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ARABIC TEXT TO SPEECH SYNTHESIS USING QURAN-BASED NATURAL LANGUAGE PROCESSING MODULE

[1]BANA ALSHARIF, [2]RADWAN TAHBOUB, [3]LABIB ARAFEH

[1]Researcher, Deanship of Scientific Research, Palestine Polytechnic University, PS

[2]Asstt Prof., Department of Computer Engineering, Palestine Polytechnic University, PS

[3]Assoc. Prof., Department of Computer Engineering, Al-Quds University, PS

E-mail: [1]bana_alsharif@yahoo.com, [2]radwant@ppu.edu, [3]larafeh@eng.alquds.edu

ABSTRACT

Natural Language Processing (NLP) Module for Arabic Text to Speech is introduced in this paper. It's a module from our integrated design for Arabic named as Holy Quran Based- Arabic Text to Speech (HQB-ATTS). HQB-ATTS system is implemented using some Tajweed rules that are used in Standard Arabic. Through this paper, new ideas are adopted and discussed in order to increase the quality of Arabic Text-to-Speech (ATTS). The innovations that have been applied in NLP module are: the use of some of Tajweed rules to build better letter to sound module, the combination of Arabic Prosody with allophone /syllables slots is a new use for a technique supported the linguistic property for Arabic, and the quality evaluation for the NLP module is performed in new method to proof the success for our hypothesis in comparison with other up-to-date approaches. The results show that this HQB-ATTS approach can significantly enhance the quality of the synthesized speech. The evaluation showed that this approach could produce a better synthesized speeches' quality than comparative ATTS synthesizers.

Keywords: *Text to Speech (TTS), Natural Language Processing Module (NLP), Tajweed Rules, Prosody Syllabification, Evaluation.*

1. INTRODUCTION

Although significant effort had been done in ATTS in last decades, the produced Arabic synthesis speech is still underestimated. The understanding of the work had been done should help in increasing the quality of this synthesis speech. In more precise terms, a need for an overall study and details ones for ATTS are missed for researchers and need a huge work to introduce it, such that better results can be achieved in ATTS.

Simulating the articulatory of human speech system with hardware machines was started in the 18th century [1]. Passing through the discovery of electricity in the early 20th century, TTS systems were developed by using it and became more natural by allowing software approaches [2]. For Arabic language in specific, it has become an interesting field for few researches through publishing the Speed Assessment Methods Phonetic Alphabet (SAMPA) for Arabic in 1997 [2] [3]. Researches in Arabic TTS were done for the syllables, diphones, di-diphones, phonetics, phonemes, morphologic and grammar in Arabic. The researchers vary in introducing a completed synthesizer, or specific in NLP module, or in DSP module. All of them aim to improve the quality of the Text-to-Speech (TTS) synthesizer depending on the overall system or partitions. At the beginning of 21th century, the Arabic TTS became an important field research [4]. This paper introduces a novel approach for NLP module in the area of the ATTS.

2. TEXT-TO-SPEECH SYNTHESIS

TTS is the major framework of producing a voice from text. It is an automatic pipeline starting from the text through grapheme to phoneme (letter-to-sound) transcription of the sentence that ends with utters sounds [1] [3].

The general block diagram for TTS synthesizers is as shown in Figure 1. TTS synthesizer consists of two main modules: the Natural Language Processing (NLP) module and the Digital Signal Processing (DSP) one. NLP module deals with the conversion of the sentences from the text form into the pronunciation one [5]. NLP could be

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composed of text analysis stage, Letter-to-Sound (LTS) Module (called Grapheme-to-Phoneme stage) and the prosody generation stage. DSP module, is the next step follows the NLP module that generates the speech. The input for DSP is the symbolic linguistic units in the form of phonemes, which are NLP outputs. DSP can be implemented

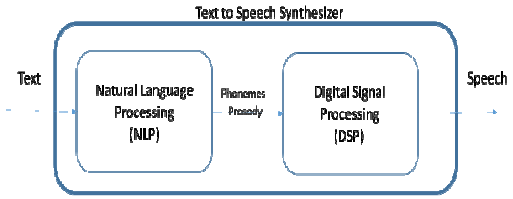

Figure 1: General TTS System [4]

using various methods such as Articulatory Synthesis, Concatenating Synthesis and Formant Synthesis [6].

