A VIDEO DEHAZING SYSTEM BASED ON FAST AIRLIGHT ESTIMATION

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OUTLINE

- **Introduction**
  - Dehazing
- **Background**
  - Hazy imaging model
  - DCP-based dehazing method
- **Proposed dehazing system**
  - Fast airlight estimation
  - Proposed dehazing system
- **Evaluation**
- **Conclusion**

INTRODUCTION

- Dehazing
  - Hazy images
    - Image quality is degraded by haze

Input

Dehazing: The signal processing used to remove haze

  - Recovered images
    - Enhance the image quality by removing the haze

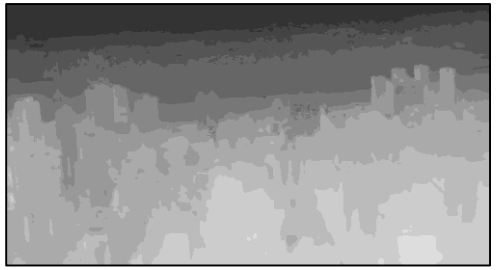
Computer vision systems

Undesired output

BACKGROUND

- Hazy imaging model[1)]

Hazy-free image

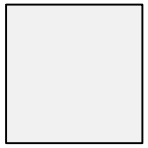


Transmission

The ratio at which "the light reaches the camera without being scattered"

$$\mathbf{I} = \mathbf{J} \cdot t + \mathbf{A} \cdot (1 - t)$$

Hazy image



Airlight

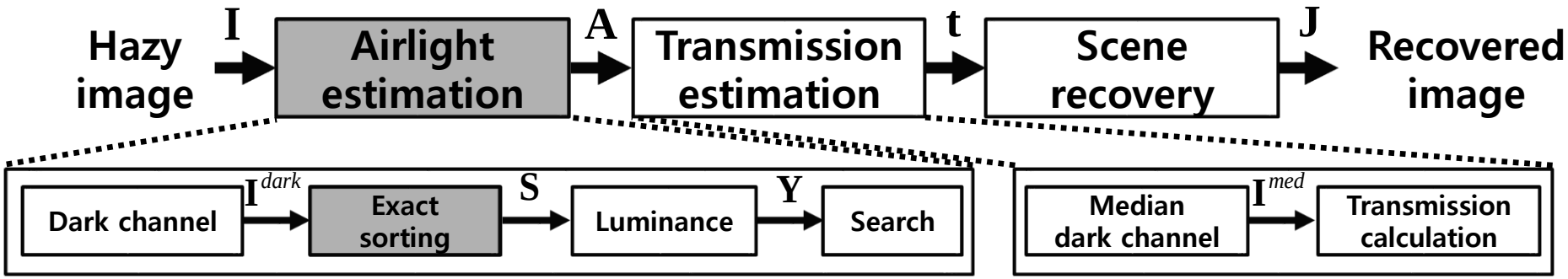
The color of the atmosphere

→ Goal of dehazing is to obtain **J** by estimating **A** and **t** using given **I**

1) S. G. Narasimhan and S.K. Nayar. "Chromatic frame work for vision in bad weather", IEEE Conference on Computer Vision and Pattern Recognition(CVPR), volume 1, pages 598-605, June 2000.

BACKGROUND

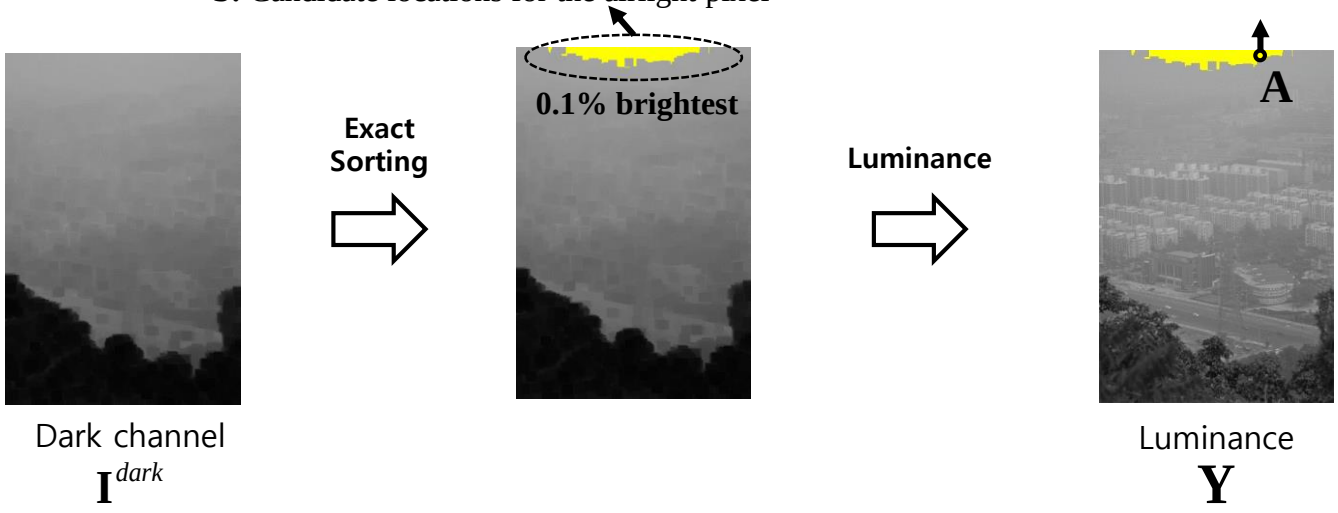
- DCP-Based Dehazing[1)]



