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Visualization Systems Supporting the Reading of Arabic Document for non Arabic Speakers

[1]R.J.R. Yusof, [1]R. Zainuddin, [1]M.S. Baba and [2]Z.M. Yusoff
[1]Faculty of Computer Science and Information Technology,
[2]Academy of Islamic Studies, University of Malaya, 50603 Kuala Lumpur, Malaysia

Abstract: This study addresses a reading comprehension problem and visualization as the suggested solution. When one read, one would intend to understand the text being read. It is absolutely an exception in the context of one Arabic document called the Quran. Thus, visualization techniques are then useful to support the understandability of the document for non-Arabic speakers such as the Malaysian and Indonesians. Descriptions and review of four prototype systems that use visualization techniques: scatter plot, trivariate plot, network diagrams, directory approach and hyperbolic. This study discusses reading and visualization theories, the problems encountered while reading the Arabic document (the Quran), comparative discussions on the prototype systems and functional requirement proposed to enhance the prototype.

Key words: Reading comprehension, information visualization, Arabic document, functional modeling

INTRODUCTION

Reading theories suggests that it is a process that involves information processing. Snowling and Hulme (2007) and ColHeart *et al.* (2007) referred reading as accessing or retrieving information from memory i.e., transforming print to speech or print to meaning. The goal of reading is to comprehend the text being read and such goal is applicable in the vast majority of the reading population. However, there also exist the phenomena in which extensive reading of a document is done without comprehension. The reason so is purely spiritual, it is reading the holy book called the Quran by the non-Arabic speakers of the Muslim community. This is where the application of information visualization in supporting the phenomena mentioned above would be significantly important. Visualization techniques and approaches are applied to four prototype systems attempting to solve some of the problems related to non comprehension of the Arabic document, the Quran. According to Colin (2000) the goal of visualization is to transform data into a perceptually efficient visual format. Here, four prototype approaches of visualization are discussed and reviewed. Discussion of other useful functionality that would help users of the document will also be included.

The prototype systems are the visualization of Al-Quran using hyperbolic, visual directory, galaxy and the integrated system. These systems attempts to show the content of the Arabic document (the Quran) in a visual representation providing searching and translation function intended to assist the comprehension of the Arabic document. Finally, representations of the structure of the document offer the users to navigate through the document in a manageable and easier manner intended to leave a cognitive perceptual map of the structure of the document on the minds of the users.

The significant review of this study is on how visualization could be use to solve reading comprehension problems. It also contributes to research in the reading comprehension and text visualization areas.

Written text is comprehended by the process of reading. Therefore, the most important reason why people read is to comprehend the text. Present memory plays an important role in reading comprehension. A theory outlined by Hunt *et al.* (2004) stated that the process of comprehension involves summarization, association to a central theme and relates to some inferring information. A fast reader may do this by looking at the title of the passage, the lead sentence of the paragraph, the recursive words and the dominant idea of the text being read. Comprehending text requires mental power and it is related to the cognitive load of an individual. If the cognitive load is reduced, then it is more likely that the individual will understand the written text. On way of reducing the cognitive load of a human individual while reading is to present the text in the visual form. Yaxley and Zwaan (2007) found that readers mentally simulate the visibility of an object during language comprehension

Corresponding Author: Raja Jamilah Raja Yusof, Faculty of Computer Science and Information Technology, University of Malaya, 50603 Kuala Lumpur, Malaysia Tel: +603-79676401 Fax: +603-79676339

thus linguistic simulation of the object properties is one of the ways that could help the reader to comprehend. Similar study by Zwaan *et al.* (2004), Gosselin and Schyns (2004) and Richarson *et al.* (2003) also supported this evidence. A related study such as by Harber and Myer (1982) found that there is greater accuracy in remembering pictograms compared to words. These theories suggest that images may be used as a basis to solve the problem encountered by readers of the Arabic document (the Quran, especially those who can read in Arabic but could not comprehend the meaning).

On the other hand, information visualization offers possible solution to the problem mentioned above. The sequential process of reading text is slow to the human compared to the parallel process of visual perception. It is therefore useful to relate comprehension theories to information visualization, a process of transforming data to a spatial representation. There are many visualization techniques being used in various domain or field of studies. These visualization techniques are related to information, displaying the information in a visual form to assist users in interpreting the data or information. These literature leads to certain patterns of concepts in information visualization. One pattern is on quantity, information visualization relates to quantity. It involves numerical data such as size, time, magnification, height, length, dimensionality, scale and others. Familiar techniques involved would be plotting graphs such as scatter plot and bar charts. The second pattern is on position and connectivity. Visualizing geographical information, hierarchical data and network diagram or scattered objects in the spatial space falls into this pattern. The rational for visualizing scattered objects is to provide clues to the users on what is available so to create potentially useful insight of the object/information. Nodes and trees such as hyperbolic trees also fall into this pattern. The two patterns are sometimes combined together to provide more effective view of the information involved. Information visualization concepts are not just about visualizing the data or information. The fact that dynamic interaction and exploration of the visual display are part of the system, contributes significantly to effective operation of interpreting data. Operation such as zooming, panning, selection and rearrangement would contribute to effectiveness. The bifocal display technique such as applied to the Perspective Wall (Mackinlay *et al.*, 1991; Hartley *et al.*, 2000) and fish-eye view that involves focus plus context (Furnas, 1986) allows focus to a set of objects and distorting others not in the main view and at the same time provides the sense of positioning (the where am I? question). In this way, users are aware of all objects that exist when dealing with large data or information and would not be lost in the experience.

