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A Bi-directional Bi-Lingual Translation Braille-Text System

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Abstract. Visually impaired people are an integral part of the society. However, their disabilities have made them to have less access to computers, the Internet, and high quality educational software than the people with clear vision. Consequently, they have not been able to improve on their own knowledge, and have significant influence and impact on the economic, commercial, and educational ventures in the society. One way to narrow this widening gap and see a reversal of this trend is to develop a system, within their economic reach, and which will empower them to communicate freely and widely using the Internet or any other information infrastructure. Over time, the Braille system has been used by the visually impaired for communication and contact with the outside world. Translation between one language and another, using the Braille coding system, has been limited, problematic, and in many cases, one-directional.

This paper describes an Arabic Braille bi-directional and bi-lingual translation/editor system that does not need expensive equipments. With appropriate rule file for any other languages, this system can be generalized to facilitate communication among literate people regardless of their disabilities (visually impaired or sighted), income, languages, and geographical locations.

1. Introduction and Background

Visually impaired people are integral part of the society. They can play a significant role in its development and prosperity provided they have systems through which they can communicate with the world. Unfortunately, they have not been so lucky to do this freely as sight-blessed people. Obviously, the system that they need for communication should depend on the hearing sense and/or touch reading. Many systems have been developed in order to achieve this purpose; the most famous system that is based on touching is the Braille system. Braille is *a writing system using a series of raised dots to be read with the fingers by people who are blind or whose eyesight is not sufficient for reading printed material*.

This paper deals with this aspect, and we believe that the system we have developed will enhance the information and communication capacity of those visually impaired people. It describes a Braille transcription software or package. This software is much more than a program that takes a text and translates it into Braille using some system of abbreviations or contractions. It also includes an input editor, which enables both the sight-blessed and the visually impaired computer user to Braille-in his/her own documents for further processing. Such a system is essential to bridge the gap between sight-blessed people and their visually impaired counterparts with respect to communication and access to information technology.

In the Braille system, the letters and digits are formed from six raised dots arranged in two columns of three rows -like a domino, from which we can form 63 different combinations, excluding the blank (Fig. 1).

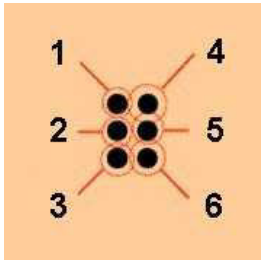

Fig. 1. Braille Cell.

Braille is not a language. It is just a code in which languages such as Arabic or English may be written and read. Braille system supports many languages in the world including Arabic. Note that both Arabic and English Braille are read from left-to-right.

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When every letter of a word is expressed in Braille, it is referred to as Grade 0 Braille. Very few books and other reading materials are transcribed in Grade 0 Braille. The system used for reproducing most textbooks and publications is known as Grade 1 Braille (some references use the terms Grade 1 and Grade 2). In this system, cells are used individually or in combination with others to form a variety of contractions or whole words. For example, in Grade 0, the phrase "كيف صار هذا" requires eleven cells. It would look like this:

KIF &AR H!A (`KIF &AR H!A`)

If written in Grade 1 Braille, the same phrase would take only six cells to write. This is because the letters 'ك' and 'ص' are also used for the whole words "كيف" and "صار" respectively. Likewise, the word "هذا" is formed by combining the cells (4) and (5), and the letter 'ه'. It would look like this:

K & ^H (`K & ^H`)

Although adaptive technologies that were developed for people with special needs are powerful tools, they are not within the reach of an ordinary person due to their high cost. So, most of the disabled people are not employed or have limited employment chances. This high cost is partly due to limited markets and having few developers in this area. Despite this high cost, the products are not up to the expected quality owing to very few competitions.

Nowadays, virtually all information can be produced electronically, and the growth of using computers in the daily activities (typing and printing) has increased dramatically. It is therefore necessary to develop more specialized technologies, within the easy reach of the visually impaired people, which will empower them so that they too can use the computer easily for their daily transactions, and make more contribution to the society and the development of IT as others do.

The aims of the system presented in this paper are therefore mainly to:

1. Minimize the gap between visually impaired people and their counterparts (with no disabilities) with regard to utilizing computers.
2. Increase the ability of communication between visually impaired persons and the sight-blessed.
3. Build an inexpensive, user-friendly Braille software for the visually impaired, which can be used on any personal computer (no need for special hardware).
4. Substitute the use of Perkins machine (Wikipedia, 2007) with computers, to facilitate integration, low-cost availability, self-sufficiency and active participation in the society.
5. Provide an automatic translation from Braille code to Arabic/English text and vice versa.

The rest of the paper is organized as follows: Section 2 surveys related literature and technologies in Braille-text translation. Section 3 discusses the main design and the implementation issues of the Arabic Braille Environment (ABE). Finally, Section 4 concludes with a brief summary on the ABE system's achievements and features.

2. Review of Literature and Technologies

A sight-blessed person can interact with the computer via different Input/Output devices, while a visually impaired person, on the other hand, is somehow forced to use specially designed devices or programs to interact with computers. The visually impaired person uses a variety of equipments and programs that enable him/her to enter data into computers or control them. Among these input devices are *Braille keyboards* (ATRC, 2007; Sighted Electronics 2007), *Voice recognition* (IBM Voice Systems, 2007), *Optical*

Braille/Character scanners (Halousek, 1999; Sighted Electronics 2007; neovision, 2007; Mennens et al, 1994). However, with respect to the output devices, there is a wide difference in the use of computers by these two categories of users. A sight-blessed user eye-reads the direct results of his/her work on the monitor or on a regular paper print, whereas a visually impaired person hand-reads his/her output produced on a specially designed paper or device. Among the output devices used by the visually impaired are *Braille displays* (ATRC, 2007; Frontier Computing 2007; RINB 2007; Visio Technology, 2007), *Screen readers* (ATRC, 2007; Freedom Scientific, 2007; Ibsar, 2007), *Braille Embossers* (ATRC, 2007; Sighted Electronics 2007; neovision, 2007), and *Screen magnifiers (*ATRC, 2007; Sensus, 2007). There are also other assistive software packages and devices, designed exclusively for visually impaired people. Among these packages are *Scientific Braille packages* (Ley, 1999; Gardner, 1993, Sahyun, 1998), *Braille Note Taker* (Freedom Scientific, 2007), and *The Reading Edge machine* (Telesensory, 2007), *tactile graphic display* (NIST, 2007), *PAC Mate BNS PocketPC* (Freedom Scientific, 2007), *and Digital Talking-Book Player* (NLS, 2007).

