Virtual Eye Doc: An Android Based App in Bengali Language for Eye Health & Vision Examination

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***Abstract*— Bangladesh is one of the most densely populated countries in the world, where a significant number of populations are suffering eye health and visionary problems. Over the last decade, a rapid growth of ICT uses has shown in Bangladesh. Thus ICT based health services would be an effective solution for providing the better health services to the citizens of Bangladesh. In this research work, an android based mobile application (Virtual Eye Doc) is developed in Bengali language to support the citizens of Bangladesh for their eye health monitoring and vision examination. The paper highlights our experiences of designing and developing the Virtual Eye Doc application. This paper also presents a qualitative and quantitative exploration of the effectiveness and the perceived benefits of this app, and suggestions for improvement of this app.**

Keywords—mobile application; eye health; myopia; field study; user experiences

I. INTRODUCTION

Bangladesh is a country of more than 163 million inhabitants [1] which had never conducted a survey pertaining to the extent and causes of blindness and vision impairment before. The Bangladesh National Blindness and Low Vision Survey(1999-2000) [2], which had a serious impact to the effective national planning and implementation of enduring eye care programs being taken under consideration by the World Health Organization publication "Global Initiative for the Elimination of Avoidable Blindness by 2020 (Vision 2020)" [3]. There are 98 million inhabitants (61.1% of the total population) aged between 15 to 64 years in Bangladesh [4]. Considering the age and gender-standardized prevalences an estimated 10 million or more myopes (<-0.5 D) and 8.9 million hyperopes (>+0.5 D) and an estimated 14.6 million would be astigmatic (>0.5 D) are present in Bangladesh [5].

Instead of focusing on the retina light focuses in front of retina, this condition of eye is termed as near-sightedness or myopia [6]. A specialized doctor who is expert in checking refractive conditions of the eye, the optometrist or an ophthalmologist performing eye examinations can diagnosis myopia [7]. Infantile myopia persists through infancy starting from birth; youth onset myopia has varying ocular power until the age of 21, between ages 20 and 40, early adult myopia occurs and after age 40, late adult onset myopia comes about [8]. Foregoing analysis in the ICTD literature reports that modeling technology-based interventions services for a developing country like Bangladesh are frequently challenged by limited access to the Internet and electronic devices [9,10]. Marching towards growth, development and equitable society Bangladesh is one of the fastest growing cellular networks in the world, with more than 96% of the population now under mobile coverage. Fast growing internet users use cell phones to access the Internet [11]. This puts forward for consideration that mobile phone based applications mostly android platform based applications might bring about a helping hand to recognize myopia before visiting an ophthalmologist. Worldwide mobile based applications assisting users with their ocular problems are developed using English language. Majority of population (85% of the total population) are classified as speakers of the native language (Bengali) and it works out to be only 2.66% of the total population as English speakers. People are likely comfortable to interact in Bengali language and people living in remote area hardly understands English language. In this paper, we report our experience in designing and developing an android based application to help recognizing eye glasses power (for near-sightedness) using Bangla letters.

II. LITERATURE REVIEW

Refractive errors are the inabilities of the eyes to focus on the visual images from the outside environment [13], which results in serious visual impairment in severe cases, blurred vision or even blindness. There are four major types of refractive errors, for instance Myopia, Hyperopia, Astigmatism and Presbyopia.

Several ways are followed to measure refractive error. A phoropter in conjunction with an eye chart (Snellen chart) is used conventionally. Phoropter contains different lenses [14], optometrist changes the lenses in response to patient feedback [12]. Though this process gives accurate outcomes but is expensive and can only be operated by trained professionals. This process presupposes a certain degree of attention and knowledge from the patient as well. Retinoscopy is a common method of measuring refractive error which does not interfere patients' co-operation [15]. Refractive error is determined by

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the movement and orientation of the reflex by projecting light into the pupil. Automated refractor also does not need patient's response; it analyzes the change of light after entering into the eye and uses that to provide objective measurement of refractive error [16]. This expensive machine needs expertise to operate accurately.

