CCITT SG XV
Specialists Group on Coding for Visual Telephony

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Title : A Hybrid Coder with Equivalent Filters

1. Introduction

This paper deals with an improved hybrid coding scheme for encoding of video signals at very low bit rates, 64 kbit/s and 384 kbit/s. In a hybrid coder with movement compensating prediction (Fig. 1), bit rate reduction is done by degrading the coefficients of the block difference $x-\hat{x}(D)$. The various schemes which are under study at present, differ mainly in this degradation process. We introduce a technique which allows for a controlled filtering and quantizing of the displaced block difference. Filtering is often more adequate than a rough quantization of coefficients.

2. Filtering of Transform-Coefficients

In nearly all coding strategies, insignificant coefficients are deleted. As depicted in Fig. 2a, this process can be modelled by filtering using a filter H which operates in the coefficient domain: The filter operator $H[\cdot]$ multiplies every coefficient of the input block by a real number. As can be shown, an equivalent operator $h[\cdot]$ exists which can be applied in the spatial domain to a block of pels and which provides, after transformation, the same result:

$$H[U] = T\{h[u]\}$$

where u is the block in the spatial (pel) domain and U is the transformed block:

$$T\{u\} = U$$

In Fig. 2a the reconstructed block $\tilde{x}$ is computed: Obviously, $\tilde{x}$ is composed of $h[x]$, which is the input signal, degraded by filtering the transform coefficients, and n which is the quantizing noise, and $\hat{x}-h[\hat{x}]$ representing an additional distortion of the block.

Using the filter h in the reconstruction loop, as shown in Fig. 2b, this distortion can be compensated for, and the reconstructed block becomes

$$\tilde{x} = h[x] + n$$

Note that the ideal case is $x = \tilde{x}$, which can be obtained without filtering and quantizing ($h = 1$, $n = 0$). Obviously, using the structure in Fig. 2b, the degradations within each block can be shared between filtering effects (some sort of unsharpness) and quantizing distortions.

Our computer simulations show, that pure quantization of the block results in unacceptable artefacts. Moderate filtering of the block yields a "smother" picture.

3. Some Equivalent Filters H[·] and h[·]

Equivalent filters used in the simulation are given in the annex.

4. Equivalent Structures

Fig. 3 presents a hybrid coding scheme, which is equivalent to the coding scheme shown in Fig. 2b. As can be seen in Fig. 3, both filters h[·] operate in the spatial domain and are equal.

5. Computer Simulations

To demonstrate the performance of the filter concept, we have inserted the filters H and h into the reference model /1/, as shown in Fig. 2b. An improvement of picture quality for 384 kbit/s codecs can be demonstrated. As a consequence of the filter concept the buffer state is lower (annex).
Five different filters are used and they are signalled to the decoder using the block attributes reserved for classification in the reference model. No extra bits are required. Further improvements are possible.

Literature

/1/ Doc. 104, Expert Group on Coding for Visual Telephony, CCITT SG XV, April 1986

