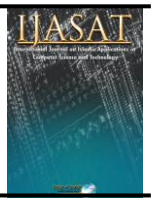

Design & Architecture of a Multimodal Interactive Quran Application for Disabled Users

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ABSTRACT
Recently, notable interest and attention has been given to the need for developing useable IT products and applications for disabled users of various types. As such, a number of conferences and research efforts have emerged worldwide with the aim of developing usable and flexible products for disabled users. Such a requirement also presents an important factor in the need to develop useable applications and products for disabled users wishing to read or learn Quran and other Islamic content in an easy manner. This paper reviews the literature on Quran and Islamic applications tailored to disabled users, and presents a flexible design, which overcomes some of the drawbacks found in previous techniques. Essentially, the proposed design is based on smart-devices and accesses multiple hardware sensors to provide users with multiple modes of interaction in order to achieve enhanced usability and flexibility, whilst avoiding many of the drawbacks found in other approaches. Some of the hardware sensors used within the multimodal application design includes; voice-interaction, head-motion interaction, device directional-movement interaction and touchscreen interaction. Finally, another notable advantage of our approach is evident in the potential scope and impact of our application for more general use with other learning content and courseware aimed at disabled users.

***Keywords*:** design and architecture, interactive smartphone application, disabled-users, multimodal application.

1. Introduction

The current era of smartphone and Internet-enabled devices has seen a huge increase in mobile and web-based learning due to the recent developments in Internet speeds and information technology, which can support faster transmission of multimedia content such as images, audio and video. Moreover, the last few years has seen significant interest worldwide in tailoring such technologies for disabled users of various types. As such, a number of conferences and research works have emerged with the goal of developing usable and flexible products for the visually impaired, the physically impaired and other users that require special needs. This requirement also encompasses efforts made by Muslim engineers, computer scientists and other technologists concerned with developing usable applications and products for disabled users wishing to read and learn Quran and other Islamic content. Hence, the objectives of this study can now be listed as follows:

- To review the literature on Quran and Islamic applications tailored to disabled users.
- To provide a discussion and analysis of some of the most related works in the domain, with comments on the main contributions made and some of the challenges that had emerged in those studies.
- To present a flexible design approach with multiple modes of operation, which overcomes some of the drawbacks found in previous techniques.

This paper presents the design and architecture of a multimodal interactive Quran application for disabled users based on smart-devices and by accessing multiple hardware sensors to provide users with multiple modes of interaction in order to provide enhanced usability and flexibility as compared with previous approaches. Following this introduction, Section 2 presents some of the related work in this area of research and Section 3 provides an analysis of the related work and includes a discussion of the challenges involved in this domain. Section 4 describes the proposed application design and architecture. Finally, Section 5 concludes the paper and outlines some opportunities for future work.

2. Related Work

Recently, a number of studies involving software and electronic devices were developed to help blind people to read the Holy Quran. For instance, Elsagheer et al. (2013a) proposed an educational environment allowing blind and handicapped people to interact with scientific materials related to Quranic content using voice commands. Google Speech API was used for this purpose. Elsagheer et al. (2013b) developed a virtual learning system (Electronic Miqra'ah) for the blind, manual-disabled and illiterate people. There is the ability to interact with the mentor in real time using voice commands in order to help memorizing the Quran, or provide guidance for error corrections, or to access Quranic lessons. The proposed Miqra'ah was based on a speech recognition engine for Arabic spoken control commands without the need for training the system. Alzubaidi et al. (2013) proposed a hands-free solution for people with physical impairments when using PCs to learn the Holy Quran by employing Microsoft Kinect Sensors. Alhaddad et al. (2013) proposed a Brain Computer Interface (BCI) system based on P300 for controlling a simplified Quran player by using the activity of the brain. It enables disabled people to play, control, and listen to Quranic recitations. Hammami et al. (2013) proposed a system that uses voice recognition of Arabic digits based on (GMM) for developing a Gaussian Mixture Model classifier as a means to respond to voice queries of an end-user. Hence, there is no requirement to display the Holy Quran pages on the navigation screen. However, it only requires the numbers of chapters and verses. Basit et al. (2013) proposed a simplified solution used for learning the Holy Quran for visually disabled persons. Basit et al. proposed a prototype exploiting the .NET framework without requiring any extra hardware device; e.g it avoids the use of hardware that does not exist in common mobile phones. Chabeb et al. (2006) proposed a WebSign software solution that enables communication with deaf and dumb users via the Web using automatic translation of written texts into sign language, embodied by a virtual avatar, employing multimedia techniques and 3D images. This solution addresses a number of problems related to sign language, which is not standardized. However, such an approach typically varies from country to country by designing a multilingual sign language application.