- Airlight Estimation

Airlight pixel: Brightest pixel in luminance **Y** for **S**

S: Candidate locations for the airlight pixel



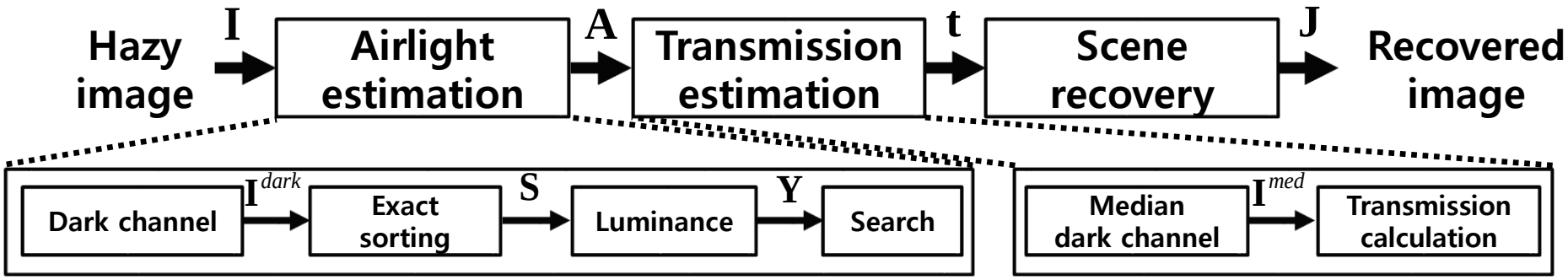
Dark channel
$\mathbf{I}^{dark}$

Luminance
Y

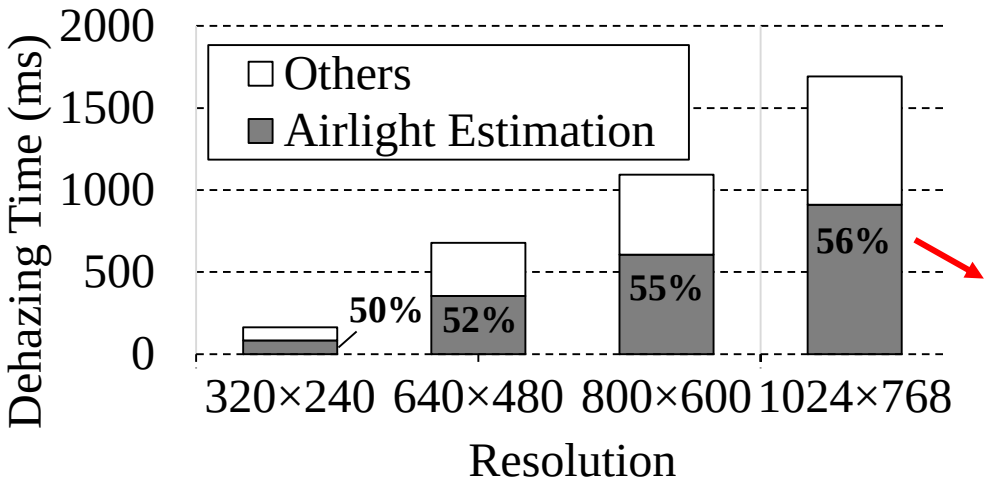
1) K. He, J. Sun, and X. Tang, "Single image haze removal using dark channel prior," IEEE Trans. Pattern Analysis & Machine Intelligence, vol. 33, no. 12, pp. 2341–2353, Dec. 2011.