First, the hyperbolic visualization took the second pattern approach, related to network and trees that are hierarchical in nature. A similar study by Honyzhi Sony *et al.* (2004) described the use of large hierarchical flex tree to visualize the directory structure of a personal computer. Perhaps, one of the most popular trees is the hyperbolic tree by Lamping and *et al.* (1995) applied as the hyperbolic browser of the World Wide Web.

Second, the integrated prototype took both the first and second pattern approaches. Particularly using the network and scatter plot, describing quantity. Many literatures in information visualization extend the idea of scatter plot as a technique to display data for effective viewing. One classical example is John's Snow London cholera outbreak diagram. Also included were the Spotfire software by Ahlberg (1996). Other examples are such by Ahlberg and Erik Wistrand (1995) who developed the IVEE software that uses starfield, an interactive scatter plot that allows users to zoom and pan, exploring the data to gain insight. As for Weippl (2001), he studies on content based relation of hypertext database, displaying scattered text in an information landscape. Other more recent study are such as the SmartINFO system by Fang *et al.* (2006).

Third, the directory took the first pattern approach particularly adapting the bar chart or histogram. There are also many studies in information visualization that extended bar chart as the effective quantity interpreter. Others such as Rao and Card (1995) on the Table Lens, the study on geographical location for supply distribution by Roth *et al.* (1997). Friendly (1994) used the mosaic plot-an extended bar chart to display Titanic data sets. Mathew *et al.* (2000) used radial visualization, a hybrid of bar chart for document searching and browsing.

Finally, the galaxy prototype took the second pattern approach. A related study by Wise *et al.* (1995) discussed the concept of document visualization using Galaxies which uses starfields displaying clusters of document in the form of scatter plots points. Points within a corpus cluster tend to be related and the gist term for the cluster is displayed creating an overall view such as the stars in the sky. Other related study is that of Rennison (1994), Galaxy of News, visualizing large quantity of news stories displayed on three dimensional news of information space.

THE PROBLEM DOMAIN

The objective of the prototype system is to assist non-Arabic speaker of the Arabic document to comprehend the Arabic document. Particularly, the prototype was developed for the Malay community in Malaysia to whom the problem of comprehension of the Arabic document applies even though they are able to read or recite it. Results from the survey that was conducted to 51 respondents from ten countries (Malaysia, Indonesia, Singapore, Nigeria, Somalia, Kenya, Eritrea, Djibouti, Sudan and Tanzania) can be shown as in Table 1 and Fig. 1. Most of the non-Arabic speakers were the Malaysian and the rest were the Arabic speaker even though their actual native language is not Arabic. Sudan was the only country with Arabic as their native language. It was found that, there is evidence that from the Malays and Africans samples taken:

- Fluency of recitation, remembering rules of recitation and comprehending the words in Quran increases with the ability to speak the Arabic language (part i supports this finding)
- The higher level reciters of Quran faced less problems in their recitation (part ii supports this finding)
- The problem of understanding Quran can be reduced by increasing the general learning method i.e., making more effort towards learning Quran or providing the alternative methods on learning Quran

Table 2 shows the language properties of the Arabic and the Malay language. Comparing the two languages, one observes that these two languages contain only slide similarities. The writing orientation, the alphabetical system and the subject and adjective phrase structure are all different. These comparisons may imply that the Malay speakers may find it hard to learn the Arabic language. However, the fact that there are many Malay words that are taken from the Arabic language may ease the process of learning the language. According to Nik (1996) there are about 1100 words from the Arabic language in the Malay dictionary: Kamus Dewan first edition during since 1970. Some Arabic words are taken purely in its original form-retaining meaning and pronunciation but some other words may have the influence of the Malay language on its pronunciation but retaining its original meaning. There are also words with the same pronunciation but have a different meaning. For example as discussed by Abdul (1996) the word hakim, yakni and jahil (from the Arabic language) retain the same meaning and pronunciation in the Malay language. The words alim, kuliah and maktab

Table 1: Independent samples test

	t-test for equality of means				
Category	t-value	Significant (2-tailed)	Mean difference	SE difference	95% confidence interval of the difference
The sum of problems for Arabic and non-Arabic speakers (equal variances not assumed)	1.885	0.068	0.835	0.443	1.735
The sum of problems of intermediate and advanced level group of reciters	1.849	0.074	0.750	0.406	1.576

