Video Image Sequence Super Resolution using Optical Flow Motion Estimation

Saeid Fazli , Hamed Fathi

***Abstract*—thereare two procedures to increase the resolution of Video Image Sequences (VIS): hardware method and software method. Generally software methods are better than hardware ones. Super resolution is one of the software methods to increase resolution of images. Super resolution algorithm is depending on calculated motion estimation between two frames. Choosing a proper motion estimation algorithm causes increment in resolution of VIS compared to other motion estimation algorithms.In this paper we use two algorithms: optical flow and block matching to increase resolution of video image sequences and we show that optical flow method has higher PSNR for VIS. Our proposed method has the highest PSNR with optical flow for Foreman video test with PSNR of 29.1.**

Keywords—super resolution; video sequence images; motion estimation;optical flow; block matching; PSNR.

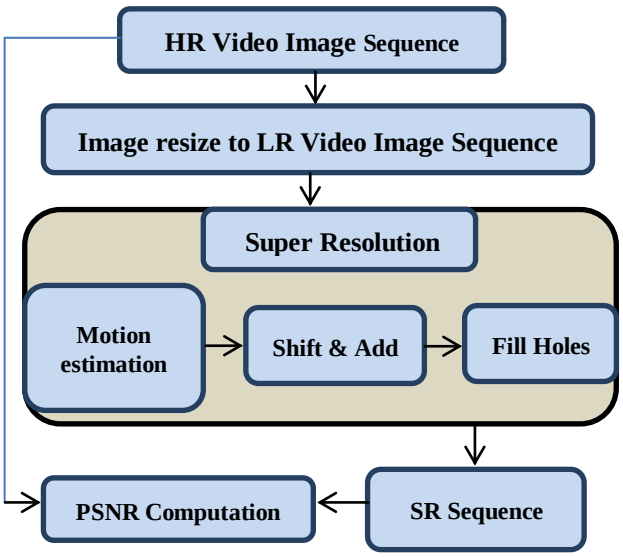
I. INTRODUCTION

There are many ways to increase resolution of VIS. Today using software methods for increment of VIS resolution is more common in comparison to hardware ways. Despite software algorithms, hardware algorithms have high costs. Super resolution is one of the ways which we use in this paper. In super resolution, we can achieve frames with high resolution by combining information of sub pixels of several frames. The main part of super resolution algorithm is using a proper motion estimation method which is divided into two main ways: pixel based method (‘direct’) and feature based method (‘indirect’). Direct methods are including four main algorithms: block-matching, phase correlation, pixel recursive and optical flow. For indirect method, features such as corner detection are used.

In [1] nine algorithms of block-matching are used. These algorithms are as follow:
1. The Three-Step Search (TSS), described in [2].
2. The New Three Step Search (NTS), described in[3].
3. The Four Step Search (FSS), described in [4].
4. The Two Dimensional Logarithmic (TDL) search, Described in [5]
5. The Cross Search (CS), described in [6].
6. The Diamond Search (DS), described in [7].
7. The Block Based Gradient Descent Search (BBGDS), described in [8].
8. The One at a Time Search (OTS), described in [9].
9. The Parallel Hierarchical One Dimensional Search (PHODS), described in [10].

In this paper we use block matching and optical flow. Both of these algorithms have advantages and disadvantages. For instance optical flow has low velocity and error ratio in comparison to block-matching. The results of estimation with block-matching and optical flow on the same testing frames, shows that optical flow has higher PSNR and the purpose of high accuracy is achieved by using optical flow.

Figure 1.Shows the block diagram of a super resolution of VIS system. As we show in this figure, we resize frames of the video to achieve low resolution and these sequences are the input of super resolution system. We do this resizing step to make a comparison step possible for comparing the frame after super resolution with the first one.



.**Fig1**. Block diagram of super resolution of VIS system

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The paper is organized as follows:
Section 2 provides super resolution algorithm. Section 3 explains our proposed method we use in this paper. The experimental results are defined in section 4 and section 5 draws and discusses conclusions.

II. SUPER RESOLUTION ALGORITHM

Super resolution algorithm includes three parts: motion estimation, shift and add, fill holes.

At first we start our super resolution step with motion estimation. We find motion vectors which are for each block in block-matching method and for each pixel in optical flow method .Motion vector is a vector which shows transformation from one image to another and in VIS it is the motion description from one frame of video sequence to another. Then we use shift and hold stage. For block-matching method blocks of second frame corresponding motion vectors (u,v) which are obtained from previous step, are transmitted to the first frame and replaced by them. For optical flow method pixels of second frame correspondingmotion vectors are transmitted to the first up-sampled frame. The last step is fill holes and that's for filling the points which are not filled in the previous step by bilinear interpolation.

