Development and Usability Testing of a Consultation System for Diabetic Retinopathy Screening

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***Abstract*—This study aims to develop a novel web-based decision support system for diabetic retinopathy screening and classification of eye fundus images for medical officers. The research delivers diabetic retinopathy information with a web-based environment according to the needs of the users. The proposed research also intends to evaluate the developed system usability to the target users. The complex characteristics of diabetic retinopathy signs contribute to the difficulty in detecting diabetic retinopathy. Therefore, professional and skilled retinal screeners are required to produce accurate diabetic retinopathy detection and diagnosis. The proposed system assists the communication and consultation among the medical experts in the hospital and the primary health cares located at the health clinics. The agile software development model is the methodology used for the development of this research project. The project collaborates with the Department of Ophthalmology, Hospital Melaka, Malaysia for the medical content expertise and testing. Representative medical officers from Hospital Melaka and all the public health clinics in Melaka were involved in the preliminary study and system testing. This research study consists of a web development producing an interactive web-based application of diabetic retinopathy consultation which comprises image processing and editing features as a core of the system. It is envisaged that this research project will contribute to the management of diabetic retinopathy screening among medical officers.**

***Keywords*—Consultation; diabetic retinopathy; eye screening; image editing; image processing; web development; testing**

I. Introduction

Diabetic retinopathy (DR) is a type of eye disease due to a diabetic condition that damages the retina, leading to blindness or vision loss. In Malaysia, diabetes in the eye is the most common cause of vision loss in working age adults. Therefore, screening of DR is important for early detection and early treatment. A precise retinal screening is required to help retinal screeners to distinguish the retinal images efficiently. This study aims to develop a web-based decision support system to screen and diagnose DR in eye fundus images. Furthermore, the study would examine the information on DR, including screening and diagnosis. This research also aims to determine the usability and needs demand by the target users of the developed system. The detection of DR is challenging due to the complex characteristics of the DR features as illustrated in Fig. 1 which emphasizes the need for highly qualified and experienced retinal screeners to ensure accurate detection and diagnosis of DR. Moreover, this system involves image processing and image editing features to enhance the visibility of fundus images captured by primary health cares. The built web-based system aims to create a new web application to provide online users with innovative services or solutions. Therefore, an enhancement web-based system based on online consultation to overcome the weaknesses of the current method such as many-to-many communication, image upload, image editing and image processing.

In this paper, basic information of DR and related works will be stated in the next section, a brief explanation on research materials and method used will be shown in the third section that includes the image processing and image editing features, while the fourth section will discuss the results of this research.

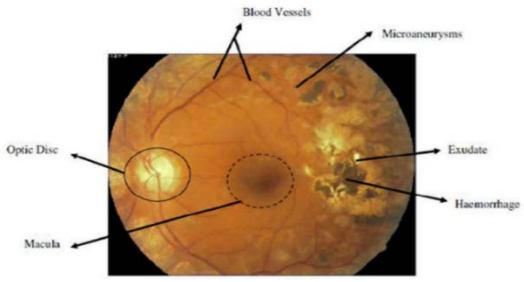


Fig. 1. Fundus Retinal Image with Lesions [1].

II. Literature Review

DR is a diabetic complication caused by elevated blood glucose levels. In order to diagnose DR symptoms, an eye screening is required. Microaneurysms, retinal haemorrhages, hard exudates, abnormal new vessels, cotton wool spots, and venous beadings are some of the signs that must be discovered throughout the DR screening process. Thus, it's essential to have a thorough consultation platform that allows primary health care to identify and classify the DR risk factors based on the patient's fundus image, since the vision impairment due to DR is increasing. Early detection and diagnosis of DR are vital for saving the vision of diabetic persons.

Globally, at least 2.2 billion people experience vision impairment, and of these, at least 1 billion people have vision impairment that could have been prevented or is yet to be addressed [2]. It is revealed that globally, 146 million (34.6%) were diagnosed as DR in 2014 for adults aged over 18 years

with diabetes [2]. The largest number of blind and visually impaired people reside in the Asian region, namely, South Asia, followed by East Asia and Southeast Asia [3]. DR caused 1.1% of all cases of blindness and 1.3% of all visual impairment in 2015. The percentage of blindness caused by DR varied in the Asia-Pacific, ranging from less than 1% in South Asia (0.16%), Oceania (0.32%), East Asia (0.51%), and Southeast Asia (0.59%) to more than 3% in Central Asia (3.60%), high-income Asia-Pacific countries (3.87%), and Australasia (4.48%). Prevalence of blindness and visual impairment due to DR decreased between 1990 and 2015 in Oceania and Central and Eastern Europe, yet increased in high-income regions of Asia-Pacific, North America, Australasia, and Asian regions [3].

Malaysia also has the largest number of people with visual impairments, namely, from Kedah, Perlis, Johor, and Perak as studied by the Malaysian [4] as shown in Fig. 2 [5]. The result shows the prevalence of all states in Malaysia. Kedah demonstrates the highest percentage of people with diabetes with a difference of 4.8% in Perlis while a percentage difference of 0.8% in Johor. It is also shown that Johor has a difference of 0.4% of diabetic prevalence with Perak.

Fig. 3 shows the results by the [6] regarding the prevalence of diabetes mellitus in Malaysia with an age group above 30 years old. The percentage of diabetes mellitus in Malaysia is increasing from 1986 to 2011. It increased by about 2% from 1986 to 1996 within the range of 10 years. In 2006, it increased by 6.6% from 1996 which is also within 10 years. It shows that the prevalence between 1996 and 2006 increased by 4.3% higher than from 1986 to 1996. From 2006 to 2011, the percentage of the prevalence is increasing by 5.9% which is lower by 0.7% than between 1996 and 2006. Overall, it shows that the prevalence of this disease is gradually increasing.

