Hybrid Method for Multi-Exposure Image Fusion Based on Weighted Mean and Sparse Representation

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Abstract

We proposed a multi-exposure image fusion method which is a hybrid of weighted mean and sparse representation produce average and texture components of fused images from input multi-exposure images. Result images of our proposed method is keep their sharpness. We measured result images objectively and perceptually.

Multi-exposure image fusion

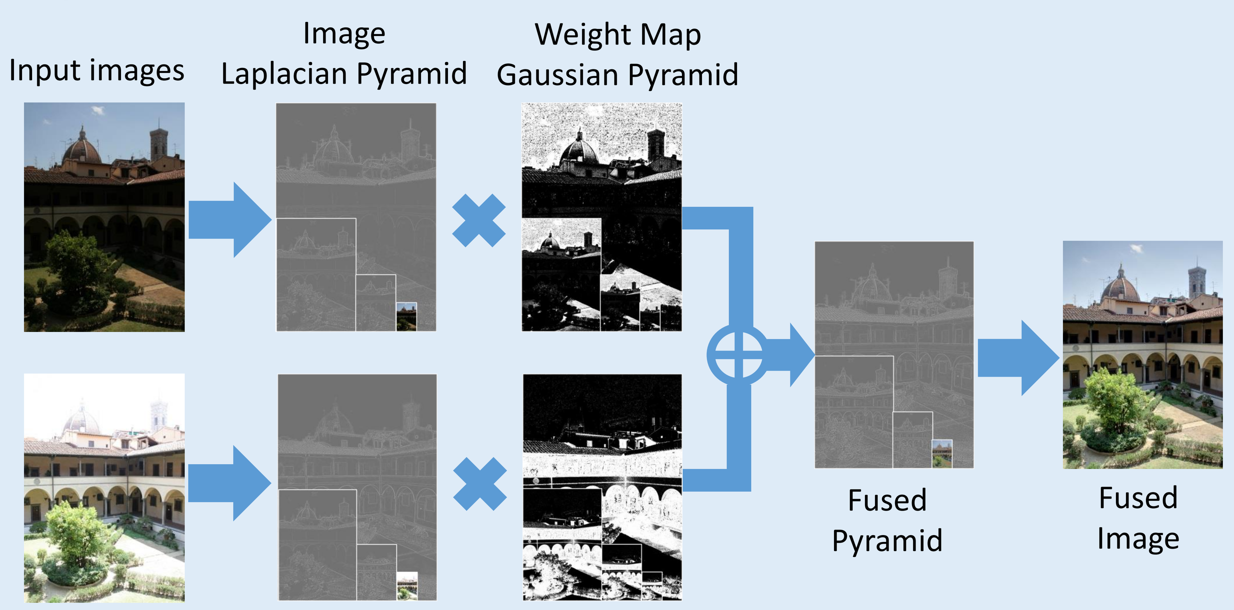
- Produce fine images without saturation regions from some multi-exposure images
- Not HDR image reproduction

Input multi-exposure images   Fused fine image

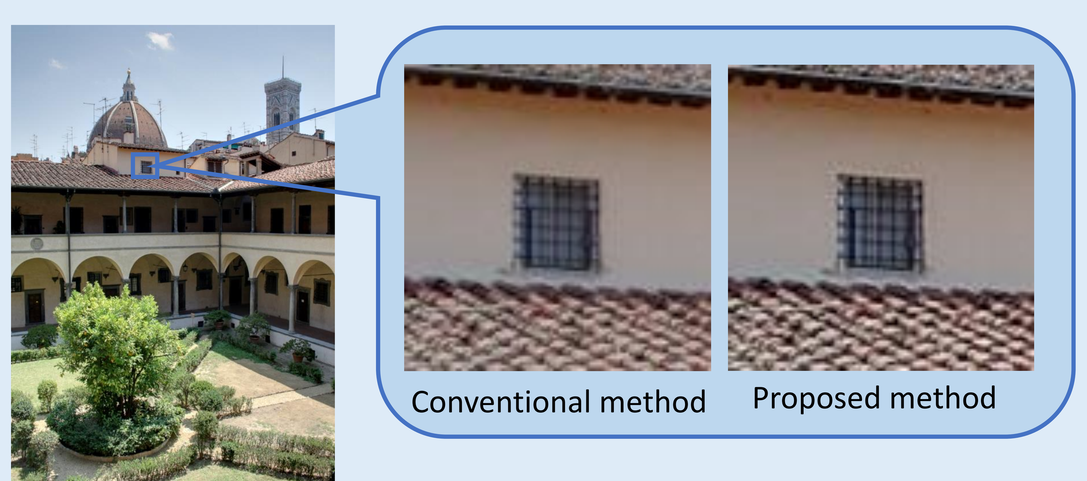
Conventional Method

Conventional method of multi-exposure fusion [1]

