Digital Image Stabilization

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Outline

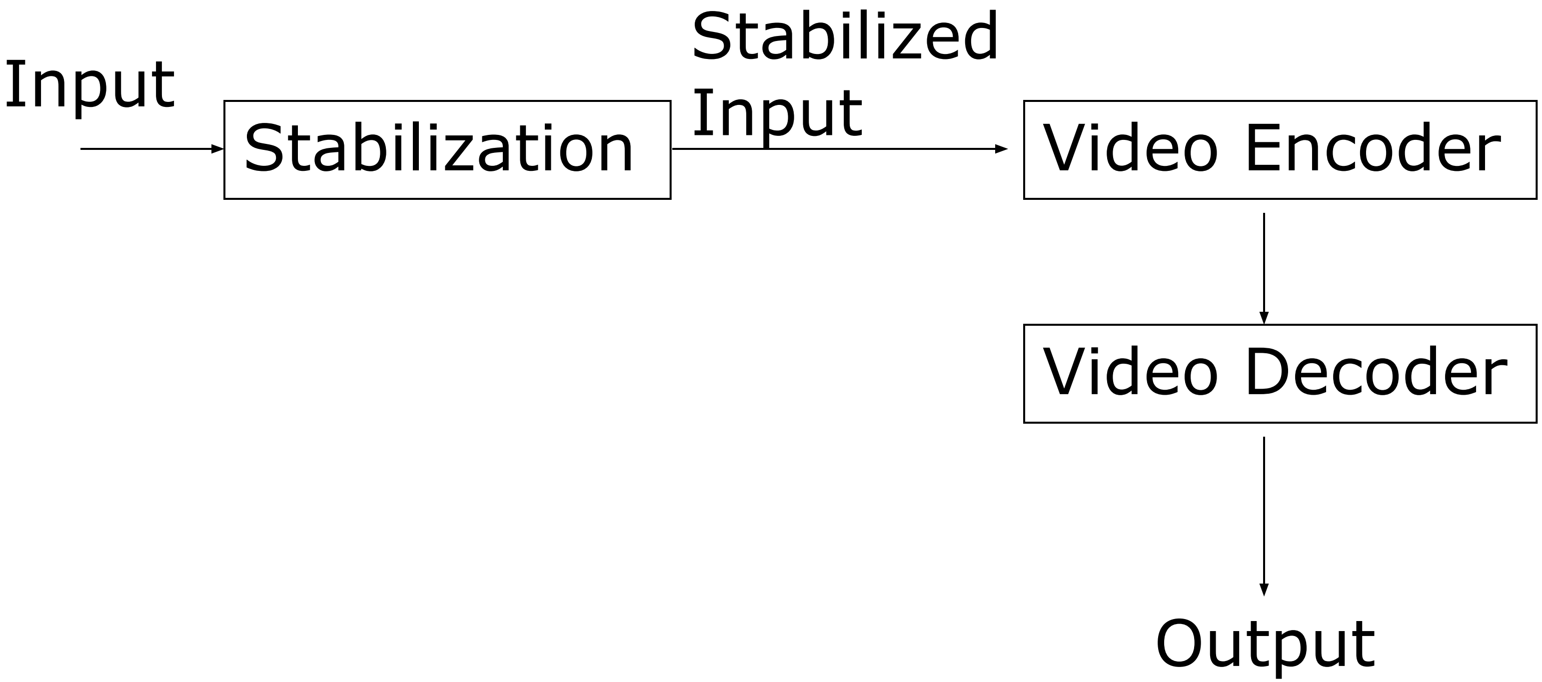
- Introduction
- Basic architecture of DIS
- MVI method for DIS
- Future work

Introduction

- An image stabilization system manages to remove unwanted movement form an image sequence
- Previous image stabilization system
  - accelerometers, gyros, mechanical dampers , angular velocity sensors…………..
- We prefer to use DIS

