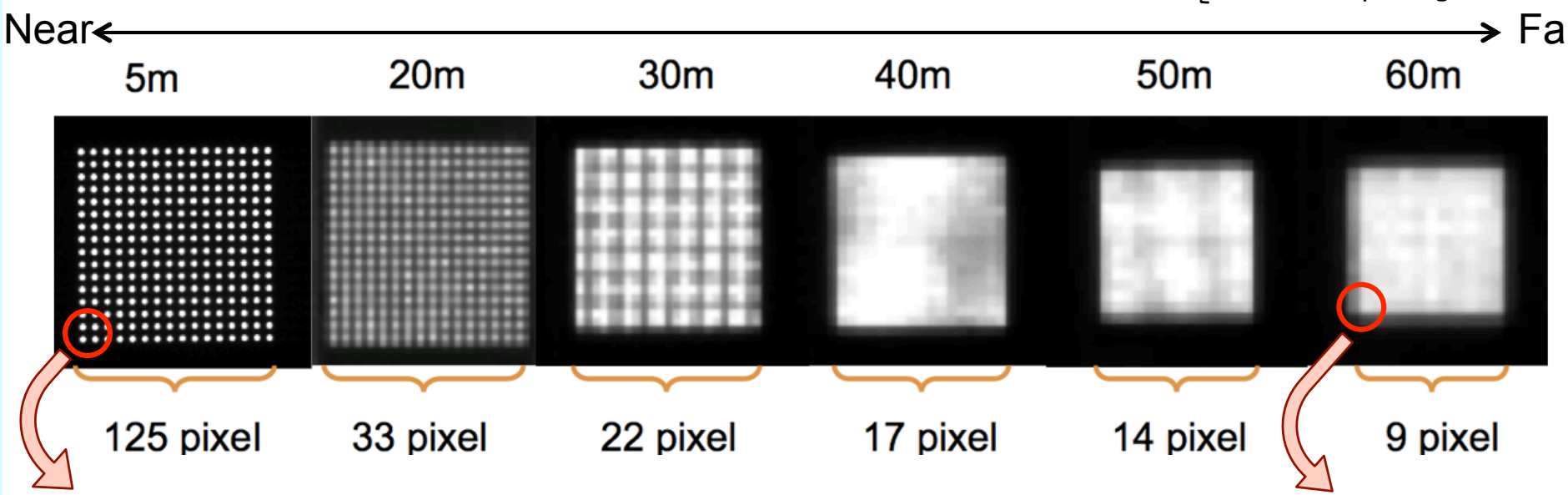

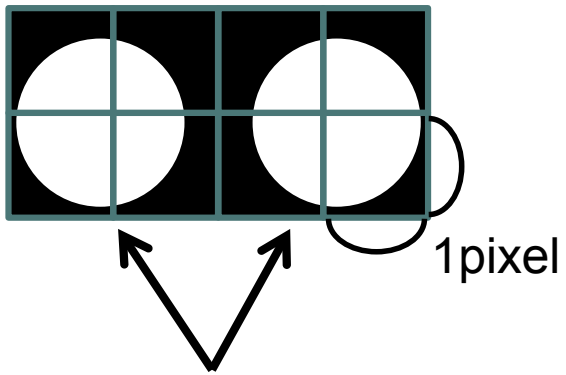

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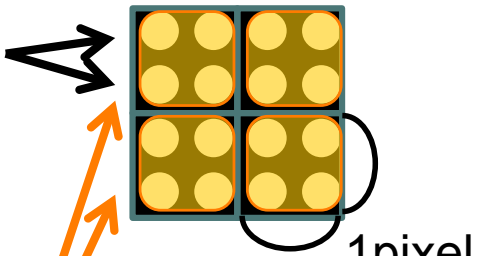
We cannot distinguish the LEDs

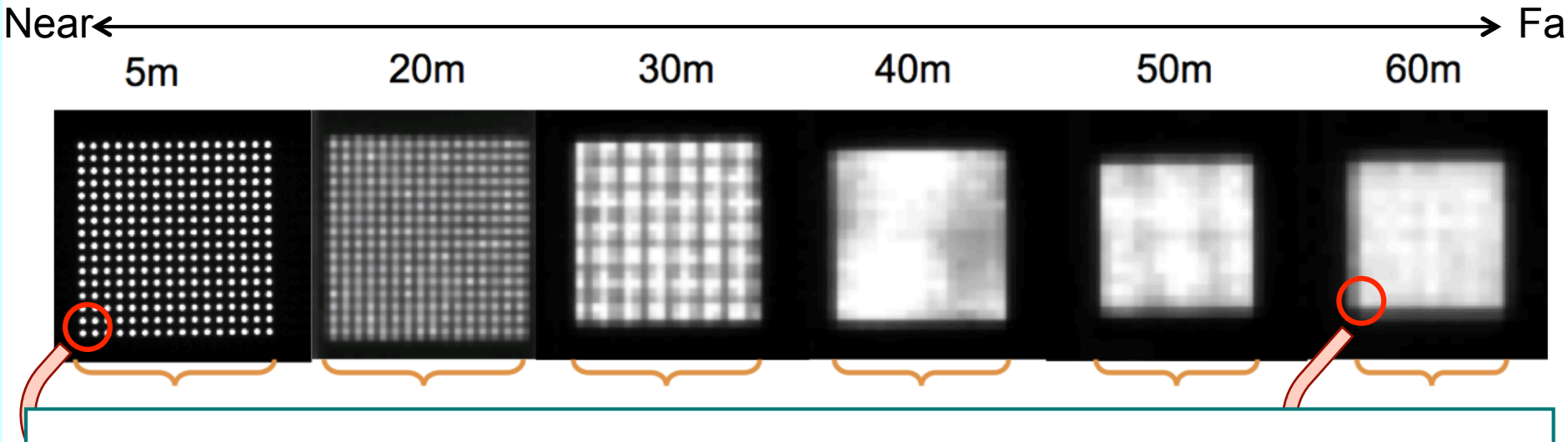
We assign the same data to 4LEDs.



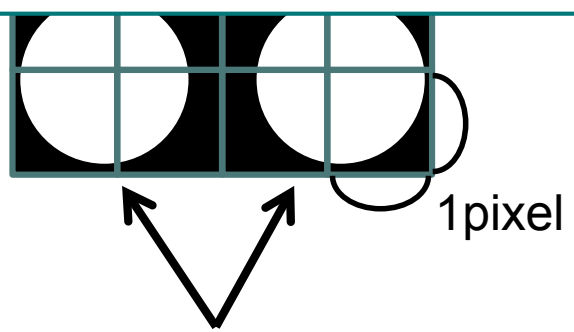
We can distinguish the LEDs blocks

Deterioration of received image

[The LED spacing: 20mm]



Application of "overlay coding" scheme[1]



