Low Complexity Global Motion Estimation Techniques for Image Stabilization

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Outline of Presentation

- Introduction
- The Sign Projection (SP) method
- The Binary Incrementation (BI) method
- Experiments and results
- References
- Conclusions

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Introduction (1)

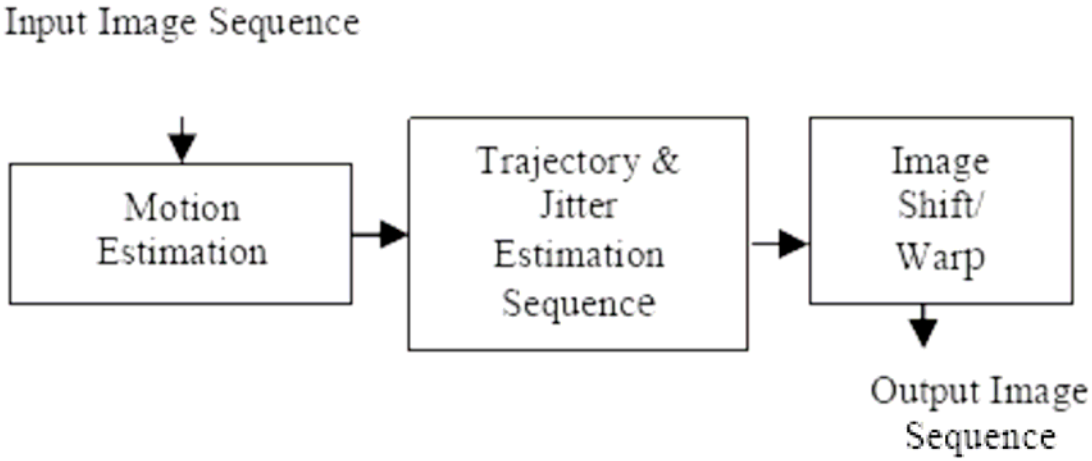

Figure 1. Block diagram of a typical image stabilization algorithm [1].

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Introduction (2)

- Optical Image stabilization
  - Best performance
  - Expensive solution
- Electronic Image Stabilization
  - Use of extra hardware such us gyroscopic sensors.
  - There are no moving parts and the power dissipation is low
  - Still an expensive solution
- Digital Image Stabilization
  - Do not need extra hardware and the power dissipation is very low
  - Only digital image methods are used

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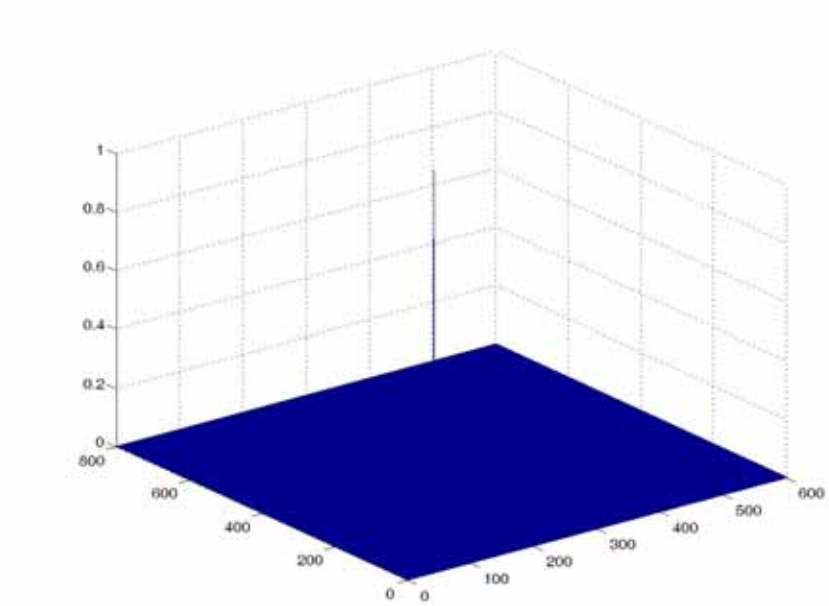
Introduction (3)

- The most popular technique is the block matching algorithm
  - Image frames are divided in non-overlapping rectangular blocks
  - The best match to the current block of pixels is searched within a certain search area in the previous frame
- The full search algorithm (FS) search all locations
  - Optimal solution
  - Very expensive solution

Introduction (4)

- An alternative to FS is the phase correlation (PC) method
  - Is based on the phase shift theorem and an IFFT is applied to the phase shift. The translation motion in the image pair is found from the delta function offset
  - It is an expensive, but robust solution