The automatic translation process between Braille system and normal text is not a new research field. It started as early as mid 1960's (Kr, 1969). To the best of our knowledge, the first Braille translation system was DOTSYS III (Sullivan, 1973). One need for such translation systems is in mainstreaming, in which disabled and non-disabled students study together in the same classroom (Brule, 1985). Moreover, one key issue for integrating visually impaired people into daily life is education. For many educational subjects, however, there is no suitable assistive technology for visually impaired people. General and specialized Braille-text translation systems can fill this gap (Alonso et al, 2006).

In recent years, there is an increasing trend to use computers for handling Braille documents using specialized software and hardware. Yet, most of the researches and software translation systems between Braille and text are towards English Braille in both grades zero and one (Das et al 1995; Blenkhorn, 1997; Blenkhorn, 2001; Falcon et al, 2005). Other nations recognized the importance of the translation systems between their language and Braille system. Examples of languages, other than English, include Japanese (Ohtake, 1996; Watanable et al, 2004), Chinese (Jiang et al, 2001), Portuguese (Reza et al, 2204), German (Slaby, 1990; Seiler & Oberleinter, 1990), Indonesia (Thiang et al, 2004), Danish (Christensen, 2006), and Spanish (Alonso et al, 2006). Moreover, the translation between printed music and Braille has received an attention from researchers (Matsushima, 1998; Leopold, 2006). Also, mathematical and scientific notations and expressions has special Braille translation mechanism (Stanely & Arthur, 2006).

The translation process can be done at software level or at hardware level. Most researches and products are at software level. However, hardware translation guarantees high-speed translation (Zhang et al 2006; Zhang et al 2007).

All these attempts enable visually impaired people to have the same opportunity to access knowledge as their sight-blessed colleagues. Unfortunately, most visually impaired people in the Arab world are deprived from this opportunity. One reason of that is the little scientific research in this regard.

Since the aim of this paper is to build a fully functional Arabic Braille Translation/Editor software, this section will focus more on the trends toward automatic Braille handing and describe the various products in this regard.

2.1. English software packages

There are many Software packages that have been developed to serve the Braille system. Among these software packages are:

Duxbury Braille Translation (DBT) Software (Leventhal & Perez, 1996; Duxbury Systems, 2007). DBT is a window-based software that automates the process of conversion from regular print to Braille and vice versa. It provides translation and formatting facilities. It also provides word-processing facilities directly in the Braille mode where the user can treat the keyboard as Perkins machine to enter Braille text as well as using the software for ordinary word processing tasks. Also, the software can translate Arabic text to Braille. With this supplement, one can create and edit natural Arabic text using Microsoft Word (Arabic version), and then import and translate the file into Arabic Braille using the DBT software. English text may also be intermixed, and both languages may be contracted, uncontracted, or any

combination. The system has only an English interface. Moreover, DBT does not support any type of sound, which is essential for the visually impaired to interact with computer.

Duxbury Braille Board (DBB) (Duxbury Systems, 2007). DBB is a window-based software system oriented to sight-blessed users. It can translate from English text to Braille system. The user can write directly in Braille using the normal keyboard. When the user presses a letter on the keyboard, its corresponding Braille cell will be displayed on screen. The system supports only English language without any contractions. Also it does not support any type of sound.

Pokadot Braille (Pokadot, 2007). This program works in MS-DOS environment. It is oriented to both visually impaired and sight-blessed persons. Therefore, it helps in communication between visually impaired and sight-blessed persons. The visually impaired persons can use the system through a predefined six keys of the normal keyboards. It gives sounds for specific notifications, such as an alert that the line is long or near to the end point. There are two menus. One for sight-blessed people; it contains choices to print on Braille printer by Braille cells. The second menu is for visually impaired people; it contains choices to translate Braille codes to English text then print it on normal printers, and to enlarge English letters to make them readable to low vision people. The two main shortcomings of this software are: no Arabic language support, and no sound for regular events.

WinBraille (Index Braille, 2007). WinBraille is a powerful Braille editor for text handling with MS-Office and other Windows programs. It has a powerful feature that is centered on its Rule File. Rule File is a file that contains the definition of the Braille system. It is similar to *Lex* analyzer (Levine et al, 1992), which is used in developing compilers. It contains every character in the language and its corresponding code in Braille system; also it contains rules for translation (and what to do with tabs, end of line, etc). Also for the reverse task, the file contains rules, which define the corresponding letter for each Braille code. The Braille codes are listed in the file by mentioning the dots numbers (as p12➔b). After editing the rules file, it should be compiled. Then from the main program, the user should choose the file to be used explicitly by Profile/Braille menu. The user can write in Braille system directly, by using the six keys of the keyboard (SDF – JKL). The system does not translate from Braille system to any other languages. Also it does not support sound feedback.

Sensus Braille Software (Sensus, 2007). Sensus Braille was developed by Sensus ApS in co-operation with Refsnæsskolen in Denmark and other Danish and International Braille authorities. It is a window-based software that automates the translation of English and Danish text into Braille and vice-versa. The software translates Standard English and Danish text (with contractions) into 6- and 8-dot Braille and vice versa. Also a user can define compositions of additional words and parts of words for a higher contraction ratio. The software does not support Arabic language, nor does it support sound feedback.