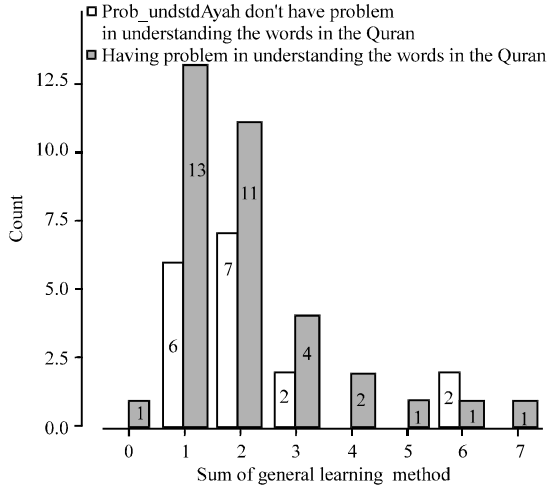

Fig. 1: Sum of general learning methods and problem of comprehending Ayah (Verse)

Table 2: Comparing Arabic to Malay language

	Language	
Proper	Arabic	Malay
Language. type	Semitic	Austronesian
Total speaker	186 million	188 million
Written script	Arabic	Jawi/Latin
Letters	28	34/26
Pronounciation	Iuner, middle, front	Middle, front
Quantity words	Within the word	Another word
Gender word	Yes	No
Writing orien.	Right-Left (R-L)	(L-R)/(R-L)
Verb position	Verb-subject-object	Subject-verb-object
Noun and adj.	Sub-adj	Sub-adj
Root word Syst.	Yes	No

(from the Arabic language) retain pronunciation but have different meaning in the Malay language. Also, the words which retain the same meaning but different pronunciation such as asl, fikr, `ilm (from the Arabic language) as compared to asal, fikir and ilmu (from the Malay language).

DESIGN AND CONTEXT

There are many literatures on the Quran (such as Abdel, 2008; Denffer, 1983; Rosmawati, 1997) which contain information about the Quran a part from actually studying the book itself, either the Arabic version only (such as printed by the government of Saudi Arabia in the King Fahd Quran Complex of Medina; http://www.qurancomplex.com/default.asp?l=eng) or the Arabic plus the translation versions (such as Maulana, 2002) or only the translation version (such as Yusuf, 2001).

The Quran is an Arabic document believed as the word of Allah, God of the heavens and the earth to the Muslims containing guidance on how to lead their lives here in this world. It is believed that it has not been altered since the day it was first revealed (in Mecca), one thousand four hundred years ago to the Prophet Muhammad (peace be upon him). It contains 114 chapters or known as Surah with total of 6236 Ayahs or Verses. It is also divided into seven Manzils or 30 parts called Juz or into 60 Hizbs. Each Hizb is divided into four. Juz, Manzil and Hizb are division or parts of the document (in approximately the same length) to be read within seven, 30 or 60 days for those who are capable of doing so. The 114 chapters are of types Meccan or Medinan (chapters revealed in Mecca or Medina, located in the Saudi Arabia). Figure 2 shows the quantity of Verses in each Surahs. Each Surah contains three to 286 Ayahs. One Ayah can contain up to

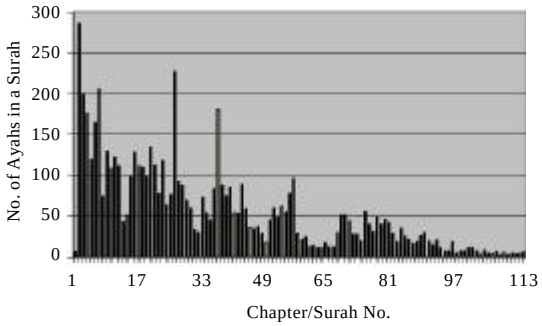

Fig. 2: The content of Al-Quran: 114 chapters and its corresponding quantity of Verses/Ayahs

161 words (referring to the longest Verse, Surah No. two, Verse No. 282). The first Surah is called Al-Fatihah (The Opening) and the last Surah is called Al-Nas (The Mankind). The longest Surah is called Al-Baqarah (The Cow) which is the second Surah in the Quran.

The prototypes: The hyperbolic approach in visualization of Quran followed the idea of Lamping *et al.* (1995). The prototype system display all Surah of the Quran in hyperbolic tree representation, letting the user zooming-in a particular Manzil, Juz, Surah and Ayah. A particular Surah can be searched by entering the Surah name and Ayah number. It also classifies the Surah into Medinan or Meccan. Figure 3 shows the root view of the document structure using the hyperbolic approach. It shows the root node at the center of the screen, which consists of seven Manzil nodes (trunks of the tree). All Juz nodes (branches of the tree), Surah nodes (sub-branches) and Ayah nodes (leaves) are distorted. Nodes with color yellow represents Manzils, nodes with color orange represents Juz, nodes with color blue represents Surah belonging to Medinan category and nodes with color green represents Surah belonging to Meccan category. User can click on either one of these Manzil to show its detail.