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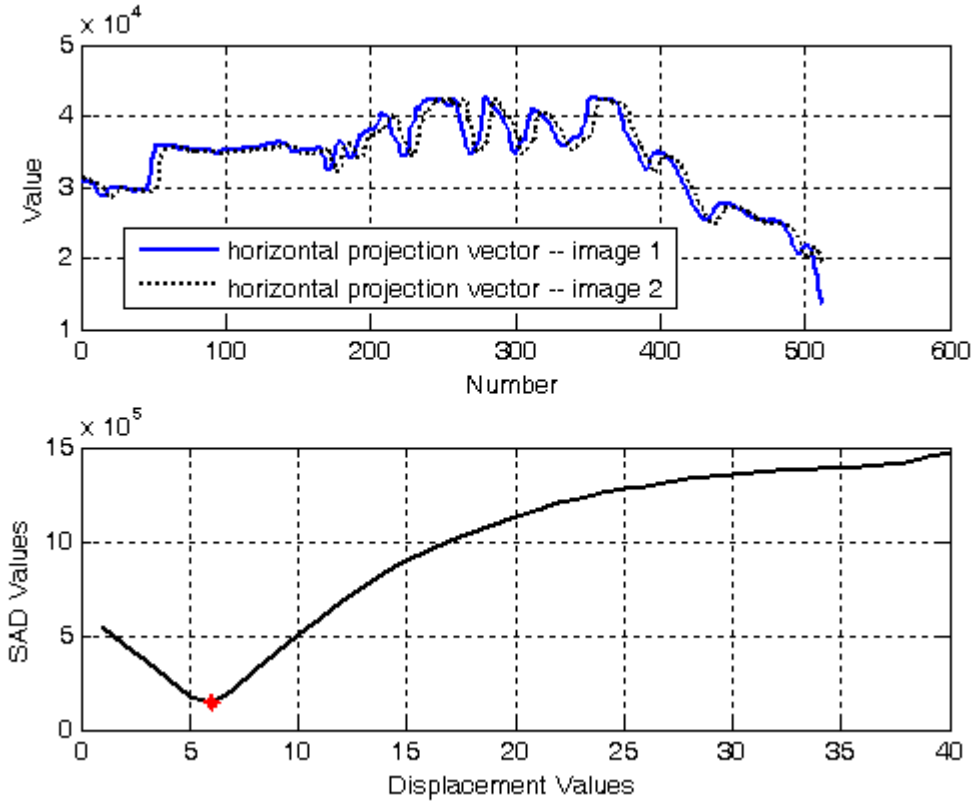
The Integral Projection method

- One simpler alternative to FS is the Integral Projection (IP) method
  - A pair of one-dimensional vectors is computed by summing the elements on one direction on a pair of consecutive frames
  - The projection vectors are correlated in order to find the best offset corresponding to the matched frames

The Integral Projection method



a) The horizontal projection vectors for both images;
b) The SAD values for the horizontal projection vectors

The Sign Projection method

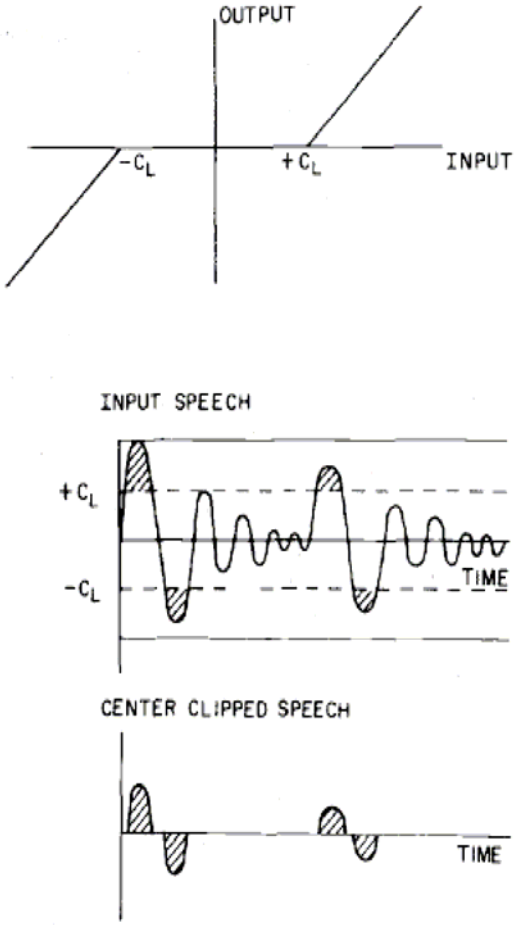


Fig. 1. Input–output characteristic and typical operation of a center clipper (after Sondhi).