Braillemaker for Windows (BrailleMaker, 2007). Braillemaker is a window-based Braille editor oriented for both sight-blessed and visually impaired users. BrailleMaker software delivers English Grade 0 and 1 automatically from many file formats. It allows printing to all embossers directly from the word processor with a link within the program (the program automatically installs in Microsoft Word, and may need to be manually installed in other programs). There is also Braille page preview and ink-dot printout. It allows six key Braillling as if typing on a brailler such as a Perkins. It has the Learner Braille feature that helps those who wish to produce Braille for learners at different levels with options on contractions (a user can develop his or her own Braille rules using a unique rule-based symbolic language called LOUIS.) The Professional version has a module for allowing the selection of two, mainly European, foreign languages within the same document. It does not support Arabic language or sounds.

Cipher Braille Translator (TeckReady, 2007). Cipher is a text to Braille program that converts text documents into a format suitable for producing Braille documents, through the use of a Braille printer. This software translates text from any saved word processor file into Braille. This can then be printed using an embosser. The user can edit, save, use style templates and enable translation rules. It does not support Arabic language or sounds.

BrailleMaster (BrailleMaster, 2007). The BrailleMaster package comes with both Windows and DOS versions. There are in fact two DOS versions - a screen-based, menu-driven version (which also contains a text editor); and a command-line based version that is suitable for batch jobs and speech output. The BrailleMaster Version 6 software

offers a number of useful Braille publishing facilities such as Braille conversion and printing, customized Braille development, and graphic Braille preview. A large print facility suitable for partially sighted persons is also included. This program allows its user to translate text to Braille then print it directly to an embosser or printer, to edit a file (including a Braille file), to print or emboss Braille from a Braille file, to view the completed Braille on screen, to customize individual Braille rules and verify them, to customize formatting and controls for an embosser or printer, to develop user defined Braille code for text translation in many languages, and to develop advanced Braille applications, such as math and music Braille code translators. The main disadvantage of this software is its lack of support for other languages specially the Arabic language, and sound feedback.

Monty Braille Translation Software (Quantum Technology, 2007). Monty Braille is window-based Translation Software. It can create documents directly in Monty or use a file from a different word processor. It can accept text files and formatted files from the Mountbatten or Duxbury format, as well as RTF files which can be produced by a number of popular Windows word processors. It supports Grade 1 or 2 Braille, and allows the user to insert its own Braille codes or abbreviations. It can also insert foreign characters (includes 12 languages) into a document. It does not support Arabic language and sound feedback.

Supernova (Dolphin, 2007; Nattiq, 2007). It is a window-based magnifier, screen reader and a Braille system developed by Dolphin Computer Access Ltd. Its main function is to convert text to speech, although it can support the conversion of text to Braille displays and note-takers. The software can read or spell out any text on screen: documents, menus, web pages, emails. Also it talks as someone type, by character, by word or both. Moreover, it reads icons and Internet graphics labels and announces font and style information and works automatically with a wide range of Braille displays and note takers. The company, with the help of third parties, is in the process of Arabizing the software (no available documentation). The Arabic version is not officially released. Printing to Braille embossers is not supported. Its price ($1950 for single license) is too high for an average visually impaired person.

2.2. Arabic software packages

Braille concept entered the Arab World as early as 1870's, but was used officially in the 1950's (AlMosa, 1987). It was slightly modified to fit the Arabic language. It passed through many changes until it settled in a way similar to the English Braille. Unfortunately, there is no unique (standard) coding for the Arabic Braille in the Arab World. For the scientific Braille notation, only few Arab countries follow the international (mainly the European) standard Braille coding. Interested reader may refer to (AlMosa, 1987); it contains a comprehensive and well-documented history of Arabic Braille and its education in the Arab World in general and in Saudi Arabia in particular.

The relationship between Arabic Braille and computer is still in its infancy. To the best of our knowledge, there is almost no scientific research conducted and published in the utilization of computers in helping Arabs who are visually impaired. However, there are very few software packages that can handle Arabic Braille. Among these packages are:

The Arabic Braille Translator (Dar-Hosbat Al-Na's Al-Arabie, 1998). The Arabic Braille translator is a window-based application that was developed by Dar-Hosbat Al-Na's Al-Arabie, Jordan. The software is designed for the sight-blessed users to translate Arabic text into Braille (one way translation) without contractions. It uses MS-Word as its platform. The system does not support the principle of rule file. Therefore, the conversion from text to Braille is static (hard coded).

Printing System with Braille Software (KISR, No date). The Kuwait institute for scientific research has developed a software package called Printing system with Braille. It is a window-based application that is oriented to sight-blessed people to convert Arabic text to Braille (one way translation). The software supports multi-level contractions as well as the conversion of Holy Quran files into Braille. The system does not support the principle of rule file. Therefore, the conversion from text to Braille is static (hard coded).

Ibsar (Ibsar, 2007). It is a windows-based system developed by Sakhr Software Co., that enables the visually impaired to make full use of the computer and provides them with the capability to use the Internet through text to speech technology, which can read both Arabic & English text on web pages, and enables the visually impaired to accomplish many tasks using the keyboard. It is a screen reader rather than a Braille environment; yet it supports some Braille handling. It enables visually impaired users to read printed books and documents as well as electronic files on their own, to create text, to save and print these texts in Braille, and to convert text to voice, all in Arabic and English. Moreover, Ibsar allows its users to send, receive, write, read, and manage the E-mail messages. It is so expensive and limited to some windows applications. It does not support Arabic Braille contraction.

Table 1 summarizes and compares the above products.

