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Full Length Research Paper

A low cost adaptive graphical user interface for the visually handicapped with multiple conditions

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Limited trials have been demonstrated that a Graphical User Interface (GUI) for the visually handicapped called Dynamic Pattern System (DPS) can adaptively utilize residual vision by generating different patterns, colors and shapes. Low vision simulators, used by normally sighted, have allowed researchers to clearly identify visual impairments that can be helped by DPS. However, it is not uncommon for the visually handicapped to suffer from multiple conditions having a multiplicative degenerative effect on their sight. This paper demonstrates how DPS can be used to assist individuals with compound sight disorders.

Key words: Visually disabled, blindness, deafblindness, low vision, assistive technologies, graphical user Interface (GUI), dynamic pattern system (DPS).

INTRODUCTION

The World Health Organization (WHO, 2010) uses a classification scheme to define the degree of visual impairment after the best possible corrective lenses have been used. A visual acuity of 6/60 (persons who can read at 6 m material, legible to a fully sighted person at 60 m) is considered severe visual impairment (AIHW, 2007). Total blindness refers to people who are unable to see light. WHO has noted:

"There are an estimated 9 million blind in sub-Saharan Africa and a further 27 million people are visually impaired. This represents 18.4% of the world's blind, despite the Region having only 11% of global population, and also the highest regional burden of blindness ratio in the world. 40% of all blind in the region live in Ethiopia, Nigeria and the Democratic Republic of Congo" (WHO, 2009).

WHO also project that in the absence of measures to counteract these trends in sub-Saharan Africa, these numbers will double resulting in significant economic and social impacts (WHO, 2009). Visual impairment is also a

significant Australian problem exacerbated by the rapidly changing age profile of the population. In 2004, of the 4.7 million Australians that are 55 years or over, 9.4% were visually impaired (DHA, 2008). Significantly, within Australia, indigenous communities eye diseases are up to ten times the national average (Vision20/20, 2007).

In many societies, social and economic inclusivity depends upon visual communication – signs, text, images, Internet, email etc. An individual's ability to use visually based information is crucial to participation in the community at large (Fewtrell, 1998). Interaction with text based materials (print, electronic) is therefore of paramount importance to enable people with visual impairments to participate in the workforce and to engage with society as a whole. Reading specifically is critical to participation in society. However, for many, visual reading is not possible using standard fonts, because in Australia only 3 to 5% of print material is in accessible format (Vision, 2009). Braille is the most commonly used technology to assist the visually handicapped. Braille uses a system of embossed and raised signs, which are formed by six dots arranged as in the Braille cell. Braille devices are commonly used but are expensive and difficult to learn due to the tactile nature of the media and may therefore be unsuitable for many with head injury or stroke effects. Similar conditions also exist for the aged. Automatic text-to-speech devices are useful, but can be

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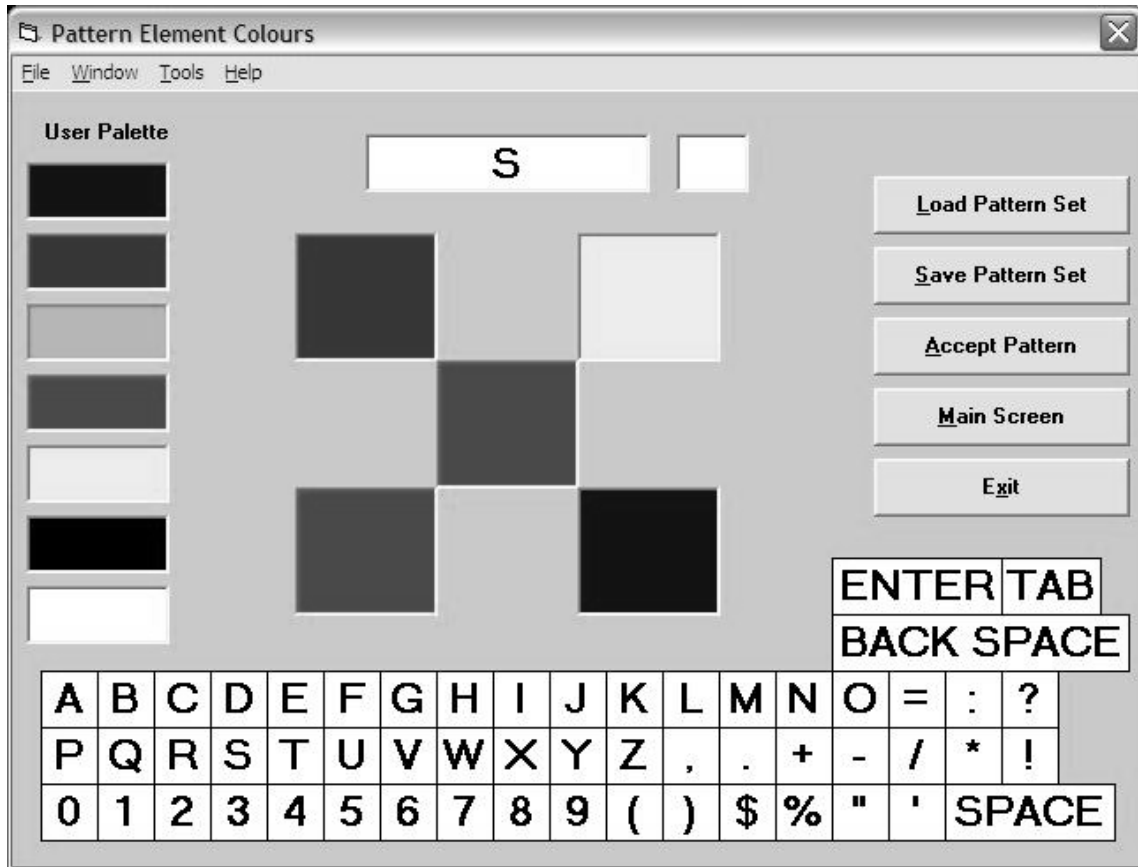
Figure 1. The DPS pattern colour selection screen. A huge range of possible colours can be added to the "User Palette", as shown, via the operating system of the PCs colour palette.