BACKGROUND

- DCP-Based Dehazing[1)]



- Profiling results of software simulation
  - 800MHz ARM Processor

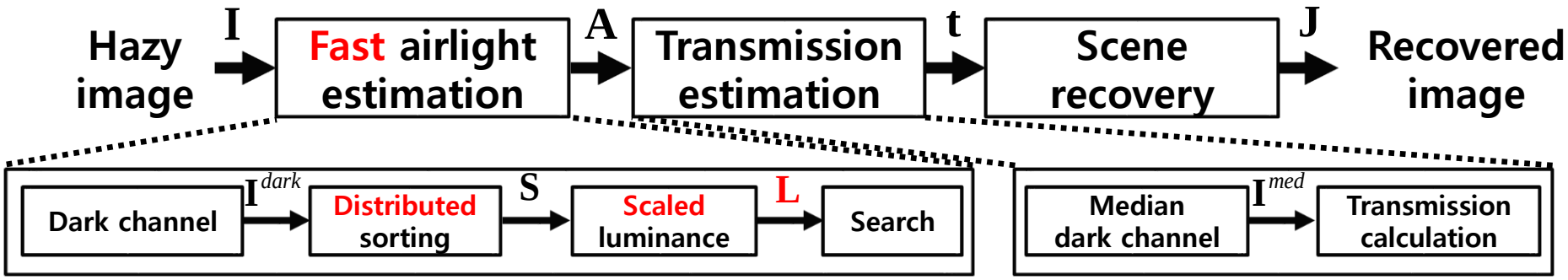


Takes more than 50% of total dehazing time due to Exact sorting of the entire pixels.

1) K. He, J. Sun, and X. Tang, "Single image haze removal using dark channel prior," IEEE Trans. Pattern Analysis & Machine Intelligence, vol. 33, no. 12, pp. 2341–2353, Dec. 2011.

PROPOSED DEHAZING SYSTEM

- Fast Airlight Estimation



- Distributed sorting with scaled luminance

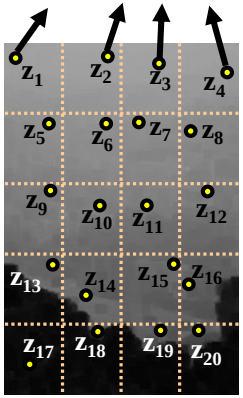
S: Brightest pixel locations in each sub-region

