Contrast Enhancement Image Processing Technique on Segmented Pap Smear Cytology Images.

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Abstract
Contrast is one of the factors that influence the accuracy of interpretation of cervical cancer cells on Pap smear images by pathologist. Blur and highly affected by unwanted noise on Pap smear images could give rise in false diagnosis rate. The current study combined moving *k*-means clustering algorithm and linear contrast enhancement to be used as contrast enhancement technique. Then, the proposed technique was used to enhance the contrast of Pap smear images. The results indicated that the proposed method could enhance the contrast of Pap smear images better than conventional linear contrast enhancement technique as well as using moving *k*-means clustering algorithm alone. The changes of grey level, size and shape of cervical cells' nucleus and cytoplasm were enhanced and thus, provide clearly seen Pap smear images for better cervical cancer screening process by pathologist.

Introduction
To date, contrast enhancement process plays an important role in enhancing medical images' quality. Several previous studies proved that contrast enhancement techniques capable to clean up the unwanted noises and enhance the images' brightness and contrast [1][2][3]. The resulting enhanced medical images provided clearer and cleaner images for better and easier disease screening process by doctor.

Pap test is the most popular and effective screening test for cervical cancer. By extracting and observing morphological of cervical cells, doctor will classify cervical cells based on Bethesda system; normal, *low grade squamous intraepithelial lesion* (LSIL) or *high grade squamous intraepithelial lesion* (HSIL) cell [4]. However, in some cases, the Pap smear images are blur and highly affected by unwanted noises [4][5][6]. Those problems could hide and obscure the important cervical cells morphologies, which can increase the false diagnosis rate. Therefore, the current study will propose a contrast enhancement technique, which combines the clustering algorithm and linear contrast enhancement technique, to enhance the changes of grey level, size and shape of cervical cells' nucleus and cytoplasm on Pap smear images.

The Proposed Contrast Enhancement Technique
As mentioned, the proposed technique includes two image processing technique, which are segmentation and contrast enhancement process, as shown in Figure 1.

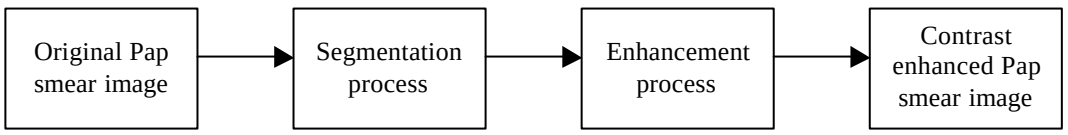


Figure 1: The proposed contrast enhancement technique.

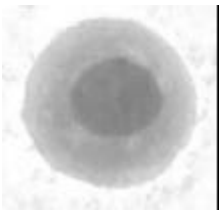
In the segmentation process, the original Pap smear images will be segmented into several regions. Commonly, in the previous studies, segmentation process is applied to segment Pap

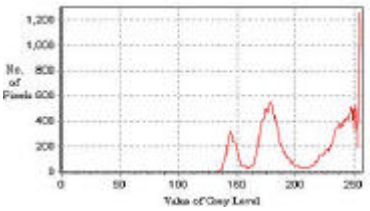
smear images into cervical cells nucleus and cytoplasm, and background regions [7][8]. In order to extend the application of segmentation process as contrast enhancement technique, the number of segmented regions must be set significantly high. This is because, by setting the number of segmented regions with small value, each segmented regions will represent large range of grey level. Therefore, any changes of grey level that occur in the nucleus, cytoplasm and background will not be seen. In the current study, the appropriate number of segmented regions that provide good Pap smear image enhancement performance is 60. For the segmentation process, the current study proposed moving *k*-means clustering algorithm [9].

In some Pap smear images, the digitisation process does not fully utilize the dynamic range that is available in digital images, which produce low contrast Pap smear images. Therefore, the current study applied linear contrast enhancement to the segmented Pap smear image as shown in Figure 1. The linear contrast enhancement algorithm manipulates the histogram of the segmented Pap smear image linearly so that it's dynamic range is fulfilled. The resultant segmented Pap smear image will appear to be more uniform in contrast.

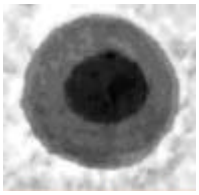
Results and Discussion

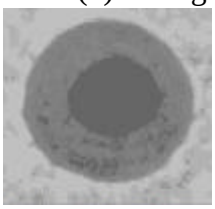
The proposed contrast enhancement technique was tested on three Pap smear images, namely Pap1, Pap2 and Pap3. As for contrast enhancement performance comparison, conventional linear contrast enhancement and moving *k*-means clustering algorithm were also applied to those Pap smear images. Figure 2, 3 and 4 show the contrast enhancement results for Pap1, Pap2 and Pap3 respectively. For each figure, image (a) shows the original Pap smear image, while image (b) represents the histogram of distribution of Pap smear image's grey level. The results for contrast enhancement using linear contrast enhancement, moving *k*-means clustering and proposed technique are shown in image (c), (d) and (e) respectively.