When classifying the related works in terms of software, it was found that there are many programs in non-Arabic languages that are used in many libraries. For instance, *Jaws* for "Job Access With Speech" has the ability to read text, images and drawings, and allows blind people to deal with the MS Office applications like Excel, Word, Access. The version 6.0 supports the Arabic language. The *Ultra Hall* Text-to-Speech reader is a software screen

reader that has been developed to act as a reader, either by using the text-pronouncing mechanism or by converting text into Braille characters which are readable online. This scheme assists the blind and other visually impaired users to pursue their educational career, carry out their functional tasks, and practice various life activities more efficiently, effectively and independently, particularly in light of the ever-increasing use of computers and its spread in most aspects of life. Hall is an easy to use software that helps a visually impaired or blind person to use a computer with ease. Accurate reading, clear pronunciation, outstanding performance, and constant development are all characteristic of this software, providing the user with a full reading of what appears on the screen while working on any application, or the Internet, which enables the user to interact with the software and the computer, and accomplish their tasks independently. *ZoomText* is a screen enlargement utility for the visually impaired; it enlarges graphics, images and even fonts to reduce visual effort to obtain information. We can find a large list of computer monitor readers for Visually Impaired users in a classification provided by Disabled World (2019).

Concerning hardware-based schemes, *Electronic line* device enables the blind to read the contents of the computer in Braille, using a notebook device with electronic lines. The device is a portable computer for the blind and visually impaired, where its advantages enable them to accomplish a variety of tasks, to cope with their different needs, in the environments of work, study or reading, and perhaps the most important of these tasks; to write, save, connect to the Internet and browse, where it provides options to derive information through reading Braille or listening through the loudspeaker so people with visual disabilities can retrieve and save what they want from the study files.

In one study, a Radio Frequency (FM) transmitter induction had provided a modified oscilloscope system used to assist beneficiaries in indoor buildings. This system provides the sound environment necessary to understand speech well. It transmits speech from the sender to the receiver. In this system, the data sender can communicate with the beneficiaries in any classroom. The transmitter can move freely within the classroom. In another study, an audio circuit device was presented for people with hearing disabilities; it offers a tool that transmits sound directly from the source to the listener's ear via a specially designed stethoscope. Sounds may be transmitted through connecting wires or over FM. It offers an easy and inexpensive solution that is easy to place in a classroom.

Input devices have been developed and made as a suitable alternative to the keyboard, using the mouse, where they are connected to the computer to make it more suitable for people with special needs, especially for those who have problems with the muscular nervous consistency or cannot hold the mouse and control. Alternative input devices include; a tracking ball which can be operated by rotating the ball directly with fingers.

3. Discussion and Analysis

Similar to normal users, people with disabilities need to use the Web and smartphone applications for their daily life activities. The Internet is one of the best tools available to people with disabilities, since audio tapes and Braille prints are expensive and sometimes not available to everyone. Despite the great possibilities of using the Web for the disabled, it has some of the obstacles that makes it difficult for such users to use the Web. Design considerations are required to make the website more accessible and user-friendly. These possibilities are still insufficient for some websites.

3.1. Technical Challenges

Many challenges and obstacles exist concerning the educational and technical means used to convey information to each category of people with special needs; assistive techniques are required to access the scientific material of the Holy Quran and its Sciences and includes:

- Developing a website and applications for Quranic sciences with voice guidance (with interactive voice commands without the use of a keyboard or mouse).
- Developing a mechanism for the recognition of spoken speech in Arabic, with high accuracy; and thereafter, developing a mechanism to identify spoken commands in Arabic.
- Processing and indexing of audio, text and visual materials (readings, interpretations, scientific content and others) and then indexed, fragmented and audited as art of an integrated library of the Holy Quran and its sciences.
- Developing an electronic reading system for learning and teaching the Holy Quran.

3.2. Assistive Techniques

Depending on the various types of disabled users, i.e. visually impaired, physically impaired, hearing impaired and other users that require special needs; different accessibility and convenience schemes are recommended as follows.

Accessibility for people with visual disabilities: including blind and visually impaired people. One effective service would be to provide an automated reader service with the possibility of shading the readable text. This service is expected to provide great assistance to those suffering from visual or dyslexia disabilities.

Accessibility for people with motor disabilities: including total or partial paralysis disabilities. An effective link shader service (e.g., when the mouse pointer passes over objects) can be used to help people with motor disabilities who have difficulty controlling accurately, and assuring them that the URL/link has been invoked correctly. This approach could reduce the need to navigate within the webpage and reduce the need to move content in different directions.
Navigating links: In general, for those who have difficulty using the mouse, the ability to rely on a few dedicated keys provides enhanced usability.

