# MOBILE VISUAL ACUITY ASSESSMENT APPLICATION: AcuMob

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***Abstract:*** *This paper presents a mobile healthcare (mHealth) system for estimation of visual impairment that provides easiness by specifying the degree of an eye as orthoscopes. Our proposed system called AcuMob which is an Android based mobile application aimed to be used by patients who have myopia. In the crowd society, our proposed app will be implemented faster than the traditional ophthalmologic examination treatments as an alternative. Because AcuMob can be used in everywhere in any time slot, it is offered in the area where the ophthalmologist is not available. The system is developed with using Xamarin framework and voice commands are used to interact with mobile app. Some preferable letters that are suggested by the ophthalmologists were used in the system. The letter categories are specified according to letters' sizes. In the start-up screen, the biggest letter is demonstrated and if the user responds correct answer, the letter's size is being smaller. However, if the user says wrong answer three times consecutively, eyesight ratio is produced by the system to the user referencing to Snellen Chart's information. This article has aimed at making a prediction about the visual impairment's degree. Thanks to AcuMob, people can get idea about their visual acuity without consulting to an eye medical doctor (MD). For the evaluation of systems' reliability, field tests were performed at Bayrampaşa Göz Vakfi Hospital in Istanbul with two ophthalmologist specialists. At the end of trials, the actual diagnosed degrees and the equivalent degree of eyesight ratios according to Snellen Chart's information is compared and the success rates are shown. The system achieved at the 65% of average success rate, which can give users an idea about current condition of their visions.*
***Keywords:*** *m-Health, Mobile application, Visual acuity, Eye test, Eyesight ratio.*

## 1. Introduction

Visual impairment is a common disease in today's world, and it is mostly seen in people who are aged 65 and older [1]. Although the number of elderly people with visual impairment is much higher, this disease is seen in children with the ratio approximately 26% in this decade [2]. With developing technology, the solutions of the diseases can be found in different platforms and the importance of eHealth has begun to be understood [3].

Ophthalmology is a medical branch that is related to vision problems so that ophthalmologic examination is very common in hospitals in order to diagnose the vision problems [4]. To specifying the degree of vision of people with visual impairment, orthoscopes are used as primary tools.

I this study, a mobile application called AcuMob that grades the eye disorders of patients was presented. Within the proposed system, voice commands were used to interact with the system and Xamarin framework was preferred to implement the application for mobile platforms. To verify the accuracy of the proposed system, patients who were examined by ophthalmologists were asked to use AcuMob after the traditional examination. The prediction rates produced by system and the real diagnostic results coming from ophthalmologists were compared.

The remaining sections of this paper are organized as follows: section two introduces the background and related work, section three explains the approach in detail, section four gives an analysis about test results and section five provides the conclusion and future work.

## 2. Background and Related Work

Visual impairment is a common disease since the birth of humankind. A huge number of systems were developed in order to find solution to this common condition.

Some of the research that has been developed in this area are summarized in this section.

Tarbert et al. presented a tablet-based application "The Stroke Vision App" for the visual impairment in stroke survivors in order to act as a screening tool. Visual acuity, visual fields and visuospatial neglect can be assessed by this application [5].

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Lewis et al. developed a simulator with using Unreal Engine 3 game engine. Opticians, visual impairment consultants and group of students tested this virtual environment and test results was promising [6].

In the study of Zhang Xiaomei, the relationship between visual impairment and higher education was investigated. They constructed a network system that includes teaching aids for higher education of people with visual impairment [7].

Another study by Geman et al., a health care self-monitoring system that includes network of sensors transmitting the information was developed. This system warns the users about the obstacles in their way by using aural warnings [8].

Fransis et al. studied the relationship of visually impaired people and their usage of e-commerce web sites. They proposed a framework that will be more suitable for people with visual impairment [9].

In the study of Murphy et al. twenty computer applications that provides touchable sensations were used in the learning phases of math and science classes of visual impaired students [10].