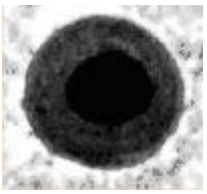




(a) Original Pap1 image (b) Histogram of grey level distribution

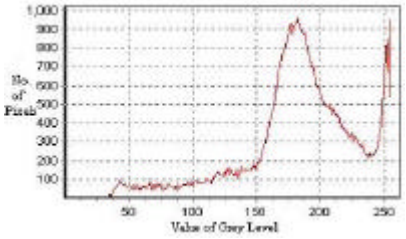




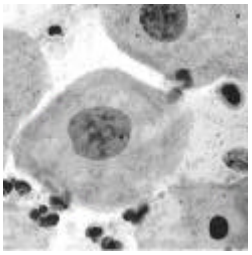
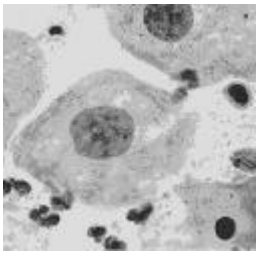
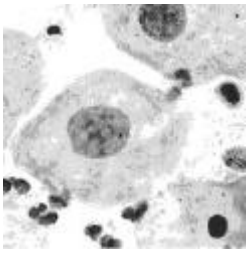


(c) Linear contrast enhancement (d)Moving *k*-means clustering (e) Proposed method

Figure 2: Results for Pap1 image after applying 3 different contrast enhancement techniques.

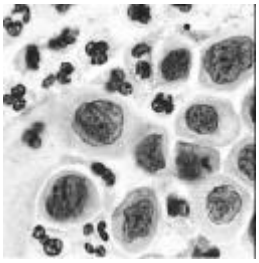
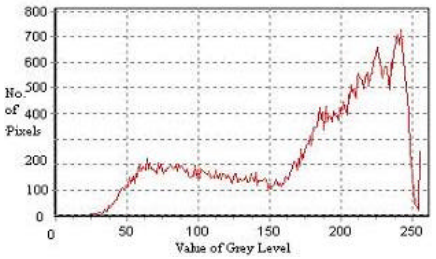


(a) Original Pap2 image (b) Histogram of grey level distribution

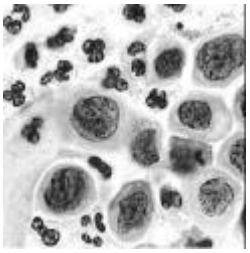
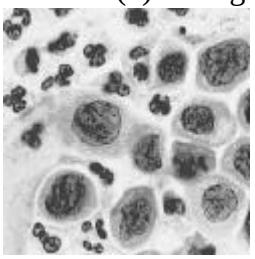
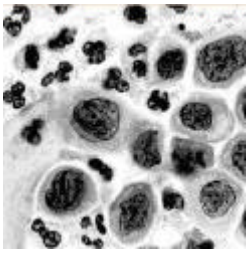




(c) Linear contrast enhancement (d) Moving *k*-means clustering (e) Proposed method

Figure 3: Results for Pap2 image after applying 3 different contrast enhancement techniques.

(a) Original Pap3 image (b) Histogram of grey level distribution

(c) Linear contrast enhancement (d) Moving *k*-means clustering (e) Proposed method

Figure 4: Results for Pap3 image after applying 3 different contrast enhancement techniques.

The contrast enhancement results obtained show that each technique produces different contrast enhancement performance. Let consider the contrast enhancement results produced by linear contrast enhancement algorithm. Based on Figure 2(b), the grey level of Pap1 image are distributed in small range of grey level dynamic range, which is between 130 and 255. The grey level range has successfully been spread to full grey level dynamic range, which significantly increase the contrast of Pap1 image, as shown in Figure 2(c). The changes of grey level, size and shape of nucleus, cytoplasm and background can be seen clearly. However, based on Figure 3(b) and 4(b) for Pap2 and Pap3 images respectively, the grey level for those images are distributed between 35 and 255, and between 25 and 255, which is almost in the full grey level dynamic range. Linear contrast enhancement could only spread the grey level within small range. As a result, the contrast of Pap2 and Pap3 image are insignificantly enhanced, as shown in Figure 3(c) and 4(c) respectively.

The contrast enhancement results obtained in Figure 2(d), 3(d) and 4(d) for Pap1, Pap2 and Pap3 image respectively, show that moving *k*-means clustering algorithm has been proved to be promising to provide better Pap smear images. Compare to original Pap smear images, moving *k*-means clustering capable to segment the changes of grey level in nucleus and cytoplasm into several clusters, which makes the changes can be seen clearer. However, the contrast of those Pap smear images were not increased.

Overall, the proposed technique produced better contrast enhancement performance as compared to linear contrast and moving *k*-means clustering algorithm. The changes of grey level, size and shape of nucleus and cytoplasm can be seen clearly, as shown in Figure 2(e),

3(e) and 4(e) for Pap1, Pap2 and Pap3 image respectively. The clear Pap smear images will assist cytotechnologist or cytopathologist for easier cervical cancer screening.

Conclusion

The current study has proposed contrast enhancement processing on segmented Pap smear images. In the beginning, Pap smear images are segmented into 60 regions using moving *k*-means clustering algorithm. The resultant segmented Pap smear image will make the changes of grey level in cells' nucleus and cytoplasm, and background can be seen clearer as well as their size and shape. Then, linear contrast enhancement algorithm is used to enhance the contrast of the segmented Pap smear image. This will provide clearer Pap smear image, which will assist cytotechnologist or cytopathologist for easier interpretation of abnormal cervical cells.

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