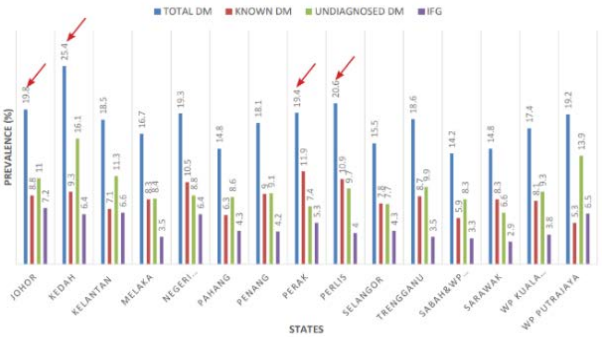


Fig. 2. Prevalence of Diabetes by States [5].

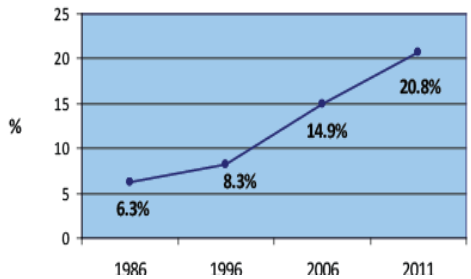


Fig. 3. Prevalence of Diabetes Mellitus in Malaysia (>30 Years Age Group) [6].

The proposed research project is a guideline in the development of a system. Several systems for detection and diagnosis of DR are reported in the literature which are development focused and proposed techniques for detecting certain features of DR. For instance, the existing system of automated DR screening detection as proposed by [7] and [8] that assist in diabetic retinopathy detection. Another existing related system is the teleophthalmology screening system developed by [9] which integrates multiple tools into ForusCare such as software platform where the system secures the image analysis module and stored and forwarded into the Amazon cloud. In addition, there are additional system features such as system installation and workflow that enhance communication and assures quality photos. [10] have developed a mobile system called mTEH that enables employees operating from different remote locations to be connected, securely stores all eye-screening participant data, and encourages improved decision-making of participants on eye health. An online teleophthalmology screening conferencing system was developed by [11] known as TeleOph as the virtual channel for DR screening. Telemedicine is a correlation between medicine and the technology available [12]. Recently, [13] proposed a telemedicine system that offers communication using 5G uRLLC and mMTC. Furthermore, another similar telemedicine that has made tremendous strides and successfully interacts with patients and doctors is HEMAN which is an IoT-based e-health care system for remote telemedicine [14].

III. Materials and Methods

The developed web-system is built using these programming languages and scripting; HTML5, PHP7, JavaScript, jQuery, CSS3, and SQL, with the CMS WordPress platform. These programming languages are chosen since these languages are able to perform responsively in any types of gadgets such as laptop, tab, and mobile [15]. This system also uses cPanel as the web hosting platform to publish the system online. Adobe Dreamweaver CC 2020 is another tool used in writing the codes and designing the interface and theme of the system. PHP7 performs many functions that need to connect to the database such as fundus image upload and retrieve. Other than that, jQuery language plays a big role in running the image editing and image processing plugin.

This section outlines the research process to accomplish the objectives of this research. Overall, the five phases cover in this research are analysis, design, development, testing, and evaluation; the methodology of this research to achieve the objectives of the research study. Fig. 4 presents the graphical illustration of the Agile model.

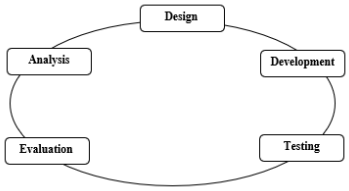


Fig. 4. Web Application Development Process.

A. Analysis

An online survey was created to collect data as the input for developing the system. The survey has been distributed to 202 primary health cares from Hospital Melaka and 32 health clinics around Melaka. This survey covered four main parts which are demographic, computer literacy/skills, current DR screening practice, and expected outcome. The details of the online survey are summarized in Table I. The online survey result clearly indicates that most of the respondents agreed to the development of the system. Moreover, this online survey helps analyze the problems, limitations, suggestions, and expected outcome of the system. Thus, it can be concluded that the proposed web-based consultation system is highly needed by primary health cares to conduct the DR screening process.

TABLE I. SUMMARY OF THE PRELIMINARY ONLINE STUDY

Date/Duration	23/6/2020 – 2/9/2020 (10 weeks)
Type of survey	Online questionnaire via Google Form
No. of respondents	202 respondents
No. of workplace	1 hospital, 32 health clinics
Type of respondents	Consultant, Specialist, Medical Officer and House Officer
No. of survey parts	4 sections - Demographic - Computer Literacy/Skills - Current DR Screening Practice - Expected Outcome

B. Design

In the design phase, considerations such as software needs, how the output of the system will look, what database will be used, and the timeline of development were identified. Fig. 5 shows the flow of the system process. The design phase for this system began with designing the web environment since the primary health cares required an online platform for the system. Therefore, this system needs to have a web domain and hosting for the system to be published and viewed on the web browser.

The next task was to design a database for the system. Designing a database requires the list of functions of the system and information needed to derive from the system to determine the possible tables and fields need to create in the database. Microsoft Visio software was used to design the Entity Relational Diagram and phpMyAdmin to create the database of the system. After the database was designed, creating web interactivity starts with the connection of the system to the database and triggering the buttons in the system. Ensuring that the connection of the database and trigger buttons are working fine will ease the next step which was designing the web-based interface with the bootstrap theme plugin. Once the system was completed with the design of web environment, database, interactivity and interface, the system proceeded to the development process.

