

Novel deinterlacing algorithm using neighboring interlaced pixels directions statistics

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Abstract

This paper proposes a novel deinterlacing algorithm using neighboring deinterlacing pixels directions weight, which can obtain the true deinterlacing direction of the interpolated pixel. The proposed algorithm determines the direction of the current interpolated pixel using MELA direction determination method. To obtain more accurate deinterlacing direction and increase interpolation direction correlation, the directions of neighboring pixels around the current interpolated pixel are considered. The current direction and the neighboring majority direction are compared to decide an interpolated method. But it cost slightly CPU time increasing since neighboring pixels directions determination and statistics. Experimental results demonstrate that the proposed algorithm outperforms the conventional deinterlacing methods.

Index Terms — Neighboring pixels directions, Majority direction, MELA.

1. Introduction

Deinterlacing is the process of converting interlaced video, such as common analog television signals or 1080i format HDTV signals, into a non-interlaced form. Interlaced video frame consists of two sub-fields taken in sequence, each sequentially scanned at odd and even lines of the image sensor; analog television employed this technique because it allowed for less transmission bandwidth and further eliminated the perceived flicker that a similar frame rate would give using progressive scan. CRT based displays were able to display interlaced video correctly due to its complete analogue nature. All of the newer displays are inherently digital in that the display comprises discrete pixels. Consequently the two fields need to be combined into a single frame, which leads to various visual defects which the deinterlacing process should try to minimize.

Conventional fixed interpolation techniques [1-6] include line average (LA) [1] and edge directional spatial interpolations. The edge directional interpolation techniques such as Edge-based LA (ELA), Efficient ELA (EELA), Modified ELA (MELA), and Direction-Oriented Interpolation (DOI) perform interpolation in the direction of the highest correlation among pixels. The ELA [2] utilizes directional correlation to interpolate a missing line between two adjacent lines of a field. Even though it provides a good result in regions where an edge can be correctly estimated, ELA gives poor visual quality in high spatial frequency regions because of the frequent interpolation errors. To improve the ELA method, several approaches have been proposed. The EELA [3] method introduced two directional measurements in order to reduce

wrong edge directions, but it cannot provide good visual quality at thin edged as well as textured regions.

The MELA [4] method can achieve better performance than both ELA and EELA since it covers vertical (90°), antidiagonal (63°), and diagonal (117°) directions. MELA, however, provides subjectively distorted results in both strong

edged or thin striped areas. In the paper, the directions of neighboring deinterlacing pixels are considered to obtain more accurate interpolation direction. The current deinterlacing direction compares with the majority direction of neighboring pixels can increase the interpolation direction correlation. fine directional deinterlacing (FDD) algorithm [5] are suitable for most real time applications due to their clarity, low cost, and easy implementation in hardware.

The remainder of the paper is of as follows. Conventional deinterlacing methods are introduced briefly is explained in Sec. 2. The proposed deinterlacing algorithm is explained in Sec. 3, and the experimental results are presented to evaluate the performance of the proposed method in Sec. 4. Finally, conclusions are presented in Sec. 5.

2. Conventional deinterlacing methods

The ELA method utilizes the edge directional correlations among pixels to linearly interpolate a missing line. If the edge direction is estimated correctly, then the ELA method yields a good result. Otherwise, the ELA method produces unwanted artifacts because of wrong edge direction, resulting in degraded subjective and objective image quality. In this method, a 3x2 localized window shown in Fig. 1 is used to

calculate the directional correlations and to interpolate the current pixel. Let $U(i)$ and $L(i)$ denote the upper and the lower reference pixel values, respectively. Index i is the current position of the pixel to be interpolated. A directional correlation measurement, $C(k)$, is defined by (1), which is the intensity change in the edge direction represented by k .

$$C(k) = |U(i+k) - L(i-k)|, -R \leq k \leq R \quad (1)$$

In ELA, R is set to the value of 1.