Considering these conceptual structures we have focused on detecting eye power of myopes because myopia is the most prevalent visual disorder resulting from refractive errors, and is estimated to effect as much as 70-90% of the population of Asian countries and 30-40% in Europe and the United States [17]. As an increasingly prevalent system of communication and access to the Internet, having low cost, mobile phone technologies have been central and promising players, supporting a wide and growing range of design mobile applications are targeted to solve prevailing problems. Snellen developed charts using symbols based in a 5x5 unit grid. The experimental charts which are developed in 1861 used abstract symbols [18]. Our project builds on this insight and we used Bangla letters to make it more user friendly to the people of Bangladesh. Beyond above theoretical insights our project also learned from "20/20 calculations" [19] that have sought to deal with problems of finding out the corresponding letter size in respect to viewing distance.

Other mobile based applications for checking visual acuity using several charts have sought to help mobile phone users. One such initiative is "Eye Exam" [20], which has several eye charts. Another noteworthy initiative is "Eye Test"[21] featuring visual acuity test generating statistical measurements, Ishihara Color blindness test, Glaucoma survey, Astigmatism test, Duochrome test, Red Desaturation test. There are still other mobile applications that have been built to offer support to daily eye exercises. For example, "Eye Exercises- Eye Care Plus" [22] which allows users to take high quality eye exercises, eye tests to track vision impairments, adaptive difficulty progression for a challenging and rewarding experiences. "Visual Acuity Test" [23] forwards glasses check, Personal vision screening to check vision improvement progress. "Central Vision Test" [24] offers voice controls to help navigate easier in addition.

Our project builds on these insights and design approaches while extending them to find eye glasses power (approximately) of Bangladeshi people using Bengali charts.

III. Design and Development

A. Need Findings:

We started our project with two studies online survey & interview blueprinted to develop a better understanding of the prevailing consequences to find out eye glasses power both in rural and urban area of Bangladesh. Our choice of selecting participants was dictated by two factors. First, rural people of Bangladesh are often more attuned to problems with their acuity test. Second, university students often suffer from eye problems due to over study, using computer and other devices. The decision to focus the pre-project study in this way poses obvious limits to generalizability of the findings and blueprint that result in accordance.

1) ***Online survey:*** We made set of questioniries to understand about the awareness of people about their eyesight problems. The set of questions are circulated through the social media (e.g. Facebook). During our survey we asked that how often they visit eye doctors. We collected responds from 190 participants, where 100 were female and 90 were male participants. Among all these participants, 32% of them said they forgot about their last visit to doctor because of their eye problem, 12% of them said they visited recently and 66% never went to the doctor. 18% are having eye problems from those who never went to the eye doctor.

2) ***Interviewing:*** A unstructured interview was conducted with rural people. We selected a village from Naogaon called Raninagar. We went number of houses of the village to talk. Only 50% of them showed interest to talk. We asked if they have eye sight problem. Through interview, we obsurved that many of them have eye sight problems but never visited to doctors but there are also few educated families who were aware of their eyesight problem. The findings showed that 93% of them never visited to doctor for eye sight problem and 7% were using spectacles but they visited eye doctor more than one year ago.

From our studies, we have found some barriers to eye health and vision examination of common people, these are:

- they are not aware of their eye problems
- not a common practice to visit eye doctors regularly
- cost and other limitations (scarcity of doctors, transport, education, etc.)

B. Computing Eye Glass Power

To develop our mobile app we used the Snellen chart [18], which is developed in 1861 using the abstract symbols based in a 5x5 unit grid [18]. The original chart represents symbols like A, C, E, G, L, N, P, R, T, 5, V, Z and etc. [26]. Instead of English letters, we have used Bengali letters like ক, খ, ট, অ, আ, etc. to make the app more user friendly.

We have used Craig's ophthalmology calculations strategy [19] to compute the eye glass power using 20/20 calculation. According to Snellen chart [18], symbols are to be shown to the patients away from 20 feet of distance to get the accurate outcomes.

Since we are developing a mobile app, we are limited to the distance of the screen which will contain the symbols or letters to examine the patients and also limited to the screen size of mobile screens. Thus we decided to take 2 feet of visual distance as standard to calculate the letter sizes to be implemented in mobile application. The minimum separation between two lines that an average person can see has been measured as an angle of one minute of arc. (1 min is 1/60 of a degree) [19]. Using this strategy a letter on a vision chart is made to measure the smallest space so that the subject can distinguish. For a 20/20 letter there are three bars and two spaces making the total letter height 5 min and 1 min between the lines [19].