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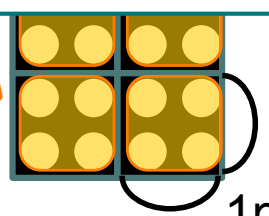
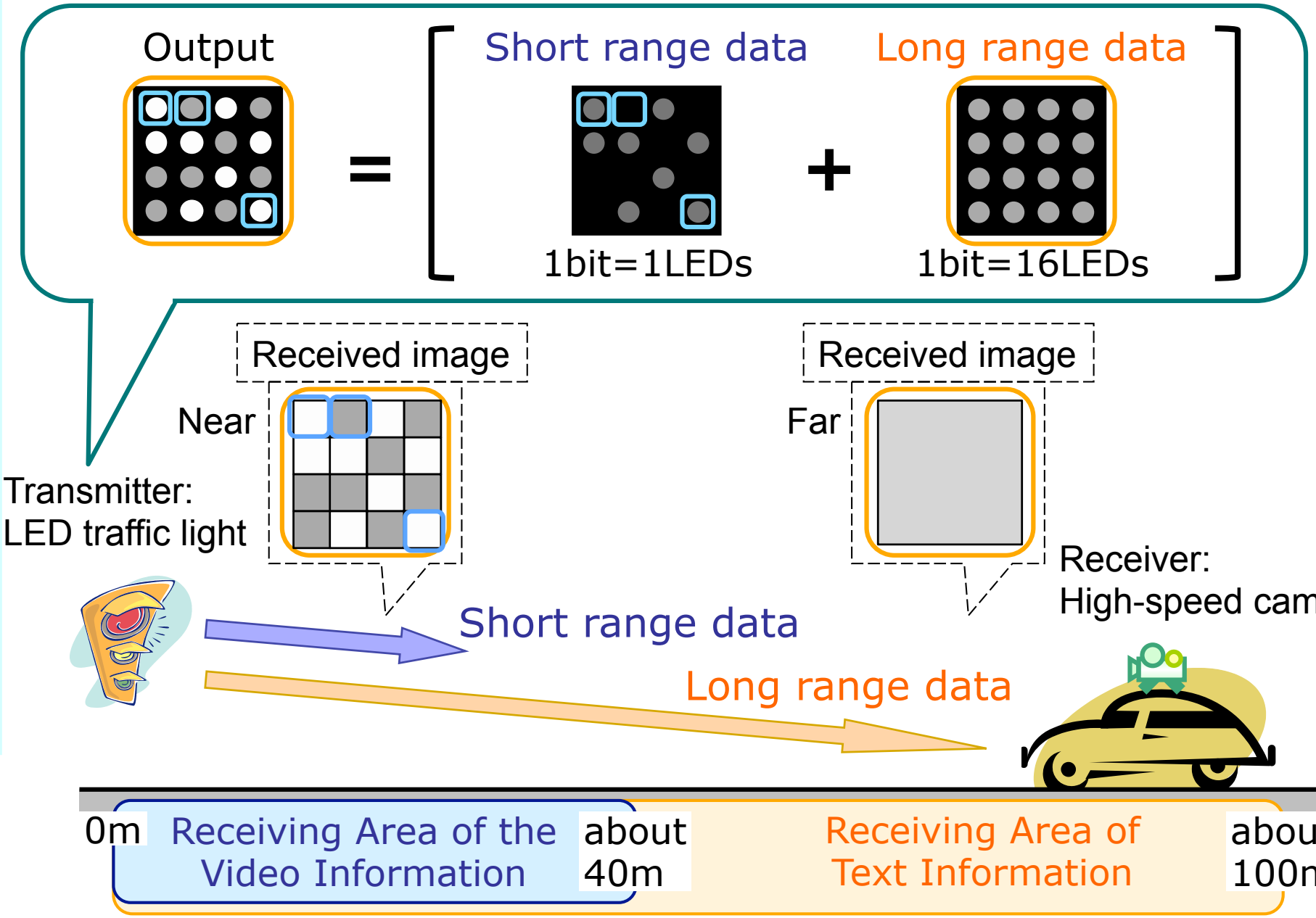


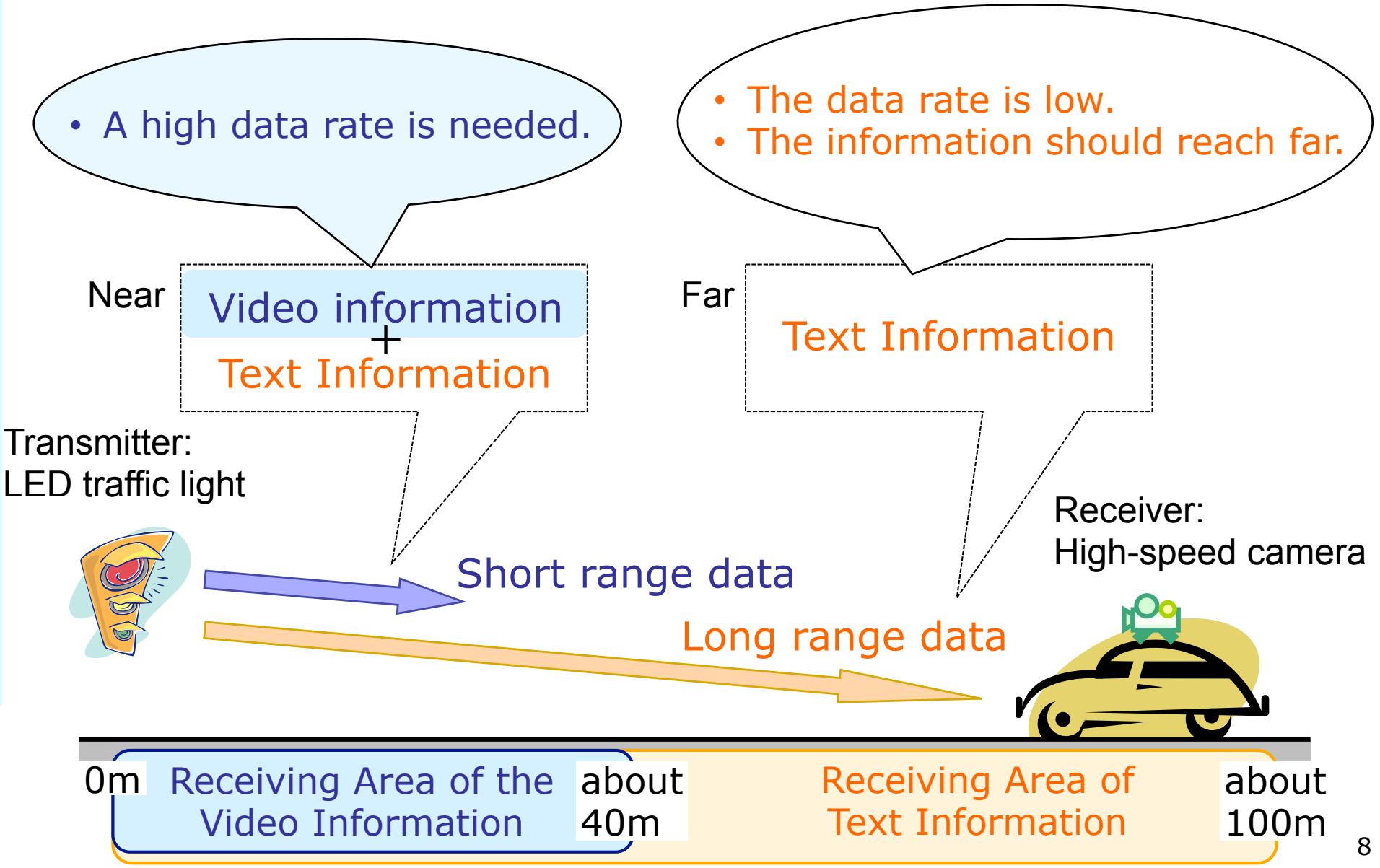
We can distinguish the LEDs blocks

[1] S.Nishimoto, T.nagura, T.Yamazato, T.Yendo, T.Fujii, H.Okada, S.Arai, "Overlay Coding for Road-to-Vehicle Visible Light Communication using LED Array and High-Speed Camera," International IEEE Conference on Intelligent Transportation Systems, pp.1704-1709, Oct. 2011.

