On the Study of Shot Segmentation in Compressed Domain

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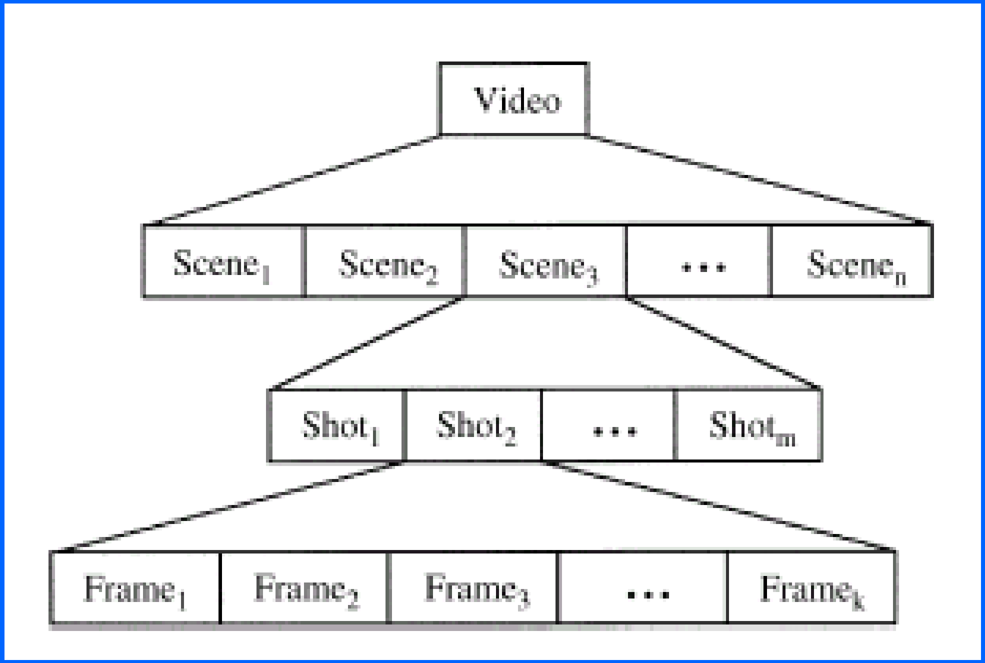
Outline

1. overview of the video shot detection
   - spatial domain algorithms
   - compressed domain algorithms
2. the proposed method
   - object-based shot detection in compression domain.
3. results
4. conclusions

Shot detection problem

The hierarchical structure of a video:

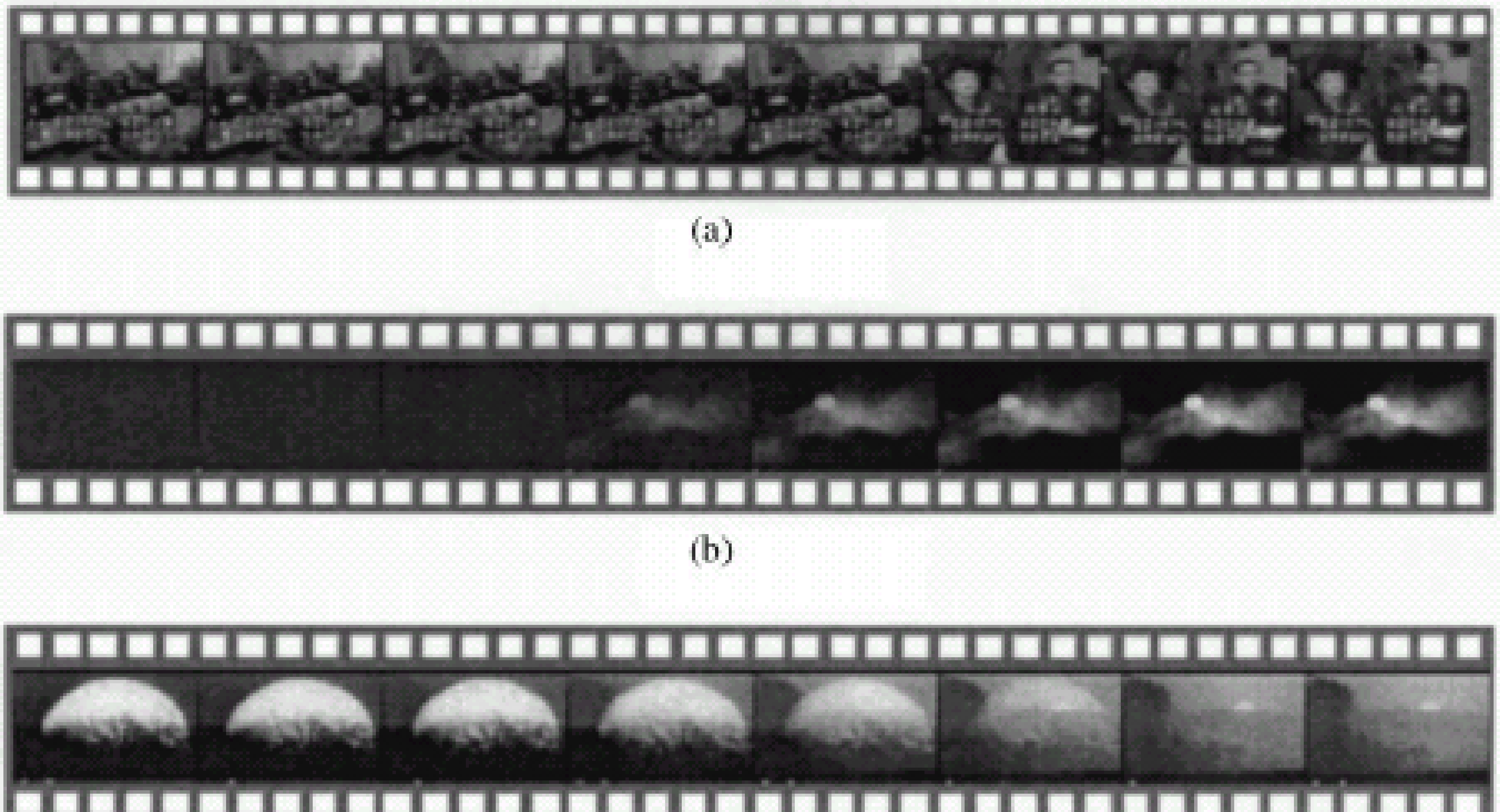
1. video
2. scene
3. shot
4. frame



Why shot detection?

1. indexing : shot classification
2. browsing : library
3. retrieval : key-frame
4. multimedia application

Three kinds of shots: Cut, Fade, Dissolve



(a)

(b)

(c)

Methods of shot detection

Spatial domain algorithms

1. color histogram :

   global histograms , regional histograms

2. edge change:

   contrast of object boundaries

   number of edge points

3. motion :

   optical flow

Compressed domain

1. DCT values:

DC value , DCT vector

2. motion vectors :

motion vector, inter/intra

color

Compare the color difference:

color distances in RGB domain

1. pixel by pixel
2. dominant colors or gray levels
3. dominant object : color-based correlation

Color histogram difference

$$CHD_i = \frac{1}{N} \sum_{r=0}^{2^B-1} \sum_{g=0}^{2^B-1} \sum_{b=0}^{2^B-1} \left| p_i(r,g,b) - p_{i-1}(r,g,b) \right|$$

if $CHD_i \leq T_{th}$ **no transition**

else $CHD_i > T_{th}$ **the shot boundary detected**

problem:

It is ineffective for the fade and dissolve

Edge-based

Edge change ratio (ECR)

