Proceedings of the 26th Annual International Conference of the IEEE EMBS
San Francisco, CA, USA • September 1-5, 2004

Oral Cancer Detection in Fluorescent Image by Color Image Fusion

C. F. Jiang, C. Y. Wang, C. P. Chiang*
Department of Biomedical Engineering, I-Shou University, Kaohsiung, Taiwan
*Department of Dentistry, National Taiwan University, Taipei, Taiwan

Abstract—**Biopsy is the main diagnosis method for oral cancer, which is the fifth most prevalent cancer in male population in Taiwan. In order to increase the accuracy of diagnosis, it is required to reveal the distribution of malignancy prior to biopsy. Based on this purpose, we developed the fluorescent image system associated with color image fusion algorithm to indicate the cancer-susceptible area in the oral image. The system therefore can assist physicians to make appropriate biopsy.**

Keywords— **Oral cancer, fluorescent image, image fusion**

I. Introduction

Oral cancer has been one of the serious cancers that affect the southern Asian, such as India, Pakistan, and Sri Lanka [1]. In Taiwan, oral cancer ranks as the fifth most prevalent cancer in male population due to their habit of chewing beetle nut [2].

Nowadays the biopsy method is still the main method for oral cancer diagnosis. However, in the early stage of malignancy, even the experienced doctor cannot easily determine the position for biopsy objectively. If the position can be focused prior to biopsy examination, it will not only increase the accuracy of biopsy but reduce the pain caused by it.

Currently the optical researchers in Taiwan is keen to develop noninvasive cancer diagnostic technique called "optical biopsy" to replace the conventional biopsy by analyzing the fluorescence spectra of the oral tissue [3-4]. Nevertheless, the fluorescent image obtained in the meantime seems to be paid less attention since it may reveal the distribution of malignancy. In our previous study [5], the 5-aminolevulinic (ALA)-induced fluorescent image acquisition system was set up. We have also shown a promising result that the difference between RGB component images of the fluorescent image may reveal the suspect malignant area [6]. However, the differentiation of the R, G, and B images by human vision did add some difficulties for utilization of the system by the physicians. This paper shows the shortage have been improved by the technique of color image fusion to indicate the cancer-susceptible area in the oral image directly.

II. Methodology

1) Fluorescent image acquisition: A violet laser diode (NDHV310ACA, Nichia, 30mW, 405nm) is used as light excitation source. The patient were put ALA, an exogenous tumor-localized fluorescent agent, on the oral mucosa. After one hour, the cancerous cells would release ALA-induced porphyrins (PpIX), which can be excited by diode laser to emit red light (wavelength= 630 nm) in the fluorescent images. For each measurement, a white light image was taken first, followed by a fluorescent image. It was used as the control in comparison with the ALA fluorescent Image. Both of them were captured by the color CCD camera at the same lesion site to localize the suspected site.

2) *Color Image processing to reveal the cancerous site:* The procedure for color image fusion is summarized in figure 1 and described in details as following:

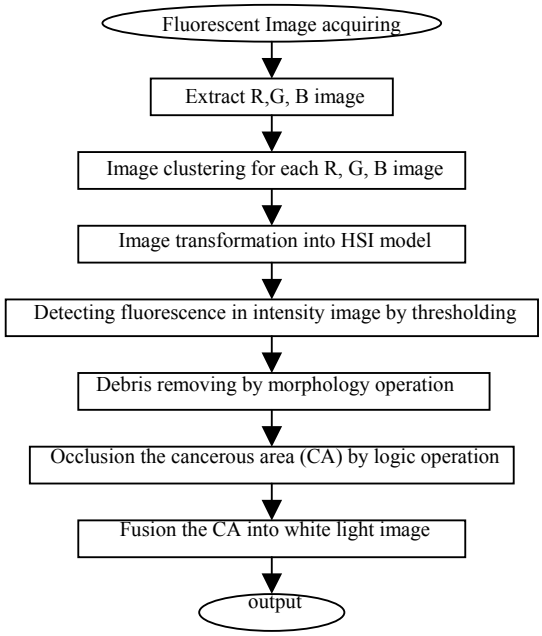


Fig. 1. the flowchart shows the procedure for color image fusion

The 3 component images based on the RGB-color-image model were extracted from the images of both types. Median filter [7] was first applied for each component image to remove the noises following the moment preserving segmentation [8], which automatically classified the image into 3 clusters according to the intensity of each pixel. The results were transformed into HSI-color-image model to obtain the intensity image (I component). The brightest area where shows the fluorescence in the intensity image could be segmented by the thresholding technique.

Some debris in the binary image left by thresholding was removed by morphological process combining with 'erosion' and 'dilation'. As indicated in our previous paper [6], the fluorescent area shown in the R component image but absent in G and B images may reflect the cancerous site. Hence, the exclusion the brightness area in G and B images from that in R image can be achieved by equation 1.

$$CA = \{S \mid \bigcup point \in R \cap Not(G \cap B)\} \qquad (1)$$

where point stands for the brightest pixels.

The final process is to fuse the binary result with the white light image for accurate localization.

III. RESULTS

The white light image with cancer-like lesion indicated by the yellow arrowheads and its corresponding ALA fluorescent image are demonstrated in figure 2.

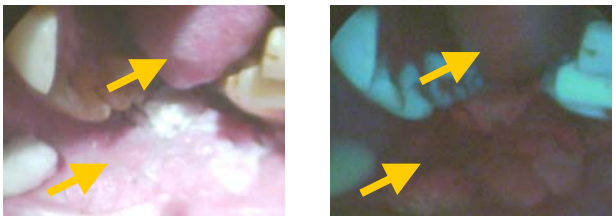
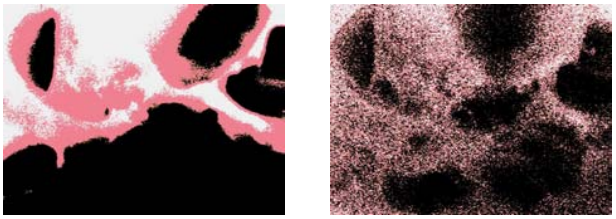


Fig. 2. *Left: original white light image ; right: ALA fluorescent image*

An example of moment preserving segmentation is given in figure 3. The right column is the results corresponding to R, G, B images of white light image in figure 2, while the same arrangement in the right column shows the result of the fluorescent image. The black regions in the left panels reveal the pixels with the brightest intensity due to the reflection of white light from the encountered surface. In contrast, the black regions in the right panels are due to the PpIX fluorescence (wavelength= 630 nm) and the reflection of violet laser (wavelength= 405 nm). Therefore the fluorescence may contribute mainly in the R image but not in G and B image wherein the brightness is the reflection of violet laser.



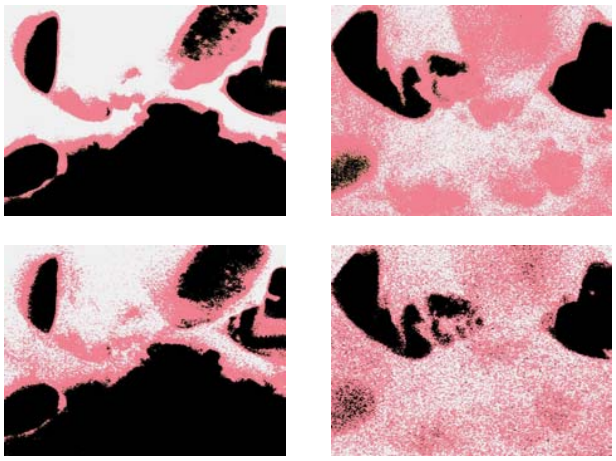


Fig. 3. Image clustering results of RGB component image (top to bottom) to reveal the three brightness levels from the brightest to the darkest as black, pink, and white. The left column is corresponding to the white light image, while the left to fluorescent image.

