



Diagram Translation by Blind Translators

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ABSTRACT

The world population is composed of a large number of people heterogeneous in several dimensions such as age, gender, social class, educational level, political and economic status, abilities and disabilities, and so forth. The dimension of abilities and disabilities has led to formation of various groups of individuals including the group of blind people. Translation is one of the professions maintained by many blind individuals resulting in formation of such a sub-group as blind translators. Blind translators, like other translators, perform different translation-related tasks, one of which is 'diagram translation', the main focus of this paper. This essay investigates different aspects of diagram translation by blind people. Major 'accommodations and assistive technologies' used by blind individuals including screen-readers, speech synthesizers, OCR technology, and Braille devices are the primary points discussed. Basic computerized systems designed exclusively for the purpose of diagram translation by such individuals are the next points covered in this paper. A significant categorization of electronic accessibility devices (based on the media of representation through either haptic or audio) with major innovations in each category are other points mentioned here. The researcher indicates various strong and weak points of these applications and technologies and makes comparisons between them in order to suggest blind translators the best options in accordance with their aims and necessities.

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Introduction

According to Shoemaker (2008), the term 'blindness' has several connotations and is difficult to define precisely. To many people, blindness means complete loss of vision with no remaining perception of light. Far more people have permanent loss of some, but not all, of their eyesight. The severity of vision loss can vary to a large extent and may result in equally varying degrees of functional impairment. "Visual impairment includes both low vision and blindness" (World Health Organization, [WHO] 2006-2011).

Modern world has made it possible for blind and visually impaired individuals to occupy a variety of domains in order to earn their livings. Kirchner and Peterson (as cited in Enerstvedt, 1996) state that blind and low vision individuals are successfully employed at every occupational level, for example, as scientists, engineers, secretaries, and teachers, managers of businesses, laborers, and household workers. However, it should not be forgotten that due to their visual restrictions, these individuals might be limited to specific working circumstances and utilize particular instruments and technologies to decrease the effects of such a deficiency to the least extent possible. One of the occupations used by a large majority of blind people is the profession called translation, meaning to render a text (oral or written), from one language (source language) to a different language (target or receptor language).

Munday (2008) believes that the term translation itself has several meanings: it may refer to the general subject field, the product (the text that has been translated) or the process (the act of producing the translation, otherwise known as translating). The process of translation between two different written languages involves the translator changing an original written text in the original verbal language into a written text in a different verbal language. If we look at a general dictionary, we find the following definition of the term translation:

Translation n. 1 the act or an instance of translating. 2 a written or spoken expression of the meaning of a word, speech, book, etc. in another language. (The Concise Oxford English Dictionary)

According to Hatim and Munday (2004), the first of these two senses refers to translation as a process, the second as a product. This immediately means that the term translation encompasses very distinct perspectives. The first sense focuses on the role of the translator in taking the original or source text and turning it into a text in another language (the target text). The second sense focuses on the concrete translation product produced by the translator. This distinction is drawn out by the definition in the specialist Dictionary of Translation Studies (as cited in Hatim & Munday, 2004):

Translation An incredibly broad notion that can be understood in many different ways. For example, one may talk of translation as a process or a product, and identify such sub-types as literary translation, technical translation, subtitling and machine translation; moreover, while more typically it just refers to the transfer of written texts, the term sometimes also includes interpreting.

Translation can be viewed as a process of movement from the source text to the receptor text. A text does not consist of just words and sentences. An author may mention the content of the text in a nonverbal manner and use beside words such other elements as tables, pictures, figures, etc. A very common nonverbal tool used by many authors in their corresponding works is the element known as 'diagram'.

Bennett (1999) says that there are a vast number of diagrams and types of diagrams in use in the world. But what exactly is a diagram, as opposed to a picture, written language, or some other method of communication? Diagrams can be seen as one part of the continuum of external representations that are typically accessed by sight. While it is hard to define precisely

what a diagram is, we can distinguish between diagram, pictures and sentence based written language. Diagrams come from the world of science and primarily attempt to convey information. Pictures, on the other hand, are part of the art world, primarily aim to invoke some emotion in a viewer. There may be diagrams that invoke emotion, or pictures that convey information, but it is the primary aim that is of interest.

The difference between sentential forms and diagrams is their physical natures. Larkin and Simon (as cited in Bennett, 1999) make the distinction by saying that:

“A data structure in which elements appear in a single sequence is what we will call a sentential representation. A data structure in which information is indexed by two-dimensional location is what we call a diagrammatic representation.”

According to Bennet (1999), several systems have been produced that attempt to present diagrams to blind people, and have met some of the criteria that the developers and testers have set themselves. There are a large number of external representations of information, and all rely on one or more of the human's senses: sight, hearing, touch, smell and taste. The term ‘blind’ means those people who do not have any useful sight. For these blind people there is a reliance on touch (tactile access), or hearing (auditory access).

There is an already established method of presenting diagrams to blind people, as mentioned by Bennett (1999), by using a haptic, or touch based, interface. Diagrammatic material may be produced with textured or raised areas to represent the diagram features. Tactile representations suffer from the semi-permanence of their nature. They are not easily modifiable when changes are made to the diagram and a new version often has to be produced. Many types often wear poorly if used often and can cost highly to produce.

De Beni and Cornoldi (as cited in Bennett, 1999) looked at imagery restrictions among blind people, and in particular congenitally blind individuals. They worked with words that they classified as having high or low visual imagery associated with them. The highly visual words were further characterized as being those that a congenitally blind person would have had direct experience of or not. Examples of the former are things such as ball or cat, while of the latter, sky and elephant. It was found that blind people performed less well than sighted people did when they were asked to create and recall complex images involving many parts. There was no difference when the participants in their experiments were asked to create and recall bizarre combinations of words. Neither was there any significant difference with the use of highly visual words of which a blind person would have had no direct experience. This may influence the complexity of diagrammatic images presentable to blind people.

