

TSTE18: Sparser modified Booth encoding

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Booth encoding

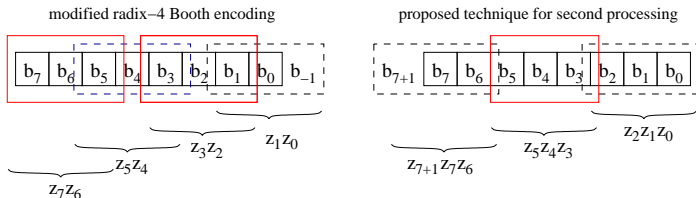
- Modified Booth-2 encoding scheme (radix-4 Booth recording)

X_{i+1}	X_i	X_{i-1}	Y_{i+1}	Y_i	PP
0	0	0	0	0	0
0	0	1	0	1	+x
0	1	0	1	$\bar{1}$	+x
0	1	1	1	0	+2x
1	0	0	$\bar{1}$	0	-2x
1	0	1	$\bar{1}$	0	-x
1	1	0	0	$\bar{1}$	-x
1	1	1	0	0	0

- Example: $01110111 \Rightarrow 100\bar{1}100\bar{1}$
- Adjacent ones are still occurring in some cases

New encoding scheme

- Why not try performing a second round of processing to reduce the adjacent ones
- An idea for a new encoding scheme



Comparison between modified radix-4 Booth encoding and the proposed technique for second processing.

- Non-scanning nature of the new technique

New encoding scheme

- Truth table of the proposed encoding

a_{i+2}	a_{i+1}	a_i	b_{i+2}	b_{i+1}	b_i
0	1	1	1	0	$\bar{1}$
0	1	$\bar{1}$	0	0	1
0	$\bar{1}$	1	0	0	$\bar{1}$
0	$\bar{1}$	$\bar{1}$	$\bar{1}$	0	1
1	$\bar{1}$	0	0	1	0
$\bar{1}$	1	0	0	$\bar{1}$	0
1	1	0	1	1	0
$\bar{1}$	$\bar{1}$	0	$\bar{1}$	$\bar{1}$	0
OTHERS \implies			*	*	*

- For regret it does not cover all possible cases of adjacent ones due to the static technique
- This is the case with the bottom two patterns

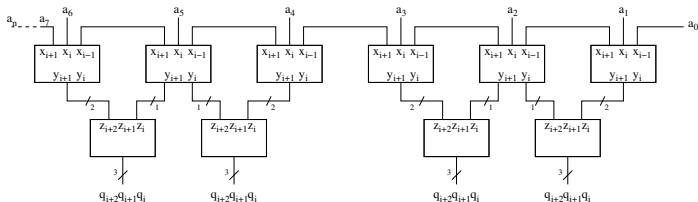
- An example of such a case where the encoding fails:

$$\left(\underbrace{101} \overbrace{101} \right)_{Be} \implies (101101)_{Ne} \quad (1)$$

- Example case when it will work:

$$\left(\underbrace{010} \overbrace{011} \underbrace{001} \right)_{Be} \implies (010001001)_{Ne} \quad (2)$$

- To get a visual overview of the whole processing:



- However not an implementation block diagram

Statistical impact of the proposed technique

- Some results from a brute-force algorithm

	6 bit	8 bit	16 bit
Max. Nr of adjacent ones (Booth)	1	2	4
Max. Nr of adjacent ones (proposed encoding)	1	2	3
Occurrence of adjacent ones (Booth)	16	92	43248
Occurrence of adjacent ones (proposed encoding)	4	54	28256

- Adjacent non-zeros occurrence reduction with $\approx 50\%$
- A comparison with radix-4 Booth encoding and traditional multiplication

	Total part.prod-s	Non-zero part.prod-s
Traditional Multiplier	100 %	50 %
Radix-4 Booth encoding	50 %	37.5 %
Proposed encoding	50 %	34.375 %

Conclusions and summary

- The presented encoding scheme is a mix between Booth encoding and CSD
- Still beneficial to do a second round of processing, if it can be implemented efficiently in hardware
- A further improvement could be a scanning coding scheme
- A second round of encoding with the scanning scheme could be equivalent to radix-16 modified Booth encoding