The visual directory prototype which closely resembles a bar chart, allows the user to navigate to a particular Surah by clicking on one of the bars which represent all the Surahs in the Quran. It is called the visual directory since the prototype uses the concept of the directory system to visualize the structure of the Quran. Figure 4 shows directory of Quran in form of bar chart visualizing all the 114

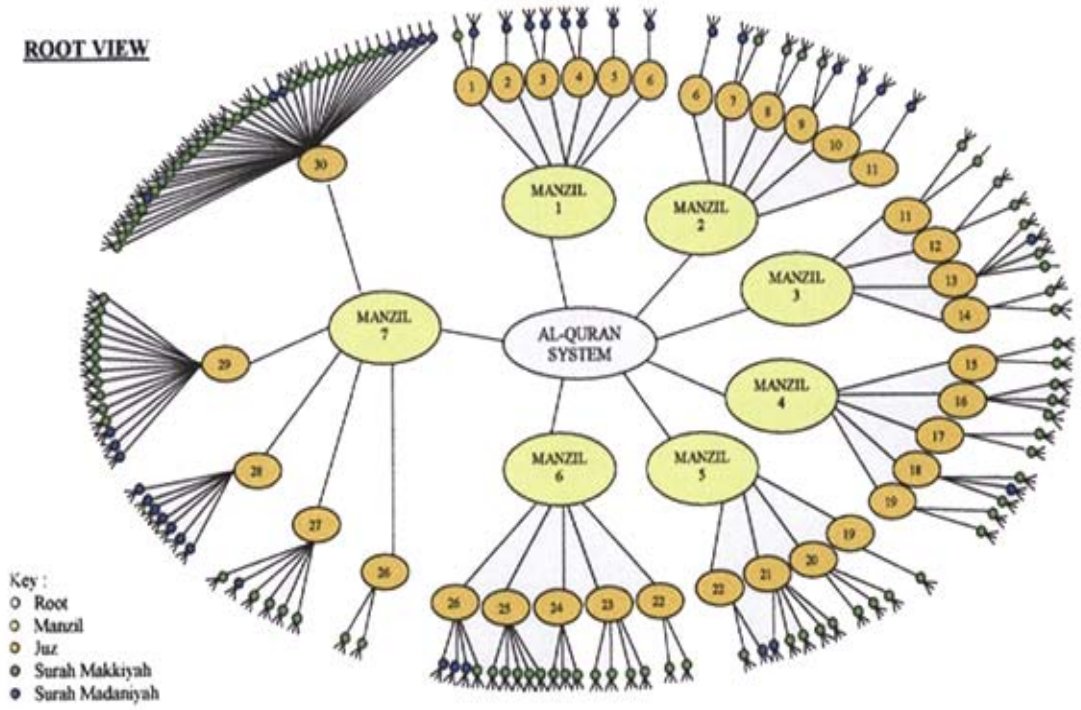

Fig. 3: The root view of the document structure using hyperbolic approach

Surah and 30 Juz of Al-Quran. The leftmost position is where the position of the first Juz and the rightmost is the 30th Juz. All the corresponding Surah is placed under each Juz and visualized according to the amount of Verses it contain (the longer the bar, the higher the amount of Verses of the Surah). It must be highlighted that if one Surah starts from a particular Juz it can continue into the next. This depends on how long that particular Surah is. Taking an example from Fig. 4a, in the first Juz, the small green bar shows the first Surah, (called Al-Fatihah) which contains only seven Verses. The second Surah is called Al-Baqarah contains 286 Verses and it continued until the third Juz (indicated by the same red bar). We can see that four colours are used to visualize Surah Meccan and Medinan so that the start and the end of each Surah can be identified if two consecutive Surah are of the same type. Each bar can be click to navigate to the particular Surah. The displayed Surah is as in Fig. 4b.

The galaxy prototype, closely followed the study by Rennison (1994). It provides a search function and displays the search results of Juz 23 resembling the stars in the sky (the galaxy). When a particular word (in Arabic) is searched, all Surahs that contains the searched word will be displayed. Figure 5a shows the interface, the searched word is colored red in this case the word

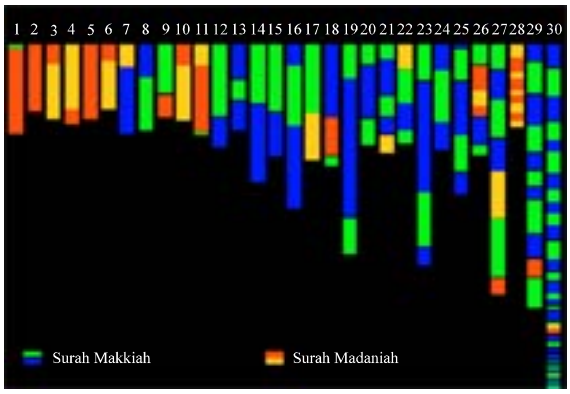

Fig. 4a: The visual directory approach

Surah Al-Falaq (113)

