Motion Compensated Deinterlacing with Variable Block Sizes

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Abstract

In this paper, we propose a new deinterlacing algorithm based on motion estimation and compensation with variable block size. Motion compensated methods using a fixed block size tend to produce undesirable artifacts when there exist complicated motion and high frequency components. In the proposed algorithm, the initial block size of motion estimation is determined based on the existence of global motion. Then, the block is divided depending on block characteristics. Since motion compensated deinterlacing may not always provide satisfactory results, the proposed method also use an intrafield spatial deinterlacing. Experimental results show that the proposed method provides noticeable improvements compared to motion compensated deinterlacing with a fixed block size.

Keywords: deinterlacing, motion compensation, variable block size, spatial interpolation.

1. Introduction

With recent advancement of display technology such as High Definition Television (HDTV) and the wide use of progressive format, the interlaced-to-progressive conversion is required, which is also called deinterlacing. It targets to fill missing lines by using spatial and temporal neighboring data.

A number of deinterlacing techniques [1-6] have been proposed, which can be roughly divided into two categories: spatial interpolation methods and temporal interpolation methods. Spatial interpolation methods perform deinterlacing using the pixels of the current frame by employing various intrafield interpolation. Spatial methods have been widely used in many applications due to their relatively light computational complexity and easy hardware implementation. However, they may produce some artifacts in edge areas and for moving objects.

On the other hand, the temporal interpolation technique is an interfield method which also uses motion compensation. Motion compensated techniques provide improved performance among various deinterlacing techniques if motion estimation is accurate and reliable. However, the motion compensated deinterlacing techniques may suffer due to time restriction, buffer constraint and incorrect motion compensation in fast moving areas. Although motion compensated deinterlacing methods usually provide high quality images, they tend to yield undesirable results when rapid motion exists.

In order to address this problem of motion compensated deinterlacing, we propose a new deinterlacing method using variable block size for motion estimation and compensation. This proposed method consists of three parts: spatial deinterlacing, temporal motion estimation using variable block size and rules to choose either spatial deinterlacing or temporal deintercing. The proposed method provides better performance compared to previous motion compensated deinterlacing methods.

2. Review of Motion Compensated Methods

In this section, some previous motion compensated methods are briefly reviewed. In most motion compensated deinterlacing, intrafield interpolation is also used.

For example, the DIMC method employs the directional interpolation as a spatial algorithm to find the best spatial interpolation direction among pre-defined directions and use either spatial deinterlacing or motion compensated deinterlacing according to the predefined rules.

In deinterlacing, it is important to preserve edges and to fill missing lines by taking into consideration edge information since edges are very sensitive to human visual system (HVS). Among various interpolation algorithms, the directional interpolation method finds the direction having the minimum difference from five directions (45˚, 64˚, 90˚, 116˚ and 135˚).

In interlaced video sequences, the correlation of successive fields having same parity is higher than that of the fields having different parities. Also it is shown that motion compensation between the same parity fields has inherent advantages compared to that between different parity fields. [7].

For instance, in the DIMC method, motion compensation was done using the previous field F_{n-1} and the next field F_{n+1} which have the same parity.

Sometimes, the directional interpolation is better than motion compensated deinterlacing. Therefore it is necessary to apply these two methods properly. In other words, in order to obtain good picture quality, one needs to motion compensated deinterlacing use intrafield deinterlacing and intrafield deinterlacing which uses motion compensation.

3. Motion Compensation with Variable Block Size

In order to address the problems with motion compensated deininterlacing, we propose a new deinterlacing algorithm using variable block size. It is based on the idea that the effectiveness of motion compensation is closely related with characteristics of videos. Although deinterlacing methods utilizing motion compensation provide good performance in most cases, motion compensated deinterlacing does not work well when scene change occurs rapidly. Furthermore, when there exists fast motion, it is difficult to obtain good performance from motion compensated deinterlacing. In order to improve the performance in such sequences, we propose to use a variable block size for motion estimation and compensation.

The correlation between successive fields where fast motion exists is generally low. On the contrary, the correlation between fields of still scenes is high. Thus, the proposed method uses a large block size in video sequences of high correlation and a small block size in video sequences of low correlation. Using a large block for fields with low correlations could deteriorate performance.

