Evolution of User Interfaces for the Visually Impaired

Umakant Mishra
Physically or mentally challenged people cannot use a computer in the same way a normal person can. For example, persons with disability in hands cannot use a standard keyboard or mouse efficiently. Persons having visual disability cannot benefit from a standard display screen. People having locomotor challenge, visual disability or hearing problem etc. cannot interact with a computer like a normal person. So it is necessary to design the computers, interfacing devices and software interfaces with special features, which can be used by the people with physical challenges.
There are many input/output devices like mouse, keyboard, pointers, and touch screens etc. to improve the human computer interaction. But it is a challenge for the inventors and manufacturers to build such devices for people with physical challenges. One of the major difficulties for the inventors is to visualize the difficulties of a visually impaired person and invent such special devices that would assist them as desired. Similarly it is challenging for the manufacturers to build these special equipments, as there are not enough customers for these products for a commercial viability.

This article analyses different types of visual disabilities, different assistive technologies for different types of visual disabilities, guidelines for developing user interfaces for the visually impaired, software products available for assisting the visually impaired, and Inventions made on such adaptive technologies. The objective is to analyze and explore various assistive technologies for the visually impaired users, and throw some light on the possibility of future improvements of such devices and/or interfaces.

2. Introduction:

The development in Information Technology gives increasing importance on building high performance user interfaces. Not only hardware interfaces but software interfaces are becoming more and more convenient and user friendly with the object oriented approach. The objects like files, folders, cabinets, printers etc. are all displayed in graphical icons. The objects are handled in a similar way like dragging and dropping as they are handled in the real life. The technology even leads to 3d display, virtual workspaces and simulations.

Although all these improvements have benefited the common users, they have very negligible impact on the blind and visually impaired users. The visually impaired users cannot use the standard user interfaces made for a common user. There are certain assistive technologies used for improving the user interfaces for the visually disabled users.

Normally human beings interact with computers by using the organ of vision, hearing and touching. When the visual interface is weak or invalid, naturally the importance goes to the other two organs. However, partially blind users still can use the visual interface although to a very limited extent. The assistive technologies built around the three major human interfacing organs are:
3. What sense organs are used for computer interaction

If we look at the use of sense organs for interacting with the computer we find that vision, touch and hearing are mostly used for computer operation. Taste and smell are hardly used. In case of a normal user the vision plays a dominant role, whereas a blind user has to rely mostly on the hearing of sounds and voice.

As we see in the above illustration, there is a need to improve the audio and tactile interacting techniques to help the visually impaired. There is also a scope to alter the visual interfacing techniques to suite the partially blind or low vision users.

4. Who are called visually impaired users

If we look at the community of visually impaired computer users there are basically two categories.

- The first category- people who had visual disability and they later became computer users.
- The second category- the computer users who developed visual disability.
Interestingly the size of both the groups are increasing. While more and more disabled users start using computers, the existing computer user community also growing old to develop visual disability.

Both the categories of visually impaired users are equally important although their expectations may slightly differ because of the difference in their previous experience with the computer. The older users who developed low vision may still like to depend more on the visual interface which they were familiar in the past. The new users may depend more on the audio interface which they use more in interacting with the rest of the world.

5. Type of Visual Disabilities and Assistive Technologies

There are different types of visual disabilities, such as low vision, color blindness and lost vision etc. Users having partial blindness get some benefit from improved visual interfaces. Users with complete blindness get no benefit from visual interface. Thus they are broadly classified into partial blindness and complete blindness.

<table>
<thead>
<tr>
<th>Type of visual disability</th>
<th>Technology involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial blindness or low vision</td>
<td>The visual interfaces need to be adaptive.</td>
</tr>
<tr>
<td></td>
<td>Supplementary audio interfaces.</td>
</tr>
<tr>
<td></td>
<td>Supplementary touch sensitive interfaces</td>
</tr>
<tr>
<td>Complete blindness</td>
<td>Substitution of visual interface by audio</td>
</tr>
<tr>
<td></td>
<td>interfaces.</td>
</tr>
<tr>
<td></td>
<td>Substitution of visual interface by tactile</td>
</tr>
<tr>
<td></td>
<td>interfaces.</td>
</tr>
<tr>
<td>Blindness with hearing Disability</td>
<td>Use of only tactile interfaces.</td>
</tr>
</tbody>
</table>
6. Assistive or Adaptive techniques for the visually impaired

As we discussed, there are various techniques to improve the adaptiveness of the user interface for the visually impaired computer users. Broadly, all these techniques can be grouped under audio, visual or tactile domains. However, it is important to find the efficient techniques under each domain and explore the possibility of combining the techniques to produce the best effect.

