Portable LED-induced autofluorescence imager with a probe of L shape for oral cancer diagnosis

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ABSTRACT

The difference of spectral distribution between lesions of epithelial cells and normal cells after excited fluorescence is one of methods for the cancer diagnosis. In our previous work, we developed a portable LED Induced autofluorescence (LIAF) imager contained the multiple wavelength of LED excitation light and multiple filters to capture ex-vivo oral tissue autofluorescence images. Our portable system for detection of oral cancer has a probe in front of the lens for fixing the object distance. The shape of the probe is cone, and it is not convenient for doctor to capture the oral image under an appropriate view angle in front of the probe. Therefore, a probe of L shape containing a mirror is proposed for doctors to capture the images with the right angles, and the subjects do not need to open their mouse constrainedly. Besides, a glass plate is placed in probe to prevent the liquid entering in the body, but the light reflected from the glass plate directly causes the light spots inside the images. We set the glass plate in front of LED to avoiding the light spots. When the distance between the glasses plate and the LED model plane is less than the critical value, then we can prevent the light spots caused from the glasses plate. The experiments show that the image captured with the new probe that the glasses plate placed in the back-end of the probe has no light spots inside the image.

Keywords: autofluorescence, LED, oral cancer, probe, light spots

1. INTRODUCTION

The squamous cell carcinoma of the lip, oral cavity and oropharynx usually are used to check the oral cancer. Oral cancer is a serious and growing problem in many developing counties and developed counties. In 2012, the new cases of Lip and oral cavity cancer in the world is around 300,373, and 145,353 deaths is due to these disease. The age-standardized rates of incidence and mortality of oropharyngeal cancer in 2012 were 4.0 and 1.9 per 100,000 persons per year, respectively[1]. In conventional examinations, the visual inspection and digital palpation of oral lesions is insufficient for oral cancer examination. The recognition of suspicious lesions with toluidine blue, brush cytology, tissue chemiluminescence, and autofluorescence are variable effectiveness[2-6]. Besides, the practitioners and patients are performed the invasive biopsies of oral lesions which require a specialist in a hospital for diagnoses. However, people living in developing countries of the low-resource regions have inadequate resources, specialists, hospitals for examination can delay for diagnosis and can lead to higher mortality. However, optical imaging provides the assistances for the clinicians to detect the oral cancer. Many previous studies have proposed the optical imaging systems that can record the spatial distribution of fluorescence image with the specific emission and the specific excitation wavelength on an oral tissue. These systems can non-invasively detect a region of oral cavity mucosa to survey the changes associated with oral cancer[6-12].

In order to provide an objective and reliable manner of oral cancer detection for clinicians to widely use in the clinics or in developing countries, a portable detection device is needed to be developed for the accuracy of the diagnosis. In this paper, we introduced our previous work, a portable LED induced autofluorescence (LIAF) imager, first. A portable LIAF imager in our previous study is developed to be used in clinics, but some parts of oral cavity can't be detected the valid images by medical doctors with the appropriate angles that they want. An improved probe of L shape contains a mirror is prosed for users to capture the valid images of oral cavity with the appropriate view angles. A glasses plate preventing the liquid entering in the body of a portable LIAF imager is set in front of the LED light model for avoiding the light spots. Finally, we show the image of the prototype with the probe of L shape, and we demonstrate the portable LIAF

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imager with the probe of L shape. The experiments show the differences between the images with the original probe and the new probe that the glasses plate placed in the back-end of the probe respectively.

