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A New Class of Lifting Wavelet Transform for Guaranteeing Losslessness of Specific Signals

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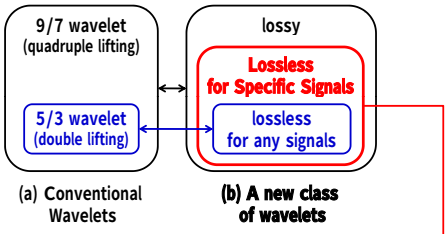
Session: SPTM-L1.4 - Wavelets Analysis
Presentation Type: Lecture
Session Location: Tiberius 1
Session Time: Tuesday, April 1, 10:30 - 12:30
Presentation Time: Tuesday, April 1, **11:30** - 11:50

Purpose of the research (1/2)

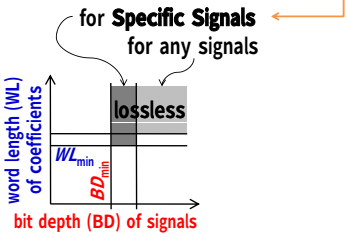


method	tap	lifting	input	property
conventional	5/3	double	any	lossless
	9/7	quadruple	any	lossy
new class	9/7	quadruple	any	lossy
			DC signals	Specific lossless

Purpose of the research (2/2)

What to do?

Determine the minimum
1) bit depth (BD) of signals,
2) word length (WL) of coefficients.



Rounding of a value

Original: $x = (-1)^S (b_{I-1}2^{I-1} \cdots + b_0 2^0 + b_{-1}2^{-1} + \cdots b_{-F}2^{-F} + b_{-F-1}2^{-F-1} + \cdots)$

Rounded: $x^* = (-1)^S (b_{I-1}2^{I-1} \cdots + b_0 2^0 + b_{-1}2^{-1} + \cdots b_{-F}2^{-F})$

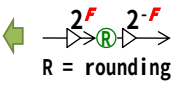
discard

S: sign I: integer fraction: F bit

$$F[x] = R[x2^F]2^{-F}$$

$$R_{Ex1}[x] = \lfloor x + 2^{-1} \rfloor = floor(x + 2^{-1})$$

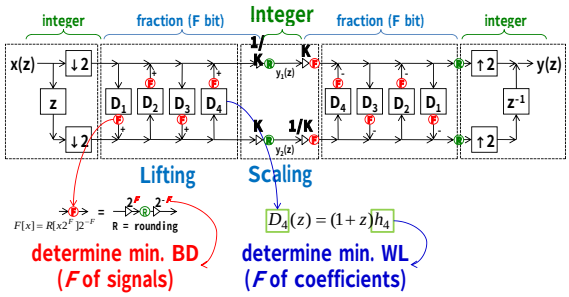
$$R_{Ex2}[x] = \lceil x - 2^{-1} \rceil = ceil(x - 2^{-1})$$



Determine the minimum What to do?
1) bit depth (BD) -> F of signals
2) word length (WL) -> F of coefficients

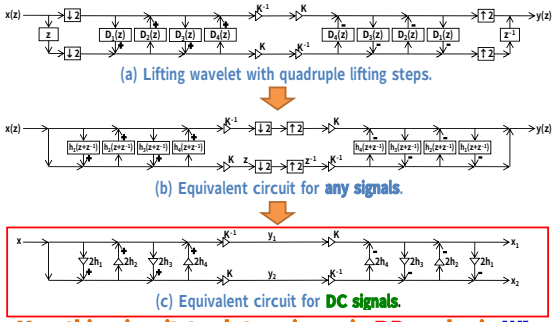
Lifting-Scaling / Integer Type

LS(I) type



A New Class = Lossless for DC signals
DC signal = Example of specific signals

Equivalent Circuit for DC Signals



Use this circuit to determine min.BD and min.WL.