There are many challenges that come with being a blind person. For those who have congenital blindness or blindness from a very young age, it can be very difficult to imagine objects and scenery in their mind, such as a sunset, or even a dog (Cataruzolo, 2009). This essay examines different solutions and systems designed to contribute to a blind individual for the purpose of diagram translation. It starts with introducing the reader some of accessibility tools and assistive technologies created for blind individuals up to the present time. Next, the role of computer and its contributions to the task of diagram translation are discussed. Finally, representation and translation of diagrams through two media (tactile sense and sounds) are examined and various systems designed to meet these two intentions are mentioned. All these information are rendered in the part ‘Review of Related Literature’. (See section2)

The last part of the paper involves researcher's ideas and viewpoints regarding the accessible accommodations and assistive technologies designed for blind individuals and his opinion about the role played by computer in the task of diagram translation by this group of translators. Some significant points about different systems, either through tactile representation or sounds, and their corresponding strengths and weaknesses are discussed in this part. Finally, the researcher makes a comparison between these systems, indicates each system's priorities over the others, and gives some suggestive opinions in order to provide better opportunities for blind translators in this area.

Statement of the Problem

Translators should take into account any format, including verbal through words and sentences and nonverbal via tables, pictures, figures, etc., which authors may use in order to communicate with the audience in their works. Diagram is a very typical nonverbal form of representing information used in various text genres. The major problem examined in this essay is the way a blind translator reads content of a diagram and translates it into a second language. The researcher investigates different instruments and technologies designed to help a blind individual to read and translate diagrams. What role computer plays in these procedures and what applications may be helpful to a blind translator for such purposes are some other points discussed here.

Significance of the Study

Translation by a blind individual, by itself, is a newly discussed subject. It is possible to diverge such a new topic into several areas and subtopics for further investigations. One of them is ‘translation of diagrams’. Thus, it can be concluded that this topic is very new subject and unlikely to have already been discussed.

A blind translator may need particular information about a diagram such as the number of its columns and rows or its location in the page in order to translate. This paper mentions some of such necessities. It would be helpful for software designers to get familiar with such requirements so that they could design more appropriate applications for blind translators. This would also contribute to solve a number of their difficulties. As a result, the researcher can claim that reading this paper can be useful for both blind translators and software designers.

Some translators may suppose that diagrams are not important and they may easily ignore to translate them. Such a wrong viewpoint may be more common among blind translators. They may regard it impossible for a blind individual to read and translate diagrams due to their visual nature. The researcher suggests such individuals to read this essay as it may change their ideas about such elements and their translation.

Finally, it can be said that this paper may lead to new works and debates among translation scholars. It has already been pointed out that translation by a blind individual is a new and to some extent unique subject. This new subject can be reduced to other subtopics, one of which is ‘translation of diagrams by blind translators’. So, rendering such a topic can provide scholars and researchers with a new subject to write about. Consequently, reading this essay can lead to publication of several books and essays discussing it and other related issues.

Research Questions

Q1. Is it possible for blind individuals to translate the diagrams drawn in a source text?

Q2. What role does computer play in the translation of diagrams by blind translators?

Q3. Which applications and technologies have been designed to facilitate translation of diagrams for blind translators?

Research Hypotheses

H1. Blind individuals are able to translate diagrams by using accessibility devices and assistive technologies.

H2. Like other professions and fields of study, computer usage for blind translators means higher speed, improvement in quality, saving time and energy, better economy, ease of performance and more enjoying tasks. Thus, it's wrong and illogical to deny the notable role computer plays in all areas including diagram translation.

H3. Screen-readers, speech synthesizers, OCR technology, and Braille and Braille translation devices are primary suggestions to blind translators in order to perform their tasks including diagram translation. In a larger domain, there are such systems as GUIB (in Microsoft Windows system) and the Mercator system (in X-Windows system), Kennel's AudioGraf (1996) and Rigas' AudioGraph (1997).

Limitations of the Study

The topic of this paper is a newly discussed and to some extent unique topic. There exist little works exclusively devoted to such a topic as 'translation of diagrams by blind translators'. This would impose restrictions on the investigator to prepare the crucial part of the paper named 'references'.

Any written document consists of different parts including title and subtitles, introduction, acknowledgements, the main body, concluding parts, references and bibliography, etc., each with particular translation rules and conventions. Each of them may impose numerous challenges upon a blind translator. Lack of time and space does not allow the researcher to examine all these parts and conventions of their translation. So, he has to restrict his scope to translation of diagrams.

Another major limitation of this research is its obligation to ignore oral translation. A famous dichotomy in the literature of Translation Studies is the distinction made between written and oral translation (interpretation). Oral translation has many dimensions and challenges for blind translators which are worthy of study. However, the researcher cannot expand the scope of his investigations to oral translation since diagrams normally play no role in this area.

Last but not least, the researcher might be accused of being biased. The researcher himself is a visually impaired student of translation studies. This may lead some of the readers of his paper to suppose that he has most often tried to make conclusions satisfying blind translators. This restriction is a challenging issue, as it might lead some individuals to ignore it and to decide not to study his paper carefully.

Review of Related Literature

Introduction

Clisby et al. (2000) define vision impairment as having 20/40 or worse vision in the better eye even with eyeglasses. They believe that people with the least degree of vision impairment may still face challenges in everyday life. According to Clisby et al. (2000), we must be aware of our own personal risk of vision loss and make any effort to preserve our precious eyesight. Our communities must be informed to prepare the treatment and rehabilitation services that will be needed. Most important, our nation's leaders must comprehend the scope of eye problems so that adequate government resources can be devoted to research, treatment and prevention. "It is important that societies be made aware of known, well-tested, cost-effective interventions for preventing avoidable visual loss" (WHO, 2006).

