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A Mobile Application for Harmonized Recitation and Text Display

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Abstract: Technological advancements have facilitated the ability of numerous individuals adhering to the Islamic faith to engage in the recitation of the Qur'an through the utilization of computers and handheld gadgets. This paper presents an Automatic Qur'an Reciter, a mobile application designed to facilitate the reading, recitation, and listening of many Qur'an recitations through a single application on handheld devices. The Automatic Qur'an Reciter functions as an intermediary connecting audio recitations with their matching textual transcripts. The application's key innovation is its ability to synchronize audio recitations with their corresponding textual transcripts in real-time. As the recitation plays, the application dynamically highlights the spoken words in the text, providing a seamless reading and listening experience. The process of highlighting takes into account various elements, including the length of the text in terms of word and letter count within the chapter and verse, the speed of recitation, encompassing variations such as rapid, medium, and slow, as well as the occurrence of pauses between words and verses. The application was evaluated using heuristic testing and cooperative testing methodologies.

Keywords: Qur'an Recitation, Mobile Application, Text-to-Speech Application, Forward Engineering, Functional Requirements

1 Introduction

The use of smartphones has experienced growth in recent years. Smartphone users have shown a desire, for new applications and frequent updates to existing programs. In today's world, the open-source Android [1] mobile operating system has become increasingly popular. Google is currently responsible for the development of the Android operating system. This operating system is specifically designed to meet the requirements of touchscreen-based devices like smartphones and tablet PCs. Additionally, Android provides user interfaces tailored for devices such as televisions (known as Android TV), cars (known as Android Auto), and wristwatches [2] (known as Android Wear). Our proposed application has been developed to support Android devices. Android has a wide user base, which means a larger potential user base for our app. By targeting Android, we can reach a vast number of users across different regions. Moreover, Android provides a comprehensive set of developer tools, including the Android Studio IDE, emulator, and debugging tools, making the development process efficient and streamlined. The software design of Android prioritizes flexibility allowing developers and device manufacturers to customize and enhance it based on their needs. An example of customization is the "Automatic Qur'an Reciter," an Android application that integrates existing materials, with novel algorithms related to Natural Language Processing and the Qur'an.

The Qur'an is the holy book of Islam that was revealed to Prophet Mohammad in the Arabic language. The Quran is structured into 114 surahs that are grouped into 30 parts (chapters). Each surah contains multiple verses (ayahs), and these verses must be presented in a

[1] Philosophy and Goals. Android Open Source Project. Google http://source.android.com/source/index.html

[2] Android (operating system), From Wikipedia, http://en.wikipedia.org/wiki/Android_(operating_system)

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sequence, unchanging order. Some suras are short with a small number of verses such as Al-Ikhlas and Al-Nas, while others have a large number of verses that are also lengthy such as Al-Baqarah and Surah Al-Imran. Muslims are required to recite the Qur'an as a religious act and during prayers. Recitation enforces the following of Tajwīd rules such as Al-Idghaam (to merge), Al-Iqlaab (to swap/turn around), and prolongation [1]. Tajwīd "is a set of rules to read the Qur'an in a correct pronunciation of the letters with all its qualities while reciting the Quran." [2]. Many applications that process text in many languages such as English are available for the wider research community. Arabic is a language with fewer resources and tools for automatic processing due to many challenges such as complex morphology, syntax, and the phonological system of Arabic. Arabic text requires pre-processing tasks that include phonetics, morphology, sentence segmentation, part-of-speech tagging, semantic analysis, named entities recognition (NER), subjective analysis, and figurative analysis. Moreover, Arabic sentences can be nominal (subject-verb), or verbal (verb-subject) with free order. English sentences are fundamentally in the (subject-verb) order. This free-order property of the Arabic language presents a critical challenge for some Arabic NLP applications. Among the variety of mobile applications (i.e. android applications), the field of Automatic Processing of Arabic is poorly applied, and there are even fewer applications concerned with Qur'anic recitation. Furthermore, most of the existing ones run the same algorithm in reciting, highlighting the recited text verse by verse. Supplementary features are also the same in all of them with poor user interfaces.