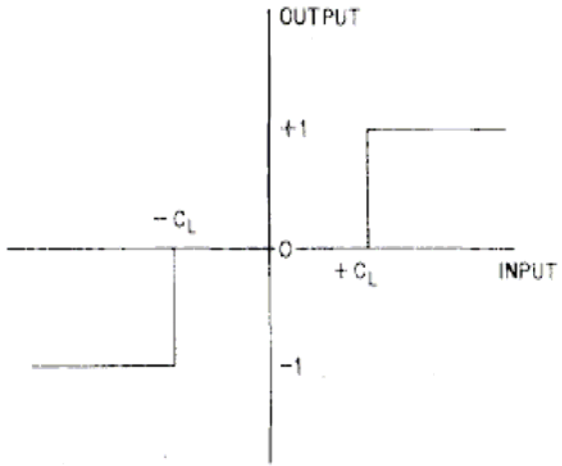


Fig. 3. Input–output characteristic of the combination center clipper, infinite peak clipper.

J.J. Dubnowski, R.W. Schafer, and L.R. Rabiner (1976). Real-time digital hardware pitch detector. *IEEE Transactions on Acoustics, Speech, and Signal Processing*, 24:2-8

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The Sign Projection method

- It is derived from the integral projection method
- Each pixel value is compared with two thresholds
- The thresholds are computed as a percentage of the dynamic range of the image crop pixel values
- A pair of one-dimensional vectors (horizontal and vertical) is obtained
- The projection vectors are correlated in order to find the best offset corresponding to the matched frames

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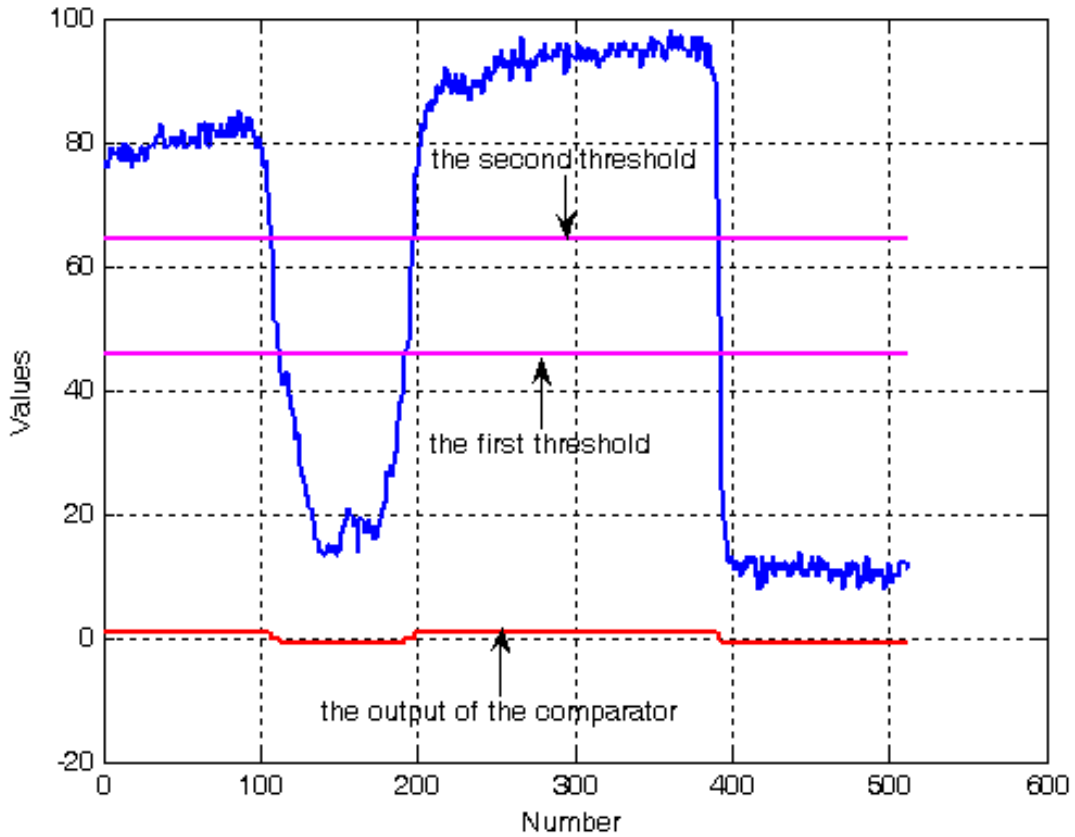
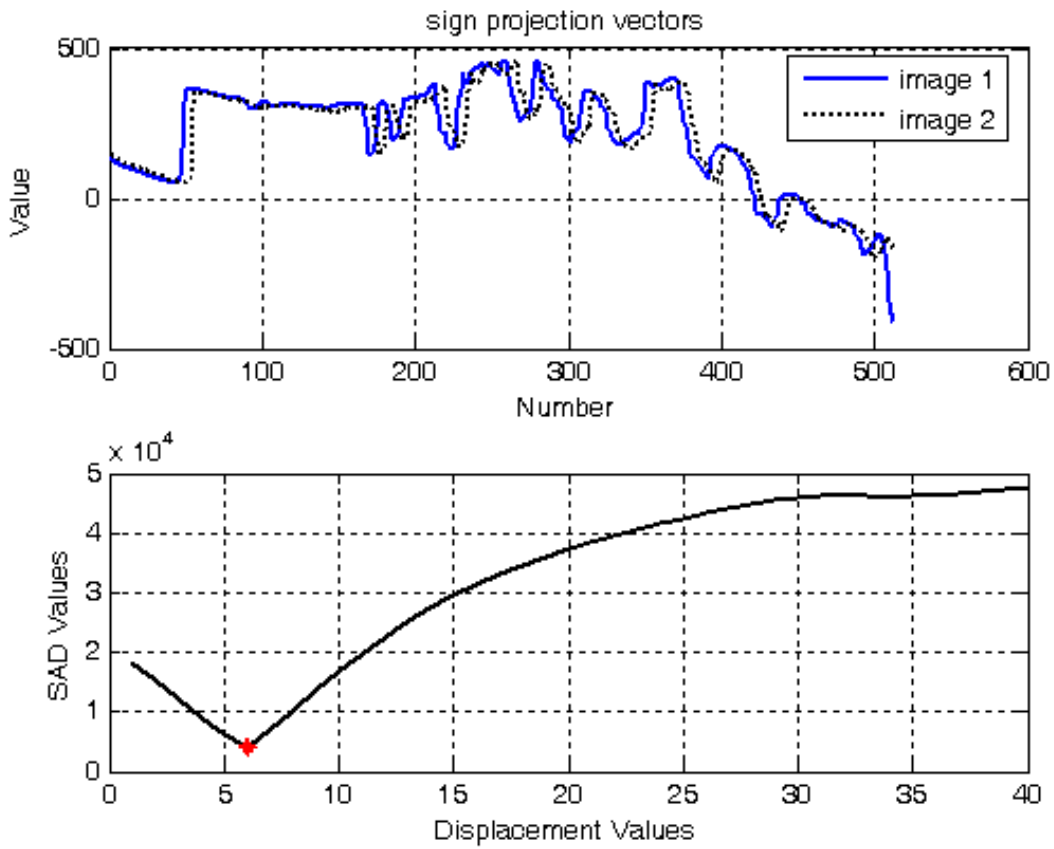
The Sign Projection method



