



E-learning Support to Visually Impaired Persons via Colour to Sound Mapping

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Abstract— *Living-beings normally perceive the world via five active senses. They often exhibit a natural instinct of self improvement through such perceptual experience. This may loosely be called as a lower form of Learning Process. If for some reason any one of the perception-processing mechanism fails or its capability is reduced then the person is said to be disabled. Passive gadgets in the form of spectacles, hearing aids etc., try only to increase the sensory capability, and are of little use in case of total absence of some perception channel. The learning process in such cases is then supplemented via other perception-mechanism; like Braille-book (touch) for visually impaired or sign-language (visual) for the hearing impaired. Presently, artificial perception with the help of sensors coupled to multimedia processing power of a typical computer system is successfully supporting the learning process of various disability cases. This paper presents an alternative use of multimedia to compliment the lack of sight in visually impaired persons for recognising colours*

Keywords— *Colour toSound Mapping, E-Learning, Perceptual Learning, Artificial Perception, Visual Imapired.*

I. INTRODUCTION

Learning is formally defined as a process of progressive change from ignorance to knowledge, from inability to competence, and from indifference to understanding [1]. Such Learning then manifests itself through improved reactions of the learner, when faced with similar situation. The candidate acquires self-dependence and confidence to face life in a better way. Learning involves relating parts of the subject matter to each other and to the real world.

II. PERCEPTUAL LEARNING

It is an accepted fact that learning process is based on perceptions which are directed to the brain by one or more of the five senses: sight, hearing, touch, smell, and taste. Psychologists have also found that learning occurs most rapidly when information is received through more than one sense [2]-[3]. This information received through sensory organs is compared with the knowledgebase by the brain to update information or knowledge-base & to draw inferences. The process of visual pattern recognition requires a comparison of stored definition of that object with the corresponding real world object, via some features like shape, colour, etc..

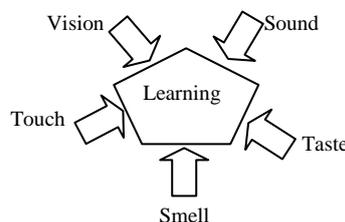


Fig 1. Perceptions using which humans learn.

A. Learning in the absence of some perception

The learning Process definitely gets hampered in case any one perception is absent. Being the major contributor, the absence of Sight slows down the overall learning process of a Visually Impaired person to a great extent. Such disabled student mostly gauges the objects by using either sound or touch[4]. Correlating the real life objects to their corresponding names becomes extremely difficult for students who are blind since birth, as they have never visualized them. Whereas the students who have become blind after about eight to twelve years of age would have seen common real life objects. Hence they are able to identify them via judicious mapping of remaining four perceptions. This can be summed up in a mapping function:

$$f(p_0) \rightarrow g(p_1, p_2, p_3, p_4) \quad (1)$$

where p_0 represents the absent perception, and p_1, p_2, p_3, p_4 are the remaining four perceptions

B. Artificial Perception to support the disabled

Artificial Perception may be defined as input via physical sensors, its transmission and subsequent interpretation by a processor. The patterns of such perceptions which are used in deciding the priority of next action is known as Information. Generalization or formation of concept / rule based on sets of similar information may be called as the domain specific Knowledge in the present context. The exchange of such Information or Knowledge via some medium between source and destination in spoken, written, symbolic, graphic or mixed form, which is equally interpreted by both the source and destination, forms the Communication between them. In case of perceptually disabled person, some channel of this natural process of communication may be inactive. Such perceptual disability of the candidate hampers the learning process via the affected channel [5], [2].

As stated above, virtual perception in the form of peripheral physical sensors, coupled with multimedia processing power of a typical digital computer system, offers an affordable active and intelligent support to a disabled [6]. This knowledge engineering process not only complements the day-to-day activities of the disabled person, but also supplements the academic endeavours, while the candidate attempts to undergo some learning / training of own interest[7].

In case of visually disabled students, multimedia can play a vital role in supplementing the missing perception. Out of the four available perceptions, sound is found to be the best substitute for the absent perception i.e. vision in the learning process[8]. This paper proposes a methodology that will help people with visual impairment to comprehend colours via corresponding audio mapping.

III. COLOUR TO SOUND MAPPING

People with visual disability would face problems while mapping the corresponding audio input as they might not have sensed such features in the object earlier. Interpreting different colours and differentiating amongst them would be one such important task. The task is accomplished by converting the colours picked up by camera into certain fixed frequency sound signals, so that visually impaired person is able to differentiate between them.

The Colour to Sound Mapping Model (CSM) assigns certain predefined audio frequencies to colours, as stated below:

$$f(i) \Rightarrow c(i) \tag{2}$$

where $f(i)$ is a function which maps certain audio frequencies to the corresponding input colour $c(i)$ signal.

The audio visual resources of a typical multi-media system are practically sufficient to accomplish this mapping. Simple initial training enables the Visually Impaired (VI) learner to comprehend the mapping process as well as the function, who then easily correlates the colours with corresponding audio signals. Thus a VI person can sense colours with their shades.