$C(k)$ is used to determine the edge direction of the highest spatial correlation φ , which is determined, as (2).

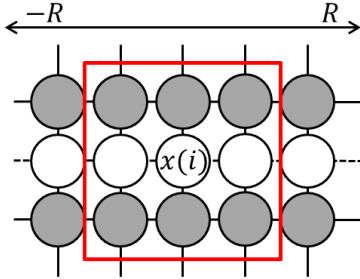


Fig. 1 3x2 window in the ELA method ($R=1$)

$$\theta = \operatorname{argmin}\{C(k)\}, -R \leq k \leq R \quad (2)$$

Then, the current pixel, $x(i)$, is interpolated by (3).

$$x(i) = \frac{U(i+\theta)+L(i-\theta)}{2} \quad (3)$$

In the EELA method, two measurements, P'_i , Q'_i , are defined as (4) within the analysis window in order to alleviate misleading decisions in determining the edge direction in which the interpolation is to be made.

$$\begin{aligned} P'_i &= |U(i-1) - L(i)| + |U(i) - L(i+1)| \\ Q'_i &= |U(i) - L(i-1)| + |U(i+1) - L(i)| \end{aligned} \quad (4)$$

Using these values, $x(i)$ is interpolated by (5) in case of $R=1$.

$$\begin{aligned} & \text{Case}(P'_i < Q'_i) \\ x(i) &= \begin{cases} \frac{U(i) + L(i)}{2}, & C(0) \leq C(-1) \\ \frac{U(i+1) + L(i+1)}{2}, & C(0) > C(-1) \end{cases} \\ & \text{Case}(P'_i > Q'_i) \\ x(i) &= \begin{cases} \frac{U(i) + L(i)}{2}, & C(0) \leq C(1) \\ \frac{U(i+1) + L(i-1)}{2}, & C(0) > C(1) \end{cases} \\ & \text{Case}(P'_i = Q'_i) \end{aligned} \quad (5)$$

Apply the ELA method

In the MELA method, two measurements in EELA are redefined and one more measurement is added as follows.

$$\begin{aligned} P_i &= (|U(i-1) - L(i)| + |U(i) - L(i+1)|) / 2 \\ Q_i &= (|U(i) - L(i-1)| + |Q_{U-i}(i) - V_{L+i}(i)|) / 2 \\ V_i &= (|U(i-1) - L(i-1)| + |U(i) - L(i)| + |U(i+1) - L(i+1)|) / 3 \end{aligned} \quad (6)$$

Therefore, this method covers the vertical (90°), diagonal (63°), and antidiagonal (-63°) directions. The MELA method is summarized by (7).

$$\begin{aligned} & \text{Case}(P_i < Q_i \text{ and } P_i < V_i) \\ x(i) &= \begin{cases} \frac{U(i) + L(i)}{2}, & C(0) \leq C(-1) \\ \frac{U(i-1) + L(i+1)}{2}, & C(0) > C(-1) \end{cases} \\ & \text{Case}(P_i < Q_i \text{ and } P_i > V_i) \end{aligned} \quad (7)$$

$$x(i) = \begin{cases} \frac{U(i) + L(i)}{2}, & C(0) \leq C(1) \\ \frac{U(i+1) + L(i-1)}{2}, & C(0) > C(1) \end{cases}$$

Case($V_i < P_i$ and $V_i < Q_i$)
Apply the bilinear interpolation method.

