Title : Real-Time Dry Eye Syndrome Analysis on a Deep Convolutional Neural Network Break Up-Time (CNN-BUT) Algorithm

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Abstract: In the present, one of the most common chronic diseases is dry eye. Extreme eye pain and visual disruption are the negative impacts of dry eye disease. This project aims to develop an application for analyzing dry eye syndrome based on a real-time analysis approach. The cornea's tear bubbles burst after a blink will be analyzed by using the Deep Convolutional Neural Network Break Up Time (CNN-BUT) algorithm. This research aims to give benefits to optometrists and ophthalmologists in assessing and diagnosing possible Dry Eye Syndrome and assist its users to know their current eye condition.

Keywords: *Dry eye; real-time analysis; Convolutional Neural Network Break-Up Time (CNN-BUT); tear bubble;*

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1.0 INTRODUCTION

In today's world, one of the most common eye problems found in the ophthalmology field is Dry Eye Disease (DED). DED is a condition which happens when quality tears are not produced, causing lack of lubrication and nourishment to the eyes. A meta-analysis study by Cai et al., (2022) showed that the estimation of pooled prevalence of DED in the Asian population was 20.1% while the incidence was recorded at 16.7%.

Currently, we cannot deny the fact that there are numerous methods or approaches that can be used to diagnose DED. However, most of the machines or devices are way too big and heavy to carry around, especially to the rural areas with difficult access to the hospital with comprehensive clinical items. According to Zeev Et al. (2014), it would be great in case there is an alternative for a lighter and inexpensive diagnostic DED test.

Therefore, the novelty and the innovativeness of this project is to develop a mobile application that serves Real-Time Dry Eye Syndrome Analysis on a Deep Convolutional Neural Network Break Up-Time (CNN-BUT) Algorithm that is much lighter, easier to carry around, user-friendly that can be used by the users or patients to constantly monitor their eye condition, and for ophthalmologists and optometrists to speed up DED diagnosis in rural areas. As the name suggests, the idea behind the algorithm is based on the combination of CNN which serves for image recognition and processing pixels of the image (Awati, 2022) while BUT focuses on analyzing the time needed for tear bubbles to burst after a complete blinking where the Range of Interest(ROI) is on the cornea area (Tsubota, 2018).

Since the mobile application is based on the BUT technique and not Tear Break-Up Time (TBUT) and Tear Film Break-Up Time (TFBUT), additional items or fluids such as a slit lamp and sodium fluorescein are not required, which makes the applicability of the mobile application higher as diagnosing of DED can be done directly using users' smartphones. With the development of the mobile application, users can conduct self-dry eye tests anytime and anywhere, know exactly their current dry eye severity level, and can be used consistently to keep on track with their current eye condition.

2.0 PROBLEM STATEMENT AND RESEARCH QUESTIONS

2.1 PROBLEM STATEMENT

- People in rural areas rarely notice if they suffer from dry eye disease due to difficulties of having their eyes checked due to isolated health facilities.
- Clinical examinations take a long time to identify dry eye disease manually.
- Optometrists and ophthalmologists faced difficulties in bringing the machine to identify dry eye disease in rural areas.

2.2 RESEARCH QUESTION

i. How can people in rural areas or isolated from hospitals and clinics identify the presence of dry eye disease easily?

ii. How to improve the efficiency of identifying dry eye disease?

iii. What is the simplest portable way that optometrists and ophthalmologists can use to conduct dry eye disease analysis in rural areas?

3.0 SOLUTIONS AND THE IMPACT OF INNOVATION

i. To develop a mobile application for identifying Dry Eye Syndrome (DES) which is convenient as it can be used by people in rural areas to conduct dry eye self-test anywhere and anytime without the need for clinical items or devices.

ii. To develop a light and efficient algorithm for identifying DES where it is useful for planning of treatment according to the patients' DES status.

iii. To assist ophthalmologists and optometrists in conducting dry eye analysis on patients living in rural areas by using their mobile phones as the 'portable' DES device.

