A Narrow Bandwidth GUI for Diagram Recognition by the Blind

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Abstract

The Dynamic Patterning System (DPS) is a narrow bandwidth GUI developed for use by people with vision impairment who cannot read even enlarged print, yet are able to distinguish a small number of colored areas on a computer screen. DPS computer program runs on standard PCs with no additional equipment required. The DPS is designed to utilize the residual vision that many people, though classified as blind, possess. It should be noted that within Western Australia people possessing 10% or less of the sight possessed by a fully sighted individual are classified as blind. This system could be of especial use to the blind-deaf rather than blind users due to the wide availability of text to speech technology. However, the problem of diagram recognition via such systems remains problematic. The authors propose a Low Speed Scanning (LSS) approach whereby users are presented with a sequence of patterns representing a shape. This paper describes the initial testing of this interface and provides results from this investigation. The problems of software provision for people with vision impairment are also considered especially in light of the Americans with Disabilities Act (ADA) legislation. Other devices developed to provide diagram transmission to the blind or partially sighted are described.

1. Introduction

Many people classified as blind have some residual vision. The New South Wales Royal Blind Society notes that:

"The definition of blindness used by medical professionals, support services and government agencies (most especially the Department of Social Security) is a visual acuity of 6/60 or less or field restriction of 10%, i.e. the person sees at 6 metres what a person with 'normal' vision would see at 60 metres, or can only see up to 10% of the normal visual field" [14].

Furthermore, even though some people with vision disabilities can read highly magnified text, on the screen of a computer, this can be difficult for many other users, as their face may need to be very close to the screen[14].

2. Web Accessibility Issues

Grimaldi and Goette have noted the importance of Internet access to the independence of individuals with disabilities [24] and Fewtrell states that: *"Participation in the broader community depends on the individual capacity to receive and use visually-based information. Limited access to visually-based information affects all aspects of the lives of people who are blind or vision impaired"* [6]. Whilst some people with vision disabilities can use screen magnifier programs [7], many may have handicaps that preclude such a solution. Sloan et al note that: *"Unfortunately, a large majority of Web sites currently suffer from accessibility problems of varying degrees of severity, which prevent the assistive technologies from correctly interpreting all of the available information"* [23].

Ladner has outlined the Americans with Disabilities Act (ADA) [9] and Reese has noted that there are important implications in the ADA for employers in respect to the provision of aids for vision-impaired employees using computer equipment [15]. ADA has its counterparts in many other countries such as the Disability Discrimination Act 1995 in the UK [20]. Yet ADA has not been without its detractors. Olsen has stated that it: *"... is a nearly perfect way to stifle creative freedom and slam the brakes on the Internet's expansion"* [12]. However, Web designers now have more opportunity to exercise their *"creative freedom"* to further enhance Internet access for both disabled as well as non-disabled users. Furthermore, other areas where ADA has been applied do not appear to have had the *"brakes slammed on"* their expansion. For example Cummings notes that: *"Ever since the ADA citizens here have seen marked improvements in the way of ramps, auditory systems, and other devices in hotels, restaurants, museums and hospitals"* [3]. Whilst Schrage notes that: "*... the National Federation for the Blind sued America Online for not moving fast enough to make its services available to the sightless"* [17], and adding that: *"Surely a policy of erring on the side of access and accommodation is not unreasonable. After all if organizations can physically modify bathrooms and stairs, they can certainly modify browsers and servers"* [17]. Vaas raises a point of economic self interest with the observation that: *"when a web site shuts out the disabled it means that its enterprise is shutting off access to a sizable slice of the customer pie"* [19].

However, there have been notable examples of improvements in access to information via the Web. The Royal National Institute for the Blind (RNIB) in the UK notes that PDF files can now be converted into text or HTTP files for use in text-to-speech or text-to-Braille converters [16], although on a large number of Web sites just getting to the stage of loading a PDF file can still be problematic for many of those with vision impairment. A hybrid solution may be required such as suggested by Paciello who states that: *"The key to reading a Web document or displayed server messages is that the output stream is ASCII. Since many blind users rely on character cell browsers (LYNX, W3, CERN Line Mode Browser) that read ASCII text in conjunction with their synthesizers and Braille displays"* [13].

3. Screen Readers

Screen readers, which can also convert text to speech via speech synthesisers, can be vital for Web access for many blind or vision-impaired users. Berry notes that: *"The use of a screen reader to access the Web was determined to be paramount by the blind respondents. They simply would not have had any independent access without this technology"* [1].