C. Development

Once all the requirements and designs were documented, the development phase took place. There are four features that are the core function of the system. This system is able to be accessed through this link; http://drcs.com.my/ which has four types of users which are: Admin, Specialist, Primary Health Care, and Public. Admin is allowed to handle the user and hospital and health clinic data. The specialists can view the list of DR cases uploaded by the primary health cares and specialists can give feedback on the DR cases while using image processing and image editing features in the system. Primary health cares are allowed to fill up DR case form including uploading fundus images from both right and left eyes, view the list of DR cases uploaded by other primary health cares, and view the feedback from the specialists and reply to the feedback given. Besides that, the public type of user can gain information on the DR and DR screening, view an example of DR fundus images, and gain knowledge on the signs of DR from the fundus images. and gain knowledge on the signs of DR from the fundus images. Table II shows the list of the system users and their accessibility.

Fig. 6 depicts the flow of the development of the DRCS. The system development began with the basic functions which were Create, Read, Update, and Delete (CRUD) function for the user, hospital and health clinic, and diabetic retinopathy's case details using PHP and MySQLi.

The image processing plugin which includes image color conversion and image filtering was developed. Subsequently, the development of image editing plugin that allows to crop, scale, and annotate the fundus image takes place. A forum area for specialists to review and comment on the DR cases with the primary health cares was provided in the system.

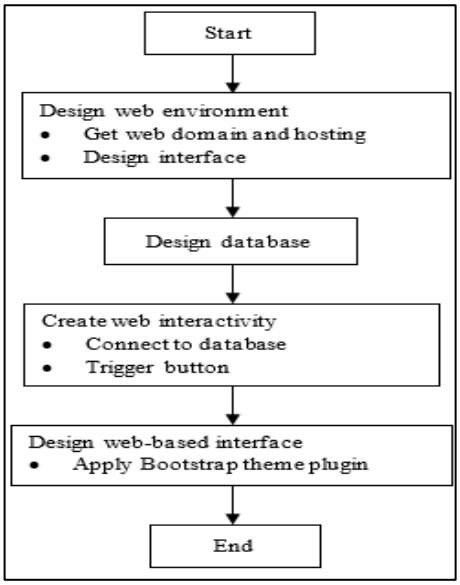


Fig. 5. Flow of the System Design Phase.

TABLE II. SUMMARY OF USER ACCESSIBILITY

Type of User	**Accessibility**
Admin	User and hospital/health clinic data
Specialist	DR case, discussion area
Primary Health Care	DR case, discussion area
Public	Information on DR and DR screening

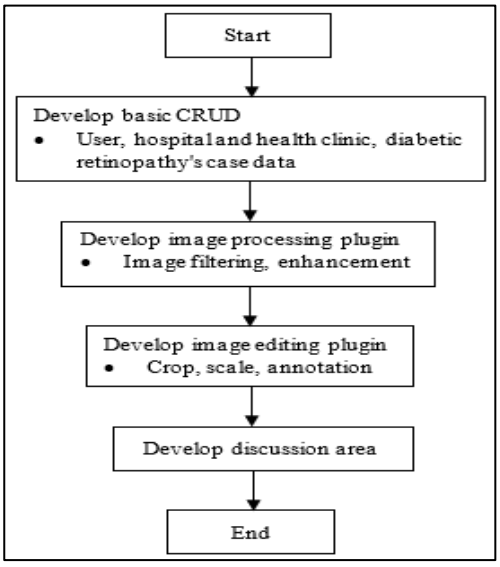


Fig. 6. Flow of the System Development Phase.

1) Create, Read, Update, Delete: CRUD is the acronym for create, read, update, and delete which are the four basic types of functionality for constructing a web application. This system development includes inserting user, hospital or health clinic, and DR's case data. Create function will be called when new data need to be added into the database. The new entry is assigned a unique ID (identity document), which can be used to access the data later. Read or view function will view all the data currently exist in the database when it is called. The system will show the list of all the DR's data in a form as shown in Fig. 7. The update function will be called when no data need to be altered. Furthermore, the data will display all information from the selected row and users are able to edit data in each column at once. After the function is called, the corresponding data will be updated into new data. The delete function is also needed in this system to remove data that are no longer needed in the database.

The admin user is only allowed to handle user and hospital and health clinic details. In this system, only the admin can handle the registration of the new system user since the access and data are strictly confidential. Besides that, the admin is able to view the details of the users, such as username, password, email, full name, doctors' level, and workplace. As for hospital and health clinic details, the admin can add, view, edit and delete the details including the type of organization either hospitals or health clinics, name, address, region postcode, phone number, fax number, email, and status of the organization. Any changes in the details can be made by the admin only for security purposes. For instance, changes in phone and fax numbers can only be done by the admin of the system.

As for DR case form, primary health cares need to insert two fundus images from the right side and another two fundus images from the left side. Two views need to be captured for each side of the eye, which are macula center and optic disc center. These requirements for inserting fundus images area are based on the DR practice mentioned by the primary health cares during the preliminary study. Each DR case form includes the patient's detail consists of name, identification number, and age as shown in Fig. 7(a). It also has patient's eye details that include the Diabetes Mellitus (DM) Type, duration of DM, HbA1C, visual acuity, ocular complaint, provisional diagnosis, and types of co-morbids that are visualized in Fig. 7(b). Fig. 7(c) to Fig. 7(e) show the fundus image section required in the DR case form which needs to be uploaded by primary health cares containing both sides of fundus image uploading form and the date of the photo taken. In order to ensure the primary health cares insert the correct image format into the file form, the error function is created if the primary health cares inserted files other than the image file format listed such as .jpeg (or .jpg), .png or .tiff file format as shown in Fig. 7(c) and Fig. 7(d). This is to prevent primary health cares from inserting unnecessary file format such as .pdf, .gif or any other file formats.