We chose to build an android application that contributes to the fields of automatic processing of Arabic and Qur'anic studies. The application will automatically process Arabic text and sounds. We have chosen the problem of an automatic Qur'an recitation system to apply knowledge and understanding of the language to the Qur'anic Arabic text and the recitation soundtracks. We aim to find a link between reciting the Qur'an and the written text or script, which could be applied in the future to other Arabic speech-to-text analysis. In addition, the main function of the application is to synchronize any soundtrack of Qur'an recitation with the text of the Qur'an by highlighting the word in the text that is being read by the reciter simultaneously.

The next section will study six examples of famous Qur'an recitation systems; E-Hafiz, Imam, Keeping Holy Quran, Ayat-AlQuran, iQuran Lite and Tanzil. Section 3 will discuss the details of synchronizing Qur'an recitation sounds with the text. Evaluation of the developed Qur'an recitation system by usability will be investigated in section 4. Conclusions and future work are presented in section 5.

2 Literature Review

To help reciting the Qur'an many applications have been developed. E-Hafiz [3] is a system that can help in reciting the Quran like a Hafiz. The Hafiz is a proficient person who memorised the Quran and simulates the teacher's role in listening, and then correcting tajwid rules. E-Hafiz was useful for those who knew the tajwīd rules. In 2013 Raja-Yusof et al., [4] proposed a system to help recite the Quran in the absence of any instructor. However, the system was only verified based on certain tajwid rules for only one chapter of the Qur'an (Surah Al-Fatih Chapter 48) which consists of 560 words. Speech Recognition technology has been used to highlight the incompatibility between students' recitations and those of experts stored in the database [5]. The image-processing technique based on tajwīd's automatic rule was also proposed in 2019 [6]. Alagrami and Eljazzar, (2020a) [7] proposed an Imam application that simulates the learning process of tajwid rules between a Sheikh and a learner. After that Alagrami and Eljazzar, [2] enhanced the Imam system to be capable of recognising four different tajwīd rules (Idghām Mīm, Ikhfaa' Mīm, Takhfīf Lām, Tarqīq Lām) in audio and then determining the correctness of pronunciation. This will facilitate learning the Qur'an for Arabic and non-Arabic speakers around the world. Additionally, deep learning models are used to identify the Qur'an reciters [8,9,10,11,12].

There are many Qur'an Recitation applications available online or in Google's Play Store, with a variety of features. For example, the following applications are discussed: Keeping Holy Qur'an [13], Ayat AlQuran [14], iQuran Lite [15], and Tanzil [16]. Keeping Holy Qur'an [13] is an application that helps to read and memorize the Qur'an, it's size is only 3.4M and it requires Android version 3.2 and up. The main features of this application are:

–Verse by Verse Recitation
–Bookmarks
–Repeat verses up to 100 times to memorize it

Ayat-AlQuran [14] is an initiative that provides versions of printed Mushafs, in electronic format. It offers a replica of Mosshaf Al Madina, a version of Mushaf Al-tajwīd that incorporates color coded norms (Colored according to tajwīd rules), and a rendition of Mushaf Warš (Riwāyat Warš'an Nāfi'). The main features of this application include:

–Users can choose to repeat to listen to each verse several times according to their preference
–Users can search through the Quran text
–Users can access more than 20 translations of the Qur'an verses
–Users can listen to the translation of the Qur'an verses in both English and Urdu languages
–The position of each verse on the page is highlighted during recitation

–The interface is available, in both English and Urdu languages

iQuran Lite [15] is an Android application that offers the full Qur'an in a complete Othmani script. It allows users to read the Qur'an and its translation verse by verse. Users can listen to audio recitations for two reciters of the Qur'an. The application has features such as verse-by-verse recitation; bookmarks; the Othmani script of the Qur'an text; and an English translation of the Qur'an verses. iQuran Lite includes Quranic supplications representing a small ontology of 10 concepts such as faith, submission, thanks ... etc. It connects these concepts with the related verses. For the last part of the Qur'an, Juzzu'Amma, the application provides color-coded Qur'an text in Othmani script that shows tajwid markup to help the user read the Qur'an accordingly.

