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Original Article

Biotechnology Section

Design of Customizable Automated Low Cost Eye Testing System

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ABSTRACT

Background and Objectives: In many underdeveloped and third world countries, eye care is often neglected due to illiteracy. Particularly people in rural areas suffer with eye problems due to mal nutrition. The government is spending lot of money and efforts in screening the people at periodic intervals. One of the challenges faced by the doctors is screening the school children.

Materials and Methods: The standard Snellen letter chart based diagnostic system does not work always. There are instances where the first few students who undergo this diagnostic system, memorize the letter sequence of the Snellen letter chart and convey the same to other fellow students. Hence other students simply read out the Snellen letter sequence from their memory, not by looking at the Snellen letter chart. Thus there is a need of randomizing the sequence of letters being displayed on the Snellen letter chart for every student to be diagnosed for eye testing.

Conclusion: In the present paper we are proposing a customizable, software based, cost effective solution which involves a standard personal computer (PC) fitted with a camera, headphone and speaker system. The envisaged system can be administered even by the trained persons. The proposed system is also suitable for remote diagnosis of patients, particularly in the field of telemedicine.

Keywords: Snellen letter chart, Telemedicine, Remote diagnostic

INTRODUCTION

The eye care is very important in every individual's life because eyes are used almost in all activities what we perform. Moreover it gives us the sense of sight by which we can observe and learn much about the surrounding world. It is the duty of every individual to safeguard their eyes by going for regular and thorough eye examination since from the childhood.

There are many eye testing and screening procedures like Observation---"ABC, Distance Acuity, Plus Lens, Near Vision Card, Near Point of Convergence, Alternate Cover Test, Stereo/Depth Perception, Color Vision Screening Test [1] which involves varieties of chart like symbol charts, HOTV Tumbling or "Illiterate" E charts, Number charts, Letter charts listed in the order of descending cognitive order.

The eyes are incredibly complicated and delicate sensory organs. Eye care is an essential part of any healthy lifestyle. According to the American Optometric Association, a healthy adult should have a comprehensive vision exam for every two years between the ages of 18 and 61 [2].

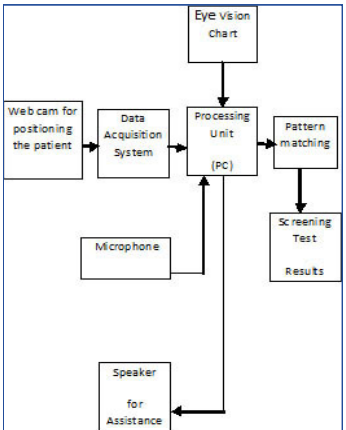
The eye test not only provides an accurate assessment of one's ability to see, but also gauges the general health of our eyes and can result in early identification of other eye problems such as diabetes or high blood pressure.

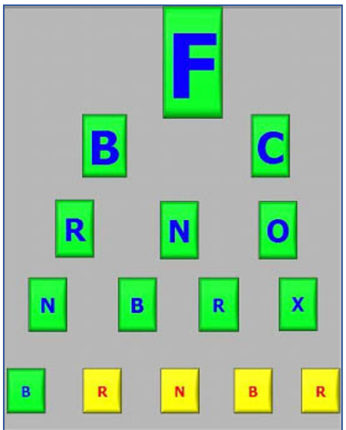
In many underdeveloped and third world countries, the vision care is often neglected among the people [3]. Particularly in remote areas due to poor economic conditions, they find it difficult to consult the doctors located in cities and moreover, even the ophthalmologist hesitate to visit those remote places in their busy schedule and poor transportation facilities [4].

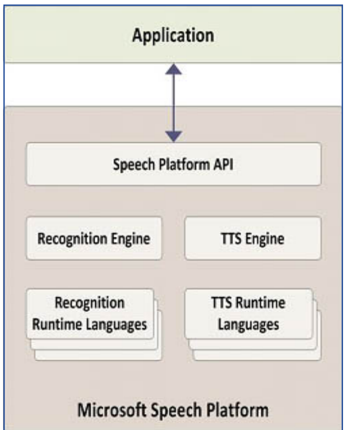
In the proposed work we are designing a low cost, customizable, PC based eye testing system. This system helps to determine how much distance and near vision the patients can bear.