Along with the recent increasing demand on TTS application, many research works have been accomplished in this area. The range of applications for a TTS system varies from simple to complex ones, such as: Aid to handicapped, telecommunication services, language education, man-machine communication, vocal monitoring …etc. [1] [3] [6] [7].

3. LINGUISTIC PROPERTIES FOR ARABIC PHONETIC

Linguistics refers to the scientific study of language including form, language meaning, and language in context. The linguistic nature of Arabic sounds must be fully understood in order to implement these features in automatic systems. The scope of this work concentrates on producing high quality TTS synthesizers based on the features included in pronunciation Standard Arabic (SA). SA is chosen for this work because it is the comprehensive class for all Arabic worlds. In addition, some rules in Tajweed (التجويد) in Quran recitation can be applied in SA as well [8].

The Arabic alphabet consists of 28 letters known as Hijaiyah letters "الاحرف الهجائية". The Arabic alphabet is written from right to left and there is no upper and lower case. There are twenty-eight Arabic consonant sounds, twenty-six of which are always consonants, but two (/w/: waaw "و", and /y/:yaa' "ي") are semivowels that can be consonant or vowels depending on the context and diacritic. Indeed, the linguistic nature of these Arabic sounds must be understood in order to implement these features in automat systems. There are six vowels in Arabic (3 short and 3 long). The short vowels are Fatha (ُ), Damma(ِ), and Kasrah(ٔ). Arabic long vowels are (alef "ا"/a: /, waw "و" /u: /, and yaa"ي" /i: /) [2] [3].

Arabic language is considered as a regular language with relatively few numbers of exceptions. Therefore, the suggested method for some Arabic researches is the rule-based method [9]. Rule-based method is a set of pronunciation rules that are applicable to words in order to determine their pronunciations based on their spelling [1].

Most research follow the theoretical proposals of McCarthy [10], which handles the theoretical challenges of Arabic morphological system poses to traditional linear theories by proposing the separation of the consonantal root and the vocalism. The consonants and vowels are mapped into the CV slots. The substitute of "c" refers to a consonant and the "v" refers to short vowel and the "vv" or "w" to long vowel. They can be written in capital or small English letters. As an example word "كَتَبْ" is presented in phonetic transcription as SAMPA assessment is "Katab", and the CV template is "cv-cv-c". This morphological analysis is used in syllabication [2] [3] [9]. Syllabification templates in TTS conversion are important because it helps in the implementation of letter-to-phoneme transcription, and it is essential in enhancing the quality of speech produced by synthesizers [2] [3].

In this research, the mentioned CV slots are applied based on Prosody Science. Al-Khalil Ibn Ahmad Al-Farahidi was the founder of Arabic Prosody Science ((علم العروض [11]. His "Kitab al-Ayn" was the first dictionary ever written for the Arabic language. In his Al-Ayn book an interesting definition for the smallest phonetic unit, he called it syllable and it is either short (ب) or long (-). Arabic prosody which is the science dealing with the patterns of sounds and rhythms in poetry. In Arabic prosody, the meter is based on syllables. The combination of Arabic Prosody with syllables slots is a novel technique in our research.

4. HOLY QURAN-BASED ARABIC TEXT-TO-SPEECH

The Holy Quran-Based Arabic Text-to-Speech (HQB-ATTS) approach is designed and

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implemented in our research aimed to increase the quality of ATTS Synthesis. HQB-ATTS is divided into two parts, the standard NLP module and the standard DSP module. The input of the HQB-ATTS system is a full diacritic Arabic text, and the output from this system is an Arabic synthesized speech. The implementation of Prosody Syllabification with Tajweed rules, which are inherited in a Quran recitation and based on Arabic allophones, are suggested to enhance the quality of the synthesized speech. The resulted speech naturalness is increased to an expected level as suggested by the work hypothesis

