Improved Low-Complexity Interpolation Algorithm for Deinterlacing

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Abstract-In this paper, we propose an improved low-cost deinterlacing method. The conventional low-complexity interpolation method for deinterlacing (LCID) has a observably better exhibition than other method using one field while requiring low complexity. However, sometimes it gives unpleasant subjective performance due to the miscalculating of edge direction. We aim to increase the interpolation accuracy of the LCID by adopting several practical weight assessments. The proposed method has a low-cost weight assessing design. The simulation-results indicate that the proposed method outperforms conventional techniques.

Keywords -interlaced-to-progressive conversion, low-cost weighted average, image interpolation.

I. INTRODUCTION

Deinterlacing is a procedure for converting a video sequence from an interlaced scanning format into a non-interlaced scanning format. This is an essential function in a digital TV system where the input signal may have different video formats. With an interlace scan, the frame rate is doubled while requiring the same bandwidth occupation [1]. However, the interlaced scanning format brings unacceptable visible artifacts such as line twitter, crawling, and interline flicker due to the nature of the interlaced scanning procedure [2, 3]. Moreover, signal with interlaced scan is unacceptable for instruments such as PC monitors, LCD displays, and video printers that need a progressive scanning format. Therefore, to convince compatibility with existing TV broadcasting standards, deinterlacing is demanded to convert interlaced signal to progressive signal.

Numerous deinterlacing methods have been presented to solve the above issues. Previous techniques can be roughly classified into four groups. The deinterlacing methods with spatial information can be classified into the first class which uses a single field [4-12]. On the other hand, the deinterlacing methods with spatio-temporal information can be classified into the second class which uses several fields [13-17]. In general, the deinterlacing methods with temporal information are more profitable but more complex than the methods with spatial information. However, they are not expected to give better performance in cases with unreliable motion information, and they need higher hardware complexity and are suffered by latent error propagations. Also, their space-time cost frequently limits their application. The temporal domain deinterlacing methods usually utilize spatial domain methods as a basis. Therefore, a new spatial domain method is still required to enhance the image interpolation performance, and we will focus here on the spatial domain deinterlacing method.

Many spatial interpolation techniques have been proposed to improve the quality of the interpolated images by enhancing the edges and the overall image sharpness. Among them are the classical edge direction-based linear filters, including edge based line average (ELA) [4], efficient ELA (EELA) [5], direction-oriented interpolation (DOI) [6], new edge dependent deinterlacing (NEDD) [7], Fuzzy detection of edge-direction (FDED) [8], Motion adaptive de-interlacing with local scene changes detection (MADLSCD) [9], deinterlacing using locally adaptive-thresholded binary image (LABI) [10], and low-complexity interpolation method for deinterlacing (LCID) [11]. An alternative is to employ a non-linear and soft computing-based approach which includes fuzzy logic for image interpolation, namely fuzzy DOI (FDOI) [12].

In this paper, following this introduction, the conventional LCID method is explained in Section II. The proposed reformed low-complexity interpolation (RLCI) method is presented in Section III, followed by simulation results and conclusion in Sections IV and V.

II. CONVENTIONAL LCID METHOD

Let \(x(i,j)\) indicates the pixel to be deinterlaced where the parameter \(i\) refers to the column number and \(j\) to the line number. To deinterlace the current missing pixel, the 2D localized window is adopted as shown in Fig. 1. Here, the parameters \(u, d, l, m, r\) represent \(up, down, left, mid, and right\), respectively. To calculate the dominant edge direction, we use four directional luminance differences, denoted as \(p, q, r,\) and \(s\), as follows:

\[
\begin{align*}
    p &= |ul - dr| + |um - dl|, \\
    q &= |um - dl| + |ur - dm|, \\
    r &= |um - dl| \times 2, \\
    s &= |um - dl| + |dm - dl|.
\end{align*}
\]

The deinterlaced pixel can be estimated as (2):

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According to the Eq. (2), the LCID algorithm is influenced by previously computed missing pixel values when \( s = 0 \). In that case, the results make the system unstable when the image contains noise, and the information tends to cause, or exaggerate, error propagation. To solve the above issue, we propose the RLCI method which is not a time-recursive scheme in the sense that the previously encoded missing pixel is not used as the reference for the pixel to be interpolated, which helps to stop error propagation of the LCID.