Table 1. Summarization of the above software packages

Software	Interface	Supported languages	Sound feedback	Platform	Braille-to-text	Text-to-Braille	Editing in Braille	Grade	User-defined rules
DBT	English	Many languages +Arabic	No	MS-Windows	Yes	Yes	Yes	0 & 1	No
DBB	English	English	No	MS-Windows	Yes	No	Yes	0	No
Pokadot	English	English	Partial	MS-DOS	Yes	Yes	Yes	Not Ava.	No
WinBraille	English	Many languages +Arabic	No	MS-Windows	Yes	No	Yes	0 & 1	Yes (Rule file)
Sensus	English & Danish	English & Danish	No	MS-Windows	Yes	Yes	No	0 & 1	No
BrailleMaker	English	European Languages	No	MS-Windows	Yes	No	Yes	0 & 1 (1 & 2)	No
Cipher	English	English	No	MS-Windows	Yes	No	No	Not Ava.	No
BrailleMaster	English	Many languages, NO Arabic	No	MS-Windows & DOS	Yes	No	Yes	Not Ava.	Yes
Monty	English	Many languages, NO Arabic	No	MS-Windows	Yes	No	No	0 & 1 (1 & 2)	No
Supernova	English	Many languages +Arabic	Yes	MS-Windows	Yes	No	No	Not Ava.	No
Arabic Braille	Arabic	Arabic	No	MS-Windows	Yes	No	No	0 & 1	No
Printing System	Arabic	Arabic	No	MS-Windows	Yes	No	No	0 & 1	No
	English	English &		MS-					

For further information on the different technologies (Software/Hardware) designed for visually impaired people, please refer to (ATRC, 2007; Al-Salman and Al-Khalifa, 2000).

3. The Arabic Braille Environment (ABE)

This system or environment is an enhancement to a previous work (Al-Salman and Al-Khalifa, 2003). In that work only a translation from text to un-contracted Braille was preformed. This enhanced system provides a bi-directional translation from Braille to text and vice versa for both Arabic and English. This system also goes in parallel with our work in the Arabic optical Braille recognition (Al-Salman et al, 2007). Fig. 2 depicts a snapshot of the

main window of the system. In this section, we highlight the main system design and implementation issues.

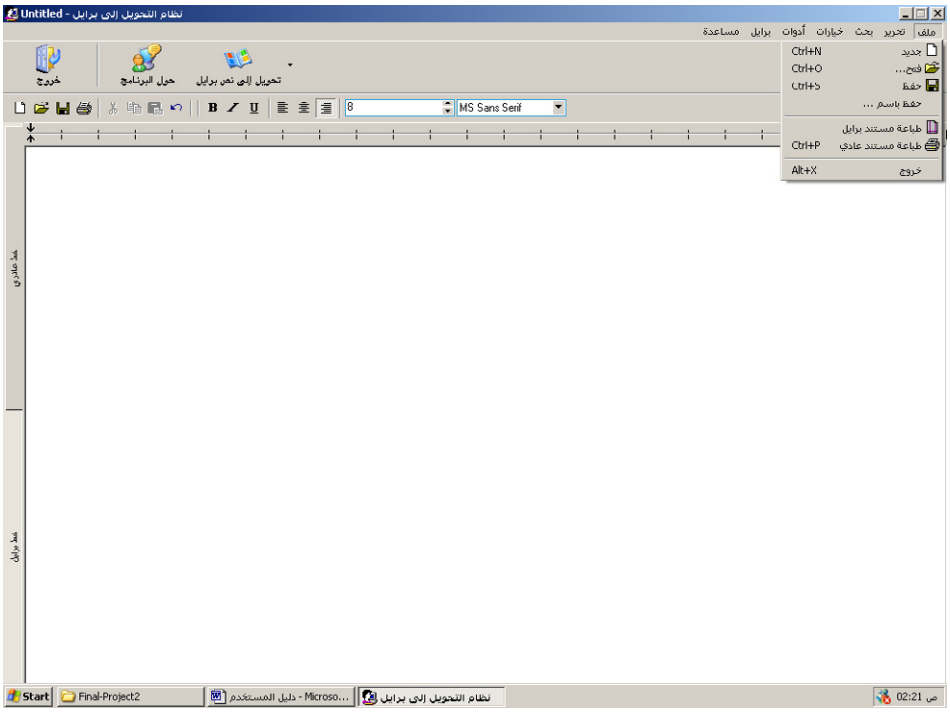

Fig. 2. Main system window.

3.1 System main functions

Figure 3 shows the interaction among system functions and their relationships with the users.

(1) **Translate text to Braille.** Translates Arabic text to Braille. (Other languages can be supported, if their Rule File is defined). It translates the text document from the source language (Arabic or English) to its corresponding Braille system. The source language should be defined in a rule file, and compiled successfully. Rule file concept will be described later. The text in the document is split into words, each of which is stored with its type (Bold, Italic, etc) and some other information necessary for the translation (e.g., the language of the word).

(2) **Translate Braille to text.** Translates Braille to Arabic text. (Other languages can be supported, if their Rule File is defined). It translates the Braille document to its corresponding default language. The user has the ability to change the default language by any successfully compiled rule file. Details about this function are given in Section 3.3.

(3) **Translate Microsoft Word/HTML Documents**. This function can open a Microsoft Word document, which may include text and tables. The function translates the text to Braille. It also translates tables to another format that a visually impaired can read. Translating and reformatting tables is not a straightforward task. Two actions are involved in order to import a document from MS-Word/HTML with tables to ABE. First, translate the document from DOC format to RTF format. Second, import the RTF format file to the program.