The main objective of this work is to increase the naturalness of the synthesized Arabic speech. Therefore, this approach introduces the Tajweed rules with real Quran recitation in order to increase the quality of ATTS. Tajweed rules cover all the letters in Quran recitation, also they are complete and well-defined [8]. These facts candidate Tajweed rules to be implemented in ATTS. Despite that, the rules in Quran recitation are more than those followed in regular SA, the pronunciation rules "مخارج الحروف" still the same. The Quran recitation differs from any SA reading because it has two exclusive rules: "الغنة و المد" [5] [12]. The sanctity of the Holy Quran prohibits the readers from using all the rules in reading classical Arabic text. The desired objective of this work is not to make a Quran synthesizer but to increase the efficiency of ATTS by using Quran recitation. It is also necessary to avoid reading regular Arabic text by using the same melody that is used in the Quran. Thus, the implemented rules from Tajweed are only those compatible with SA. A novel approach, in this research, is to implement the Tajweed rules, which are matched with SA reading in sufficient organization without the need for loops [5]. The rules that are used in Elothmany [2], El-Imam [3]and Al-ghamdi [4] are used and upgraded with additional rules.

The implementation of HQB-ATTS follows the following assumptions:

- "Tajweed rules increase the ability of speaking Arabic proficiently even not in Quran" [8].
- "The smallest unit in Arabic is Prosody" [11]
- The suggested segmentation unit for Arabic based on Arabic linguistic features in this work is allophones. Simply because it is a single phoneme with features and vowel [4] [5].

Tajweed rules are suggested here to implement LTS model and Arabic Prosody Science (علم العروض) in order to perform syllabification in NLP. Prosody Science segmentation is used also in segmenting the syllables while building the database.

The proposed HQB-ATTS block diagram with its data flow is shown in figure 2. In this approach, the allophonic/syllabic units that are taken from the text are extracted using Quran Tajweed rules. The implementation of LTS module is done by using Tajweed rules to build rule-based system with an exceptions' table.

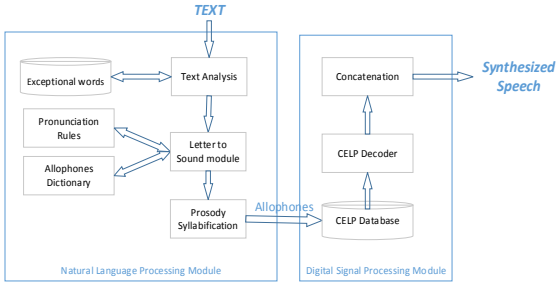

Figure 2: Block Diagram For HQB-ATTS

First, the input is Arabic diacritic text, which is analyzed to extract the exception words from it and to replace them with phonemic transcription. Then, Prosody syllabification is performed on the whole sentence. The purpose of syllabification is to be used in LTS module and with Arabic allophones to estimate the allophonic/syllable units. After the Prosody syllabification is completed, searching for these units in the database (audio and CELP databases are built) by selecting syllable waves files should be done. And the final step is concatenating these files to produce the synthesized speech. The database is built by manual segmentation and notation for verses and then by labeling them with their allophonic/syllable names. The CELP database is built by encoding the segments of Quran recitation using CELP.

5. NATURAL LANGUAGE PROCESSING MODULE

In the NLP module, as its name reflects, processing is done within the natural language. In this case, the input is a full diacritic Arabic text. On the other hand, the output is the allophonic/syllable segmented units. The NLP

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module consists of Text Analysis, Prosody Syllabification and letter to sound ruling blocks.

5.1 Text Analysis

Handling the exceptional words is the concern of this part of the algorithm. The exceptional words are those words that are pronounced in a way that is different from how they are written in regular pronunciation language. Arabic is a regular language that is mostly pronounced as it is written [6]. Using a rule-based system that is mixed with a table for exceptional words is the best combination for Arabic [3]. The search in the table will be sequential and acceptable because of the small size of the table. The algorithm is close to the one for Elothmany [3], but there are some exceptional words that are taken from the Al-Gamidi et al. [4]. The table of the exceptional words is built manually as shown in Table 1.

5.2 Letter-to-Sound Rules

Letter-to-Sound (LTS) phase or Grapheme to phoneme is done by using a set of rules; which are estimated from some linguistics study of Arabic. The advantages for rule-based system are the small memory size that is needed and the adaptation with new words. Regular pronunciations for Arabic language make the LTS to be selected to be used in the implementation of ATTS [2] [3]. In this approach, the set of rules are collected from Tajweed rules and then they are reordered.

