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# Eyesight Tests and Lazy Eye Exercise by using Virtual Reality Mobile Application

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***Abstract*—Please Eye and visual disorders are increasingly becoming an issue throughout the world. An estimated 1.3 billion individuals worldwide are blind or have vision impairment. According to a statistical study [1], if researchers focus more on these disorders, the number of people with vision impairment will be much lower. Amblyopia, myopia, and hypermetropia are a few of the eye conditions that relate to blindness and vision problems; they represent prevalent issues that can result in blindness. To better understand eye illness demands, researchers conducted interviews with several ophthalmologists and patients. The results of these interviews revealed that late vision checking is one of the most common factors exacerbating vision difficulties. To aid patients in identifying the signs of eye disorders, this study proposes and develops a virtual reality (VR) mobile application that offers eye vision tests and workouts to improve people's eyesight. The program aims to provide activities to treat lazy eye illness, a distinct eye condition.**

***Keywords—virtual reality (VR), Artificial Intelligent, Lazy eye exercise.***

## I. INTRODUCTION

Blindness and vision impairment are now two of the biggest issues people of all ages can experience. According to an article published by the World Health Organization [1], over a billion people worldwide suffer from eye disorders. However, this figure could be potentially lower if diagnoses for problems with vision impairment were improved [1]. Amblyopia is a commonly reported eye condition that can result in blindness, as can myopia (short-sightedness) and hypermetropia (long-sightedness). A further major eye condition that negatively impacts people's lives is colour blindness. Approximately 1 in 200 women and 1 in 12 males worldwide are affected by it [2]. Many people experience eye conditions, including amblyopia, strabismus, myopia, hyperopia, and colour blindness. Additionally, these illnesses can have a serious effect on children's vision. Due to potential issues, it may be challenging for the patients to participate in sports or other activities, maintain their academic progress, or both. Furthermore, poor vision can also make it difficult for people to maintain independence, find employment, and drive. Even going to the clinic to train their eyes might be exhausting for those with lazy eyes. All eye illnesses may be avoided if patients are identified and treated at an early stage.

This project proposed the development of a VR-Android mobile application connected to VR goggles that facilitate various tests and exercises for diagnosing eye disorders. The app was designed to treat the affected eye for patients with lazy eyes by having them continue their lazy eye exercises. Performing regular vision checks can assist specialists to track eyesight developments, monitor vision issues, and implement measures to improve visual workouts.

## II. BACKGROUND

While patient cooperation is crucial for clinicians to provide an accurate diagnosis, it cannot always be taken for granted, especially when working with young patients. Keeping children's attention is one of the biggest issues in this situation. This can be especially problematic for

ophthalmologists who need to evaluate the patient's vision by having them gaze at projected letters before attempting to identify them. This exercise can be so monotonous for the patient that occasionally, especially in the case of very young children, their answers become inaccurate, if not downright incorrect, resulting in them losing interest in the task at hand.

Amblyopia1, more commonly known as lazy eye, is one of the unfortunate eye illnesses for which an early diagnosis is crucial [3]. Numerous businesses have started offering content and services using VR and AR technologies as they have emerged as promising technologies in the entertainment and display industries. VR and AR can be applied in various contexts, even those with wholly dissimilar goals and guiding principles, and they have been found to increase participation in specific training exercises and activities. The VR market is anticipated to reach US$ 120 trillion in 2020 [4]. The use of a three-dimensional (3-D) artificial environment in computer games is known as VR gaming [5]. To enable users to suspend disbelief and see the VR environment as genuine, VR software creates VR environments that supersede the user's perception of the actual world around them.

The main goals of VR games are to provide a fun and entertaining environment in which they can be taught specific abilities and skills that they may use in the real world.

The fun element of VR games entails that they can be far more engaging in comparison to alternative teaching modalities. If users are having fun while playing, they will likely keep playing and learn the lessons the game is trying to teach them more quickly. At some point, the user starts to apply that particular behaviour in the real world outside the game.

In reality, there are many applications for VR gaming. VR gaming was first formally employed in the military [6], where it was used to train soldiers using simulations of real- world situations. Other application areas include the educational field, which can help kids memorize more information, implement a different teaching method [7], or teach a specific behaviour to future employees. In the current study, we concentrated on the medical industry as one key application area where VR games can be used for both patient and doctor therapy.

When we discuss (VR) games for doctors, we refer to all simulations and virtual environments that are used to train new doctors a specific procedure and develop their skills before performing on actual patients [8]. It is clear that VR games can be employed with both younger and more elderly patients. In the case of the former, they can be particularly helpful because they can capture children's attention. As a result, they can be used to engage kids and carry out tasks like disease assessment or long-term rehabilitation programs, even at home and outside of the hospital. Similar field applications will be covered in the sections that follow.