Kii et al. built an accessible optical wireless pedestrian support system that is using a visible light communication with self-illuminated bollards to determine the best distance for danger notification [11].

In the study of Amin et al. a system named Mongol Dip was built to provide audio-based interfaces in the usage of computers [12].

Vlaminck et al. built a drag detection system that provides a 3D atmosphere, which uses multiple sensors to help visual impaired people by increasing their mobility [13].

In the study of Santos et al., a wireless interactive system composed of some modules was designed. This system works with smartphones and embedded systems. Information on the bus stop module is transferred to those who have visual problems for making their transportation easier [14].

Mauro et al. designed a system called DroneNavigator to be used in navigating visually impaired people. They used small insights drones to sense the environment and objects to warn users [15].

In the study of Emiliano et al., visually impaired people can get the information about the environment and routes thanks to their solution Audioguide. The goal of this system is to provide independency to people that have visual impairment during their locomotion [16].

Lisa et al. built an Android application that is used in learning area of geometry for visually impaired students. The system provides an atmosphere to visually impaired students to investigate basic geometric structures showed on a tablet through sound and vibrotactile feedback. A tactile experience is provided by a physical application, which can be a manipulable deformable shape sensed by the tablet [17].

Erin et al. provide a system that contains Wizard-of-Oz navigation interfaces in order to respond to different instruction periods during in situ navigation tasks. They realized an experimental study with nine visual impaired people, and provided them the directions [18].

In the study of Alireza et al. a method was proposed to help people with visual impairment about playing soccer more adequately. The system uses headphone-rendered special audio, a personal computer, and sensors to provide 3D sound representing the objects [19].

## 3. Methodology

AcuMob was developed to be used for people with visual impairment who can benefit from this application to state their visual acuity anywhere. Voice commands is the only used interaction method for implementing our application. With using to users' voice commands, the system process acuity and states vision problems.

It is planned to use the application from 3 meters to the users. Bluetooth earphones was used to capture voice commands more effectively. Patients are asked to respond correctly to the demonstrated letter within 5 seconds. At the end when patient cannot recognize the screened letter, AcuMob produces a result like "The patient's capacity of see is 70%". As the final step of proving the success of AcuMob, the data coming from the doctors are compared with our application to evaluate the success of prediction.

In today's world, ratio of visual impairment is increasing day by day so that some solutions in order to ease doctor's workload should be found. Our proposed model is designed to be serviced under this goal.

The system was developed using Xamarin framework and Bluetooth earphones was used by the users as supporting device. The vision ratio's information is provided by the Snellen Chart's information.

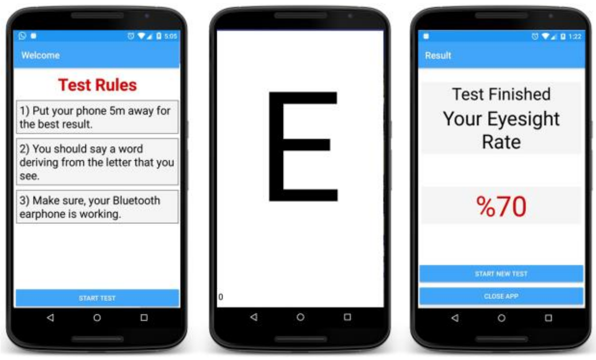


**Figure 1.** Interfaces of AcuMob

As shown in Figure 1, at the beginning of the application, the system welcomes the user with displaying rules of experiment. Local variables *LetterCategory* and *WrongLetterCounter* were initialized to zero in the start-up. These definitions are used for counting how many times the users respond wrong letters. Then, AcuMob shows the randomly selected first letter and wait 5 seconds to user's perception. After that, the system gives a message that "You can say letter" to user. The decision part that is whether the category of letter is greater than zero or not. If the category of letter is greater than zero, the program outputs a message that is "You see perfectly" that means the user do not have any vision problem. However, if the category of letter is different from zero, another decision part puts into process. This time, if the user does not spell the letter correctly, the system gives a message that is "You did not say correctly" and if this situation repeats three times, the system determines the vision ratio of the user according to values of vision table. If the total number of mislocal letters is less than 3, the system shows another letter with the same size and the user waits 5 seconds and say the letter that is seen from the system just like in the previous steps. Another possibility that, if the user says the letter correctly, the system gives a message about saying the letter successfully, category of letter is planned to be incremented.