Lazzaro notes that screen readers can:

- *Read text in character units*
- *Read text in words*
- *Read text in line units*
- *Read text in window units*
- *Speak keystrokes as individual letters or whole words*
- *Track and verbalize cursor movements*
- *Track and verbalize mouse movements*
- *Freeze screen for passive reading functions*
- *Control synthesizer's volume, pitch and speaking rate*
- *Speak or filter punctuation*
- *Speak numbers as words or digits* [10].

He also notes that: *"Monitoring can be used to look for error messages that pop up on screen, or for system prompts that ask you for information"* [10].

4. Dynamic Pattern System (DPS)

The deaf-blind are a group that screen readers may not help. Hence investigations by the authors are now tending more towards testing this group. One attempt involves using any remaining residual vision that partially sighted people may possess. They may be able to see a few areas of different colors, which maybe sufficient to allow different combinations of colored elements to represent a set of alphanumeric characters.

An alternative reading aid is utilized namely DPS whereby a pattern or a series of patterns can represent an ASCII character [20, 21]. Each pattern consists of a number of distinct areas, each of which can assume one of a set number of colors. A particular set of patterns representing a set of characters is known as a patternset. The DPS computer program converts text into a sequence of patterns that are shown on the computer screen. De La Harpe has compared the screen output of a DPS system with that of standard word processor screens noting that: *"... the only difference to a casual observer would be that the screen would display patterns rather than text"* [4].

The DPS program was written to test both the design of the patternsets and the general feasibility of such a system. The DPS consists of an easy to use graphical user interface allowing patternsets to be designed, saved, tested and used as a default. The variables in patternset design are: the number of elements, the shape of elements, the element color, the background color, and the timing which includes both the presentation time of the patterns and the time between sequences of patterns representing words. There can be up to five elements within each pattern. The reason for this limitation is that if a larger number of elements could be distinguished by volunteers then they could also recognise alphanumeric characters negating the purpose of using a pattern system such as DPS. The screen for setting parameters for pattern presentation is shown in Figure 1. It should be noted that the screen seen by volunteers during a test would only consist of patterns or sequences of patterns.

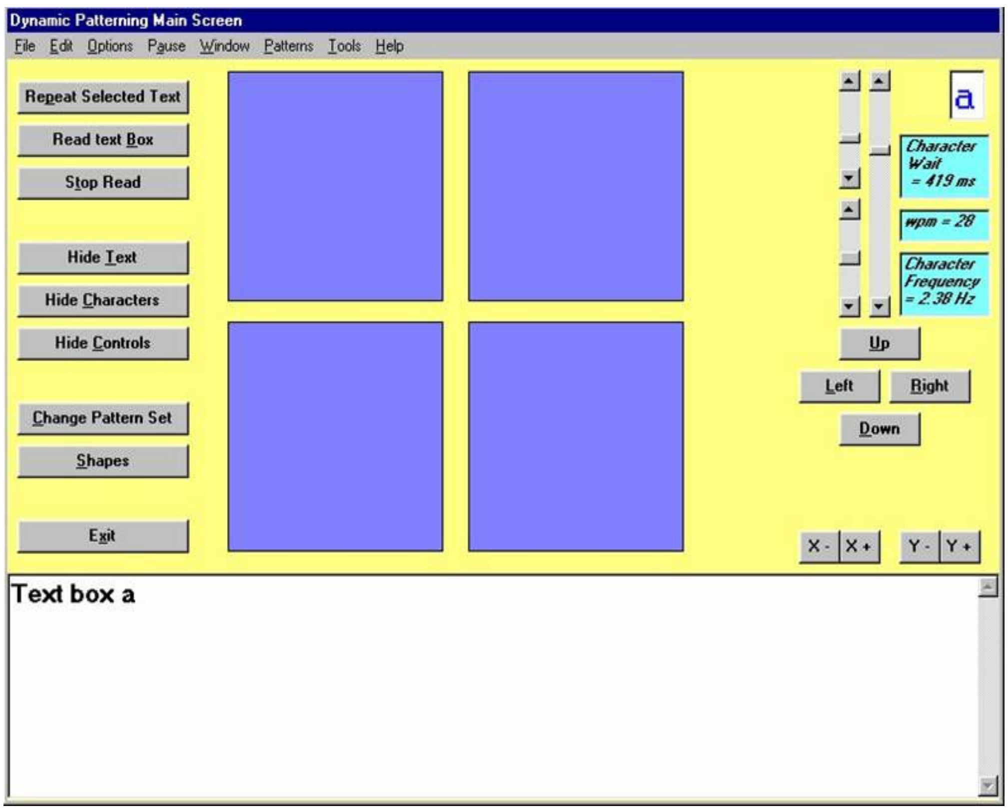

Figure 1. The DPS main parameter setting screen for controlling the presentation of sequences of patterns to a volunteer.