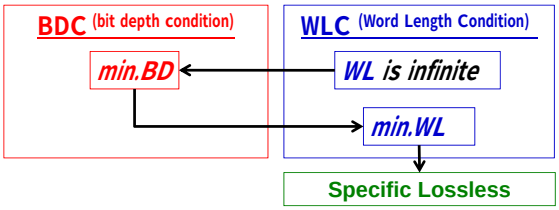
$$\begin{bmatrix} D_1(z) & D_2(z) \\ D_3(z) & D_4(z) \end{bmatrix} = \begin{bmatrix} h_1 & h_2 \\ h_3 & h_4 \end{bmatrix} \begin{bmatrix} 1+z^{-1} & 0 \\ 0 & 1+z^{-1} \end{bmatrix}$$

$h_1 = -1.586134342059924$
$h_2 = -0.052980118572961$
$h_3 = +0.882911075530934$
$h_4 = +0.443506852043971$

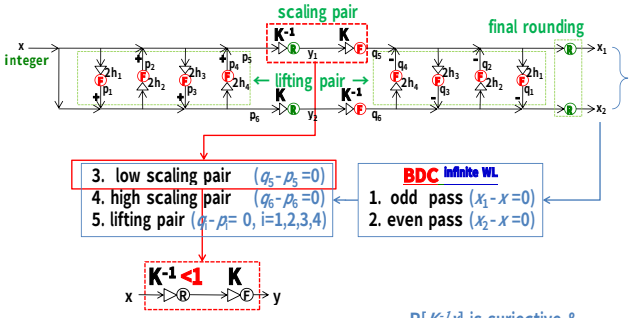
$K = +1.230174104914001$

K >1

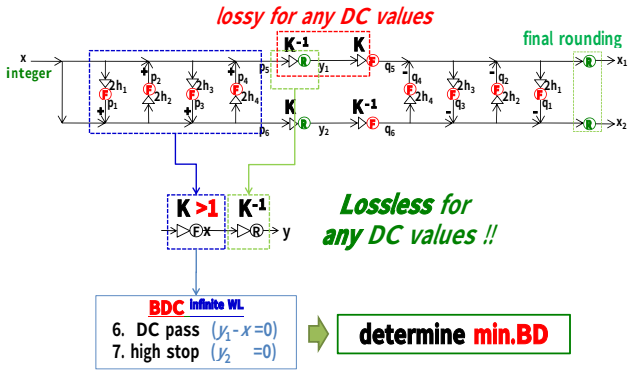
Min. BD *(bit depth)* and WL *(word length)* for Specific Lossless



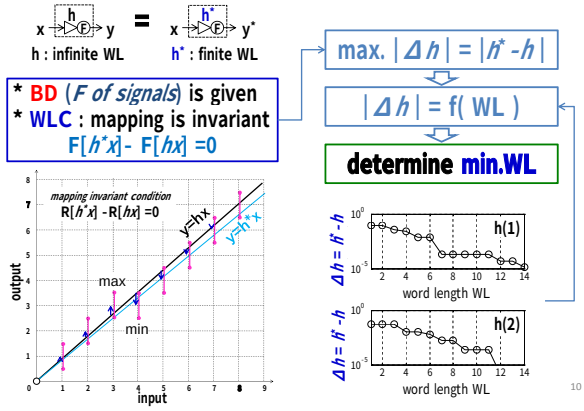
BDC (bit depth condition) under infinite WL (1/2)



BDC (bit depth condition) under infinite WL (2/2)

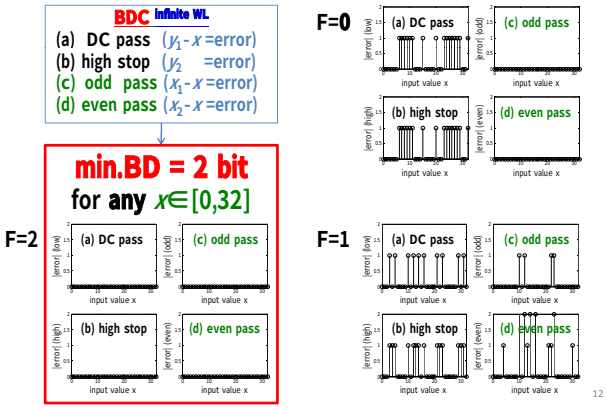


WLC (Word Length Condition) under min.BD



Simulation Results

min.BD for Specific Lossless *under infinite WL*

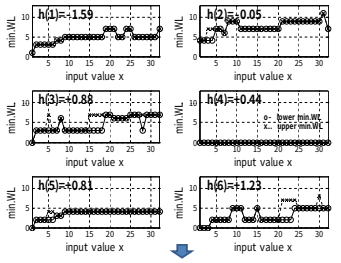


min.WL for Specific Lossless under min.BD (F=2)

DC lossless
for any value
of $x \in [0,32]$

min. WL
which satisfies
all the conditions.

