Live-Cell Image Enhancement using Centre Weighted Median Filter

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Abstract: - Digital image processing is required for almost all type of images. Live-cell images are one of those image requires digital image processing. This paper proposed a centre weighted median filter for live-cell video enhancement. Three different types of filters were compared and results showed that the most effective filter is the centre weighted median filter.

Key-Words: - Live-cell, Centre Weighted Median Filter, Digital Image Processing

1 Introduction

Digital images are always affected by noise, blurring, incorrect colour balance and poor contrast. These digital images can be acquired through scanners, digital cameras, CCD cameras (Charged Coupled Devices), video cameras, optical microscope or laser-scanning confocal microscope. Image processing software will be required to enhance these images.

Live-cells images suffered similar problems and relies on digital image processing. In this paper, stages of the enhancement process will be explained. The focus is on noise removal of live-cells video sequences.

The main purpose of digital image processing is to produce higher quality images. Cell images will have to go through a few stages, namely color correction, contrast enhancement, noise filtering, image sharpening and finally high quality of visibility images will be produced.

Optical microscopy coupled with CCD cameras is one of the methods used to capture live-cell images. Currently optical microscopy is a rapidly developing field that depends highly upon digital image processing techniques [2]. However, even with carefully configuration of the microscope, captured digital images often display uneven backgrounds, excessive noise, artifacts, poor contrast and color balance errors [2].

2 Digital Image Processing and Live-Cell Images

Some investigators rely on the power of digital image processing to extract information from noisy or low-contrast images rather than adjusting the microscope or image sensor [2]. Combination of careful adjustment of the microscope or image sensor with digital image processing should produce much higher quality of visibility.

The proposed method is not limited to live-cells images. Still images such as captured by automated microscopy will be able to use the same tool. Analysis of captured images from well plates can go through the same cell image enhancement process. Visual inspection can be done and is fast, information-rich and can distinguish subtle effects [3]. However, automated image analysis tool will be required for screening large number of images. Image analysis tool can reduced the number of images that will be required for visual inspection.

A video sequence is basically a sequence of still images called frames. Therefore, a video sequence can be extracted to produce a set of still images. These still images can go through the enhancement process. Finally, the enhanced images can be joined together to create a video sequence. This video sequence will have better quality of visibility. Figure 1 shows the stages that live-cells video will have to go through to produce a better visibility video sequence.

3 Noise Filtering

There are different types of noise filters. The efficiency of median filter in removing noise is proved from previous research project. Median filter is able to preserve the detail of an object and do not change the shape of object. Many types of applications have used median filters. Applications of the enhanced median filter in different type of

applications can be found in [4 - 14]. In the cell image enhancement an enhanced median filter will be used.