Our proposed model is represented in the flowchart below as Figure 2.

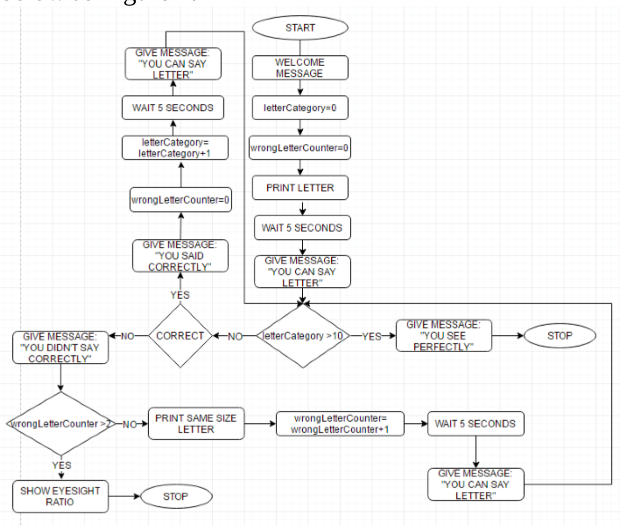


**Figure 2.** Flowchart of the System

Some letters like A and E are preferred to show for patients to state vision problem. Operator Doctor Şeref Kayabaş from Bayrampaşa Göz Vakfı Hospital from İstanbul recommend these letters to achieve maximum results. Also, as mentioned in other research articles, these letters are frequently used for vision tests [20]. The letters and whose sizes that were used by the program are shown in the Table 1 below.

**Table 1.** The Letters and Sizes

| Letters | Sizes |
|---|---|
| 'E' | 160 pt. |
| 'M' | 160 pt. |
| 'F' | 60, 160 pt. |
| 'U' | 105 pt. |
| 'H' | 33, 41, 49, 105 pt. |
| 'S' | 105 pt. |
| 'N' | 80 pt. |
| 'V' | 80 pt. |
| 'T' | 41, 49, 80 pt. |
| 'Z' | 66 pt. |
| 'P' | 66 pt. |
| 'D' | 66 pt. |
| 'K' | 33, 60 pt. |
| 'L' | 33, 41, 60 pt. |
| 'A' | 49 pt. |
| 'R' | 45 pt. |
| '0' | 45 pt. |
| 'Y' | 45 pt. |

Letters were used in different sizes, because AcuMob provide the users to test the letters' sizes from larger ones to smaller. In the flowchart of the system, letter category was defined to show the sizes of letters. For instance, the letter 'H' is used in sizes that are 33, 41, 49 and 105. For the size 105, letter category is defined as 2. For the size 41, letter category is defined as 8 etc. If the user vocalize the incorrect letter three times consecutively, the system determines the vision ratio. This vision ratio is given according to Snellen Chart that is basic, mostly used and time saving chart in our daily life. It is mostly used from the distance 4 meters to 6 meters [21]. Table 2 shows the Snellen Chart's information and our system's ratios.

**Table 2.** Snellen Chart and Vision Ratio Information [22]

| Snellen Chart Information (Letter's Sizes) | Proposed System's Vision Ratio | Visual Acuity |
|---|---|---|
| 20/200 ft/m | 10% | 2.0-2.50 sph. |
| 20/100 ft/m | 20% | 1.75-2.0 sph. |
| 20/70 ft/m | 28% ~ 30% | 1.5 sph. |
| 20/50 ft/m | 40% | 1.0-1.25 sph. |
| 20/40 ft/m | 50% | 0.5 sph. |
| 20/30 ft/m | 60% | 0.5 sph. |
| 20/25 ft/m | 80% | 0.5 sph. |
| 20/20 ft/m | 90% | 0.0-0.25 sph. |

According to Table 2, the biggest letter's size is computed as 20/200 and it has the same size with our system's biggest letter's size that is defined as Letter Category 1. In this situation, the system gives a message to users "Your vision ratio is 10%". For example, the smallest letter's size for system is 33 that is defined as Letter Category 9, so according to Snellen Chart, the smallest letter's size is 20/20 ft/m that is the 1 means the users see perfectly, and the system gives message to users "You see perfectly!".

