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Tele-Ophthalmology for Rural Areas in Indonesia: Preliminary Study of Image Acquisition Rate Using Various Bandwidth

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Abstract. This paper describes about preliminary study for calculating image acquisition rate in order to develop Tele-Ophthalmology for rural areas in Indonesia. It is motivated by our previous research about cataract screening techniques using low-cost and easy-to-use equipment such as digital camera. During its development, our method still requires an involvement from an ophthalmologist. While in Indonesia, especially in rural areas there are a lot of limitation both of health facilities and ophthalmologists. To solve this problem, we plan to develop Tele-Ophthalmology by utilizing a webcam. In order to implement in a real condition, we conducted a preliminary study for getting the best configuration between image resolution and bandwidth availability in Indonesia.

Keywords: Tele-Ophthalmology, rural areas, limited health facilities, bandwidth availability, image resolution

1. Introduction

Today's technology provide many advantages of human life especially advancement of Information Technology. Information technology has the potential to transform healthcare as it has transformed many parts of economy and society in recent decades. Health information technology can allow clinicians to have real-time access to complete patient data, and provide them with support to make the best possible decisions. It can help patients become more involved in their own care. In other hand, at the same time the function of human organ is getting decrease. One of them is eye.

The most common eye disease in the world is cataract. That is a clouding in the lens of the eye that affects vision [1]. The World Health Organization Report published in 2001 estimated that there were 20 million people who are bilaterally blind people (i.e., eyesight less than 3/60 in the better eye) whose blindness was caused by age-related cataract. That number will have increased to 40 million by the year 2020 [2]. Increasing age is associated with an increasing prevalence of cataract, but in most developing countries, cataract often occurs earlier in life. One of the developing countries that have the highest number of people with cataract is Indonesia. Currently, in Indonesia there are about 200.000 people sufferers by cataract each year. In other hand, there are only about 1600 ophthalmologist only. Also, the most common cancer caused by ultraviolet is eye tumor, because Indonesia is located in Equator line in which the people who lived in this area will get a lot of ultraviolet with other location. In addition, ophthalmologists are not evenly distributed [3]. Cataract exhibits a lot of whitish color inside a pupil. A cataract can occur in either or both eyes [4]. The three classes of cataract are immature, mature and hypermature, which differ in seriousness. Figure 1 shows examples of the range of serious and non-serious conditions.

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To avoid blindness, we need to detect cataracts early. Today, ophthalmologists use a slit lamp to obtain clear information about the inside of the eye lens for detecting eye diseases like cataracts and glaucoma, for example. Performing early detection for avoiding blindness using a slit lamp may not be a problem in developed countries like Japan, the USA, the UK, etc for example. However, it is a problem for some developing countries like Indonesia, Nepal, Vietnam, etc.

Based on conditions in developing countries like Indonesia which has a limited number of both ophthalmologists and health facilities, we already proposed a simple method for cataract screening. Our method able to classify cataract into two conditions, Non-Serious Condition and Serious Condition. Regarding Figure 1, Non-serious conditions include normal and immature. In this condition patient does not need surgery. Serious conditions include mature and hypermature. In this condition a patient has to get a surgery as soon as possible to save a patient from blindness [5][6][7][8][9][10][11][12]. However, although a patient was diagnosed as a serious condition it does not mean we have to send him/her to hospital for getting a surgery immediately. Patient still requires further examination from ophthalmologist.

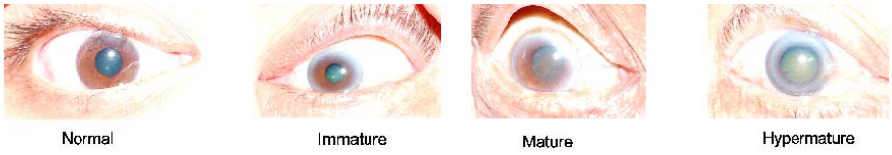


Fig. 1: Examples of Eye Image

Other hand there is a technology called telemedicine. Telemedicine is the integration of electronic information and medical technology by which people in remote and underserved areas can get access to specialized expert health care, this case the system is called Tele-Ophthalmology. To handle situation, Tele-Ophthalmology would be an effective and efficient way to diagnose eye disease that actually occurs in a patient, to determine whether or not a surgery will be performed, and also to determine when a convenient time to perform a surgery.

In order to develop Tele-Ophthalmology, there are many factors to be considered. Some of which closely related to this case is image resolution and bandwidth. This paper will emphasize to calculate image acquisition rate using various bandwidth as preliminary study to establish Tele-Ophthalmology for rural areas in Indonesia in order to get the best combination according condition in Indonesia.