1 قُلْ أَعُوذُ بِرَبِّ الفلق

2 مِن شَرِّ مَا خَلَقَ

3 وَمِن شَرِّ غَاسِقٍ إِذَا وَقَبَ

4 وَمِن شَرِّ النَّفَّاثَاتِ فِي الْعُقَدِ

5 وَمِن شَرِّ حَاسِدٍ إِذَا حَسَدَ

Fig. 4b: The displayed Surah

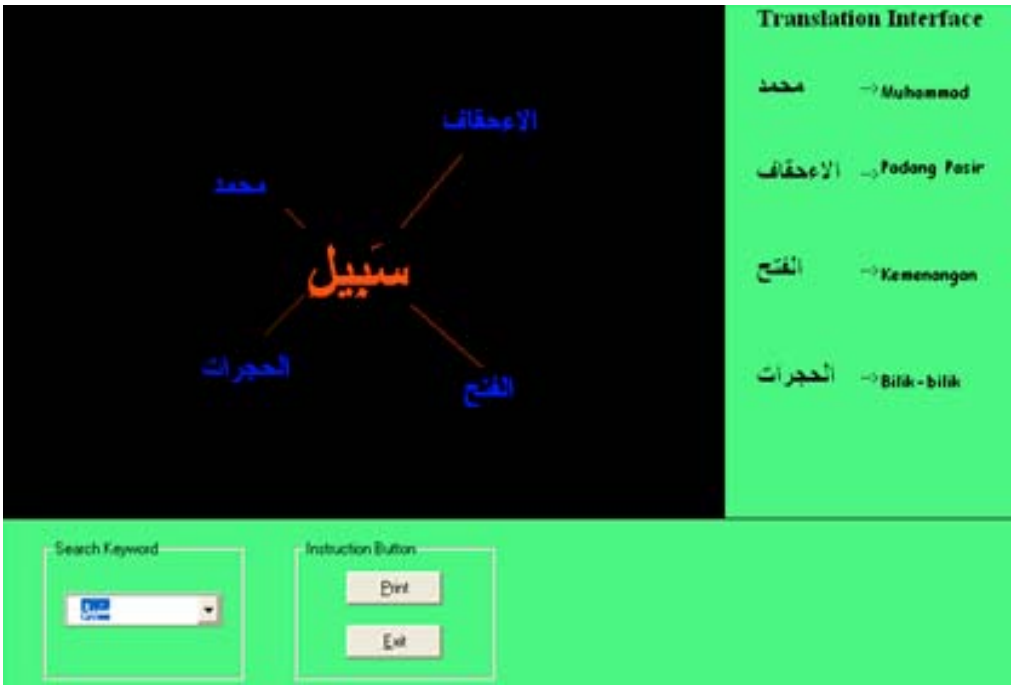

Fig. 5a: The display for the searched word (سَبِيل)

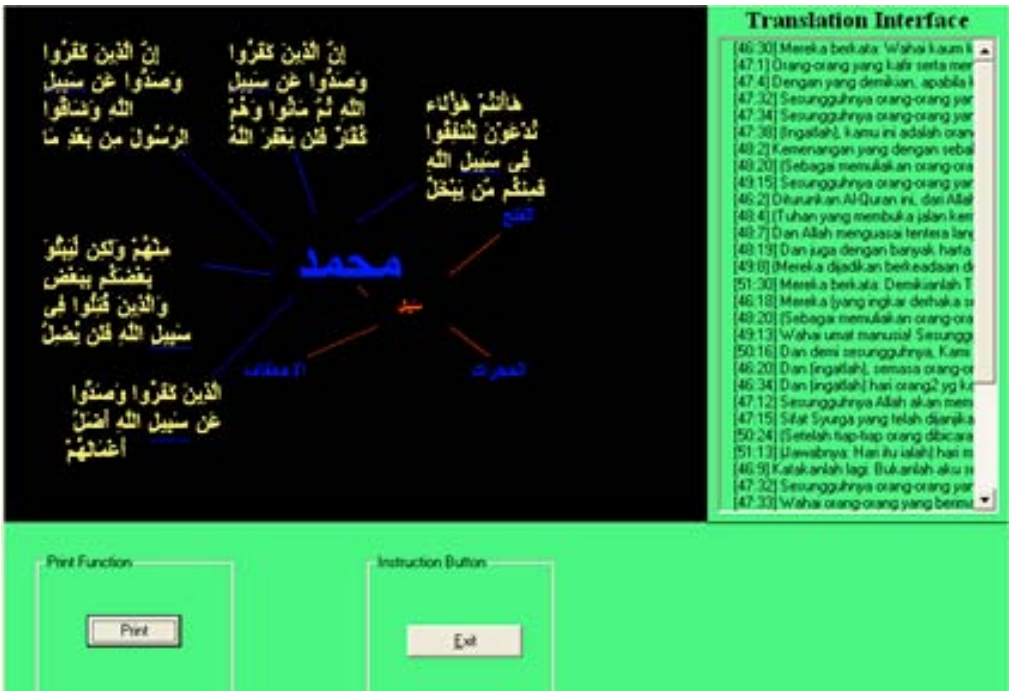

Fig. 5b: The display when one Surah (Muhammad/محمد) is clicked

(جبل) which is bigger in size whereas Surah is colored blue and smaller in size. On the right side of interface, is where the translated name of the Surah in Malay language. Once the Surah is clicked it will be bigger in size and the search word appears smaller and blended in the background.