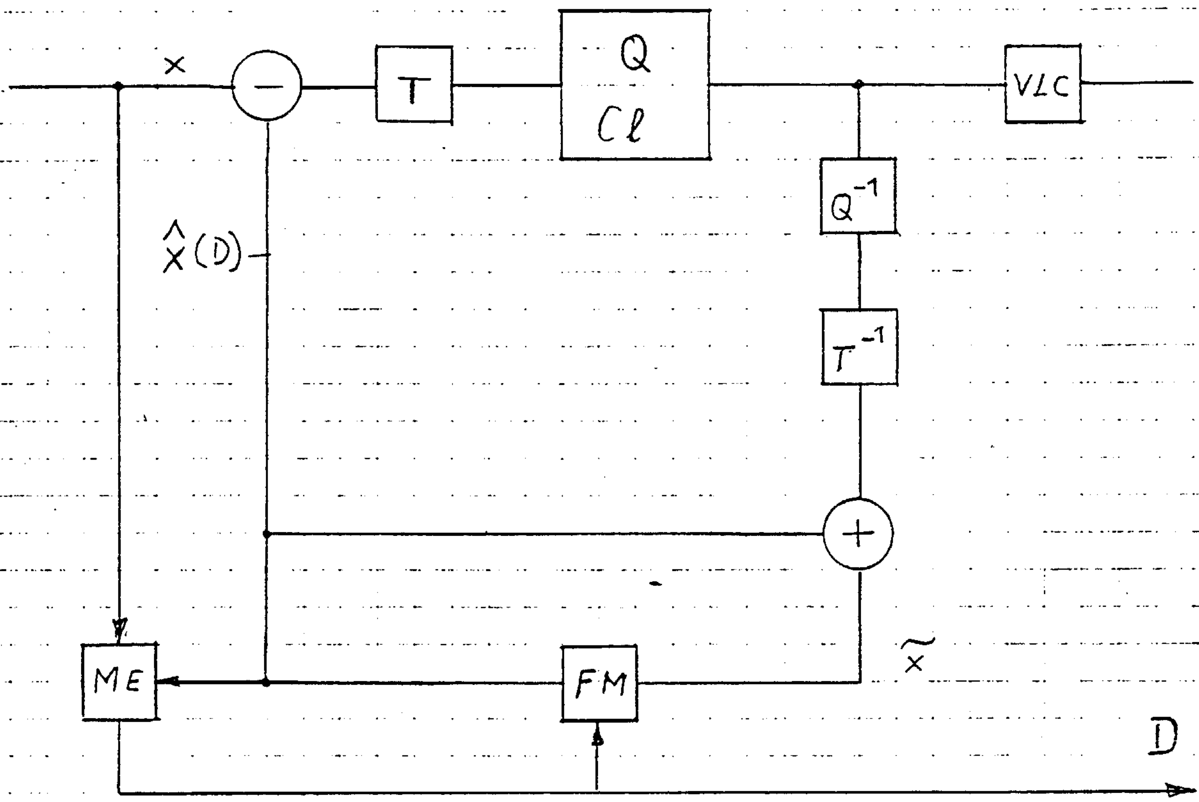

Fig. 1

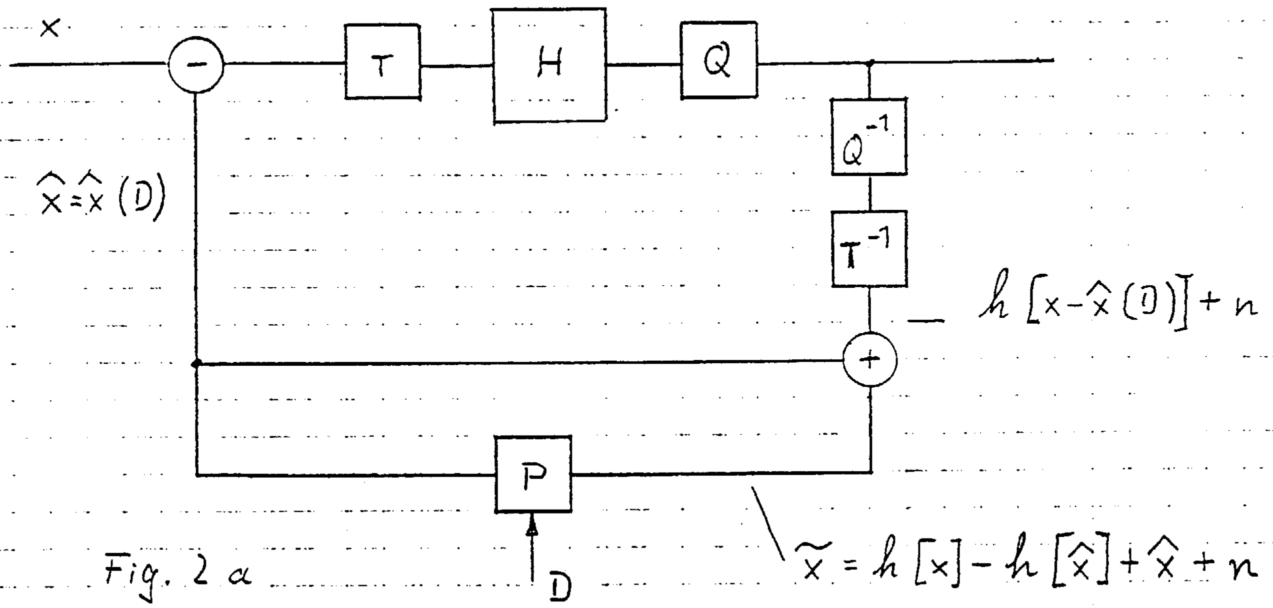
x
T
H
Q
Q^{-1}
T^{-1}
$\hat{x} = \hat{x}(D)$
$h[x - \hat{x}(D)] + n$
+
P
D
$\tilde{x} = h[x] - h[\hat{x}] + \hat{x} + n$

