Senior Design / BS Project
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Wide FOV Fundus Camera for Telemedicine

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SENIOR DESIGN EXPO

Abstract

Our handheld system includes a Raspberry Pi board, a touch screen display, a customized optical lens group, a ring LED light, and a Li-battery. Wide FOV of 60° is observed with proper lens configuration and can be expanded by using image stitching and structure from motion algorithms. This customized low-cost handheld fundus camera provides better image quality than cellphone-based fundus imaging solutions and offers more operational features than traditional portable fundus cameras. It may benefit field portable ophthalmic diagnostic applications.

Introduction

Wide FOV of 60° is observed with proper lens configuration and can be expanded by using image stitching and structure from motion algorithms. This customized low-cost handheld fundus camera provides better image quality than cellphone-based fundus imaging solutions and offers more operational features than traditional portable fundus cameras. It may benefit field portable ophthalmic diagnostic applications. On the other hand, GUI design will be considered during the Fundus camera design.

Fig 1.1 Fundus Camera Prototype

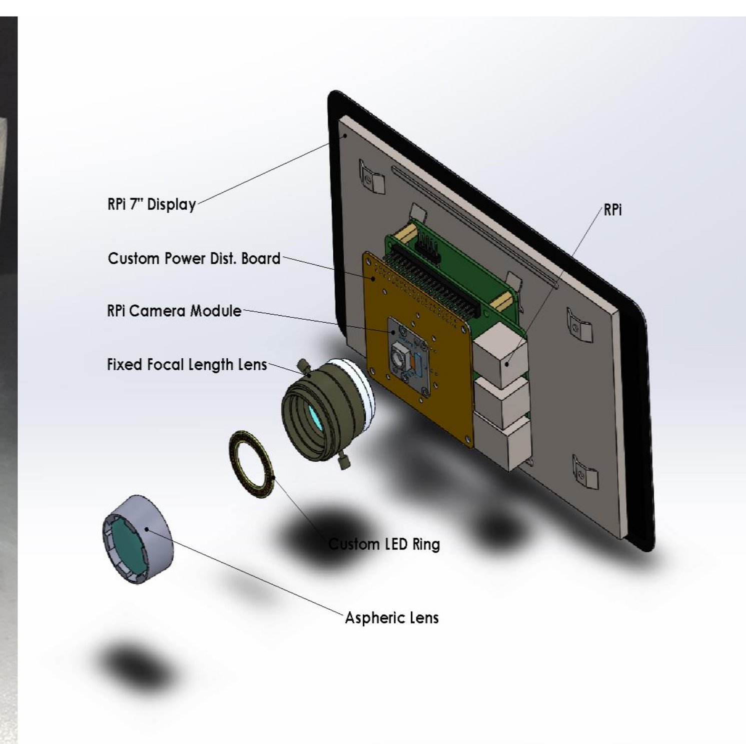

Fig.1.2 Distribution of optical components in a sequential fundus imaging system.

Methods | Design | Analysis

Method: Our fundus camera system consists of a RPi board, a touchscreen display, a customized optical lens group with ring LED light illumination, a Li-battery charging system, and a custom printed circuit board to handle power as shown on Fig.

Design: 1. The user interface design. The software program ran within the RPi is based on open source Adafruit code for a simple point and shoot camera. It immediately gives the RPi the following capabilities: 1) ability to take still images and save them into a folder within the RPi file system [1]. The interface also provides the ability for user to input and save patient information; 2) control camera parameters such as ISO and size of image. The RPi has already come with Wi-Fi ability to access the internet [2]. 2. Telemedicine Design: The fundus camera is capable of pairing images that are taken with the patient's information and store the data locally or immediately send the data to a remote server. Therefore, it is necessary to save all patient information and diagnostic information on the doctor's remote computer. The patient information interface, the diagnostic interface, and the log interface are all indispensable. Techniques such as secure shell (SSH) protocol provide the security needed to keep this information confidential whenever an open network is utilized to communicate. 3. Web Application: Design a web application for nurses or doctor use, which can track patients' information and their pictures of retina eye taken from our Raspberry Pi 3 Fundus Camera. Users (nurse or doctor) are able to create/update/delete patients' information from website.

Fig.3.1 Components assembled for compact system

Fig.3.2 Optical lens and its design

Results

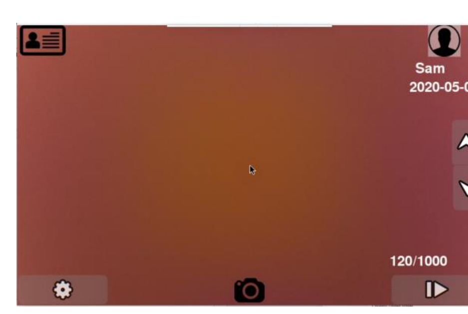

Fig. 4.1 GUI main screen of Fundus Camera

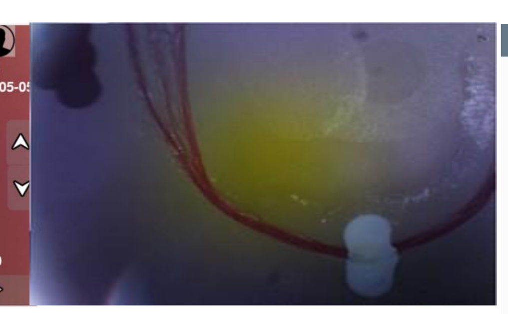

Fig. 4.2 The stitched image with a wider FOV

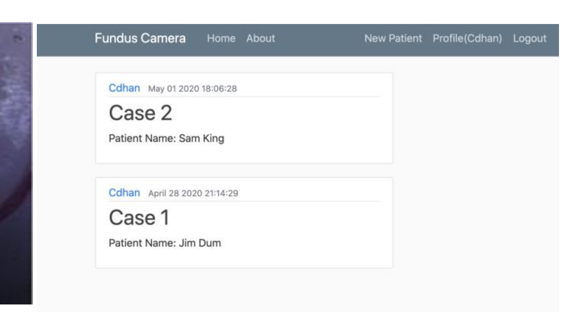

Fig.4.3 Web Page

Conclusion

A wide field of view, smart, low cost, and portable fundus camera has been designed and prototyped. The utilization of the RPi 3 for a fundus camera makes for a large leap forward in telemedicine. It has the ability of fundus imaging with high resolution of 17.54 µm. With image stitching and the acquisition of multiple retina images at different off-axis eye rotations, we have demonstrated a FOV of approximately 60°. It has a Wi-Fi connection to support remote image sharing and cloud storage and processing. Its portability makes it possible to provide diagnostic assessment of eye disease at the point of care, such as remote regions where the transportation of a desktop fundus camera is not practical. As for web application, Django is used for designing and implementing our Fundus Camera web page, allowing users(doctors/nurses) to create, update or delete patient information they gathered, and only assigned doctor can review his patients while other cannot.

Acknowledgments

PhD student: Diego Palacios

References

1. L. Ada, "Adafruit PiTFT 3.5" Touch Screen for Raspberry Pi," (2020)
2. D. Toslak, A. Ayata, C. Liu, *et al.*, "Wide-field smartphone fundus video camera based on miniaturized indirect ophthalmoscopy," *Retina (Philadelphia, Pa.)* **38**, 438–441 (2018). 29095361[pmid].

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