There are two approaches to do the importing. The first approach is to use the Handle System Call. It is fast because it uses low-level instruction, but it needs very careful handling because it deals with Windows Registry. The second approach is to use some Delphi features, such as OLEServer, Word97, ComObj, and

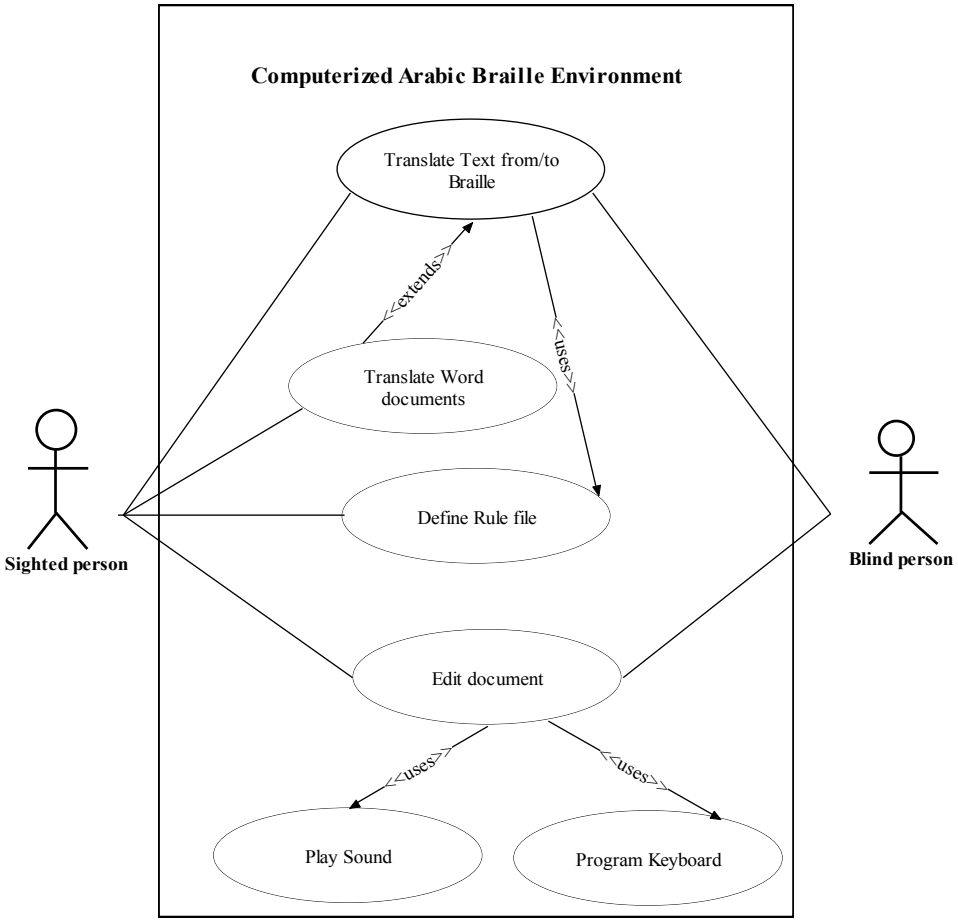

Fig. 3. Interactions in the Arabic Braille environment.

ActiveX. This approach is slower than the first one, yet it is saver. So, we decided to use the second approach.

Importing the file with the second approach can be done in two ways; either import the complete file at once (with the risk of system hang-up in the case of a large file), or divide the file into paragraphs and import one paragraph at a time. The second approach prevents the system from hanging-up. If there are tables in the imported MS-Word document; then the TImport Class will translate them to a new format that a visually impaired person can read easily (See Fig. 4).

As shown in Fig. 9, there are five types of tables starting from the top right:

a) A table with row titles and column titles where the main are row titles.
b) A table with row titles and column titles where the main are column titles.
c) A table with only row titles.
d) A table with only column titles.
e) No titles.

These days, electronic documents are being exchanged freely and widely using the Internet. Being connected by the Internet has become very critical to educational, social, economic and IT development in the society. Hence it is highly important and beneficial to enable visually impaired people to exchange freely their Braille Documents using the Web as well. The first step to achieve this is to convert the Braille Document to HTML file, so that the browser can render the document. HTML Import is the second method in Web Braille exchange. This feature receives the HTML Braille document and translates it into Braille document.

Fig. 4. Translation Table Interface.

(4) **Edit Document.** This system gives the visually impaired user the ability to write directly a Braille document. Also, the system gives the sight-blessed user the ability to write in normal text (as with other editors). Writing Braille cells will be done through six defined keys (chosen from the keyboard). The user has the ability to redefine those six keys. By this function, we can simulate Perkins typewriter using normal keyboard. When typing, the Braille cells will be displayed on the screen with a sound of the typed character. We should point out that some visually impaired people may prefer to type in normal text rather than Braille. Therefore, this editor is equipped with a sound for the typed character. Also, the editor can import other kinds of documents into the system for further processing. Moreover, in Braille editing mode, the corresponding normal text is simultaneously displayed in the bottom of the screen.

(5) **Rule File.** The rule file is central to the translation process between text and Braille. The user should write in a file (rule file) the original language letters (including the special symbols) and their corresponding Braille cells. If the Braille document contains more than one language, the user should specify in the rule file a Braille character for language switching. The rule file should include the names of files that have the letters' sounds. Our system implements two rule files, one for the Arabic language and another one for the English language. However, the user may define a rule file for any other language that is supported by his/her MS-Windows. Moreover, the system will take care of formatted text (**Bold**, *Italic,* Under Line, Center…etc). It can also handle tables.

The main functions over a rule file are as follows.

1. **Add a language.** This option is used to create a new rule file for a new language. When translating a document written in this new language the translation rule is taken from the new rule file.
2. **Add a contraction.** This option is used to add a new contraction to a rule file for any language. After the addition of the new contraction, the translation can be done according to the rules in the new contraction by selecting the contraction name from the Contractions Order option.
3. **Add words.** This option is to add new words to a contraction in a rule file.

Figure 5 shows the design of the rule file interface in which the user can enter his/her Braille rules and then the system saves it internally as a text file, called a *Rule file*. Due to the importance of the rule file, we will dedicate a section for it (Section 3.2).