<table>
<thead>
<tr>
<th>Visual Techniques</th>
<th>Useful for partial blindness</th>
<th>Useful for complete blindness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of deep color and high contrast color schemes for text, graphics and GUI</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Using large fonts, large icons, large cursors, large mouse pointers etc. for better visibility.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Using screen magnifiers- the external software tool that is used to magnify the screen contents.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Illuminated keyboards.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Using special display devices like large size monitors, CCTV (Closed Circuit Televisions), projectors etc.</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Audio Techniques</th>
<th>Useful for partial blindness</th>
<th>Useful for complete blindness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voice recognition and Text to Speech Technologies for voice interaction with the computer. listens to the voice commands.</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Narrators or audio descriptors which audibly describes different parts of the display or program.</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Screen readers that use TTS to audibly read the text displayed on the screen.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Audible feedback on different mouse events. For example different sounds on onmouseover, onclick, ondrag, ondrop and similar events.</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Key tones or audio feedback on pressing keys on keyboard. Special sounds for special keys.</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sound notifications when features are turned on or off</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
### Tactile Techniques

<table>
<thead>
<tr>
<th>Technique</th>
<th>Available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Braille Keyboards</td>
<td>-</td>
</tr>
<tr>
<td>Special keyboards, large special keys, other special hardware interfaces.</td>
<td>Yes</td>
</tr>
<tr>
<td>Braille monitors or Braille embossers, that provide dot matrix dynamic display of contents</td>
<td>Yes</td>
</tr>
</tbody>
</table>

### Combined Techniques

<table>
<thead>
<tr>
<th>Technique</th>
<th>Available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karaoke type highlighting the text word by word while reading out the text. (Audio + Visual)</td>
<td>Yes</td>
</tr>
<tr>
<td>Speech synthesizers that gives audio feedback on what the user has typed. For example, the user types “a” and computer speaks “a”. (Audio + Tactile)</td>
<td>Yes</td>
</tr>
<tr>
<td>Braille display with sound and music (Audio + Tactile)</td>
<td></td>
</tr>
</tbody>
</table>

### 7. Common Assisting Options useful for the Visually Impaired

There are some assistive techniques, which are normally available in many applications and operating systems. This is because these features are not only helpful to the impaired user but also helpful to the normal user. It is important for the visually impaired user to know and make use of these features whereas a normal user can well manage without turning on any of them.

- Selecting a lower screen resolution for larger display of items.
- Turning display to high contrast for better visibility.
- Choose suitable color options.
- Select large icons and bigger font size in display settings.
- Change mouse pointer to bigger size and prominent color. Use pointer trails.
- Toggle on key tones, which beeps a tone when a key is pressed.
- Toggle on sound notifications when some feature is turned on or off.
- Assign sounds to different system events.
• Using short cut keys or function keys for frequently used (or difficultly accessible) operations.
• Configure browser to supersede the original font size and display in larger fonts.

8. Tips for the Developers to Build Adaptive Interfaces

The look and feel of the GUI is very important to make it adaptive to the visually (and even otherwise) impaired users. Some people wrongly believe that the GUI is only meant for aesthetics, but it has so many impacts on different aspects like speeding up the operation, hygiene to the eye and brain, assisting to the impaired users and so on.

While developing applications for a target group that might include visually impaired users, the developers should take care of the following aspects in their graphic user interfaces.

• Using larger fonts for better visibility.
• Use larger and with color contrast. The 16x16 small icons to be replaced with 32x32 or even larger icons. The icon size should be matching with font size.
• Include plenty of warnings and alert messages to ensure that the user is doing what he wants to do. This can be enabled in a special checkbox in the options menu.
• Include beeps, tones and audio messages as much as possible. Small tones after completion of any operation makes sure that the operation is done.
• Informative voice messages can be managed by using wav files even without installing TTS engine. Quite a few wav messages can be included in the application to be enabled optionally.
• Voice interacting features with TTS and Speech Recognition engines will be quite good for visually impaired users.

9. Some software products for assisting the visually impaired

Microsoft Narrator- is specially made for the blind and visually impaired users. It reads the contents of the start menu, program menu and web links. When the narrator is turned on it reads aloud every keystroke made by the user. (www.microsoft.com).
**Home Page Reader** – is a talking web browser from IBM. It supports several languages. This is intended for blind and visually impaired internet users. The JavaScript support allows to speak aloud all the contents on the web page. This enables blind and visually impaired users to complete on-line forms for doing transactions over the web. ([www.ibm.com](http://www.ibm.com)).