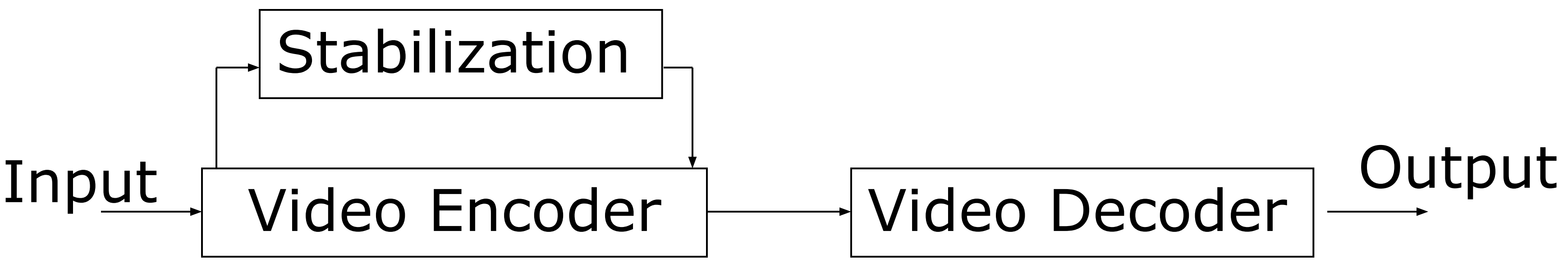
Basic architecture of DIS

- Pre-processing



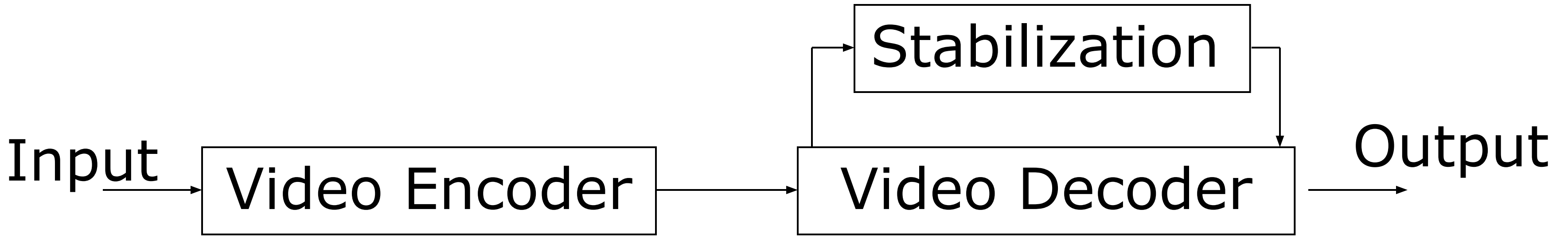
Basic architecture of DIS

- stabilization-aided encoder



Basic architecture of DIS

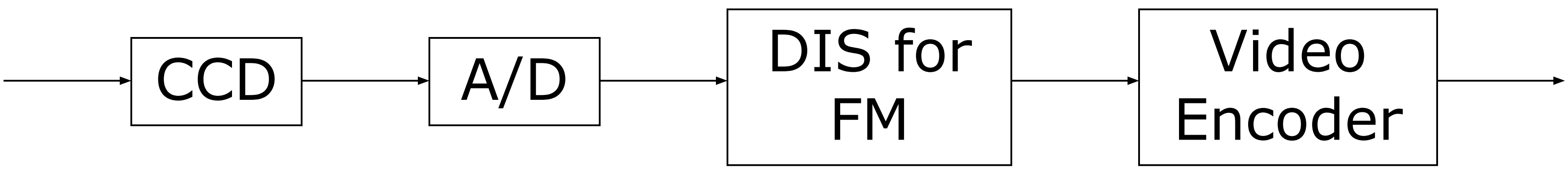
- stabilization-aided decoder



MVI Method for DIS

- MVI : Motion Vector Integration
- Basic idea :
  - Using some propose method to find reliable local motion vector(LMV)
  - Calculate the global motion vector(GMV) form LMV.
  - Integrating the previous frame GMV and current frame GMV to calculate AMV.
  - Using AMV to compensate current frame to be stabilized frame.
- Reference paper [1-4]

New Algorithm and Architecture of Digital Image stabilization System

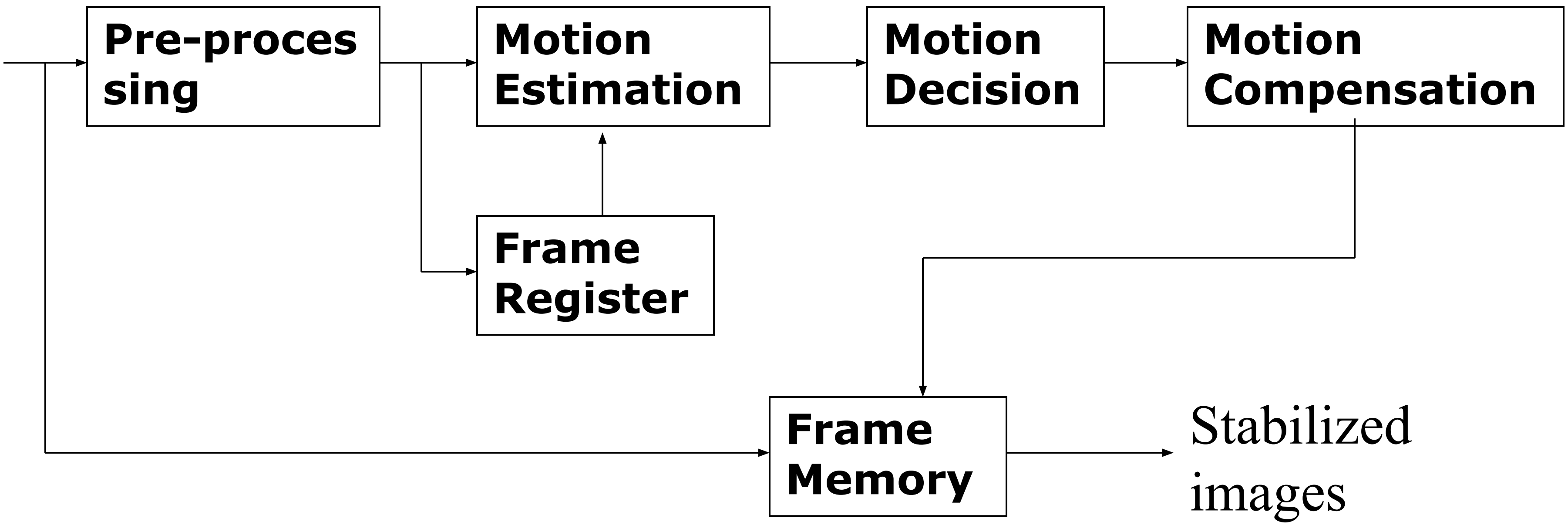


Block diagram of a digital video camera with DIS system.

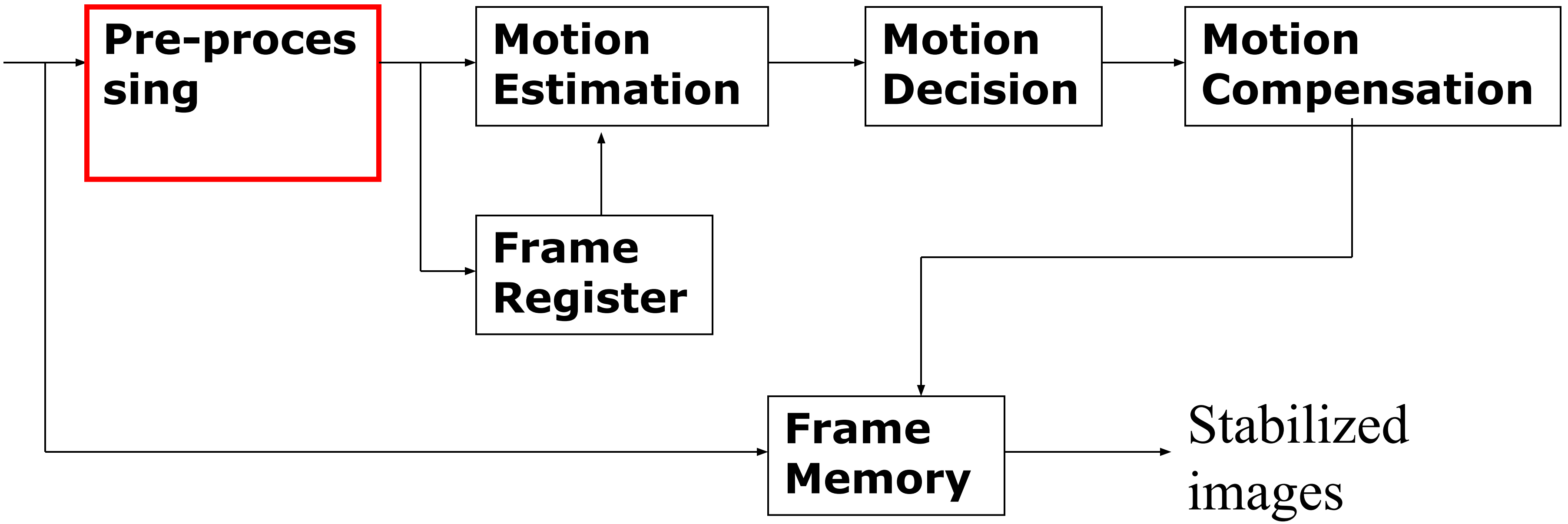
New Algorithm and Architecture of Digital Image stabilization System