The shapes of the pattern elements and the background color can be varied. The presentation speed of patterns can also be varied thereby allowing a close match to a user's pattern reading ability. Using this program it is possible to design an individualized patternset that maps to the ASCII character set. The DPS program allows the user to read an entire file, or to select blocks of tests, which can then be automatically converted into patterns. This can be repeated continuously for training purposes. The color of each element can be selected as shown in Figure 2.

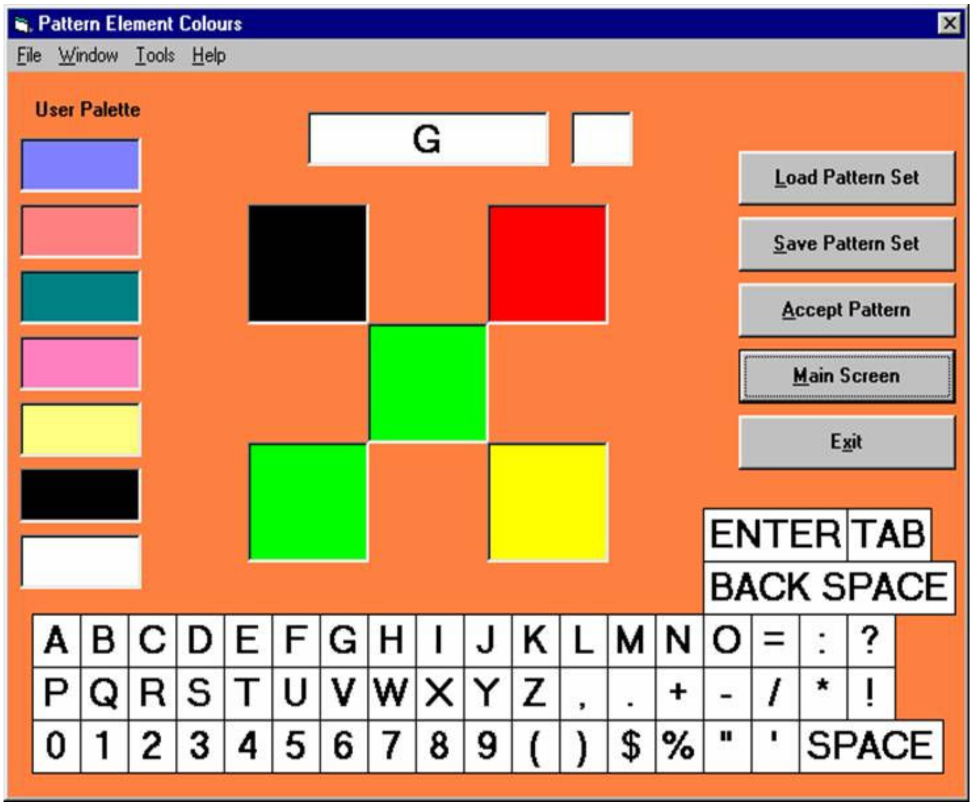

Figure 2. The DPS screen for selecting element colors

At present the DPS program does not distinguish between upper and lower case letters. This is to reduce the number of patterns that users need to recognise. However it would be a fairly simple change to enable upper and lower case patterns to be represented. One way of assisting such recognition could be by making the pattern size noticeably larger, and/or brighter.

5. Dangerous Interfaces?

The authors initially tested the DPS program on themselves and as well as on volunteers who, with practice, learnt to recognize some basic words and phrases. Safety features were included in the DPS program to avoid pattern presentation speeds that might induce fits in photosensitive epileptics [18]. Advice was also obtained from neurologists specializing in the field of epilepsy, from the Epilepsy Association of WA, from medical practitioners and also from publications. Research involving human subjects at Australian universities must have ethics committee approval and this was duly obtained.

6. Individualized Patternsets

As there are many conditions that can lead to partial sight, hence patternsets may need to be individualized to each user to enable them to make effective use of their limited vision. This can be regarded as an interface matching solution.