## III. RELATED WORK

### *A. Maintaining Testing Vision Applications*

There Several mobile applications can be employed to evaluate eye vision acuity. These consist of both traditional vision acuity tests and more contemporary approaches, as well as the well-known examination board test. Tests for red desaturation, macula, and colour blindness are available in some applications [9].

### *B. Existing mobile Application*

- Independent Me (IM-VR)

A VR game has been developed for children with cerebral palsy that offers rehabilitation exercises via a fun approach that is underpinned by the following objectives: Enhance the child's use of creativity and level of independence. Increase the likelihood that kids will attend their training sessions [10].

The proposed application (VR-EYE) and Independent Me are similar in that they both use VR games to provide engaging ways to assist patients, as seen in figure 1. This application helps to raise the amount of patient interest in visiting clinics.


Fig. 1 One of the levels of the game using VR technology [10]

The suggested program differs in that the goal of IM-VR is to assist children with cerebral palsy, whereas the VR-EYE application offers a game that encourages patients who have lazy eyes to complete rehabilitation exercises. While IM-VR does not use any portion of the vision tests for its intended use, the VR-EYE application does.

- Optics Trainer Application

The optics Trainer application was developed using VR technology. The program facilitates at-home visual rehabilitation and training. This application results from a collaboration with the Vision Therapy Clinic in Brookfield. As such, it is designed to give patients a legitimate prescription. The application framework for the optics trainer is shown in figure 2 [11]. The Optics Trainer application, which has similarities with the VR-EYE application, offers training for lazy eyes by selecting a lazy eye to focus on anti- suppression and fusion. The eye doctor can monitor the patient's score and subsequently determine the most suitable prescription. There are some differences of note between the two applications; for instance, the Optics Trainer app does not include vision tests for myopia, hyperopia, or colour blindness. Additionally, the Optics Trainer program does not support the Arabic language, while the proposed application does.


Fig. 2 Optics Trainer Application, The Vision Therapy Framework

- Remmedvr application in IEEE

RemmedVR uses VR technology to provide telemedicine for domestic vision care. This program was created to assist children by simultaneously engaging both eyes in play and instruction [12]. Because it offers patients lazy eyes training, the software is similar to VR-EYE. RemmedVR is different from the VR-EYE application in that it does not include vision tests for myopia, hyperopia, or colour blindness. The proposed program does. The ability for ophthalmologists to remotely observe patients in the VR-EYE app is a further difference of note between the two applications.

- Vivid Vision

James Blaha, a programmer with strabismus and amblyopia, invented Vivid Vision, a sophisticated treatment system using VR vision therapy for strabismus and amblyopia [13]. Vivid Vision, a creative environment built with an Oculus Rift Development Kit, uses therapy concepts for amblyopia, perceptual learning, and suppression. The system includes six games, each focusing on a specific set of visual abilities. One of these games is called Bubbles. It involves players using one hand to pop the closest bubble out of a group of bubbles. The game's objective is to isolate stereoscopic depth perception utilizing a stereo acuity task. The level of task complexity can be automatically adjusted during VR therapies, measuring the patient's progress while requiring less continual clinician observation. Additionally, therapies can be immersive and much more enjoyable for the patients.

The VR-EYE application and the game shown in figure 3 both employ VR to entertain and engage youngsters. Additionally, both programs improve the likelihood that kids would attend their sessions. The applications include two vision tests, lazy eye training games, and training games for vision. The VR-EYE program is specifically designed for usage at home, while the system can be used both in the home and clinic setting while being directly supervised by a clinician. Vivid is quite pricey in contrast to the planned, free-use application.

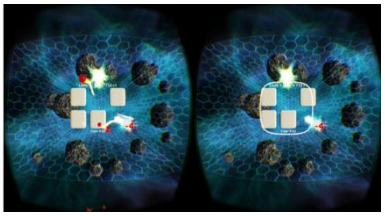

Fig. 3 VIVD application, VR-based Treatment for Vision Disorders

- Macula Test Application

By warning the user in the earliest stages of the disease and highlighting a problem with the macula caused by diabetes or macular degeneration, the Macula test application was created to test for macula disorders in the eye [14]. It reminds patients to conduct the tests on a frequent basis. The objectives of the two apps are similar. Both programs remind the user to conduct the test on a frequent basis. The key difference between the Macula Test Application and the proposed VR-

EYE application is that the former was designed to treat macula disease, while the latter is for patients with acuity vision disorders, colour blindness, or lazy eyes. The features offered by each of the similar solutions discussed above are summarized in Table 1 below.