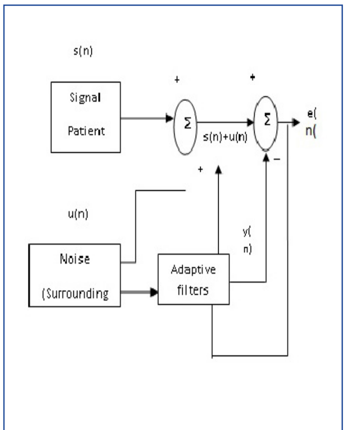
MATERIALS AND METHODS

The proposed system only needs a normal PC and a (low cost) camera along with a headphone and speaker system. The necessary Graphical User Interfaces (GUIs), databases and algorithms have been developed indigenously using relevant LabVIEW software modules.

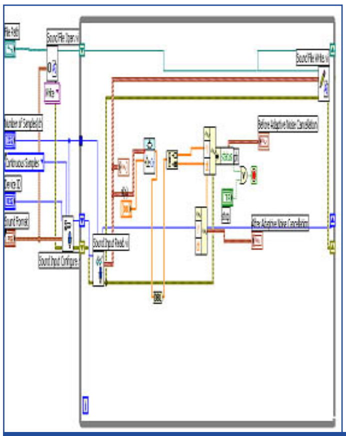


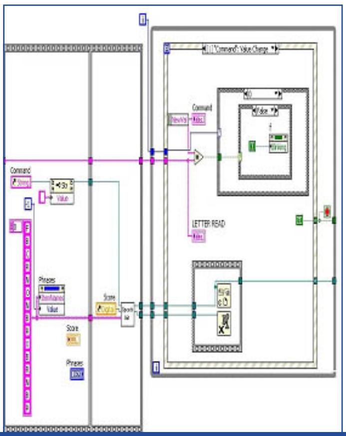


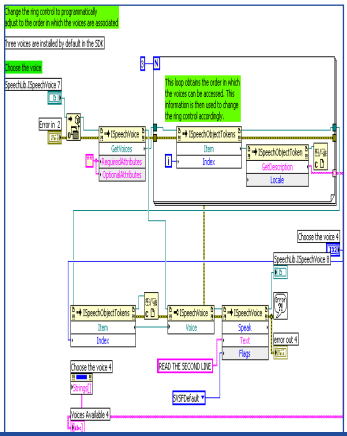


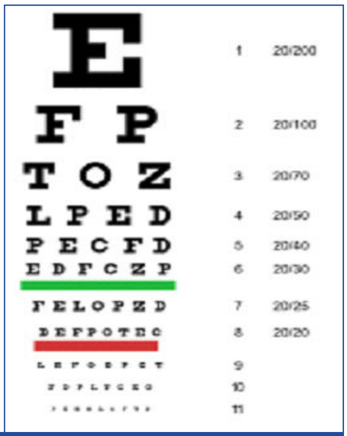


[Table/Fig-1]: Various modules involved in our implementation **[Table/Fig-2]:** Design of snellen letter chart **[Table/Fig-3]:** Overview of microsoft speech platform **[Table/Fig-4]:** Typical adaptive noise cancellation system









[Table/Fig-5]: Adaptive noise cancellation implementation using lab view **[Table/Fig-6]:** Speech recognizition implementation using labview **[Table/Fig-7]:** Text to speech implementation using lab view **[Table/Fig-8]:** Snellen chart with vision format

In this paper only distance visual acuity (vision screening) function is taken into consideration which is a more sensitive technique [5]. As per the guidelines developed by the American Academy of Pediatrics Section on Ophthalmology, in cooperation with the American association for Paediatric Ophthalmology and Strabismus and the American academy of Ophthalmology, a well-lighted room is chosen for screening. The screening chart will differ for children and adults. For children who are unable to perform vision testing by letters and numbers, the tumbling E or HOTV test chart is used.