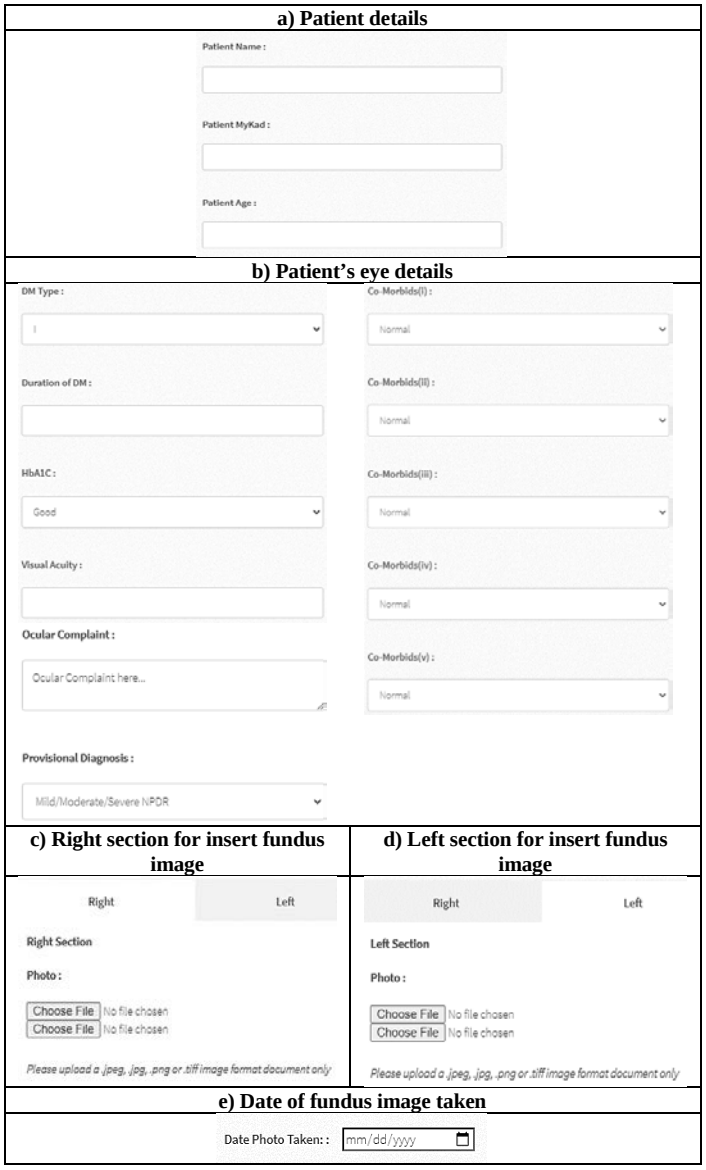


Fig. 7. DR Case Form.

2) Image processing: Image processing performs some operations on an image to produce an enhanced image and is useful in extracting useful information from it. Image preprocessing techniques involved in the proposed work include color image conversion, contrast enhancement, filtering and segmentation among others. Current fundus images might not be so clear due to the noise during the image capture process. Therefore, this system includes image processing techniques which is important to help in processing the fundus image into a clearer version and able to help the primary health cares to detect the signs precisely. This plugin includes color image conversion such as grayscale, black and white as shown in Fig. 8(a) and Fig. 8(b), respectively. This plugin includes image filtering such as thresholding and edge detection as presented in Fig. 8(c) and Fig. 8(d). Thus, these image processing features help specialists view and locate the complex signs of DR such as microaneurysms and neovascularization.

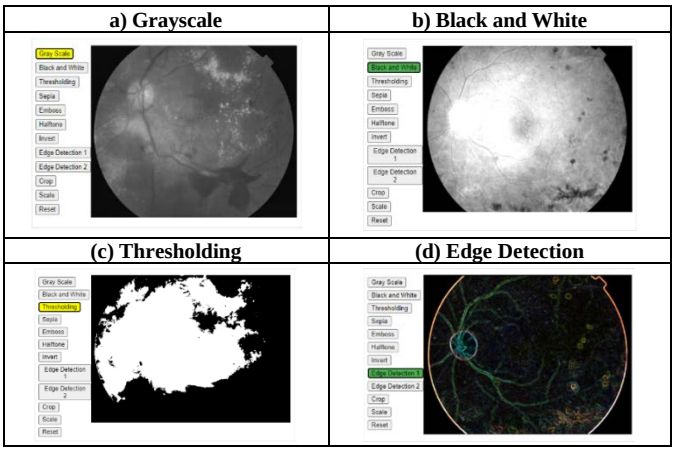


Fig. 8. Example of Image Processing Plugin.

3) Image editing: Image or photo editor plugin was implemented to support basic editing on the image uploaded such as adding text, crop, and scale. Fig. 9 shows an example of an image editing feature which is annotation of the eye image which could help the specialist to review or respond to the DR case submitted by the primary health cares effectively. This annotation feature is important to facilitate the specialist to label the signs of DR on the fundus image since the specialists are expert in detecting the critical signs of DR. Therefore, specialists are able to use any suitable tools of annotation listed in Table III by labelling or drawings on the fundus images that later can be viewed by the primary health cares. Several annotation styles were provided to the specialists to annotate the fundus image such as adding box, circle, adding text for notes, arrow, and draw. Each annotation tool is effective in labelling the signs of DR which ease the specialist to point out the critical signs for the primary health cares' view. At the same time, primary health cares are also able to see the label created by the specialist clearly. This annotation tool also provides the undo and redo button to erase the last change done to the fundus image.

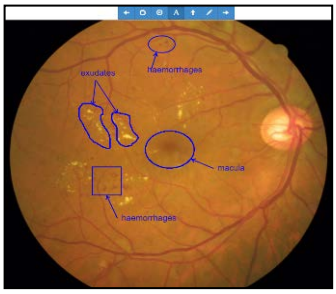


Fig. 9. Example of Applying Annotation Feature of Image Editing on the Fundus Images (Fundus Image Taken from the [4]).