3. The proposed deinterlacing algorithm

Above, the paper has reviewed some conventional deinterlacing methods. In this paper, the interpolation direction is obtained from the current deinterlacing pixel direction and its neighboring interpolated pixels' directions. And the current pixel deinterlacing direction is calculated using MELA direction determination method. The MELA direction determination using (1) and (6) and direction decision principle is defined as (8).

$$\begin{aligned} & \text{Case}(P_i < Q_i \text{ and } P_i < V_i) \\ & \text{Case: } C(-1) < C(0) \rightarrow \text{P direction} \\ & \text{Case: } C(0) \leq C(-1) \rightarrow \text{V direction} \\ & \text{Case}(Q_i < P_i \text{ and } Q_i < V_i) \\ & \text{Case: } C(1) < C(0) \rightarrow \text{Q direction} \\ & \text{Case: } C(0) \leq C(1) \rightarrow \text{V direction} \end{aligned} \quad (8)$$

The positions of the 8 neighboring pixels ($N_1, N_2, N_3, N_4, N_5, N_6, N_7$ and N_8) of the current pixel (x) are shown in Fig. 2.

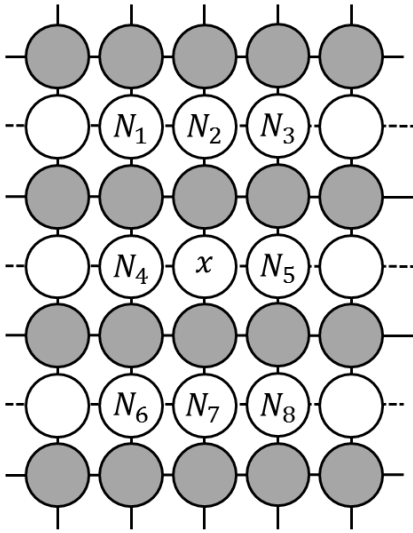


Fig. 2 $N_1 \sim N_8$ are neighboring pixels

The proposed algorithm firstly calculates the directions of neighboring pixels ($N_1, N_2, N_3, N_4, N_5, N_6, N_7$ and N_8) and current pixel (x) using (8). Second, the proposed algorithm classifies the 9 directions and counts amount of each direction. The total amount as $Amount_p, Amount_q$ and $Amount_v$. The proposed algorithm uses MELA direction determination can only obtain P, Q and V directions. The max amount of direction is call majority direction (MD) and the max direction amount is recorded and called MA. The current deinterlacing pixel direction is determinated and recorded as D_c . If D_c is MD and MA is not less than 4, it means that the current region

shows high direction correlation, the current pixel is interpolated using ELA [2] along D_c direction. And if D_c is MD and MA is equal to 3, it means the current region has medium direction correlation, so the pixel is interpolated by an adaptive local weighting scheme is applied, which is propose in FDIF [5]. If D_c is not same with MD, the current is considered as a low direction correlation region, and the current pixel is interpolated using LA [1]. The detail deinterlacing interpolation equation is shown as (9)

$$\begin{aligned}
 &Case(D_c = P) \\
 x(i) &= \begin{cases} \frac{U(i-1) + L(i+1)}{2}, & Amount_p = MA \geq 4 \\ A * \frac{C_{-1}}{C_{-1} + C_0} + B * \frac{C_0}{C_{-1} + C_0}, & Amount_p = MA = 3 \end{cases} \\
 &Case(D_c = Q) \\
 x(i) &= \begin{cases} \frac{U(i+1) + L(i-1)}{2}, & Amount_q = MA \geq 4 \\ E * \frac{C_1}{C_1 + C_0} + B * \frac{C_0}{C_1 + C_0}, & Amount_q = MA = 3 \end{cases} \\
 &Else
 \end{aligned} \tag{9}$$