2. Related Works

There are some application of Tele-Ophthalmology was conducted in several years [13][14][15]. In summary, previous works focused on the use of some advanced equipment such fundus camera, perimeter, etc. Currently we would maximize the functionality of our cataract screening system [5][6][7][8][9][10][11][12] by involving ophthalmologist in hospital to give instruction about what should be done by patients with serious conditions in rural areas and gradually system will be developed for other ophthalmology functions.

3. General Concept

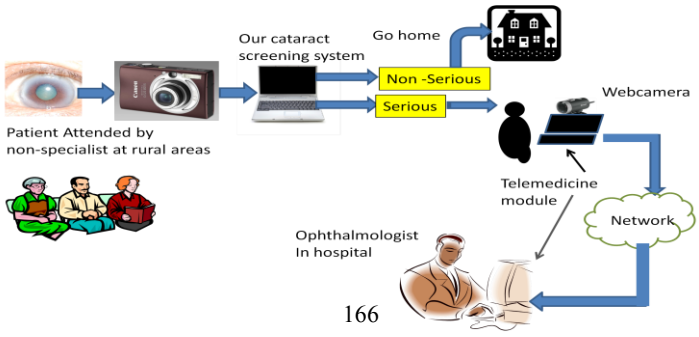


Fig. 2: General Concept of our Tele-Ophthalmology

General concept of our Tele-Ophthalmology is described in Figure 2. First, patients in rural areas photographed using a digital camera by non-specialist. Second, images will be analyzed by our cataract screening system to classify between serious conditions and non-serious conditions. Patients with non-serious conditions able to go home immediately, while patients with serious conditions require further examination. Third, images for serious conditions will be sent to ophthalmologist in hospital for getting further analysis through computer network. Additionally, patients with serious conditions will be interviewed by an ophthalmologist who is in hospital through webcam that are connected to computer network in order to make an accurate diagnosis of eye disease that actually suffered and to give instructions about the things should be done regarding their illness.

4. Calculating the best combination of image resolution and bandwidth

4.1. System Requirements

In order to implement our concept as described in Figure 2, our teleophthalmolgy will meet the following requirements.

a. Easy to Use: our system provides user-friendly GUI (Graphic User Interface) as described in our previous work, therefore non-specialist in rural areas will spend only a few minute to classify patients between non-serious and serious condition based on images was produced by digital camera with resolution about 946 x 629 and it is hoped this system will give more accurate results for higher resolution.
b. Privacy-preserving: Sometimes, when an ophthalmologist is consulting patient, he may require additional medical images to make an accurate diagnosis. To this end, he informs the staffs in rural areas to prepare more data for the patient, stop consulting the patient and selects the next patient for consultation. To protect patient's private information and videoconference, all data are transferred via a secure channel.

4.2. Bandwidth Availability

Indonesia is an archipelago which consist about 17.000 islands as described in Figure 3. Most of areas are categorized as rural areas and most of capital city is located in Jawa Island. In other hand, Internet users in Indonesia in 2011 are estimated about 5.5 million people. This number increases about 13 percents than previous year. The available bandwidth is about 10 Mbps. Currently Indonesia government has a program called "Indonesia connected" in which this program attempts to connect 33 provinces can be connected in "Palapa " ring project broadband network [16].

Fig. 3: Map of Indonesia (Source: http://www.google.com)

4.3. Image Resolution

The term resolution is often used for a pixel count in digital imaging, although American, Japanese and standards specify that it should not be so used, at least in the digital camera field [17]. An image of N pixels high by M pixel wide can have any resolution less than N lines per picture height. But when the pixel counts are referred to as resolution, the convention is to describe the pixel resolution with the set of two positive integer numbers, where the first number is the number of pixel columns (width) and the second is the number of pixel rows (height).

Web graphics also are measured by pixel only, usually in relation to monitor size. Basically, one image pixel from a web graphic displays as one monitor pixel. Higher megapixels increase the resolution of the images but equally important is the quality of the individual pixels. A bigger pixel size result in better sensitivity to light and produces stronger image signal. Stronger image signal improve image quality, better color fidelity and less noise due to improvement in signal to noise ratio. Increasing megapixels count on a given size sensor chip can have negative impact on image quality. Pushing more pixels on a given sensor chip results in smaller individual pixel size. This means lower quality sensor resulting to increased noise level, lower dynamic range, reduced color fidelity and finally poor image quality. In this experiment, we set some combination of resolution, there are; 1280x960, 1024x576, 960x720 according to the minimum resolution was required in our cataract screening system as discussed in subsection 4.2.

4.4. Frame Rate

In motion pictures, television and in computer video displays, the frame rate is the number of frames or images that are projected or displayed per second. Frame rates are used in synchronizing audio and pictures, whether film, television or video. In motion pictures and television, the frame rates are standardization by the Society of Motion Picture and Television Editors (SMPTE). SMPTE Time code frame rates of 24, 25 and 30 frames per second are common, each having uses in different portions of industry. This calculation using a set of combination of frame rate, there are: 24, 25, 30, 50, 60 and 72 [19].