According to WHO (2006), blindness has profound human and socioeconomic consequences in every society. The economic effects of visual impairment are divided into direct and indirect costs. The direct costs are those of the treatment of eye diseases, including the relevant proportions of costs for running medical and allied health services, pharmaceuticals, research and administration. The indirect costs include lost earnings of visually impaired people and their caregivers and costs for visual aids, equipment, home modifications, rehabilitation, welfare payments, lost taxation revenue and the pain, suffering and premature death that can result from visual impairment. Poverty underlies not only the causes but also the perpetuation of ill health, including eye health, and thus the health status of a population and its socioeconomic conditions are correlated. Poverty additionally imposes barriers to access to health care.

Possible Accommodations and Assistive Technologies

If you have visual problems, there is a wide range of specialist equipment and household items available to help. These include clocks and watches with large numbers, big button telephones, and large print books and calendars (retrieved from www.stroke.org.uk). There are literally hundreds of assistive technology devices for people with low vision and blindness:

cassette tape recorder; talking clocks, calculators, timers, etc.; a Qualified Reader: a person familiar with any job-related technical language who can read material for the individual; personal Braille computer printer or Braille service (if the person uses Braille); a computer with text-to-speech software (screen readers) or screen enlarger software; PDA (personal digital assistant, a handheld computer organizer) with speech or Braille output; adjustable lighting intensity and a variety of possible light sources (different sources can be different colors: sunlight, fluorescent, incandescent, etc. and each person with low vision will have their own preferences for color and intensity); adjustable source lighting, such as gooseneck lamps or clip-on lamps; pocket flashlight; magnifying lenses; clocks, telephones, calculators, etc. with large numbers, buttons, and displays; prescriptive sunglasses ('Absorptive lenses'); photocopier with enlargement feature; writing tablets with bold lines or raised lines; boldly colored tape to mark edges of steps, edges of desks, etc.; tape or strips of different textures for tactile marking; large print or Braille labels to go on drawers, folders, bookcases, etc.; visor to block out glare from sky; no reflective desktops or other surfaces; talking money identifier or talking cash register; telephone light sensor: monitors face of telephone and vibrates if a line is lit or flashing; low vision assessment, if individual is not familiar with the various low vision aid options. Screen readers are software applications that are installed on the computer to provide translation of the information on the computer screen to an audio output format. The translation is passed to the speech synthesizer and the words are spoken aloud. Screen access programs (screen readers) speak aloud what's on a computer screen, including desktop icon labels, document contents, and drop-down and tool bar menu items. They also speak each keystroke, provide auditory cues (like the ping indicating the cursor is in a search field), and an audible hierarchy for navigating within and among applications. Another screen access solution is CDesk, which combines screen reading, scanning, and magnification in one Windows-based application (retrieved from www.tldp.org/HOWTO/Accessibility-HOWTO/visual.html).

Speech synthesizer can be a hardware device or text to speech (TTS) software application that creates the sounds

necessary to provide speech output. (They can be divided into hardware and software speech synthesizers). A hardware speech synthesizer is connected to the computer's serial or parallel port and translates the text to a spoken output. Normally there are Braille labels on all controls to indicate the off and on position, and volume controls. Hardware synthesizers also have the ability to speak in different tones that can be setup to indicate various parts of a document or text. Some models will provide a connection for headphones. A software speech synthesizer is an application that translates the text on the screen to speech output and provides speech synthesis, so that the screen reader application can read information out loud to the user (retrieved from

www.assistivetechology.about.com/od/ATCAT1/a/Computer-Resource-List-For-Blind-And-Visually-Impaired.htm).

Screen readers read stored documents and web pages. But students have to read many things that are not on their computers. These include book chapters, articles, and class handouts. Optical Character Recognition (OCR) scans and converts printed words into electronic text that students can read and edit. Some OCR products require flatbed scanners to capture text and use software to convert the scanned images. Other products use cameras that are connected to the computer. Some products, like the popular Kurzweil 1000 support both options. People who want to read things but do not need or want a computer can use reading machines that use OCR to convert text to speech (retrieved from www.sites.allegheeny.edu/disabilityservices/students-who-are-blind-or-have-a-visual-impairment).

Braille terminals are normally used by individuals who are totally blind and may be hearing impaired as well. A Braille display uses a series of pins to form Braille symbols that are continuously updated as the user changes focus. A Braille embosser is a hardware device for printing a hard copy of a text document in Braille (retrieved from www.accesson.ca).

Braille translation software is required to translate the on-screen text to a Braille format. Braille translation software converts electronic files into Braille that can be read on a refreshable display or printed on a Braille embosser. Though many screen access programs offer Braille output, there are programs designed for specialized notation such as music. There is also disparity in how well programs format such things as captions, tables, and graphs (retrieved from www.tsbvi.edu/resources/1074-overview-of-technology-for-visually-impaired-and-blind-students).

Diagram Designation and Representation

According to Bennett (1999), a large number of the differences in the Cognitive Dimensions between Visual Programming Languages and sentential programming languages can be used to highlight information pertinent to our use in presenting auditory representations of diagrammatic forms. Most of diagrams will start as being conceived wholly as visual constructs. Bennet indicates that the process of diagram design and how translation fits into this must be considered so that blind people could access diagrams.