Algorithm of conventional method



Result image



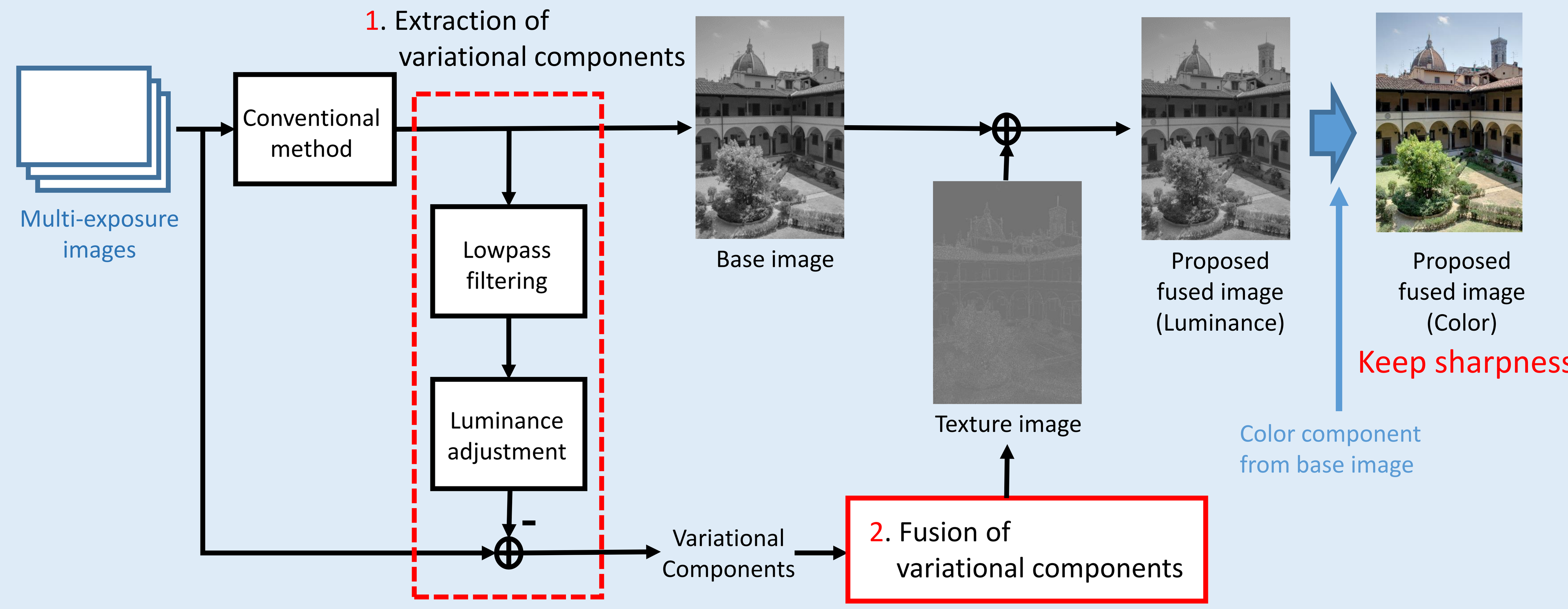
Fused image (Conventional method)