2. A PORTABLE LED INDUCED AUTOFLUORESCENCE (LIAF) IMAGER

The portable LIAF imager proposed in our previous study contains multiple wavelength of LED excitation light to induce autofluorescence and multiple filters for specific fluorescence images. The system block diagram is showing as Fig. 1, and Fig. 2 shows the constructiondrawing of LIAF imager. The portable LIAF imager have LED light module of multiple wavelength for excitations. There are a rotary filter ring integrate with the detector head for user to select the band of filter they interested. The Probe ahead the LED light module is for the fixing object distance and shading the ambient light. The filter ring behind the LED light module can rotate by fingers to change filters, and the filter location is fixed by a positioning beads. The excitation light emitted from LED light module projects on the target of oral mucosal surface, then the autofluorescence will be induced from oral mucosal surface and go through the Probe, a hole in the middle of the LED light source as Fig. 3 showing, one of the filter on the filter ring. Finally, the image module contained a lens module and a color CMOS captures the fluorescence images. The embodiment of the portable LIAF imager show in Fig. 3.

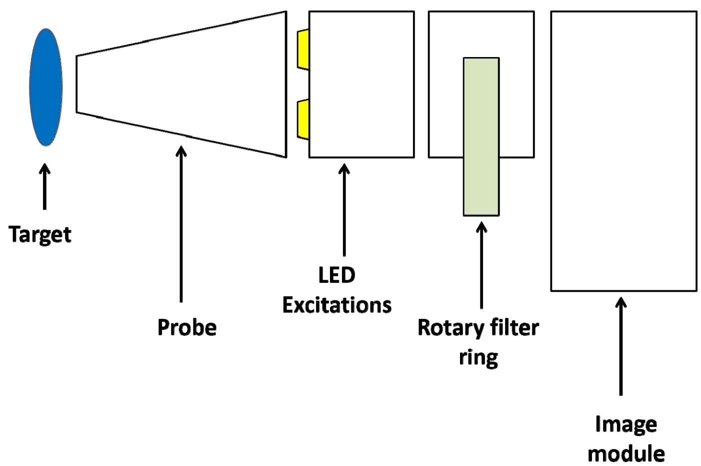
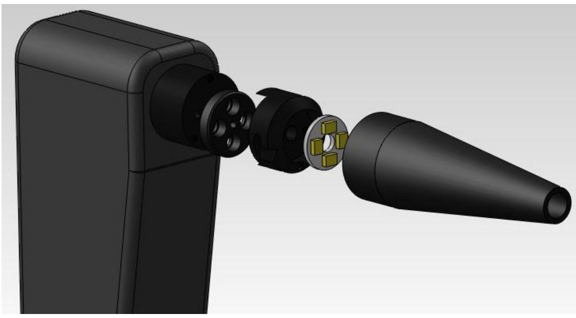


Figure 1. System block diagram of the portable LIAF imager.



(a)

(b)

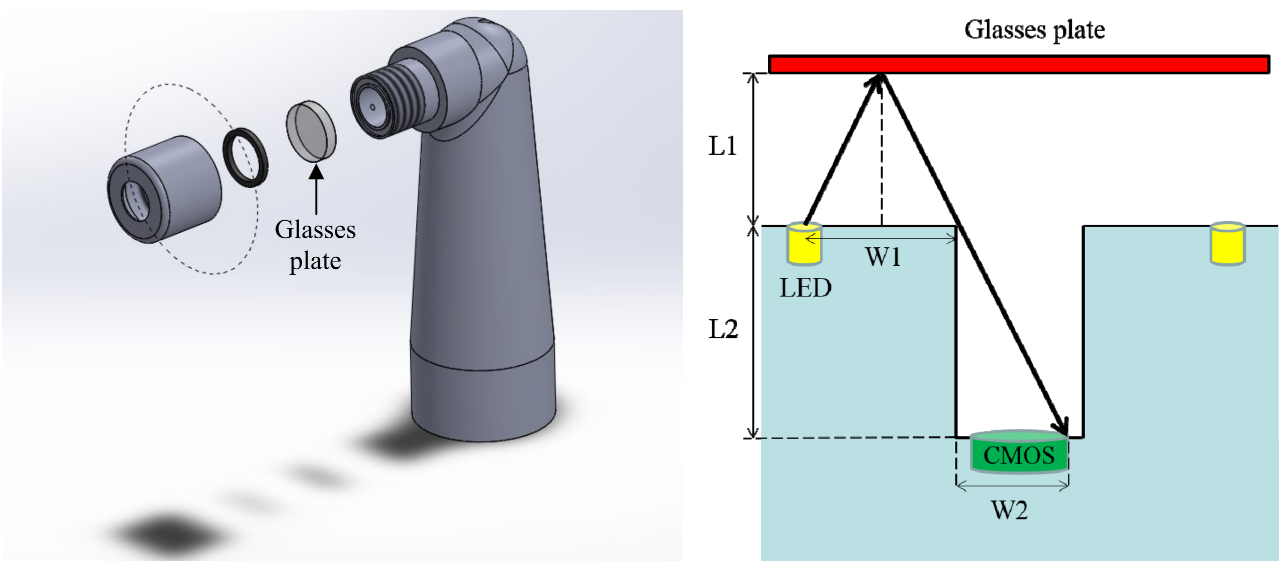
Figure 2. (a) The construction drawing of the portable LIAF imager; (b) the embodiment of the portable LED Induced Autofluorescence (LIAF) imager.