The pixel values, the thresholds and the output of the comparator for one row.

The Sign Projection method



a) The horizontal sign projection vectors for both images;
b) The SAD for the horizontal sign projection vectors

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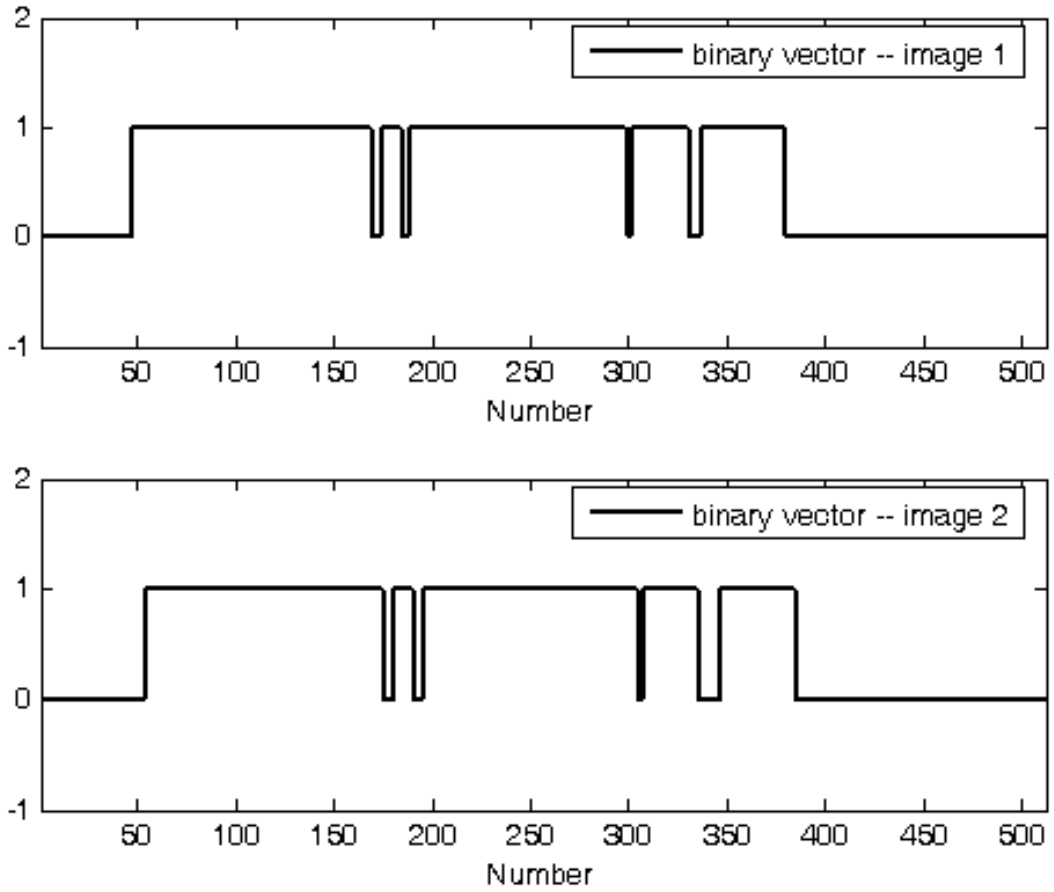
The Binary Incrementation method