**BrailleMaster** from TVI (Technologies for the Visually Impaired) – provides simple way to translate text to Braille, Braille editing and printing. ([www.tvi-web.com](http://www.tvi-web.com)).

**Supernova** - is a product from Dolphin specially made for the visually impaired. It has features like screen magnification to increase visibility and speech features to read text, emails, web pages and windows menu items. It also supports refreshable Braille display to help the blind and deaf-blind. ([www.dolphinuk.co.uk](http://www.dolphinuk.co.uk)).

**Magic**– from Freedom Scientific Group. Magic combines magnification features for the low vision users. Magic comes in professional and standard editions packaged with or without speech. It has features like mouse speech (reading the word under mouse pointer), keyboard echo (reading characters while typing) and other features. ([www.freedomscientific.com](http://www.freedomscientific.com)).

**JAWS** from Henter-Joyce is smooth in screen reading and providing output in refreshable Braille. ([www.hj.com](http://www.hj.com)).

**outSPOKEN, inLARGE** from Alva Access Group. outSPOKEN has different versions for Windows and Macintosh. ([www.aagi.com](http://www.aagi.com)).

**ZoomText** – the screen magnification software from Ai Squared. It enlarges, enhances and reads aloud everything on the screen, documents, emails etc. It has two components, viz, magnifier and screen reader. ([www.aisquared.com](http://www.aisquared.com)).

### 10. Inventions on Adaptive Techniques

As we discussed earlier, it’s a great challenge for the inventors to visualize the difficulties of the visually impaired user and design such interfaces which would be helpful to them. If we look at the patent database, the numbers of such patents are very few. Still there are some patents assigned to IBM, Microsoft and other companies, which are great inventions on user interfaces for the visually impaired. We will discuss on six such patents in the following pages.
Evolution of UI for Visually Impaired, by Umakant Mishra

Invention-1: US patent 5223828

Conventionally the message boxes (on software user interfaces) are displayed in a box with options as “yes”, “no” etc. This method is quite convenient for the normal user but does not help the visually impaired. There is a need to enable the visually impaired user to interact with such message boxes.

US patent 5223828 discloses a method of enabling the blind users to handle the message boxes. As per the invention, initially when the message box first appears, the text contents are audibly announced (using TTS or so). Then a homing signal is given by using a tone. The pitch of the homing sound changes according to the distance between the buttons and the mouse pointer. When the mouse pointer moves closer to the options there is an increase in the pitch of the homing sound which gives a feedback to the user whether the pointer is moving closer to or going away from the option buttons. When the pointer moves on to a push button, the caption of the push button is re-announced. Thus the user moves the mouse from button to button to hear the options and finally selects the one desired.

Invention-2: US patent 5287102

The previous invention although helps the blind user to handle a message box, it does not help her to locate other icons on the desktop. There is a need for her to locate different icons on the desktop and visualize their positions on the screen.

US patent 5287102 discloses a method of enabling a blind user to locate icons on a graphical user interface. According to the invention the system will provide audio information about the position of the pointer on the screen. When the pointer is located in the background the system generates one type of sound and when the pointer is on an icon, it generates a different type of sound. When the
pointer is positioned in the background it gives a stereophonic sound to inform about the location of the pointer whether positioned towards the left or right side of the screen. Besides, when the pointer is on an icon positioned in the left side there is more sound from the left speaker and when the pointer is on an icon positioned in the right side there will be more sound from the right speaker. This stereophonic effect helps the user to know the position of icons on the screen.

Invention-3: US patent 5461399

In previous invention the blind user knows about positions of different icons on the desktop. But in case of a GUI environment having multiple windows, the blind user cannot know whether the pointer is on window-1 or on window-2, or the pointer is on an icon in window-1 or is on an icon in window-2. There is a need to develop a method for the blind users to differentiate the icons in one window from another.