This tells the user which image to focus on. Figure 5b shows that once the Surah is clicked, the focus is now on the particular selected Surah which display the particular Ayah/Verse that contains the searched word (جبل). The translation of the Ayah is also provided in the left hand side of the interface. If the Verse is selected, the whole Surah will appear for the user to recite. User is also provided with the Print function.

The integrated prototype provide three visualization: the scatter plot the trivariate plot and the network and connectivity plot. The search function for the system is in Malay particularly for Juz 26; it displays the frequency of occurrence for the searched words. For the scatter and the trivariate plot users are able to compare many searched words together while the network and connectivity approach only allowed comparison of two words. Figure 6a is the scatter plot approach, although it looks more like a line graph, the point scattered on the graphs were connected together rather than left as it is. Figure 6b is the trivariate plot which is actually the three dimensional image of the scatter plot. In actual fact, there is no third variable involved. The variables are the

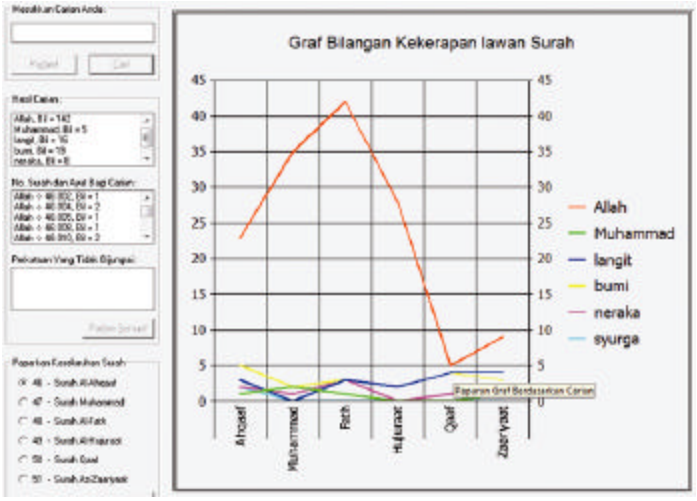

Fig. 6a: The scatter plot (left) searching the words Allah, Muhammad, Langit, Bumi, Neraka and Syurga

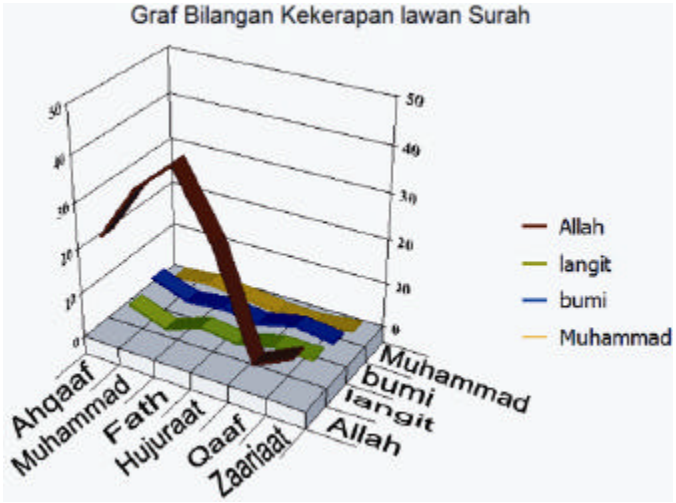

Fig. 6b: The trivariate plot (right) searching the words Allah, Langit, Bumi and Muhammad

frequency of the search word related to another variable which are the Surahs in Juz 26. The trivariate plot can be rotated manually or automatically. Figure 7a shows the network approach showing the search results for Langit and Bumi in Malay language. Figure 7b is the interface for displaying the Arabic text of the Quran and the Malay translation. Users are also able to print and save the graph or image of the searched results. In addition to that, the audio recitation of the Surahs in Juz 26 is also provided.

The comparative functional specification of the prototypes: The overall functional specifications of the prototypes covers searching function, visualization of the searched result, audio recitation, translation, save and print function, classification of Juz'/part and Surah (chapters) and classification of Medinan or Meccan. Table 3 shows the overall functional requirements that are provided by the prototypes systems. All prototypes provide the search and visualization functions. The tree structure system provides partial search functionality. Arabic text of the Quran are provided by all except the hyperbolic and tree approaches. Only the integrated prototypes provide the translation of the Quran in the Malay language. The visual directory and hyperbolic tree do not provide any translation. The classification of the Quran into Meccan, Medinan, Juz and Surah are provided by the visual directory and hyperbolic prototype.

