

Three Dimensional Discrete Wavelet Transform with Reduced Number of Lifting Steps

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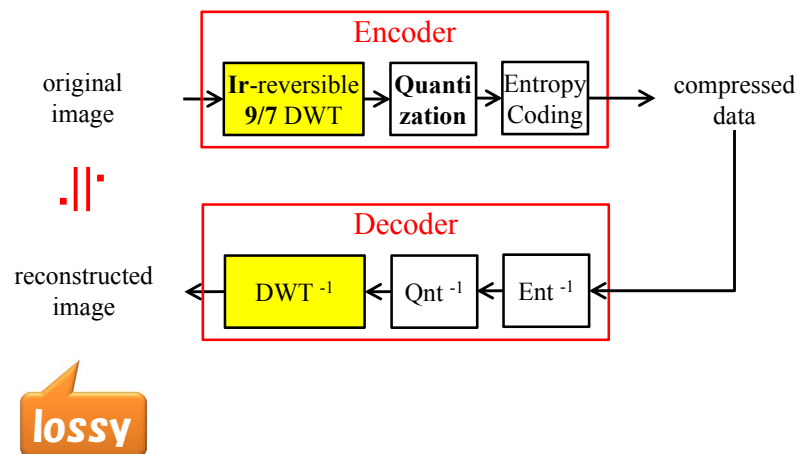
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Tokyo, 191-0065, Japan

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Our Purpose

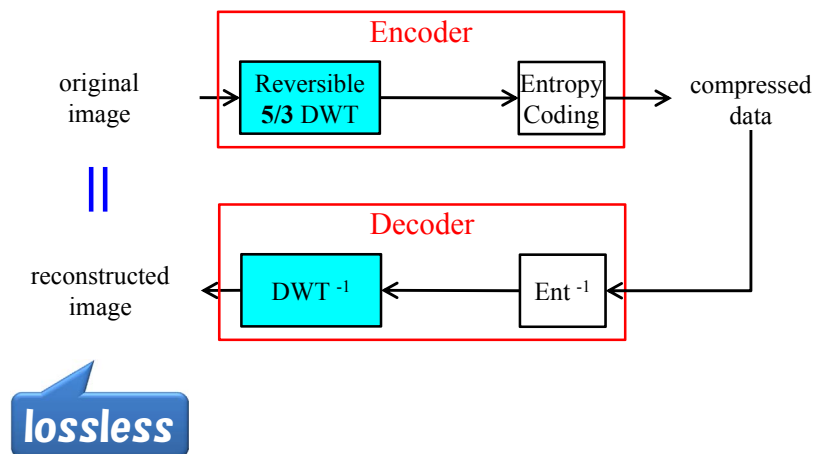
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JPEG 2000 'Lossy' Coding



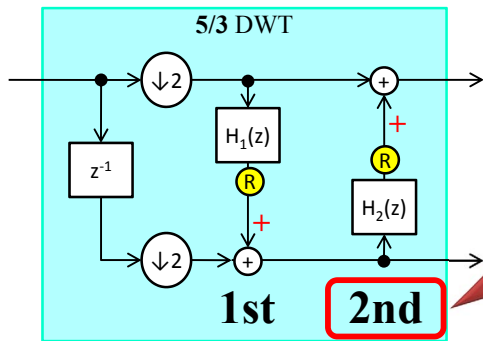
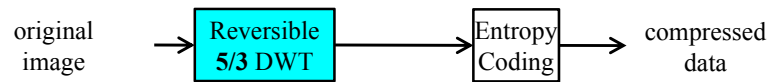
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JPEG 2000 'Lossless' Coding