3.1 Intra Field Interpolation

In intra field interpolation, it is important to find edge information in order to obtain good picture quality. A number of interpolation methods have been proposed, which take into account edge information. In this paper, we use an enhanced ELA (Edge Based Line Averaging) algorithm. Difference vectors are obtained from adjacent three or more pixels in the immediate upper and lower lines of a pixel to be interpolated. From the pattern of the increase or decrease, difference vectors are assigned weight as follows [8]:

$$Weight\begin{cases} weight = 3 & Inc \,\&\, Dec \\ weight = 2 & Flat \,\&\, (Inc\, or\, Dec) \\ weight = 1 & (Inc \,\&\, Inc)\, or\, (Dec \,\&\, Dec) \end{cases}.$$

In the vector consists of three pixels, two weights are obtained. Then the difference is computed using the following equation:

$$Diff(i,j) = K * w1 * w2 + |u(i) - v(j)| * w1 * w2$$

where, $u(i)$ is a vector in the upper line and $v(j)$ is a vector in the below line, and K is constant. We choose the edge direction which has the minimum difference. Finally, the average of the pixels along the edge direction is computed and used as a spatial interpolated value.

3.2 Determination of Block Size

Preliminary experiments showed that a fixed searching block size is not efficient in motion compensation. In still scenes, a large block size produces improved picture quality. In scenes with fast motion, a small block size is more efficient, providing more accurate motion vectors. In the proposed algorithm, the block size is determined in two steps. First, we determine the block size of field ($BlockSize_{Field}$). Next, we determine the sub-block size ($BlockSize_{InField}$) within the field.

In the proposed method, we first compute the average difference between two adjacent fields:

$$Avg = \sum_{i,j} |F_p(i,j) - F_f(i,j)| / (m*n)$$

Then, this value is used to determine $BlockSize_{Field}$ as follows:

$$BlockSize_{Field} = \begin{cases} Size1 & Avg < Th_1 \\ Size2 & Avg > Th_1 \end{cases}$$

Where the large block size $Size1$ is set to 48x18 and the small block size $Size2$ is set to 16x8.

. In other words, we propose to use two values as a starting block size for each field and the average difference between two fields is used as a criterion.

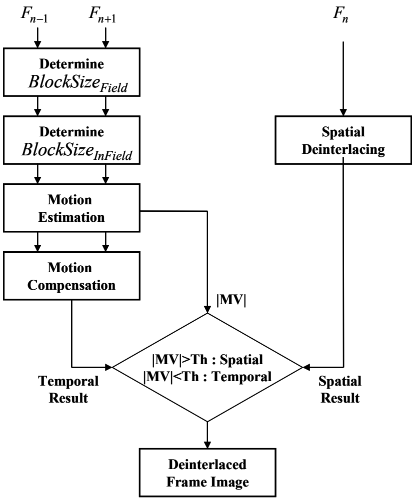


Fig. 1 Block diagram of the proposed method.

3.3 Various block size in block-wise operation

After the block size of a field is determined, we further adjust the block size in order to take into account local motion variation. In particular, the block size can be further reduced depending on the characteristics of a field. Fig.1 shows a block-diagram of the proposed method. First the absolute magnitude sum of motion vectors of a block is computed. If the sum is smaller than a threshold, motion compensation is performed with the starting block size. However, if the sum is larger than the threshold, the starting block is divided into four blocks as follows:

$$BlockSize_{InField} = \begin{cases} BlockSize_{Field} & \|MV\|_T < Th2 \\ Quarter\ Of\ BlockSize_{Field} & \|MV\|_T > Th2 \end{cases}$$

where, $\|MV\|_T = |MV_x| + |MV_y|$.

Motion compensation is done using the four quarter blocks. In next block, this process of motion compensation is repeated. Fig.2. shows selected block sizes for motion compensation.

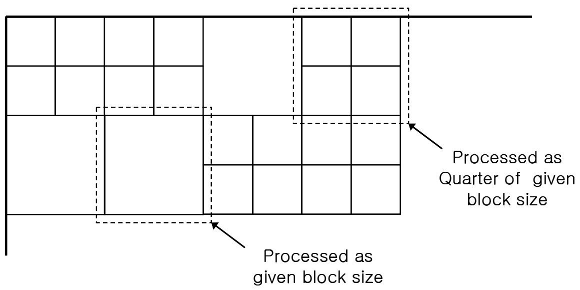


Fig.2 Adjustment of block size within a field.

4. Experimental Results

Experiments were conducted using several video sequences and the proposed method is compared with several existing deinterlacing methods - directional interpolation and motion compensation (DIMC) [6], edge based line averaging and motion compensation (ELAMC) [3], modified directional interpolation and motion compensation (MDIMC) [1]. As a spatial algorithm, MDI employs 6-tap filter of Hamming windowed sinc function in vertical interpolation.