Snellen chart with images is used for the illiterates [6]. So by keeping this entire scenario into consideration, in this work Snellen letter chart (which is a generally accepted standard for testing visual acuity) is designed and developed using software. The GUI developed is suitable for screening the children above 6 years and older, and the 20 feet distance is taken into consideration [7].

The Microsoft speech SDK function is used for recognizing a person's voice and respective pattern matching algorithm is developed for the vision screening process.

Implementation

The [Table/Fig-1] below describes the various important modules of our implementation.

We have used a webcam to acquire the image of a patient to be diagnosed and the acquired image is logged by the data acquisition system and processing is done by NI Vision Assistant Toolkit in LabVIEW. The patient's face is captured by the camera and the unique characteristics (overall shape) is calculated over the Region of Interest (RoI) which are related (directly proportional) to the number of pixels occupied by the target object in the image frame. We know that if a patient.

stands near the camera of the PC, his face will be bigger. If he moves behind gradually the size of his face in the field of view will also shrink accordingly. Hence by counting the number of pixels of face image, one can calibrate the distance between the patient and the camera. Once the right distance of nearly 20 feet is achieved, the patient will be alerted by an audio signal (beep sound) from the speaker.

Once the patient is positioned at the right place, the eye chart window will be displayed automatically as shown in [Table/Fig-2] and the patient will be instructed to read the characters one by one available in the chart via microphone and the speaker is used to provide audio assistance to the patient after every line is read.

The Microsoft Speech SDK Toolkit in LabVIEW (as shown in the [Table/Fig-3] consists of software development kit and run time languages that enable speech recognition and it can generate synthesized speech (text-to-speech) to enhance user's interaction with our applications. In the present work it is used to recognize the patient's voice.

The data acquisition system not only picks the patient's voice, but also picks and amplifies surrounding noise. Hence, one has to filter/cancel this noise.

Adaptive Noise Cancellation (ANC) is one of the major real-time methods available as shown in [Table/Fig-4] to remove noise from a signal.

Here s(n) is the patient's speech acquired. u(n) represents the surrounding noise, y(n) is the output signal (with noise) and e(n) is the resulting signal (without noise).

The Adaptive noise cancellation filter is implemented in LabVIEW as shown in [Table/Fig-5] to remove the unwanted surrounding noise [8].

Speech acquisition requires a microphone coupled with an analog-to-digital converter (ADC) that has the proper amplification to receive the voice speech signal.

One has to sample it, and convert it into digital speech which can be easily communicated to PC. Sound Input Configure and Sound Input Read functions available in LabVIEW as shown in [Table/Fig-5] are used to read the data from sound input device such as microphone. In this paper, microphone is used by the patient to read the characters one by one available in the Snellen chart. The acquired audio input is fed to the Adaptive Filter function which extracts the sound of interest from background noise.

The Speech Initialization API Module in LabVIEW as shown in [Table/Fig-6] will automatically "listen" and perform voice recognition analysis on the audio stream, and will also convert speech (audio signal) into text. In this paper the patient's voice is acquired, processed and converted into text/character by the Speech API module. Character recognition is done by pattern matching [9]. This technique is used to compare the character read by the patient with the stored character present already in the database. Once if it gets matched, that respective character starts to blink in green color else the character will blink in yellow color.

The Microsoft .NET connectivity feature in LabVIEW creates a Speech Synthesizer assembly to read the provided text using all default parameters. It's been configured to be called as a convenient subVI for placement in any code segment.

Text to speech Technique is made for communicating the audible information to the user, when digital audio recordings are inadequate, for developing a user friendly speech synthesizer.

LabVIEW expansive ActiveX controls and property nodes as shown in [Table/Fig-7] are used to convert text written in LabVIEW into audible speech which in turn is used to assist the patients by the loud speaker after every line is read. This system widely helps in developing a Computer Human interaction.