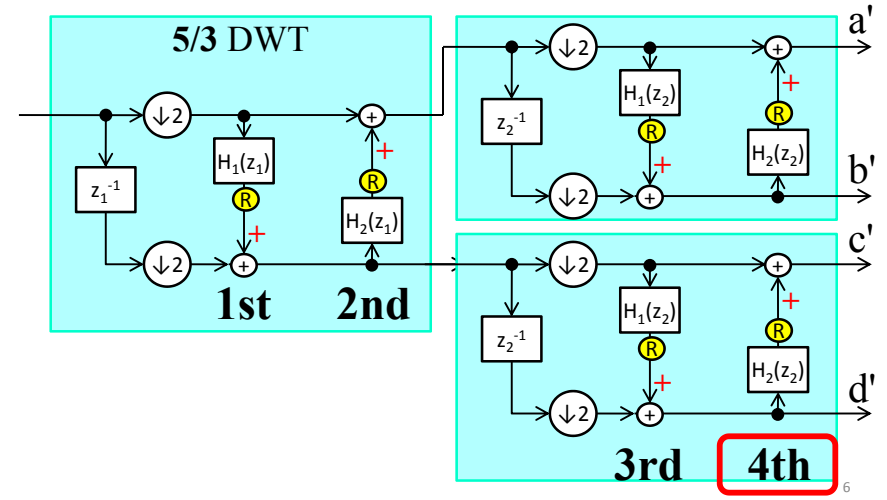
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Lifting Steps in 1D DWT