In HQB-ATTS rule system, the rules are ordered in an optimized way to fit the sentence without loops and to fit the sentence in a matching way with all the cases. The rules are programmed using Matlab(R2013b) environment. The grapheme to phoneme conversion contains sequential procedure calls without looping. The general algorithm for HQB-ATTS letter-to-sound conversion is shown in algorithm 1. From Arabic Tajweed rules, Arabic linguistics and Al-ghamdi [4], Table 2 is created and it introduces the rules with a description and an example in order to be implemented in algorithm 1.

Table 1: Exceptional Words

Exceptional word	Phonemic transcription	Exceptional word	Phonemic transcription
إله	/إلاه/	لكن	/لاكن/
أولو	/أُلو/	لِكَيْ	/لِكَيْ/
أولئك	/أُلائك/	الله	/اللاه/
باسم	/بِسم/	□للهم	/اللاهم/
□لتي	/اللتي/	هأنتم	/هاأنتم/
□ود	/داوود/	هٰذَا	/هاذا/
ذلك	/ذالك/	هٰذَا□	/هاذا□/
ذلكم	/ذالكم/	هذه	/هاذه/
□لذي	/اللذي/	هذين	/هاذين/
□لذين	/اللذين/	هكذَا	/هاكذا/
□لرحمن	/الرحما□/	هؤلاء	/هاؤلاء/
□لسمٰوات	/السماوات/	هِي	/هِي/
طه	/طاها/	يسين	/يا□ين/

Algorithm 1: Letter-to-Sound Algorithm

Input: Normalized Diacritic Quran verse/sub-verse
Output: allophone text for the sentences
Begin
  Chopping text to allophones
  Apply Geminate rule
  Apply Alef rule
  Apply Alef maqsoora rule
  Apply Ta' marboota rule
  Apply delete lam shamsiah rule
  Apply Tanween rule
  Apply Hamza mamdooda rule
  Apply Hamza rule
  Apply Confluence dwells
  Apply Congener rule
  Apply Lam r ule
  Apply Ra' rule
  Apply convert long vowels to short vowels rule
  Apply last vowel in sentence rule
End

5.3 Syllabification Process

In this part of the work, a direct Prosody syllabification is done for the complete verse (called a sentence). Syllabification means partitioning the words into units, each unit is called syllable and it is either short or long. In this description the sign (c) is given for the short syllable, and (-) for the long syllable. The algorithm for Prosody syllabification is introduced in Algorithm 2. A short syllable (c) is made up of a consonant followed by a short vowel. Long syllable has one of the two following

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patterns: A consonant followed by a long vowel or consonant with a short vowel followed by a consonant.

Algorithm 2 : Syllabification Algorithm

```
Input : allophones text for the sentences
Output : String contains the syllables of the phonemes
For each Diacritic-Arabic-phonemes
Begin
while not end of sentence
read char
If char++ is  (a: or u: or i:) or holds "ْ" then cut  (char,
        char++) as long syllable and char++
else cut (char) with its diacritic as short syllable
char ++
end if
end while
End
```

The syllabification processes for an example: هَذا مِنْ مَسْؤولِيَّات دافِعُ الضَّرائِبِ , passes the following steps:

Phonetics: /ha:Da: min mas?u:lijja:ti da:fi?'i d'd'ar'a:?ib/

Phonemes: /ha:/ /Da:/ /min/ /mas/ /?u:/ /lij/ /ja:/ /ti/ /da:/ /fi/ /?'id'/ /d'a/ /ra:/ /?'ib/

Prosody syllabification: - - - - - - - c - c - c - -

Notation depends on Prosody syllabification. Figure 3 illustrate the manual syllabification for a verse "تبارك الذي بيده الملك وهو على كل شيء قدير". For less than 8 seconds, accurate cut for 24 syllables has been done, such that those syllables can be used in coming concatenations.