Accessibility for people with hearing disabilities: including the deaf and people with hearing impairment. Modern technologies have played an important role in activating communication with people with hearing impairments. This scenario is found particularly in the development of electronic communication skills with computers and software, with languages that include; French and Arabic. This language has been developed in the form of a program designed to help the deaf to communicate through this language using hand gestures that appear on the computer screen. It can convert written texts on websites or in files saved on the device in .txt or .doc format with facial drawings that form audio clips, words and sentences.

4. Proposed System Design and Architecture

The design and architecture of the multimodal interactive application comprises of the front-end user interface and the back-end content storage and retrieval system. Multiple modes of user interaction presents the user with the flexibility of several options for interacting with the front-end of the smart-device. Advantageously, this approach combines the benefits of several previous techniques into a single user application. Hence, it is expected that this approach shall address the requirements of various groups of disabled users. Figure 1

illustrates the concept of the proposed multimodal application consisting of four modes of operation at the front-end. The four modes of interaction includes, Fig1(a) swipe/touch-mode, (b) voice-command input, (c) head-movement mode, and, (d) device movement/rotation mode.

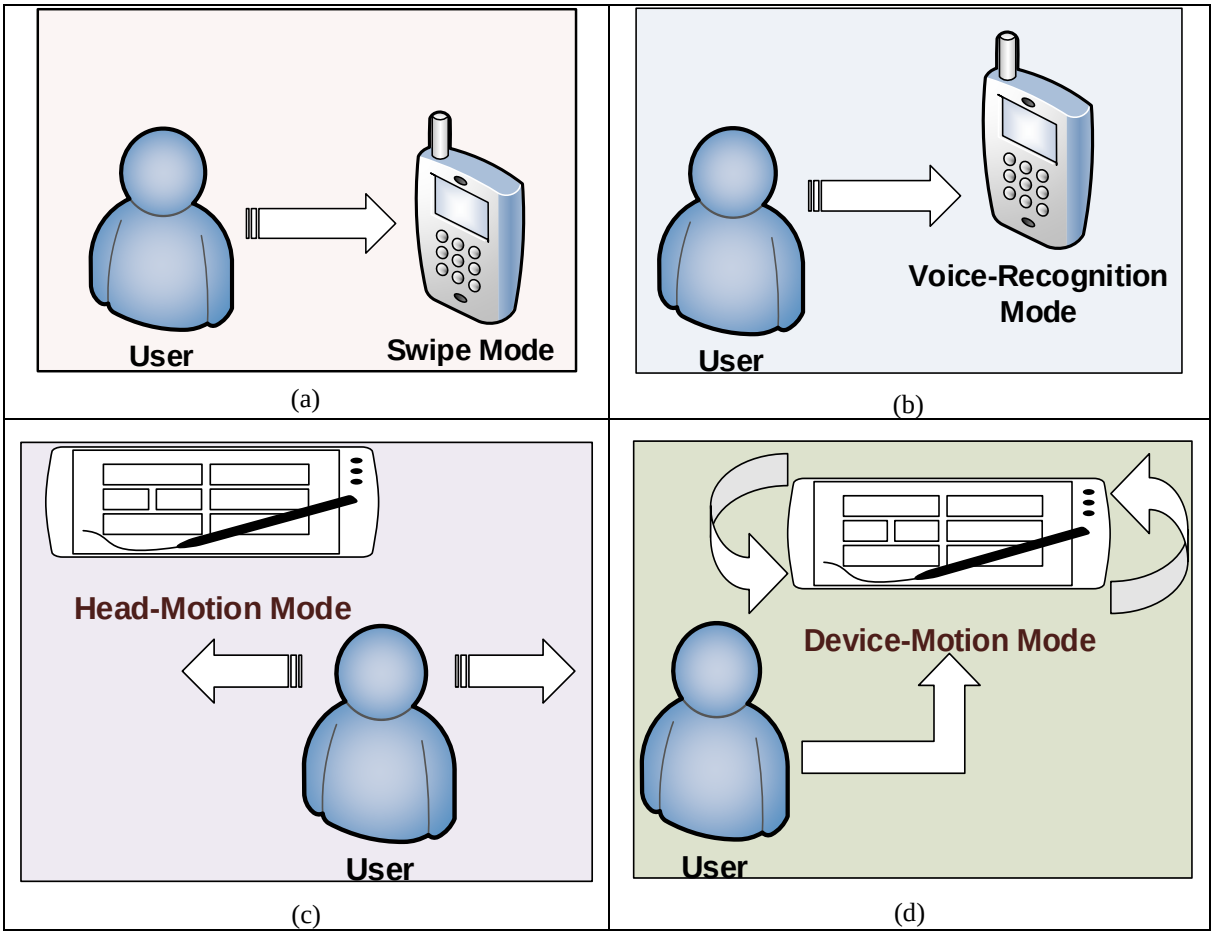

Figure 1(a-d): Summary of proposed different modes of user-interaction

User commands input using any of the four modes is used to navigate between the pages within the application itself or within the content stored in the back-end server. The different modes of user interaction can be classified into their user groups as follows:

- Swipe Mode (Fig. 1a): general user operation.
- Voice-Recognition Mode (Fig. 1b): blind and physically handicapped users.
- Head-Motion Mode (Fig. 1c): physically handicapped users.
- Device-Motion Mode (Fig. 1d): blind users.