- It is also derived from the integral projection method
- Each pixel value is compared with a thresholds and counted if the value is above the threshold
- The pair vectors obtained on each direction are compared with another threshold
- The thresholds are computed as a percentage of the dynamic range of the image crop pixel values and vector values respectively
- A pair of binary vectors (horizontal and vertical) is obtained
- The horizontal and vertical displacements are given by the minimum of the sum of XOR output values

The Binary Incrementation method



The horizontal binary vectors for both images.

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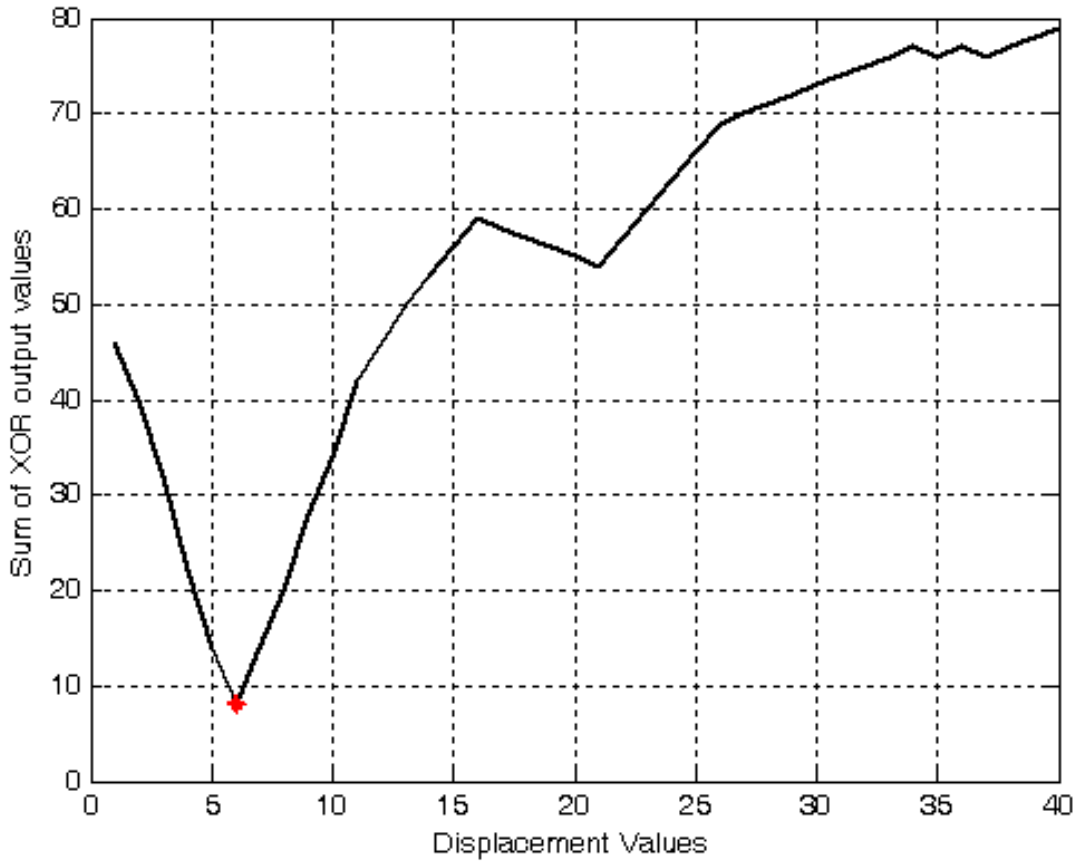
The Binary Incrementation method



The sum of XOR output values.