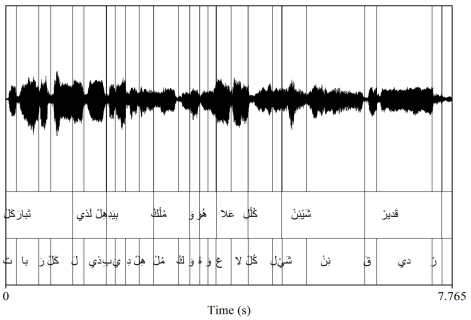

Figure 3: Prosody Syllabification And Notation For "تَبارَكَ الذي بِيَدِهِ المُلْكُ وَهُوَ عَلى كُلِّ شيءٍ قَدير"

The novelty in this part of the work is the prosody syllabification. This syllabification is valid for any SA text [15] and it has not been used in ATTS synthesizers. This syllabification is based on Arabic linguistics features and it focuses on Sokoun diacritic (ْ), which shows that Sokoun is a good co-articulation point. This research analyzes Arabic speech from the side of time domain and pitch contour. The result from this analysis proves that the Sokoun is a suitable co-articulation point that increases the smoothness. The possible syllables from using these techniques are only cv, cw, and cvc. Thus the possible number of syllables for Arabic is

$$28\times4+28\times3+28\times3\times28+28\times3 \approx 2600 \text{ syllables} \quad (1)$$

This is bigger than diphones' number for Arabic, which is about (28+6+6)2 = 1200 diphones [10].

Analyzing the Arabic speech signal considering time domain shows clear correlation point for units where "ْ" exists. From the spectrum and the pitch contour for a word "تَقْبَلْتُمْ", Figure 4 shows the syllables chopping.

6. DISCUSSION

The reason of missing the quality evaluation procedures for NLP Modules is the lack of tangible standardized results. The results from NLP module are symbolic linguistic units in

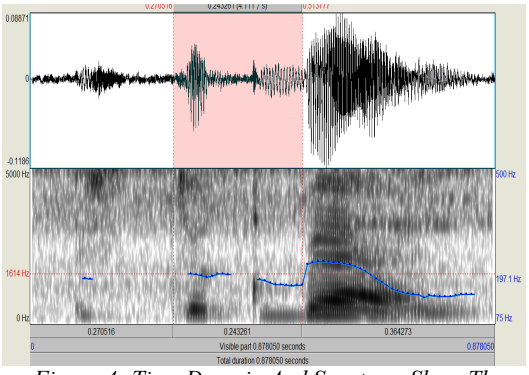

Figure 4: Time Domain And Spectrum Show The Sokoun Chopping For "تَقْبَلْتُمْ", The Red Lines Cut "تَقْ"

phonemic or phonetic representations for the texts. These representations can be modeled using any symbols, which increase the distance far from standardization. Usually, using SAMPA (Speech Assessment Methods Phonetic Alphabet) for Arabic with a diacritic text is a good basement in ATTS [12]. Nevertheless, the Letter-to-Sound rules (LTS) phonetics that are used in researches are varied for some basic issues, e.g. Mad Alalif "ا" is aa or a: or AA … etc. Some researches took some features from the text analysis [2] [3]. The output of this track is phonemic text with prosody information, which cannot be easily compared with others [13]

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The NLP module that is introduced in HQB-ATTS is compared with El-Imam's research [3] and with ATTSIP [2] that is introduced by Elothmany. In addition, HQB-ATTS letter-to sound rules are compared with Al-ghamdi rules [4]. The comparison is based on the similarity between the works that were done in this research and their approaches. Clearly, in this work, the rules are developed from El-Imam, Al-ghamdi and Elothmany by basing on Tajweed rules. The most common part in NLP module among the HQB-ATTS, El-Imam and Elothmany is the use of SAMPA phonetics with some added symbols from each.

The grapheme to phoneme rules that are presented in El-Imam [3] were: Sukon deletion rules, Elusion rule (like "الف واو الجماعة"), Replacing "ى" with "ا", Tanween rules, Arabic ligature rules (like "ؤ" and "ئ"), Glottal stop insertion rule (for "ء"), Gemination rules (الشدة), Shamsi rule, Long vowel generation rule (حروف المد), Diphthong generation rules (الحركات على (و) وعلى (ي)), and Short vowel replacement rule. El-Imam's rules are included in HQB-ATTS rules with modifications, but "Sukon deletion" is not included because it is an important part in Prosody syllabification. The Elusion rule in Al-Imam' rules missed the case of the (ال التعريف) in the begging of the sentence, which is covered in HQB-ATTS. The rest of the rules are included in another order and declaration. Most of assessment sentences that are shown in El-Imam research are tested in HQB-ATTS NLP rules, such as " التِّمْساح، رابِطَه، خادِمْ، تِتئناف", and all that shows the success of the ruling approach. Errors in El-Imam's rules weren't not detailed in his research [3]. Although SA sentences were not focused on El-Imam rules, which produces cuttings in the synthesized speech for the synthesized sentence, HQB-ATTS solves them from Prosody science syllabication. HQB-ATTS was tested on El-Imam tested samples, and this showed the HQB-ATTS's success.