III. PORPOSE METHOD

Optical flow is more accurate than block-matching so we use optical flow algorithm instead of block-matching in [1].

In this paper we use Lucas &Kanade method. In this method we consider main formula of optical flow for a neighborhood of intended pixel and by least square method we find motion vectors (u,v).The optical flow equation is defined as follow:

$$f_x u + f_y v = -f_t \qquad (1)$$

A considered 3 by 3 window is as follow:

$$f_{x1}u + f_{y1}v = -f_{t1} \qquad (2)$$
$$f_{x2}u + f_{y2}v = -f_{t2}$$
.
.
$$f_{x9}u + f_{y9}v = -f_{t9}$$

$$u = \frac{-\sum f_{yi}^2 \sum f_{xi}f_{ti} + \sum f_{xi}f_{yi} \sum f_{yi}f_{ti}}{\sum f_{xi}^2 \sum f_{yi}^2 - (\sum f_{xi}f_{yi})^2} \qquad (3)$$

$$v = \frac{\sum f_{xi}f_{ti} \sum f_{xi}f_{yi} - \sum f_{xi}^2 \sum f_{yi}f_{ti}}{\sum f_{xi}^2 \sum f_{yi}^2 - (\sum f_{xi}f_{yi})^2} \qquad (4)$$

Lucas & Kanade's basic idea is based on three hypotheses:

1. Brightness constancy: pixelmovement from one frame of an image to another frame would not change brightness of that.
2. Temporal persistence or "small movement": respective to the motion scale in the image, the temporal growths are very fast so that the movement of object is very few from one frame to another.
3. Spatial coherence:for the points which are neighborand belong to the same surface, the motion is similar.

In most cases and for most situations, the following pyramid-based method is better. Pyramids can be used to compute large optical flow vectors. Figure 2illustrates how pyramid Lucas &Kanade optical flowis working.

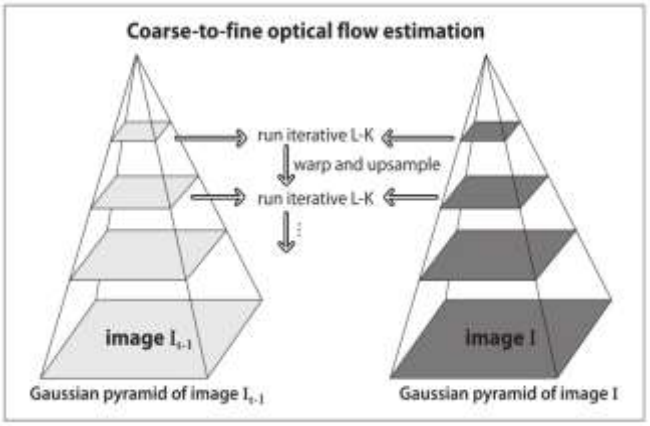

Figure 2. Pyramid Lucas & Kanade optical flow

As we see in figure 2 at the top of the pyramid optical flow is run to find out motion vectors. The estimated motions of each level are the starting point of motion estimation in next level.

IV. EXPERIMENTAL RESULTS

In this paper, we use two sets of video tests, which are namedNEWS and FOREMAN that their formats are CIF. At first, we apply super resolution algorithmwhich isusing block matching motion estimation.
We use two measurements benchmark to calculate performance of the system for each test frames. PSNR,

$$\text{RMS}=\sqrt{\frac{1}{m*n}(I_{HR}-I_{SR})^2}\text{m,n=size }(I_{HR}) \qquad (5)$$

$$\text{PSNR}= 10 * \log_{10}\left(\frac{max I_{HR}(i,j)}{RMS}\right)^2 \qquad (6)$$

Figure 3-8 show the results of them. The latter, we apply super resolution algorithmwith optical flow for two sets of video tests.Figure 9-14 show the results of them.