TABLE III. LIST OF ANNOTATION TOOLS

Annotation tools							
Function	Undo	Box	Circle	Text	Arrow	Draw	Redo

4) Forum: Based on the previous preliminary survey conducted, primary health cares mentioned that one-to-one conversation is a limitation in the current communication method. Therefore, developing a platform for discussion would be beneficial for primary health cares to share and learn by discussing with the specialist. In this system, the discussion area is mainly for the consultants and specialists to give their comments and verification to the data provided by the primary health cares in the DR case form. Fig. 10 shows an example of the discussion area of the case details where Fig. 10(a) is a form for the specialist or the primary health care to write the review and Fig. 10(b) is the listed review and comments done by the specialist.

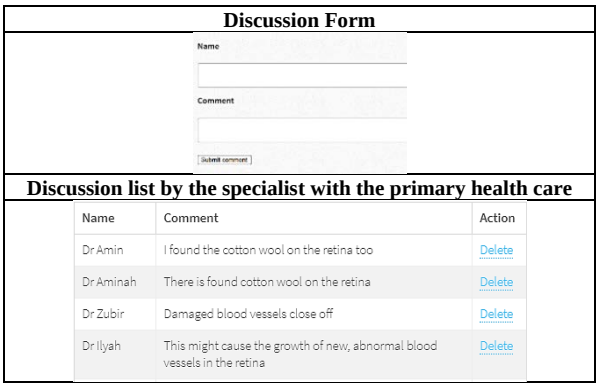


Fig. 10. Discussion Area for the Primary Health Cares.

IV. RESULTS AND DISCUSSION

Alpha testing has been conducted to evaluate the usability of the system prototype. This testing was done by the consultants, specialists, and primary health cares from the Department of Ophthalmology, Hospital Melaka. The testing covers the functionality of the features available in the system. Table IV summarizes the alpha testing conducted. There are three different users in this system which are admin, specialist, and primary health care which give different perspectives for each user. Therefore, three different results are reported based on each type of user. Moreover, these results are important for this study to identify the effectiveness of the features for DR

screening consultation. This section is divided into three types of user which are admin, specialist, and primary health care.

The first part of the questionnaire; demographic information of the respondents, aims to provide an overview of the general details of the respondents such as gender, age, level of work, current workplace, and years of work experience. These data are useful for strategic planning for consultation web-system. Based on the result summarized in Table V, the respondents are mostly female between 40 and 50 years old. The result also shows that the respondents are currently working in Hospital Melaka with more than 10 years of working experience in the medical sector.

A. Admin

1) Functionality of DRCS: The functionality of the system in the admin site covers the functions of CRUD in user, hospital, and health clinic details. The results of this functionality testing are detailed in Table XI. Based on the overall result for admin site, most of the respondents successfully used the functions in the system which are the basic CRUD functions for user details, hospital, and health clinic details.

TABLE IV. SUMMARY OF THE ALPHA TESTING CONDUCTED

Date/Duration	11/12/2020 (3 hours)
Type of survey	Online questionnaire via Google Forms
No. of respondents	10 respondents
No. of workplace	Hospital Melaka
Type of respondents	Consultant, Specialist, Primary Health Care
No. of survey parts	4 sections - Demographic - System Functionality - System Usability - Suggestion for Improvement

TABLE V. DEMOGRAPHIC

	Doctor's Level			**Total**
	Consultant	***Specialist***	***Primary Health Care***	
Gender	-	2	-	**2**
• Male	1	6	1	**8**
• Female	1	8	1	**10**
Age	-	-	-	**0**
• Less than 20 years old	-	-	-	**0**
• 20-30 years old	-	6	1	**7**
• 30-40 years old	-	2	-	**2**
• 40-50 years old	1	-	-	**1**
• More than 50 years old	1	8	1	**10**
Current Workplace	1	8	1	**10**
• Hospital	-	-	-	**0**
• Health Clinic	1	8	1	**10**
Working Years	-	-	-	**0**
• Less than 3 year	-	-	-	**0**
• 3-5 years	-	-	1	**1**
• 6-8 years	-	1	-	**1**
• 8-10 years	1	7	-	**8**
• More than 10 years	1	8	1	**10**

2) Usability of DRCS: The usability of the system in admin site was evaluated based on how easy the system is used. From this section, respondents were able to find the design flaws in terms of error messages during the input of data, confirmation message before the data were deleted, and whether the functions applied in fundus images work as it supposed. Results of the system usability for admin are shown in Table VI. Overall, the results from this testing show that the respondents are satisfied and at ease with the design and performance of the system.

3) Suggestion for improvement: Based on the alpha testing with the doctors, the respondents suggested sending an auto-mail to the registered users including the username and password. They also suggested having a mobile-friendly view of the system for a compatible platform of the system.

B. Specialist

1) Functionality of DRCS: The functionality testing for the specialist site covers the functionality of the DR cases and image editing. Table VII shows the results of the testing. Based on the overall result for the specialist site, most of the respondents successfully use the functions in the system which are the DR cases view, functionality of the annotation tools, and image editing tools.

2) Usability of DRCS: In the specialist site, usability is evaluated based on the friendliness of the system to the users. The result of this usability testing is shown in Table VIII. Overall, the results from this testing show that most of the respondents agree with the friendliness of the system design except for information finding, where the result mostly shows disagreement due to the unavailability of the searching function.

3) Suggestion for improvement: Several suggestions were given by the respondents regarding the specialist site. For instance, it is suggested to provide a full scale for viewing the fundus image such as the zooming tool. Besides that, it is better to include the security function for patients and doctors' privacy. Regarding the case form of diabetic retinopathy, the respondents suggested a better arrangement of the data in the form containing the demographic information of the patients. For the discussion area, the respondents suggested that the specialist or primary health cares who are assigned to handle the case can only edit and delete the discussion. It is also suggested to disable the discussion area once the diabetic retinopathy case is completed to avoid any changes in the data.