Table 3: Overall functional requirements of the prototype systems

	Prototype			
Function	Integrated system	Directory approach	Galaxy approach	Hyperbolic approach
Arabic text of the Quran	√	√	√	√
Search	√	√	√	√
Visualization of searched result	√	√	√	√
Audio	√	×	×	×
Translation	√ BM	×	√ BM	×
Save	√	×	×	×
Print	×	×	√	×
Juz (Parts) and Surah (Chapters) class	×	√	×S	√
Medinan or Meccan class	×	√	×	√

*BM mean Malay language

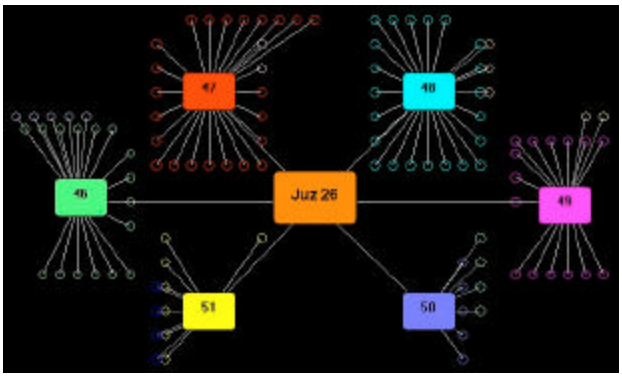

Fig. 7a: The network approach on showing the searched result for the word Allah, Langit and Bumi,

Fig. 7b: The Arabic text and the translation in Malay

THE PROPOSED REQUIREMENTS SPECIFICATIONS

The main objective of the prototype system is to assist non-Arabic speaker of the Arabic document to comprehend the Arabic document. Towards achieving the main objective, the system should also ease the users getting through the document, navigating and exploring the document without facing too much difficulty. Table 4 shows the general structure of the Quran. Based from this table and other factors the proposed functional specifications of the systems are as follows which can be translated into the use case diagram of Fig. 8:

- Visualization strategies to help understand the Arabic document
- A searching function for the document in Arabic and the supporting language (in this case Malay/English)
  - Searching words
  - Searching Surah/Ayah
- The translation of the document
- The display of the Arabic document
- The classification of the Juz (parts) and Surah (chapters) of the document
- The classification of the type of Surah (Medinan or Meccan)
- Audio recitation of the Arabic document
- Other functions such as saving and printing the document or the visual image

The proposed systems allow the user to view the Arabic document and the translation. It also provides audio recitation for users to hear the correct recitation of the Arabic document. In Fig. 11 it is proposed that visualization is provided for three modules. The first is for the document structure, the second is for the search results and the third is the content. Based from the analysis of the prototype system, it was found that visualization was used for the document structure: the Juz, Manzil, Ayah and etc. (such as the hyperbolic and directory approach) as well as for the search results (such as the scatter and trivariate plot, the network, galaxy, tree and tile approaches). These features are useful and should be included in the proposed system. In addition to that, visualization should also be provided while recitation of the document occurs assisting the users in understanding the Arabic content.

Figure 9 is the class diagram translated from Table 4. In each of the Juz, Hizb and Manzil, contains the Surah/chapter which has Ayah/Verses of the Quran. The sequence diagram of the interaction between users and the visualization image and the search function is as shown in Fig. 10. When the user clicks the visualization image of the document structure, the particular Ayah/Verse corresponding to the point of click will be extracted from the database and then displayed on the screen. When user tries to search for a particular word the word will be extracted from the database and then an image relating to the words searched to the Quran structure will be displayed. For example, if the word sky is searched, the visualization image will show all the word sky found in Juz 26. The search can be compared to several other

Table 4: The general structure of the Quran

Document structure name	Unit	Note
Juz/part	30	There is at least 1 Surah per Juz and the 30th Juz has 37 Surah
Hizb/part	60	There is at least 1 Surah per Hizb
Manzil/part	7	There is at least 1 Surah per Manzil
Surah/chapter	114	Can be of type Madaniyah or Makiyah, longest Surah:286 Verses and shortest Surah:3 Verses
Ayah/Verse	6236	Longest Verse:182 words and shortest Verse:1 word