Airlight pixel: Brightest pixel in **L** for **S**

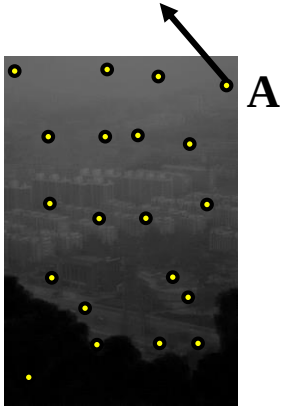
Dark channel

$\mathbf{I}^{dark}$

Distributed sorting



Scaled suminance

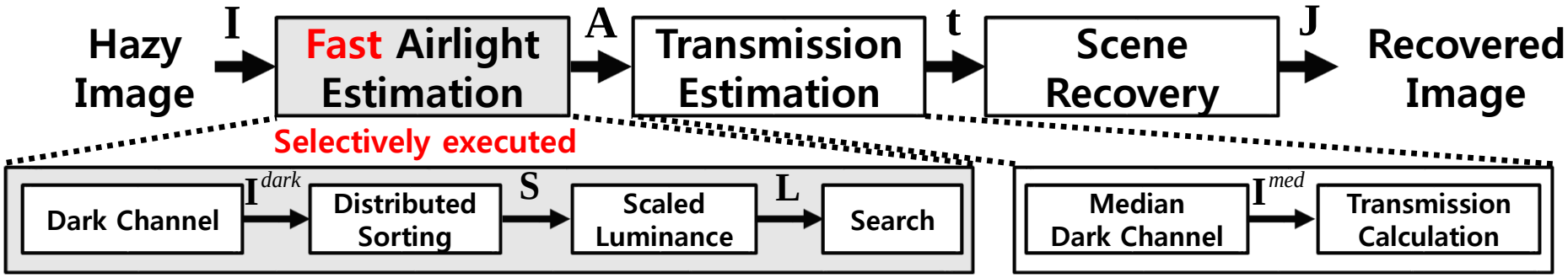


Scaled luminance

$\mathbf{L} = \mathbf{Y} \cdot \mathbf{I}^{dark}$

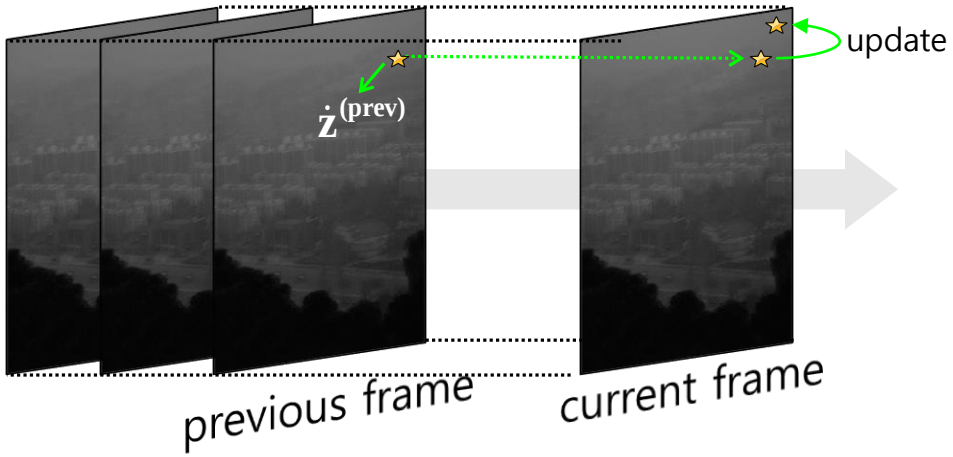
PROPOSED DEHAZING SYSTEM

- Fast Airlight Estimation



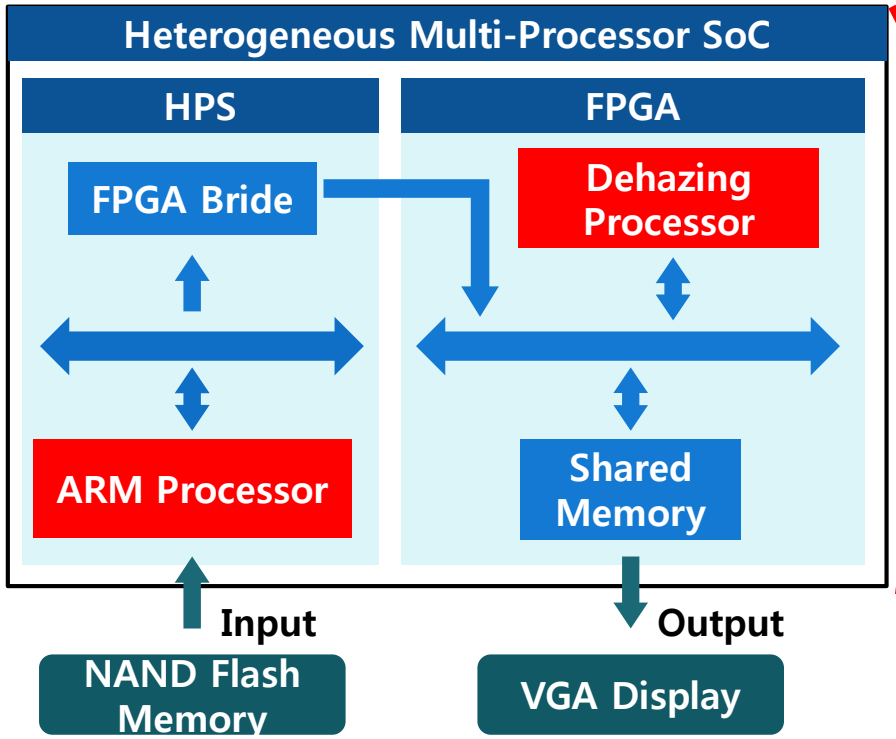
- Selective Airlight Estimation
  - Coherence between successive video frames is presented.

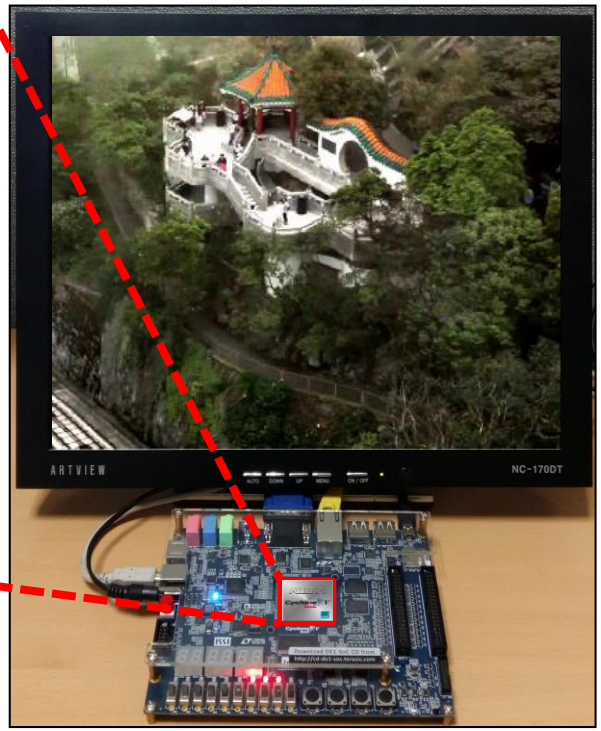
$$|L^{(prev)}(\dot{\mathbf{z}}^{(prev)}) - L^{(current)}(\dot{\mathbf{z}}^{(prev)})| > L_{th}$$