Overlay coding

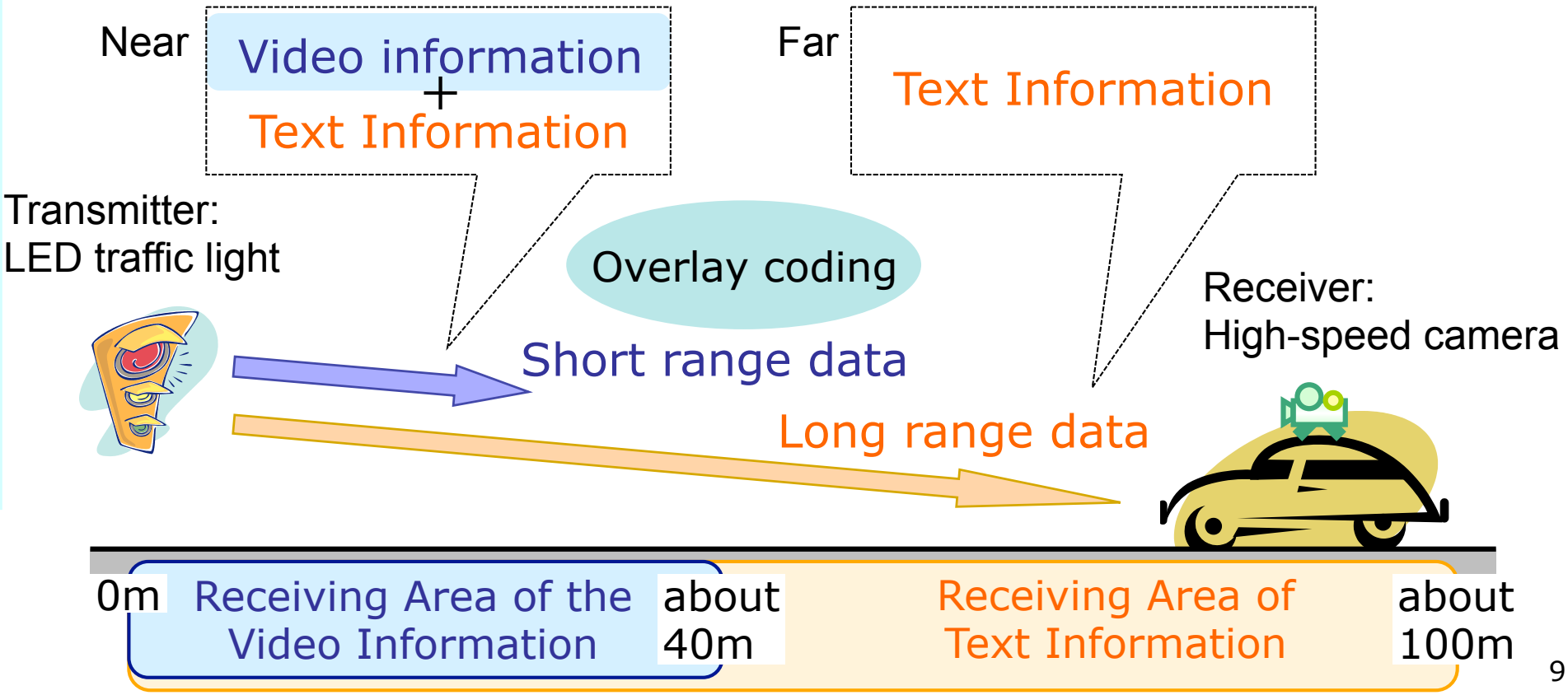


The information that we want to send

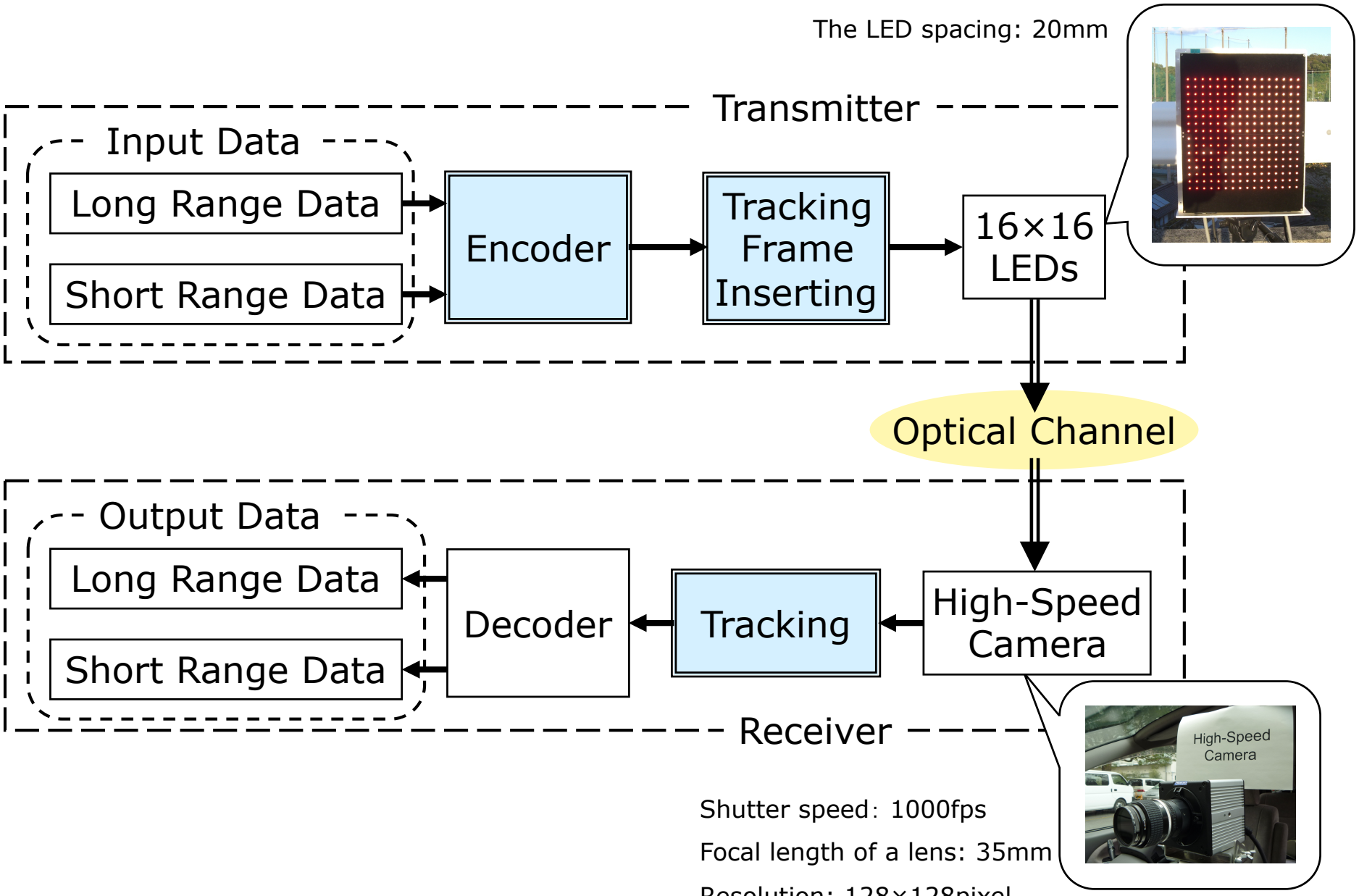


Purpose of this presentation

Introduction of a scheme to improve data rate of short range data for "Overlay coding"



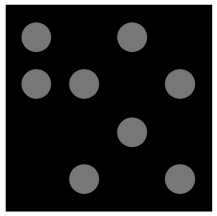
System Model



To improve a data rate

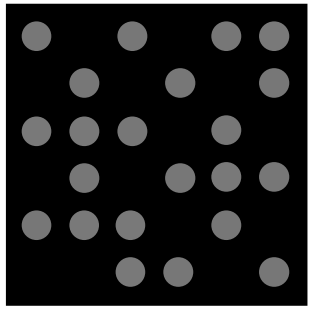
◇The number of LED of the LED array is increased