C. Primary Health Care

1) Functionality of DRCS: In the Primary Health Care site, various parts are available in the system such as DR case details, fundus images processing, and discussion area for the primary health care, and specialist. This section provides the evaluation results on the functionality of the DR case details, fundus images, image processing, and image editing. Based on the overall result, most of the respondents have successfully used the functions, as presented in Table IX.

2) Usability of DRCS: The usability of the system for the primary health care's site was evaluated based on the easiness and efficiency of the system. Table X shows the result of the usability testing of the primary health care's site. Overall, the results from this testing show that the respondents mostly agree with the design and performance of the system, except for the information finding where respondents found it is difficult to search for the information of DR case or patients details when there are many DR cases listed in the system. This is due to the lack of searching feature in the system.

3) Suggestion for improvement: The alpha testing for primary health cares revealed that the respondents suggested more security for patients' details since the data are confidential. In addition, respondents suggested for the primary health cares' discussion area to be anonymous or semi-private.

TABLE VI. ADMIN TESTING ON USABILITY

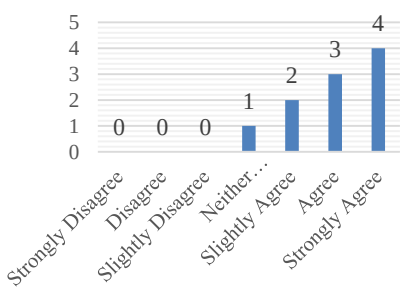
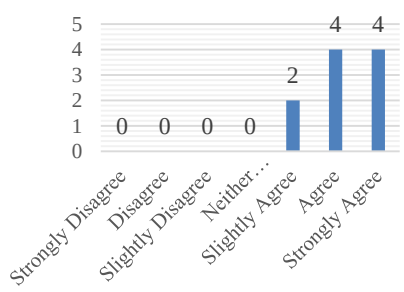
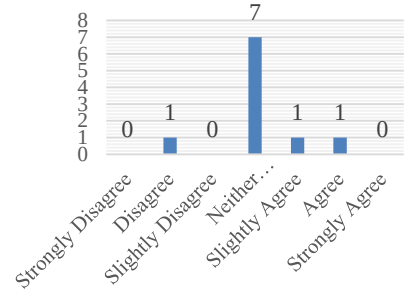
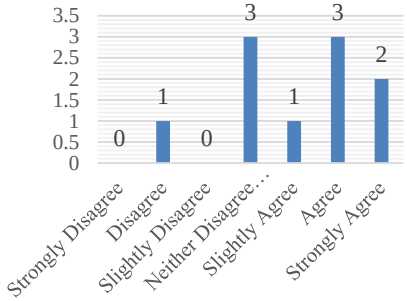
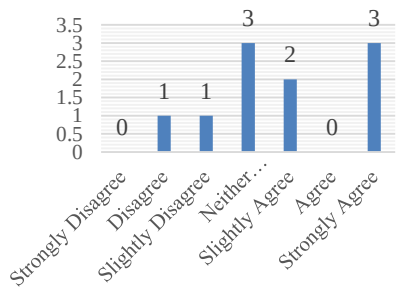
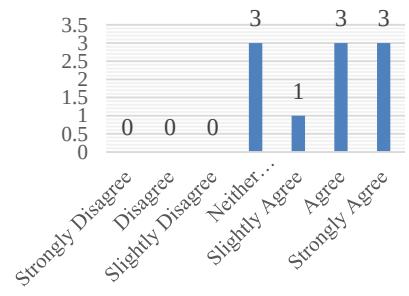
Ease of use	**Ease to learn using the system**	**System gives error messages**
		
Ease in information finding	**Expectation functions and capabilities included in the system**	**Satisfied with overall system**
		

TABLE VII. FUNCTIONALITY TESTING ON SPECIALIST SITE

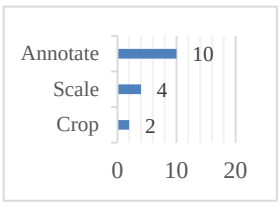
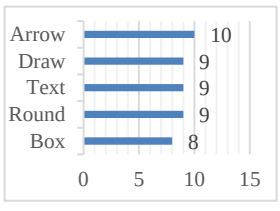
List of DR cases submitted by other Primary Health Cares able to view		**Successfully view DR case details**		**Successfully comment on DR case details**		**Annotation tool working fine**		**Requiring the annotation tool**	
Yes **No**	10 0	**Yes** **No**	10 0	**Yes** **No**	9 1	**Yes** **No**	10 0	**Yes** **No**	10 0
Image editing style required		**Annotation style required**		**Image editing buttons are working fine**		**Image editing features offered are suitable**		**Image editing features offered sufficient**	
				**Yes** **No**	9 1	**Yes** **No**	8 2	**Yes** **No, need magnifiers**	8 2