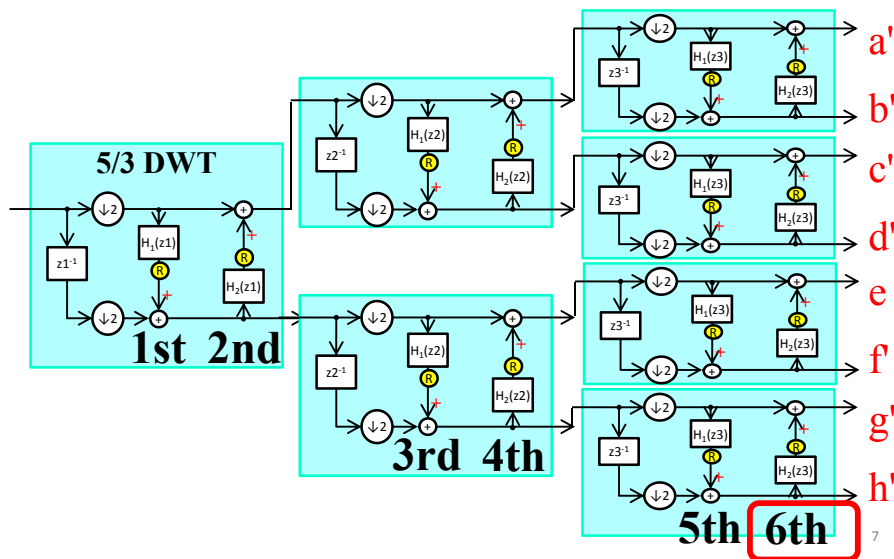


We reduce the total number of lifting steps of 3D DWT

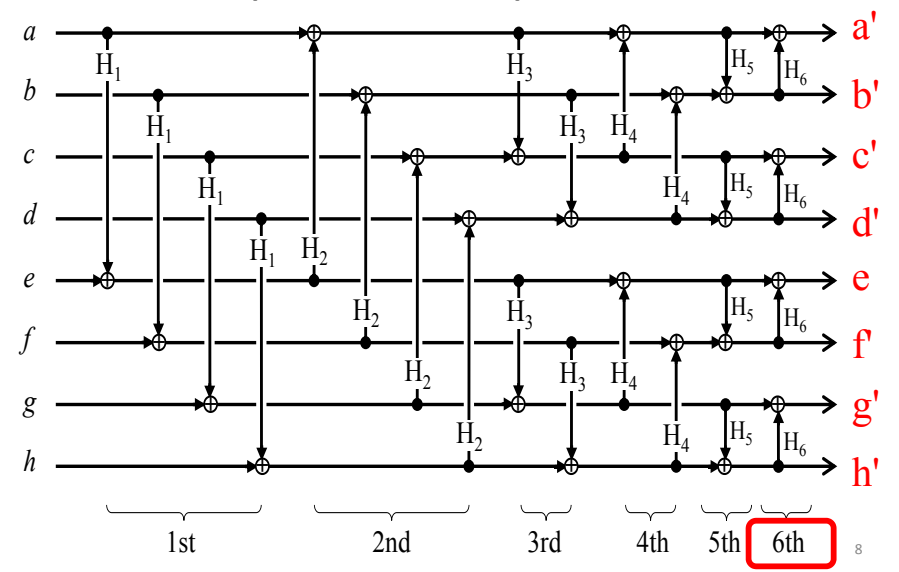
Lifting Steps in 2D DWT



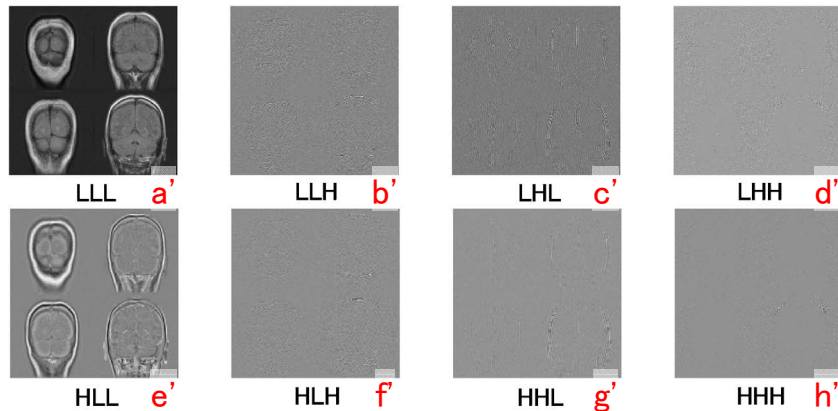
Lifting Steps in 3D DWT



Equivalent Expression



Output of the 3D 5/3 DWT



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Previous Works

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Previous Works

2D	separable		5/3 DWT	9/7 DWT
	non separable	type I	ISCAS '02	ICIP '09
type II		---	ICASSP '10	

- **[ISCAS '02]** S. Chokchaitam, M. Iwahashi, "Lossless / Lossy Image Compression based on Non-Separable Two-Dimensional L-SSKF," IEEE International Symposium on Circuits and Systems (ISCAS), pp.421-424, May 2002.
- **[ICIP '09]** M. Iwahashi, H. Kiya, "Non Separable 2D Factorization of Separable 2D DWT for Lossless Image Coding," IEEE Proc. International Conference on Image Processing (ICIP), pp.17-20, Nov. 2009.
- **[ICASSP '10]** M. Iwahashi, H. Kiya, "A New Lifting Structure of Non Separable 2D DWT with Compatibility to JPEG 2000", IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), pp.1306-1309, March 2010.

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Our Proposal

2D	separable		5/3 DWT	9/7 DWT
	non separable	type I	ISCAS '02	ICIP '09
type II		---	ICASSP '10	
3D	separable		5/3 DWT	9/7 DWT
	non separable		today!	---

We extend to 3D

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Total Number of Lifting Steps

2D	separable		4	8
	non separable	type I	3	7
		type II	---	6

Total number of lifting steps were REDUCED!

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Total Number of Lifting Steps

2D	separable		4	8
	non separable	type I	3	7
		type II	---	6
3D	separable		6 (100%)	12
	non separable		4 (66.7%)	---

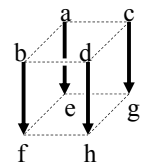
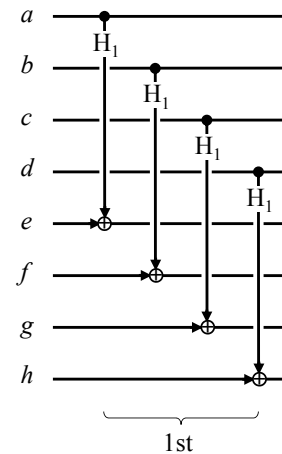
Our goal