Proposed system gives a result about user's visual acuity at the end as a percentage. According to Snellen Chart that can be seen in Table 2 above, the proposed system's vision ratio corresponds to user's real visual acuity (eye's degrees) so that users shall get idea about their visual acuity in the neighborhood of.

## 4. Results and Discussion

We did some field tests to measure the performance of our implementation with visual impaired people in the hospital.

The test procedure was applied like below:

- Primarily, the ophthalmologists examined their patients.
- Then, the ophthalmologists diagnosed the degree of visual impairment of left eyes of patients (1.0, 2.0, etc.).
- Similarly, the ophthalmologists diagnosed the degree of visual impairment of right eyes of patients (1.0, 2.0, etc.).
- Then, the patients who were examined were directed to use ACUMOB application as an alternative approach.
- After that, Bluetooth earphones was used by the patients and the letters were seen in the phone's screen that was five meters away from them.
- Then, the eyesight ratios of left eyes were gathered and the comparison between results coming from

ophthalmologists and the ratios coming from system was realized.

- In the same vein, the eyesight ratios of right eyes were gathered and the comparison between results coming from ophthalmologists and the ratios coming from system was realized.
- Finally, the predicted success rate of the system was evaluated by the doctors.

As detailed in Table 3, the ophthalmologist firstly examined five patients. Their right and left eyes' visual acuities were examined and diagnosed separately. The measurements on the right side of the table show estimates of the same patients by the AcuMob system.

**Table 3.** Comparison between Patient's Information and Proposed System's Eyesight Ratios

| Traditional Examination | | | AcuMob Scores | | |
|---|---|---|---|---|---|
| **Patient 1** | 1.0 | 1.0 | **Patient 1** | 30% | 30% |
| **Patient 2** | 1.50 | 1.0 | **Patient 2** | 20% | 30% |
| **Patient 3** | 1.25 | 1.75 | **Patient 3** | 50% | 40% |
| **Patient 4** | 1.5 | 2.0 | **Patient 4** | 40% | 30% |
| **Patient 5** | 2.50 | 2.25 | **Patient 5** | 30% | 30% |

In Table 4 below, according to the values coming from Table 3, the success rates of right eyes and left eyes' acuities were computed by using proportion technique. For right eyes of these five patients, the total success rates were found as 61.6%, and for left eyes of these patients. The total success rates shoed up as 69.16%. The mean performance of the patients in the first group was determined as 65.38%.

**Table 4.** Comparison between Patient's Information and Snellen Chart's Estimated Prescription

| Traditional Examination | | | AcuMob's Readings | | | Success Rates | |
|---|---|---|---|---|---|---|---|
| | Right Eye | Left Eye | | Right Eye | Left Eye | | |
| Patient 1 | 1.0 | 1.0 | Patient 1 | 1.5 | 1.5 | 66.6% | 66.6% |
| Patient 2 | 1.50 | 1.0 | Patient 2 | 2.0 | 1.5 | 75% | 66.6% |
| Patient 3 | 1.25 | 1.75 | Patient 3 | 0.5 | 1.25 | 40% | 71% |
| Patient 4 | 1.5 | 2.0 | Patient 4 | 1.0 | 1.5 | 66.6% | 75% |
| Patient 5 | 2.50 | 2.25 | Patient 5 | 1.5 | 1.5 | 60% | 66.6% |
| | | | | | **TOTAL** | **61.6%** | **69.16%** |

In Table 5 below, another group of five patients were examined by the ophthalmologists. Their right and left eyes' visual acuities were examined separately. On the right side of the table, the estimates produced by AcuMon are shown, as in the first experiment.