PROPOSED DEHAZING SYSTEM

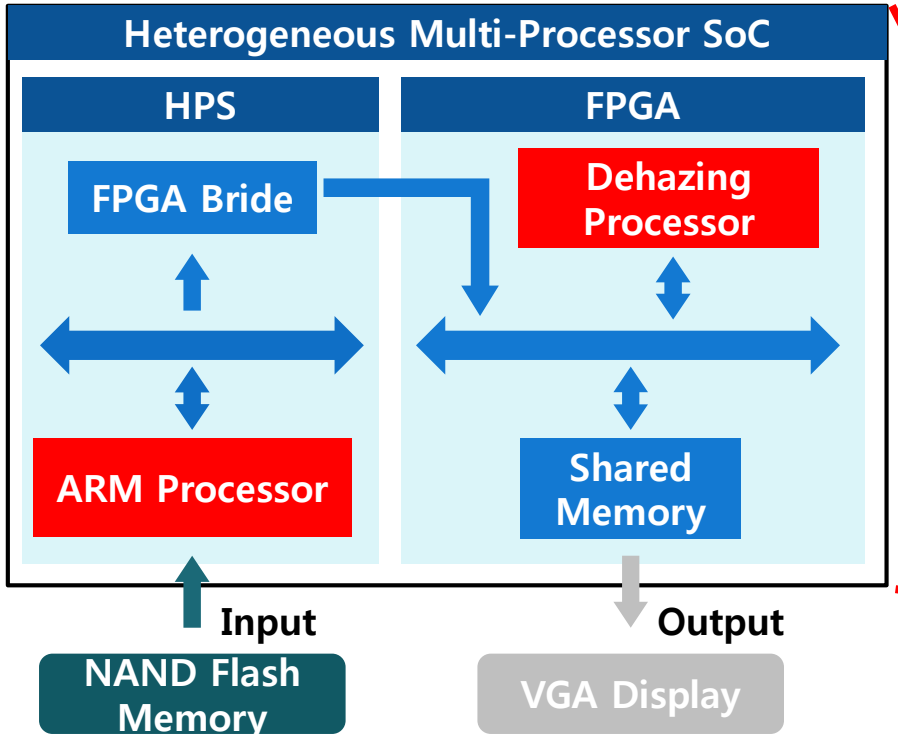
- Overall Architecture
  - ARM Processor in HPS
    - Control process
  - Dehazing Processor in FPGA
    - Overall dehazing process with fast airlight estimation

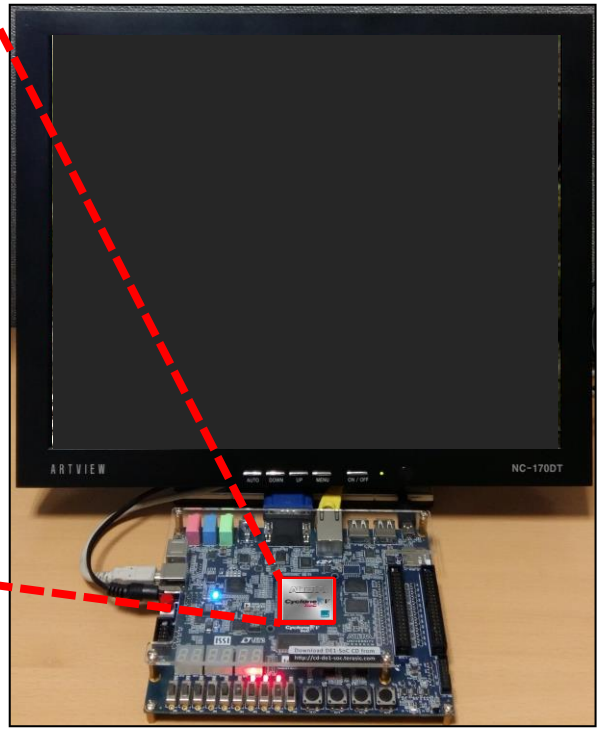




PROPOSED DEHAZING SYSTEM

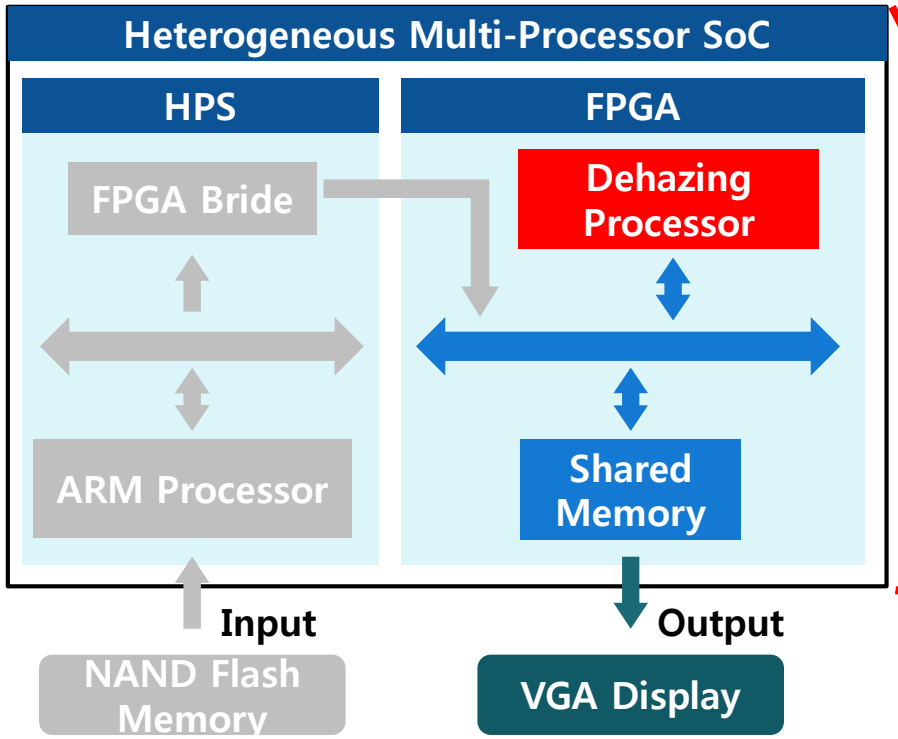
- Operating mechanism
  - Read the hazy video stream from the NAND flash memory.
  - Extract a hazy image from the hazy video stream.
  - Feed it to the dehazing processor through the FPGA bridge.