$$x(i) = \frac{U(i) + L(i)}{2}$$

Where

$$A = \frac{U(i-1) + L(i+1)}{2}$$

$$B = \frac{U(i) + L(i)}{2}$$

$$E = \frac{U(i+1) + L(i-1)}{2}$$

Table 1. PSNR and CPU time for different intrafield deinterlacing methods

| | | lane | baboon | man | peppers | aerial | airfield | Average |
|-----------------|-----------|-------|--------|-------|---------|--------|----------|---------|
| LA | dB | 37.69 | 24.08 | 29.30 | 33.81 | 28.61 | 28.53 | 30.34 |
| | time(sec) | 0.02 | 0.02 | 0.03 | 0.02 | 0.01 | 0.02 | 0.02 |
| ELA | dB | 35.85 | 23.47 | 28.60 | 34.14 | 27.66 | 27.54 | 29.54 |
| | time(sec) | 0.21 | 0.20 | 0.22 | 0.21 | 0.19 | 0.23 | 0.21 |
| EELA | dB | 35.93 | 23.48 | 28.62 | 34.12 | 27.68 | 27.55 | 29.56 |
| | time(sec) | 0.23 | 0.22 | 0.24 | 0.23 | 0.21 | 0.24 | 0.23 |
| MELA | dB | 37.34 | 23.76 | 29.33 | 34.08 | 28.23 | 28.17 | 30.15 |
| | time(sec) | 0.24 | 0.24 | 0.26 | 0.24 | 0.22 | 0.25 | 0.24 |
| FDD | dB | 37.85 | 23.93 | 29.40 | 33.83 | 28.60 | 28.61 | 30.37 |
| | time(sec) | 1.30 | 2.45 | 1.66 | 1.32 | 1.90 | 1.85 | 1.75 |
| Proposed | dB | 38.06 | 24.04 | 29.59 | 34.17 | 28.87 | 28.72 | 30.58 |
| | time(sec) | 1.57 | 2.55 | 1.85 | 1.44 | 2.00 | 2.10 | 1.92 |

4. Experimental results

In the experiment, LA, ELA, EELA, MELA, DOI and FDIF are used to evaluate performance of the proposed algorithm. Eight well-known still gray images of 512×512 (lena, baboon, man, peppers, aerial, airfield) are used for experiment. To measure the performance of objective visual quality, a peak

signal-to-noise ratio (PSNR) is applied and the PSNR is obtained by (10)

