Open Problems Identified for NETRA: A Vision Rehabilitation Research Project

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***Abstract*—We are working on vision rehabilitation research project named NETRA (means eye). The project aims at providing a good level of vision to visually impaired people. This paper describes the open problems identified for research and provides a definitive path for the researchers to follow who want to pursue research in this area.**

***Index Terms*—Computer vision, vision rehabilitation, artificial intelligence, stereo acoustic transform.**

I. Introduction

There are about 45 million visually handicapped people worldwide. According to Times of India (TOI), published on 14th Oct. 2001, 25 percent of world's blind are in India. Two million visually impaired people live in Europe and about three million in United States. TOI, 18th June 2000, published that number of visually handicapped people worldwide would double by 2020. These visually impaired people experience serious difficulties in leading an independent life, due to reduced perception of the environment. Most blind and visually impaired people confront serious difficulties when they find themselves in new, unknown environment. The blind person experiences great trouble finding the needed items in a superstore, since all packed items feels similar. Many other problems encountered by the visually impaired does not seem obvious to sighted people. The new Rs. 2 coin is given circular shape similar to shape of Rupee 1 coin, without keeping in consideration that octagonal shape of Rs. 2 coin is used by blind to distinguish it from Rupee 1 coin. The vision aid for blinds has been under extensive research from the beginning of 1970's [1]. Two low-technology aids for the blind, the long cane and the guide dog, have been used by the blind for many years. These aids proved to be of some help but are not enough to enable them to lead a normal life.

Today, computer engineering, ophthalmology and biology are uniting in efforts to restore sight to the blind. Number of researchers worldwide is united for a noble cause. They are attempting to develop ways to make the blind see. All research teams have one overall goal "Electronic sight should be available to those with no vision". In "Out of the Dark" broadcasted on 5th Jan. 2003 on CBC News: Sunday, Dr. Dobelle predicted that by the end of this century, Braille and guide dogs will be obsolete.

The field of vision rehabilitation has come a long way, however it has yet far to go. Three types of vision rehabilitation that has been investigated are:

1) Enhanced vision, which refers to aids that process the images for maximum visibility and then present the information to still viable parts of individual's seeing retina.
2) Prosthetic vision, which presents processed visual information to the inner retina or visual pathways through electrical stimulation of the surviving neurons.
3) Artificial vision, which processes and interprets visual information and presents the results to the individual through other sensory modalities.

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II. Enhanced Vision and Prosthetic Vision

Enhanced vision and Prosthetic vision restore vision by linking cameras to the human nervous system and is subject of intensive research by both the medical and engineering profession. These approaches may restore the vision of a certain proportion of blind people in the long term but research in the area is incomplete and prototypes are not expected before second or third decade of the century. There is and is likely to remain much dependence on artificial vision during early part of the century.

III. Artificial Intelligence

In Artificial Vision, information of vision grabbed by cameras is transformed and transferred to another sensory organ. The selection of the substitute sensory organ is vital. The system should not overload the selected sensory organ neither affect the natural behavior of the organ. Skin and Auditory system has been used as substitute sensory organs in the existing work. There are many negative aspects of skin being used as substitute sensory organ. Highly sensitive skin surface like lips, fingertips are to be used, where stimulating devices had to be placed in exact position daily. Using stimulating device on these surfaces may cause irritation, pain, muscle activation and reduction of sensitive life of skin. Auditory system has been proved as much better choice as substitute sensory organ. Auditory system has enhanced frequency and intensity discrimination. Several studies indicated that the blind individuals can process auditory information faster and are better than sighted individuals at auditory discrimination [2].

IV. Open Research Problems

We have identified following open research problems for NETRA research:

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A. Which Sensory Organs Should Be Used as Susbtitution to Vision? Can Various Sensory Organs Be Used in Combination so that Maximum Information Can Be Transferred to the Person without Overloading the Selected Sensory Organ?

Skin and auditory system has been used as substitutive organ for vision. It is known that maximum dynamic range of skin sensitivity is around 50dB, auditory system is 120dB while that of vision system is 200dB [3][4][5]. Using auditory system as complete substitution to vision, overloads the auditory system. Still complete vision information cannot be transferred. The use of more than one sensory organ to provide substitution to vision has been not been completely explored in the literature. The first open problem of the NETRA research is to explore the use of more than one sensory organ for substitution.

B. How Meaningful Information Can Be Extracted from Images/Videos Using Artificial Intelligence? How User Can Convey to System the Type of Information in which He Is Interested?

The second open problem posed by NETRA research is to find out the mechanism by which meaningful information is extracted from images/videos. To incorporate properties of human vision like lateral inhibition, focusing on object rather than the background and stepped weightage, the image processing model has to be specifically designed [6][7].

C. Study and Design of Transforms that Converts Information Extracted from Images to the Information Presentable to Other Sensory Organs. Efficient Design of These Transforms Is very Essential for Overall Success of the System.

Two methods of presenting visual information have been explored in the literature. These methods convert visual information in auditory or tactile form. "vOICe Learning Edition" is one such Patented software tool: Patent #: US: 5,097,326, which converts visual information into sound [8]. Major shortcomings of vOICe are: low resolution of 64-by-64 pixels which renders it useless for reading magnified text by blind, no depth perception, can't track moving cars. Design and implementation of such transforms require exhaustive research exploration. Popularity and adaptability of artificial vision entirely depends upon these transforms.

D. Study and Design of Training Methods and Systems

How brain is able to make pictures from sounds is not yet known. There is new evidence that parts of brain responsible for sight after some training responds to changes in pitch. The capability of brain, known as brain plasticity, is currently being studied at many universities across the globe. Success of artificial vision system also depends upon the ease with which user get accustomed to it. Hence, study and design of training methods and systems cannot be overlooked and will be another challenging area of research.

E. How Embedded Technology Can Be Beneficial in Design of System?

The problem concerns exploration of the use of the embedded technology in system design, so that system can be compact, lighter in weight and the user can easily travel with it. Earlier systems were heavy, nearly 5 kilogram in weight.

F. How Strategic Planning and Quality Control Assessment Helpful in Determing Navigable Paths in Indoor Environment?

Infrastructure support, strategic planning and quality control assessment can be used in determining navigable paths in indoor environment. A centrally located server will have the information about dimensions of rooms, paths, objects and other obstacles. The blind user's location along with the information about the obstacles in the user's field of view will be transmitted to the server via wireless medium. The central server does strategic planning, determines the navigable path and suggests it to the user. This scheme enables the user to categorize objects as movable or immovable and create navigable paths by displacing small movable objects.

The major challenges involved are maintenance and updation of information about obstacles, definition of planning rules for path determination. Since determination of navigable paths and obstacle detection require accuracy, quality control is another challenge.

V. Conclusion

The major researches in the area of vision rehabilitation of blind people revolve around the following issues:

1) They should be able to freely navigate in unknown environments.
2) They should be able to recognize people and objects.
3) They should be able to read magnified text.

NETRA research is an initiative to help visually impaired by technological means.

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