Tanzil [16] is a Quranic project launched in early 2007. The project aims to produce a highly verified error-free Qur'an text (i.e., Unicode Qur'an text) to be used in Qur'anic websites and applications. Much of the available online Qur'an text suffers from (i) missing diacritics; (ii) text conversion between Othmani and Modern Standard Arabic (MSA) script; and (iii) missing special Arabic diacritics with "Windows-1256" character set. An error-free Qur'an text can be downloaded from the Tanzil project website [3]. Users can select Qur'an text in Othmani or MSA script. They can choose to add special markers to be included with the Qur'an text such as pause marks; sajdah signs; rub-el-hizb signs and superscript or dagger 'alif. The Qur'an can be downloaded in four formats, text; text with verse numbers; XML; or SQL (MySql dumb file).

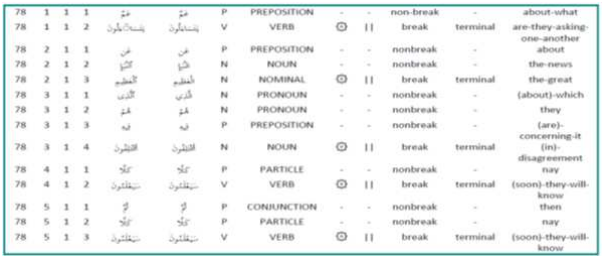
Tanzil provides an online user interface that allows users to view the Qur'an text and listen to recitation of the viewed verses. The application provides the Qur'an recitations of 26 reciters in addition to the translations of the Qur'an in many languages. The Tanzil interface has many features such as verse-by-verse recitation; play scope control; and interleaved recitation. When a user selects to play a chapter of the Qur'an, the text of the verse being recited at that time is highlighted.

However, the existing systems have the following problems: 1. Most Qur'an Recitation applications feature verse-by-verse audio playback, not word-by-word per verse. 2. GUI is poor and unattractive. 3. Application only available in the Arabic language.

The Automatic Qur'an Recitation we present aims to overcome some of these problems by:

–Providing a well-designed graphical user interface, to make it easier to use by a wider range of users
–Using a powerful algorithm (which will be discussed in the next sections), to make highlighting word by word possible
–Providing Arabic and English interfaces to make the application usable by as many users as possible.

[3] Download Qur'an text page: http://tanzil.net/download/



78	1	1	1	عَمَّ	عَمَّ	P	PREPOSITION	-	-	non-break	-	about-what
78	1	1	2	يَتَسَآءَلُونَ	يَتَسَآءَلُونَ	V	VERB	۩	‖	break	terminal	are-they-asking-one-another
78	2	1	1	عَنِ	عَنِ	P	PREPOSITION	-	-	nonbreak	-	about
78	2	1	2	ٱلنَّبَإِ	ٱلنَّبَإِ	N	NOUN	-	-	nonbreak	-	the-news
78	2	1	3	ٱلْعَظِيمِ	ٱلْعَظِيمِ	N	NOMINAL	۩	‖	break	terminal	the-great
78	3	1	1	ٱلَّذِى	ٱلَّذِى	N	PRONOUN	-	-	nonbreak	-	(about)-which
78	3	1	2	هُمْ	هُمْ	N	PRONOUN	-	-	nonbreak	-	they
78	3	1	3	فِيهِ	فِيهِ	P	PREPOSITION	-	-	nonbreak	-	(are)-concerning-it
78	3	1	4	مُخْتَلِفُونَ	مُخْتَلِفُونَ	N	NOUN	۩	‖	break	terminal	(in)-disagreement
78	4	1	1	كَلَّا	كَلَّا	P	PARTICLE	-	-	nonbreak	-	nay
78	4	1	2	سَيَعْلَمُونَ	سَيَعْلَمُونَ	V	VERB	۩	‖	break	terminal	(soon)-they-will-know
78	5	1	1	ثُمَّ	ثُمَّ	P	CONJUNCTION	-	-	nonbreak	-	then
78	5	1	2	كَلَّا	كَلَّا	P	PARTICLE	-	-	nonbreak	-	nay
78	5	1	3	سَيَعْلَمُونَ	سَيَعْلَمُونَ	V	VERB	۩	‖	break	terminal	(soon)-they-will-know

Fig. 1: A sample of the BAQ corpus version 1.0

3 Algorithm Approach and Implementation

Most of the existing systems provide sound-to-text synchronization by splitting the sound files of the recitation into smaller chunks. Each chunk contains the recitation of only one verse. When the user selects a verse, the matching sound file of that verse is played. There is no automation done for sound-to-text synchronization in most of these systems. The Challenging and novel part of this project is to develop a new algorithm for sound-to-text synchronization based on:

1.The word and letter frequency of the recited chapter
2.The length of the soundtrack
3.Recitation style
4.Tajwid rules

The algorithm will highlight individual words being recited rather than highlighting the recited verses. This section will discuss the sound-to-text algorithm in detail. It will cover text and sound data preparation as inputs for the algorithm; the algorithm itself; and the interface and the functionality of the Qur'an Reciter application.