$$PSNR = 10 \times \log_{10} \left(\frac{255^2}{MSE} \right) \tag{10}$$

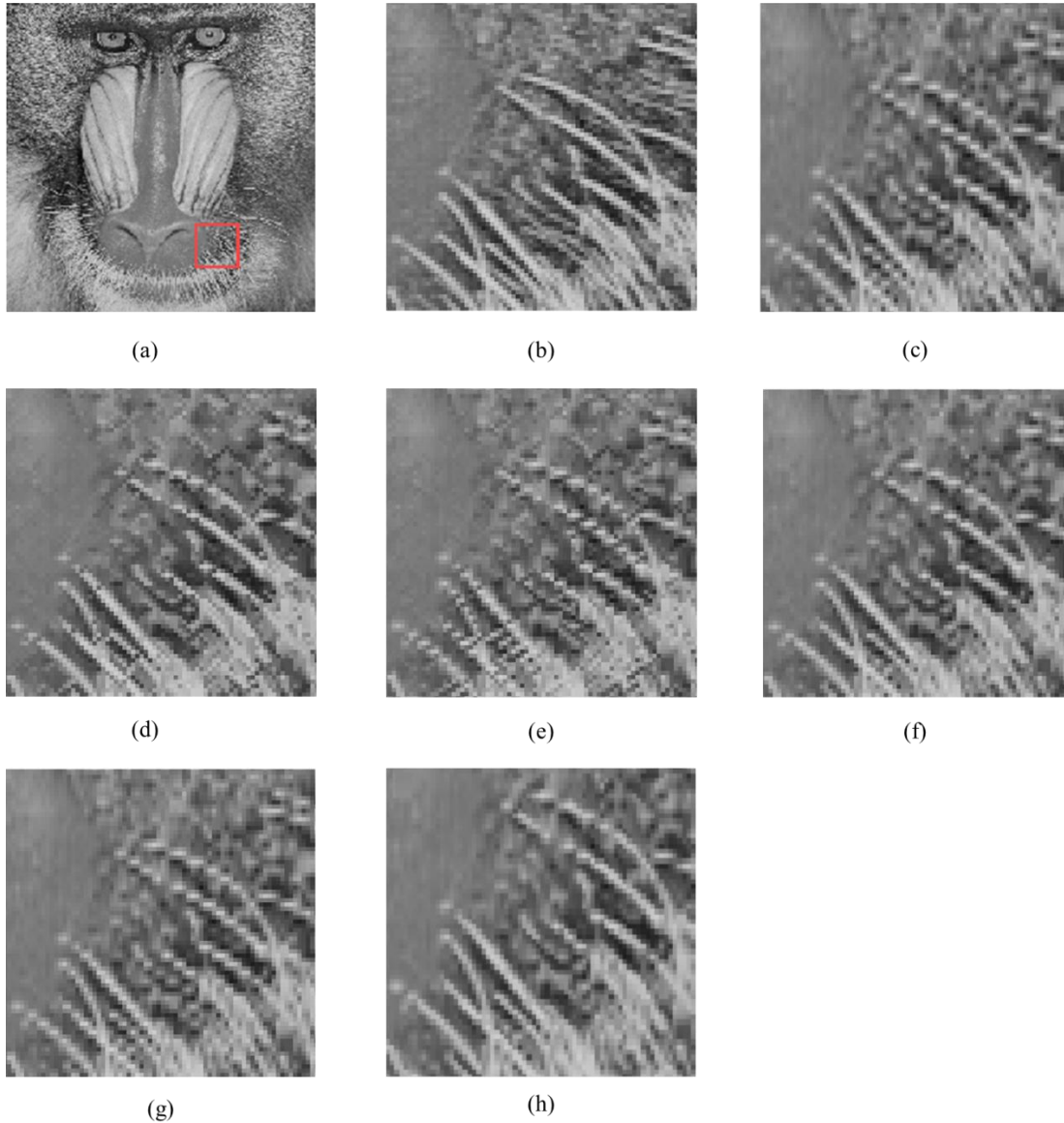


Fig. 6 (a) Original Baboon, (b) original partial image. Experimental results, for visual comparison, after using the deinterlacing methods of the (c) LA, (d) ELA, (e) EELA, (f) MELA, (g) FDD, (h) Proposed.

Here, MSE denotes the mean squared error. Table 1 depicts the results of the PSNR and CPU time of conventional algorithms and the proposed algorithm. As shown in Table 1, the proposed algorithm provides the best PSNR performance, but requires a little more CPU time than other algorithm because of neighboring pixels directions determination. The PSNR performances improvement over that of FDD ranged

from 0.11 to 0.34 dB with an average improvement of 0.19 dB. But slightly increase CPU time by average 0.17 sec. For the subjective performance evaluation of the result images processed by different methods, the Baboon image is used as shown in Fig. 3. Magnified images are presented in Fig. 3 (b)-(h) to enable the subjective consideration of the edge details. It provided poor result images from the subjective

point of view as shown in Fig. 3. Because LA always interpolates the missing pixel by averaging the upper and lower pixels, direction of texture is hard to be preserved, as shown in Fig. 3 (c). Because ELA and EELA consider only three directions, they are very sensitive to noise so that inaccurate edge detections lead to image degradation, as shown in Fig. 3 (d) and 3 (e). MELA and FDD show similar result in Fig. 3 (f) and 3 (g). The proposed algorithm show better visual performance in Fig. 3 (h). These extensive experimental results show that the proposed methods may be superior to other intrafield deinterlacing methods in terms of subjective image quality.

5. Conclusion

In this paper, the directions of the neighboring pixels are considered to estimate the region direction correlation. The experimental results show that the proposed algorithm performs better than any other previous technique. Since the current interpolates along the high correlation direction. The proposed algorithm can significantly improve both PSNR and objective qualities of reconstructed images. But it cost slightly CPU time since neighboring pixels directions determination and statistics.

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