TABLE I. Summary of features between the existing solutions and the proposed project

| Application / Features | 1 | 2 | 3 | 4 | 5 | The proposed app |
|---|---|---|---|---|---|---|
| Arabic Language | | | | | | ✓ |
| Mobile app | ✓ | | ✓ | ✓ | | ✓ |
| Reminder/Notification | | | | ✓ | | ✓ |
| Free | ✓ | | | | | ✓ |
| Sign in / Signup | | | ✓ | ✓ | | ✓ |
| Eye Test | | | | ✓ | | ✓ |
| Eye Eexercise (Games) | | ✓ | ✓ | ✓ | | ✓ |
| View test results | | ✓ | ✓ | ✓ | | ✓ |
| Interactive VR to help patient. | ✓ | ✓ | ✓ | ✓ | | ✓ |

## IV. METHEDOLOGY

The first stage involved identifying the requirements and collecting the relevant data. To determine requirements two methods were used questionnaires and phone interviews. In addition, some ophthalmologists were asked for their insights on Twitter.

The questionnaire was conducted in two weeks, we received 223 responses. Participants of the questionnaire were patients, relevant of children patients and ophthalmologists 58.7%, 30.5% and 10.5%, respectively.

A questionnaire was categorized to three sections served as the study's first technique of data collection. The first two sections of the questionnaire dealt with the patient, while the third section considered the ophthalmologist's knowledge and experience. The first section was for the patient and patient's relatives: In this section all questions about the patient such as (age, gender, type of eye diseases, etc..), we add patient's relatives because it is difficult to reach all patients. The percentage of patients under 18 was 33.3% which is the target of the study other participants were over 18 years. The response of the question "What type of eye diseases do you face, or your kids face" was 85.3% of participants suffered from visual impairment, and 13.2% of participants had lazy eye diseases, and hypermetropia patients had the similar percentage, 2.9% who suffered from colour-blind.

The second section of the questionnaire was an initial section for ophthalmologists, questions were about the information and experience of the ophthalmologists in his field, and what type of disease of patient they face. 54.2% of ophthalmologist's participants had experiences more than 10 years, the expert in this field is very useful for the study to provide insights into the proposed app. 66% of the ophthalmologist participants conducted lazy eye diseases exercise for their patients that is shown in the figure 4, 88.2% of who did the lazy eye diseases exercise were kids that is presented in the figure 5.

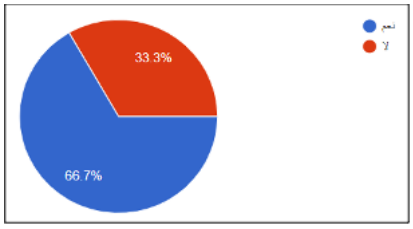


Fig. 4 The percentage of patients who had lazy eye exercises.

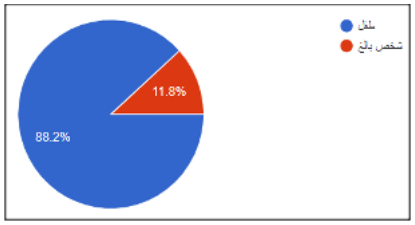


Fig. 5 The percentage of children and adults who conducted the lazy eye diseases exercise.

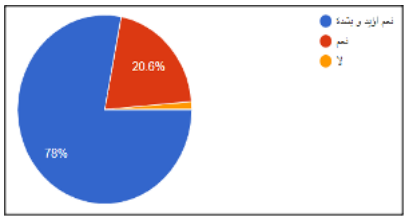


Fig. 6 The proportion of participants that prefer the presence of a lazy eye exercise in the proposed application.

The third section of the questionnaire was about measuring participants' knowledge about VR technology. The first question was "Are you familiar with VR technology" the results were as follows: 26.9% of users who have a good knowledge, and 22.9% who were not familiar. AS presented in figure 6, 78% of the responds strongly agreed with providing a lazy eye exercise in the proposed application, and 20.6% of the responds

agreed with it, very few participants were not agreed with it.

Interviews with ophthalmologists with more than 5 years of experience treating eye disorders at Khaled clinics constituted the second method. During the interview we explained the idea of the proposed application and then we conducted open ended questions. The questions were about providing their opinion toward features that involved in the app, their responses were highly agree about them and most of them recommended that the app should support Arabic language. In the end of interviews, we asked them "Do you want to add any of the extra feature that would make the application more efficient with the patient" most of the interviewees suggested adding a reminder for exercise feature. After collecting and analyzing data, we designed, implemented, and tested the proposed application, figure 7 presents the life cycle of the proposed application. More details about design, implementation and testing will be described following the sections.