Fig. 2 a

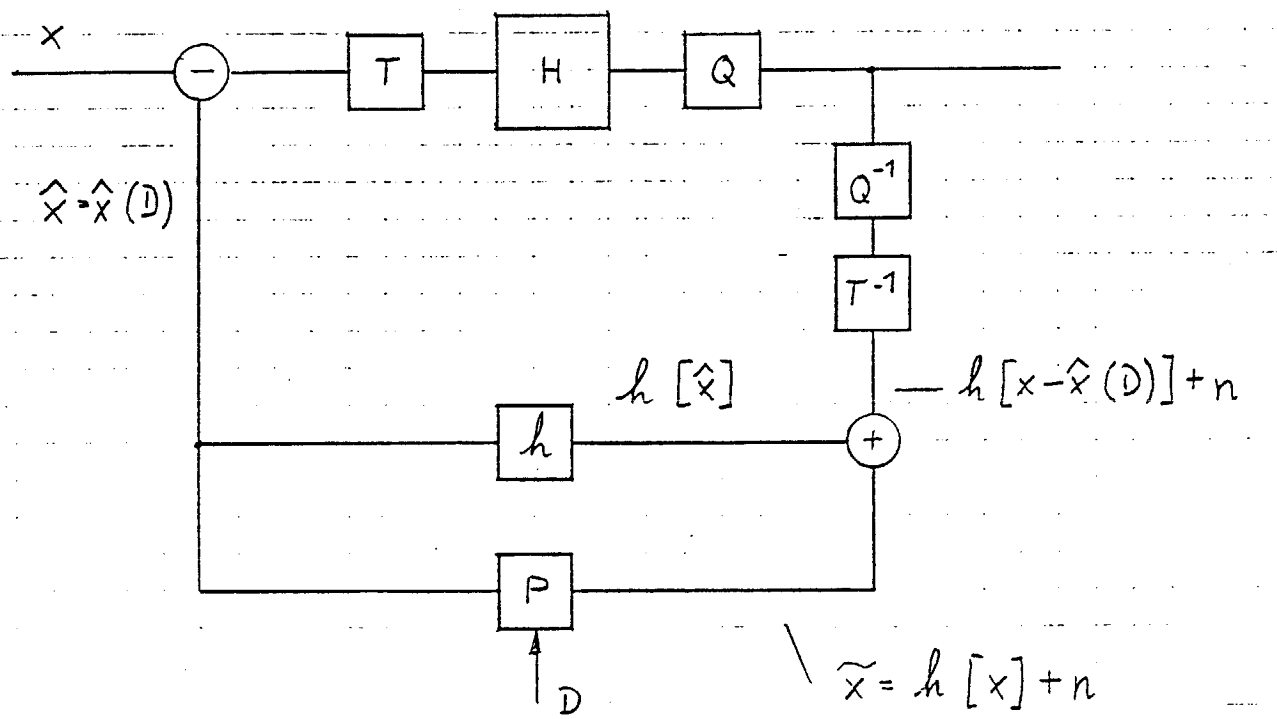
x
T
H
Q
Q^{-1}
T^{-1}
$\hat{x} = \hat{x}(D)$
$h[\hat{x}]$
$h[x - \hat{x}(D)] + n$
h
+
P
D
$\tilde{x} = h[x] + n$