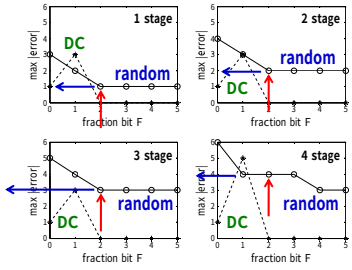
(a) DC pass
(b) high stop
(c) odd pass
(d) even pass



min.WL for any $x \in [0,32]$

h(1)	h(2)	h(3)	h(4)	K^{-1}	K
7	12	14	0	4	13

Reconstruction error for **random** input (1/2)

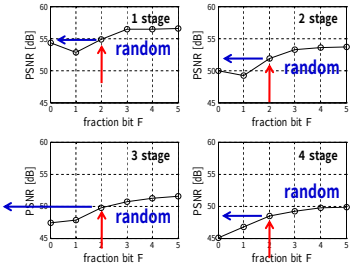


Max. |error|
at min.BD (F=2).

stage	1	2	3	4
random	1	2	3	4
DC input	0	0	0	0

min.BD
for any |x| ∈[0,128]

Reconstruction error for **random** input (2/2)



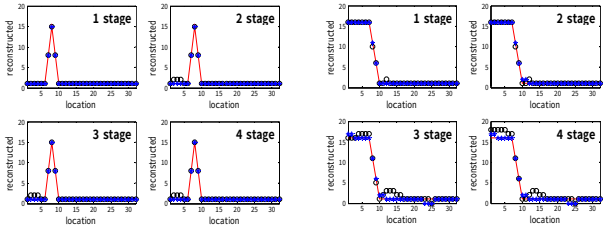
PSNR
at min.BD (F=2)

stage	1	2	3	4
random	54.87	51.86	49.75	48.47
DC input	∞	∞	∞	∞

Negligible at
PSNR < 48[dB]

Reconstruction error for **impulse** and **step** input

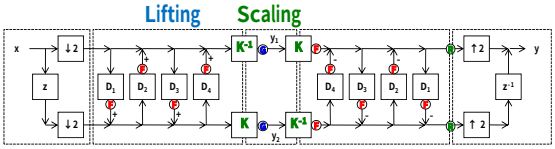
- input
o with DC lossless
* w/o DC lossless



tranERR_2.m

Variations of the **Specific Lossless** Wavelet

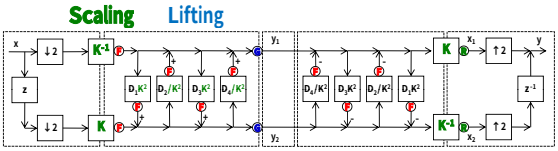
LS type conventional



(a) Lifting -Scaling(**LS**) type

	register	band	name
F>0, G=0	Fraction	Integer	LS(I) type
F =G > 0	Fraction	Fraction	LS(F) type

SL type Newly introduced



(b) Scaling-Lifting (**SL**) type

	register	band	name
F>0, G=0	Fraction	Integer	SL(I) type
F =G > 0	Fraction	Fraction	SL(F) type

results of variations

method	input	min. BD		min. WL							
		F	G	forward		back		lifting			
				K^{-1}	K	K	K^{-1}	h_1	h_2	h_3	h_4
LS(F)	random	3		4	10	10	4	0			
SL(F)		1		4	9	10	4				

PROPOSAL

method	input	min. BD		min. WL							
		F	G	forward		back		lifting			
				K^{-1}	K	K	K^{-1}	h_1	h_2	h_3	h_4
LS(F)	DC signals	2		4	0	13	0	7	12	14	2
SL(F)		1		4	10	9	4	0			
LS(I)		2	0	4	0	13	0	7	12	14	0
SL(I)		3		4	10	10	4	11	14	7	

Conclusions

Proposed a New Class of Wavelet
- Specific Lossless *lossless for DC signals

Determined
- minimum BD for the Specific Lossless
- minimum WL under the min.BD

Standard requirement
- guarantee no error for white balance