3.1 Data Preparation

Textual and audio data are prepared to serve as inputs for the sound-to-text synchronization algorithm. Textual data is prepared using the boundary annotated Qur'an (BAQ) dataset for machine learning [17,18]. The BAQ corpus provides prosodic and syntactic information. Figure 1 shows a sample of the BAQ corpus version 1.0.

The BAQ corpus is stored in a tab-separated column file where each word in the Qur'an is stored in a line. The first four columns indicate the index of the word (i.e. word's position) in the Qur'an. These are chapter, verse, sentence, and word numbers respectively. The Arabic script of the word is defined in a decorative Othmani and MSA (Modern Standard Arabic) script given in the fifth and sixth columns respectively.

Syntactic information is presented in the seventh and eighth columns. A PoS (Part-Of-Speech) tag is assigned to each word in the corpus. These tags are limited to three PoS tags noun, verb, particle. The eighth column expands

the three PoS tags into more detailed PoS tags of 10 categories nouns; pronouns; nominals; adverbs; verbs; prepositions; lam prefixes; conjunctions; particles; disconnected letters.

Prosodic information is presented in the next four columns. Column nine indicates the tajwid boundary symbols as presented in the Qur'an. Column ten shows each word classified via the boundary category as {major, minor, none} represented by different symbols to denote pauses, defining tone units, and defining non-breaks. Column eleven classifies words into a binary classification of break or non-break. The last column of this group indicates the sentence terminal. The last column in the dataset represents a word-for-word English Translation.

The algorithm will use the MSA text and the prosodic information from the BAQ corpus. Syntactic information and translation will be integrated in later releases.

Audio files were collected randomly from available resources for Qur'an recordings. Audio files are in mp3 format. A collection of mp3 audio recordings from three famous Qur'an reciters was selected. These audio files are used mainly for implementing and testing the algorithm. In the final implementation of the Qur'an reciter application, users can select their favorite reciter. The algorithm synchronizes the selected audio recording with Qur'an text.

3.2 Sound-to-text Synchronization Algorithm

The sound-to-text synchronization algorithm is designed to match the audio recordings of the Qur'an with the text of the chapter being recited. It highlights the word being recited. The process highlights the text of the recited chapter word by word at the same time as these words are being recited. Provided that the mp3 audio files do not have any kind of synchronization information. The task done by the synchronizing algorithm is based on formulated calculations.

The algorithm processes the input audio mp3 file and finds its duration. The text of the chapter being recited is retrieved from the BAQ corpus and displayed in the application interface. The algorithm simply calculates the number of words in the recited chapter. Then the duration of a single word is found by dividing the duration of the audio mp3 file by the number of words in the chapter. The following formula is used to calculate the duration time of a single word in the recited chapter.

$$T(Word) = (T(mp3))/(Numberofwordsinthechapter) \quad (1)$$

Where: T(word) is the calculated duration time for a word and T(mp3) is the duration time of the audio mp3 file.

This formula was used initially to calculate the duration of a word. The duration time of a word is the same duration time needed to highlight a word. Due to the variation of word length in the recited chapter and the time of pauses, equation 1 did not produce accurate results for highlighting the recited words. The next release of the application will modify the formula to include the prosodic information provided by the BAQ corpus.

The algorithm was modified by manually providing information about the duration time for each verse. We listened to the audio mp3 files, and we registered the start time and the end time for each verse. The following formula used this information to calculate the duration time of a single word in the recited verse.

$$T(Word) = \frac{T(end) - T(start)}{NumberOfwordsInTheVerse} \quad (2)$$

Where:

–T(word) is the calculated duration time for a word
–T(start) is the start time of the verse
–T(end) is the end time of the verse

Equation 2 eliminates the time spent on pauses between verses. However, it divided the duration time of the verse equally for each word in the verse which does not consider that words in the recited verse vary in length. The next release of the Qur'an reciter application will depend on the length of words in terms of the number of letters that constitute a word. The next release also will use prosodic information represented as pause marks and included in the BAQ corpus.