Fig. 2 b

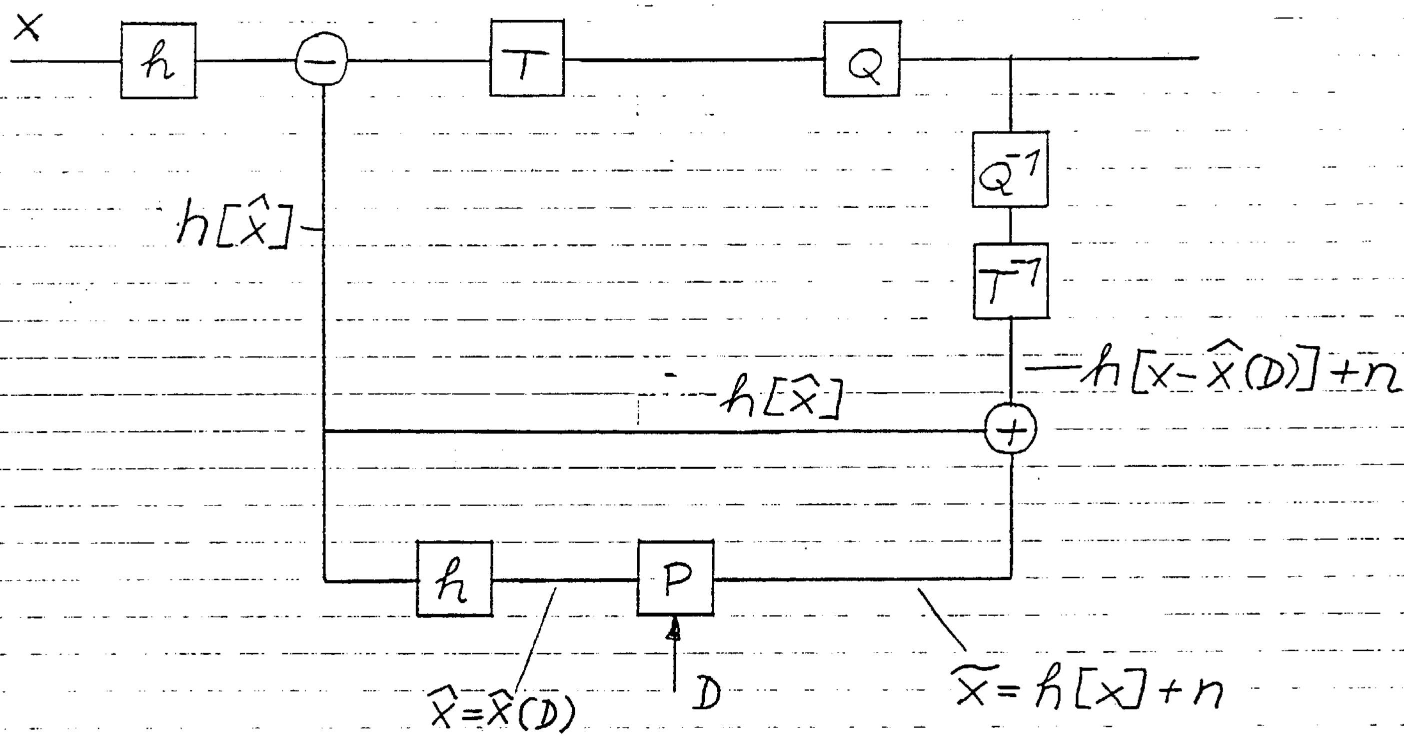

Fig. 3

Legende

X	input block
D	displacement vector
$\hat{X}$ (D)	predicted block
$\tilde{X}$	reconstructed block
n	distortion
T	transform
T^{-1}	inverse transform
Q	quantisation
Q^{-1}	reconstruction
Cl	classification
VLC	variable length coding
H [ ]	filter operator in coeff. domain
h [ ]	corresp. filter operator in spatial (pel) domain
FM	frame memory
ME	motion estimation
P	predictor