As mentioned by Bennett (1999), a software engineer who uses the Representation Design to create diagrams that describe the software in production would be a Designer of a Diagram, and is also referred to as a Diagram Designer, and each diagram that is produced in this way would be an Instance of the Representation. The rest of the team that the software engineer works in are likely to use these diagrams.

Bennet (1999) says that if there is a desire for the Blind and sighted readers to be able to have a dialogue, there must be an

equivalence between aspects of the diagrams produced using the original Representation Design and the Translation Design. Hence, both parties must have a shared language with which to talk about the diagram in question. This language is at the detail level of the diagram. The depth to which this shared language reaches will be dependent on the type of conversation that the two readers are required to have.

For instance, it may be sufficient for parties to be able to talk about links between elements, in which case it would be sufficient for the diagrams to simply use the same labels and have a similar language for describing the links. However, both parties may wish to be able to talk about groupings of elements and relative positions of these. In this latter case, it would be insufficient for the translation to have different structure of arranging the groups with no way for the parties to translate rapidly between the two. If the sighted reader talks about a group being to the right of another, but the blind reader is only able to refer to a group being a sub-group of a different one, there would be insufficient common language for the co-operation.

However, as discussed by Bennett (1999), the likely situation, in terms of making information available to blind people, is that there is little dialogue between designers of the visual parts of the process and those involved in the translation process. While it might be advantageous if dialogue were to occur, or for the designer of the Representation, or Designer of the Diagram to consider the Reader Capabilities of a blind reader, there is little doubt that this happens only rarely.

Having considered the general process of translation, according to Bennett (1999), the factors that influence the quality of the translation should be taken into account. The quality can be affected by both stages of the translation: both at the Design of the Translation and the Individual Translation. Two dimensions are considered in more depth: the effect of the expertise in the domain of the representation and the effect of expertise in translation. This is done while also taking into consideration the expertise of the blind reader who will use the translation.

As indicated by Bennett (1999), the Designer of a particular instance of a diagram will create certain types of information during the design process. These are then available to a Designer of an Individual Translation, who will use this information to produce a form usable by the blind reader. Many diagram forms are not entirely novel, but are based around some already well-known convention. For instance, trees, flow diagrams and matrices are all common types of diagram system. Learning the underlying principles of how the information is organized in such systems allows information from any domain to be extracted with little or no learning of the system. In these systems, information is typically organized with a flow from top to bottom or left to right (in western culture).

Computer Usage and Diagram Representation

As mentioned by Bennett (1999), computers are tools that are now accessible, to a certain extent, by blind people. Computer usage by blind individuals has been a great enabling technology for them. While it has not always been so, most recent history of computing has included access through typewriter-like keyboards and a video terminal. In order to enable access to the information presented on the visual terminal, another medium is utilized to present the information to blind people. When computer programs were based around a purely text-based display, Bennett points out that the translation of this into another medium for blind people was at one level, remarkably easy, but at another extremely hard.

It was easy, as the vast majority of what was of interest to the blind user was text based and could be easily translated into either Braille directly, or into synthesized speech, using screen readers. However, it was difficult as soon as the interaction went outside the normal command line interface style, there were few organizing principles that allowed the screen reader to work easily and fluently with the many different applications produced.

The challenge came with the rise of increased use of graphical forms in the interface. One of the first people to look at this area was Edwards, as cited in Bennett (1999), with his work on graphically based interfaces using sound feedback. This used the exemplar of a graphically based word processing system, Soundtrack. With the introduction and wide acceptance of the Graphical User Interface (GUI) by sighted people, blind individuals found it impossible to use this new technology for a period of time. It took time for screen reader developers to catch up and to enable blind people to use this method of interaction. Computer usage in the 1990s, as discussed by Bennett (1999), has been typified by the use of the GUI. Two such systems are the Microsoft Windows system and the X-Windows system. These have both been made accessible to blind people using different screen reading applications. There are numerous systems that work in the Microsoft Windows environment, and these can be typified by the GUIB project, while the X Windows system has been adapted by the Mercator project.

The GUIB system tries to present the interface using a model of the screen that is presented to a sighted person. In other words, it uses a simple mapping, attempting to represent the physical structures that appear on the screen. It does this by creating two separate models of the display: an on-screen model which attempts to translate the pixels into the items that they represent, and an off-screen model which attempts to model the logical structure of these. It is the on-screen model which is represented in the dynamic Braille display, with assistance in providing functionality to the user (Bennett, 1999).

The Mercator system uses a different system, which represents only the logical structure of information and removes the concepts of GUIs, non-relevant to a blind user, such as overlapping windows. In many ways, the information in the interface is denser, in that every node of the tree structure which is used to represent the interface has information at it. The ordering of the objects in the tree is according to the hierarchy of X`widgets` (or parts) that make up the interface. However, this is not necessarily the same order as a sighted user would perceive them on-screen, though it should be for well designed software (Bennett, 1999).

Mynatt and Weber (as cited in Bennett, 1999) identifies four design issues for translating GUIs:

- Coherence between visual and non-visual interfaces
- Exploration in a nonvisual interface
- Conveying graphical information in a nonvisual interface
- Interaction in a nonvisual interface.

Accessibility through Tactile Representations

Bennet (1999) has mentioned a number of different systems available to create static tactile representations. Brulé (as cited in Bennett, 1999) summarized some of these in his paper on his own particular workstation. He talks about different methods of production, each with advantages and disadvantages. Each has its own features in terms of resolution of lines, ability to present different heights of lines and ability to reproduce textures.

