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Digital Image Sensor Integration in the Scope of EyeFundusScope: A Retinal Imaging system for Mobile Diabetic Retinopathy Assessment

Motivation and Purpose

Diabetic Retinopathy (DR) is a pathology of the ocular fundus that affects millions of people around the world, being one of the main causes of avoidable blindness in adults with diabetes.

DR occurs due to a long period of hyperglycemia, which causes an accumulation of fluid inside the ocular lens, that controls the focus of the viewed images.

This liquid accumulation leads to several changes, depending on the stage of the pathology, such as the modification of the lens' curvature, the creation of microaneurysms, vessel occlusion, excessive vessel permeability, formation and contraction of fibrous tissue.

On early stages, DR is mostly asymptomatic, therefore a timely diagnosis is very important to provide a most effective treatment.

There are several diagnosis techniques, being the most common:

- Ophthalmoscopes;
- Table-top Fundus Cameras;
- Handheld Fundus Cameras.

Even though the most commonly used diagnosis method is through non-mydriatic cameras, which are Table-top Fundus Cameras, that do not need the use of pharmacological substances for pupil dilation, these are very expensive and non-portable. This raises a big problem in terms of making the diagnosis affordable and available to everyone, especially in rural areas.

EyeFundusScope is a Handheld, non-mydriatic, Fundus Camera prototype. More specifically, it is a smartphone-based imaging acquisition system, designed for DR assessment, that aims to suppress the issues referred above.

Given the common obstacles for this type of acquisition, such as the smartphone camera's being in constant evolution by manufacturers, an approach for low level control of high resolution and low cost camera modules should be considered.

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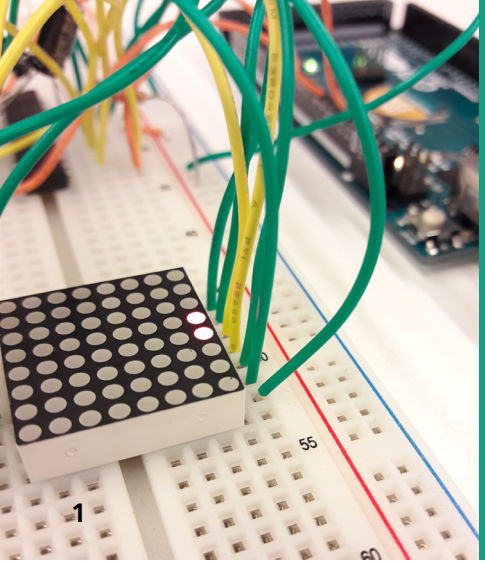

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3 *Android application for UVC Compliant Camera and Internal Point Actuators control.*

Approach

The solution achieved for this problem includes an Android application that establishes a communication protocol between Android smartphones, external UVC compliant cameras and a LED matrix.

Regarding the camera solution, the application allows the user to preview a display and simultaneously capture and save images to the gallery.

With the designed application, different commands can be send to an Arduino MEGA Board, in order to change the states of specific LEDs in the matrix into On or Off. This feature's purpose is the creation of Internal Fixation Point Actuators. This way, it will become possible to capture a wider fundus area, for a more accurate diagnosis.

In early stages of this work, a Raspberry Pi NoIR camera module was suggested, due to its operational simplicity and good low light environment capture characteristics, but after a few tests, the reached conclusion was that UVC compliant cameras would be a better option to integrate with the smartphone-based imaging system, since these are Plug&Play devices, that present a simpler solution for user interaction.

Two different UVC compliant cameras were tested, including a simple Logitech C270 WebCamera, and a Cypress Ascella camera, as a higher resolution camera module.

Quantification

The previously presented approach was thought out to use the smartphone's camera for image data acquisition. This method has proved to be a good solution, since it solved important issues related with the optical system.

Nevertheless, there is still room for improvement regarding the prototype, since the optical system integration raised some problems, being the most important:

- Placement of the camera in the smartphone, which varies very often with different manufacturers. This causes issues in centering the camera in the optical path, that needs to be meticulously aligned, in order to capture an accurate image of the fundus;
- Variation in the camera's Field Of View (FOV), which also alters calculations in the alignment of the optical path lenses.

In order to suppress these prototype limitations, this project proposes to include an external UVC compliant camera that can be fixed and centered inside the prototype, being connected through the USB port of the Android smartphone.

The innovation in this project assures that a greater percentage of Android devices will be fully compliant with EyeFundusScope.

As future improvements to this work, it is important to have better control of the UVC camera settings, as well as establishing protocols for the Internal Fixation Point Actuators.

1 *LED Matrix for Internal Fixation Point Actuators.*

2 *UVC compliant cameras used for testing.*