- Lack of features
- Existence of moving objects
- Intentional panning
- Existence of repeated patterns
- Intentional zooming
- Low signal-to-noise ratio
- Large movement out of the searching range of block matching
- Complicated Motion (e.g. rotatory motion)

A general structure of DIS system with frame memory



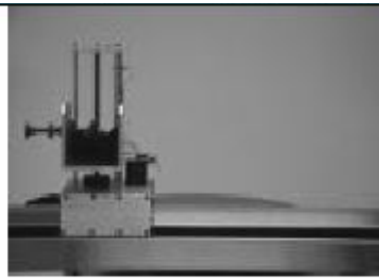
Pre-Processing



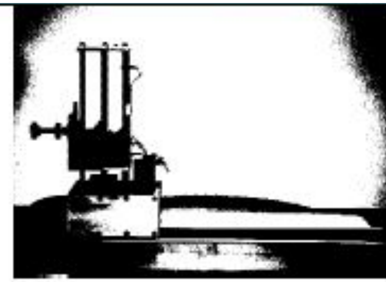
Pre-Processing

- **Block Matching over Bit-Planes**

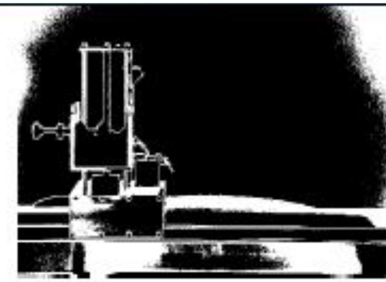
$$f(x,y) = a_{K-1}(x,y)2^{K-1} + a_{K-2}(x,y)2^{K-2} + \ldots\ldots + a_1(x,y)2 + a_0(x,y)$$



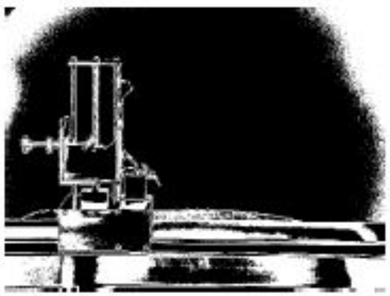
Original image



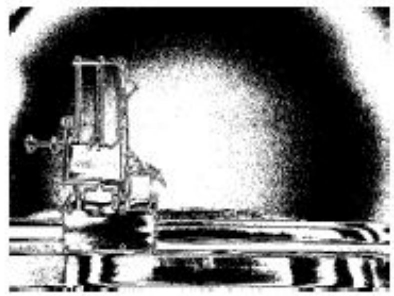
bit-plane 7



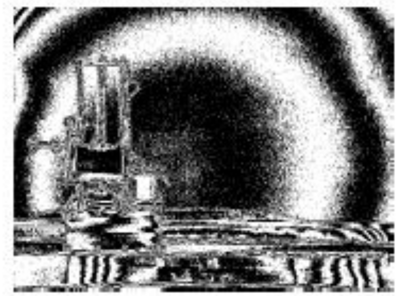
bit-plane 6



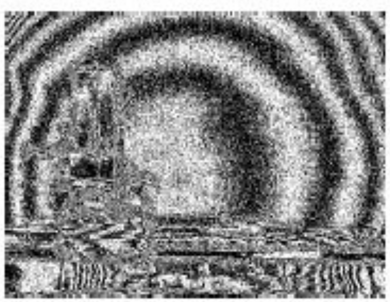
bit-plane 5



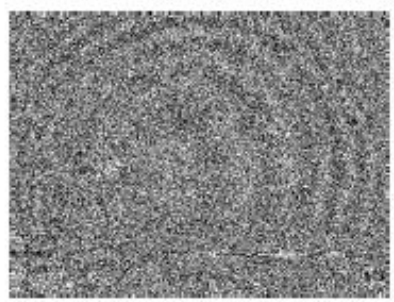
bit-plane 4



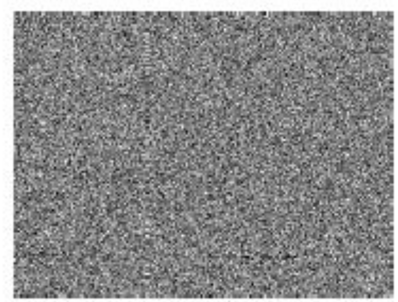
bit-plane 3



bit-plane 2



bit-plane 1



bit-plane 0

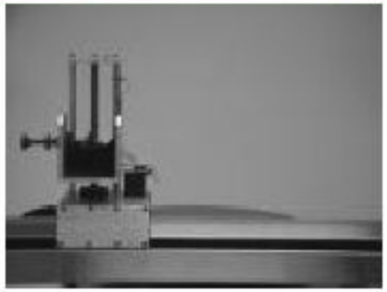
Pre-Processing

- **Block Matching over Gray-Code**

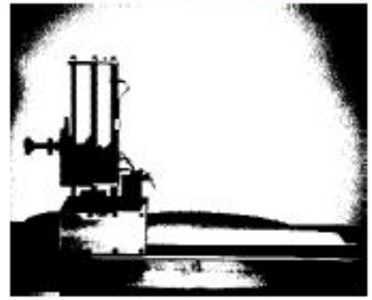
$$f(x,y) = a_{K-1}(x,y)2^{K-1} + a_{K-2}(x,y)2^{K-2} + \ldots\ldots + a_1(x,y)2 + a_0(x,y)$$