Figure 4 shows binary images achieved by a serious of operation decribed in figure 1. Refer to the figure caption for details.

Fig. 4. Top: the union of the brightest area separately in R,G,B image in right panel of figure 2. Middle: the union of the brightest area only in G and B image. Bottom: The difference between the above two images shows the cancerous area.

The cancerous areas shown in the bottom panel of figure 4 were finally put with pseudo color and fused with the white light image for correct localization as in figure 5.

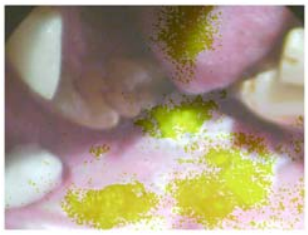


Fig. 5. The detected areas are put into the green color and fused with the white light image to show the correct site.

IV. Discussion

The detection system is based on this assumption that the metabolism rate of the malignant tissue is higher than the normal cells, therefore it can release the PpIX and shows the fluorescence more than the normal tissue. In white light image, the reflection of the white light is evenly distributed in the RGB three component images. Since no induced fluorescent effect occurs, the black regions in these images are the same consequently. In the contrast, the ALA fluorescence with the wavelength of red light mainly contribute into the red images, as a result, the black region segmented from the red image is widely spread in the tough. This is quite unique in comparison with the black region in the green and blue images where the black region almost occurred around the teeth

These results indicate that the brightest region in the red component image are contributed by fluorescent effect and laser beam reflection, while, the brightest regions in green and blue component images are mainly due to laser source reflection. Therefore, the difference in black regions between red image and the other component images may reveal the distribution of malignancy in oral cavity.

V. Conclusion

The location for biopsy determines the accuracy of oral cancer diagnosis. The empirical decision for biopsy location increase the risk of incorrect treatment as well as the pain of the patient. This paper demonstrates that the ALA fluorescent image system can reveal the distribution of oral malignancy and therefore may assist the physician to make a proper biopsy.

Acknowledgment

This research was supported by the Grant NSC 92-2218-E-214-003 of National Science Council of Taiwan.

References

[1] Control of Oral Cancer in Developing Countries – W.H.O. meeting report. World Health Bulletin 1984; 62: 817-830

[2] Department of Health, the Executive Yuan, R.O.C, Cancer Registry Annual report, Republic of China. 1996.

[3] C. Y. Wang, C. T. Chen, C. P. Chiang, S. T. Young, S. N. Chow, and H. K., "Chiang Partial least-squares discriminant analysis on autofluorescence spectra of oral carcinogenesis", *Applied Spectroscopy.* Vol 52(9), pp. 1190-1196, 1998

[4] C. Y. Wang, C. T. Chen, C. P. Chiang, S. T. Young, S. N. Chow, and H. K. Chiang, "A probability-based multivariate statistical algorithm for autofluorescence spectroscopic identification of oral carcinogenesis. ", *Photochemistry and Photobiology.* Vol. 69(4), pp. 471-477. , 1999

[5] C.Y. Wang1, T. Tsai , C.T. Chen, C.F.Chiang, H.M. Chen, C.P. Chiang, 2003, A Fluorescence Imaging System for Oral Cancer and Precancer Detection, IEEE EMBS Asian-Pacific Conference on Biomedical Engineering, Japan, *IEEE press 019318-1*

[6] C.F. Jiang, C.Y. Wang, and C.T. Chen 2003 , Detection of Oral Cancer by ALA Fluorescent Image, IEEE EMBS Asian-Pacific Conference on Biomedical Engineering, Japan, *IEEE press 019301-1*

[7] R.C. Gonzalez and R.E. Woods, Digital Image Processing, 2nd ed., Prentice Hall, 2002

[8] N. OTSU, "A Threshold Selection Method from Gray-Level Histograms", IEEE Trans. SMC 9 (1):62-66, 1979