4.5. Pixel Clock

The pixel clock is a high frequency pulse train that determines when the data lines have valid data. The pixel clock frequency determines the rate pixels are acquired [18]. This simulation using a set of combination of pixel clock, there are: 25.175, 31.5, 36, 38.1, 40, 50, 49.5, 56.25, 65, 75, 78.75, 94.5.

5. Results and Discussion

Although the computation for calculating the approximate image acquisition is a simple computation, however in this case we developed a simple simulation using Matlab to speed up computation. First, we specify the desired data rate to achieve during the acquisition refer to image resolution. The results are shown in Figure 4.

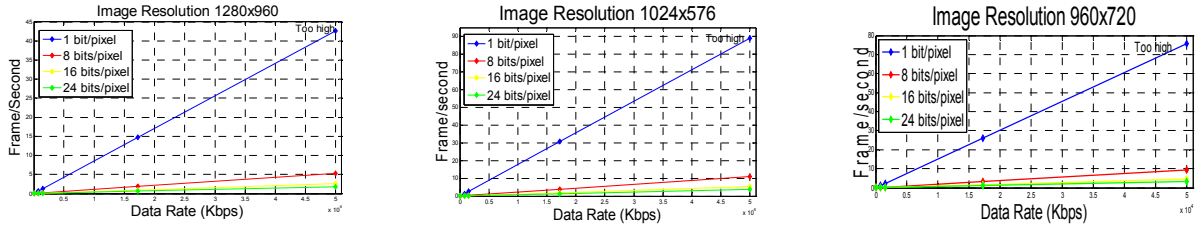
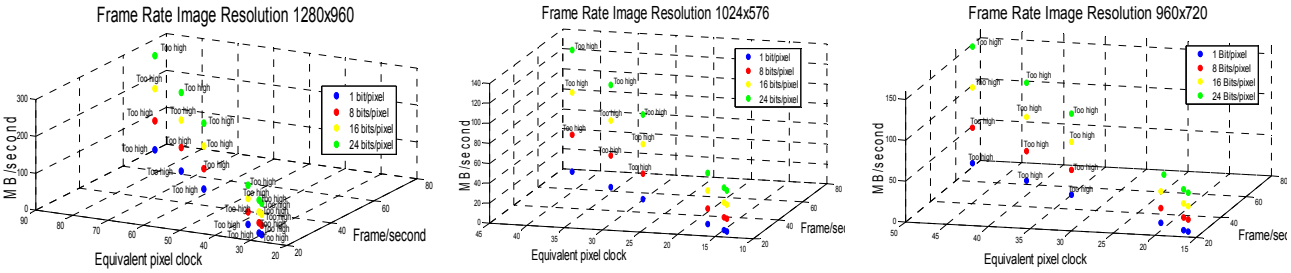


Image resolution to bandwidth (1280x960) Image resolution to bandwidth (1024x576) Image resolution to bandwidth (960x720)

Fig. 4: Performance of desired data rate associated with image resolution

Referring to Figure 4, simulation results show that basically all image resolution which use in all bandwidth combinations worked properly. However, on the bandwidth 6.25 MB/s always gave results too high when this bandwidth combined on all image resolution using in this simulation.

Second simulation, we specify the desired acquisition frame rate to achieve refer to image resolution. The results are shown in Figure 5.



Frame rate to image resolution (1280x960) Frame rate to image resolution (1024x576) Frame rate to image resolution (960x720)

Fig. 5: frame rate associated to Image Resolution

Referring to Figure 5, the results show that for image resolution 1280x960 when implemented in all combination in this simulation always gave a high frame rate. For image resolution 1024 x 576, when the parameter is 1 bit/pixel, it shows that simulation work properly in all combination. However, when parameter is 8 bits/pixel, 16 bits/pixel and 24 bits/pixel, it show that combination work properly only for the frame rate 24, 25 and 30 only. For image resolution 960x720, the combination will work properly only for the frame rate 24, 25 and 30. Stronger image signal improve image quality, better color fidelity and less noise due to improvement in signal to noise ratio.

6. Conclusions and Future Works

These calculations fairly represent bandwidth availability in Indonesia for developing Tele-Ophthalmology in rural areas in which we can implement image resolution more than 1280x960 for getting a good quality of images especially for displaying eye area of human. However, we have to consider another combination in order to send image data. Referring to the calculation results, it will work properly when the image resolution is 1024x576 by considering if this image is combined with frame rate; 24, 25 and 30. It is also happened for other image resolution. Then we conclude that the best frame rate can be used for developing Tele-Ophthalmology is 24, 25 and 30.

Further works, we will implement this simulation into real work by involving an ophthalmologist for assessing image quality to diagnose real eye disease on cataract patients with serious conditions. Also we will consider about the security and privacy of patient image data.

7. Acknowledgment

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