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Existing method
and
Proposed method

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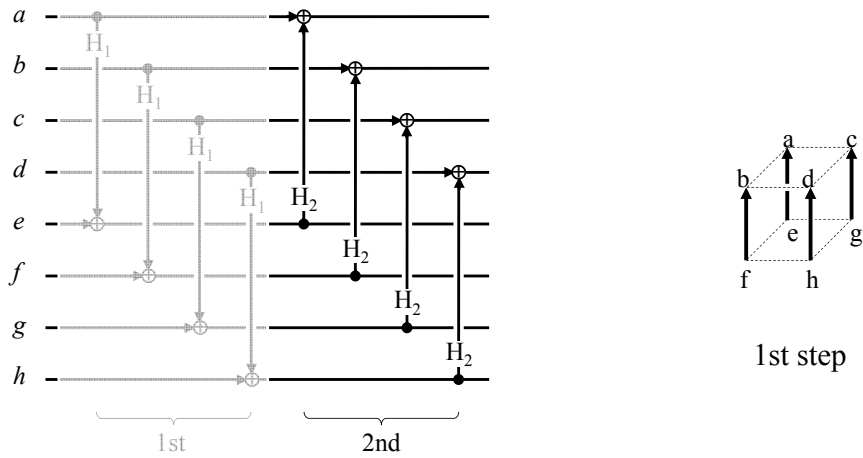
Existing method



1st step

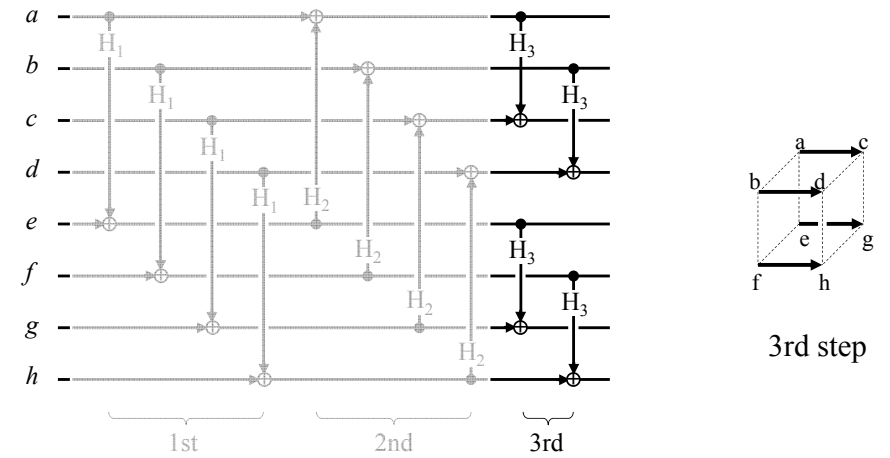
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Existing method



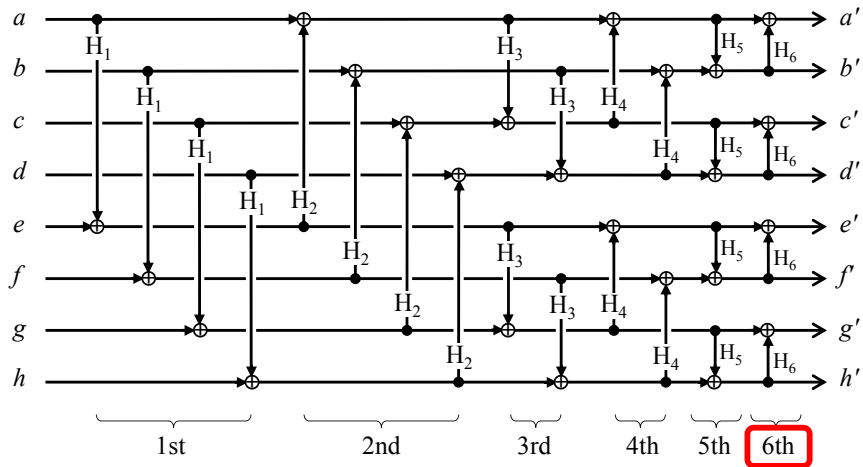
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Existing method