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Motion filtering

- The next step is the low pass filtering
  - We used the jitter calculation proposed in [1]

$$A[n] = aA[n-1] + av[n]$$

  - Where A[n] is the accumulated jitter for frame *n*, *v*[n] is the computed motion estimate for frame *n*, and *a* is a dampening factor.
- The last step is the image shift using the maximum buffer area of the image sensor

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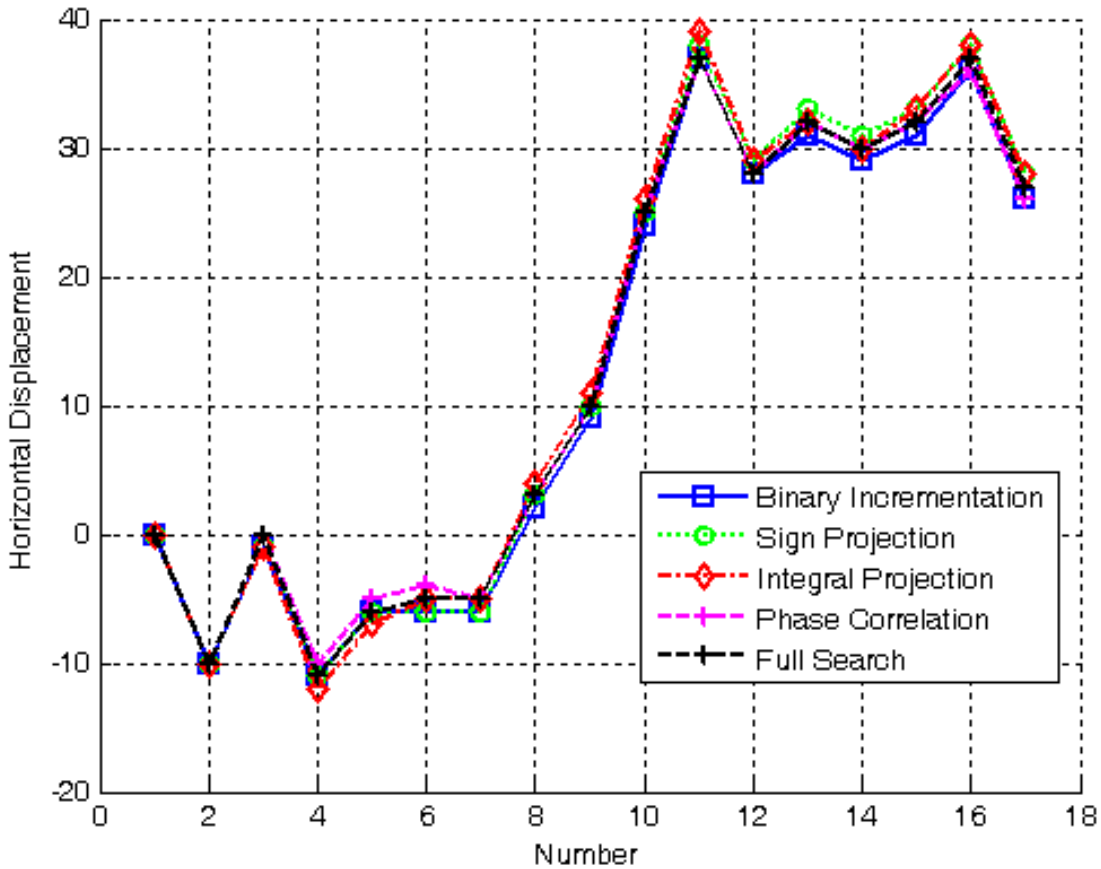
Experiments and Results



The horizontal displacements estimated by the BI, SP, IP, PC and FS methods for a burst of pictures.

