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# Multi-Frame Super Resolution Using Frame Selection and Multiple Fusion for 250 Million Pixel Images

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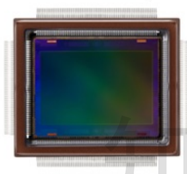
## Introduction

### Background

- An extremely high-resolution image can be taken for a wide area by using the camera with a built-in Canon's APS-H size 250Mpixel CMOS image sensor(Fig. 1)
- Quality of the an enlarged tiny part in this kind of image tends to get poor due to spatial deformations and noise mainly caused by long distance and atmosphere turbulence.
- Multi-frame super-resolution performs well in enhancing the quality of images deformed by deformation and blur

Sensor-chip



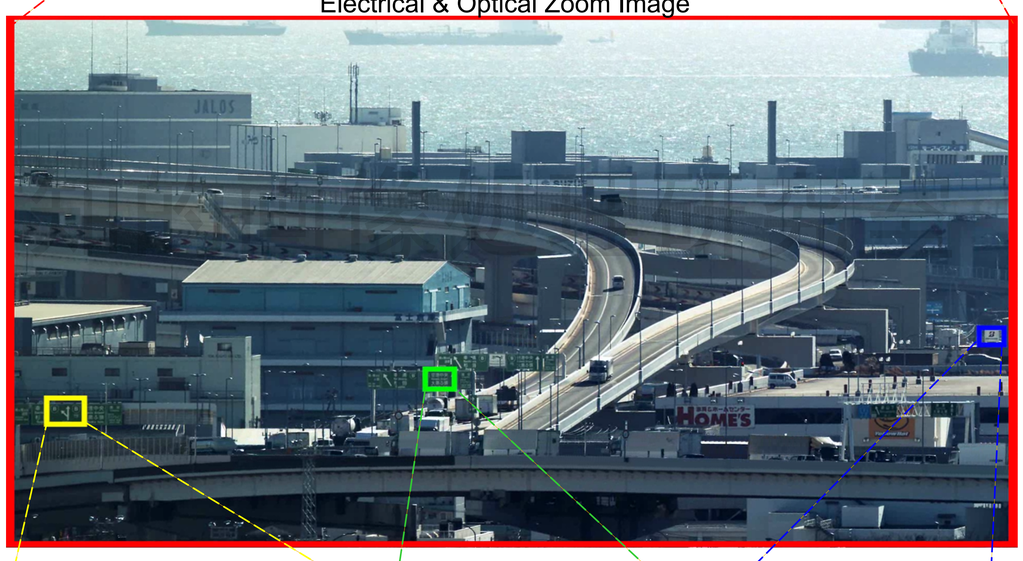
Camera

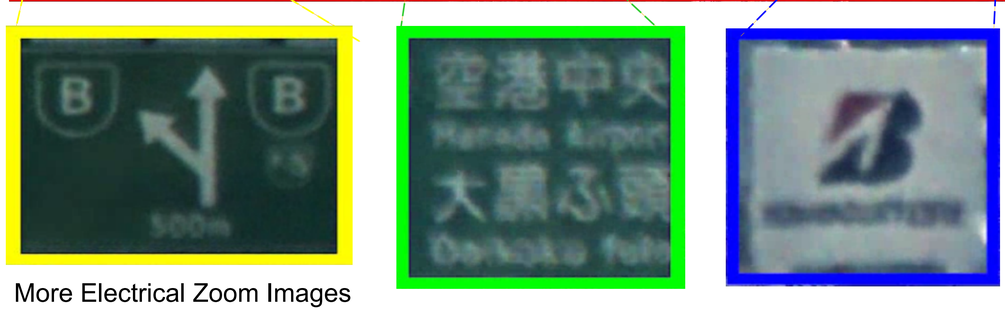
| 250Mpixel-CMOS-Imge-Sensor-Specifcation | |
|---|---|
| Number of Pixel | 19,598(H) x 12,588(V) |
| Pixel Size | 1.5μm x 1.5μm |
| Image Size | APS-H-format =32.84mmx 25.84mm |
| Frame Rate1 | 5fps = Full Pixel 19K13K |
| Frame Rate2 | 24fps = Select Pixel 8K4K |
| Frame Rate3 | 48fps = Select Pixel 4K2K |

Fig.1 Canon's 250 million pixel CMOS-image-sensor specifications and photograph

### 250 Million Pixel Images

Electrical & Optical Zoom Image




More Electrical Zoom Images

Fig.2 Example of 250 million full-pixels images (top), part of the full-pixels image (middle), and its three detailed structure images (bottom) before processing

## Conclusion and Future Work

### Contributions

(1) We proposed a frame selection scheme based on its edge image for fast and accurate SR reconstruction.
(2) We proposed a multiple fusion scheme, which is robust to blur, deformation, and noise. The computation cost is almost as the same as the conventional single scheme.