The input or output of a DPS can be read as standard text by conventional text-based word processors, web browsers and other standard IT equipment. The use of DPS may allow partially sighted users to communicate with each other via their own individualized patternsets. Furthermore a fully sighted person can both send and receive conventional text when communicating with a person who is using a DPS.

The machinery on which to run the DPS program is now readily available due to the proliferation of cheap and powerful PCs. Transmission via the e-mail only involves standard text files and the DPS program runs on standard PCs using a Windows environment. The DPS program is written in Visual Basic. As Visual Basic for Applications (VBA) is included in many common Microsoft programs this could be used to run DPS as a front end for these programs. These include Microsoft Word, Excel, Access, Internet Browser and Outline for E-mail as well as many other popular computer programs. Thus the DPS program would merely convert the text to patterns and visa versa when using these popular packages.

Our initial investigations used thirteen blind volunteers mostly attending a local institute for the blind, and who had some residual vision. This research discovered that some volunteers were far better at remembering and discerning patterns than the first author, both in their speed of acquisition and in their retention. The small amount of initial self-testing undertaken by the authors was insufficient regarding the difficulty of learning this system. For example, one volunteer could recognize fourteen patterns making up more than ten words included in sentences after only one ten minutes and one twenty minute practice session, although this was exceptional. There are other possible reasons to utilize the residual sight of visually disabled users even though they may not also be deaf. Referring to the power of Graphical User Interfaces (GUIs) Edwards notes that:

"… the fundamental problem is that sight is very efficient. This is often summarized (somewhat loosely) by saying that sight has a very broad bandwidth" And that: *"they present a lot of material on the screen but rely on the power of sight to cope with all of it. None of the non-visual senses has that same power, that bandwidth"* [5]. In this sense the DPS program could be regarded as a form of narrow bandwidth GUI.

It is also possible to represent a character by a sequence of patterns, rather than just an individual pattern. A pattern sequence may include changes such as: enlargements, contractions, reflections, rotations, and pattern inversions. This may be a further aid to recognition of diagrams via character representations with multiple pattern representations. Such a representation is possible with the DPS system although this entails using sequences of characters to simulate such effects.

7. Diagram Recognition by the Blind or Partially Sighted

In addition to the textual presentation problem there is also the problem of interpretation of diagrams by the partially sighted. Mereu and Kazman have used sounds to indicate position in a 3D environment for use by visually impaired users. This was achieved by using different types of sound to indicate the x, y and z-axis and a varying scale of these sounds to indicate position on an axis [11]. Again this system may not be useful for the deaf-blind. Kruse has used the idea of replacing a scene with a description. *"The blind user can ask the system questions such as: What is in the foreground? What is in the background? Name all the objects in increasing distance from the viewer's standpoint. Name all sub-objects of object x"* [20].

Kruse et al have also investigated the translation of numeric diagrams such as charts using sound to represent numerical values [8]. Again this may not be suitable for the deaf-blind. Colwell et al report on the use of Haptic Virtual reality for blind computer users. They note that: *"Haptic perception incorporates both kinesthetic sensing, (i.e. of position and movement of limbs), and tactile sensing, (i.e. through the skin)"*. And that: *"Navigation could be aided by the use of texture to distinguish different areas of WWW pages"* [22]. The objects in these diagrams and scenes could be touched to obtain information on quantity, size and size position as well as texture.

8. Low Speed Scanning (LSS)

The DPS program has been designed to have a high level of flexibility due to its input being based on the ASCII character set. For diagram recognition tests diagrams are first converted manually into series of lines using characters in the ASCII set. This could be automated should the method found to be useful. For example a square could be represented in the DPS text box composed of two characters as shown below in Figure 3. The star character '*' represents the outline of the diagram whilst another pattern can represent the white space.

```
*******
*     *
*     *
*******
```

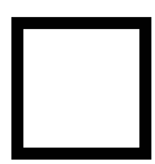

Figure 3

The user viewing the pattern sequences would need to keep in mind the two-dimensional pattern represented by such sequences. Thus the ‘scanning’ is provided by the user who mentally builds up images from the pattern sequences. This ‘Scanning’ is ‘Low Speed’ because it takes place at speeds thousands of times slower than the electron beam that scans the front face of the monitor tube when forming a computer generated screen image. Hence it can be referred to as a LSS system.

The initial scanning experiments using the DPS were such that the scanning was assumed to take place in the left to right direction across the screen. The scanning is assumed to start at the top left hand comer of the image being transmitted and work downwards line by line i.e. the same as a reader of English reads a printed page. There are other possible scanning systems such as right to left or top to bottom of the object line by line but as the DPS system was designed to scan text for English reading so it was the easiest test to perform without needing to modify the computer program running the DPS.