$$ECR_n = \max\left(X_n^{in} / \sigma_n , X_{n-1}^{out} / \sigma_{n-1} \right)$$

σ_n : the number of edge pixels in frame n

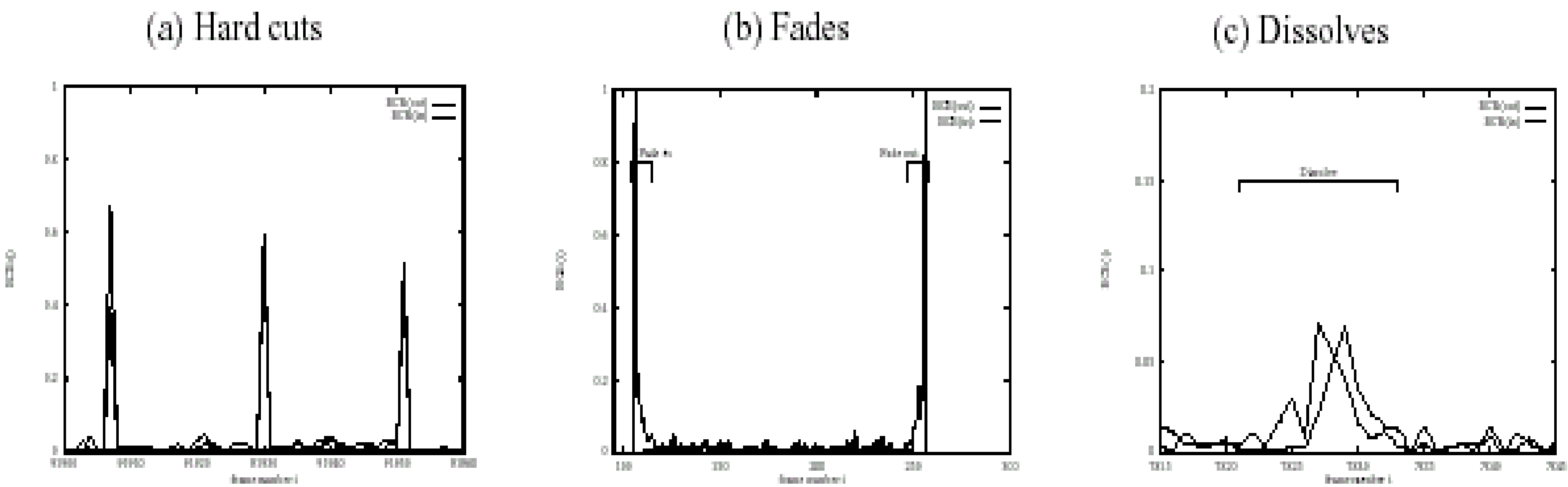


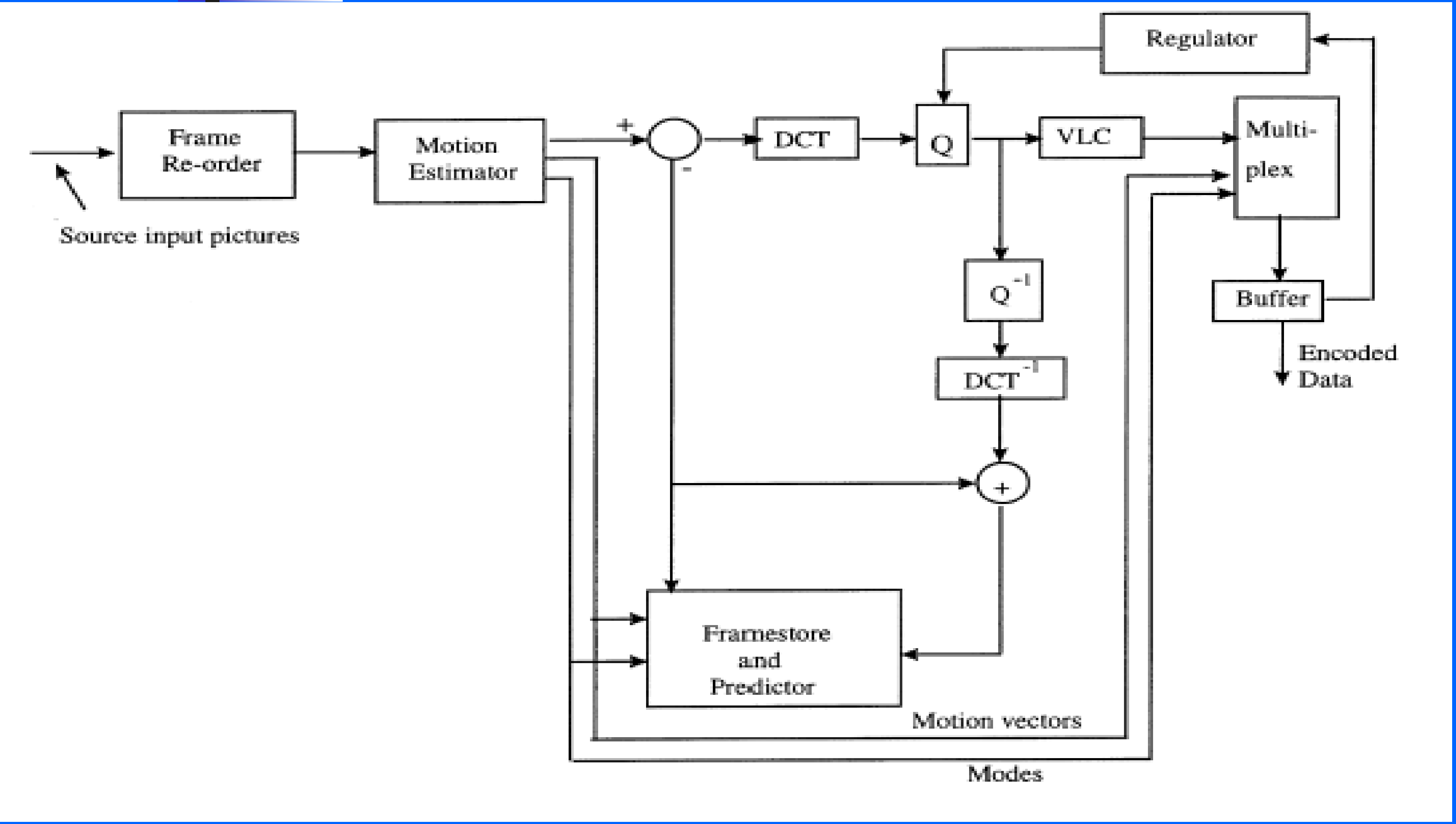
Figure 1: Typical *ECR* patterns for hard cuts, fades and dissolves

The comparison in the spatial domain algorithms:

1. The most reliable method for cut detection is the color histogram. On contrary, the edge-based algorithm is more effective for the fade and dissolve.
2. Both methods suffice from the computation complexity.
3. The performance of Edge-based methods is greatly influenced by the global motion or large object motion.
4. Results of state-of –the-art algorithms:

   cut: ~ 95%   gradual transition: ~ 70%

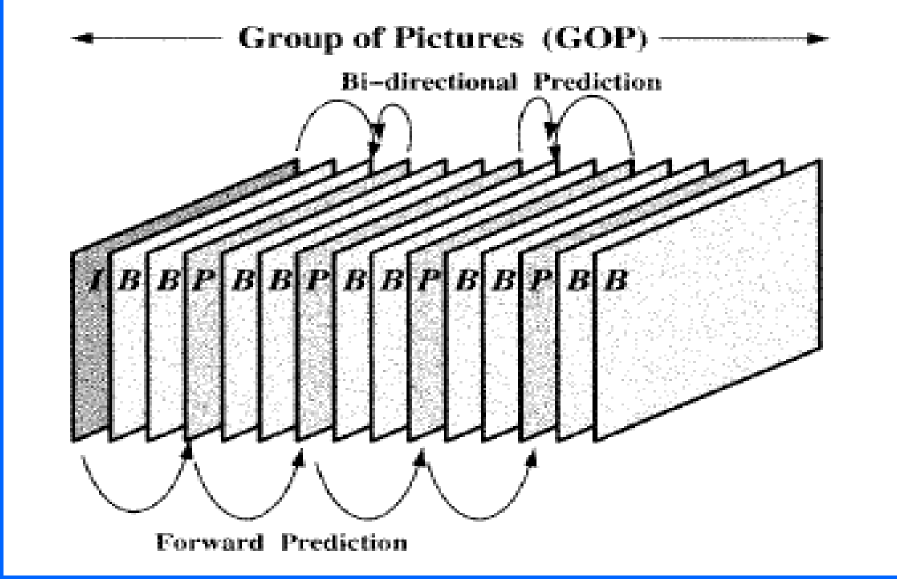
MPEG Algorithms



GOP

I frame:
  DCT coefficients

P frame:
  motion vectors
  residual values



B frame:
  forward and backward prediction
  vectors
  residual values

Compressed domain algorithms

1. DCT coefficients in the I frame:

    dc value comparison.

    the comparison of DCT vector which is constructed by 16 DCT coefficients.

2. Motion vectors in B frame:

    correlation of two frames is evaluated by the statistics of # of prediction forward or backward vector

$$(N_{forw}, N_{back}) < T$$

3. Motion-prediction statistic

$$\frac{1}{\min\left(\frac{(N_{forw}+N_{bidir})}{N_{total}},\frac{(N_{back}+N_{bidir})}{N_{total}}\right)}$$

only use for B frame

4. Intra/Inter 比例法

$$N_{intra} / N_{inter} > T$$

only use for P frame

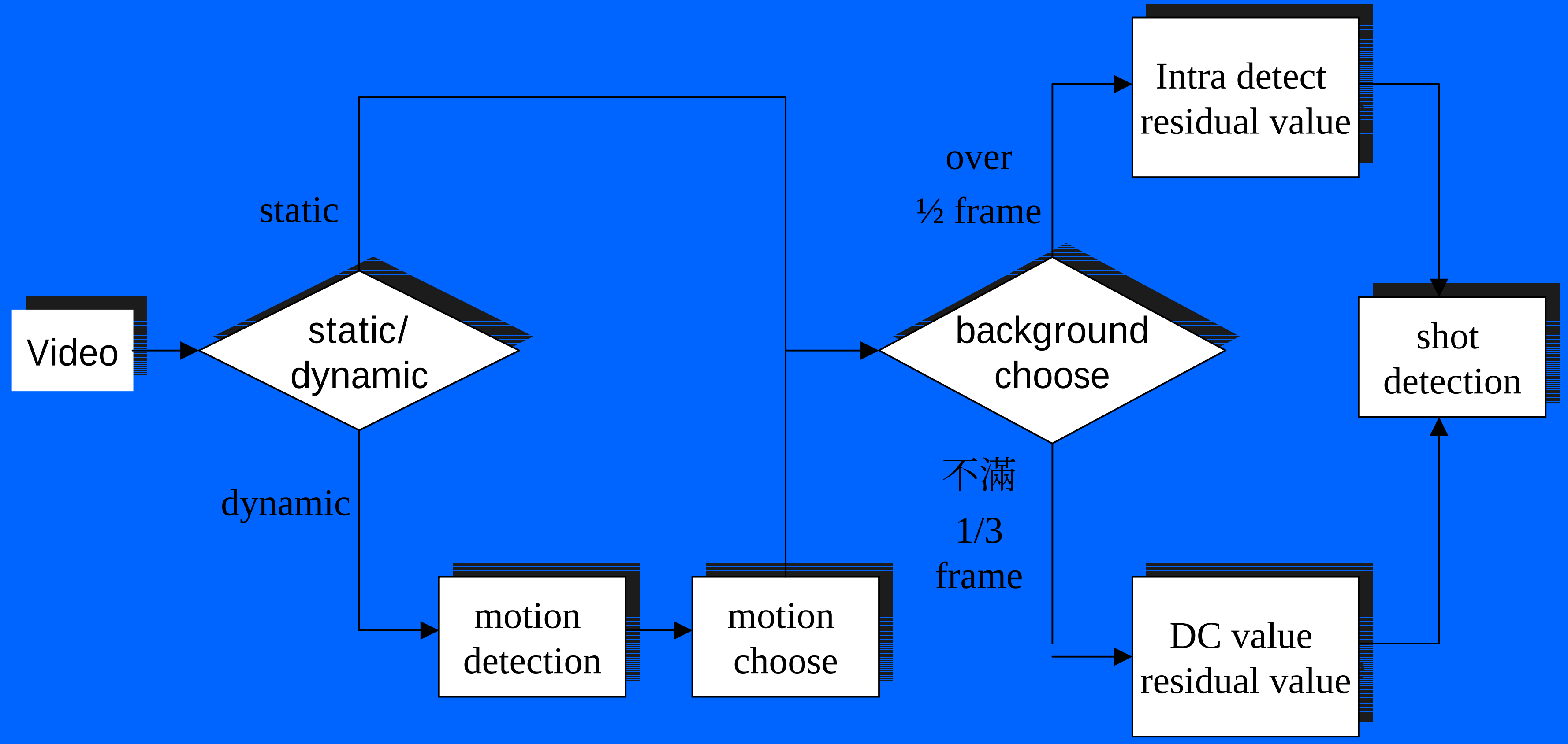
The comparison in the compression domain algorithms:

1. DCT coefficients are still very effective for the detection of hard cut.. However, one can't access the DCT coefficients in P and B frame.
2. Motion vectors are very unreliable for the detection of shot detection.
3. Too small amount of data in the compressed domain for the shot detection, especially in the detection of gradual transition.

Solution: **Partially restore the spatial information.**

dc coefficients of each block.

System I


Video
static/
dynamic
static
dynamic
motion
detection
motion
choose
background
choose
over
½ frame
不滿
1/3
frame
Intra detect
residual value
DC value
residual value
shot
detection

Background choose

Motion value: Camera motion , Object motion

Frame size 176*144 (QCIF)

Sample interval 30 frames

Sample range 1/2~1/3 block number

1. static/dynamic detection
2. motion detection
3. motion choose
   B: background motion
   F: foreground motion
   f : unstable motion

B	B	B	B	B	B
B	f	f	f	f	B
B	f	F	F	f	B
B	f	f	F	f	B
B	B	f	f	f	B
B	B	B	B	B	B

Block number

1. over 1/2 block number

   Intra block detection

   residual value choose

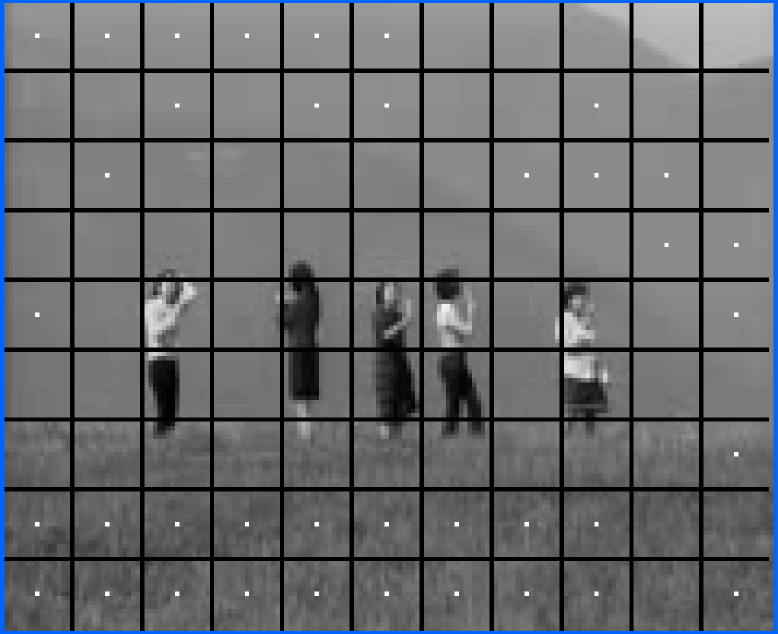
2. under 1/3 block number

   unstable motion

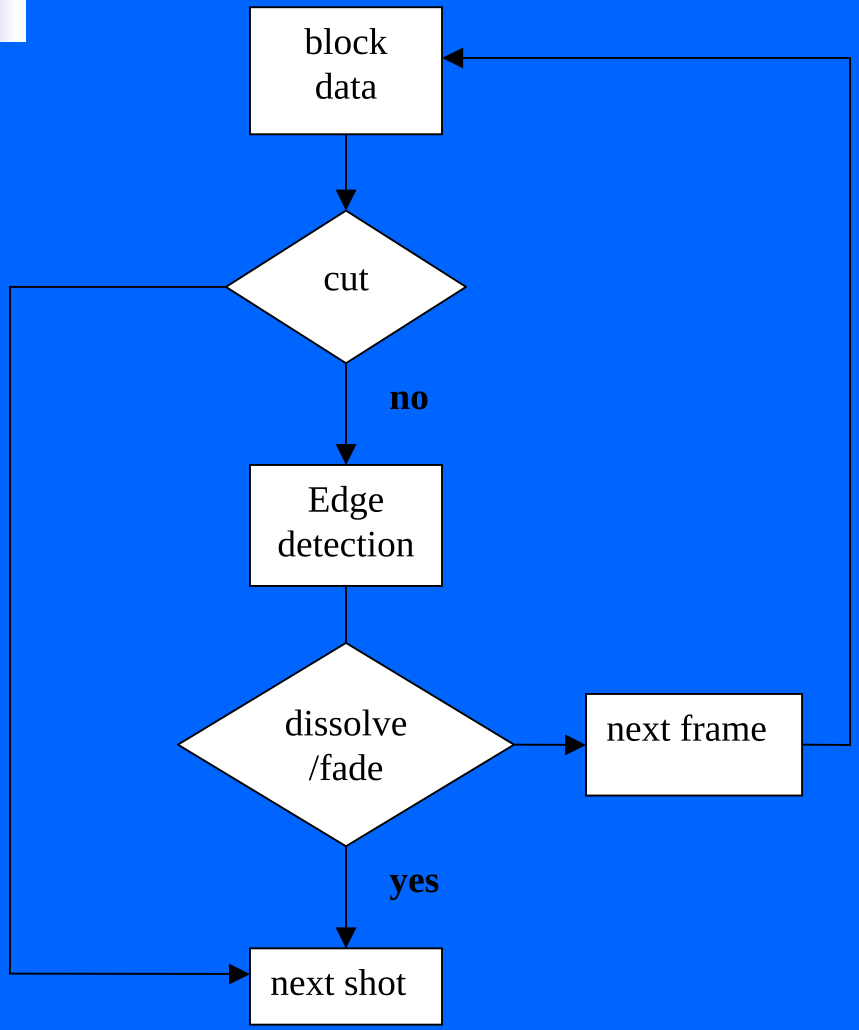
   residual value choose

   Intra block detection

Results of background block selection



Shot detection



1. cut detection:

based on the number of intra-block for the selected background..

2. Fade and dissolve detection:

based on the curve of average gradient value for the selected background along time axis:

Fade: a consecutive number of frame with zero value.

Dissolve: a concave hyperbolic curve along time axis.

Sobel mask

Z_1	Z_2	Z_3
Z_4	Z_5	Z_6
Z_7	Z_8	Z_9

-1	-2	-1
0	0	0
1	2	1

G_x

-1	0	1
-2	0	2
-1	0	1

G_y

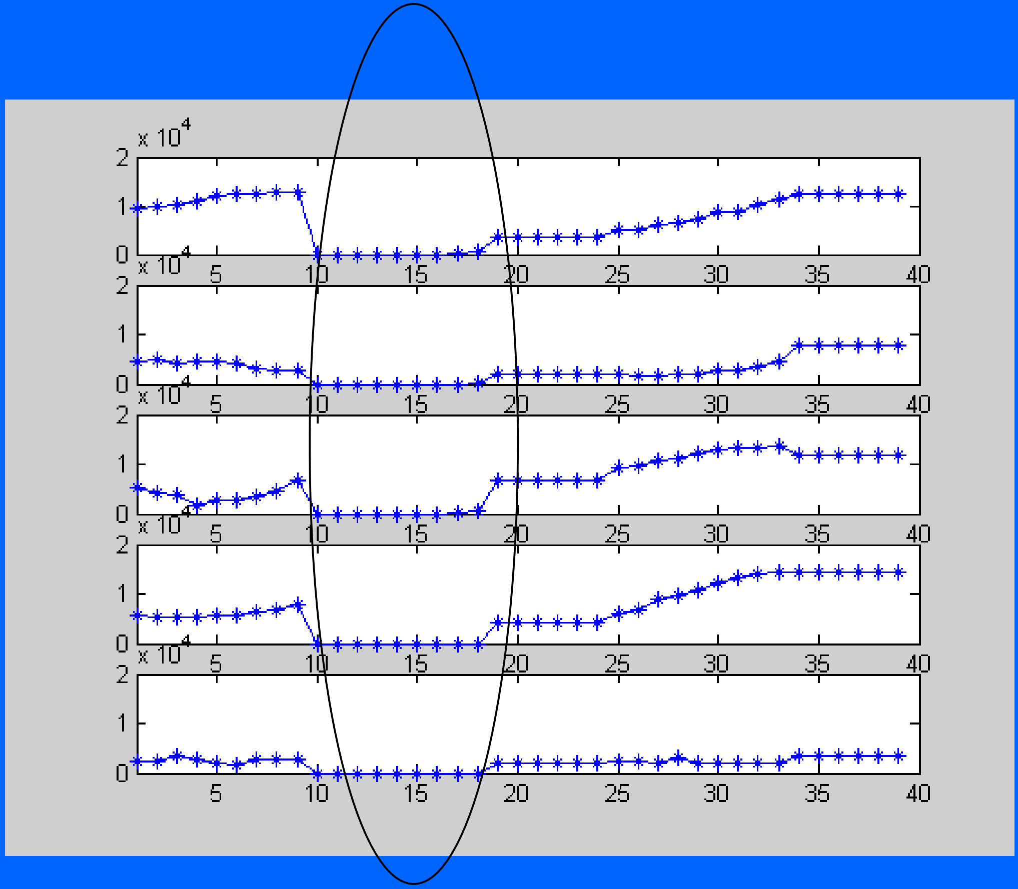
$$G_x = (Z_7 + 2Z_8 + Z_9) - (Z_1 + 2Z_2 + Z_3)$$