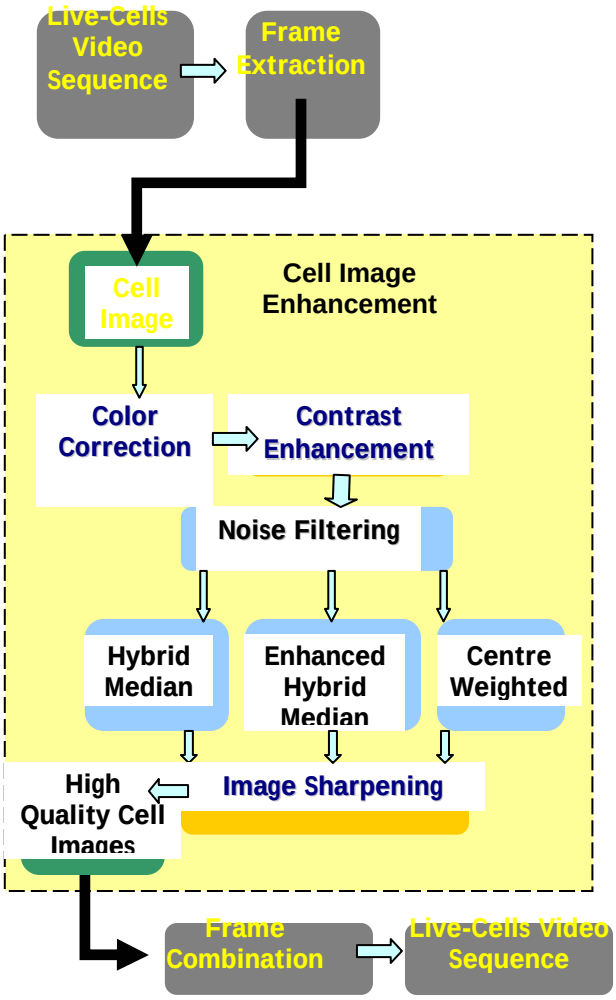

Fig. 1. Live-Cells Video Enhancement

2.1 Median Filter

Median filter is a nonlinear filter. A nonlinear filter has a result that cannot be found by a weighted sum of the neighborhood pixels, such as is done with a convolution mask. However, the median filter does operate on a local neighborhood. Firstly, the size of the local neighborhood (kernel, window) is defined. Then, the pixels in the neighborhood are ranked in the order of their levels by using sorting algorithm. Finally, the center pixel is replaced with the median, or center, value present among its neighbours, rather than by their average [15]. This operation will be repeated until the whole pixels of the image are being read

The two major disadvantages of median filter are that it will round off the corner of object in the image and it takes longer time to sort the pixels in the image in order to get a median value. One of the objectives is to solve the corner round off problem.

2.2 Enhanced Hybrid Median Filter

A normal hybrid median filter is just like a combination of many median filters. It performs median filtering with different shape of kernel separately and gathers the median values to determine the final median value.

An enhance hybrid median filter were proposed and it will do the median filtering by using square-mask, plus-mask and x-mask separately to get the median values for each of them. These median values will be sorted to get the median value. The center pixel from the sorted values will be used as the median value.

The difference between our enhance hybrid median filter is the calculation of the center pixel value. In typical hybrid median filter the center pixel value is determined through mean value from the median values that was calculated.

2.3 Centre Weighted Median Filter

The proposed centre weighted median filter applies the concept of center weighted median filter to the enhanced hybrid median filter that is mention before. Center weighted median filter is a filter that gives more weight to the center pixel. This weight corresponds with the size of the kernel. If the size of kernel is three, then the weight of the center pixel is three.

The figure weight will be used to repeat the center. For examples, if the kernel size is 3x3, then the total number of pixels that will be converting to array for performing sorting will be 11. This filter is able to preserve details of image better than the proposed hybrid median filter

4 Results and Evaluation

Results from the prototype are shown in Figure 2. A few snapshots were taken. Picture used was a co-distribution of microtubules and ER in the lamella of an epithelial cell imaged using digital multi-wavelength fluorescence microscopy was taken from MBC Online, The American Society for Cell Biology (C. Waterman-Storer, 1998). Artificial noise and blurring effect were added onto the image. The output image has higher visibility.

Results were compared among the three different filters, namely the hybrid median filter, the enhanced median filter and finally the centre weighted median filter. Mean absolute error (MAE)

and mean square error (MSE) will be used for the evaluation. Table 1 show the results of images that were corrupted by uniform noise with different type of filters used. Table 2 show the results of removing 10% of Gaussian noise and Table 3 shows the results of removing 10% of salt and pepper noise with different type of filters used. The proposed centre weighted median filter produce better results compared to the other two methods.

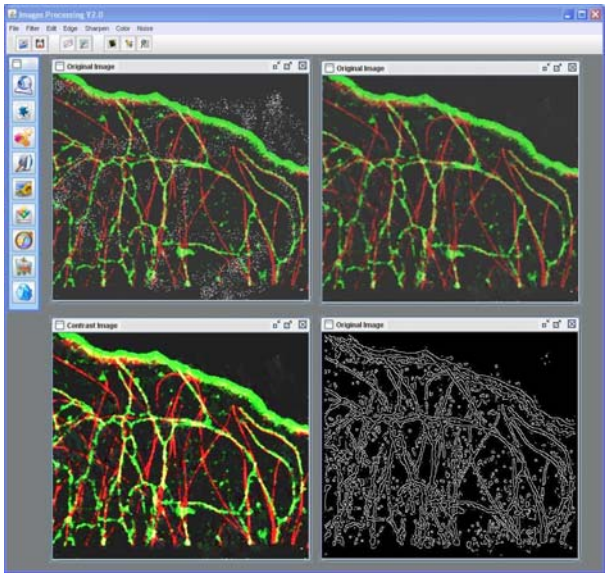

Fig. 2. Snapshot of the Tool

TABLE 1. Results of Filters for Uniform Noise Corrupted Image

Filter	Size	MAE	MSE
Hybrid Median	3x3	30	656
Enhanced Median	3x3	30	656
Center Weighted Median	3x3	20	394