When a doctor use a portable LED Induced Autofluorescence (LIAF) imager in the clinics, a doctor cannot easily detect the deep part of the oral cavity with a right angle. In Fig. 3, when we want to detect the deep part tissue with a right angle, the probe will be stopped by the mouth, or the images captured on the deep part of oral cavity are not detect with right angle. Therefore, a new probe designed as L shape is introduced in the following section.

Figure 3. The demonstration of a (LIAF) imager with original probe.

3. DESIGN AND EMBODIMENT OF THE PROBE

First, we designed a probe of L shape that contained a mirror to reflect the light from LED module and the image back to CMOS. A glasses plate preventing the liquid entering in the body of a portable LIAF imager is set in the front-end of the probe as Fig. 4 (a) showing. But the light spots on the images are caused by the reflection light from the glasses plate as Fig. 4 (b) showing, and they cause some part of the image saturation and block the information of the saturation part as Fig. 7 showing.

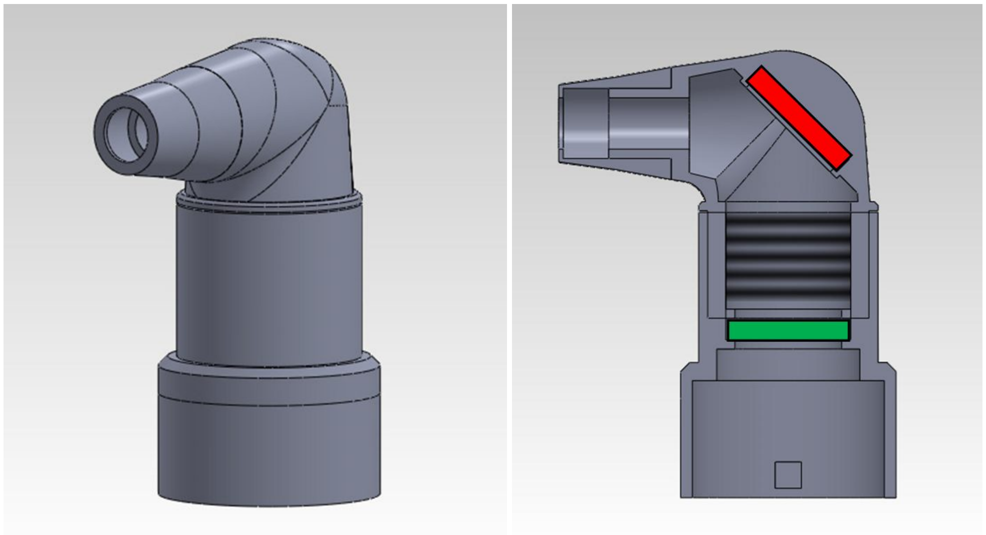


(a) (b)

Figure 4. (a) Initial design of the L shape probe; (b) the light spots are caused by the reflection light from the glasses plate.

