Filtering Effects on Adaptive Multi-resolution Motion Estimation (AMRME) in Frame Interpolation Application

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Abstract

Different types of filters, together with sub-sample, can be used to produce multi-resolution (MR) images. This paper investigates the effects of using several famous N^{th} order low-pass FIR digital filters (using Blackman, Bartlett, Hamming, Hanning and Averaging windows) to produce MR images in the application of adaptive multi-resolution motion estimation (AMRME) for frame interpolation. It is expected that using different filters will greatly affect the performance of the AMRME algorithm as in the application of MR in video coding. However, our simulation results on image sequences show that the use of different kind of filters does not affect the AMRME performance in frame interpolation. Moreover, nearly similar results are produced when using only sub-sample to produce the MR images.

1. Introduction

The multi-resolution or pyramid structures of images have been widely used in image processing community due to its divide-and conquer capabilities [1]. For motion estimation application, global (and large) motion is first estimated at a coarse level of resolution with reduced sampling rate as allowed by the Nyquist criterion. The results of the coarse level estimates are then propagated to successively higher resolution levels (higher sampling rates) by taking the motion evaluated at the coarse level as an initial estimate for the motion at the next level. This is done iteratively until the full-resolution level is reached. Not only does the Multi-Resolution Motion Estimation (MRME) approach reduce the computational time in comparison with the single-resolution block matching methods, but it also achieves better picture quality.

2. Filters in MR structure

Many variations of the MRME are available in the literature, for example in [1], [2] and [3]. Recently, adaptive MRME (AMRME) was developed to combat the rigid structure of the MR [4]. The variants of the MRME technique differ in terms of the representation of the multi-resolution images, the levels of the pyramid, the block size and search space at each level, the motion estimation technique at each level, and general data-flow (coarse-to-fine or fine-to-coarse). Filters, followed by sub-sampling are used to represent the image in multi-resolution structure.

The effect of using different types of filters to produce the MR images is presented in this paper. Section 3 discusses the methods to produce the MR images using several filters followed by the application in motion estimation and frame interpolation. Results of the experiments and discussion are given in Section 4. Finally the paper is concluded in Section 5.

3. Method

The results of the experiment are produced according to the following steps:

Step 1: Apply different type of filters as shown in Table 1 to the image in previous frame and next fame. Each filter has different number of filter coefficients depending on the filter order.

Step 2: Sub-sample the image to produce different level of images. Example is shown in Figure 1. Two image pyramids is formed, one for previous frame and one for next frame.

Step 3: Perform AMRME as in [4] between the two image pyramids. A motion vector for every pixel at the lowest level of the image pyramid is obtained.

Step 4: Average between pixels in previous and next frame according to formula in [5].

Step 5: Find mean square error (MSE) between original and interpolated frame.

Table 1 Different type of filters

Filter Name	Filter Window	Filter Order
bm3	Blackman	3
Bm5	Blackman	5
Bm7	Blackman	7
Bt3	Bartlett	3
Bt5	Bartlett	5
Bt7	Bartlett	7
Hm3	Hamming	3
Hm5	Hamming	5
Hm7	Hamming	7
Hn3	Hanning	3
Hn5	Hanning	5
Hn7	Hanning	7

4. Results and discussion

The simulation is performed on 4 QCIF (176x144) image sequences namely Coastguard, Carphone, Miss America and Susie for frame interpolation from 5 frames per second (fps) to 10 fps. The MSE is calculated between interpolated frames and the original frames and averaged over the whole frames in the image sequences. Figure 3 shows the result of the simulation.

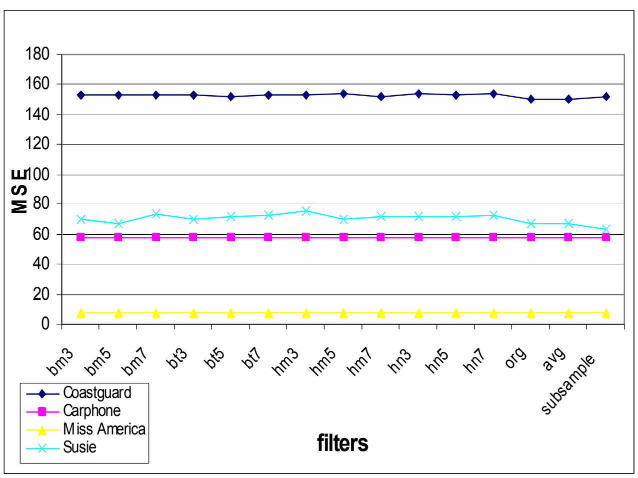

Figure 3 Effect of using different filters on AMRME algorithm for frame interpolation

All the filters gave the same performance in terms of MSE including averaging and sub-sampling. For Susie sequence, the MSE is a little lower for sub-sampling, but it is still within the 70 range. Coastguard has high MSE due to its fast motion and Miss America has the lowest MSE because of its little motion.

5. Conclusion

Using different type of filters to produce MR images does not affect the performance of AMRME algorithm in frame interpolation. This is shown using simulation on image sequences. Hence, it can be concluded that any type of low pass filters, including averaging, can be used to construct MR images. Moreover, sub-sampling, which is the easiest way to create MR images, performs almost the same as other filters.

6. References

[1] S. Zafar, Y. Q. Zhang and B. Jabbari, "Multiscale video representation using multiresolution motion compensation and wavelet decomposition". *IEEE J. Selected Areas Commun., Vol. 11*, 1993, pp 24-35.

[2] D. Tzovaras, M. G. Strintzis and H. Sahinoglou, "Evaluation of multiresolution block matching techniques for motion and disparity estimation". *Signal Processing: Image Communication*, *Vol. 6*, 1994, pp. 59-67.

[3] I. Rhee, G. R. Martin and R. A. Packwood, "A multi-resolution block matching technique for image motion estimation". *IEE Colloquium on Multiresolution Modelling and Analysis in Image Processing and Computer Vision*, 1995, pp. 5/1-5/6.

[4] H. A. Karim, M. Bister and M.U. Siddiqi, "Low Rate Video Frame Interpolation - Challenges And Solution", *Proceedings International Conference on Acoustics, Speech, & Signal Processing, Vol. 3, 2003*, pp. 117-120.

[5] R. Castagno, P. Haavisto, and G. Ramponi, "A method for motion adaptive frame rate up-conversion'', *IEEE Trans. on Circuits Syst. Video Technol. vol. 6, no. 5*, 1996, pp. 436-445.