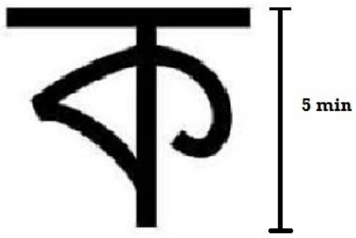

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Fig. 1. A Sample Letter.

Thus the length of our testing distance is calculated using the Reduced Schematic Eye [19]. The Reduced Schematic Eye, that follows the formula presented in Figure 2, is a simplified model of the optics of the eye, useful for calculating both object and retinal image size [19].

We calculated the letter height, L, at distance, D, for both 20 feet and 6 meters and 2 feet for our mobile application. To simplify the numbers we did the calculation at 1 degree then divide by 12 to get the result with respect to 5 min.

tanA = L/D ; L=D tanA

tan 1deg = 0.0175

D = 240 in or 6000mm

L(1 deg) = 20 ft x 12 in/ft x 0.0175 = 4.2 in for 1 deg
L(1deg) = 6000 x 0.0175 = 105 mm for 1 deg

L(5min) = 4.2/12 = 0.35in, Height of 20/20 letter at 20 ft
L(5min) = 105/12 =8.75mm

L(1 deg) = 2 ft x 12 in/ft x 0.0175 = 0.42 in for 1 deg
L(1deg) = 600 x 0.0175 = 10.5 mm for 1 deg

L(5min) = 0.42/12 = 0.035in, Height of 20/20 letter at 2 ft
L(5min) = 10.5/12 = 0.875mm

Fig. 2. Calculation of Letter Size.

We also converted the estimated visual acuity (calculation using the formula presented in Figure 2) to diopter. In this case, we employed the findings of Henry [25] in Table I.

TABLE I. CONVERSION OF VISUAL ACUITY TO DIOPTER.

Myopia	
Nearsighted	
Minus (-) Sphere	
Ages: All	**Estimated Visual Acuity**
-0.5	20/30-40
-0.75	20/50
-1	20/60
-1.25	20/70
-1.5	20/100
-2.5	20/200

C. Developing Mobile App

The mobile application is built for android supported devices. The main feature of this app is 'test the eye power'. In addition, the app also included the features like color-blindness test, healthy eye tips and eye exercise tips. The feature of 'eye power test' is discussed briefly below.

When user taps "Eye Power Test" button, a page with instruction on how to test your eye and what exact distance the mobile phone from eye is to be held is popped up which is shown in Figure 3(a). Then the application will tell you to select any of your eyes (left or right to test) and the other should remain closed. Consecutive pages are designed having Bengali letter as shown in Figure 3(b).

Upon clicking "স্পষ্ট" (which means "Clear" in Bengali) user will be taken to next page for further test with consecutive letters. The result will be shown in pressing "ঝাপসা" as in Figure 4(a) (which means "Blur" in Bengali) three consecutive times, this is shown in Figure 4(b).

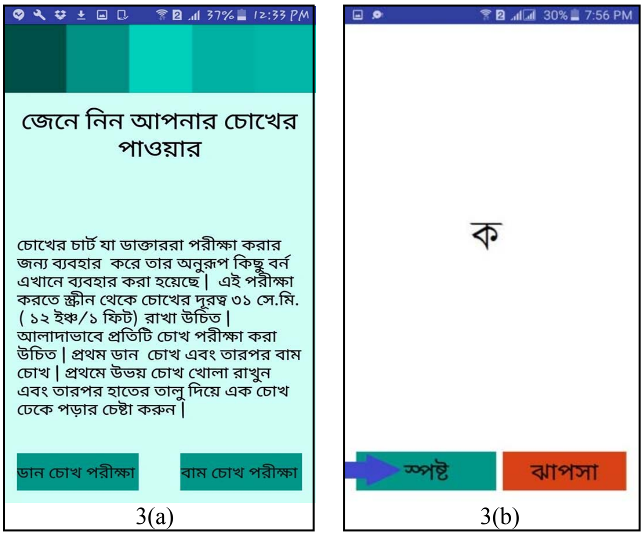
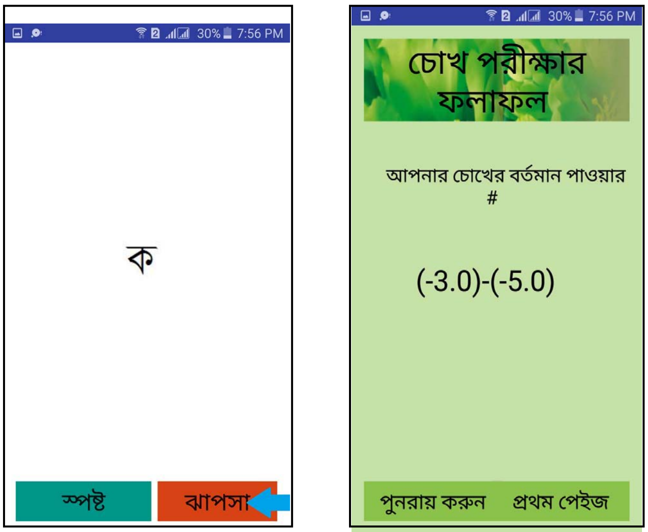