4.0 RESEARCH METHODOLOGY

The research methodology of this project is primarily based on qualitative research. To receive enough input or information in developing the intended mobile application, there are 2 approaches of qualitative research used including interviews and focus groups. The interview conducted is to gain enough information regarding DES with the director of MSU Vision and Eyecare, Ap Dr. Mohd Zaki Bin Awang Isa. Apart from that, the focus groups mainly emphasize the technical development of the mobile application that comes from 2 different backgrounds including computer science and optometry students. With qualitative research being our main research methodology with 2 components, enough information was received for the mobile application development. The application is also planned to be developed based on Rapid Application Development (RAD) methodology which includes requirement planning, user design, construction, and cutover. To sum up, the discussion brings the flow of the system in the form of a flowchart that can be referred to as below.

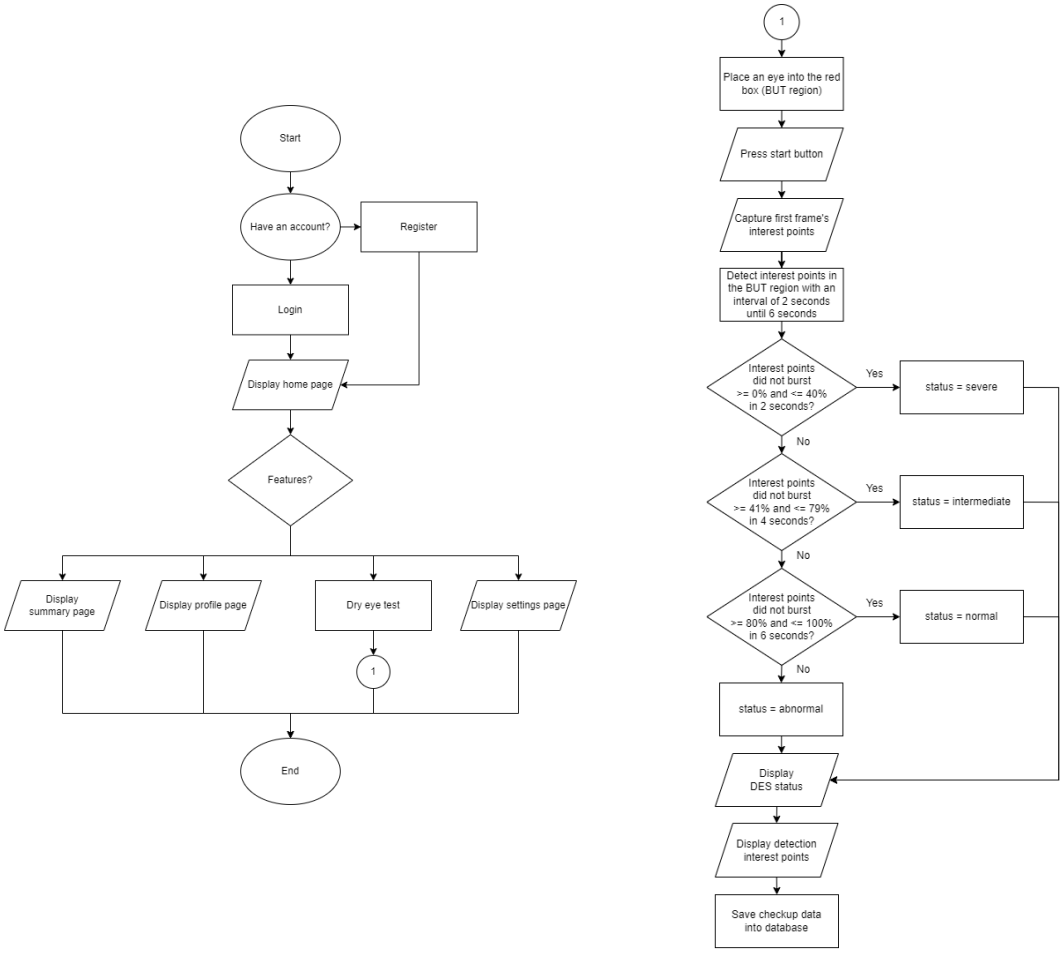

Figure 1: Flowchart of Mobile Application to Analyze Dry Eyes.