problematic for the deaf-blind (Leuterman, 2002). People who suffer from Diabetic Peripheral Polyneuropathy (DPP), a major cause of blindness in Australia, lose sensitivity in their fingertips, which excludes the use of Braille (NIH, 2009a). Furthermore, dedicated effect text to speech translators can be expensive and entail a steep learning curve. Yet in many societies social inclusivity may significantly dependent upon text based information. Relatively, few visually handicapped are totally blind; most have some residual vision (RBS, 1996). However, it should be understood that even after use of the best corrective lenses, for many, this residual vision cannot be used to identify even enlarged text and yet, it may be possible to identify different colors and very simple patterns.

The Dynamic Pattern System (DPS) software allows sighted users to create a limited number of colored shapes of various sizes to depict letters, symbols and words. These colours can be chosen from a large range of possible colours via a colour palette. A particular pattern representing an alphanumeric character may be represented by the colors of the colored shapes. These can be chosen to match the visually impaired volunteer's remaining visual capacity (Figure 1).

The complete set of patterns, of area sizes, their distance apart and on screen presentation times on screen area placement, pattern inter pattern and inter-word presentation times and the pattern's background color representing the alphanumeric character set, is known as a pattern set. Using the DPS, the on screen controls and the text box enables the parameters of a pattern set to be enabled and then tested by the researcher (Figure 2). A given pattern set may be saved and loaded as a default for a particular user or can be saved or can be selected from a range of available pattern sets.

Each unique pattern that was matched to the residual vision of the blind person is used to represent an alphanumeric character, phoneme, word or phrase. In effect, each visually impaired person is provided with their own individual GUI based set of patterns, known as a pattern set suited to their own visual ability.