### Future Work

Image restoration using deep convolutional neural networks

## Proposed Method

### Algorithm

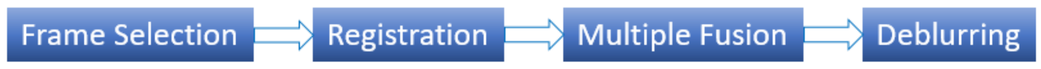
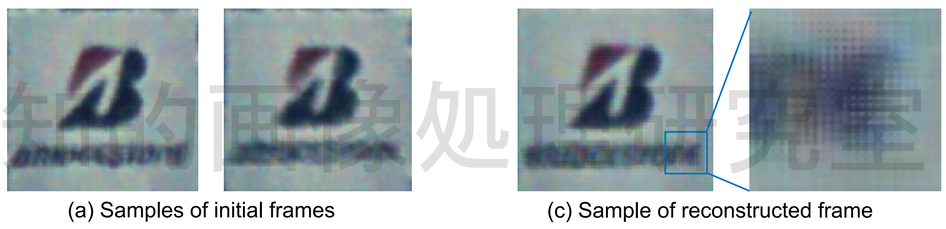



Fig.3 Brief algorithm of our method

### Frame Selection



(a) Samples of initial frames

(c) Sample of reconstructed frame

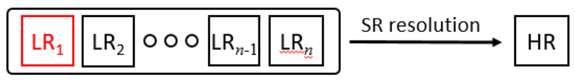
(b) Edge images of (a)

Frame selection 1: To eliminate degraded images caused by atmospheric turbulence before registration

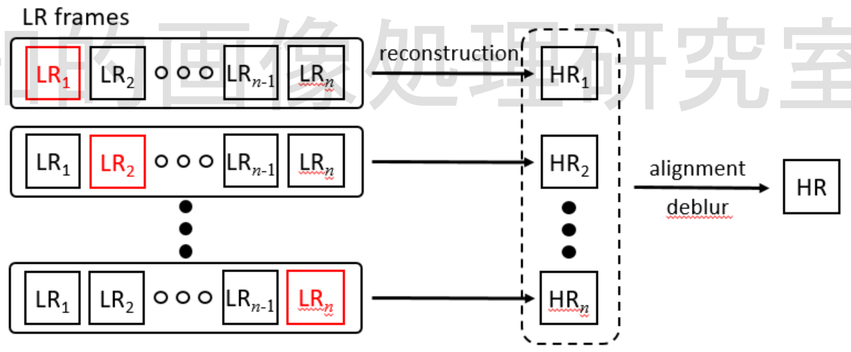
Frame selection 2: To reduce processing time of blur removal after multiple fusion

### Multiple Fusion

Conventional multi-frame super-resolution




Proposed multi-frame super-resolution




## Experimental Results

### Result


### Quantitative Evaluation with Simulated Images [1]

TABLE I
QUANTITATIVE COMPARISON OF OUR PROPOSED METHOD WITH CONVENTIONAL MULTI-FRAME SR METHODS

| SIDBA | LR image ($\mu \pm \sigma$)[a] | Reconstructed HR image | | |
|---|---|---|---|---|
| | | IBP | L1+BTV | Our Method |
| Pepper | 20.57 ± 1.40 | 22.41 | 22.28 | **23.92** |
| Airplane | 19.53 ± 1.28 | 20.96 | 20.92 | **22.43** |
| Lenna | 21.17 ± 1.22 | 22.51 | 22.29 | **23.70** |
| Sailboat | 19.39 ± 1.12 | 21.58 | 21.62 | **22.68** |
| Parrots | 21.90 ± 0.76 | 23.93 | 23.79 | **24.35** ← PSNR |

[a] $\mu$ : Mean, $\sigma$ : Standard Deviation

[1] Y. Li, Y. Iwamoto, K. Ogawa, Y.-W. Chen, "Computer Simulation of Image Distortion by Atmospheric Turbulence Using Time-Series Image Data with 250-Million-Pixels," International J. Computer Electrical Eng., Vol.10, pp.565-573, 2018.