Bennet (1999) named a number of different systems produced to represent visual information in a dynamic manner. That is to say, they are capable of being updated, without re-

production of the material. Most are based around arrays of pins that are individually moved into one of two positions: down, where they are hidden from touch by a grid; and up, where they may be felt by fingertip. There are engineering difficulties with producing these pin grids. Large grids are not able to be reliably produced and cost is high and update is relatively slow, in the order of a second for a grid that displays forty Braille characters. Orlosky and Gilden present a system to simulate the ability to present a 'full (computer) screen' of Braille (Orlosky & Gilden, 1992, as cited in Bennett, 1999). This system presents a method of having a single-line, dynamic Braille display mounted on a 'track' so that it may be moved up and down. The position that the display is vertically on its 'track' is fed back to the computer so that the pins of the display can reflect what would appear at that position.

Accessibility through Sounds

Sound in the computer interface has been looked at for a period, and it is probably Gaver's SonicFinder, (as mentioned by Bennett, 1999), that is the first striking example of this being used in a fashion noticed by many people. Sonic Finder was interesting as it went beyond the simple 'beep' to try to convey more than the auditory equivalent of an exclamation mark. Gaver was not the first person to use sound in this way, according to Bennett (1999), but it has been seen as significant as being a principled introduction of sound into the interface.

Bennet (1999) talks about Gaver's distinction between sound and vision. According to Gaver, while sound exists in time and over space, vision exists in space and over time. By this he means that sound is inherently transitory, it is often the case that the beginning and end of a sound is experienced by a listener, and also can be heard when the source is not visible; while objects need to be visible to be available for repeated sampling. Sound can present information when visual access is not possible, or is undesirable, and vision can present information that requires access over time.

"AudioGraf is a computer, sound and touch-pad based system" (Kennel, 1996, as cited in Bennett, 1999). The system, as described by Bennet (1999), takes a relatively direct approach to diagram translation. Diagrams in the AudioGraf world are split into a hierarchy of graphic elements: Frames, Text and Connections. These elements are modeled with a direct mapping from original diagram to a location on the touch-pad. Therefore, an element that appeared in the top-left of the diagram would be located so that it would be described by the user pressing the touch-pad in the top-left. Descriptions are in synthetic speech and non-speech sounds.

Bennett (1999) says that the AudioGraf system supports several different views of the diagram. The first view is called 'counter', which is designed to enable search and localization of elements in the diagram. This mode displays the number of items under the user's finger. The other modes described by Kennel, as pointed by Bennett (1999), are 'element', 'attribute' and 'links'. The element view is accessed by greater pressure on the touch-pad and gives greater information about the elements, while the attribute mode gives the greatest amount of information about the element. The links mode is used to optionally give information about the links on the diagram incident on the element under the cursor. The links have to be set up manually by the diagram designer.

As discussed by Bennett (1999), with technology existing at the time of production of AudioGraf it was not possible to determine whether the user was pressing to indicate a very precise location or a more general area, so the system used the idea of a cursor of user-variable size. When a user pressed on a

part of the touch-pad, all the information that was under cursor was vocalized, a large cursor would give information about a larger area, centered at the touch point, while a smaller cursor gave information from a smaller area.

While similar in name to Kennel's AudioGraf, Rigas' AudioGraph (Rigas and Alty, 1997, as cited in Bennett, 1999) is a very different system. Audiograph is a system based on sonification of drawn diagrams converted into bitmap images. Rather than exploration by a user using some kind of focus or cursor to control what information they heard, scanning was performed by the system according to some pre-determined system.

Bennett (1999) points out that before discussing how Rigas presents diagrams, it is useful to understand how he represents position. This is done by translating the space to be represented into a grid of discrete locations. Each of these locations can be represented by their x and y co-ordinates. The co-ordinates are then translated from their numerical form into a musical form. Rigas (as discussed by Bennett, 1999), investigated three different methods for his Doctoral thesis: single notes, note pairs and notes sequence. The single note system presented the single note alone that represented how far along the axis the co-ordinate was, without reference to any other note in the system. The note pair played both the base note and the note of interest. The note sequence used scales of notes, playing this and then in order all the notes between this and the target note followed by the target note. Different instruments were utilized for the x and y axes. It was found that the note sequence method was most successful in terms of accuracy and this was extended to be used in the Audiograph system.

Rigas' quite extensive testing on both his method of presenting position and the use of Audiograph was discussed by Bennett (1999). The results were encouraging. Using the note-sequence method, simple co-ordinates were successfully understood and errors were rarely worse than ± 4 in either co-ordinate on a 40 by 40 grid. Participants with minimal training understood simple shapes, such as circles, lines and rectangles, in about 50-60% of the time. With training, most simple shapes were understood. The system also allowed users to recognize shapes that they had not been trained on previously.

Rigas, mentioned by Bennett (1999), agrees that three limitations have become known in his testing:

1. Listening to a reasonably complex diagram can take some time;
2. The support for communicating relations between objects is poor;
3. Memorability for large non-meaningful graphical spaces is low.

Bennet (1999) points out that it was with presentation of more complex shapes that the system seemed to suffer. Rigas tried to present simple images of items such as cars. In these cases few, if any of the participants could identify the subject of the diagram. Recognition improved enormously when the subject area of the diagram was given to the participant (e.g. method of transport). This raises questions as the extensibility of this method and what problems it would be possible for this method to be useful for. It would seem that the method is best suited to simple diagrams of a relatively small scale. Examples in the computer domain might be icons or for use for describing simple clip-art.

Presentation of position, as indicated by Bennett (1999), was limited in Rigas' work to a 40 by 40 grid. While in sound this is a large space, it would still be too crude to represent the locations of items much smaller than an icon on a modern

computer screen. There are restrictions to human perception of sound and music as how far this method could be extended to provide greater resolution. However, it does present a seemingly intuitive and simple method of presenting position on the scale indicated.

