An Interface to aid Rural Health Workers in the Preliminary Diagnosis of Cataract at the Slit Lamp using LOCS III

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Abstract

In India there is an inequitable distribution of wealth & resources; while 70 % of population lives in villages, about 80 % of ophthalmologists practice in cities [4]. India has 1 ophthalmologist per 100,000 of its population [4] and this ratio is even more dismal for rural areas. In such circumstances, ophthalmologist-based model is not a cost- effective screening method. On the other hand, an ophthalmologist led screening model offers a cost-effective and feasible screening model for screening of eye diseases. Such a model can be beneficial in filling the critical gaps in the government health services. Based on ethnographic studies conducted in Assam, India, We propose and discuss the design of an experimental interactive interface that can help trained rural health workers diagnose and classify the extent of cataract in the preliminary stages. This has two significant benefits:
1. The Cataract patients, usually old, and living in rural areas do not have to travel miles away from home only to be told to come back a few months later as the cataract was not sufficiently mature for a surgery yet.
2. It provides for a more efficient system that helps the already overburdened ophthalmologists concentrate their time on patients who actually need immediate surgeries thus directly influencing the quality of eye care.

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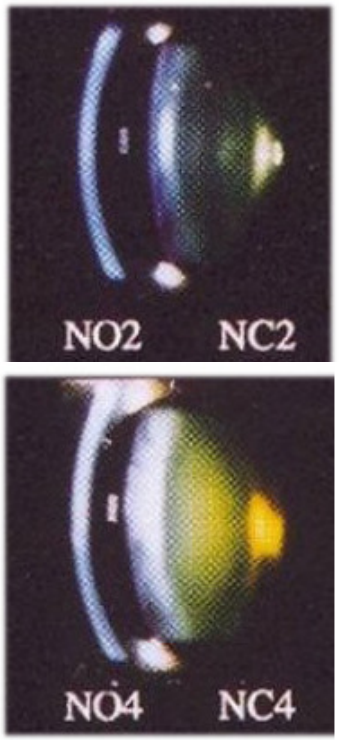
ACM Classification Keywords

Screen Design, Graphical User Interfaces, User-Centered Design, Interaction Styles, Healthcare.

Introduction

India's health-care system includes a very large rural system administered by the Government of India. According to 1991 census, the system provides health care for a rural population of 630 million people in 32



Nuclear Opalescence (NO) is designated as the brightness of scatter from the nuclear and Nuclear Color (NC) as the intensity of brunescence.

states (Rural Health Division 1995). Rural India faces many very serious health problems that are not adequately addressed and many primary health centers have resulted in breakdown due to inadequate infrastructure, shortage of physicians and poor health management (4). The National Health Policy (NHP)-2002 report mentions: " While there is a general shortage of medical personnel in the country, this shortfall is disproportionately impacted on the less developed and rural areas. No incentive system attempted, so far, has induced private medical personnel to go to such areas; and, even in the public health sector, the effort to deploy medical personnel in such under served areas has usually been a losing battle. In such a situation, the possibility needs to be examined of entrusting some limited public health functions to nurses, paramedics and other personnel from the extended health sector after imparting adequate training to them." Although nearly 75% of Indians live in rural villages, more than 75% of Indian doctors are based in cities[1].The government spends just 0.9% of the country's annual gross domestic product on health and a little of this spending reaches remote rural areas [3]. There is also the added inconvenience both monetary and otherwise because the poor Indian villagers have to spend considerable amount of money for travel and boarding of both themselves and their escorts. This inconvenience is particularly exacerbated when an old patient is involved. While the innovative telemedicine initiatives taken by organizations such as Indian Space Research Organization (ISRO) have given a meaningful direction to rural health care in the country there is still a pressing need to meet the shortage of doctors for the rural population. Training the rural health workers to share some of the tasks can be a powerful method to alleviate the situation.

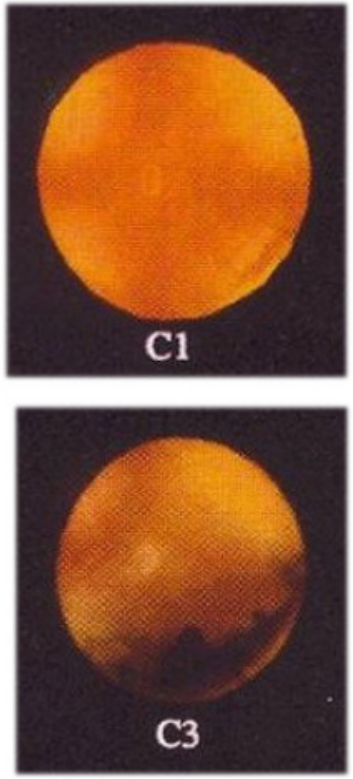
Eye Care in Rural India

In India blindness is a major public health problem. It is estimated that there are 18 million people blind in India, which constitutes one-fourth of the total number of the blind worldwide. The greatest prevalence of blindness in India is in the rural districts: firstly, because the majority of our population lives in rural areas and, secondly, because these rural areas have the least access to eye care services in particular and health care services in general. Control of blindness in India has neither been effective nor efficient. The focus has primarily been on cataract surgery in make-shift environments, particularly in rural India. The quality of eye care available to the people in rural India is sub-optimal because of the lack of infrastructure and of human resources, i.e., capable and well-trained personnel for providing quality eye care. In such situations with the growing demands on ophthalmologists an efficient screening process for various eye diseases is very useful. There can primarily be two kinds of screening processes:

1. Ophthalmologist based.
2. Ophthalmologist led.

A huge human resources base is available in India in the form of volunteers from village themselves, women's groups, youth groups, self-help groups, the National Service Scheme, community associations, user groups etc. Unfortunately, these resources are yet to be optimally utilized, as there is no visible or regular system to enroll volunteers, provide them orientation/ training and utilize their services in the voluntary sector on a defined basis.

There is an imperative need to train volunteers to perform basic tasks so that the quality of health care can be improved. Organizations such as the Self Employed Women's Association (SEWA) Rural Team who "realized that quite a bit of the preventive and health promotion work and part of the curative work could be done by grassroots workers"[6] have realized this and this has provided them the impetus to combine primary eye care with traditional Community Rehabilitation of the Blind (CBR). Such innovative ventures, however, have hardly been aided by technological innovations designed to allow these workers to make a smoother transition to more specialized tasks than they are usually used to. Thus while there is considerable research going on in the



The amount of cortical cataract is determined by looking at the extent of spoking (blackness) with reference to 5 standard photographs

areas of telemedicine and software to facilitate the same, there is unfortunately very little work going to to design systems with these grassroots workers as their primary users. We explain the design of an exploratory tool that makes it easier for such grass roots workers to make a preliminary diagnosis and determination of cataract in conjugation with already established tests like Snellen tests and standard questionnaires using the LOCS III system as the basis of judgment.

Cataract Classification and Grading Systems

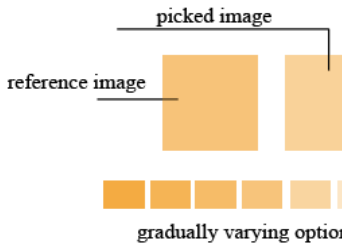
Cataract is the major cause of blindness in the world and the most prevalent ocular disease [7]. Age-related cataracts are the most common and account for around 77% of the blindness in India. There are three main morphological types of age-related cataracts: Cortical Cataracts, Nuclear Cataracts, Posterior Sub-capsular Cataracts. Cataracts may be graded by visual inspection and assignment of numerical values to indicate severity. Usually photographs of slit lamp cross-sections of the lens are used as references for grading nuclear opalescence and nuclear color, and photographs of the lens seen by retro-illumination are used as references for grading cortical and sub-capsular cataract. The OCCCGS employs standard diagrams and Munsell color samples to grade specified features within different anatomical zones in the lens. The LOCS III scheme uses photographic images as reference standards. Both systems use a decimalized scoring system.

Lens Opacities Classification System (LOCS) III

The Lens Opacities Classification System, version III (LOCS III), is a widely used, scientifically valid, standardized photographic comparison system for grading the features of the human age-related cataract [8]. It has been used to grade the type and severity of cataract in cross-sectional studies and the progression of cataract in longitudinal studies. It also has been used to grade cataracts at the slit lamp. Grading using LOCS III involves the assessment of 4 features shown on 3 sets of photographs on an 8.5-inch × 11-inch color transparency[8]. The LOCS III system uses six photographic references for nuclear color and nuclear opalescence and a series of five photographic references for cortical and posterior sub capsular opacities. Nuclear Opalescence (NO) is designated as the brightness of scatter from the nuclear region and Nuclear Color (NC) is designated as the intensity of brunescence. The amount of Cortical Cataract (C) is determined by comparing the estimated aggregate of cortical spoking to that seen in 5 separate photographs. A numerical grade of severity is assigned to each reference photograph which is arrived at by locating the image of the patient's lens on the scale of severity for each feature represented in the color transparency. To interpolate the appearance of cataracts that fall between the reference photographs clinicians can use decimals to grade the cataracts in finer incremental steps [13]. The NC and NO are thus graded on a decimal scale of 0.1 to 6.9. The severity of C and P are graded on a decimal scale of 0.1 to 5.9. The final LOCS III grade comprises 4 decimal values, 1 each for NO, NC, C, and P[8].