A sequence of such patterns shown on screen representing a sequence of alphanumeric characters may be used to represent a word, sentence or paragraph. When a user enters information into the DPS program via the keyboard the patterns representing the characters entered can also be seen on screen. This, or other text
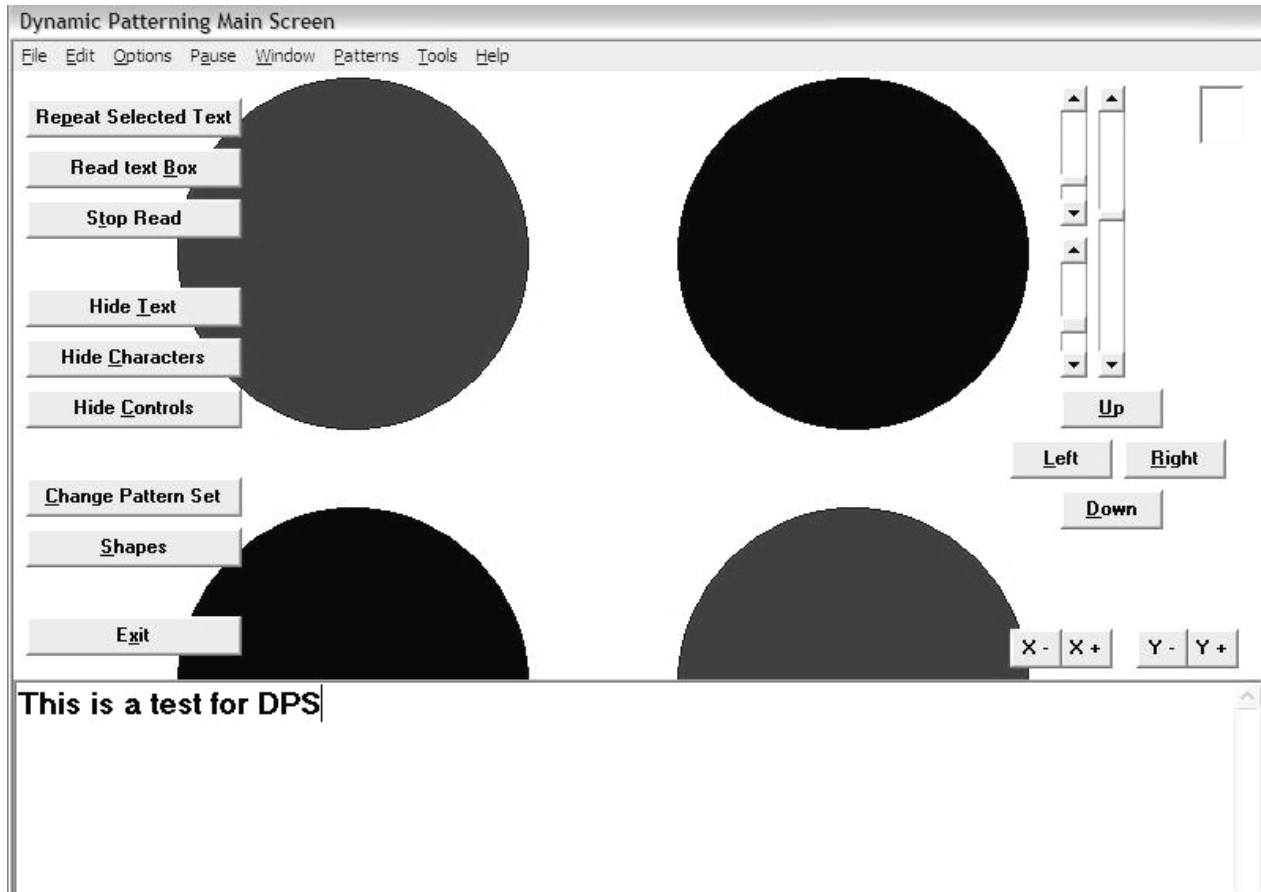
Figure 2. The DPS main screen with controls, text box and character box showing. The top left-hand circle is red and the top right-hand circle is black whilst the bottom left-hand circle is black, bottom right-hand circle is red.

based information, can be read by the visually impaired user via the DPS by its automatic translation of text into the required on-screen patterns. The DPS has been implemented as an experimental test bed to be used with the assistance of a fully sighted researcher. When viewed by a visually impaired user the DPS software allows for the on-screen controls text box and other potentially distracting on-screen information to be hidden for testing purposes (Figure 3). Limited trials have demonstrated that, DPS could be of assistance to the visually handicapped (Veal et al., 2004; Veal and Maj, 2005; Veal et al., 2009; Veal, 2007). The DPS software has been designed to also run on a range of low power older cheaper PC. A PC capable of running Windows 95® is sufficient. Although, the software is also designed to work on newer version of Windows ® and in its version. This is of special importance for use in situations where the cost of the necessary computer hardware may make the use of this software prohibitively expensive.

One of the main problems with our evaluation of the DPS has been quick and effective access to a range of individuals with some of the many visual disabilities to be tested. However, low vision simulators are available,

which, when worn by someone with normal sight, allow different visual impairments to be tested prior to being tested on visually impaired volunteers (VRS, 2010). An advantage of such a method is that developments and test regimes can be pre-tested by developer and necessary changes in the conditions, software, methods implemented hence accelerating the development processes. Eleven visual conditions have been pre-tested using low vision simulators. The general conditions that permit the perception of enlarge fonts were identified as:

1. Homonymous hemianopsia
2. Central scotoma
3. Tunnel vision
4. Impaired acuity (from 20/80 to 20/400)

For the following conditions, one research reported that, it was not possible to read even enlarged text but it was possible to see different colored patterns and shapes as outlined in Table 2. Hence, the following conditions may be assisted by the DPS software (Table 1):