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Existing method



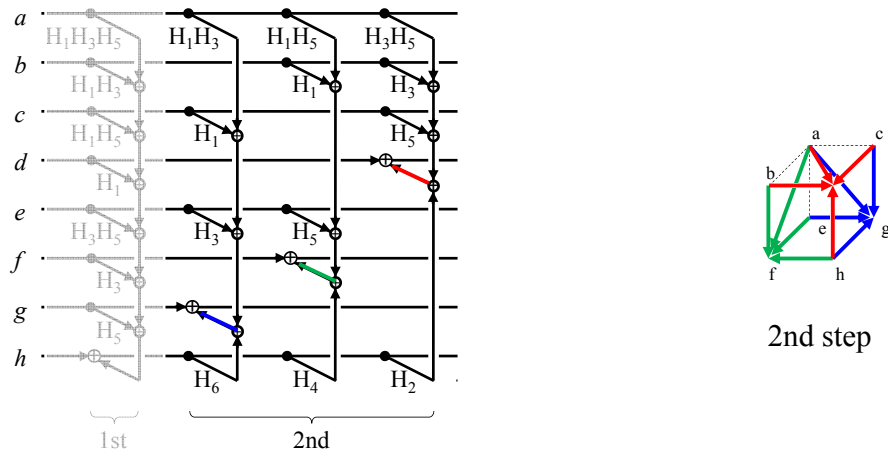
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Proposed method



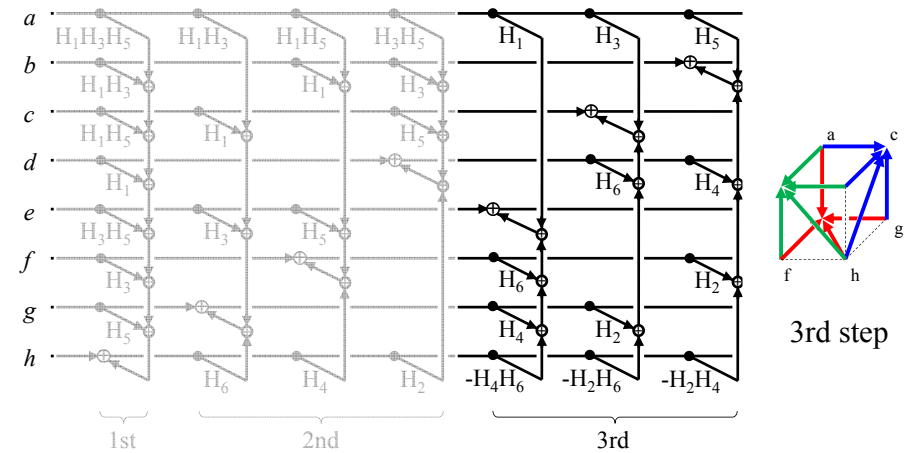
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Proposed method