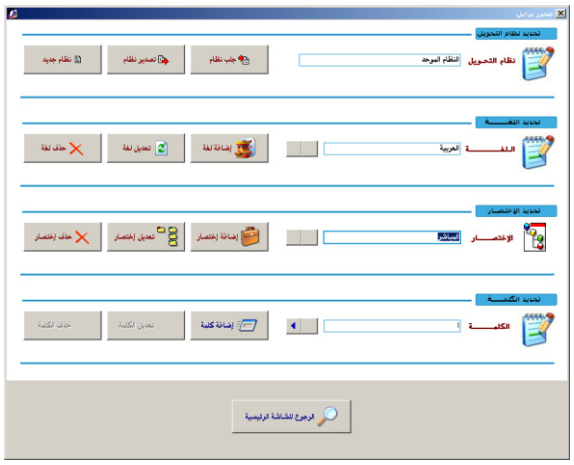

Fig. 5. Rule file interface.

(6) **The sound function.** This function is designed for the visually impaired user. As we know, the visually impaired person has only two ways to interact with the computer, either by touching, or by listening. In the Braille editor, any letter typed will be spoken. This gives the visually impaired a feedback of what he/she has typed. This feature can be also offered in the Normal text Editor.

(7) **Keyboard Function.** To simulate Perkins typewriter, the keyboard should use only six keys (plus some function keys); other keys should be disabled. We have chosen (SDF-JKL) keys, as the default keys to represent dots 1,2,3 and dots 4,5,6 respectively. We have chosen them because there is a small projection on the first letter of each group. The user should be able to re-define the keys easily. The user should have also the ability to reprogram the timer, which counts the allowed interval time between bouncing and debouncing the keys to make a single character. So if the character bouncing is in the time range which is allowed between bouncing and debouncing, the pressed character will add a new dot to the same Braille cell (@➔C); else it will make a dot in a new cell (@➔@A). So, if the user is a slow typist then the program can be modified to satisfy his/her speed.

(8) **Editorial Functions.** The system provides the essential editorial functionalities such as: cut/paste/replace/search, etc.

(9) **Print Function.** The system is able to print directly to a Braille embosser without the need for any third party programs. Also the user can adjust the print properties to serve his/her needs such as: page header and footer, page numbering, spaces between lines, number of characters in each line, etc. Furthermore, the system supports remote printing to enable the use of one embosser to serve all users, thereby cutting down the printing costs.

(10) **System Help Function.** A thorough and comprehensive help directions (in Arabic), to guide the user on how to use the system and all the different features that are included.

3.2 Rule file

The rules in the rule file are arranged based on their priority. The rules written at the top of the file have higher priority than rules written beneath them. Because of that, the words that are not included in the contraction rule are always at the top. The user does not need to know such information to build his/her own rule file, because the system has a special interface (as mentioned above) to ease the building of rule files with their proper priority.

The system creates one rule file for each defined language. The user can define as many languages (or rule files) as he/she wants. The current system supports two predefined languages: Arabic (Saudi Arabia) and English (USA). The rule is designed to be very flexible and general. The rule file interface provides the user with many options for each word contraction. Fig. 6 shows a screenshot of such options.

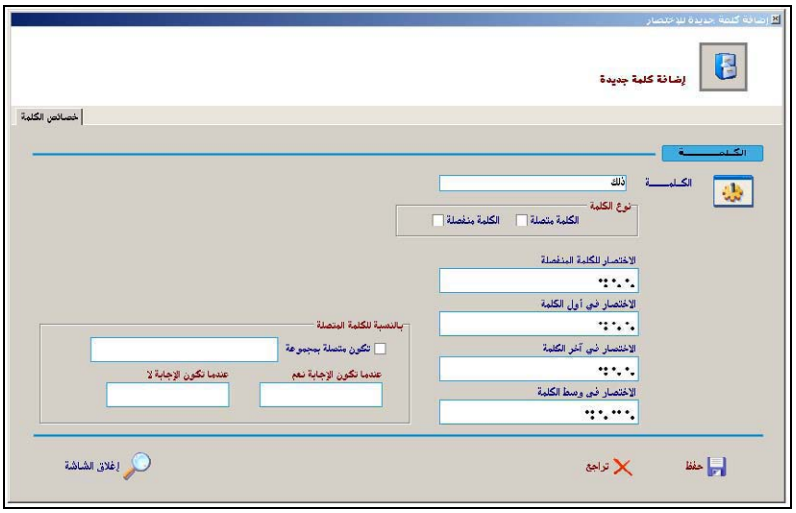

Fig. 6. Add a word into the rule file.

The rule file for a language is basically a text file. Each language may have multi-level contractions (Grades) in the same file. Those grades contain the translation rules. There are no limitations on the number of languages, or on the contraction levels. Each contraction is separated from the other contractions by a file separator. This gives the system the ability to distinguish between contractions. Moreover, within the same contraction level, the rules are written line by line, where each line represents one rule. A rule may be a simple character match, or a complex word with exceptions. In the case of contraction, Fig. 7 shows the complete flowchart for the translation rules. The rule file structure is basically an array of languages. Each language may have a number of grades (levels of contractions). Those grades contain the translation rules. Fig. 8 shows the whole rule file structure. A full online help is available with system showing how to create and edit a rule file.

3.3 Braille to text translation

Before starting Braille-to-text translation, the system should determine the source language of the Braille. Therefore, the first step the user should do, after typing or importing the Braille code, is to determine the language of the Braille text. If the user does not determine the language, the system will perform the task by analyzing the Braille text to identify its original language. Figure 9 illustrates the Braille-to-text data follow diagram. Fig. 10 gives more details for Fig. 9 in an algorithmic approach.

To identify the source language, the identification process traverses the Braille code applying some techniques and statistics. Although the identification process may not be accurate, but it has been found to identify the source language of the majority Braille codes. We have identified a list of the most frequently used words in Arabic and English languages. We have divided this list into two levels:

Level 1: High frequently used words (and we give it a highest priority)

Level 2: low frequently used words (and we give it a lowest priority).