The proposed application design can be deployed onto smartphone devices or smart-tablets, most of which generally include the required hardware sensors used in this study. The back-end server side includes the Quran and related content stored within a database. The main contribution presented here is found in the front-end interactive user-interface. In particular, known approaches used for disabled-users (e.g. voice and swipe modes of interaction) were combined with other new methods (e.g. device-rotation mode and head-motion mode) as part of a single dynamic application. Additionally, based on initial user interactions, the application can be optimized to focus on the user-selected mode of interaction for greater accuracy; e.g. other unused modes of operation can be turned-off for increased accuracy of user-commands and for battery-optimization.

5. Conclusion and Future Work

Several techniques and approaches used for assisting disabled users accessing Quran content were summarized from the related literature. Each of those approaches had particular benefits making them suitable for only a specific group of disabled-users. The originality in this work was found in the idea, which had combined some known techniques together with other new approaches for supporting larger groups of disabled users to use smart-device based Quran applications. Finally, a notable advantage of our approach was evident in the potential scope and impact of our application for more general use with other learning content and courseware aimed at various groups of disabled users. Several opportunities for future work shall consider investigating the performance and limitations of developing a hybrid multi-platform application for various smartphone platforms versus development of native applications specific to each platform. The design architecture presented here could be enhanced as part of future work by considering the design practices in Tayan et al. (2017a) and Ghembaza et al. (2018), the security recommendations for smartphone applications discussed in Tayan (2017b), and survey-based smartphone design recommendations found in Alsamarrai et al. (2013) and Zakariah et al. (2017).

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Abstract in Arabic

تصميم وبنية تطبيق قرآني تفاعلي متعدد الوسائط للمستخدمين ذوي الاحتياجات الخاصة

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الملخص: في الآونة الأخيرة دعت الحاجة بشكل ملحوظ إلى تطوير منتجات تكنولوجيا المعلومات وتطبيقات حاسوبية قابلة للاستخدام من طرف مستخدمين ذوي الاحتياجات الخاصة من أنواع مختلفة. لهذا اهتمت عدد من المؤتمرات لمناقشة الجهود البحثية في جميع أنحاء العالم بهدف تطوير منتجات قابلة للاستخدام ومرنة لهذه الفئة من المستخدمين. يمثل هذا المتطلب أيضًا عاملاً هامًا في الحاجة إلى تطوير تطبيقات ومنتجات قابلة للاستخدام من مستخدمين ذوي الاحتياجات الخاصة الذين يرغبون في قراءة أو تعلم القرآن الكريم والمحتوى الإسلامي بشكل عام بطريقة سهلة. تستعرض هذه الورقة الدراسات والأبحاث المتعلقة بالتطبيقات الإسلامية وتطبيقات القرآن الكريم المصممة للمستخدمين ذوي الاحتياجات الخاصة، وتقدم تصميمًا مرنًا يتغلب على بعض العيوب الموجودة في التقنيات السابقة. يعتمد التصميم المقترح بشكل أساسي على الأجهزة الذكية، والوصول إلى أجهزة استشعار متعددة لتزويد المستخدمين بأنماط متعددة من التفاعل من أجل تحقيق سهولة الاستخدام والمرونة، مع تجنب العديد من العيوب الموجودة في المقاربات الأخرى. بعض أجهزة الاستشعار المستخدمة في تصميم وبُنية تطبيق متعدد الوسائط تشمل التفاعل الصوتي، تفاعل حركة الرأس، تفاعل حركة اتجاه الجهاز، وتفاعل الشاشة التي تعمل باللمس. أخيرًا، هناك ميزة أخرى واضحة لمقاربتنا المقترحة في التطبيق المرتقب وأثر هذه المقاربة للاستخدام مع محتوى تعليمي آخر وبرامج تعليمية موجهة للمستخدمين ذوي الاحتياجات الخاصة.

الكلمات المفتاحية: تصميم وبُنية التطبيقات الحاسوبية، التطبيقات التفاعلية للهواتف الذكية، المستخدمين ذوي الاحتياجات الخاصة، تطبيقات متعددة الوسائط.