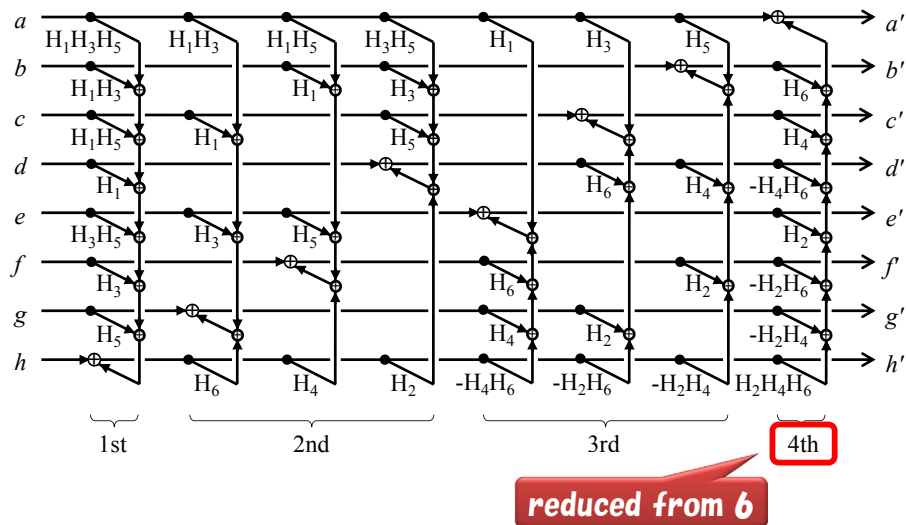
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Proposed method



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Proposed method



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Comparison

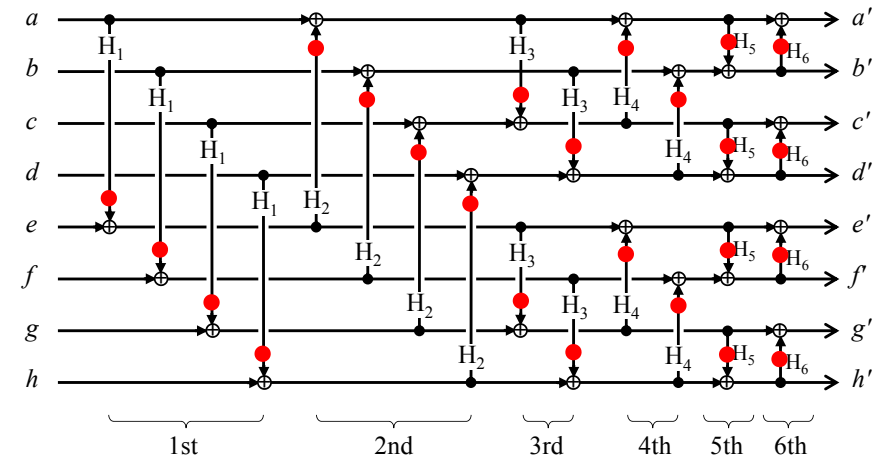
criteria		rounding operation		lifting steps	
DWT		5	3	5/3	9/7
2D	separable	4	4	4	8
	non separable	type I	4	3	7
		type II	---	1	---
3D	Existing	24 (100%)	48	6 (100%)	12
	Proposed			4 (66.7%)	---

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Evaluation of Rounding Errors

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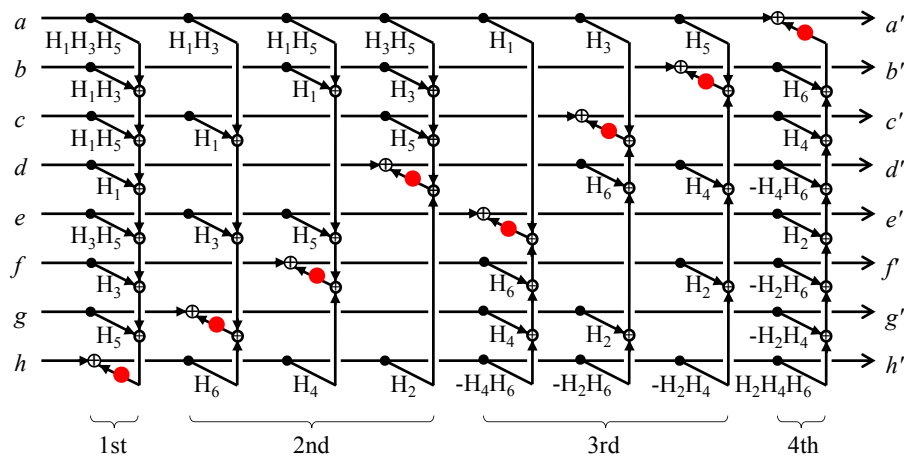
Existing method