**Table 5.** Comparison between Patient's Information and System's Eyesight Ratios

| Traditional Examination | | | AcuMob Scores | | |
|---|---|---|---|---|---|
| **Patient 1** | 0.50 | 0.75 | **Patient 1** | 40% | 40% |
| **Patient 2** | 1.5 | 1.5 | **Patient 2** | 20% | 20% |
| **Patient 3** | 2.75 | 2.50 | **Patient 3** | 30% | 30% |
| **Patient 4** | 1.0 | 1.25 | **Patient 4** | 30% | 50% |
| **Patient 5** | 1.75 | 1.75 | **Patient 5** | 40% | 40% |

In Table 6 below, according to the values coming from Table 5, the success rates of right eyes and left eyes' acuities were computed again by using proportion technique. For right eyes of second group, the total success rates were found as 65.2%, and for left eyes, the total success rates were found as 66.2%. The mean performance of the patients in the second group was determined as 65.7%.

**Table 6.** Comparison between Patient's Information and Snellen Chart's Estimated Prescription

| Traditional Examination | | | AcuMob's Readings | | | Success Rates | |
|---|---|---|---|---|---|---|---|
| | Right Eye | Left Eye | | Right Eye | Left Eye | | |
| Patient 1 | 0.50 | 0.75 | Patient 1 | 1.0 | 1.0 | 50% | 75% |
| Patient 2 | 1.5 | 1.5 | Patient 2 | 1.75 | 1.75 | 85% | 85% |
| Patient 3 | 2.75 | 2.50 | Patient 3 | 1.5 | 1.5 | 54% | 60% |
| Patient 4 | 1.0 | 1.25 | Patient 4 | 1.5 | 0.50 | 66% | 40% |
| Patient 5 | 1.75 | 1.75 | Patient 5 | 1.25 | 1.25 | 71% | 71% |
| | | | | | **TOTAL** | **65.2%** | **66.2%** |

As can be seen from the tables, the success rates of the system are about 60%. This score is truly acceptable to give an idea to the users about their visual acuities from a mobile application. Users were provided with an assessment of eye values in 2 minutes without any medical expert support. It is quite practical to use this app with any Android-based smartphone in any environment. In situations where the environment is silent, it has been experimented that the application works successfully without using headphones.

## 5. Conclusion

This research has aimed at making a prediction about the visual acuity of users via a mobile application. Thanks to AcuMob system, people can get idea about their visual acuity approximately.

The proposed system was developed on the Xamarin framework and it is designed to be used in Android platform. As part of future work, the necessary arrangements will be made so that AcuMob can also run on the iOS platform.

The proposed system was implemented for the patients who have visual impairment problem that is myopia. In the future, the proposed approach can be developed for the patients who have hypermetropia.

Totally, 18 letters and 9 letter's sizes were used in the interfaces of AcuMob. In the welcome screen of the application, the biggest letter is demonstrated As the user responds correctly, the letters are reduced in size. However, if the user says wrong answer, another letter with same size is seen on the screen. If the user responds three times wrong answer, the system outputs the eyesight ratio to the user. According to Snellen Chart's information, the eyesight ratio can be computed.

For the system reliability, the field tests were performed in Istanbul Bayrampaşa Göz Vakfı Hospital with two ophthalmologist specialists. Firstly, the ophthalmologists examined their patients and the visual acuity of their visual impairment is diagnosed. After that, the patients were asked to try AcuMob program by themselves. Experimental phone was placed five meters away from the patients so that the Bluetooth earphones is used to capture patient's commands.

At the end of trials, the diagnosed degrees and the equivalent degree of eyesight ratios according to Snellen Chart's information is compared and the success rates are shown. AcuMob achieved at the 65% of success rate that is acceptable for an alternative diagnosis, for ten patients.

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