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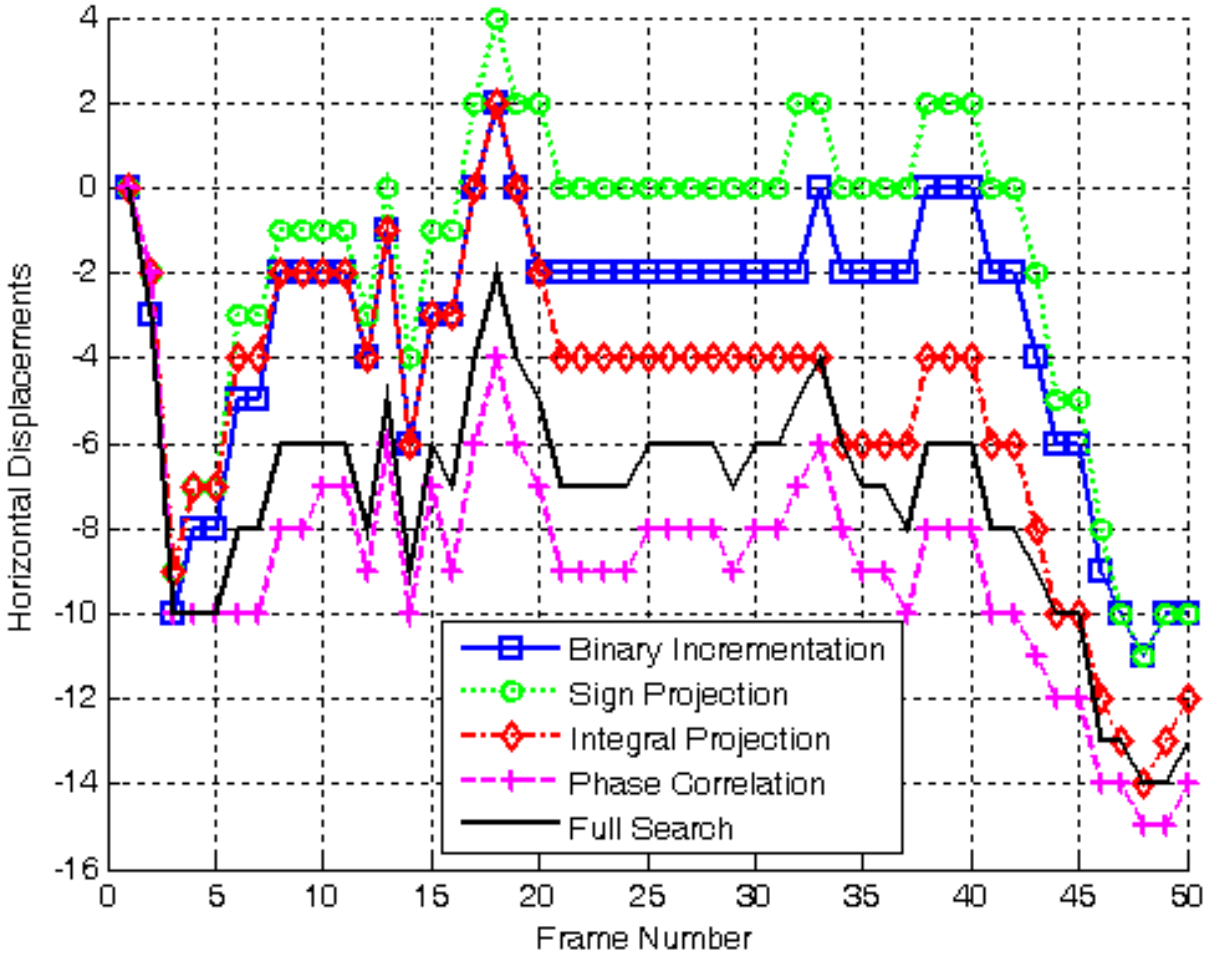
Experiments and Results



The horizontal displacements estimated by the BI, SP, IP and PC methods.