In Fig. 4 (b), the distance L_1 means the distance between the glasses plate and LED light module, the distance L_2 means the depth from the CMOS and the plane of LED light module, the radial width W_1 means the radial width from the cone wall of the cylindrical hole to the LED, the width W_2 means the radial width from the cone wall of the cylindrical hole to the far edge of CMOS. When the distance L_1 is longer than the value calculated by (1), the light spots will be caused by the glasses plate. Therefore, we redesign the probe of L shape contained a mirror similar to the original as Fig. 5 (a), but the glasses plate is placed in the back-end of the probe and in front the LED model as Fig. 5 (b) showing.

$$L_1 = \frac{W_1}{2 \times W_2} L_2 \quad (1)$$



(a) (b)

Figure 5. (a) The construction drawing of the new probe of L shape; (b) a cross section of the new probe of L shape.

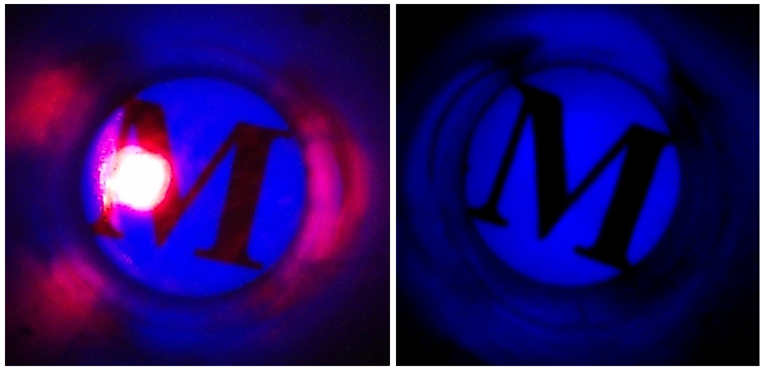
In Fig. 5 (b), the mirror is marked the red block and the glassed plate is marked the green block. The distance L_1 is less than the critical value calculated by (1), then the light spots is prevented to produce on the images. Figure 6. (a) shows the embodiment of a portable (LIAF) imager with the new probe of L shape, and Fig. 6 (b) shows the demonstration of a portable (LIAF) imager with the new probe of L shape. The practitioners can easily capture the images of oral cavity with the right angle, and subjects do not need to open their mouse constrainedly.

(a) (b)

Figure 6. (a) The embodiment of a portable (LIAF) imager with the new probe of L shape; (b) the demonstration of a portable (LIAF) imager with the new probe of L shape.

4. EXPERIMENTS

We captured the character M for experiments. The images are captured with the initial design probe and the new probe that the glasses plate placed in the back-end of the probe respectively. Figure 7 (a) shows an image captured with the initial probe that the glasses plate is placed in the front-end of the probe. There is a light spot in the middle of the image, and it block the information in the saturation range of the light spot. .Figure. 7 (b) shows an image captured with the new probe that the glasses plate is placed in the back-end of the probe. No light spots are inside the image, and we can read all the information on the image. Therefore, the glasses plate is placed in the back-end of the probe better than in the front–end of the probe.



(a) (b)

Figure 7. (a) An image captured with the initial probe of L shape that the glasses plate is placed in the front-end of the probe; (b) an image captured with the new probe of L shape that the glasses plate is placed in the back-end of the probe.

5. CONCLUSIONS

In this paper, we proposed a new probe of L shape contained a mirror for doctors to capture the images of oral cavity with the right angle. Beside, a glasses plate is inserted for preventing the liquid entering in the body of a portable LIAF imager. The glasses plate is placed in the back-end of the probe better than in the front–end of the probe because the distance L_1 is less than the critical value calculated by (1). The practitioners can easily capture the images of oral cavity with the right angle, and subjects do not need to open their mouse constrainedly. The image captured with the new probe that the glasses plate placed in the back-end of the probe has no light spots inside the image. In the future, the new probe will be utilized in the clinical trials for better services of oral cancer detection.

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