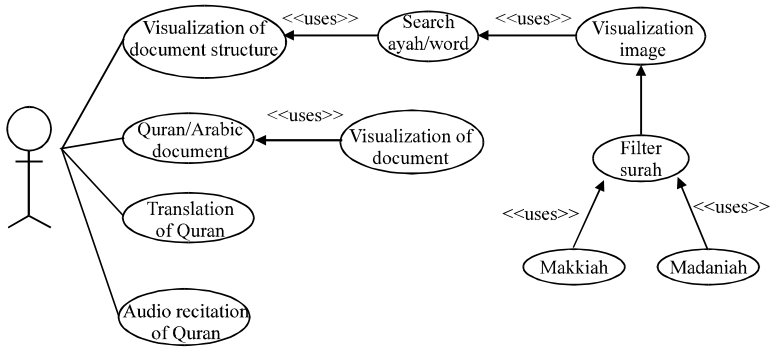

Fig. 8: Use case diagram for the proposed system

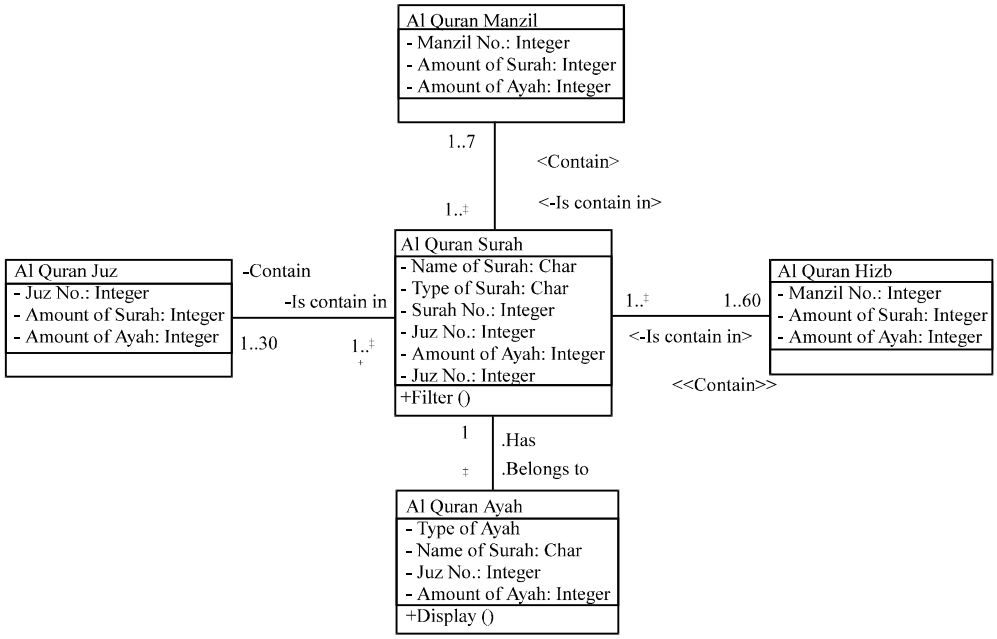

Fig. 9: Class diagram for Surah/Chapter, Ayah/Verse, Juz/Part, Manzil/Part and Hizb/Part

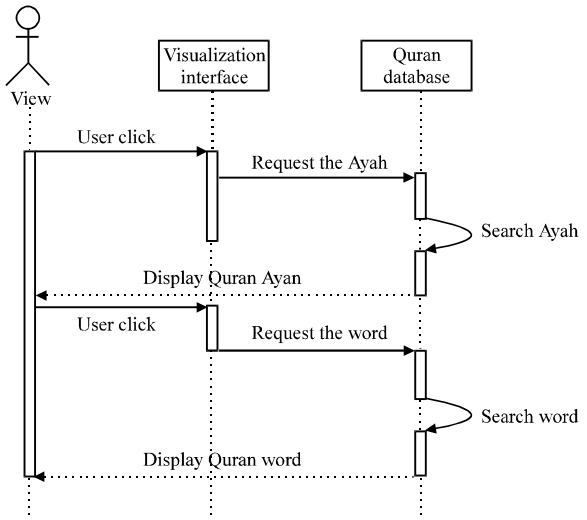

Fig. 10: Sequence diagram for user search

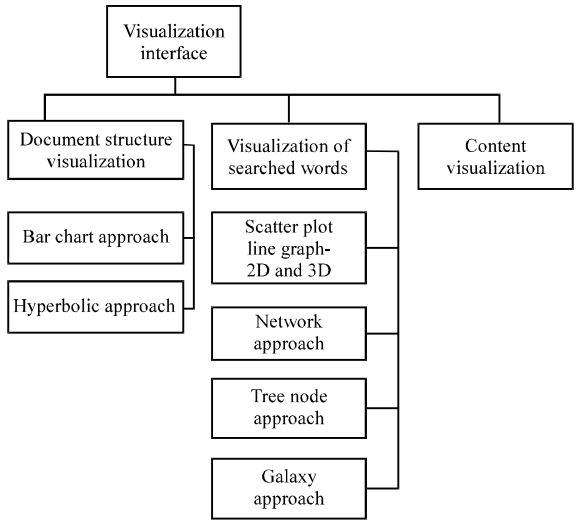

Fig. 11: The visualization strategies

searches so that users can view and compare the frequency of occurrence of the many words in the document. This feature will establish an overview to the user of the content of the document which should be useful to those who do not understand the original text in Arabic (a feature found in the prototype discussed earlier).

CONCLUSION AND FUTURE STUDY

The goal of reading is to comprehend the text being read. This is common to the majority of the reading population. However, because of purely spiritual reason, the Quran is read or recited by most of the non-Arabic speakers without comprehension. The prototypes

discussed in this study intended to assist these readers in the comprehension of the document. The strategy of solving this problem is a visualization strategy. It can also be considered as a learning tool for the Arabic language.

An Arabic document such as the Quran can be supported by a system that provide features such as visualization of the document, relating the Arabic text with it's translation, audio recitation of the document and search functions to explore the content of the document. It is also proposed that the visualization strategy should be developed on the content of the document while the process of reading takes place. Additional preliminary study on how well users perceived visualization data of the Arabic document should also be considered. Further experimental study of the visualization strategy chosen would have to be carried out within the intended user community.

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