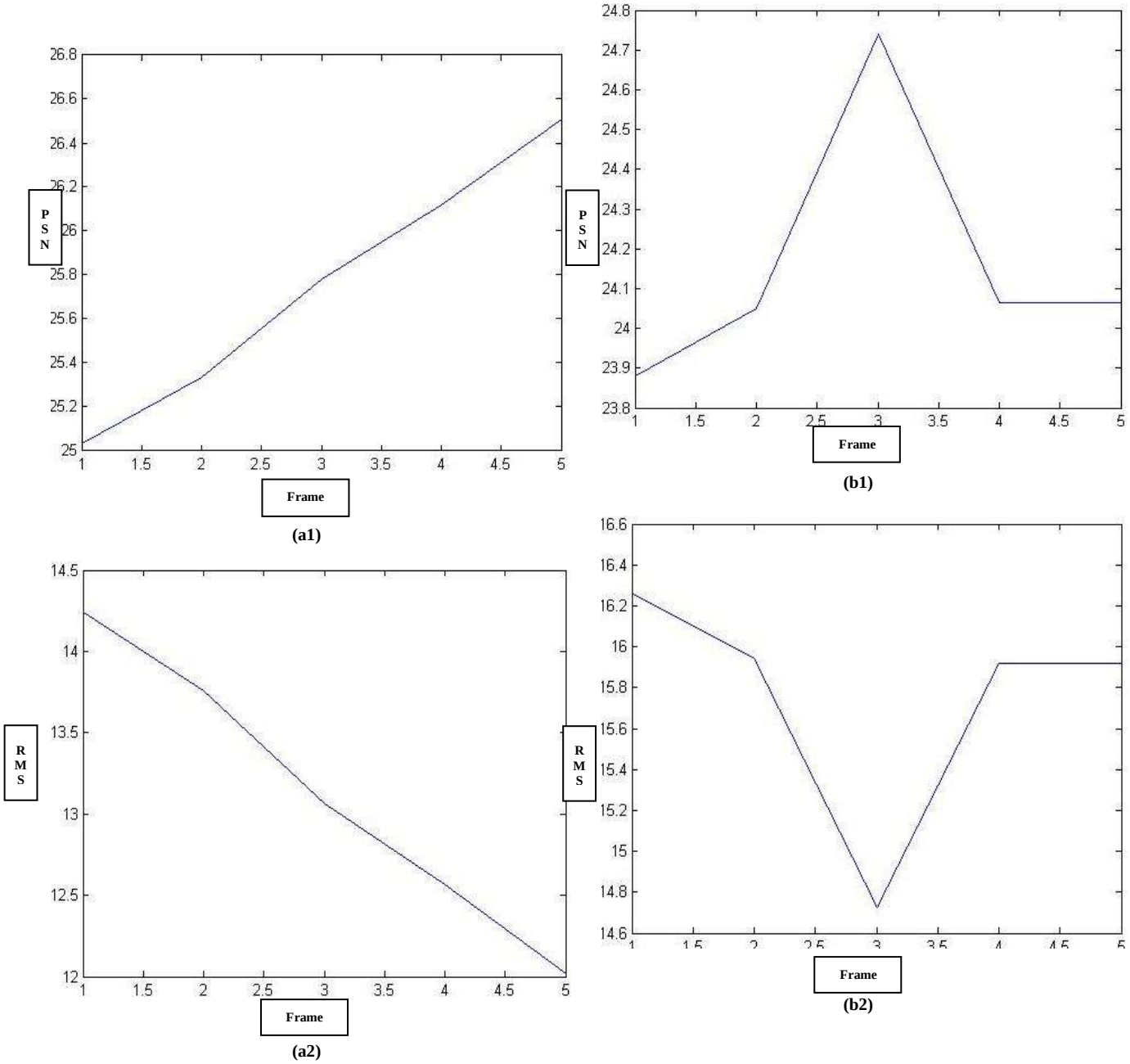

Figure (3). The similarity of the High resolution frames and Super resolution frames with Block Matching motion estimation,a1 and a2 are PSNR and RMS for foreman video test. b1 and b2 are PSNR and RMS for news video test.

(a) **(b)**

Figure (4). Super resolution frame with block matching, a is foreman video test and b is news video test