4×4LED array
1bit=1LED



we send 16bits
at a time

6×6LED array
1bit=1LED

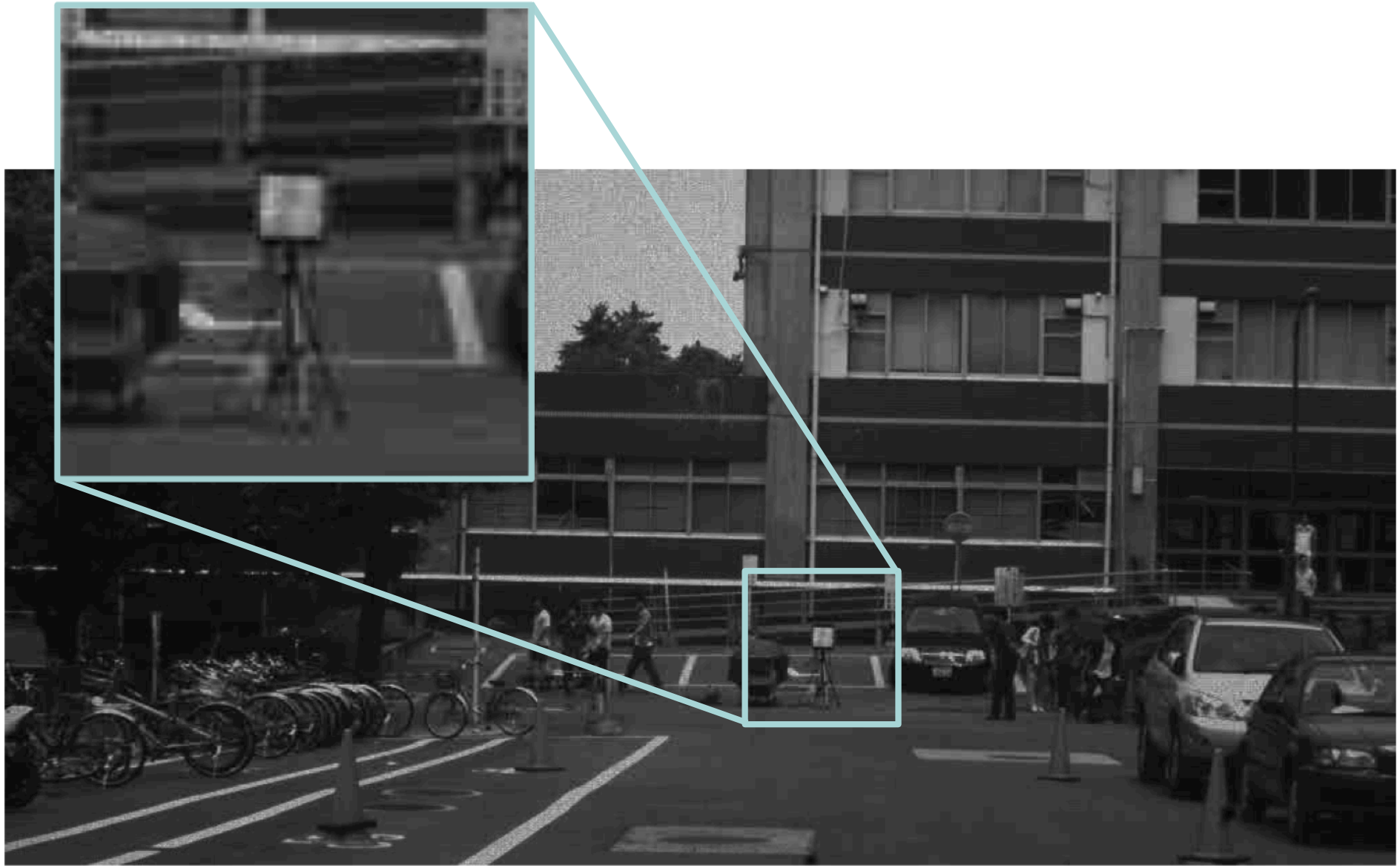


we send 36bits
at a time

- It is easy to improve a data rate
- But in the real life,
  we cannot change the number of LED of the transmitter
  (e.g. traffic lights, etc.).

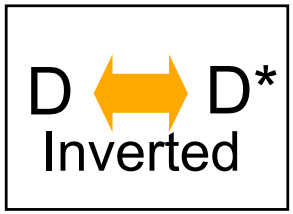
We pay attention not to the spatial dimension but to the temporal dimension.

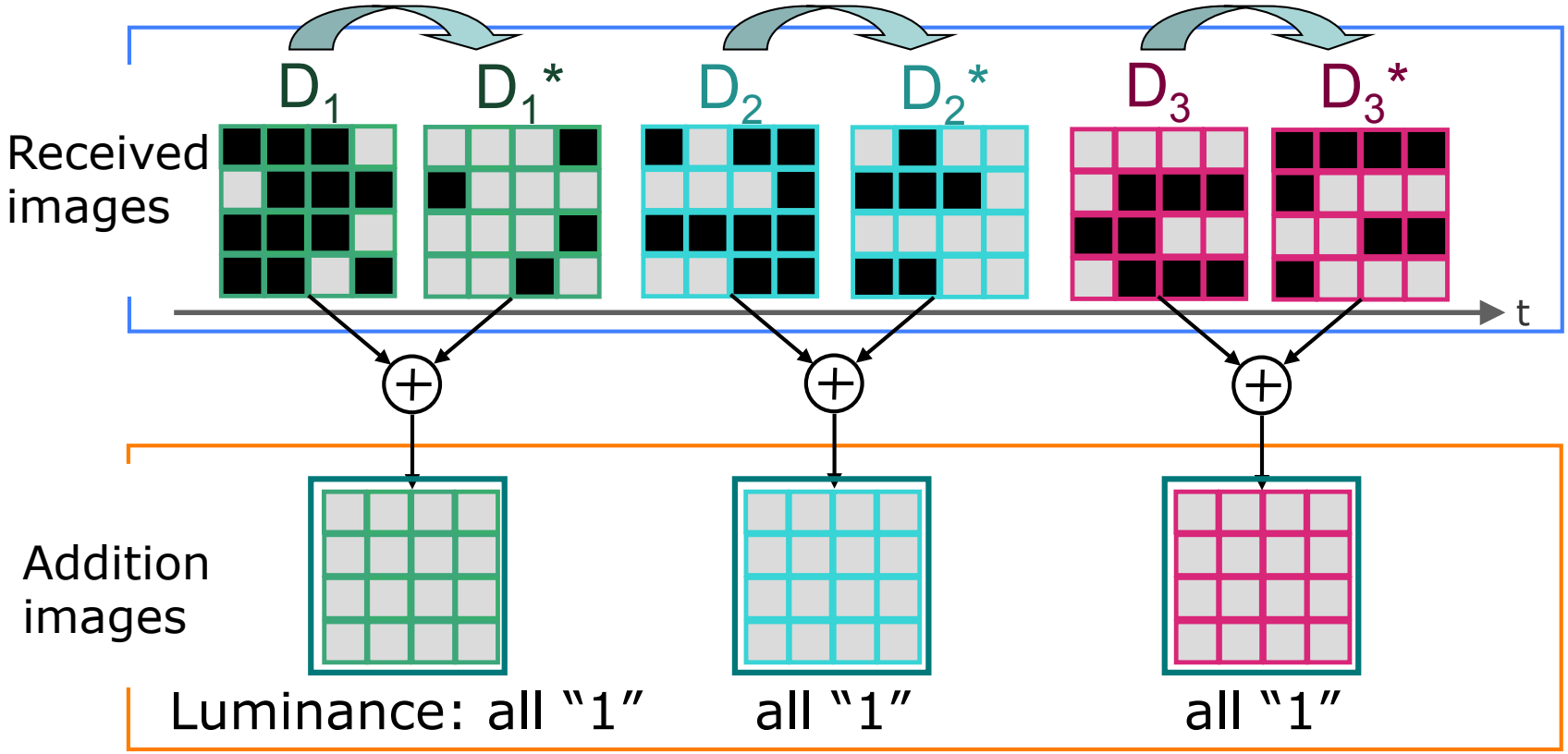
Tracking of LED array



Tracking method using inverted signals

- For tracking the transmitter in driving situation, we use the inverted signals[2]
  - We distinguish the template of the transmitter