Discussions and Conclusions

Discussions

Starting to read this part, the readers are suggested to review part 2. In order to prepare this part, the researcher read the previous part several times. He studied each sub-section, mentioned his beliefs and viewpoints about each one, investigated the various assistive technologies and the systems suggested for diagram representation one by one, indicated the strong and weak points of each system, and made concluding points to answer research questions and support his hypotheses. These are all mentioned in the following paragraphs.

Introduction

Eyesight and its health are precious properties possessed by a large majority of people. An exception to such a large majority is blind population, by itself, a large sub-group. An additional sub-group of blind population is the group called 'blind translators.' Such individuals perform a variety of translation tasks, one of which is translation of diagrams.

Blind individuals should use particular instruments and technologies to perform their tasks including the task of diagram translation. Besides the treatment and rehabilitation services and government resources for research, treatment and prevention, it is upon the communities and nations' leaders to be aware of such translators and their necessities for such a task and to attempt as much as possible to provide these necessities. The costs of designing and distributing these facilities fall into the second category of the economic effects of visual impairment (indirect costs). (See 2.1)

Possible Accommodations and Assistive Technologies

The fact that there exists a wide range of specialist equipment and household items available to help blind people is a promising fact for such individuals. This means that various organizations and institutions pay to blind people and their concerns and requirements and design several instruments and technologies to satisfy their necessities. These assistive technologies are not only limited to such household and daily living cases as clocks and watches with large buttons, talking calculators, pocket flashlight, visor, etc., but also include accessible devices and applications designed to perform professional and job-related activities like personal Braille computer printer or Braille service, text-to-speech and screen enlarger software, photocopier with enlargement features, and many other instances. A large number of these and other accessible instruments and assistive technologies can be used by blind individuals in different ways for the purpose of diagram translation which is the main focus of this paper.

The first step for a blind individual to translate a diagram is to read the diagram and to receive such information as the number of its columns and rows and its content. He may even need to know its location in the source text. The first solution sounds to be to ask a qualified person (if available) or any other sighted individual to give him these information. He can also ask the client or anyone else to record this information on a tape or CD and give it to him. However, the problem is not so easy to be solved. There may be no sighted individual available to the blind translator to provide such information. Using recorded data on a tape or CD necessitates particular devices and listening to them and keeping the receiving data in mind take a period, each can be challenging for him. Asking the client to provide such

information has its own consequences and may cause the client to change his translator and prefer a sighted one.

Screen readers are another good suggestion for blind translators for the purpose of diagram translation. Blind people can use screen readers to read the content of electronic documents including diagrams beside words and sentences. Screen access programs are mostly designed in such a way that allow the users to navigate on diagrams column by column and row by row. By each keystroke, diagram's cell and its content is vocalized and the blind user will be able to render columns and rows one by one in the receptor language. These points are also true for speech synthesizers (either hardware or software).

Diagrams may have been drawn in non-electronic materials. Blind translators require to be able to access different document formats, from printed to electronic ones. The technology of Optical Character Recognition (OCR) is a very useful device for such a purpose. The blind individual can scan the printed material, convert the image into an electronic format and read it using screen readers and speech synthesizers. This opportunity involves reading diagrams drawn in the source text.

The Braille dimension of assistive accommodations and technologies is the dimension at which few cases of use in the area of diagram translation may be observed. This is so because firstly, Braille is known by individuals suffering from visual deficiencies. There are very few people sighted to be able to use this system. On the other hand, representation of visual elements including diagrams in an accessible way is the main weakness of Braille terminals, Braille embossers, and Braille translation software.

Diagram Designation and Representation

The researcher believes that the first step in the process of diagram translation is to agree that representation of such visual constructs as diagrams in an accessible format is a possible task. A blind individual who decides to translate a document must be prepared to face its content in any shape, either sentential or diagrammatic. Modern world and its progress have made it possible for blind translators to access visual elements including diagrams in both source and receptor languages.

It has already been pointed out that it would be helpful for blind people to have some dialogue with sighted individuals regarding the representation and translation of diagrams. Although such a situation rarely occurs, many people including blind individuals themselves, diagram designers, sighted people, government officials, etc., can contribute to enhance the possibility of such an opportunity. The individuals responsible for diagram designation would act better if they were aware of blind people's needs related to different parts of diagrams. Hence, it is suggested that diagram designation and representation teams involve a blind individual among their members. This blind member can contribute to the team to make diagrams and their parts in accessible formats.

The fact that many diagrams are designed based on some previously determined conventions is a very noteworthy issue. Such a less amount of novelty can be used to create some molds and insert the data into them to make diagrams accessible to blind individuals. As a result, less amount of time and energy should be spent to make diagrams accessible for blind people. This low level of novelty can also be useful during the task of translation as the blind translator spends less time to identify different parts of the diagram and therefore, can save in his time to complete the target text and deliver the client.

Computer Usage and Diagram Representation

It is impossible to ignore the crucial role played by computer in the modern world and present day. No job and

profession can be found in which computer usage exhibits higher speed of performance, less amount of cost, more comfortable action, and more enjoyable task. Computer is an essential tool for translation and more essential for blind translators. This is also true in the case of diagram translation.

The textual aspect of diagrams is the easiest one for the task of translation. The words and phrases mentioned in each cell can be translated, either word-for-word or in a content-based way, and the results be located in the corresponding cells in the target diagram. However, the difficult dimension (to have organizing principles allowing screen access software to work easily and fluently with different newly-produced applications) and such visual constructs as GUI should also be taken into account by diagram and software designers.

Two strengths can be attached to the GUIB system used by Microsoft Windows system. Presenting the interface by using a model of the screen presented to sighted individuals may help the blind individual feel less distinction and divorce from other individuals and grant him more self-confidence. Using the same model of interface presentation also contributes to blind people to get familiar with the same elements as used by sighted individuals. Such an opportunity would increase the possibility of dialogue between blind and sighted individuals, (the problem discussed in section 2.3).