US Patent 5461399 discloses a method to solve this problem. The blind user can differentiate the icons of one window from another by hearing the sound associated with the icons. According to the invention, two different sounds will be associated with each object on the screen. The first sound is common among all objects in the class (i.e., same for all icons in a window) but unique among other classes (i.e., different for icons in different windows). The second sound is unique to the object in the class (i.e., different sounds for each individual icon in the window). By listening to their audio signals of the objects the visually impaired user can identify different objects inside the class and distinguish them from the objects in other classes.
Invention-4: US patent 6445364

When the user has a very low vision he can see only the large objects. The conventional GUI does not help him. There are certain mechanisms to enlarge the display on a conventional screen; the enlargement displays only part of the page or object or worksheet and the rest extends beyond the screen. One may go for large monitors or projectors but those are expensive, space consuming and not suitable for individual use.
US Patent 6445364 addresses this problem by inventing a virtual monitor for enlarged display. The invention is a head mounted display, which allows enlarged virtual display of the computer output. The user can move his head to view the desired direction. This enlarged computer output is found to be beneficial for the visually impaired users.

**Invention-5: US patent 6459364**

There are devices for Braille output from a computer in a dot matrix pattern. But the device is not very much suitable for internet browsing. Although the device can organize the output in Braille form, the user cannot quickly view the hyperlinks as he has to serially read through the entire text to find a link of his interest. Besides there should be a mechanism to select hyperlinks to move from one page to other.

US Patent 6459364 solves this problem of browsing by disclosing a internet browser for the visually impaired users. As per the invention the display is provided in the Braille format through a matrix of movable tactile elements. The hyperlinks in the web page are displayed in one side of the screen for easy access, and the normal web page is displayed on the other side of the screen for reading.

The display is made by movable dots on the surface and displays in Braille format. The dots are down when inactive and raised when active. The images can also be displayed in this device by using different patterns of dot matrix. The display includes a touch sensor to detect the pressure of the finger to take input in case of hyperlinks. This is used as a special hardware for browsing World Wide Web.
**Invention-6: US patent 6489951 and 6496182**

A touch sensitive screen displays the information and also receives the input by sensing a user’s touch on the touch sensitive screen. This mechanism is helpful for users having limited sight but does not benefit the users who have completely lost their sight.

US Patent 6489951 and 6496182 discloses a touch sensitive screen which is helpful for users having very limited sights or no sights. When the visually impaired user touches an object, the system announces the text associated with that area through audio output. The touch sensitive screen has two modes, the scroll mode and explore mode. In scroll mode, the user can use a scroll thumb to scroll through a list, in explore mode the user can drag the finger on to a control and lift the finger of the touch sensitive screen.

![Touch Sensitive Screen](image)

**11. Scope for future improvements and inventions**

There is enough scope for improving user interfaces for visually impaired users. Some possible areas of improvements and inventions are as below.

- Magnifying GUls, which includes magnifying fonts and icons in the GUI.
- Dual mode GUls to have normal mode and magnified mode.
- Scalable icons— which can grow bigger or smaller depending on user preference.
- Automatic re-alignment and re-positioning of icons when the size is altered.
• Voice enabled components to build the application. The application built with voice enabled components will be voice enabled.
• Implementing different Language in screen reading and speech recognition.
• Special visual with voice both integrated.
• Using vibrations on the Braille screen for animations, warnings and special events.
• Periodic announcement of computer status, when the user is not interacting for long time.
• Simple Braille input and Braille output computers without conventional display unit.

Let’s hope that the future will see much more inventions on the user interface for visually impaired users. The designers and manufacturers will take the challenge of improving the assistive technology for visually impaired and other users having physical challenge.

12. Summary of Findings

• The number of inventions for visually impaired users is very few. One of the reasons is the difficulty of invention, the other probably commercial viability.
• As the visual capability of the blind users is week or nil, the assistive technologies give more importance on the other two organs, i.e., hearing and touching.
• There is scope for further improvements in assistive technologies. Hopefully, the inventors will take the challenge of reducing the difficulties of the visually impaired users and users having other physical challenge.

Reference:


About the author

After working for more than 18 years in various fields of Information Technology Umakant is currently doing independent research on TRIZ and IT since 2004. He last worked as Director and Chief Technology Officer (2000-2004) in CREAX Information Technologies (Bangalore). Before that he worked as IS/IT manager (1996-2000) for ActionAid India (Bangalore).

Umakant is a Master in Philosophy (MA), Master in Business Administration (MBA), Bachelor in Law and Logic (LLB), Microsoft Certified Systems Engineer (MCSE+I), Certified Novell Engineer (CNE), Master Certified Novell Engineer (MCNE), Certified Intranet Manager (CIM), Certified Internet Professional (CIP), Certified Software Test Manager (CSTM) and holds many other global IT certifications.