Figure 1 above shows the flowchart of the application. The flowchart uses standardized symbols to indicate the system flow from the start point to the end point. The flowchart is also separated with the use of a connector or on-page reference that is represented with a circle filled with the number 1, meaning that the circle shape with the number 1 represents the flowchart on the right.

5.0 RESULT / EXPECTED RESULT

Through this mobile application which we named ‘Eye Buddy’, we expect that it could meet 4 different results. The first expected result would be able to assist the users, especially those living in rural areas to assess their eye condition anywhere and at any time as long as they have a mobile phone with the mobile application installed. Since those living in rural areas might find it difficult to reach the hospital with proper clinical items and devices for optometry purposes, with the help of the mobile application we expect that it can make things easier for them to conduct self-test dry eye checkups without the necessity of going to the hospital for checking purposes.

The second expected result is that we expect the mobile application to have a usable algorithm that can accurately identify dry eye disease by specifying the status or the severity level in a few seconds. With a click, the users’ eye condition will be assessed based on the algorithm we have created that makes use of the Convolutional Neural Network (CNN) for detecting tear bubbles bursts that indicate a dry eye area.

The third expected result is dry eye prognosis can be determined by constantly and consistently making use of the mobile application for monitoring a dry eye condition. It is essential to use this mobile application in a consistent manner as our health itself is not predictable, the same goes for our eyes where its condition might be different from time to time. Additionally, those who received high severity level or severe status can take an early action by seeing the optometrists or ophthalmologists so that they can get a proper eye treatment.

The fourth expected result is it makes things easier for ophthalmologists and optometrists to visit different rural areas for medical checkup purposes as they are not required to bring a huge and heavy conventional dry eye diagnostic device. Since some people living in rural areas are not able to afford a mobile application, ophthalmologists and optometrists can also make use of the mobile application to assess the dry eye condition of people living in rural areas by using a portable device which is lighter and easier to use compared to the conventional dry eye diagnostic device.

5.0 FINDING AND DISCUSSION OF THE PROJECT OR INNOVATION

The system was entirely created by using Flutter as its front-end technology, Firebase as our NoSQL database, and Python for the DES analysis algorithm and meet all the points stated in the research questions, solutions, and impact of the project or innovation. The targeted users not only involve the user but also optometrists and ophthalmologists for checking their patients' eyes in a lighter and easier solution than bringing a huge and heavy DES diagnosis machine in rural areas.

Additionally, the mobile application was able to perform its main task which is to detect the status of a user or patient's dry eye status. However, the system also comes with several weaknesses in which future improvement is needed to be implemented for improving severity level accuracy. This is due to the fact that the system suffers from a flaw in detection accuracy as the algorithm is not able to differentiate the presence of a tear bubble or face skin.

Next, for future improvement in determining the accuracy rate of the algorithm used, more samples or tests are needed. This is to assist all the targeted users to be able to expect the test accuracy since the actual and a more accurate DES diagnosis machine is not being used. Even though it is a good approach to use the mobile application to monitor eyes' condition, it does not change the fact that seeking the optometrists and ophthalmologists is still the optimum solution for detecting and getting advice regarding dry eye disease. But, the mobile application can still be used to serve as an assistant for optometrists and ophthalmologists in having initial knowledge regarding their patients' eyes.

Overall, the mobile application has a huge potential to make a huge impact on eye health in rural communities and in the optometry industry. It is something that has not been developed previously, which can be referred to as a new invention in the current era of emerging technology.

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