Representing the logical structure of information and removing the concepts of GUIs irrelevant to blind users can be considered as a strength for the Mercator system. This would decrease the amount of time a blind individual must spend for the task of translation since there exists no overlapping and redundant element to be translated. On the other hand, removal of overlapping windows may lead to loss of some information considered not important by the system but significant for the translator. So, it is questionable whether the overlapping windows removed contain crucial information or not.

The four design issues related to GUIs translation which have been identified by Mynatt and Weber are noteworthy. The Mercator system sounds to convey graphical information in a more suitable manner and possess better options for exploration and interaction in a nonvisual interface. The reason for such a claim is its representation of the logical structure of information. The GUIB system utilized in Microsoft Windows system, on the other hand, is supposed to have higher coherence between visual and nonvisual interface. This is so because in this system, the information is represented as it is done for sighted people. It can be concluded that the same representation is rendered to both groups and thus the two are coherent with each other.

The Attempts for the Accessibility of Diagrams Through Tactile Representations

Dynamic representation of visual information which is based on the tactile sense of the blind individual can be regarded a very typical and useful system to make information accessible for touching ability, unlike auditory, visual, and other senses, is possessed by all people. It is not restricted to a specific group of blind individuals. This is the main advantage of such systems. In addition to typicality, their capacity to be used in any location and at any time contribute to the independence of blind people. They have some disadvantages including engineering difficulties to produce pin grids, high cost, and slow update.

The Attempts for the Accessibility of Diagrams through Sounds

Sound and vision are two separate media through which human perceives and analyzes the world around himself. Although smell, taste and touch are the other senses used by human to perceive the world, there's no doubt that most of the

connections between human's mind and his environment are established via visual and auditory channels. These two work in separation but their activities and tasks are highly related to each other. As mentioned by Gaver, sound is by nature transitory, its beginning and ending more sensible, capable of being heard while the object is not visible, and can be utilized with no need to visual access. On the opposite side, visual elements exist over time, can be observed with their whole parts, and are conditioned by the presence of the object. The only similar point between them, as indicated by Gaver, is their independence from each other in the case of being present.

AudioGraf system can, to a large extent, contribute to blind individuals to study the diagrams used in an electronic document. When the blind user touches various locations on the touch-pad and receives some information about the object in its corresponding location in the source diagram, the same feeling as that a sighted person observing the diagram would be simulated for him. The user may also need different amount of information about the diagram and its content based on his time, purpose and requirements. The modes 'element', 'attribute', and 'links' are suitable options for the user for this intention. The cursor size (large or small) is another option for the user to determine the amount of receiving information needed.

The distinction in their spellings ('f' for Kennel's system and 'ph' for the system designed by Rigas and Alty) helps others not to be confused with these homophones. In addition to spelling, they differ in two other aspects. Diagrams in AudioGraf are split into some elements where numerous differences are seen between the original diagram and the second one. In AudioGraph, on the other hand, less changes are made in the original diagram, for bitmap images used in them are the same as the source diagrams. The second difference lies in the fact that AudioGraph users, as already was mentioned, have less control over the system, while AudioGraf users have more control by using some kind of focus or cursor to determine the amount of receiving information.

Translation of spaces into a grid of discrete locations, representation of each location by its x and y co-ordinate, and their subsequent translation from numerical into musical form is a three stage process which should be investigated from the viewpoint of its time dimension. Translators must examine how long it takes for the system to perform this process and determine if this process is finished before the deadline given for the target text to be delivered.

The three limitations found by Rigas should also be taken into account. Although it may be time-consuming to listen to a complex diagram, this limitation does not sound too problematic for blind individuals mostly possessing high auditory ability. The second limitation is more noteworthy as translation, by its nature, pays a high attention to relationships between objects. The third limitation is even more significant to be taken into account. Such a limitation can make translation a difficult task for the blind individual as he has to firstly revise the original diagram and delete its extraneous graphical spaces and then translates it if possible. The inability to present more complex shapes and its restriction to diagrams of small scale and presentation of position equal to 40 by 40 grid are other limitations already discovered for Rigas' work.

Conclusions

Blind population has always existed, does exist now, and will exist at any time in the future. Governments and societies cannot ignore these individuals and must agree them as an inevitable group attached to their communities. Thus, like all other members of society, governments and their officials must

consider their concerns and requirements and make attempts to satisfy them. Planning country's budget, particular resources should be allocated to blind population living in the country and be scheduled to provide the basic accommodation and accessibility technologies necessary for them.

One of the professions favored by many blind people in the world is the profession of translation. Translation is a task which necessitates minimum amount of physical and mechanical skill. Most of its necessities are mental and emotional. Hence, it is no surprise to see that several blind individuals select translation as their profession.

Translation of diagrams is one of the challenging areas of translation for blind individuals. Diagrams are constructs consisting of a number of columns and rows which form several cells. Each cell may contain a word, phrase or sentence, number, sign, picture, etc. Diagrams and their contents contain information which can be crucial to the comprehension of the whole text. No translator, sighted or blind, can pass them without taking into account such visual elements as diagrams, their contents and relationships to the content of the text. The researcher thus concludes that it is important for blind translators to find solutions to read these challenging constructs and transfer their contents to the target text in an appropriate manner.