$$g_i(x,y) = a_i(x,y) \oplus a_{i+1}(x,y), \quad 0 \leq \text{i} \leq \text{K-1}$$

$$g_{K-1}(x,y) = a_{K-1}(x,y).$$



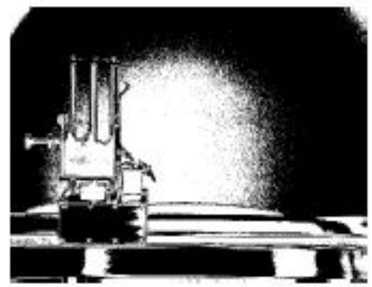
original image



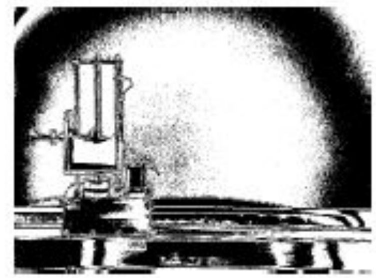
gray-code plane 7

gray-code plane 6

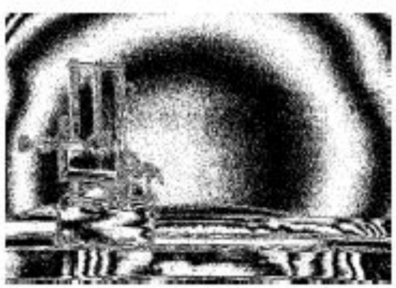
gray-code plane 5



gray-code plane 4

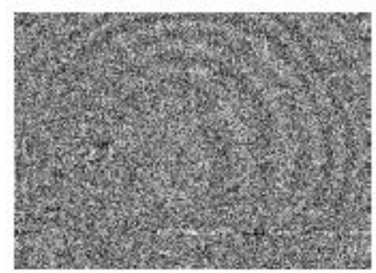


gray-code plane 3



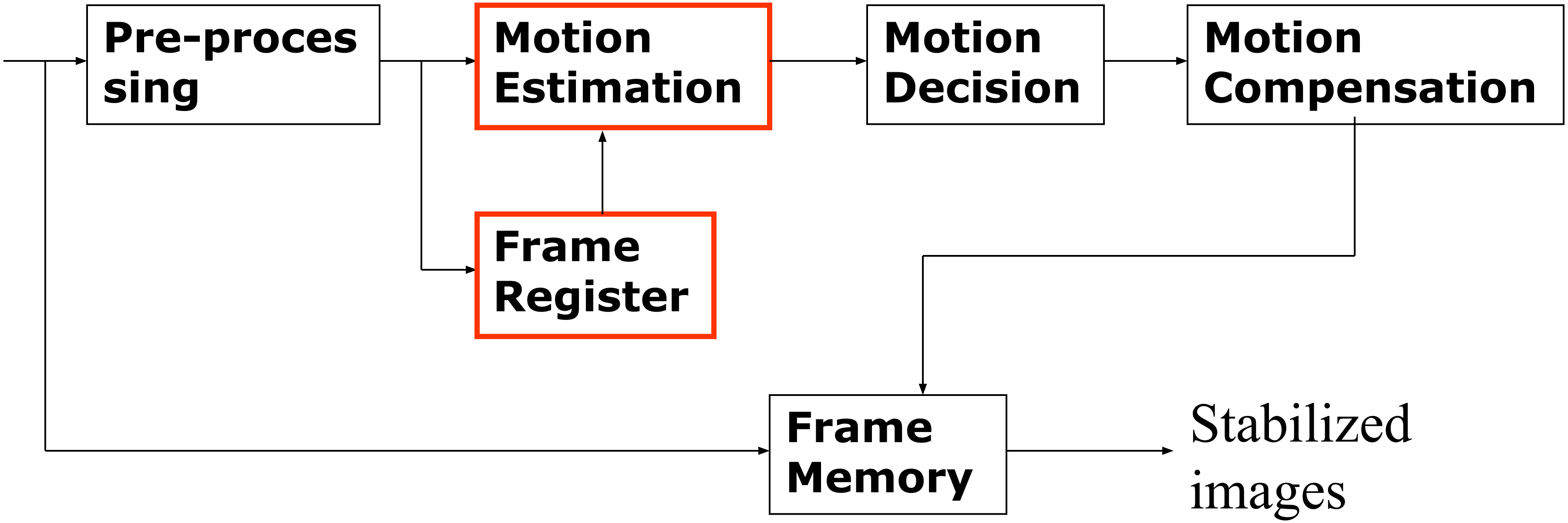
gray-code plane 2