TABLE VIII. SPECIALIST TESTING ON USABILITY

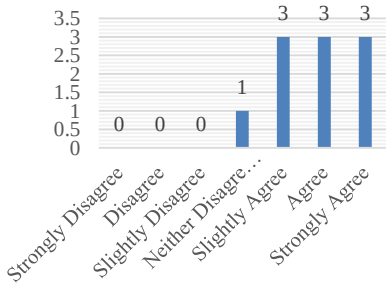
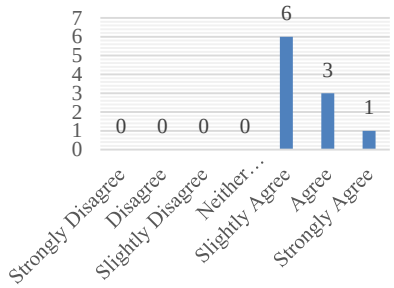
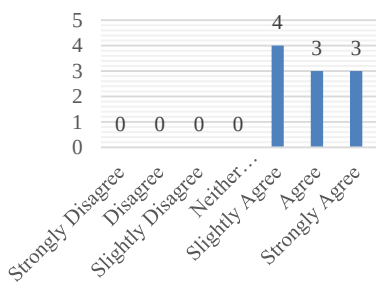
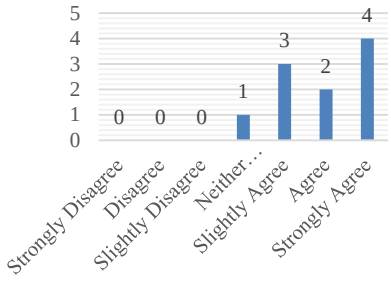
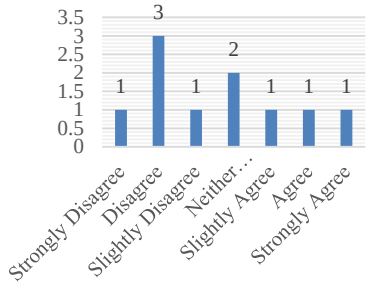
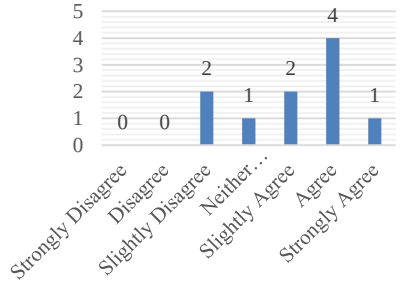
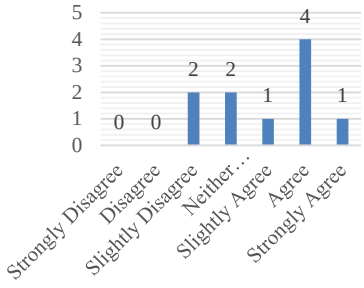
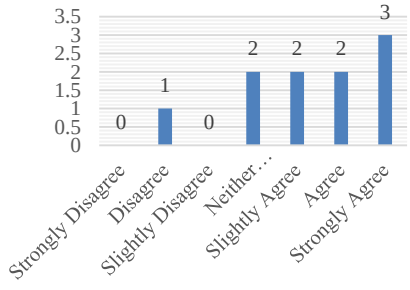
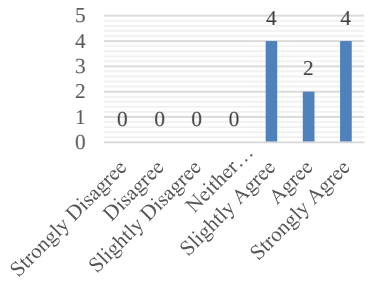
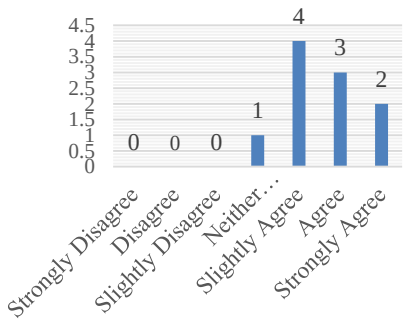
Simple usage of the system	**System effectively diagnose the signs of DR**	**Annotation features able to use on the fundus efficiently**
		
Ease learning to use the system	System gives error messages	Ease in information finding
		
Expectation functions and capabilities included in the system	**Ability to consult primary health care on DR through the system**	**Communication medium among specialist and primary health cares can be done in the system**
		