To read the diagrams drawn in the source text, there are a variety of recommendations to blind people. Most of popular screen-readers distributed around the world are capable of vocalizing diagrams drawn in electronic documents and allowing their users to navigate on them cell by cell. Speech synthesizers (hardware or software application) are other options aiding to meet this purpose. Designers of OCR technology should keep in mind that documents in print format contain both sentential and visual elements including diagrams. Therefore, they must design OCR machines and applications able to scan and convert diagrams and other visual constructs into accessible formats. The highest amount of restriction sounds to be assigned to Braille devices and Braille translation software as it is difficult, almost impossible, for such systems to provide access to diagrams for blind individuals.

A text given to translate can contain any type of content, both verbal and nonverbal language. By nonverbal, the researcher means any kind of visual representation such as figures, tables, pictures, and most importantly, diagrams. The researcher believes that basic methods and principles of translating nonverbal representations must be located in the curriculum of translator training. Blind translators should also be taught to translate such visual constructs as diagrams. This allows blind individuals to be able to accept any type of document to translate and prevent to reject any document having diagrams to be rendered in the receptor language. It also makes them feel no distinction from sighted translators which in turn increases their self-confidence and improves their self-reliance and being independent from sighted people.

It is obvious that translation of constructs and representations already known by blind individuals would be less time-consuming and an easier task. Blind translators should pay attention to the fact of novelty and its influence upon the quality and speed of their action. As a result, it is suggested that diagrams with more conventional designs are given to blind translators. Some marginal information about the structure and representation of diagrams having special constructs is the researcher's recommendation.

The researcher highlights the significance of co-operation between blind and sighted individuals through the representation and translation of diagrams. Such a cooperative action becomes

more prominent in the case of making diagram representation and translation systems. This opportunity would be beneficial to both parties. It will help designers to create more useful systems and not to waste their time producing technologies with extraneous options not essential for blind users. Blind people, on the other hand, will use more powerful assistive technologies by making manufacturing companies and their engineers aware of their basic necessities and requirements.

The significance of dialogue between blind translators and sighted individuals and the necessity of a shared language among them was already discussed (See 2.3.) The researcher believes that blind individuals themselves can contribute to improve such an opportunity. He suggests them to create groups and communities aiming to innovate such a shared language and also, attempting to join engineering teams in order to help them design more accessible diagrams. These groups and communities also, according to the researcher, will make changes in the viewpoint of engineering teams' members and show them how helpful it is to use blind people and their advices in their projects.

It is waste of time and space to talk here about the crucial role played by computer industry in translation field. This is obvious through such terms coined recently as machine translation, CAT (computer-aided translation), TMs (translation memories), parsers and terminology management systems. It is wrong to neglect blind people out of such a world as recent advancements have made computer an accessible device in a majority of aspects for this community.

Regarding the text-based display of computer programs, the researcher points out that drawing a diagram in the target document and inserting the translated items into the corresponding cells may not be as easy as reading the source diagram and its contents. Such a condition would be harder where the source diagram has a large number of cells. In addition to the limitations of existing applications' capacity to permit a blind person to independently draw a diagram, it will be difficult for him to keep in his mind a large number of cells and their corresponding contents to render in the receptor language. The researcher recommends that besides diagram representation, attempts should be made to design applications allowing blind users to design diagrams by themselves. His suggestion for the hard dimension (compatibility with newly-created applications) is to expand the relationships between companies producing and distributing accessibility software and other companies producing computer programs. This would lead to two consequences. First, the former group of companies becomes more quickly aware of newly-produced software and thus, immediately starts designing accessibility applications for them. On the other hand, other companies' familiarity with these individuals and their needs contribute to distribution of computer programs more compatible with their accessibility software.

The GUIB system and the Mercator system already discussed have each specific strengths and weaknesses. It is suggested that blind users determine their priorities before selecting which system to use. The system's capabilities and options should correspond to the user's necessities and selecting a wrong system is equal to waste of time, costs and energy. The strength assigned to each system can be considered as the weakness of the other one and vice versa. Although imaginative, the best system sounds to be the one possessing all the exclusive characteristics of both systems. By this, the researcher means to design a system in which the user has the option to use a representation similar to that of GUIB or a representation like that of Mercator. The user may want to use the logical structure

of the original information and disregard the overlapping windows (Mercator) or may wish to utilize the same structure as that used by sighted individuals (GUIB). The researcher recommends computer companies to attempt to produce a system having both options.

The four design issues mentioned by Mynatt and Weber are noteworthy and should be considered in producing GUI translation systems. Like the previous paragraph, the researcher believes that production of a system in which all these factors have been taken into account will promise maximum quality in performance by the user. More than the system designers, the blind users are paid attention to where the researcher advises them to determine their priorities and necessities according to which the best system is chosen. If high coherence between the visual and nonvisual representations is significant, users are proposed to utilize the GUIB system. On the other hand, the Mercator system is recommended to those users who assign more priority to interaction, exploration and conveying nongraphic information. There is no doubt that the operating system used by the individual (Microsoft Windows or X Windows system) is another factor to choose GUIs translation system.

Systems and devices in which human's visual and auditory senses are involved mostly necessitate electricity to function. Electrical devices are used in artificial environments where particular equipments have already been provided for them to function. Those devices which work using batteries are vulnerable to be overcharged. Rare are such opportunities for tactile devices which are mostly mechanical rather than electrical. As a result, the researcher suggests blind individuals to select their accessibility instrument according to the location where such devices are utilized and its electrical equipments.

Kennel's AudioGraf (1996) and AudioGraph designed by Rigas and Alty (1997) are two other choices provided to assist blind translators for the purpose of diagram translation. Each has employed particular techniques and possesses specific characteristics which should be kept in mind by the user in order to make the best choice. Once again, the researcher recommends the users to review strong and weak points of both systems, compare them in all dimensions related to their requirements and finally, select the system by which they meet their goals as much as possible.

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