Resultant image of conventional method is blur

Proposed Method

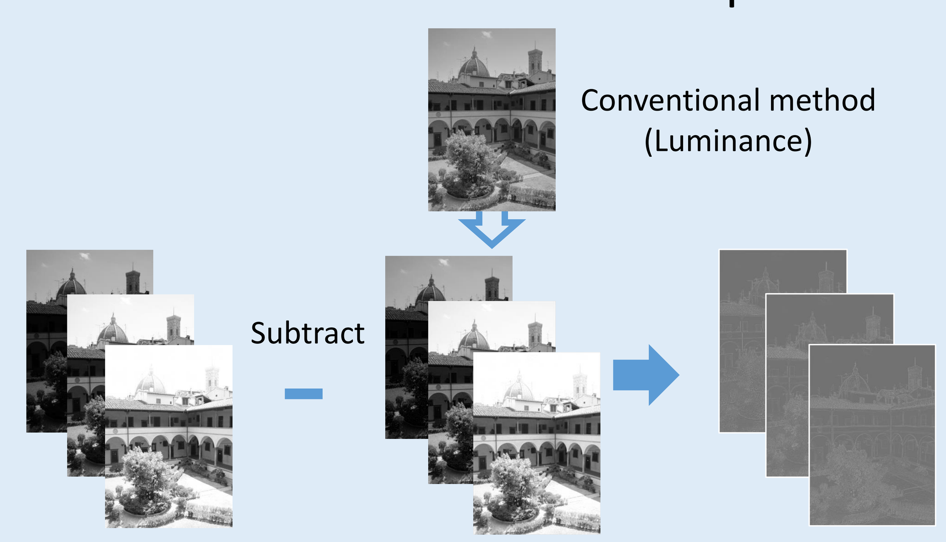
Framework

Algorithm of proposed method



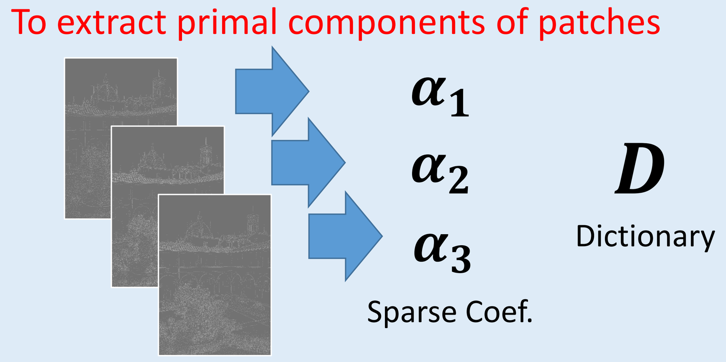
Calculate texture image

1. Extraction of variational components



2. Fusion of variational components

To extract primal components of patches



Approximated by D and α

D means a set of atoms learned by K-SVD.[2]

where $\alpha_l \in \mathbb{R}^N$, $D \in \mathbb{R}^{M\times N}$ — N: order of patches, M: order of atoms, l: image index

2.2.Fusion of sparse coefficients

Calculate fused sparse coefficients a_f by weighted mean

$$\boldsymbol{a_f} = w_1\boldsymbol{\alpha_1} + w_2\boldsymbol{\alpha_2} + w_3\boldsymbol{\alpha_3}$$

Weighting function

$$w_l = \frac{1}{S} g(\sigma_l)$$

$$S = \sum_l g(\sigma_l)$$

w_l:weight

σ_l : standard deviation of $\boldsymbol{x_l}$

Define 1/0 = 0

To avoid the effect of saturation regions, g( ) is defined as follows:

When the patch variance is low, g( ) imposes the weight to be low and vice versa.

Because, saturation regions generally have low variances and high variance patches usually have important edges and textures.

To enhance primal components,

low values of $\boldsymbol{a_f}$ are discarded.

Because, low coefficients produce insignificant components which seem like noises.