24 Rounding Operations are included.

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Proposed method



8 Rounding Operations are included.

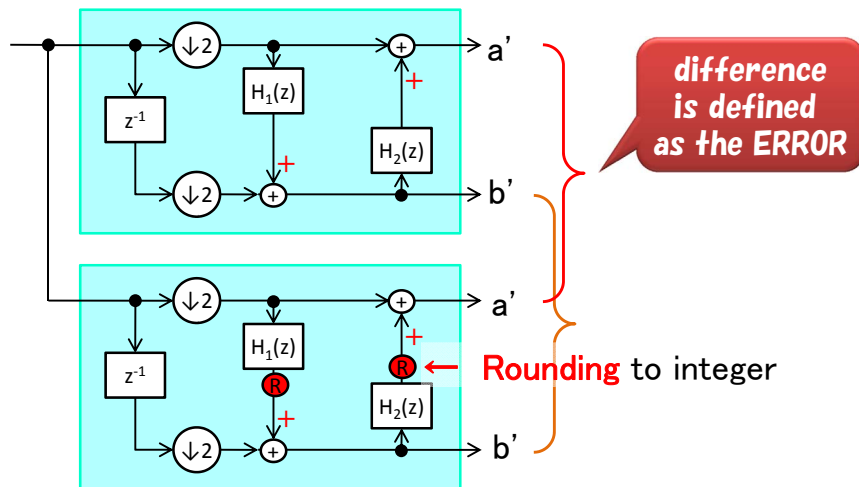
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Comparison

criteria		rounding operations		lifting steps		
DWT		5/3	9/7	5/3	9/7	
2D	separable	4	32	4	8	
	non separable	type I	4	16	3	7
		type II	---	12	---	6
3D	Existing	24 (100%)	48	6 (100%)	12	
	Proposed	8 (33.3%)	---	4 (66.7%)	---	

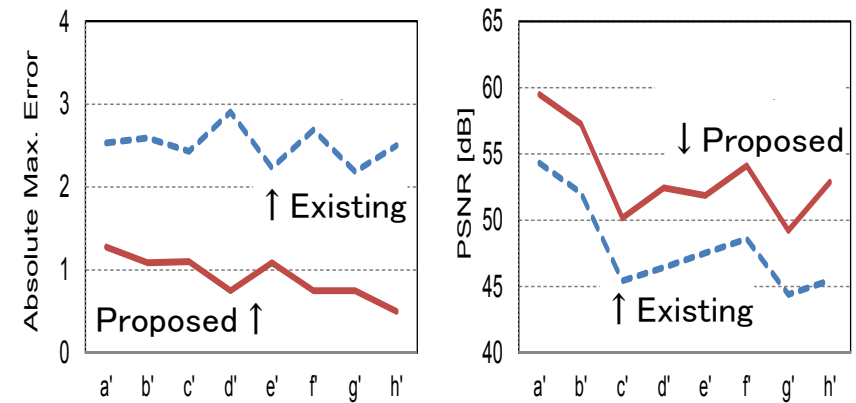
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Evaluation of Rounding Error



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Evaluation of Rounding Error



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Conclusion

- A non-separable 3D DWT compatible with an existing separable 3D DWT was proposed.
- Introducing 3D direct memory accessing, total number of **lifting steps** was reduced to **67 %**.
- Total number of **rounding operations** is also reduced to **33 %**.
- It is advantages for implementation that our DWT has compatibility with a DWT module widely used as an international standard.

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Thank you

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Our Proposal

		double	quadruple
2D	separable	5/3 DWT	9/7 DWT
	non separable	type I	ISCAS '02
		type II	---
3D	separable	5/3 DWT	9/7 DWT
	non separable	today!	APSIPA '13

↑
Oct.29-, Kaohsiung