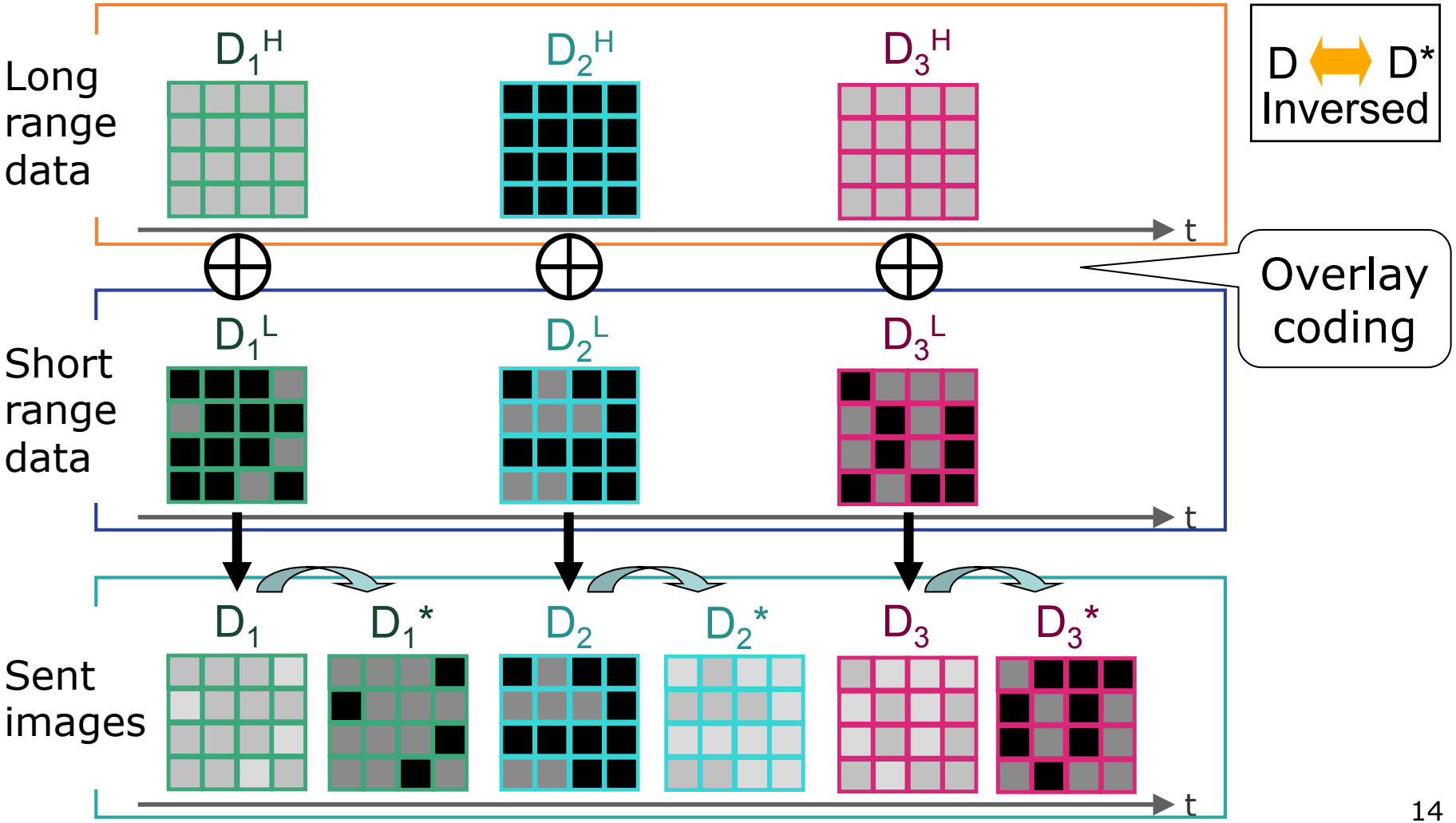




[2] T. Nagura, T. Yamazato, S. Arai, H. Okada, T. Yendo, T. Fujii,
"LED Array Tracking Method for Road-to-Vehicle Visible Light Communications in the Driving Situation,"
IEICE Transactions on Communications, vol.J95-B, no.2, pp.326-336, Feb. 2012.

Inverted signals for overlay coding (1/2)

- Long range data and Short range data use inverted signals.



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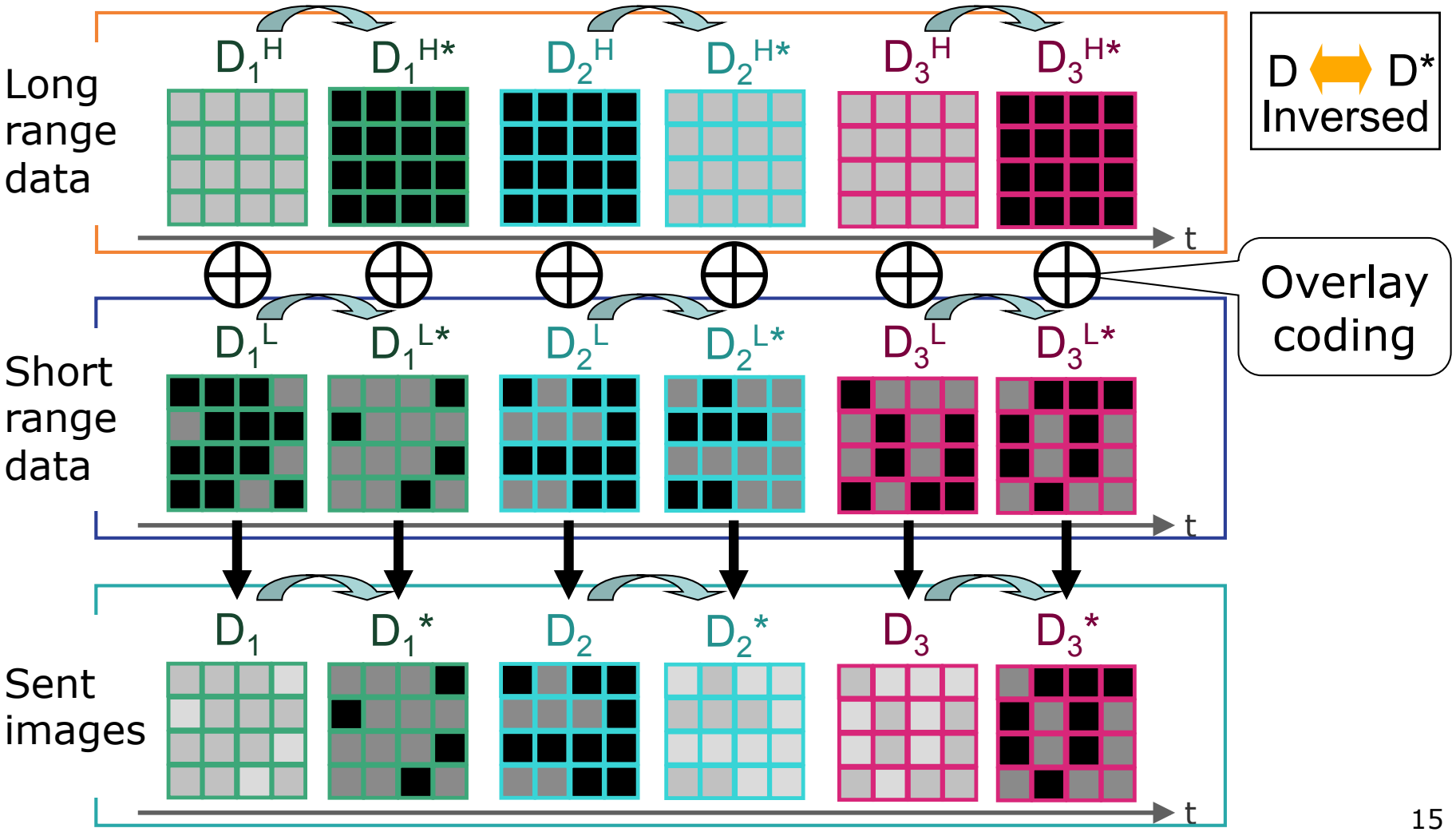
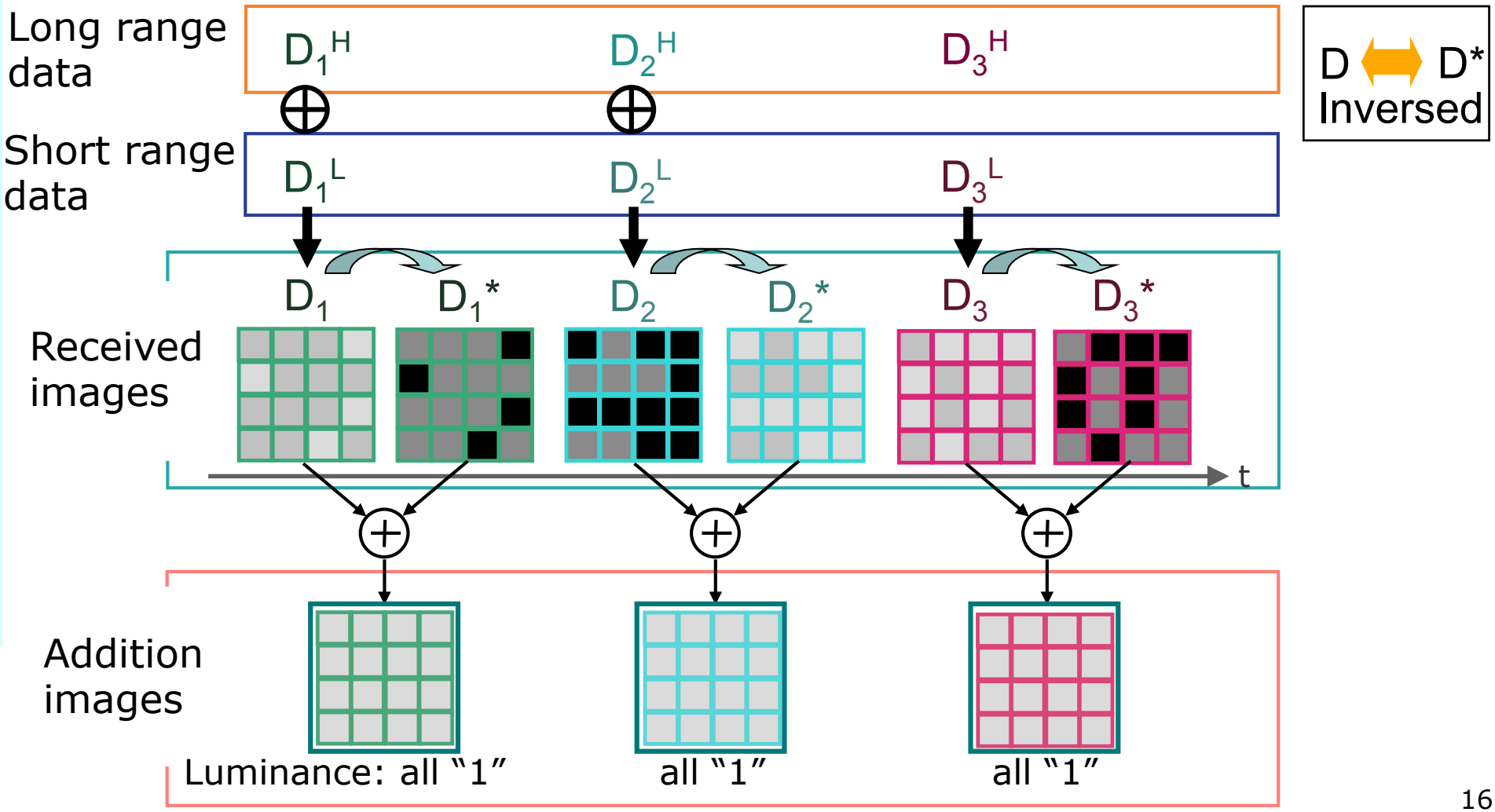