Table 1 shows the performance comparison. As can be seen, the proposed method significantly outperforms the existing methods. Fig.3 shows the PSNRs of *Mobile & Calendar* and *Akiyo*. The proposed method shows noticeable improvement over the existing methods. This improvement is presented in difference image. Fig.4 shows the difference image between original image and reconstructed images of 50th frame of the *Mobile & Calendar* .

Table 1. Average PSNR for video sequence

Video	Size	DIMC	ELAMC	MDIMC	Proposed algorithm
Akiyo	CIF	43.722	44.779	45.726	**47.279**
Mobile	CIF	24.793	24.787	25.325	**26.471**
Container	CIF	28.241	28.518	28.464	**29.564**
Miss America	CIF	38.91	39.320	39.347	**40.821**
Stefan	CIF	27.276	27.374	27.451	**27.542**
Foreman	QCIF	35.886	36.419	36.501	**38.364**
Hall Monitor	QCIF	27.961	28.145	28.426	**32.266**
Coastguard	QCIF	27.586	27.766	27.760	**28.494**
Container	QCIF	26.547	26.728	26.823	**28.588**
Silent	QCIF	37.688	37.665	37.688	**39.234**
Average		31.861	32.150	32.351	**33.862**

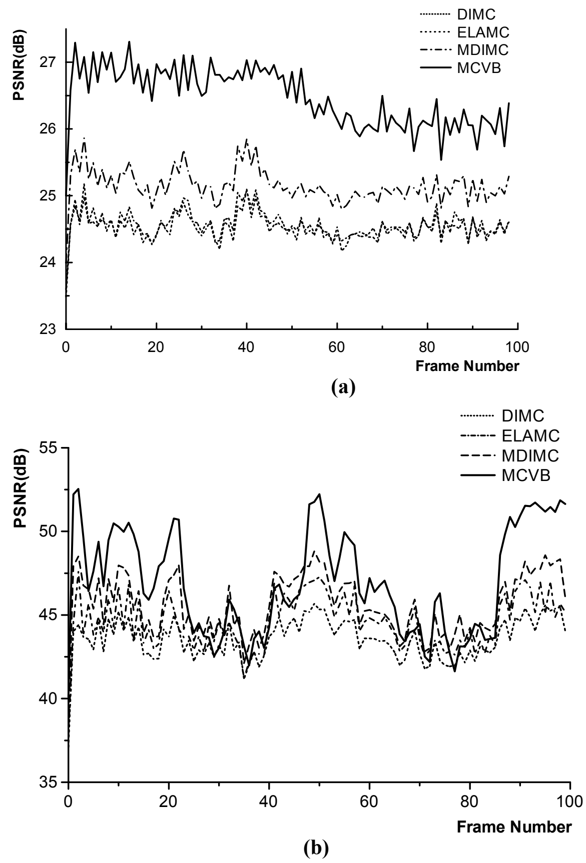
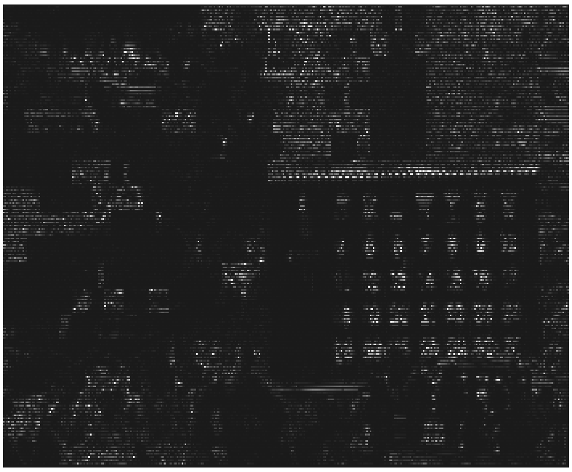


Fig. 3 PSNRs of the methods on video
(a) *Mobile & Calendar* (b) *Akiyo*

MCVB : Motion compensated deinterlacing with variable block size
MDIMC : MDI and motion compensation.
ELAMC : ELA and motion compensation
DIMC : directional interpolation motion compensation.

(a)



(b)

(c)

Fig.4 Difference images of methods on *Mobile & Calendar* (50th frame)
(a) Original image (b) DIMC (c) MCVB

. Conclusion

We proposed a new deinterlacing method which uses a ıriable block for motion compensation. In the proposed gorithm, the initial block size of motion estimation is :termined based on characteristics of adjacent frames. ıen, the block size is further divided depending on ock characteristics. Since motion compensated :interlacing may not always provide satisfactory results, e proposed method also use an intrafield spatial ıinterlacing. Experimental results show that the ·oposed method outperforms existing deinterlacing ethods including motion compensated deinterlacing ethods with a fixed block size.

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