Fig. 3. Screenshots of our app.



4(a) 4(b)

Fig. 4. Screenshots of our app.

The results (suggested eye glass power) based on the formula as discussed in Sub-section B.

The suggested eye glass power will be stored in a database for regular checking to monitor the history of eye power.

D. Evaluating the App

An experiment was came out to understand the efficiency & ease of use of our mobile application. The experiment was performed with randomly selected 10 participants. Each participant used the app to test their eye power. The glass power range was recorded by our apps for each participant as shown in Table II. Table II also shows the glass power measured by doctors.

The results showed that about ease of use, services and accuracy of our app, where our app was accurate for about 60% of total participants, a bit less accurate (with error of less than 1D) for 30% and a bit more error in (with error of greater than 1D) 10% of our participants' cases.

Besides, participants gave positive feedback for the value and comfort provided by the instant results of the eye power tests. Recommended eye glass power by our app as well as by doctors for respective participants are reported in Table II.

However, participants suggested adding up significant ophthalmologist's places, which would help them finding the exact doctors. Feedbacks from users suggest a number of new features to be added, for example, map view of doctor's addresses to find out the location easily.

TABLE II. EXPERIENCES CHART.

Participant	Glass power recommended by doctor		Glass power range recommended by our app	
	For left eye	*For right eye*	*For left eye*	*For right eye*
P1	-1.75	-2.25	(-2.0) - (-3.0)	(-2.0) - (-3.0)
P2	-1.25	-0.75	(-0.75) - (1.0)	(-0.75) - (-1.0)
P3	-3.25	-4.75	(-3.0) - (-5.0)	(-3.0) - (-5.0)
P4	-1.00	-1.00	(-0.75) - (-1.0)	(-0.75) - (-1.0)
P5	-3.5	-3.5	(-3.0) - (-4.0)	(-3.0) - (-4.0)
P6	-0.5	-0.5	(-0.75) - (-1.0)	(-0.75) - (-1.0)
P7	-1.00	-1.00	(-0.75) - (-1.0)	(-0.75) - (-1.0)
P8	-1.00	-1.00	(-0.75) - (-1.0)	(-0.75) - (-1.0)
P9	-0.25	-0.25	Eyes are okay	Eyes are okay
P10	-2.5	-2.5	(-2.0) - (-3.0)	(-2.0) - (-3.0)

IV. CONCLUSION

In this paper, we represented a mobile application to test eye glass power for people of Bangladesh based on Snellen chart and by using Bangla letters as the symbol of the chart. Besides we used 20/20 calculation strategy of Dr. Craig Blackwell [22]. To convert the refractive error calculated from 20/20 calculation of letters to visual acuity (in diopter), we used Henry B Peter's relationship between refractive error and visual acuity at the three age level [28]. Our system is quite successful in measuring the myopia with less than 1.0 diopter of error.

Our work is still in progress. The mobile application retains a small but active group of users. Our team is working to incorporate some of the considerations from early stage usage and user feedbacks. Development of the mobile application and long-term maintenance responsibility and adding up doctors' places and eye hospitals are being divided with respect to particular zones is also in process and on the way of implementation.

In the context of Bangladesh, a developing country with less than 3% of population having expertise in English hardly install an interacting mobile application in English language. So we have developed this useful app in Bengali, intended to support mostly rural area people of Bangladesh.

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