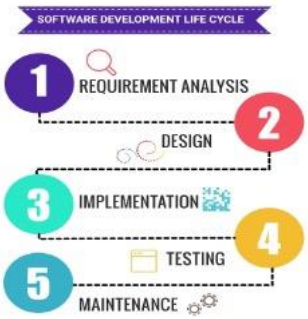


Fig. 7 Life cycle of the proposed application

## V. THE PROPOSED APPLICATION

### A. *Desgin*

The suggested app has the following attributes: Virtual Reality Game (VRG) considers exercises to address lazy eye conditions. Depending on the type of lazy eye condition, various physical workouts may be performed. The suggested software offers VR exercises to make training enjoyable and encourage the patient to finish the activity. According to a recent study, patients with lazy eyes between the ages of six and twelve can benefit from vision-improving exercises. Additionally, the study discovered that lazy eye exercise has a greater impact on young children. Thus, it might be utilized as a cure for the condition in certain age groups [1].

The VR application offers two separate tests: a colour vision test and an acuity vision exam. After that, the database will be saved with the results from both tests. Reminder notifications will also be made to set the time and remind users to engage in eye training or test their eyes. The proposed solution's architectural diagram is shown in figure 8. The application operates in the VR environment on these screens (the prototype text is in English due to the design program; the final text will be in Arabic).

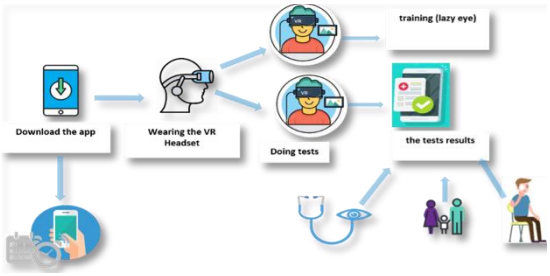


Fig. 8 The architectural diagram of the proposed solution.

### B. *Implementation*

Different tools were employed during the implementation stages to develop the application, hardware, and software. A Galaxy 8+ smartphone, Samsung Gear VR headset, and laptop were the key pieces of gear utilized to implement, emulate, and test the program. Various programs were utilized during the development stages, including Visual Studio, which offers a completely integrated programming environment for implementing the app, Unity, a video game engine for creating 2D or 3D games, Xampp MySQL to store user accounts and their results, and others.

### C. *Testing and Maintence*

The testing techniques were used following the application's implementation. The built application was tested to ensure it was functioning and reacting as it should. Unit tests and integration tests were employed. The unit test approach was used to test each function separately to guarantee that each function operates correctly and without defects or problems. Input fields that require the user to enter certain data, for instance, were examined. To guarantee that all functions operate without mistakes, relevant functions were integrated throughout the integration test. The signup and login screens, as well as the main menu of the proposed application, are merged as an example of integration testing. When a user successfully signs up or logs in, the signup or login screen is closed, and the main menu screen displays without any unexpected issues.

## VI. RESULTS, DISCUSSION

Notably, from the results of the questionnaire is very crucial to develop a mobile application connected to VR goggles that facilitate various tests and exercises for diagnosing eye disorders. 85.3% of 223 people participated in the study suffered from visual impairment, 13.2% of them had lazy eye diseases. Also, 66% of the ophthalmologist participants conducted lazy eye diseases exercise in a traditional way using pen and paper for their patients, and 88.2% of who did the lazy eye diseases exercise were kids. Moreover, a very large number of participants agreed with using VR technology for lazy eye exercises all these results are very strong evidence of important of the proposed application.

Designing, implementing, and testing the application were successful. The interfaces of VR-EYE application and navigation menu are presented in figures 9,10 and 11. After the patient selects a test from the main menu, the user will go to the test menu and there are two options as shown in figure 12, start the test or information about the test. Then the user will start the game which is a lazy eye exercise the snapshot of the game is presented in figure 13. The idea of the game is that the user can improve his lazy eye (affected eye) through training the eye by moving and tracking the colored ball and gaining the scores if the ball touches the diamonds. After the test is finished, the result is displayed to the patient as shown in figure 14.