IV. METHODOLOGY

A simple application was designed using an Integrated Development Environment (IDE) which requires the user to roll the mouse over blocks of colours placed one below the other. As the mouse pointer rolls over a specific block of colour, the application generates corresponding sound frequency. Initially, seven standard colours: Voilet, Indigo, Blue, Green, Yellow, Orange and Red (VIBGYOR) were chosen and were mapped with certain predefined sound frequencies. Standard Piano notes were selected for mapping with these colours.

Table 1. Sound to colour mapping

Colour	Sound (Piano Notes)
Red	A
Orange	B
Yellow	C
Green	D
Indigo	E
Blue	F
Voilet	G

In order to test the mapping, twenty visually impaired students from a blind school were selected as subjects. Training was imparted to these students and they were made comfortable with the sound frequencies generated by the application. They were told the corresponding colour of each sound frequency. The sound to colour mapping used is as shown in Table 1.

The subjects were in the age group of thirteen to eighteen. Out of the twenty subjects eight were totally blind and eleven were having Low Vision. Out of the eight totally blind students five were blind by birth and three lost sight by the age of ten. Of the eleven low vision students, ten had the deformity by birth and two had developed low vision by the age of four. The details of all the subjects is listed in Table 2. The purpose & procedure was conveyed to each participant after due consent, such that everyone would receive appropriate information of the ongoing activity

Table 2 Details of subjects

Serial No. of the subject	Age	Sex	Studying in Class	Nature of Visual Impairment	Blind Since (X) years of Age
1	18	M	9	Total Blind	6
2	16	F	7	Total Blind	10
3	14	F	6	Total Blind	By Birth
4	14	F	6	Total Blind	By Birth
5	18	M	9	Total Blind	By Birth
6	16	F	7	Total Blind	4
7	15	M	7	Total Blind	By Birth
8	16	F	7	Total Blind	By Birth
9	16	M	10	Low Vision	By Birth
10	15	F	9	Low Vision	By Birth
11	16	F	8	Low Vision	By Birth
12	18	M	9	Low Vision	By Birth
13	18	M	9	Low Vision	By Birth
14	17	M	7	Low Vision	By Birth
15	13	M	7	Low Vision	2
16	16	M	7	Low Vision	By Birth
17	14	M	7	Low Vision	By Birth
18	16	M	6	Low Vision	4
19	17	F	7	Low Vision	By Birth
20	15	M	7	Low Vision	By Birth

On the first day of the two day schedule the students were called individually to a room and were made to listen to seven different sound frequencies mapped to seven colours. The sound frequencies corresponding to these seven colours were played one by one repeatedly until the students were confident of naming the colours associated with them. The training was repeated twice a day for all the nineteen students after a gap of almost two hours and they were called the next day to identify the same colours mapped to the sound notes being played randomly. The responses were tabulated for interpretation.

V. RESULTS AND DISCUSSION

From the responses of the students as tabulated in the table3, it was observed that 25% of the students were able to identify all the colours mapped to the respective sound frequency correctly. Out of the students who could identify all the colours correctly 80% were totally blind. Only one student who had low vision could identify all the colours correctly. 90% of the students could identify the first colour correctly whereas 100% could identify the last correctly. 60% of the students could identify the first four colours correctly. It was also observed that students with low vision had difficulty in differentiating between sound frequencies as compared to students who were totally blind.

On the basis of these results we propose a Colour to Sound Model (CSM) to help visually impaired persons identify Colours. The schematic of the proposed system is as shown in Fig.2.

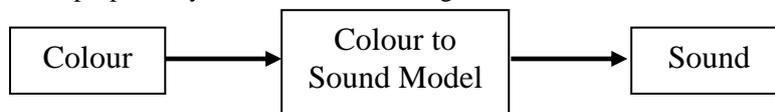


Fig. 2. Colour to Sound Model

The CSM implementation currently involves converting the seven Colour inputs to a mapped Sound frequency which can be extended to multiple Colours.

Table 3. Summarised results

Colours	Voilet (G)	Blue(F)	Indigo (E)	Green (D)	Yellow (C)	Orange(B)	RED(A)
Percentage of Subjects who identified the Colours correctly	90	80	70	80	45	35	100

VI. CONCLUSION

The basic objective of the above experiment was to find out whether the students would be able to identify the colours on the basis of the sound mapping. The practical results thus obtained are illustrative and would help visually impaired understand and identify colours. This would help us in developing a Sound Based Virtual Environment (SBVE) for VI students to comprehend colours based on certain sound frequencies / notes, thus empowering them with a sense of colour. The use of multimedia computer systems can play a very important role in the teaching-learning process of a visually impaired person. This study corroborates the above statement and the fact was acknowledged by all the subjects involved. The CSM model can be used create a SBVE to improvise the teaching-learning process of visually impaired, equipped with a lap-top computer & a web-cam.

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