Normal visual acuity is commonly referred as twenty / twenty vision, which is equivalent to six / six vision in metric [10]. Twenty / Twenty indicates the patient see at 20 feet a letter with the clarity that the normal eyes will see the same letter at 20 feet which is described as normal vision. The format of 20/40 vision indicates, 20 is the distance in feet between the patient and the chart. The 40 is the distance where the patient can read the chart (only from 20 feet away) but, a normal person could read the same chart from 40 feet away. This approach is called as near sighted or Myopia - Short Sighted [11] and the power will be in terms of negative.

In the same way if the format is 20/200 vision indicates the approach as a farsighted or hyperopia – long sighted and the power will be in terms of positive. Based on this scenario, each and every line on the chart will have some vision range format as shown above in [Table/Fig-8] In this paper, we are taking this vision range format into consideration [12]. Finally the result (i.e.) respective degree of vision loss will be calculated and indicated to the patient based on the characters not read by the patient.

Often school children while undergoing the eye screening test in schools use to memorize the letters available in the Snellen chart and inform the other students who are yet to undergo the test [13]. To resolve this problem, we are displaying a shuffled Snellen letters chart which differs for each and every individual undergoing the test [14,15].

CONCLUSION

A vision screening cannot diagnose exactly what is wrong with their eyes; instead the degree of vision loss will be indicated to the patient without consulting an ophthalmologist or optometrist.

In the proposed system, eye screening test can be carried out even by the trained nurses or volunteers at remote locations of patients. Patients need not visit health centre for eye checkup.

The proposed system can be even hosted on websites. Hence diabetic or high blood pressure patients who need periodic eye check up can regularly test their eyes from home itself. It can also be used as a useful tool for telemedicine.

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REFERENCES

[1] Adam T. Gerstenblith and Michael P. Rabinowitz, The: Wills Eye Manual Office and Emergency Room Diagnosis and Treatment of Eye Disease. Lippincott Williams and Wilkins, Sixth Edition, 2012.
[2] Joseph DiGirolamo. The Big Book of Family Eye Care: A Contemporary Reference for Vision and Eye Care. Basic Health Publications, First Edition, 2010.
[3] Proctor Susan P. Guidelines for School Vision Screening Programs. Denver. Second Edition, 1991.
[4] Robert H. Duckman. Visual Development, Diagnosis, and Treatment of the Pediatric Patient. First Edition, 2006.
[5] William B. Trattler, Peter K. Kaiser, Neil J. Friedman. Review of Ophthalmology Saunders Publication. Second Edition, 2012.
[6] Harry G. Randall. The A Complete Guide to Eye Disorders and Eye Book: Health, Johns Hopkins University Press. First Edition, 1998.
[7] John M. Corboy. The Retinoscopy Book: An Introductory Manual for Eye Care Professionals. Slack, Fifth Edition, 2003.
[8] Jon B Olansen, Eric Rosow. Virtual Bio-Instrumentation Biomedical, Clinical, and Healthcare Applications in LabVIEW. Prentice Hall. [Kindle Edition], 2001.
[9] Rafael C. Gonzalez. Digital Image processing. Prentice Hall, Third Edition 2007.
[10] Robert Abel. The Eye Care Revolution: Prevent and Reverse Common Vision Problems. Kensington, Newyork, Revised Updated Edition 2004.
[11] Sumeet Dua, Rajendra Acharya U. Computational Analysis of the Human Eye with Applications. World Scientific Publishing Company, First Edition, 2011.
[12] Alvin Silverstein, Virginia Silverstein, Laura Silverstein Nunn. Handy Health Guide to Your Eyes. Enslow Publishers, Kindle Edition, 2013.
[13] Yawn, BP, Lydick EG, Epstein R, and Jacobsen SJ. Is school vision screening effective? *Journal of School Health*.1996;66(5),171-5.
[14] Nguyen, T. Vision assessment to help children attain Academic excellence., annual meeting of the California School Nurse Organization, Hollywood, 2005.
[15] Jack J Kanski. Clinical Ophthalmology: A Systematic Approach. Butterworth-Heinemann, Boston. Fifth Edition, 2003.

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