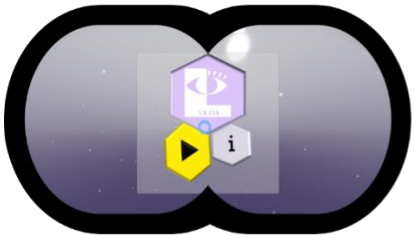

Fig. 9 Start User Interface Application

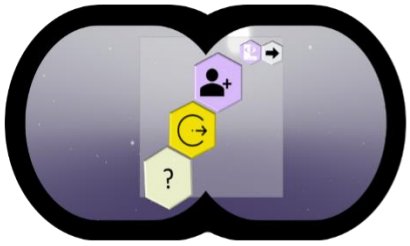

Fig. 10 Registration user interface

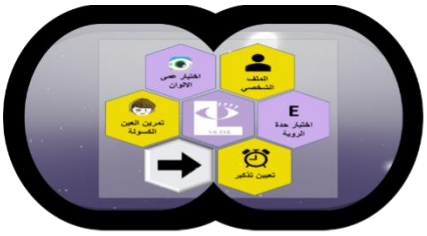

Fig. 11 Main menu of the application


Fig. 12 The interface of vision test

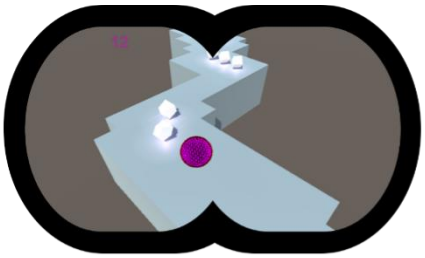

Fig. 13 lazy eye exercise (game)

Fig. 14 End the test and display the result.

## VII. LIMITATION

In the visual acuity test, the patient can perform the test from a fixed distance of 20 feet, In the real clinics, the test can be done from several distances for a more accurate result. Furthermore, due to the brief duration of the study, researchers were unable to develop a colour blindness test after receiving ophthalmologist feedback about the application.

## VIII. CONCLUSION AND FUTURE WORK

The paper provided the background of used technology, and a literature survey of similar projects contains what the similarity features and differences. As discussed in the literature review all similar project have limitations that can be solved the proposed application. Then, data collected from two different methods survey and interviews, after analyzing the data in order to determine the

functional requirements, it was found from these studies that most of the responses agreed about project features, and they supported the project idea of including VR for the detection some eye diseases and enhance eye health for lazy eye patients. the description of designing, implementation testing phases were briefly provided. The application was developed successfully. However, regarding the short period of the study there is a limitation which is as the accuracy from the virtual distance in the acuity test.

Future work may involve developing additional features to support the VR-EYE project, such as showing the dates of acuity vision tests and lazy eye exercises, displaying test results in the user's profile, creating a reminder to prompt the user to use the application after setting up a reminder, including a colour blindness test, etc. Additionally, users could be given the option to register and log in using a Google account for quick access to the program, allowing users to customize the interface's colour theme and exercise time based on ophthalmologist recommendations. A new macular disease test will also be included.

## ACKNOWLEDGMENT

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# اختبارات البصر وتمرين العين الكسول باستخدام الواقع الافتراضي

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***المستخلص.*** تتزايد أمراض رؤية العين مؤخرًا يومًا بعد يوم. يعد العمى وضعف البصر مشكلة رئيسية في العالم، حيث يعاني ١,٣ مليار شخص من مختلف الأجيال. وفيما يتعلق بدراسة إحصائية [١]، فإن عدد المرضى الذين يعانون من ضعف البصر يقل بشكل ملحوظ إذا اهتم الباحثون أكثر بهذه الأمراض. بعض امراض العيون ذات الصلة هي الغمش وقصر النظر ومد البصر، وهذه هي أبرز المشاكل الشائعة التي يمكن أن تؤدي إلى العمى. أجرى الباحثون مقابلة مع العديد من أطباء العيون والمرضى للتحقق من احتياجات أمراض العيون، وأشاروا إلى أن أحد أكثر الإجراءات التي تسبب تفاقم مشاكل الرؤية هو التأخر في فحص الرؤية. تم اقتراح هذا البحث وتطويره باستخدام تقنيات الواقع الافتراضي – المقترح عبارة عن تطبيق للهاتف المحمول يوفر فحوصات وتمارين لبصر العيون لتعزيز رؤية الناس لمساعدة المرضى على تشخيص أعراض أمراض العيون. التطبيق هو تطوير تمارين لعلاج مرض معين للعين وهو مرض كسل العين.

***الكلمات المفتاحية***ـ تقنية الواقع الافتراضي، الذكاء الاصطناعي، مرض كسل العين.