Inverted signals for overlay coding (2/2)

- For tracking transmitter, use addition images.
  - We can distinguish the shape of the transmitter



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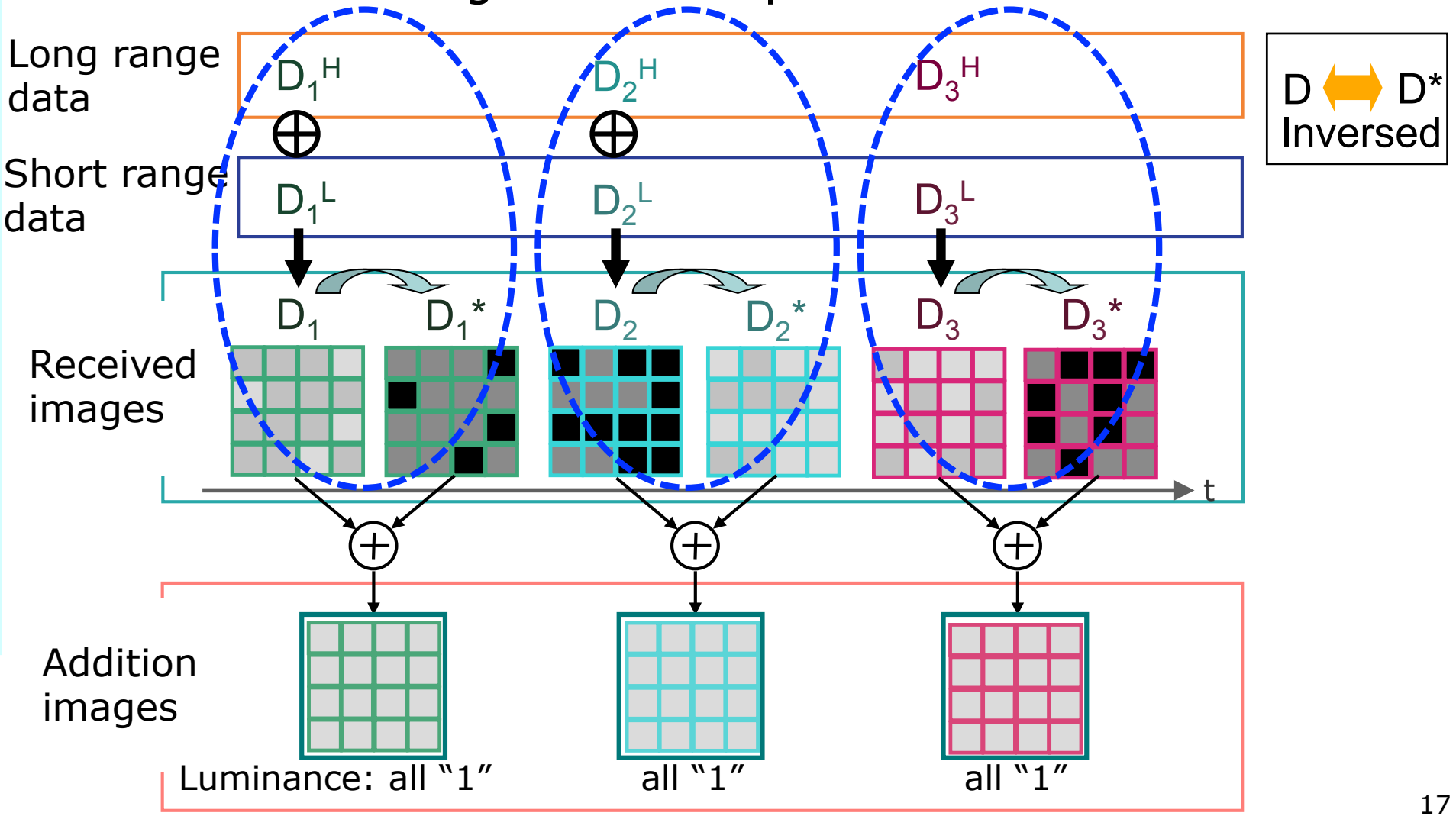

