DE-INTERLACING OF VIDEO DATA USING MOTION VECTORS AND EDGE INFORMATION

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ABSTRACT
EDDI (Edge Dependent De-Interlacing) is a new method for effectively removing jagged edges from interlaced video. It detects and quantifies edges for optimal image interpolation, with applications in high-end as well as in economy de-interlacing.

INTRODUCTION
Philips has a strong position in the high-end TV market with its ‘100 Hz’, ‘Digital Scan’, ‘Natural Motion’ and ‘Digital Natural Motion’ TV sets. The main capabilities that have been needed for this success have been true-motion estimation, de-interlacing and picture rate conversion. In this paper, we introduce a new concept, EDDI, for improved Edge Dependent De-Interlacing.

Attempts to use edge information to de-interlace video have been reported before [1, 2, 3], but the algorithms that we propose in this paper either have a better performance, or a simpler implementation than the earlier techniques. This is because we have focused our edge dependent interpolation on just those few pixels in the image that will certainly profit from edge based interpolation.

The first application we designed is an economy concept that applies EDDI to improve a vertical-temporal (VT) median filter [2]. It was observed that for long diagonal edges in the image, this gives even better results than advanced motion compensated (MC) de-interlacing techniques, although admittedly these are better in all other critical picture parts. The second de-interlacing concept we designed therefore uses EDDI to replace the output from MC de-interlacing by an edge dependent interpolation on long diagonal edges. Experimentally, it was verified that the result is superior over all other available de-interlacing methods.

EDDI
We observed that the improvement potential of edge-based interpolation, even when compared to simple line averaging, exists only in near horizontal edges. We concluded that in other parts, edge based interpolation can only introduce risks. We reduced the sensitivity of our detector for these parts using a high-pass filter in the vertical domain (to detect edges) cascaded with a low-pass filter in the horizontal domain (to reduce the sensitivity for near vertical edges). Let $F(\hat{\mathbf{x}}, n)$ be the luminance value of a pixel at position $\hat{\mathbf{x}} = (\hat{x}, \hat{y})$ in picture number $n$, then the output of the filter is defined by:

$$F_x(\hat{x}, n) = \sum_k H(k) F(\hat{x} + \hat{k}, n)$$

with $\hat{k} = (k_x, k_y)$, and

$$H(k) = \begin{cases} -1, & (-1 \leq k_x \leq +1 \lor k_y = \pm 2) \\ 2, & (-1 \leq k_x \leq +1 \lor k_y = 0) \\ 0, & (\text{otherwise}) \end{cases}$$

Figure 1 illustrates the effectiveness of the pre-filter. Figure 1a also suggests that the edge orientation, i.e. the optimal interpolation angle, is indicated by the length of the white and black bars, while the position of the edge is identified by the zero-crossings in the horizontal dimension. We found that this information can directly be used as a basis for edge orientation detection. However, a protection algorithm proved useful to make the edge interpolation more robust.
ROBUST EDGE INTERPOLATION

The essence of the robustness improvement is that we mix the output of the EDDI algorithm, $F_i(x,y,n)$, with the output $F_i^2(x,y,n)$ of an initial de-interlacing method, as shown in Figure 3b. The initial method is VT-median filtering [2] for the economy version and MC adaptive recursive [2] for the high performance application. The control parameter of the mixer, $k$, is set such that the absolute difference between the output $F_0(x,y,n)$ and $F_i(x,y,n)$ equals half the absolute difference of $F(x−l,y+1,n)$ and $F(x+l,y−1,n)$. This is achieved using:

$$1 - k = \frac{|F(x−l,y + 1,n) - F(x + l,y - 1,n)|}{2|F_i^2(x,y,n) - F(x - l,y + 1,n)|}$$

(3)

The rationale is that $F_i(x,y,n)$ results from edge controlled interpolation between original pixels $F(x−l,y+1,n)$, where the estimated interpolation angle determines $l$. With the same interpolation angle, we can also predict $F(x−l,y+1,n)$ from $F(x+l,y−1,n)$. As the interpolated pixel $F_i(x,y,n)$ has a position exactly in between $F(x−l,y+1,n)$ and $F(x+l,y−1,n)$, we expect the error in the prediction of $F_i(x,y,n)$ to be twice as small as the prediction error in $F(x+l,y−1,n)$.

RESULTS

In Figures 2a-b, the much improved performance of the economy de-interlacer is shown next to the output of a vertical-temporal median de-interlacer without EDDI. Figures 2c-d illustrate the improvement of advanced MC de-interlacing with EDDI. It is essential that the replacements only occur on long edges, where due to the aperture problem the motion vectors are often unreliable. In all other image portions, MC de-interlacing will generally be superior over any other method [2] and the use of edge based interpolation only introduces risks.

CONCLUSIONS

A new edge interpolation method can be integrated with a VT-median in a low-cost de-interlacing method, or can be used to post-process MC de-interlaced video signals. The latter option, by combining knowledge of edges and motion, results in the best currently known algorithm.

REFERENCES