gray-code plane 1

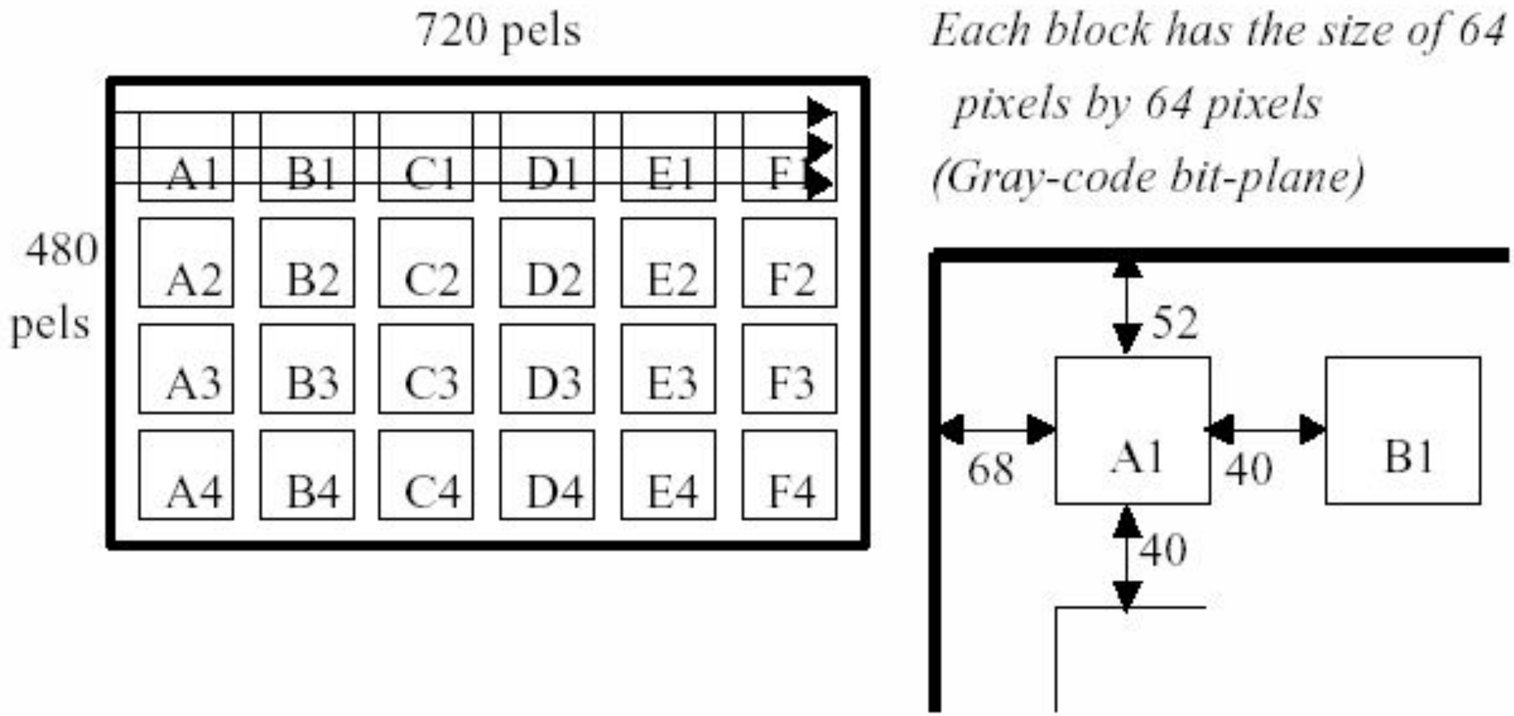


gray-code plane 0

Motion Estimation



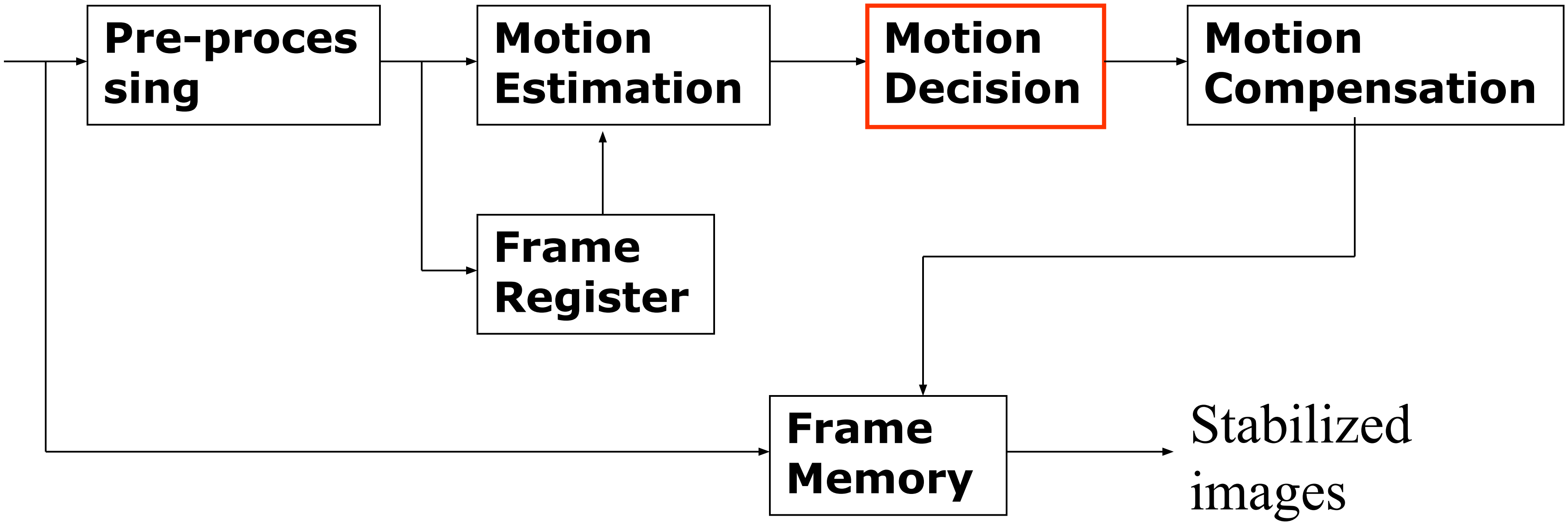
Motion Estimation



Motion Estimation

$$c(m,n) = \frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} g_k^t(x,y) \oplus g_k^{t-1}(x+m, y+n)$$

Motion Decision



Motion Decision
(Lack-of-Feature Condition)

$$R_t(p,q) = \sum_{r=1}^{N} \left| I_g(t-1, x_r, y_r) - I_g(t, x_{r+p}, y_{r+q}) \right|$$