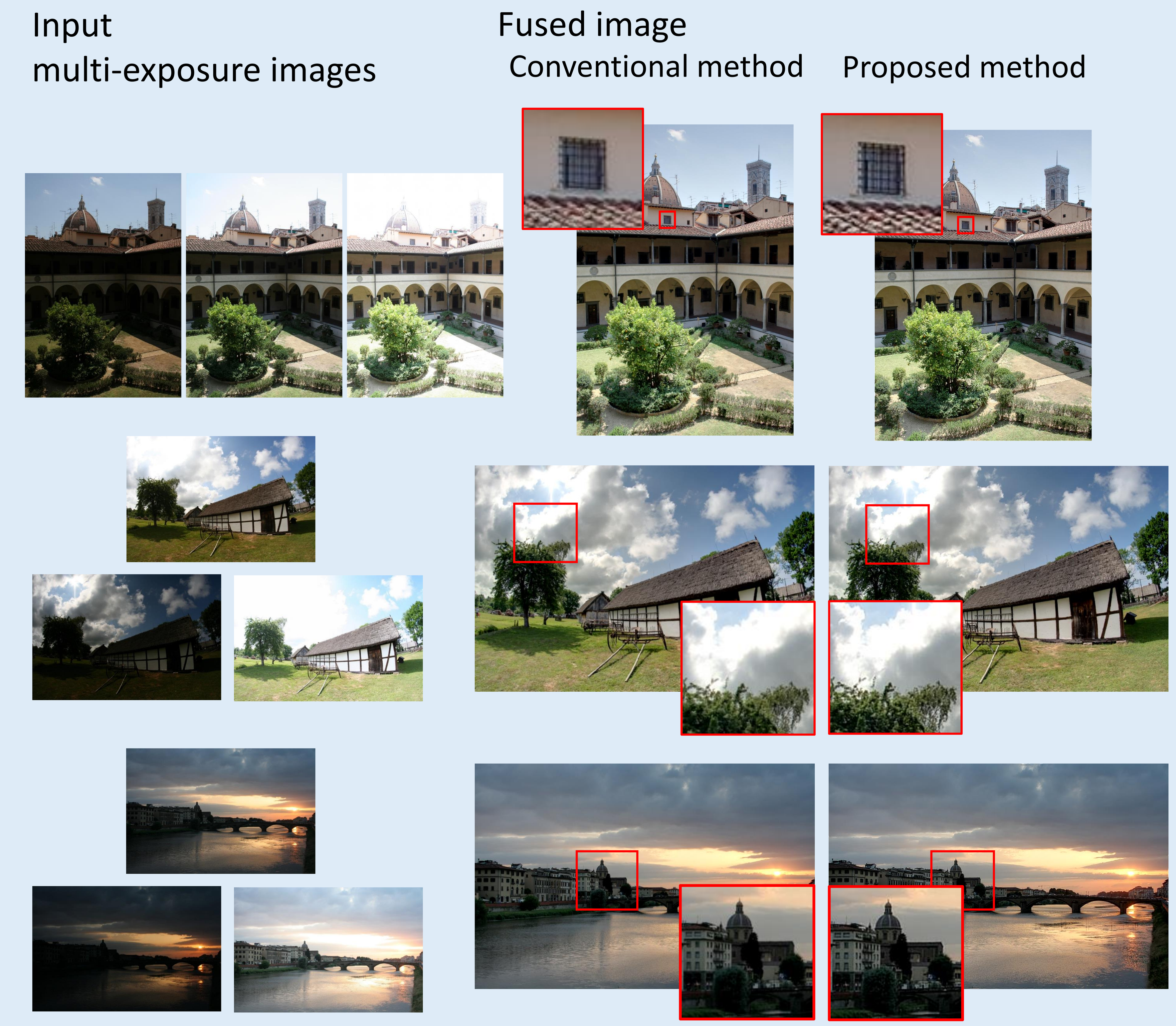
2.3.Calculate fused variational components

Calculate fused variational components by multiplying $\boldsymbol{a_f}$ and $\boldsymbol{D}$.

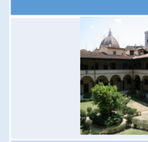
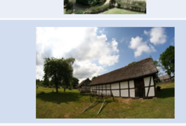
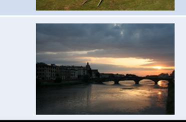
$\boldsymbol{D} \cdot \boldsymbol{a_f}$

Patch of Fused Variational Components

Result



TMQI(Tone-Mapped Image Quality Index)[3]

	Conventional method [1]	Conventional method [4]	Proposed method
	0.934	0.503	0.943
	0.679	0.568	0.682
	0.310	0.328	0.642
Average	0.554	0.444	0.639

TMQI is an objective measure that measures tone-mapped images based on a modified structural similarity method between images before and after tone-mapping and its statistical naturalness. The fused images seem to be the tone-mapped images, and the TMQI is valid as a measure for them. However, due to not obtaining images before tone-mapping, we can only use the statistical naturalness.

The values are in [0,1] and a higher one is better. In the table where 'Average' mean the proposed method and average values of 10 test sets.

Conclusion

- We proposed a hybrid method for multi-exposure image fusion based on weighted mean and sparse representation.
- The resultant fused images are visually natural and have sharp edges and textures.
- The results of proposed method are superior to results of conventional methods on objective evaluation.
- As future work, we tackle an alignment procedure considering the proposed algorithm.

References

[1] T. Mertens, J. Kautz, and F. Van Reeth, "Exposure fusion: A sinple and practical alternative to high dynamic range photography," *Comput. Graph. Forum*, vol. 28, no. 1, pp. 161-171,2009.

[2] M. Aharon et al., "K-SVD: An algorithm for designing overcomplete dictionaries for sparse representation," IEEE Trans. Signal Process., vol. 54, no. 11, pp. 4311–4322, 2006.

[3] H. Yeganeh and Z. Wang, "Objective quality assessment of tone-mapped images," *IEEE Trans. Image Process.*, vol. 22, no. 2, pp. 657–667, 2013.

[4] P. Sen, N. K. Kalantari, M. Yaesoubi, S. Darabi, D. B. Goldman, and E. Shechtman, ''Robust patch-based HDR reconstruction of dynamic scenes,'' *ACM Trans. Graph*., vol. 31, no. 6, pp. 203:1-203:11, 2012.