The algorithm was further enhanced to calculate the time spent on each word precisely by taking into account the number of letters in each word. The below equation was used to calculate the highlight time for each word in a verse.

$$T(Word) = \frac{T(end) - T(start)}{NumberOfwordsInTheVerse} X\#letters/word \quad (3)$$

The Qur'an reciter application provides information about the selected chapter being recited. This information includes the chapter name and number, the number of verses in the chapter, and the category of the chapter classified as Meccan or Medinan.

3.3 Graphical User Interface (GUI) Implementation

The GUI builds the human-machine interface of a system for efficient interaction with the user. A well-designed GUI can free the user from learning complex commands to accomplish a certain task. The Qur'an reciter application's interface was designed to allow users to easily interact with the application. It allows easy use because it requires less experience and training. The GUI of the application is also designed to be simple and with fewer dialog screens. Figure 2 shows the Qur'an reciter application interface for the general task of reciting a selected chapter.

Fig. 2: The Qur'an Reciter Application GUI. (a) Welcome screen, (b) Reciter selection screen, (c) Chapter selection screen, (d) Text-to-sound synchronizing screen (recited words are highlighted in red)

4 Testing and Evaluation

The testing and evaluation of the Qur'an recitation application were conducted to assess and ensure that the application meets the functional and non-functional requirements of developing a good software application. Testing and evaluation of the application is considered a verification and validation process. Verification and Validation (V&V) tests are designed and implemented to find defects and correct them before the release of the application. Following a system testing approach will assist in mitigating risks and ensuring a successful project. System testing is divided into various levels including (i) unit testing; (ii) system testing; and (iii) acceptance testing. They are all performed during the testing phase of the project. Unit and system testing are performed by the testing team and developers, whereas acceptance testing is done by the end user.

4.1 Heuristic Evaluation

The researchers employed heuristic evaluation as a method to assess the usability of the program and detect any issues pertaining to the design of the user interface. The process entails evaluators thoroughly studying the interface and assessing its adherence to established usability guidelines. The heuristic evaluation techniques were employed by a panel of four Information Technology (IT) specialists to assess the interface of the Qur'an Recitation application.

To achieve a highly precise heuristic evaluation, a comprehensive system of severity ratings was devised to assess the impact of each issue encountered within the application. Table 1 presents the severity ratings, while Table 2 provides a summary of violations categorized by heuristics. The utilization of cooperative evaluation serves as a method to enhance the quality of a user interface specification by identifying potential usability issues within an initial prototype. The evaluation method incorporates the user as an engaged participant.

Table 1: Severity Ratings and their Descriptions.

Severity rating	Description
0	No effect problems: I don't agree that this is a usability problem at all
1	Cosmetic problem only: need not be fixed unless extra time is available on the project
2	Minor usability problem: fixing this should be given low priority
3	Major usability problem: important to fix, so should be given high priority (loss of sub-function) Text follows
4	Usability catastrophe: imperative to fix this before the product can be released (loss of main function) Text follows

Table 2: Summary of Violations by Heuristics.

Heuristic numbering schema	Frequency	Ratio (%)
H1	1	4.54
H2	3	13.63
H3	2	9.09
H4	7	31.81
H5	3	13.63
H6	2	9.09
H7	4	18.18
Total	22	100%

Table 3: Summary of Valuations by Severity Rating for Participant 1

Severity rating	Frequency	Ratio (%)
0	2	100%
1	0	0
2	0	0
3	0	0
4	0	0
Total	2	100%

Table 4: Summary of Valuations by Severity Rating for Participant 2

Severity rating	Frequency	Ratio (%)
0	18	81%
1	3	14%
2	0	0
3	1	5%
4	0	0
Total	22	100%

Table 5: Summary of Valuations by Severity Rating for Participant 3

Severity rating	Frequency	Ratio (%)
0	14	63%
1	5	23%
2	3	14%
3	0	0
4	0	0
Total	22	100%

As Tables 3, 4, and 5 showed, the participants found our proposed application usable. The ratio of severity rating 0 (No effect problems: I don't agree that this is a usability problem at all) was 100%, 81%, and 63% for participant 1, participant 2, and participant 3 respectively.