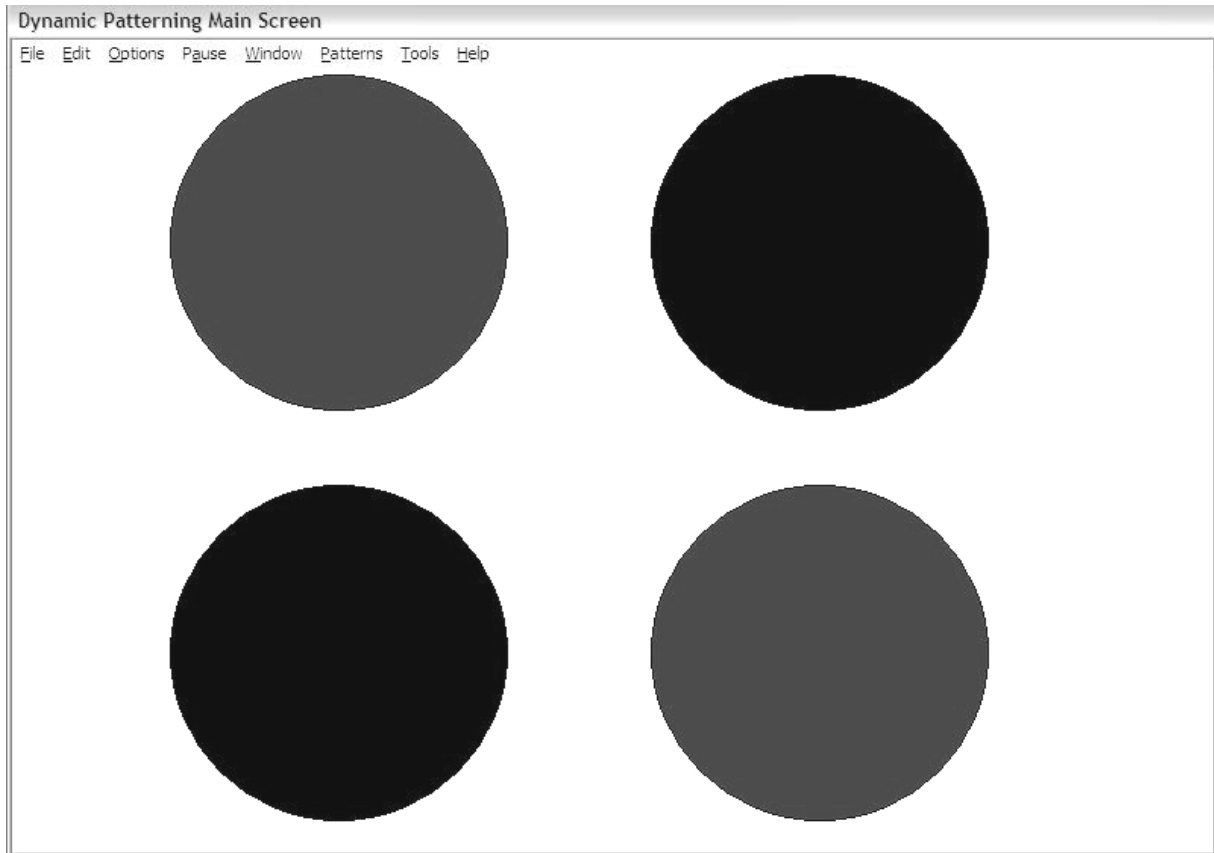1. Diabetic retinopathy (visual acuity 20/100, 6/30).

Figure 3. The DPS pattern presentation screen with the other details, as shown in Figure 2 that is now hidden. The top left-hand circle is red and the top right-hand circle is black, whilst the bottom left-hand circle is black and the bottom right-hand circle is red.

2. Impaired acuity (visual acuity 20/800, 6,240).
3. Central scotoma (visual acuity 20/400, 6/120) (Veal and Maj, 2010).

For this research, ASCII character reading is defined as the ability to uniquely perceive text without moving ones head. With the above conditions, it may be possible to distinguish between light and dark. Hence, if fonts are enlarged e.g. 72 point and more, it is possible with the eyes very close to the screen, to track a single ASCII character by moving ones head. Visual impairment can be due to a wide range of different medical conditions. Unfortunately, it is not uncommon for the visually handicapped to suffer from more than one medical condition with a multiplicative detrimental effect on vision. (Nirmalan et al., 2005; Rubin et al., 2001).

MATERIALS AND METHODS

Materials low vision simulators were used in this investigation and although these simulators do not allow all possible visual handicap conditions to be replicated, the lenses are not only interchangeable but may also be combined in order to simulate different combinations of visual impairments. These simulators are worn over the glasses, to avoid adding extra conditions due to the any correctable vision problems possessed by the sighted users. The simulators provide a range of typical eye conditions for the wearer to experience. The effects are obtained via appropriate combinations of light filters.