TABLE 2. Results of Filters for Gaussian Noise

Filter	Size	MAE	MSE
Hybrid Median	3x3	60	2391
Enhanced Hybrid Median	3x3	60	2391
Center Weighted Median	3x3	45	1718

TABLE 3. Results of Filters for Salt and Pepper Noise

Filter	Size	MAE	MSE
Hybrid Median	3x3	57	4712
Enhanced Median	3x3	57	4712
Center Weighted Median	3x3	47	4209

5 Conclusion

The tool will be useful for high-throughput cell images. Image and video enhancement of live-cells are required for better visibility. High quality images will produce higher accuracy in cells recognition. Large amount of images requires high computing power. Technology advancement in parallel computing will be able to solve the problem. The tool will be useful for high-throughput cell images.

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References:

[1] M. W. Davidson, M. Abramowitz, Olympus America Inc., and The Florida State University. Introduction to live-cell imaging techniques: http://micro.magnet.fsu.edu/primer/techniques/ livecellimaging/index.html

[2] M. W. Davidson, M. Abramowitz, Olympus America Inc., and The Florida State University. Digital imaging in optical microscopy: http://micro.magnet.fsu.edu/primer/techniques/ livecellimaging/index.html

[3] J. C. Yarrow, Z. E. Perlman, N. J. Westwood and T. Mitchison, A high-throughput cell migration assay using scratch wound healing, a comparison of image-based readout methods, BMC Biotechnology Online, September 2004.

[4] A. C. Bovik, T. Huang and D. C. Munson, "A generalization of median filtering using linear combinations of order statistics," *IEEE Trans. Acoust., Speech, Signal Processing*, vol. ASSP-31, pp. 1342-1350, Jun. 1983.

[5] L. R. Rabiner, M. R. Sambur, and C. E. Schmidt, "Applications of a nonlinear smoothing algorithm to speech processing," *IEEE Trans. Acoust., Speech, Signal Processing*, vol. ASSP-23, pp. 552-557, Dec. 1975.

[6] T. *S.* Huang, G. J. Yang, and G. Y. Tang, "A fast two-dimensional median fiitering algorithm," *IEEE Trans. Acoust., Speech, Signal Processing*, vol. ASSP-27, pp. 13-18, Jan. 1979.

[7] E. Ataman, V K. Aatre, and K. M. Wong, "A fast method for real-time median filtering," *IEEE Trans. Acoust., Speech, Signal Processing*, vol. ASSP-28, pp. 415-420, Aug. 1980.

[8] T. Chen, K.-K. Ma and L. -H. Chen, "Tri-state median filter for image denoising," *IEEE Trans. Image Processing*, vol. 8, pp. 1834-1838, Dec. 1999.

[9] Hakan G¨uray Senel, Richard Alan Peters II, and Benoit Dawant, "Topological Median Filter", IEEE Transaction on Image Processing, vol. 10, no. 12, December 2001.

[10] K. Manglem Singh, I. K. Bora and S. Birendra Singh, "Rank-ordered Mean Filter for Removal of Impulse Noise from Images", IEEE ICIT, Bangkok, Thailand,2002.

[11] K. Manglem Singh and P. K. Bora, "Adaptive Vector Median Filter For Removal Impulse From Color Images", IEEE, 2003.

[12] C. P. Mauer and V. Bindokas, "3d Hybrid Median Filter", 2004. http://rsb.info.nih.gov/ij/plugins/hybrid3median.html

[13] C. P. Mauer, "2d Hybrid Median Filter", 2004. http://rsb.info.nih.gov/ij/plugins/hybrid2median.html

[14] T. Rabie, "Adaptive hybrid mean and median filtering of high-ISO long-exposure sensor noise for digital photography", Journal of Electronic Imaging 13(2), 264– 277, April 2004.

[15] M. A. Schulze, "What Are The Mean And Median Filters", April 2001. http://www.markschulze.net/java/meanmed.html.

[16] 6. T. Rabie, Adaptive hybrid mean and median filtering of high-ISO long-exposure sensor noise for digital photography", Journal of Electronic Imaging 13(2), 264– 277, April 2004.