$$G_y = (Z_3 + 2Z_6 + Z_9) - (Z_1 + 2Z_4 + Z_9)$$

$$Gradient \quad value = |G_x| + |G_y|$$

Average gradient for Fade

We can detected it by **a=0**



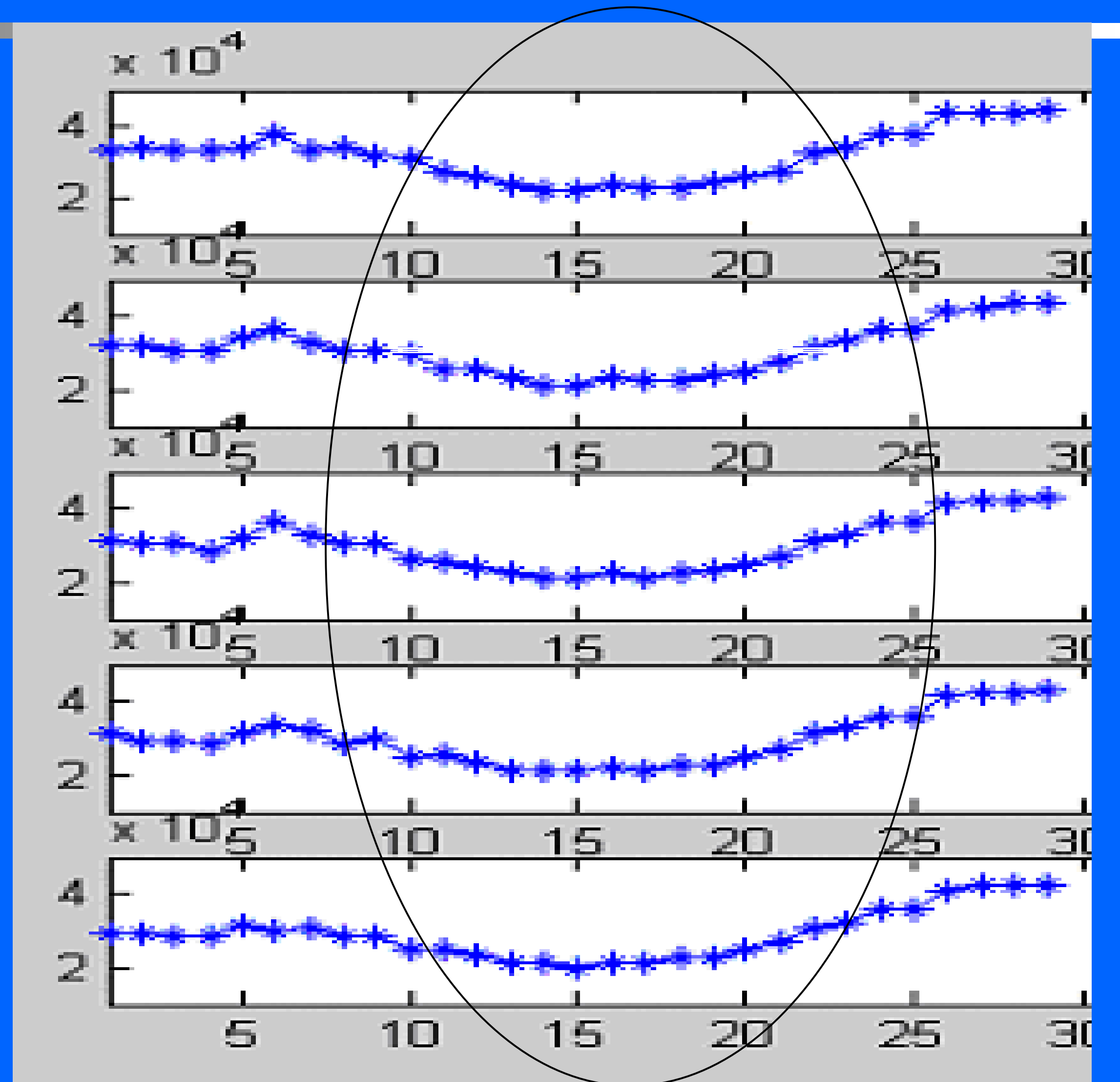
$\nabla I = y = ax^2 + bx + c$

Average gradient for Dissolve

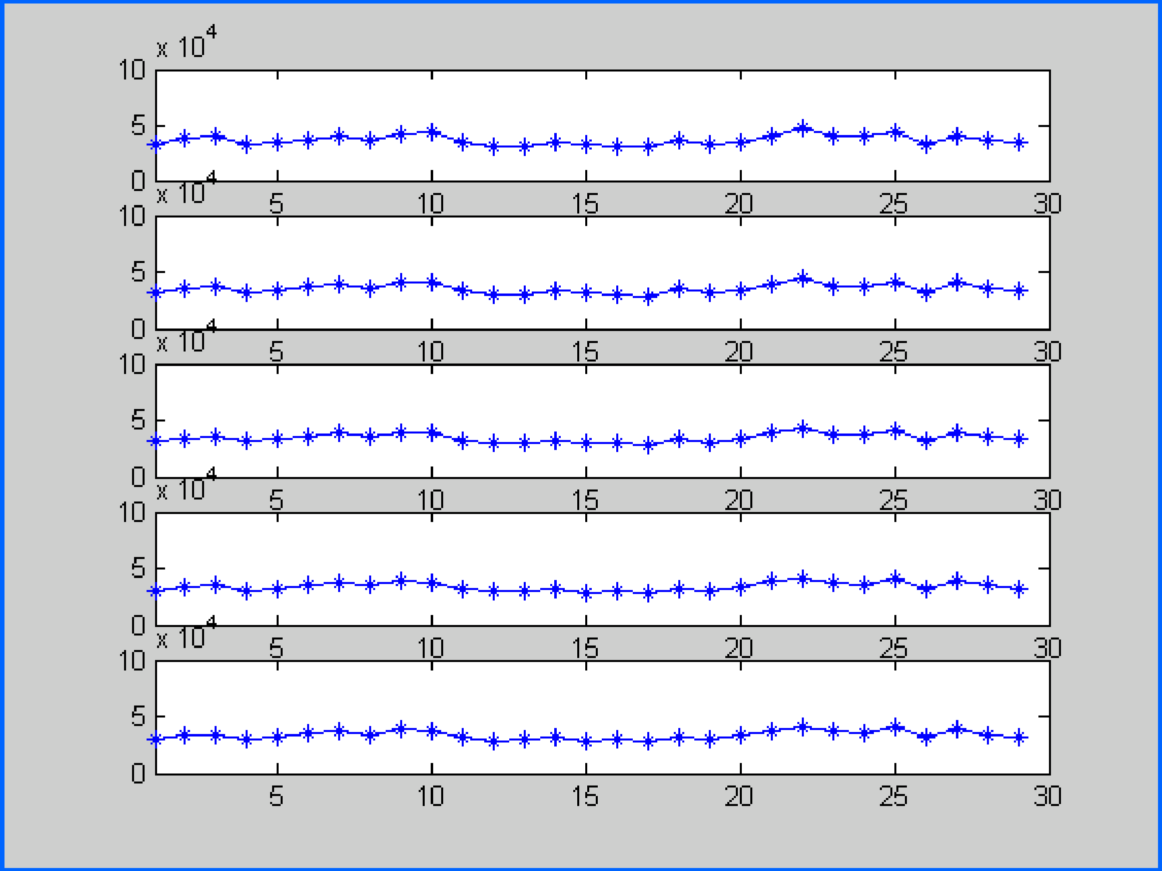
$$\nabla I = y = ax^2 + bx + c$$

$$\nabla I = y = a(x + b')^2 + c'$$

we can detected it by a > 0



Average gradient within a same shot



experimental results

$$Rcall = \frac{Detects}{Detects + Miss} \qquad Rrecision = \frac{Detects}{Detects + False}$$

video	Recall (cut)	Precision (cut)	Recall (fade)	Precision (fade)	Recall (dissolve)	Precision (dissolve)
Test data	93.3% (28/30)	96.6% (28/29)	95.6% (22/23)	100% (23/23)	83.3% (25/30)	80.6% (25/32)
A Few Good Man	92.9% (78/84)	94.0% (78/83)	88.9% (8/9)	72.7% (8/11)	82.3% (14/17)	70% (14/20)
average	93.0%	95.5%	93.75%	91.1%	83.0%	75%

Comparison with compressed domain algorithms

Algorithm A: Use dc coefficient to evaluate the frame different proposed by : B. L. Yeo and B. Liu, "A Unified Approach to Temporal Segmentation of Motion JPEG and MPEG Compressed Video "

Algorithm B: Use dc coefficient histogram to evaluate the frame different proposed by : K. Shen and E. J. Delp, "A Fast Algorithms for Video Parsing Using MPEG Compresssed Sequences"

	Recall (cut)	Precision (cut)	Recall (dissolve)	Precision (dissolve)
Algorithm_A	82.4%	81.2%	32%	26%
Algorithm_B	85.6%	43.2%	16.7%	29.4%
Proposed method	93.1%	97.1%	83.0%	75%

Some problems of the proposed method

1. Illumination problem:

   Nonuniform illumination will cause the large difference in the DC and gradient value

2. Fast motion:

   We have the problem to select the background block when the large motion occurs such as zooming or panning.

3. The similar background:

   When the consecutive shots has the similar background, then the proposed method has the difficulty to detect the shot boundary.