Satisfied with overall system		
		

TABLE IX. FUNCTIONALITY TESTING ON PRIMARY HEALTH CARE SITE

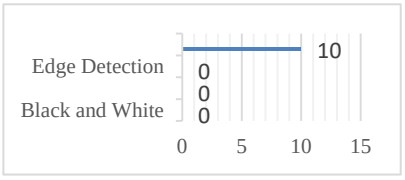
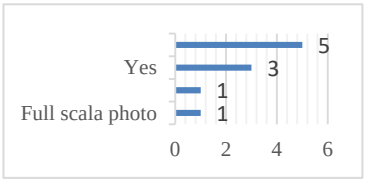
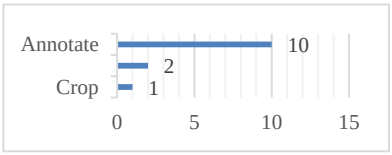
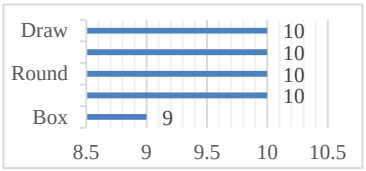
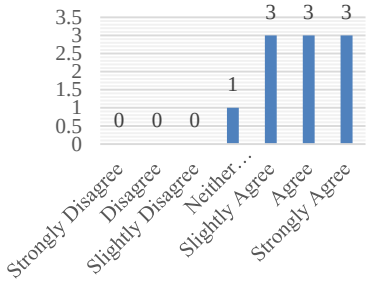
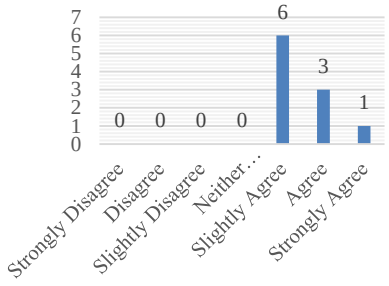
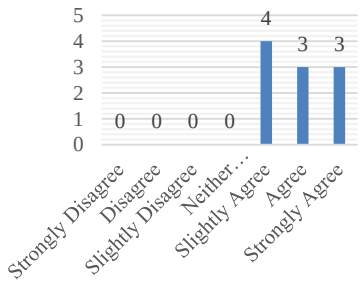
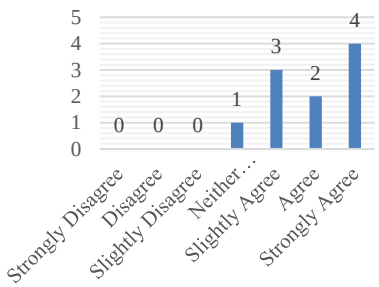
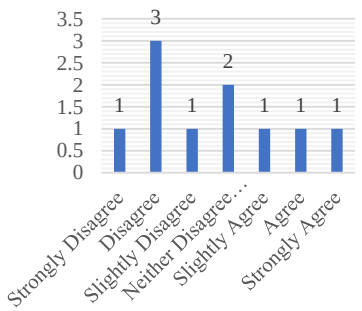
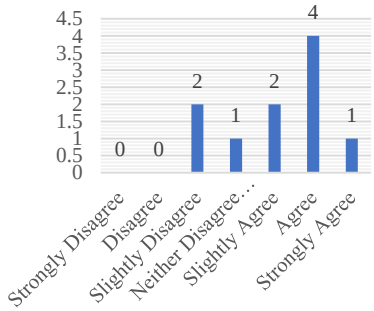
Ability to view DR case details list submitted by Primary health cares		**Successfully add new DR case details**		**Successfully view DR case details**		**Successfully edit DR case details**		**Successfully delete DR details**	
Yes **No**	10 0	**Yes** **No**	10 0	**Yes** **No**	10 0	**Yes** **No**	8 2	**Yes** **No**	7 3
Successfully comment on DR case details		**Successfully upload fundus images**		**Able to view a fundus image**		**Successfully change/reupload another fundus image**		**Successfully delete fundus image**	
Yes **No**	10 0	**Yes** **No**	9 1	**Yes** **No**	10 0	**Yes** **No**	9 1	**Yes** **No**	10 0
Image processing buttons work fine		**Offered suitable image processing features**		**Required image processing features**		**Offering sufficient image processing features**			
Yes **No**	9 1	**Yes** **No**	9 1						
Annotation tool works fine		Requiring annotation tool		Image editing style required		Annotation style required			
Yes **No**	10 0	**Yes** **No**	10 0						
Image editing buttons are working fine				**Image editing features offered are suitable**		**Image editing features offered sufficient**			
Yes **No**	10 0			**Yes** **No**	10 0	**Yes** **No, need magnifiers**	9 1		

TABLE X. PRIMARY HEALTH CARE TESTING ON USABILITY

Simple usage of the system	**System effectively diagnose the signs of DR**	**Annotation features able to use on the fundus efficiently**
		
Ease learning to use the system	**System gives error messages**	**Ease in information finding**
		

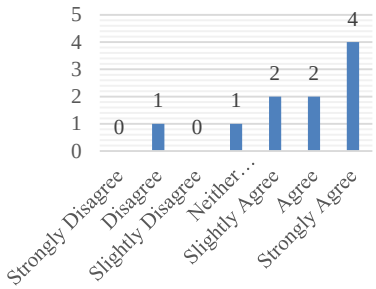
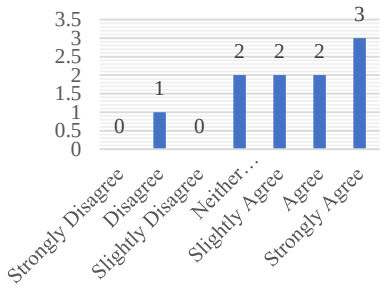
Expectation functions and capabilities included in the system	Ability to consult primary health care on DR through the system
	

TABLE XI. FUNCTIONALITY TESTING ON ADMIN SITE

Ability to view user details list		**Successfully add new user details**		**Successfully edit user details**		**Successfully delete user details**	
Yes	10	**Yes**	10	**Yes**	10	**Yes**	8
No	0	**No**	0	**No**	0	**No**	2
Ability to view hospital / health clinic details list		**Successfully add new hospital / health clinic details**		**Successfully edit hospital / health clinic details**		**Successfully delete hospital / health clinic details**	
Yes	10	**Yes**	10	**Yes**	10	**Yes**	8
No	0	**No**	0	**No**	0	**No**	2

V. DISCUSSION

In summary, a total of 10 respondents from Hospital Melaka have participated in the alpha testing of the system. The results of this testing enable a further review and evaluation of the functionality and usability of the developed system. Throughout the development of the system, it can be concluded that the system is able to overcome the problems and challenges of DR screening with the existence of the image processing and image editing plugins in the web-based environment. The image processing approach provides image filtering features and other image processing techniques which produce the image improvement and enhancement of several image characteristics or features for the next stage of processing. As for image editing, the annotation feature allows the primary health cares to draw or write on the fundus image, where the specialist is required to scribble some comments on the fundus image. Moreover, with the discussion area provided in the system, it allows the specialist to provide opinions and verify the content of the case details. This function also allows discussion and knowledge sharing of DR signs with other primary health cares through an online platform.

VI. CONCLUSION

The newly proposed system integrates image processing and image editing in a web-based method for DR screening. It improves the communication channel between the specialist and primary health cares. Furthermore, the proposed image processing and editing features reduce the burden in detecting the complex signs of DR in fundus image and create a sharing platform to discuss the DR cases among the users. This paper covers the analysis, design, development and testing phases of DRCS and place more details on the development part of the system. The project contributed to the medical and education fields. Furthermore, it sparks the users' awareness of computer technology that is useful through this application. The findings of this study will positively impact medical and education fields as it helps increase the efficiency among medical experts in treating eye diseases. This project would be a point of reference or benchmark for other eye disorders such as radiology, cornea, skin and hypertensive retinopathy.

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