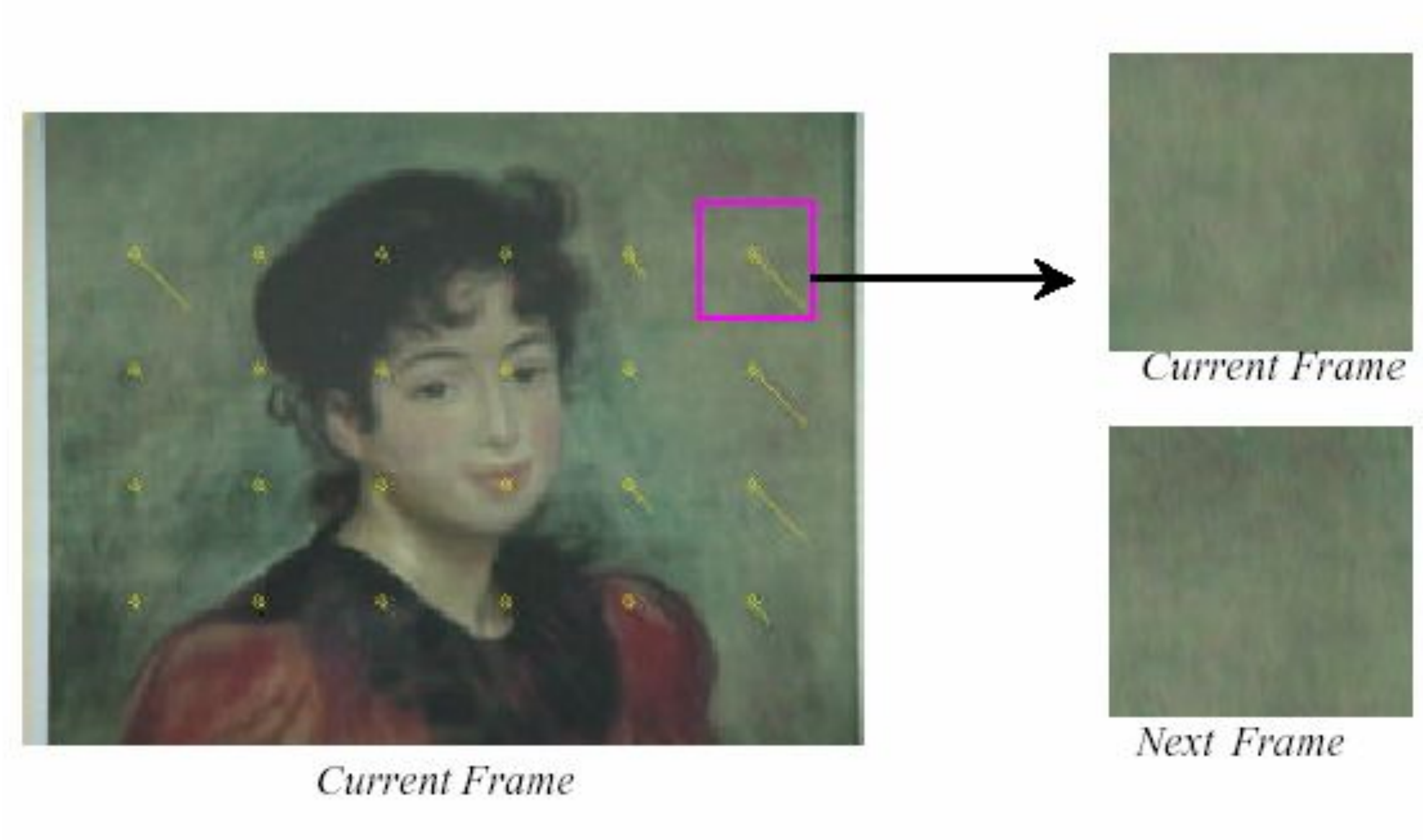
$$\boxed{R_{iave} - R_{i\min} < C_{lack\_of\_feature}}$$

R_{iave} : *the average of correlation values,* $R_{iave} = \frac{1}{mn}\sum_{p=1}^{m}\sum_{q=1}^{n} R_t(p,q)$, *where p,q are in the searching range.*

$R_{i\min}$: *the minimum of correlation values,* $R_{i\min} = \frac{1}{mn}\min_{p,q} R_t(p,q)$, *where p,q are in the searching range.*

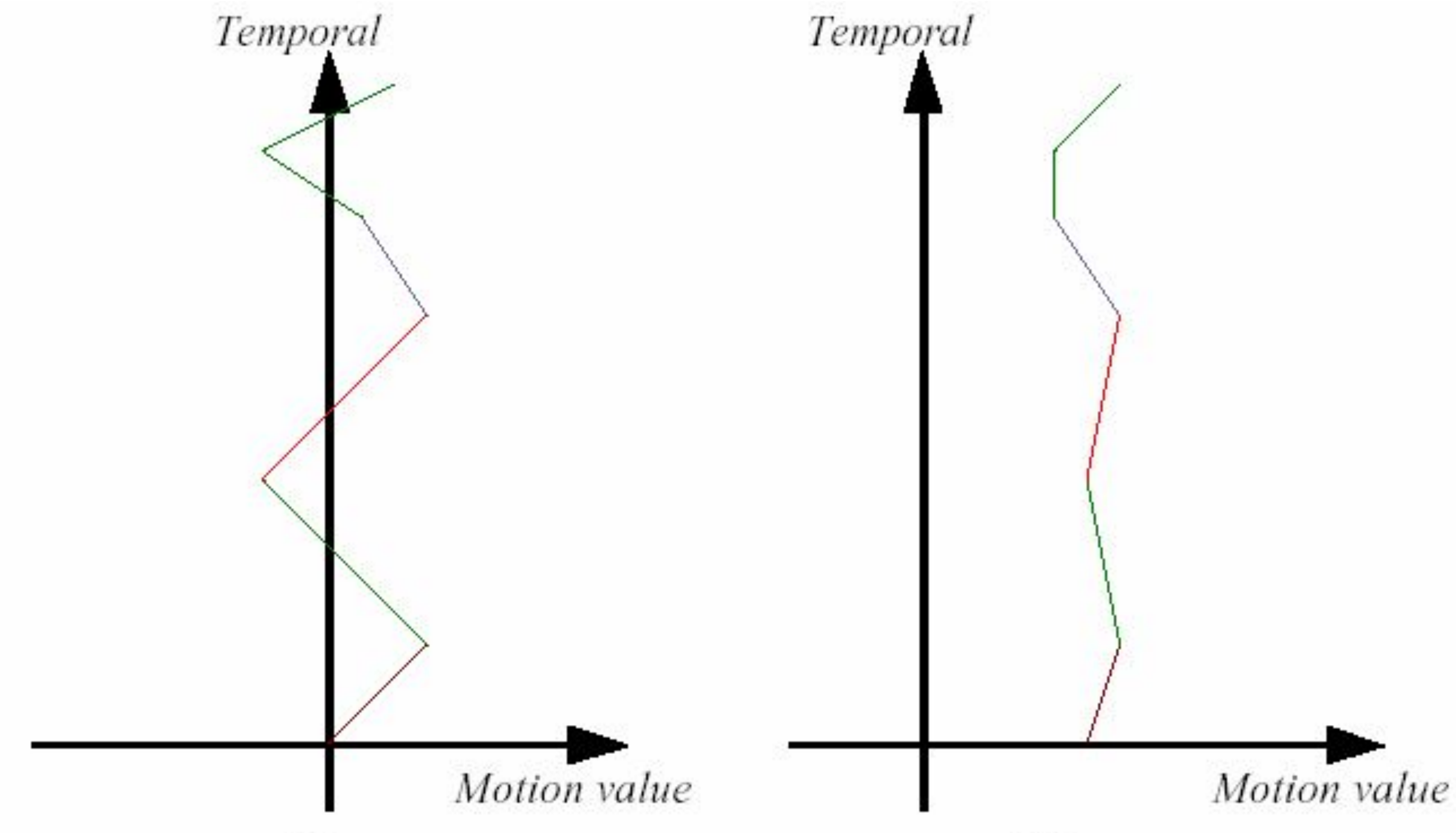
$C_{lack\_of\_feature}$: *the threshold to judge lack_of_feature.*