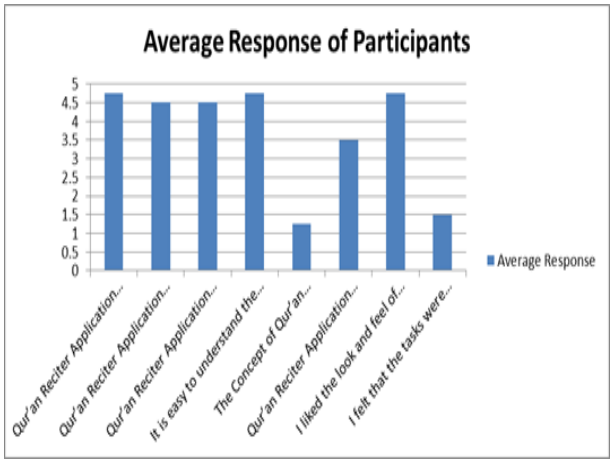


Fig. 3: Participants Responses to the Post-Test Questionnaire

4.2 Cooperative Evaluation

To conduct the Cooperative Evaluation for the Qur'an Recitation application, four participants were selected randomly. Participants were guided to perform the cooperative evaluation test by running the application and filling in the form with the required information needed to perform the test. The default time needed to perform 7 tasks in the application was defined. Then, these default times were compared with actual completion times for participants. The result of comparisons showed that the default time for completion of the 7 tasks was 18 seconds while it took the four participants on average 11 seconds to accomplish the task.

To collect comprehensive information that can be evaluated and subsequently used to improve conditions pertaining to the application, participants were asked to fill in a post-test questionnaire. This questionnaire captures the participants' opinions about the application. The questionnaire consisted of 8 questions. Participants were asked to evaluate each question with a score between 5 (highest) to 1 (lowest). Table 6 summarizes the questions and the achieved scores of the questionnaire. Figure 3 summarized the archived results.

As Table 6 illustrates, most of the participants agreed that our proposed application is easy to use and has an interactive interface. All the participants were satisfied about the Graphical User Interface of the application. Moreover, all the participants agreed that no prior experience is needed to use our application.

Table 6: Participants Responses to the Post-Test Questionnaire

No.	Statement	P1	P2	P3	P4	Average
1	Qur'an Reciter Application is easy to use	5	5	4	5	4.75
2	Qur'an Reciter Application has accomplished its goals	4	4	5	4	4.5
3	Qur'an Reciter Application Interface is Interactive	5	5	5	4	4.5
4	It is easy to understand the functionality of the Application without prior experience	4	5	5	5	4.75
5	The Concept of Qur'an Reciter Application was difficult to understand	2	1	1	1	1.25
6	Qur'an Reciter Application felt complete	3	3	4	4	3.5
7	I liked the look and feel of the tool	4	5	5	5	4.75
8	I felt that the tasks were difficult to complete using the application	2	2	1	1	1.5
	Average	3.63	3.75	3.75	3.63	3.63

5 Conclusions and Future Work

This paper presented the development and the algorithm for implementing a novel Qur'an recitation application. The paper presented and studied the existing Qur'an websites and applications that implement some functionalities of Qur'an recitation applications. None of

the existing applications implements any kind of sound-to-text automatic synchronization that highlights the words being recited. We have developed a novel algorithm that automatically synchronizes the sound from mp3 audio recordings of the Qur'an and the matching text of the recited chapter. Words of the recited chapters are highlighted word by word alongside the audio recording being played. The algorithm depends for its textual data on the BAQ corpus which provides textual, syntactic, and prosodic information needed to calculate an approximate duration time for each word of the recited chapter. The application was tested and evaluated for usability using heuristic and cooperative tests. These tests were carried out by potential users of the application. The users tested the application and answered the questions of the tests. Acceptable results were gained from the different types of tests.

This version of the Qur'an Recitation Application only used word counts to estimate the duration time of each word within a recited chapter. The next release of the application will use letter frequency, tajwid rules, and syntactic and prosodic information provided by the BAQ corpus. We expect an accurate estimate of the duration time for the recited words. The sound-to-text synchronizing algorithm was successfully applied to the Qurian. For future work, we will apply our proposed algorithm to synchronize films' subtitles and songs' lyrics.

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