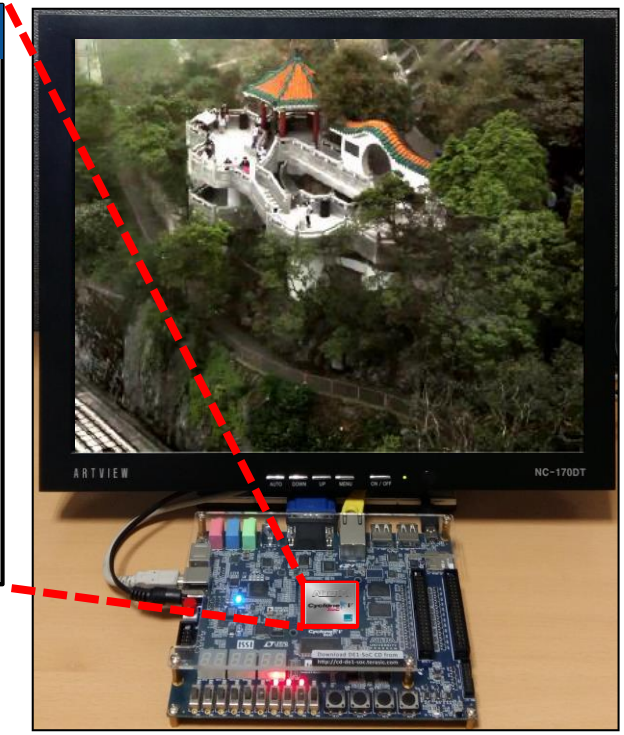




PROPOSED DEHAZING SYSTEM

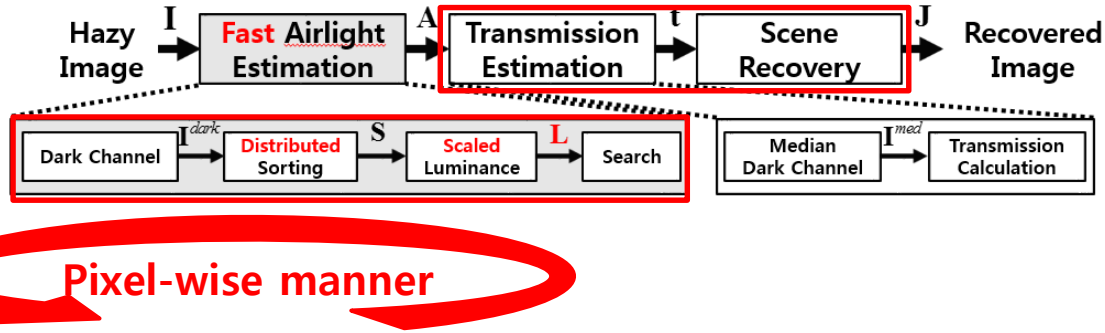
- Operating mechanism
  - The dehazing processor performs the oveall dehazing process.
  - The dehazing result is displayed through the VGA output.