Al-ghamdi rules [4] had missed the definition of the first "ا" in the sentence, which is defined in HQB-ATTS in this work. Otherwise, Tajweed rules cover the rules in Al-ghamdi's work.

Although the rules that are used in ATTSIP LTS module is not similar to those that are used in HQB-ATTS, the main difference between them is the disappearance of FOR loops in HQB-ATTS that produce the algorithm as sequential, quick and simple procedures. To determine the time-consumption in both cases, calculating the steps number was done for NLP, in order to transform it from grapheme to phoneme in some sentences like "هذا من مسؤوليات دافع الضرائب" using HQB-ATTS and ATTSIP. After the grapheme to phoneme process, the symbols are compared to check if HQB-ATTS is able to solve the missed features that were in ATTSIP. Manually the rules for ATTSIP, as defined in the work are calculated

HQB-ATTS: ha:Da: min mas?u:li:a:ti da:fi? 'i d'd'ar'a:? ib/ with 6 steps

ATTSIP: ha: Da: min mas? u:li:a:ti da:fi?'i d'#d'#a#r#a:#?ib with 6 steps

The previous case showed a match between both approaches, but in HQB-ATTS, depending on the Prosody-syllabled Tajweed rules, the approach deletes the rule of magnifying d' "ض", a "", r "ر" and a: "ا" . Here are some examples that show a fail in ATTSIP and a success for HQB_ATTS:" فإ", "وبالآخرة", "رام الله", و الاخرة" عار□الا". The sentences that are used in ATTSIP are tested with HQB-ATTS and there were no errors.

7. CONCLUSION

In this work, the overall architecture and general features of ATTS have been presented with a comprehensive survey. Holy Quran-Based ATTS (HQB-ATTS) approach has been introduced as well that aims at to enhancing the quality of the Arabic synthesized speech. This approach is based on some of the Holy Quran Tajweed rules, which are used in SA speech as well as on Prosody syllabification in concatenating allophones/syllables. The implementation shows that the Tajweed rules have additional rules that help to reach the desired completeness in grapheme to phoneme transcription for Arabic rule-based system. The Quran recitation is used for notating and segmenting the units, which are used in concatenation of the synthesized speech in DSP module. The units are segmented using Prosody syllabification, which don't exceed 2700 units for Arabic. The prosody syllables of " بِسْمِ اللهِ الرَّحْمنِ الرَّحيم" for example are 10, which are " بِسْ مِلْ لا هِرْ رَحْ ما نِر رَ حي مْ". This segmentation method had not been used in ATTS, and with this approach, the co-articulation problem decreases because of the segmentation, which happens near the letters that hold Sukon (ْ). In addition, this syllabification shows a continuity in the synthesized speech between words because it joins the graphemes, and the segmentation is done regarding to the long and short diacritics.

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TABLE 2: HQB-ATTS RULES

#	Rule	Description	Examples	
			Input	output
1	قانون لشدة **Geminate rule**	Geminated consonant will be replaced by same two consonants. The first is un-voweled (ْ) and the second holds the short vowel (diacritic sign) which was on the geminated sign.	الصَّلاة بيَّت	الصْصَلاة بيْيَت
2	قانون لالف (ا) **Alef Rule**	If Alef (ا) is at the beginning, and it is followed with Lam (لْ), then it will be replaced (ا) by (أ). Else If Alef (ا) is at the beginning, and it is in a word where the third letter is (ُ), then replace the Alef (ا) by (أ). Else If Alef (ا) is at the beginning of the sentence, then replace it by (!) Else delete (ا)	السماء ادعوا ابن، ٱم بالْمؤمنين	ألسماء أُدعو إبن، إٱم بلْمؤمنين
3	قانون لالف لمقصورة **Alef Maqsoora rule**	Replace the (ى) by the (ا)	رمى	رما
4	قانون لتاء لمربوطة **ta' Marboota rule**	If (ة) at the end of the sentence, replace it by (ه) Else, replace it by (ت)	المدرٱةَ جميلة	المدرٱتْ جميله
5	قانون بحذف لال لشمسية **Delete Lam Shamsiah rule**	If (لْ) followed by (ت ، ث، د، ذ، ر، ز، س، ش، ص، ض، ط، ظ، ل، ٱ), then delete it (لْ)	ألسماء	أَسماء