III. THE PROPOSED RLCI METHOD

The RLCI method is an improved version of the LCID method that was explained in Section II. The idea behind the RLCI is to add further weight assessing evaluator for computing the directional correlation more efficiently. The computationally low-cost structure of the RLCI algorithm was designed for easy realization. Given in Fig. 2, it is known that the measurements \( \Gamma_{\theta} \) stand for the luminance difference value on the edge direction with \( 0^\circ \), \( 90^\circ \), \( 45^\circ \), \( 60^\circ \), \( 120^\circ \), and \( 135^\circ \), respectively.

The idea behind our work is to give larger weights to the directions that have a smaller \( \Gamma_{\theta} \) as the center.

The interpolated pixel can be estimated as (5).

\[
x_{\text{RLCI}}(i,j) = \begin{cases} 
\frac{(\omega_{x=\theta,H} | u + w + d + m)}{2 (\omega_{x=\theta,H} + \omega_{x=\theta,V})} & \text{if } \{\text{MIN} = \Gamma_{x=\theta,H} \} \& \{\Gamma_{\theta} \neq 0\} \\
\frac{((\omega_{x=\theta,H} | u + w + d + m) + (\omega_{x=\theta,V} | u + w + d + m)})}{2 (\omega_{x=\theta,H} + \omega_{x=\theta,V})} & \text{if } \{\text{MIN} = \Gamma_{x=\theta,V} \} \\
\frac{((\omega_{x=\theta,H} | u + w + d + m + d) + (\omega_{x=\theta,V} | u + w + d + m + d))}{2 (\omega_{x=\theta,H} + \omega_{x=\theta,V})} & \text{if } \{\text{MIN} = \Gamma_{x=\theta,V} \} \\
\frac{((\omega_{x=\theta,H} | u + w + d + m + d) + (\omega_{x=\theta,V} | u + w + d + m + d))}{2 (\omega_{x=\theta,H} + \omega_{x=\theta,V})} & \text{if } \{\text{MIN} = \Gamma_{x=\theta,V} \} \\
\frac{(\omega_{x=\theta,H} | u + w + d + m + d)}{2 (\omega_{x=\theta,H} + \omega_{x=\theta,V})} & \text{otherwise}. 
\end{cases}
\]

The idea behind our work is to give larger weights to the directions that have a smaller \( \Gamma_{\theta} \) as the center.
IV. SIMULATION RESULTS

The experiments of the proposed RLCI method were conducted on seven test sequences of CIF size (Akiyo, Flower, Foreman, Mobile, News, Stefan, and Table Tennis). To compare the RLCI algorithm with conventional techniques, we use the following dissimilarity function, i.e., peak signal-to-noise ratio (PSNR) in decibels (dB).

To calculate the average PSNR improvement up to -0.36 dB. Next we adopt the subjective image visual measure, to demonstrate the quality advantage of our proposed deinterlacing algorithm. Figure 4 shows the simulation results for the 65th Akiyo sequence.

V. CONCLUSION

In this paper, we proposed a reformed low-cost weighting supported deinterlacing method using single field. The presented rules are used to reduce artifacts occurring in edge directional interpolation, especially for lower angles. The proposed method was tested on seven CIF video sequences. Simulations results show that the developed method breakthrough resolution degradation caused by incorrect edge direction detection and gives better visual quality.

ACKNOWLEDGMENT

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REFERENCES


Table 1. PSNR comparison for CIF sequences (dB/frame).

<table>
<thead>
<tr>
<th>Method</th>
<th>Akiyo</th>
<th>Flower</th>
<th>Foreman</th>
<th>Mobile</th>
<th>News</th>
<th>Stefan</th>
<th>Tennis</th>
<th>Average</th>
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<tbody>
<tr>
<td>ELA</td>
<td>37.68</td>
<td>21.93</td>
<td>31.40</td>
<td>23.34</td>
<td>31.53</td>
<td>25.97</td>
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<td>26.36</td>
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<td>ROI</td>
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<td>22.25</td>
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<td>FDOI</td>
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Table 2. Average CPU time for CIF sequences (ms/frame).

<table>
<thead>
<tr>
<th>Method</th>
<th>Akiyo</th>
<th>Flower</th>
<th>Foreman</th>
<th>Mobile</th>
<th>News</th>
<th>Stefan</th>
<th>Tennis</th>
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<td>36.8</td>
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<td>539.0</td>
<td>312.5</td>
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<td>15.8</td>
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<td>33.0</td>
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<td>63.9</td>
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<td>43.75</td>
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Reference Number: W09-0047
Figure 4. Magnified subimages cut from the testing image: the 65th Akiyo. (a) Original, (b) ELA, (c) EELA, (d) DOI, (e) NEDD, (f) MADLSCD, (g) LCID, and (h) RLCI.