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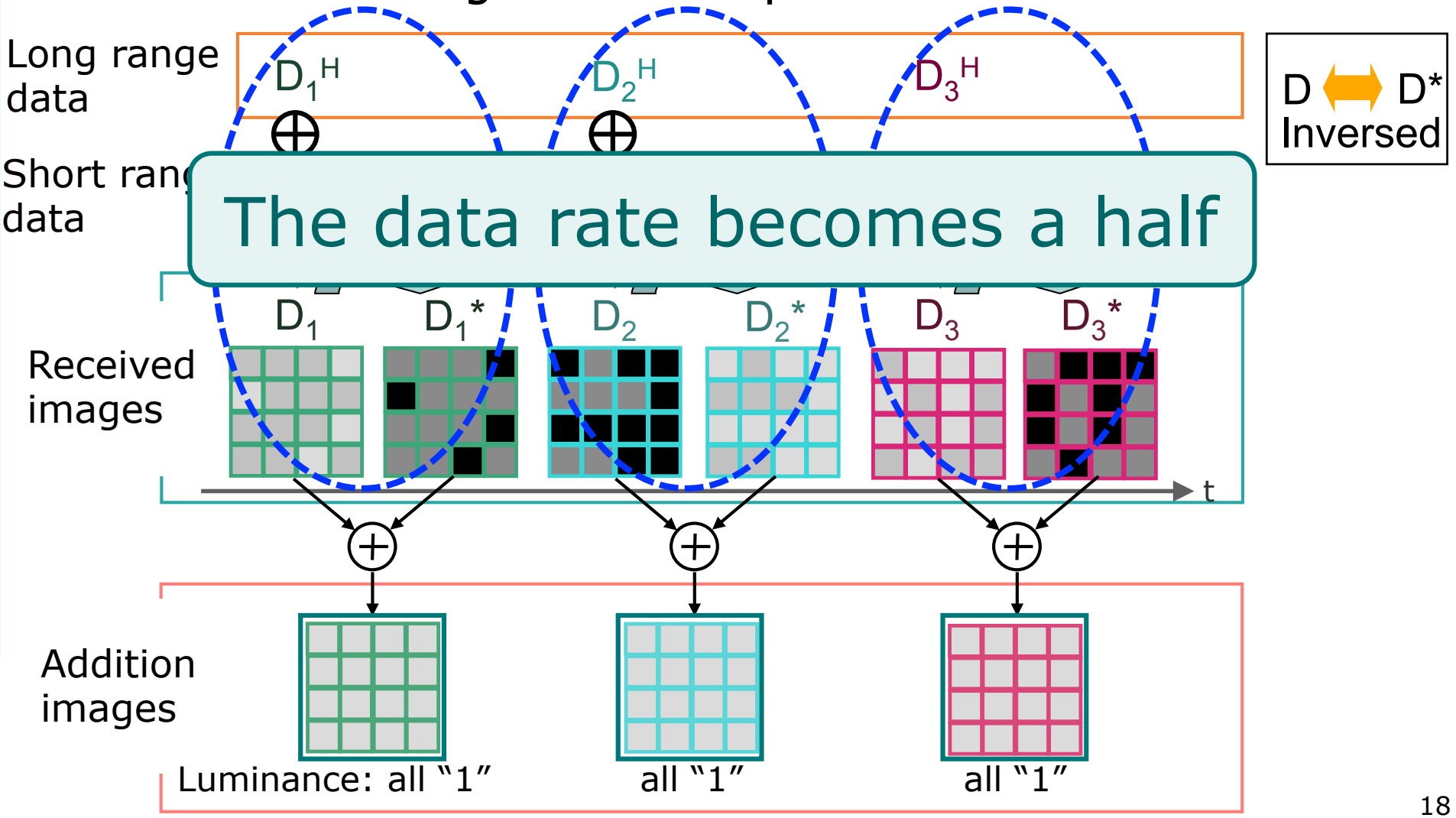
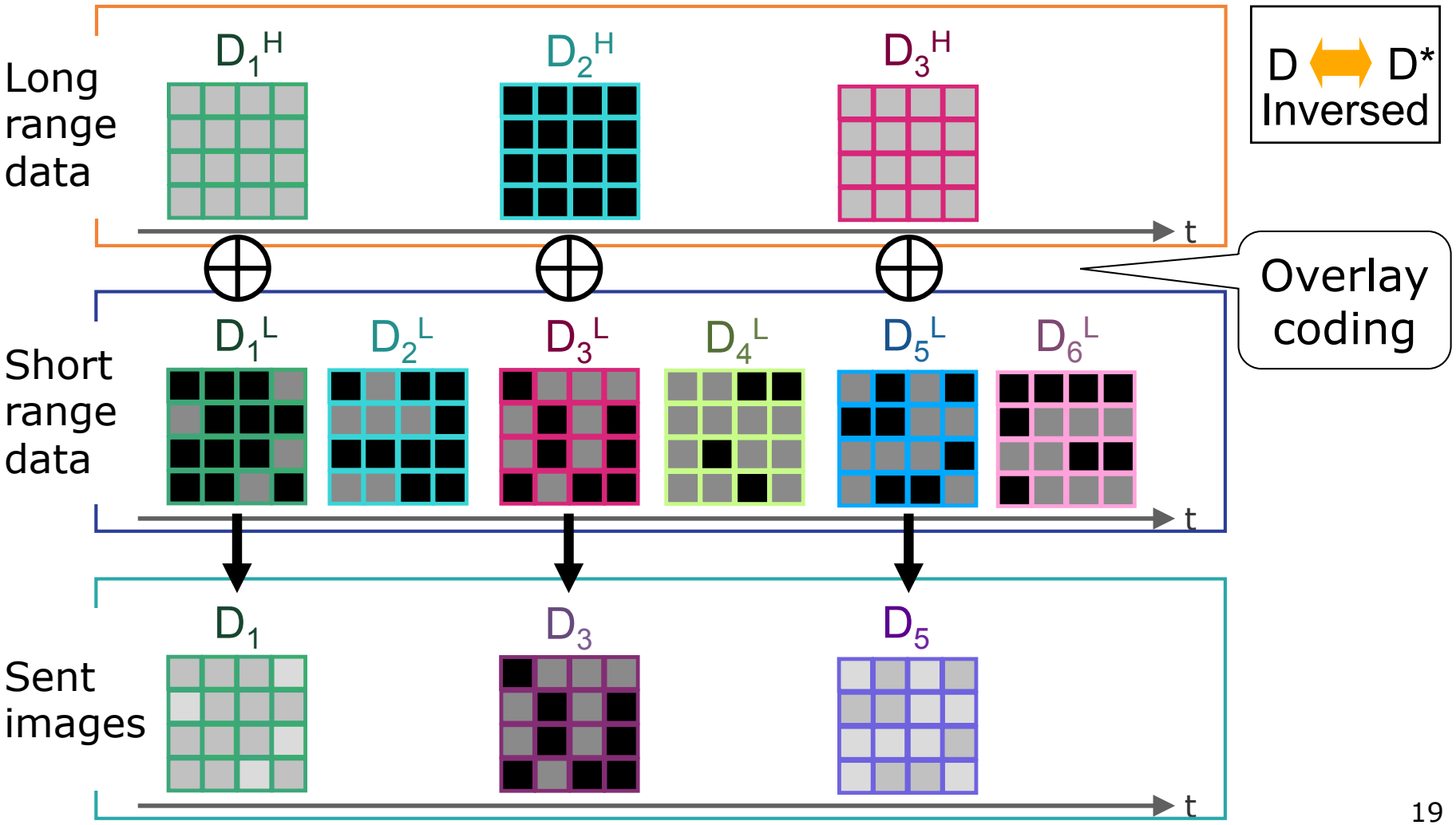


Proposed method

◇Long range data use inverted signals.
Short range data DO NOT use inverted signals.



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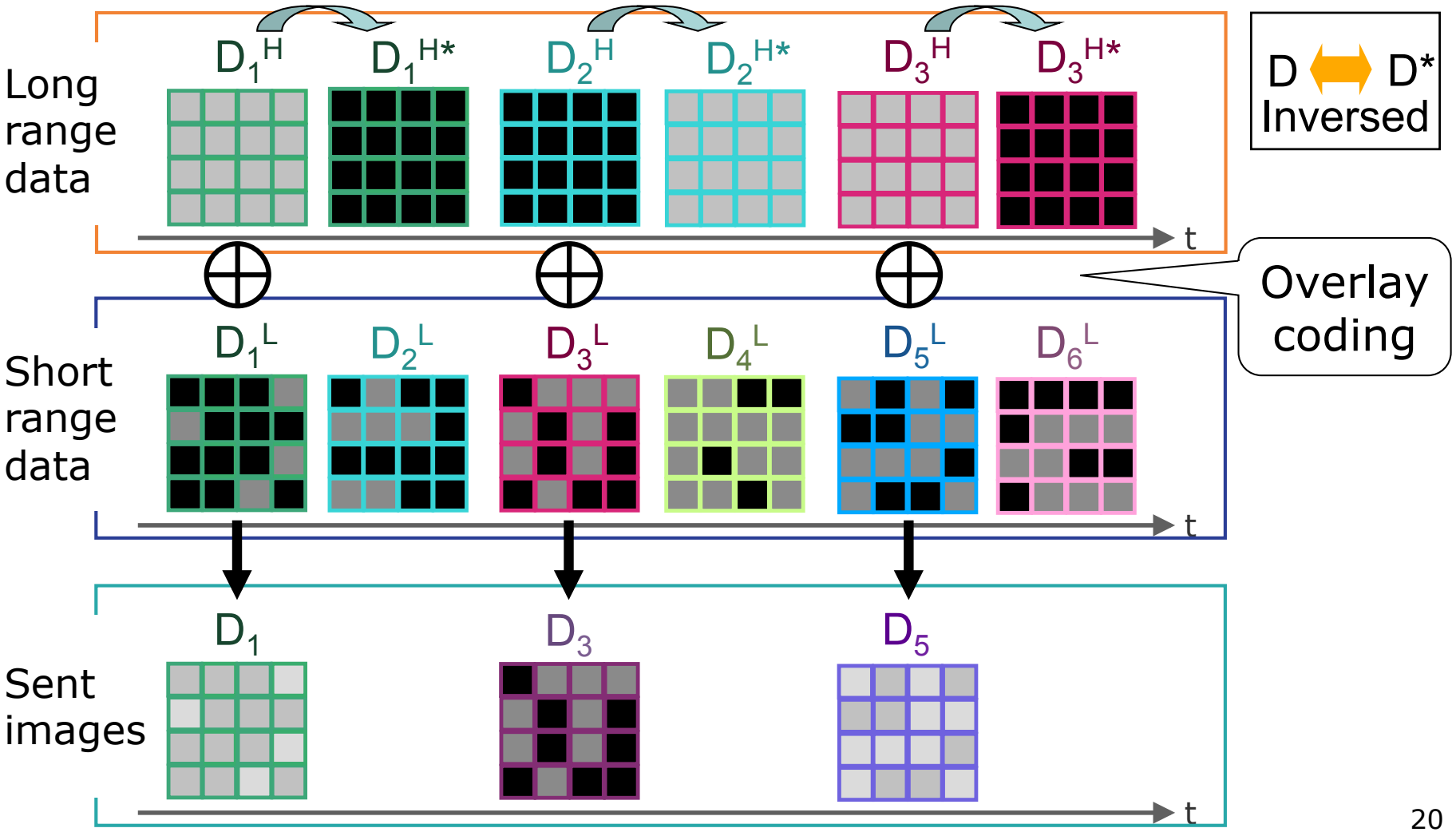