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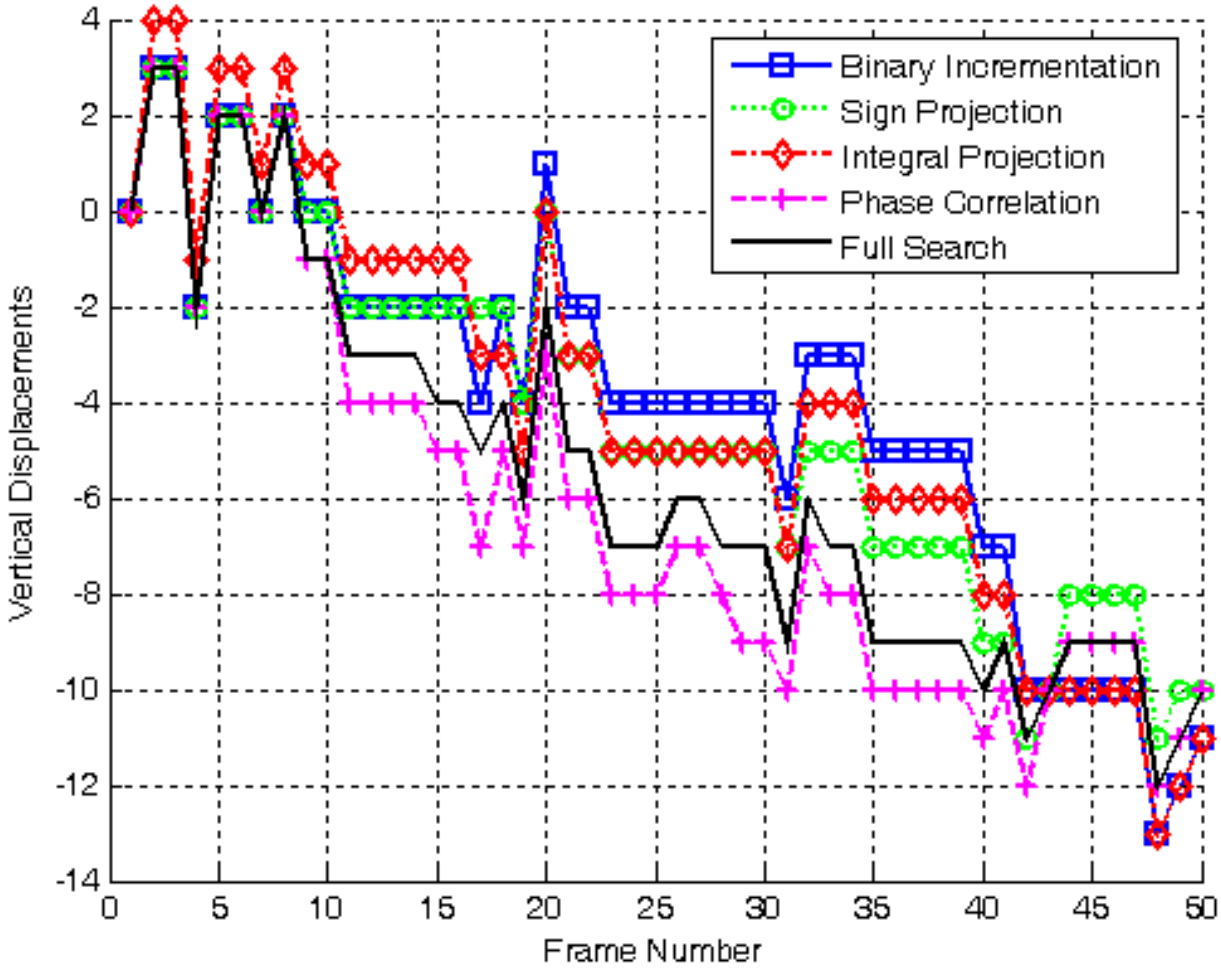
Experiments and Results



The vertical displacements estimated by the BI, SP, IP and PC methods

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Experiments and Results

Method	PC	IP	SP	BI
E for burst pictures	0.1556	0.1860	0.1664	0.1951
E for low quality movie	0.1681	0.2661	0.2088	0.3243

Error Values for Global Motion Vectors computed by different methods

$$E = \frac{1}{N}\sqrt{\sum_{i=1}^{N}\left[\left(h_i^{FS} - h_i\right)^2 + \left(v_i^{FS} - v_i\right)^2\right]}$$

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Experiments and Results

- The accuracy of the proposed methods can be improved by applying them on different parts of the frames and use the median values. It also increase robustness to independently moving objects from one frame to another
- Sub-sampling with a specified factor (up to three) is possible for the SP and BI methods. The accuracy of the motion estimation can be recovered by interpolating the computed vectors with the same factor

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References

- [1] A. Deever, “In-camera, all-digital video stabilization”, in proc. ICIS’06, Rochester, New York, May 2006, pp. 190-193.
- [2] Kuglin C D., Hines D C. The phase correlation image alignment method. In *Proc. Int. Conf. Cybernetics and Society*, IEEE, Bucharest, Romania, Sept. 1975, pp. 163-165
- [3] K. Sauer and B. Schwartz, 1996, "Efficient Block Motion Estimation Using Integral Projections", *IEEE Trans. Circuits, Systems for video Tech.*, vol. 6, No. 5, October, pp. 513-518
- [4] J.J. Dubnowski, R.W. Schafer, and L.R. Rabiner. (1976). Real-time digital hardware pitch detector. *IEEE Transactions on Acoustics, Speech, and Signal Processing*, 24:2-8
- [5] B. Natarajan, V. Bhaskaran, and K. Konstantinides, “Low-complexity block-based motion estimation via one-bit transforms,” *IEEE Trans. Circuit Syst. Video Technol.*, vol. 7, no. 5, pp. 702-706, Aug. 1997

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Conclusions

- The Sign Projection and Binary Incrementation are proposed for global motion estimation
- They achieve similar performance with more complicate methods but at lower cost
- They can be seen as a combination of the integral projection and bit transform methods, therefore can have an efficient hardware or software implementations
- The improvement of the performance for small block sizes is under investigation