6	قانون لتنوين
	Tanween rule
		If (اً) at the end of the sentence, replace it by (ا)
		If (ٍّ ٌّ ًّ) at the end of the sentence, replace it by (ْ)
		Else replace it by one similar diacritic and (ْ)
			آتيناه حكماً
			كفواً أحدٌ
			كفواً أحد
				آتيناه حكما
				كفواً أحدْ
				كفوَْ

7	قانون لهمزة لممدودة (آ) **Hamza mamdooda rule**	If (آ) replace it by (اأ)	آية	أاية
8	قانون لهمزة **Hamza rule**	If (أ، ئ، إ، ؤ) replace it by (ء، ء، ء، ء) respectively	ملائِكة	ملاءِكة
9	قانون لتقاء لساكنين **Confluence dwells**	When 2 un-voweld letters come between 2 consecutive words, if the first un-voweled letter is preceded by (ُ ِ ٍ) , then insert (ُ ِ ٍ) respectively after the first consonants	لمنْ الأرض	لمنِ الارض
10	قانون لمتجانسين **Congener rule**	If (ذ، ت، ت ، د) followed by (ظ، ط، د، ت), replace the first (ذ، ت، ت ، د) by (ظ، ط، د، ت)	إذْ ظلموا قالت طائفة اجيبت دعوتكم قد تعلم	اظ ظلموا قالط طائفة اجيبد دعوتكم قت تعلم
11	قانون لال **Lam rule**	If (ل) in Allah (الله، اللهم) in the beginning of the sentence or it is preceded by (ِor ُ), then (ل) is magnified. Else, it will be soft	ٱ الله بِالله	مفخمة مرققة
12	قانون لـ ء **Ra' rule**	If (ر) is (ِر) or ((ْر) and preceded by (ِ)), then it is soft, else it is magnified	مرْيم فرْعو	مفخمة مرققة
13	قانون تحويل لصوائت لطويلة لى قصيرة **convert long vowels to short vowels**	If Mad (ا،و،ي) is followed by (ْ) then replaced it by (ِ ُ َ) respectively	رمى الرجل في البيت	رمَ الرجل فِ البيت
14	قانون حذف خر صائت في لجملة **Delete last vowel in sentence**	The last short vowel in the sentence is replaced by (ْ)	السلامُ عليكمْ	السلامْ عليكمْ

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The results show that the HQB-ATTS approach, which is implemented using Tajweed-rules as a rule-based system for NLP module, and that applies the Prosody syllabification for concatenation in Digital Signal Processing (DSP) module, can significantly enhance the quality of the synthesized speech. This approach is deterministic for Arabic and its linguistics' properties. The proposed approach was tested on small data samples. The samples are notated and segmented from real Quran recitation that base on Prosody Syllabification. The experiments showed that this approach could produce a better-synthesized speeches' quality than comparative ATTS.

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AUTHOR PROFILES:

Bana AlSharif received the master degree in Informatics from Palestine Polytechnic University (PPU), in 2015. She is a research student of Deanship of Scientific Research at PPU. Her interests are in Human Computer Interactive (HCI), Artificial Intelligent, Graphics.

Labib Arafeh: Associate professor, Department of Computer Engineering, Faculty of Engineering, Al-Quds University, Palestine. His research interests lie in major aspects of computing applications for people, including Essay-Type Auto Grading Systems; development of e-learning systems for practical / experimental courses; He has a Ph.D. in Instrumentation / Pattern Recognition & Intelligent Systems, from University of Manchester Institute of Science and Technology (UMIST), Computer Science from University of Essex, and B.E in Electronics from Bangalore University.

Radwan Tahboub: Assistant professor in Tele-communication and Information Technology. Chairperson of the of CE/CS department. College of Information Technology and Computer Engineering at Palestine Polytechnic University.

Ph.D. from Bucharest Polytechnic University, Romania, 2007. M.sc. in CSE from Bilkent University in Ankara Turkey, 1992. B.sc. degree in EE Eng. from Middle East Technical University in Ankara Turkey, 1990.