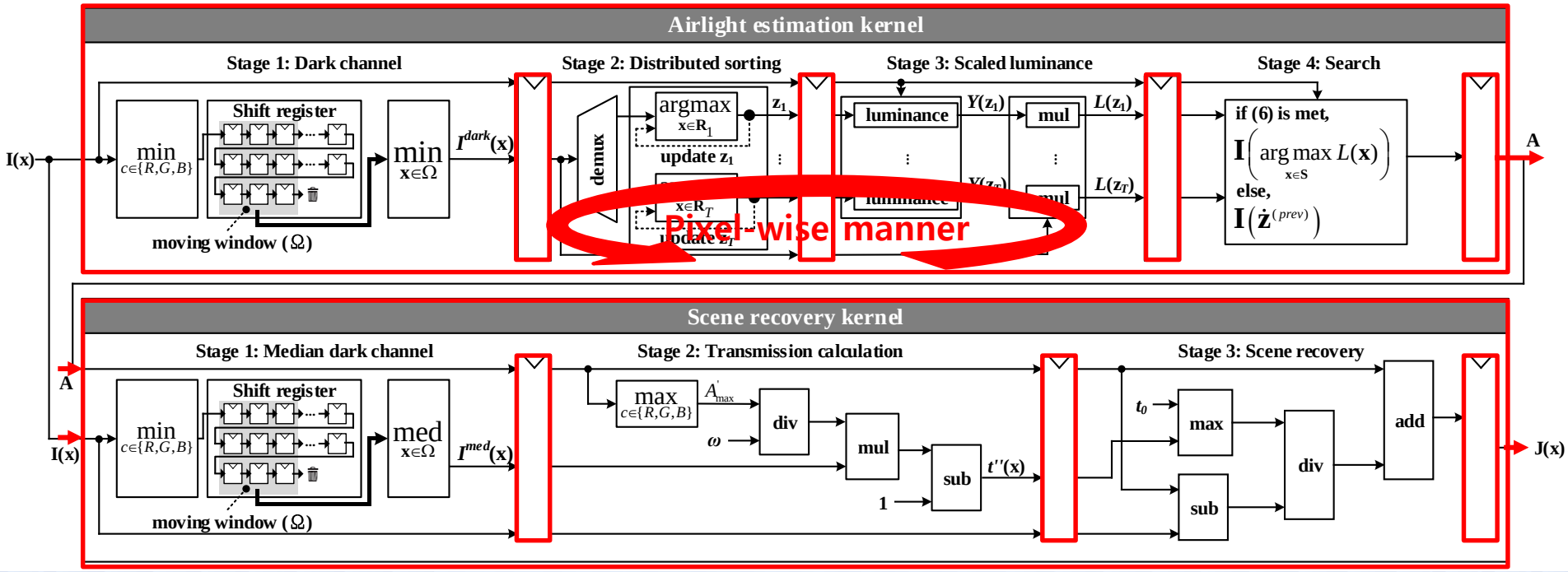




PROPOSED DEHAZING SYSTEM

- Dehazing processor
  - Two OpenCL kernels
    - Airlight estimation kernel
    - Scene recovery kernel

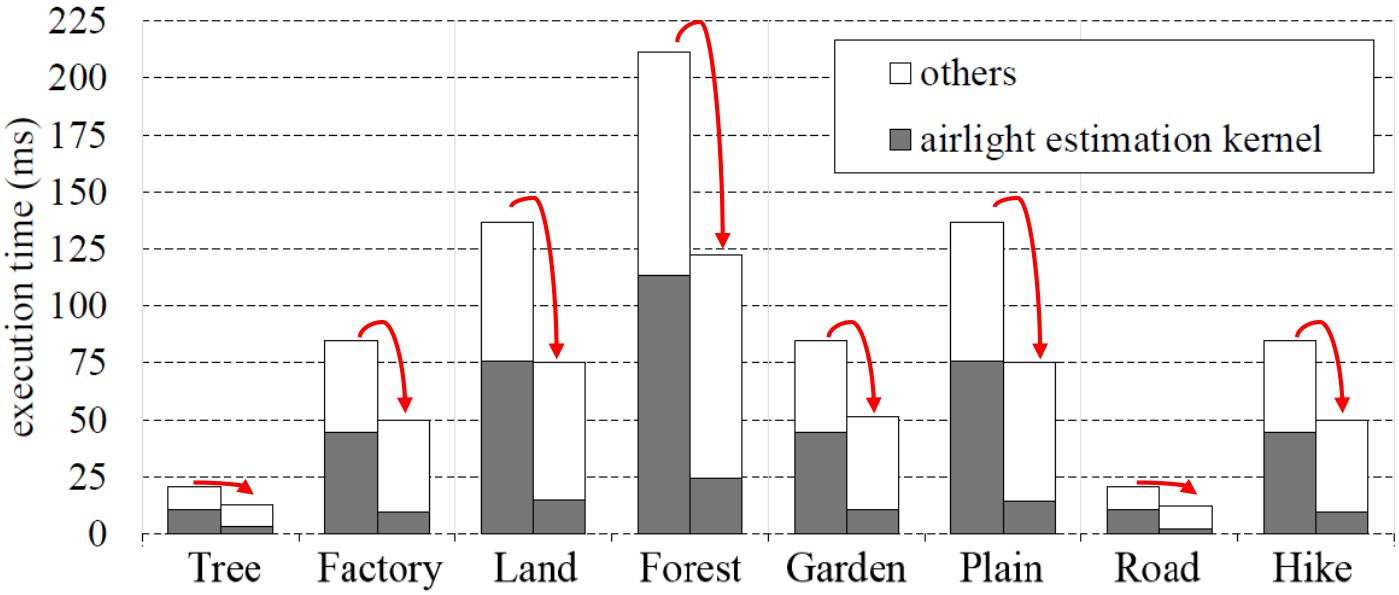




EVALUATION

- Dehazing time

40% reduction in average



- FPGA resource utilization

		320×240	640×480	800×600
resource utilization	ALMs	21.3k	28.2k	32.0k
	registers	43.0k	46.6k	53.4k
	DSPs	26	36	42
	memory (bits)	1.2M	2.5M	3.2M
frequency (MHz)	HPS	800	800	800
	FPGA	86.3	88.2	88.7