In Tables 2 and 3, we listed these words for Arabic and English languages. In addition to this, we used another method - the capitalization indicator (dot 6-**,**), to recognize English language. This cell is placed before the English letter to indicate that it is a capital. This indicator must anteceded by a delimiter, whereas the corresponding Arabic letter of this cell (**,**) is "Shadda" (ّ) which cannot be anteceded by a delimiter•.

• This cell is also used in Arabic language for some contractions in Grade 1, but using it as "Shadda" is the majority.

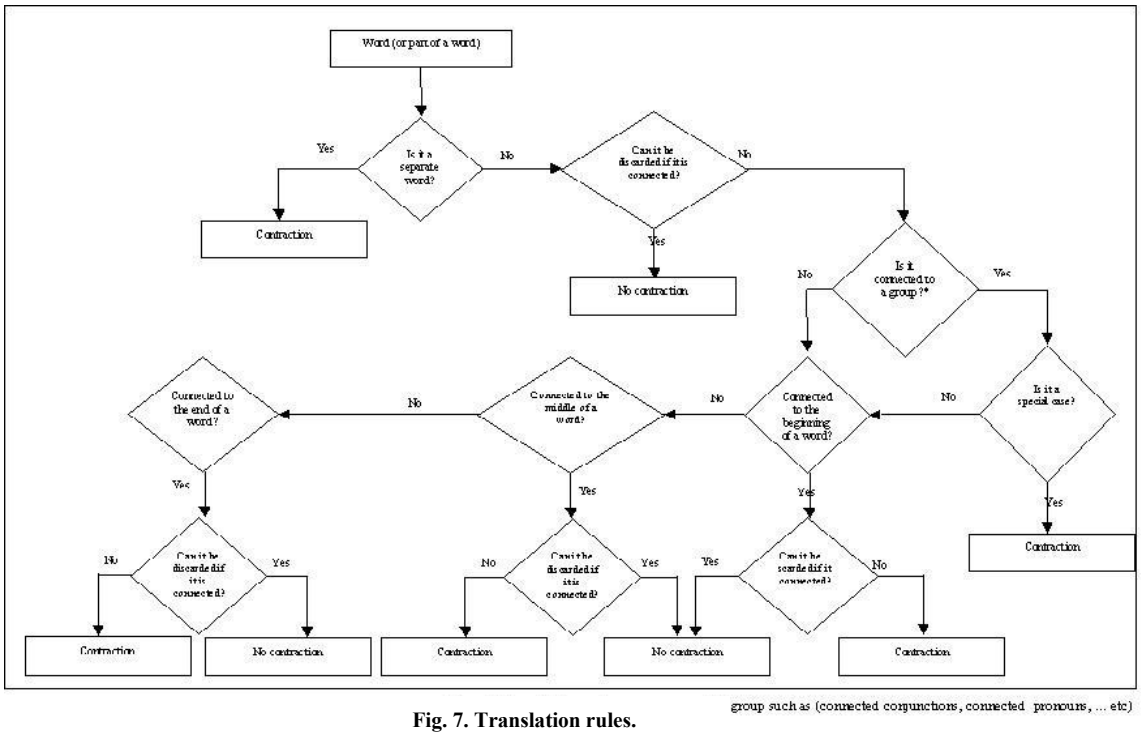

Fig. 7. Translation rules.

4. Conclusions

Visually impaired people are an integral part of the society. However, their disabilities have made them to have less access to computers, the Internet, and high quality educational software than the people with clear vision. Consequently, they have not been able to improve on their own knowledge, and have significant influence and impact on the economic, commercial, and educational ventures in the society. One way to narrow this widening gap and see a reversal of this trend is to develop a system, within their economic reach, and which will empower them to communicate freely and widely using the Internet or any other information infrastructure. Moreover, many visually impaired people are blessed with incredible talents and skills. As normal people, they are a fertile land for creativity and innovation. The fact that they are visually impaired does not mean that they are disabled to serve humanity in its various fields.

From this perspective, we have designed and implemented this software to serve this class of people. The software is concerned with translating natural languages, including Arabic and English, into Braille System and vice versa. The Braille system is one of the most used systems for non-visual communications as it is based on the touching sense, through which the visually impaired people can explore the world of knowledge, and be removed from isolation without withholding or constraining them from making their own contributions and innovations in the growth of the society. We believe that this system has been able to achieve its designed objectives, which are to:

1. Enable visually impaired people to input their data into computer like any normal user (whether using Braille keyboard or normal keyboard).
2. Enable sight-blessed people to read Braille documents that are written using embossed font by translating them into normal text.