Motion Decision (Lack-of-Feature Condition)



Motion Decision
(Lack-of-Feature Condition)

Motion Decision
(Existence of Moving Objects)



Random-like motion

temporally correlated motion

Motion Decision (Existence of Moving Objects)

$$|MV(t_1)-MV(t_2)|+|MV(t_2)-MV(t_3)|+\ldots\ldots+|MV(t_{N-1})-MV(t_N)|\equiv T_1$$

$$\frac{1}{N}\sum_{i=1}^{N} MV(t_i)\equiv T_2$$

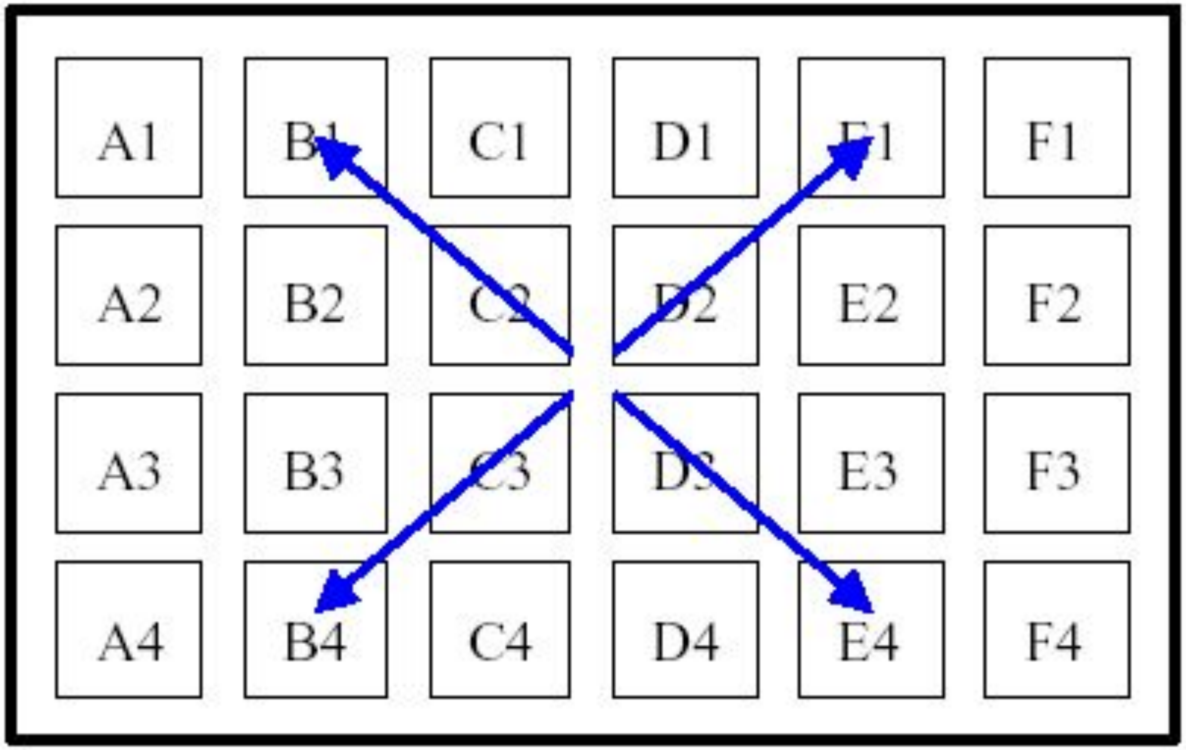
If ***T1/T2 < K1*** *and* ***T2*** $\geq$ ***K2*** *then temporally correlated motion*

else random-like motion

Motion Decision (Intentional Panning Condition)

- If 80% of the VALID_LMV are detected as temporally correlated motion, we consider that the camera is under a panning condition and no motion compensation is needed Otherwise, we assume that these temporally correlated motion vectors are caused by some moving objects in the image.