As the DPS presents patterns representing the characters read from its text box in serial form some indication as to the start of a new line or the ending of the present line is required. This character could either be a line return ASCII pattern representation or any other character representation. It should be noted that these can be adjusted to match the vision capabilities of the user. This pattern then acts as a signal for line-flyback analogous to that which occurs in the case of a TV or computer monitor, or a start of a new line using a word-processing analogy. In Figure 4 the white space would be indicated by the space character pattern. Using a letter ‘s’ for example could indicate the line-flyback character pattern for the start of a new line. Text can also be included as descriptive information.

```
s          ********
s          *      *
s          *      *
s          ********
```

Figure 4

In a more developed working model special control character patterns are to be used to avoid the same patterns used for text representation. Simple shapes can be represented for tests such as a triangle, as in Figure 5, and these can be either filled or unfilled.

```
s        *             *
s       ***           * *
s      *****         *   *
s     *******       *******
```

Figure 5

However, a vital question remains to be answered. Will such a system actually work? The following experiments were undertaken as an initial attempt to answer this question.

9. The Experiments

The authors first attempted to recognize different shapes via the LSS. As we were working with disabled subjects all tests were initially first tested on the experimenters themselves. The shapes included squares triangles and rectangles of various relative sizes. Shapes were then placed next to each other to build more complex images. More detailed tests involved the use of shapes denoting the main body of symbols such as those representing 'AND' and 'NOT' gates shown in Figures 6 and 7. Volunteers were asked to differentiate between these shapes using the letter 'P' to indicate the commencement of a pattern, '*' to indicate a part of a line or the body of the diagram and the letter 's' to indicate the start of a new line.

```
P
s ********
s ************
s **************
s *************
s *********
```

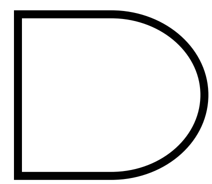

Figure 6

```
P
s *
s ***
s *******
s ***
s *
```

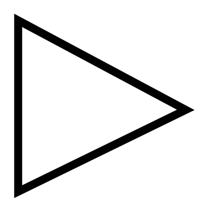

Figure 7

10. The Results

The authors tested this diagram recognition LSS system on both themselves and on other volunteers the following changes were found to enhance the effectiveness of the diagram recognition process:

- The inclusion of a sequence of letters such as 'P's as a 'start of diagram symbol' so that the user would be ready to attempt to interpret the following sequence of patterns as a diagram.

- A sequence of occurrences of a letter representing a new line pattern such as ‘s’s to provide users with a better indication to prepare for the scanning of the next line than just a single pattern.
- The shapes could be more effectively distinguished initially using a standard diagram size.
- Allowing sufficient white space patterns after the main part of the object representation to allow the user to appreciate the relative position of the object’s outline in the diagram representation.

Those tested included a person who was unable to read with one eye but could however distinguish the patterns presented via the DPS system. Volunteers could discern multiple object diagrams such as a triangle placed on top of a square. However volunteers found it difficult to differentiate between isosceles triangles of similar size but with different angles. There are also problems due to ‘quantization errors’ resulting from the representation of detailed diagrams using groups of single characters.

More control of the DPS by the volunteers is needed. This will require further modification of the DPS program. This should allow users to repeat the scanning of a whole object, lines representing an object or even single stepping through the pattern representation of the object. Not too surprisingly many of these operations are similar to those found in screen readers for text to sound conversion. Furthermore, under the DPS program such control ought to be simply attained via the keyboard or menu choices all of which should also be presented in the form of pattern sequences.

The diagram presentation system using the DPS computer program will be tested on more vision impaired volunteers. These volunteers will only need to be able to differentiate between the four symbols used to transmit the diagram information, namely a white space symbol, a symbol representing the diagram body, a start of a new diagram symbol and a start of new line symbol.

11. Conclusions

There are a range of methods to assist Web access for those with visual disabilities yet there remain many problems to overcome. More research into LSS needs to be undertaken. A larger range of vision-impaired volunteers need to be accessed. The recognition of a much greater range of diagrams by volunteers also needs to be tested. Preferably many of these volunteers would need to be deaf-blind. Further modification of the DPS program needs to be undertaken to allow users to excise more control of both the patterns and the pattern presentation process.

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