filters in the spatial and transform domain

Annex

filter-class		Spatial domain 1	2	3	4	5	6	7	8	Transform domain 1	2	3	4	5	6	7	8
1	1	100	0	0	0	0	0	0	0	100	100	100	100	100	100	100	100
	2	0	100	0	0	0	0	0	0	100	100	100	100	100	100	100	100
	3	0	0	100	0	0	0	0	0	100	100	100	100	100	100	100	100
	4	0	0	0	100	0	0	0	0	100	100	100	100	100	100	100	100
	5	0	0	0	0	100	0	0	0	100	100	100	100	100	100	100	100
	6	0	0	0	0	0	100	0	0	100	100	100	100	100	100	100	100
	7	0	0	0	0	0	0	100	0	100	100	100	100	100	100	100	100
	8	0	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100
2	1	93	6	1	0	0	0	0	0	100	99	95	90	85	82	80	80
	2	6	88	5	1	0	0	0	0	99	97	93	88	84	81	79	79
	3	1	5	88	5	1	0	0	0	95	93	89	85	80	77	76	76
	4	0	1	5	88	5	1	0	0	90	88	85	80	76	73	72	72
	5	0	0	1	5	88	5	1	0	85	84	80	76	72	70	68	68
	6	0	0	0	1	5	88	5	1	82	81	77	73	70	67	66	66
	7	0	0	0	0	1	5	88	6	80	79	76	72	68	66	65	64
	8	0	0	0	0	0	1	6	93	80	79	76	72	68	66	64	64
3	1	85	12	2	0	0	0	0	0	100	97	89	79	70	64	61	60
	2	12	75	10	2	0	0	0	0	97	94	86	77	68	62	59	58
	3	2	10	75	10	2	0	0	0	89	86	79	71	62	57	54	54
	4	0	2	10	75	10	2	0	0	79	77	71	63	55	50	48	48
	5	0	0	2	10	75	10	2	0	70	68	62	55	49	45	43	42
	6	0	0	0	2	10	75	10	2	64	62	57	50	45	41	39	38
	7	0	0	0	0	2	10	75	12	61	59	54	48	43	39	37	37
	8	0	0	0	0	0	2	12	85	60	58	54	48	42	39	37	36
4	1	78	19	4	0	0	0	0	0	100	96	84	69	55	46	41	40
	2	19	63	15	4	0	0	0	0	96	91	80	66	53	44	39	38
	3	4	15	63	15	4	0	0	0	84	80	70	57	46	38	35	34
	4	0	4	15	63	15	4	0	0	69	66	57	47	38	31	28	29
	5	0	0	4	15	63	15	4	0	55	53	46	38	30	25	23	22
	6	0	0	0	4	15	63	15	4	46	44	38	31	25	21	19	18
	7	0	0	0	0	4	15	63	19	41	39	35	28	23	19	17	17
	8	0	0	0	0	0	4	19	78	40	38	34	28	22	18	17	16
5	1	70	25	5	0	0	0	0	0	100	94	78	58	40	28	22	20
	2	25	50	20	5	0	0	0	0	94	88	74	55	38	26	20	19
	3	5	20	50	20	5	0	0	0	78	74	61	46	31	22	17	16
	4	0	5	20	50	20	5	0	0	58	55	46	34	23	16	13	12
	5	0	0	5	20	50	20	5	0	40	38	31	23	16	11	9	8
	6	0	0	0	5	20	50	20	5	28	26	22	16	11	8	6	6
	7	0	0	0	0	5	20	50	25	22	20	17	13	9	6	5	4
	8	0	0	0	0	0	5	25	70	20	19	16	12	8	6	4	4
6	1	63	31	6	0	0	0	0	0	100	93	73	48	25	10	2	0
	2	31	38	25	6	0	0	0	0	93	86	67	44	23	9	2	0
	3	6	25	38	25	6	0	0	0	73	67	53	35	18	7	2	0
	4	0	6	25	38	25	6	0	0	48	44	35	23	12	5	1	0
	5	0	0	6	25	38	25	6	0	25	23	18	12	6	2	1	0
	6	0	0	0	6	25	38	25	6	10	9	7	5	2	1	0	0
	7	0	0	0	0	6	25	38	31	2	2	2	1	1	0	0	0
	8	0	0	0	0	0	6	31	63	0	0	0	0	0	0	0	0

Annex

Buffer - states
split screen / Trevor White