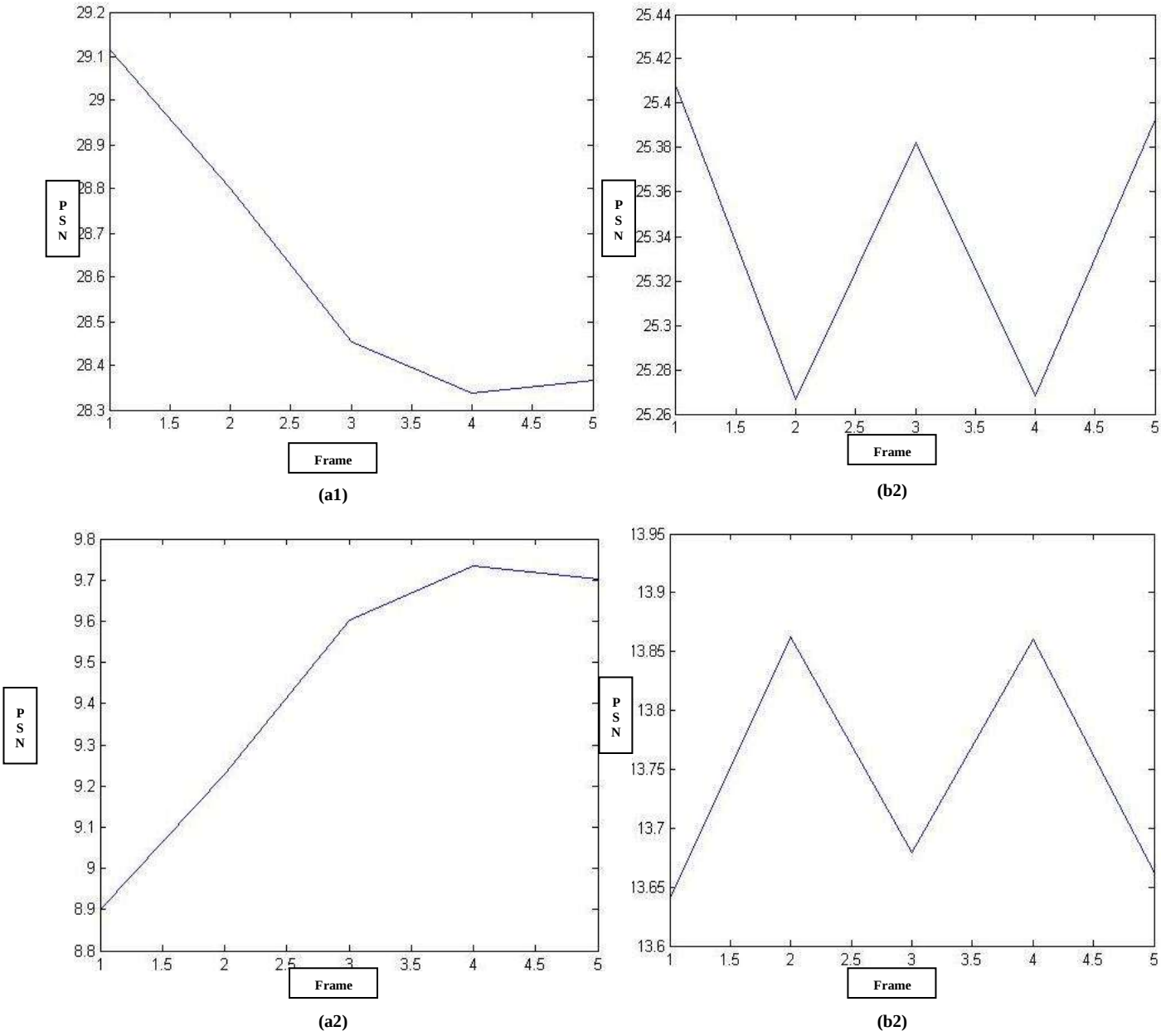

Figure (5). The similarity of the High resolution frames and Super resolution frames with Optical Flow motion estimation,a1 and a2 are PSNR and RMS for foreman video test. b1 and b2 are PSNR and RMS for newsvideo test.

Figure (6). Super resolution frame with Optical flow, a is foreman video test and b is news video test

V. CONCLUSION

This paper proposed and presented a new algorithm to enhance a high quality video sequence by super resolution with motion estimation. We presented a powerful super resolution method based on optical flow and block-matching motion estimation. This method can improve quality of video sequence images and so that it can increase the resolution of video.

We used two video test sets: News and Foreman. The proposed method improved the resolution of them. With optical flow motion estimation algorithm we achieved maximum PSNR of 25.1 for 5 first frames of News video and 29.1 for 5 first frames of Foreman video. We also achieved maximum PSNR of 24.6 for News and 26.5 for Foreman and for 5 first frames of both video sets.

Except that the minimum value of PSNR for News with optical flow was 25.3 and for Foreman was 28.3 while the minimum values were 23.9 for News and 25 for Foreman with block-matching algorithm. This shows that optical flow has increased the whole PSNR values. In this paper we showed that optical flow's improving resolution performance is better than block-matching.

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