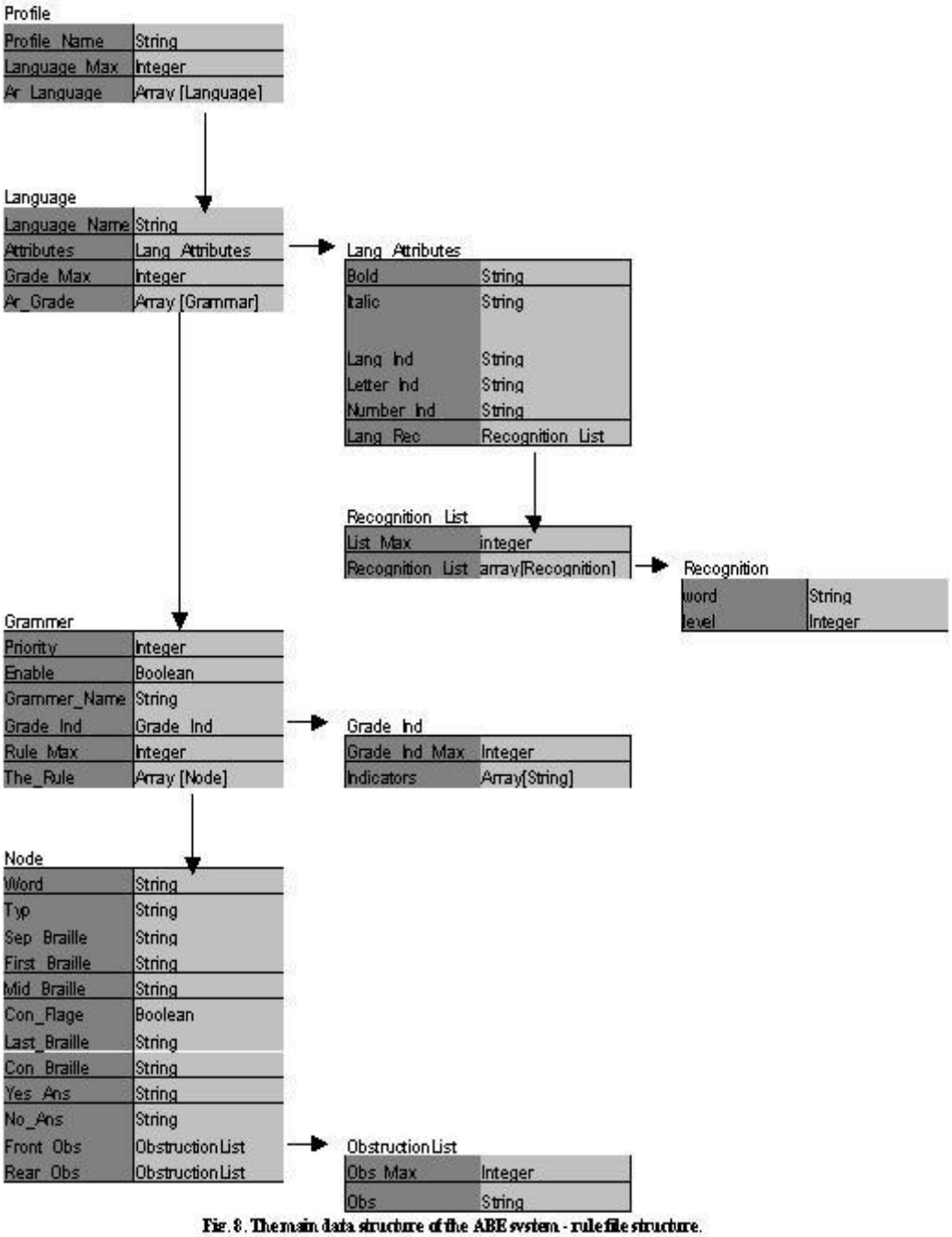

Fig. 8. The main data structure of the ABE system - rule file structure.

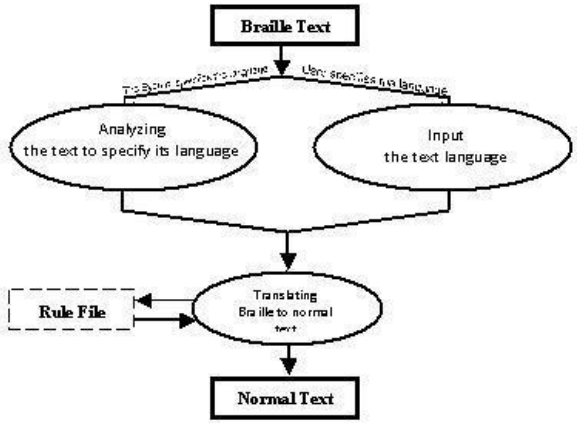

Fig. 9. Braille-to-text data flow diagram.

3. Enable visually impaired and sight-blessed students to be put and taught together in one classroom. This can be done by providing a network of computers for all students connected with teacher computer. The visually impaired student can write what he/she wants in Braille and the system translates it into normal text that the teacher can read.
4. Retranslate a Braille code to another language (e.g. from English to Arabic).

Moreover, the system has many features that are collectively not available in many other systems. These features include: Arabic user interface, ability to add any natural language (Arabic and English are already predefined in the system using rules files), sound feedback, bi-directional translation (from Braille-to-text and vice versa), ability to write directly in Braille, and supporting grade 0 and 1.

- Identify the source language (see next paragraph).
- Read Braille code cell by cell.
- Determine the letter status. Status of the letter could be:
  - *Separate* (anteceded by a delimiter and followed by a delimiter).
  - *First* (just anteceded by a delimiter).
  - *Mid* (neither anteceded by a delimiter nor followed by a delimiter).
  - *Last* (just followed by a delimiter).
- Search the rule file structure, using the letter and its status, for the corresponding normal letter (or word, in case of contractions) and then put it in the translated text window of the normal text.

Fig. 10. The algorithm for Braille-to-text engine.

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نظام ترجمة بين برايل والنص المقروء: ثنائي الاتجاه ثنائي اللغة

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ملخص البحث. أضحى نظام برايل وسيلة هامة للتواصل بين المعاقين بصريا فيما بينهم ومع العالم الخارجي. إن الترجمة الآلية بين النصوص المطبوعة في اللغات المختلفة ونظام برايل يكتنفه شيء من المحدودية والمشاكل البرمجية، علاوة على أنها في الغالب ذات اتجاه واحد في الترجمة.

هذا البحث يتناول تصميم وتنفيذ نظام للترجمة الآلية بين برايل العربي أو الإنجليزي من جهة وبين ما يقابلها من نص مطبوع باستخدام جهاز الحاسب العادي. يمكن تعميم هذا النظام ليخدم أي لغة أخرى باستخدام ما يسمى بـ "ملف القواعد". إن أنظمة الترجمة هذه تساهم بشكل فاعل في التواصل بين المعاقين بصريا وزملائهم في أقطار المعمورة.