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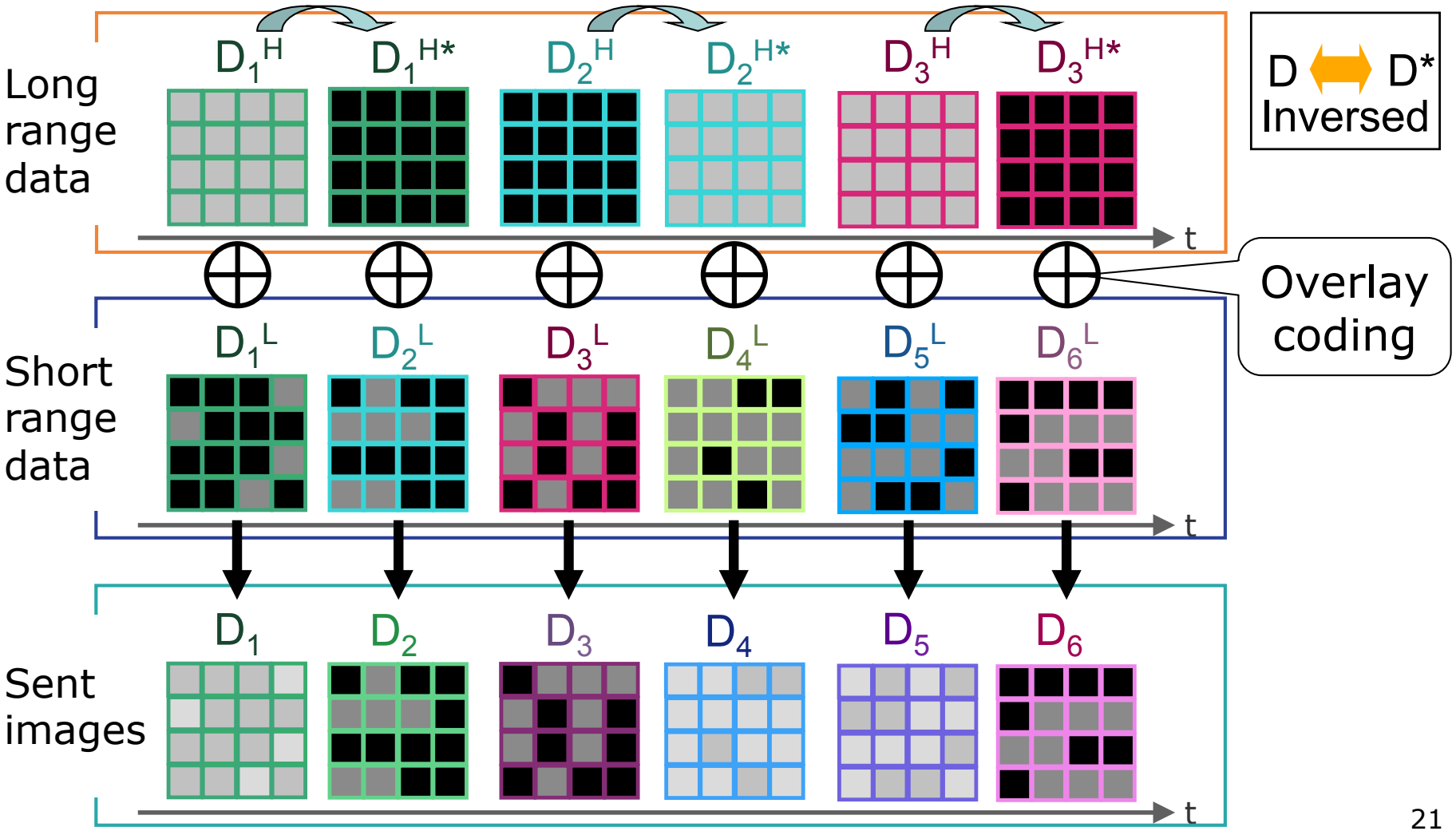


Experimental parameter

Lightning frequency of LED	3kHz
LED spacing	20mm

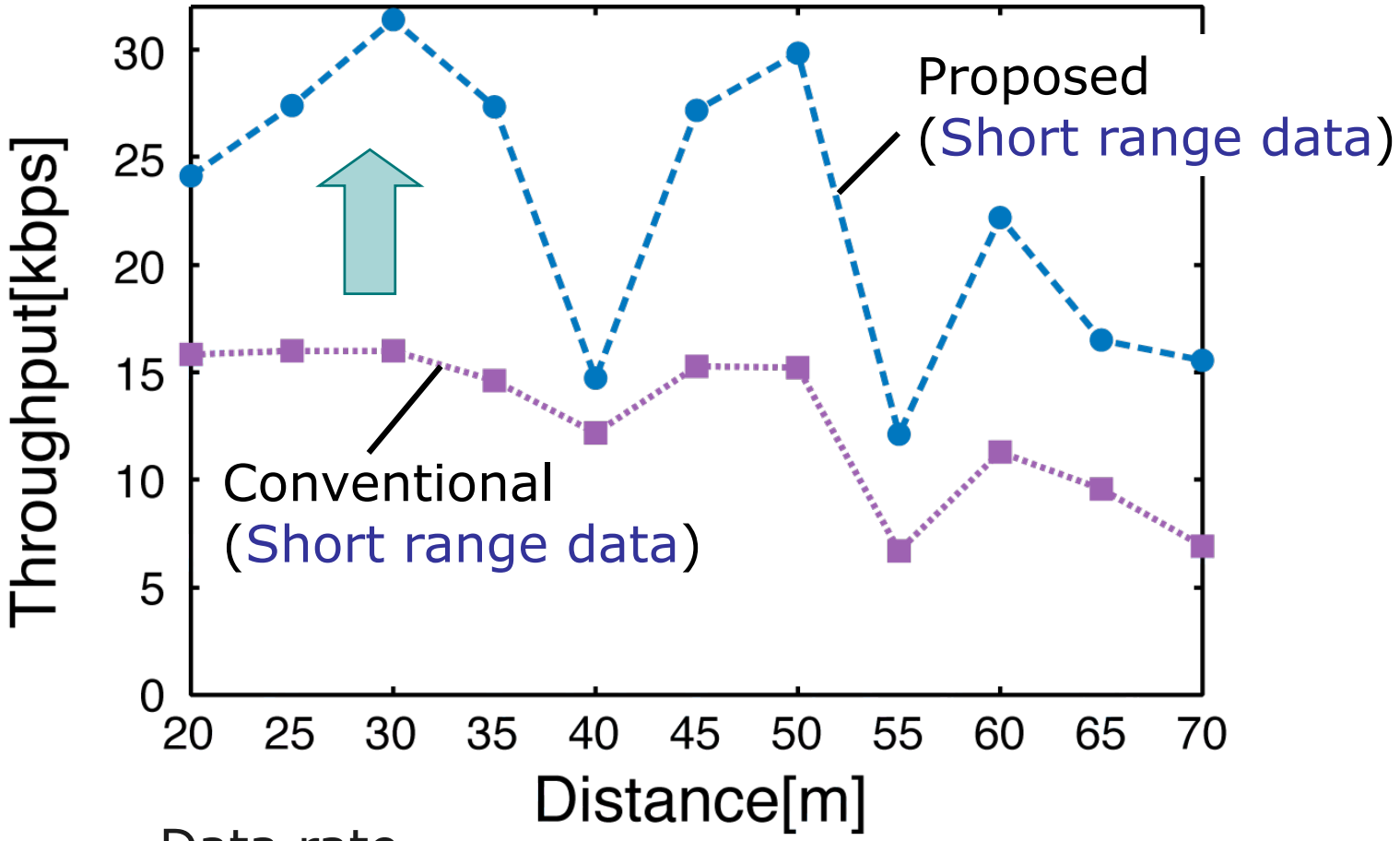
Shutter speed	1000fps
Focal length of the lens	35mm
Focus of the lens	infinity
Resolution	128×128pixel

	Conventional method		Proposed method	
Data	Long range	Short range	Long range	Short range
Data rate[kbps]	4	16	4	32

Twice

Experiment result

◇Throughput



Throughput: R(1-SER)

Data rate

Symbol error rate

Conclusion

- We proposed the data rate improvement method for overlay coding
  - For the long range data:
    We transmit original signals and inverted signals alternately.
  - For the short range data:
    We transmit only original signals
    while we transmit inverted signals of long range data.
  - We can improve the throughput
    without changing the number of LED.