Methods

A fully sighted individual was tested using a standard Snellen eye chart (ISEE, 2009) and found to have a visual acuity of 5/6 and could read 8 point ASCII characters at a distance of approximately 50 cm from the screen of a PC. Furthermore, they could also distinguish a wide range of different colors, shapes and sizes using the DPS software. Various visual disorders were simulated by combining different lenses and the authors selected a range of eye conditions where the DPS could be of assistance (Table 1). The laboratory in which the experiment was undertaken was a closed room with no outside light. Furthermore, the room's artificial lighting was kept constant for the duration of the experiment.

RESULTS

The results of reading characters on the DPS and via a word processor program were evaluated (Table 2) by a normally sighted person. The baseline visual acuity of

Table 1. Some conditions that could be assisted by DPS.

Condition	Visual acuity	DPS colors	DPS shapes
Diabetic retinopathy	20/100, 6/30	Full colour spectrum visible	Distinct shapes visible.
Impaired acuity	20/800, 6/240	Full colour spectrum visible	Distinct shapes visible.
Central scotoma	20/400, 6/120	Full colour spectrum visible	Distinct shapes visible.

Table 2. Multiplicative visual disorders using the DPS and an eye chart.

Condition 1	Condition 2	DPS	Comments
Visual acuity 6/120		Coloured patterns can be perceived	Enlarged characters 'read' only by tracking
Visual acuity 6/120	Visual acuity 6/240	Coloured patterns can be perceived	Enlarged characters 'read' only by tracking
Visual acuity 6/60	Diabetic retinopathy 6/30	Coloured patterns can be perceived	Enlarged characters 'read' only by tracking
Visual acuity 6/240	Diabetic retinopathy Visual acuity 6/30	Coloured patterns can be perceived	Character tracking not possible

108 6/120 was progressively exacerbated by further reductions in visual acuity and also diabetic retinopathy. Diabetic retinopathy was chosen as this is a common condition with diabetics. For three of the four conditions enlarged character tracking was possible. However for one condition, diabetic retinopathy with combined visual acuities of 109 (6/240) and 105 (6/30) character tracking was not possible. Significantly, for all these conditions, including exacerbated diabetic retinopathy; different colored patterns could be perceived using the DPS software. The results from Table 2 clearly indicates that, the DPS does enable patterns representing characters to be read under conditions where, either they could not be read or read only with difficulty without the use of the DPS

DISCUSSION

Diabetic retinopathy is one of the leading causes of blindness worldwide. All people with diabetes mellitus (Type I, juvenile onset and Type II adult onset) are potentially at risk. Significantly, nearly 45% of Americans diagnosed with diabetes have some degree of diabetic retinopathy (NIH, 2009b). This risk is exacerbated with time – the longer a person has diabetes the higher the risk of developing this condition. After 20 years of diabetes, nearly all Type I and over half of Type II have some degree of diabetic retinopathy. Diabetes typically affects normally sighted individuals and its onset has no early warning signs. People with diabetes are 25 times more likely than the general population to become blind (Williams et al., 2004).

The ability to perceive visual information without moving one's head is important because this is how the normally sighted read that is, a single character can be read without head tracking. This represents, in effect, a high bandwidth communication channel. More results are required on both an Australian and at an international level via the assistance of perspective partner organizations to assist and test a greater range of conditions with a larger number of volunteers. The authors are actively searching for such partnerships and would be happy to be contacted on this or other similar issues.

Conclusions

This paper has demonstrated that there are two benefits to employing the DPS software. Firstly, it is possible to perceive encoded communication without head-tracking and hence, represents a relatively high bandwidth communication channel. Secondly, work to date suggests that DPS may be able to assist the visually handicapped who are unable even to use head tracking for on screen character recognition. The acuity levels chosen were those for whom DPS usage would be advantageous. A better acuity would mean users could track enlarged text without difficulty. More research needs to be undertaken both on a national and an international level in association with partners in the field with volunteers who are blind or deafblind with a range of visual disabilities. If large numbers of volunteers were to be involved in such a project, then this numbers involved could help to more fully confirm its findings.

Furthermore, the DPS software is designed to operate on standard PCs that need not be modern or of high power; thus making the use of DPS more affordable and assessable for many blind deafblind people and their respective organizations. There is a large projected increase in the number of people world-wide classified as

blind from international organizations. Methods of enabling the visually disabled, many of whom possess some remaining vision, to access electronic print media is of crucial importance.

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