Design Concept

The current diagnosis system using the standard LOCS III transparency images depends on the following factors: 1. The expertise and experience of the ophthalmologist in assigning the decimal part of the grade in between 0.1 to 0.9 and 2. The ready availability of transparency sheets and the various limitations of a physical transparency (eg. duplicating, staining etc) We propose an interactive system where the standard set of LOCS III images can be compared with an image of the patient's eye using a computer. The system is based on a visual comparison of the patient's image with the reference image and then based on his selection further narrowing down the match to give a finer grading. By aiding the operator to arrive at a grading of the eye through a visual



comparison rather than basing the decision on his experience and expertise we believe that the system will be helpful for trained rural health workers in performing a preliminary diagnosis of the grading of the cataract and serve as an initial screening measure. The design of the interface also facilitates a better way to compare the two images and provides a reference of the image during the last diagnosis to allow comparison of the degradation of the cataract from the last visit.

Development of the Interface

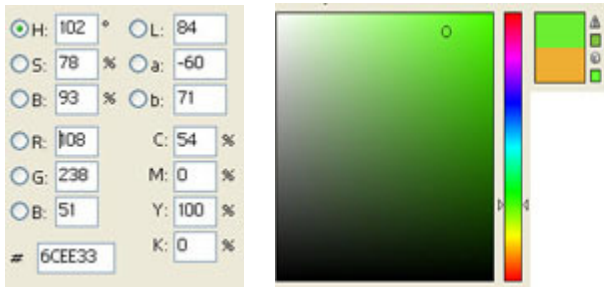


Figure 1: representing color a) in numbers b) visually

The concept of grading the decimal part of the LOCS III visually rather than by assigning a number to it based on experience is analogous to selecting a color by defining the decimal equivalents of its value as opposed to visually selecting from a number of gradually varying alternatives and by comparison with a reference. The latter case is clearly much simpler for even a novice. The interface should provide a number of gradually varying alternatives (ideally the number of alternatives between two base images should be definable depending on how fine one wants to grade) which can be browsed between and then juxtaposed against the reference to carefully compare which one is closest to the reference image. Additionally it will also be desirable on the interface to have a record of the patient's previous diagnosis (if any) so that we may have an idea of the cataract has degraded since the last checkup. The two images on the left - reference and the picked image- are grouped together and different from the left most image to better facilitate **c**omparison amongst the two rightmost images being compared.

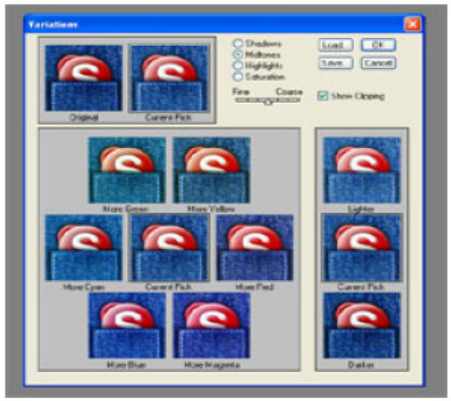
The object of interest zooms up to provide a clearer view as well as stress an interaction affordance.

Display style for sub images when main image is in the corner.

on each side.

The horizontal bar at the base which has the standard set of LOCS III images as well as the gradually varying in between options is designed in accordance with zoom and elision methods so as to keep only the relevant images for a particular image in context at any given interaction. The images also zoom up each time the evaluator shows interest in them (moves mouse over them) to provide a better thumbnail perspective of the image. In case the base image in which interest is shown not one of the extreme images (i.e 1 or 6) the three gradually varying images on either side of the middle base images appear.

Relevant sub image zoomed in others zoomed out



Since images which differ by very little from each other are to be selected from it becomes very important how we deal with the other images when the user is browsing one. In Adobe Photoshop variations dialogue box above depending on the image selected all the other images dynamically change color. While this might work in a context where we wish to quickly see the various types of changes that will occur in the image during preliminary user testing phase we realized that when this model is applied to comparing an image with another reference image it became very confusing for the user if the images changed suddenly. The users showed a preference for having an idea of what had changed, having a method to get back to where they were, and having a means to predict what would the changes in the image be on performing an interaction. To make the users aware that the images are being changed, on clicking the base image the appearance of the sub mages is deliberately animated to clearly show that the images are progressively appearing from between the two base images. On clicking on a sub image, we zoom up the sub image and zoom out the remaining two images so as to make it easier to compare the sub image with the reference and the currently picked image. The reduction of surrounding detail helps the user focus and helps in a better comparison of the images.

Deliberately gradual animated appearance of sub images to show change

Usefulness of such a System

Waiting times for cataract surgery historically have been longer than for many less cost effective treatments. Several reasons exist for large ophthalmic waiting lists, amongst them a major one being a shortage of ophthalmology consultants. This requires an optimum management of the time of the existing ophthalmic consultants and hence a preliminary screening procedure like this would be of immense help in reducing the rush and promising necessary ophthalmic care to those who really need it most. Also, the fact that health workers can now perform a preliminary diagnosis would help older people save the trouble of traveling miles just for a preliminary checkup where they are told to come back later. This would save the patients physical, mental and financial inconveniences. Further, such a system would help keep a record of the patient and thus better manage each individual case and at the same time provide a valuable database of graded images that can be analyzed to reveal interesting insights into how Lens Opacifications may be impacted by regional factors.

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