Motion Decision
(Optical Zooming Condition)



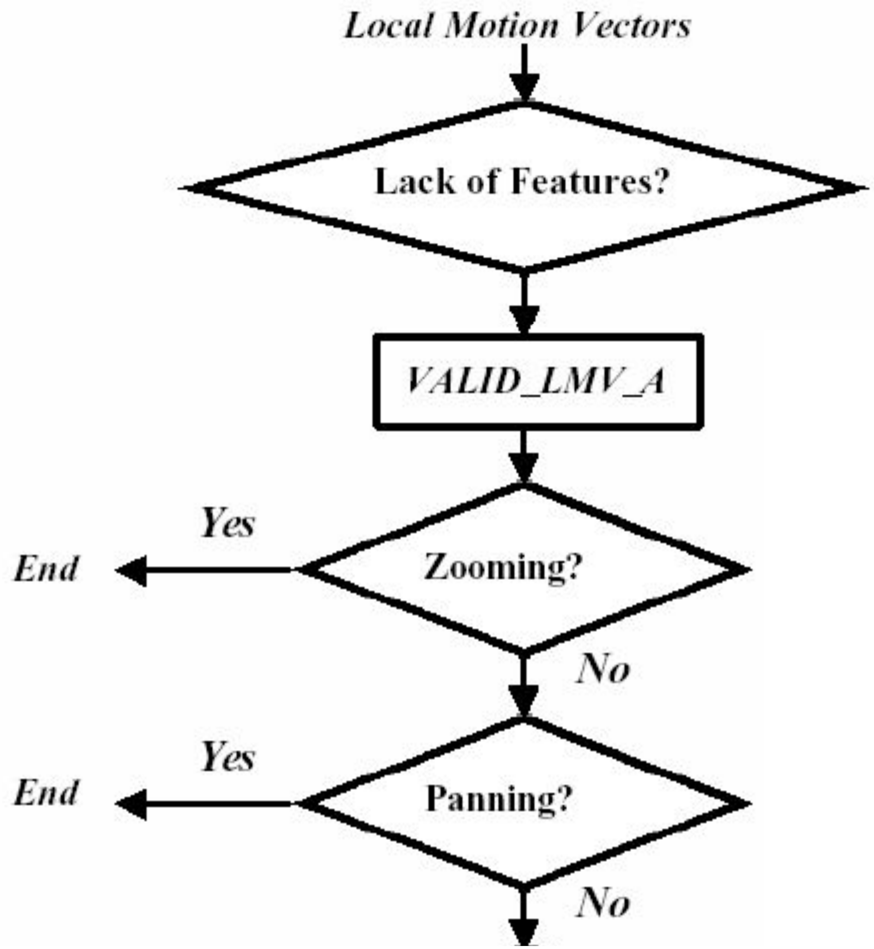
Motion Decision
(Spatial Noise Checking of Noise Level)

$$\mu = \left(\sum_{n=1}^{N} LMVn\right) / N$$

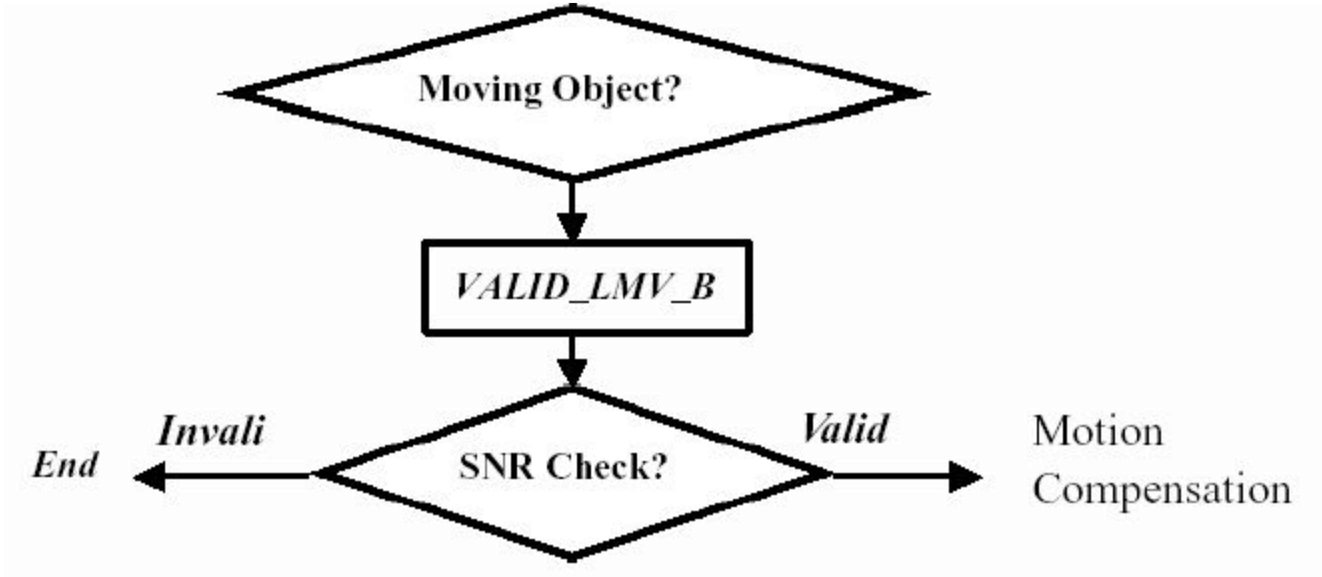
$$\sigma^2 = \left[\sum_{n=1}^{N} (LMVn - \mu)^2\right] / N$$

$If\ \ \sigma^2 > k1\ or\ N < k2$ ***Invalid*** *Otherwise* ***Valid***

Procedure of Motion Decision



Procedure of Motion Decision



Motion Compensation

- Frame Motion Vector (FMV)

$$(\hat{u}_x, \hat{u}_y) = FMV = \frac{1}{N}\sum_{t=1}^{N} LMV_t$$

- Accumulated Motion Vector (AMV)

$$AMV[t] = a \times AMV[t-1] + FMV[t]$$

- Motion Compensation

$$\begin{cases} \overline{X}_{t+1} = X_t + u_x \\ \overline{Y}_{t+1} = Y_t + u_y \end{cases}$$

Simulation Result

Future work

- Understanding mpeg4 framework in order to write my propose method program in it.
- stabilization-aided encoder