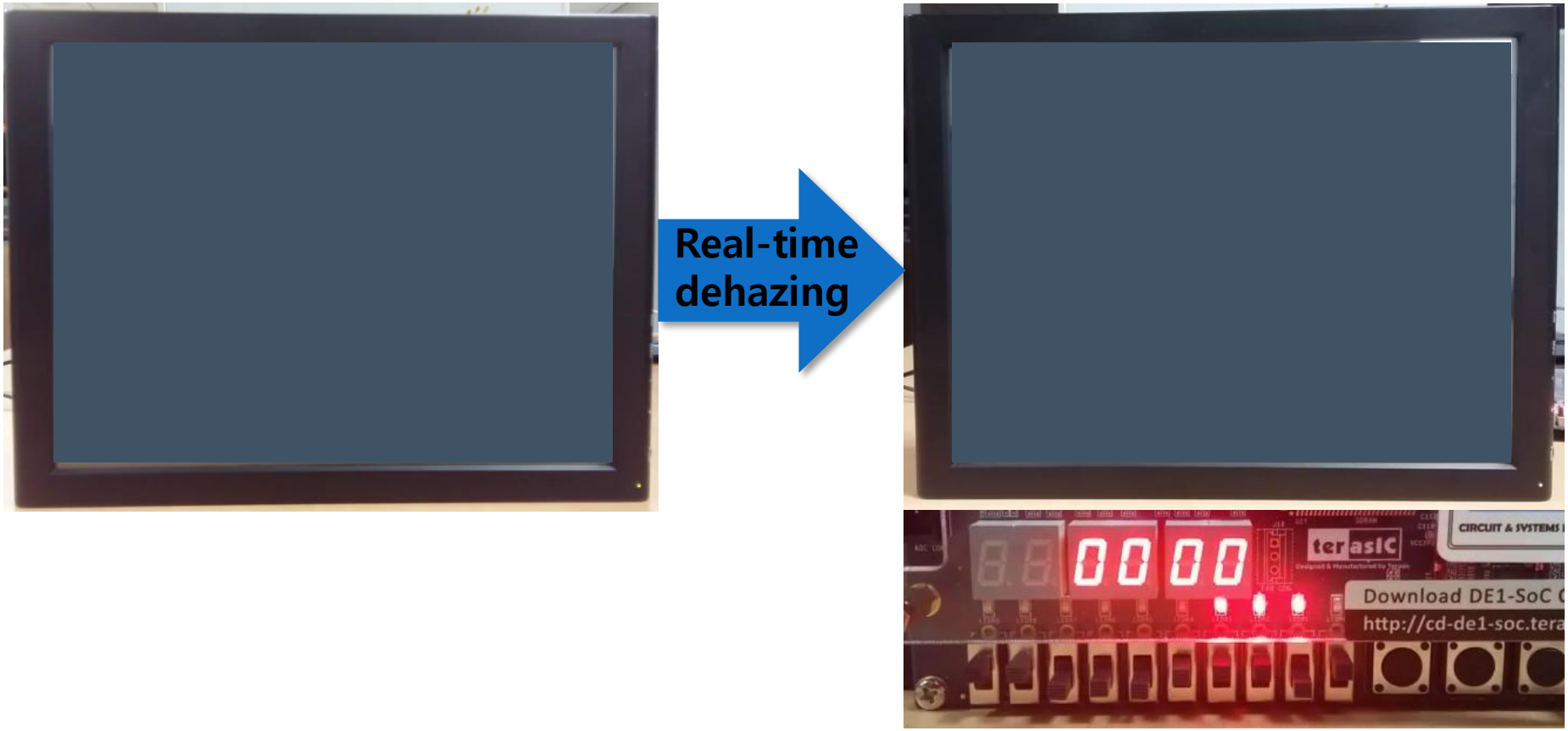
EVALUATION

- Dehazing Quality

Hazy Images | Dehazing results (referential) | Dehazing results (proposed)

EVALUATION

- Demo
  - Hazy video stream
  - Proposed dehazing system



CONCLUSION

- Main Contribution
  - Low-complexity dehazing method based on fast airlight estimation
    - Distributed sorting with scaled luminance
    - Selective airlight estimation
  - Efficient dehazing system based on low-complexity dehazing method
    - The overall dehazing time is reduced by 40% in average