LIPS TRACKING IDENTIFICATION OF A CORRECT PRONUNCIATION OF QURANIC ALPHABETS FOR TAJWEED TEACHING AND LEARNING

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(Received: 17th Mar. 2016; Accepted: 7th Feb. 2017; Published online: 30th May 2017)

ABSTRACT: Mastering the recitation of the holy Quran is an obligation among Muslims. It is an important task to fulfill other ***Ibadat*** like prayer, pilgrimage, and ***zikr***. However, the traditional way of teaching Quran recitation is a hard task due to the extensive training time and effort required from both teacher and learner. In fact, learning the correct pronunciation of the Quranic letters or alphabets is the first step in mastering ***Tajweed*** (Rules and Guidance) in Quranic recitation. The pronunciation of Arabic alphabets is based on its points of articulation and the characteristics of a particular alphabet. In this paper, we implement a lip identification technique from video signal acquired from experts to extract the movement data of the lips while pronouncing the correct Quranic alphabets. The extracted lip movement data from experts helps in categorizing the alphabets into 5 groups and in deciding the final shape of the lips. Later, the technique was tested among a public reciter and then compared for similarity verification between the novice and the professional reciter. The system is able to extract the lip movement of the random user and draw the displacement graph and compare with the pronunciation of the expert. The error will be shown if the user has mistakenly pronounced the alphabet and suggests ways for improvement. More subjects with different backgrounds will be tested in the very near future with feedback instructions. Machine learning techniques will be implemented at a later stage for the real time learning application.

ABSTRAK: Menguasai bacaan Al-Quran adalah satu kewajipan di kalangan umat Islam. Ia adalah satu tugas yang penting untuk memenuhi ***Ibadat*** lain seperti solat, haji, dan ***zikir.*** Walau bagaimanapun, cara tradisional pengajaran bacaan Al-Quran adalah satu tugas yang sukar kerana memerlukan masa latihan dan usaha yang banyak daripada guru dan pelajar. Malah, mempelajari sebutan yang betul bagi huruf Al-Quran adalah langkah pertama dalam menguasai ***Tajweed*** (Peraturan dan Panduan) pada bacaan Al-Quran. Sebutan huruf Arab adalah berdasarkan cara penyebutan tiap-tiap huruf dan ciri-ciri huruf tertentu. Dalam kertas ini, kami membina teknik pengenalan bibir dari isyarat video yang diperoleh daripada bacaan Al Quran oleh pakar-pakar untuk mengekstrak data pergerakan bibir ketika menyebut huruf Al-Quran yang betul. Data pergerakan bibir yang diekstrak daripada pembacaan oleh pakar membantu dalam mengkategorikan huruf kepada 5 kumpulan dan dalam menentukan bentuk akhir bibir. Kemudian, teknik ini diuji dengan pembaca awam dan kemudian bacaan mereka dibandingkan untuk pengesahan persamaan bacaan antara pembaca awam dan pembaca Al-Quran profesional. Sistem ini berjaya mengambil pergerakan bibir pengguna rawak dan melukis graf perbezaan sebutan mereka apabila dibandingkan dengan sebutan pakar. Jika pengguna telah tersilap menyebut sesuatu huruf, kesilapan akan ditunjukkan dan cara untuk penambahbaikan dicadangkan. Lebih ramai pengguna yang mempunyai latar belakang yang berbeza akan diuji dalam masa terdekat dan arahan maklum balas akan diberi. Teknik pembelajaran mesin akan dilaksanakan di peringkat seterusnya bagi penggunaan pembelajaran masa nyata.

KEYWORDS: *tajweed; points of articulation; lips reading;movement of lips; video signal signalling*

1. INTRODUCTION AND BACKGROUND

The Quran is the holy book for Muslims and it has been sent and written in the Arabic language:

> *"Indeed, We have sent it down as an Arabic Quran that you might understand".*
> {Quran, 12:2}

It is reported that Prophet Muhammad, peace and blessings of Allah be upon him (pbuh) said:

> "Whoever recites a letter from the Book of Allah, he will be credited with a good deed, and a good deed gets a ten-fold reward. I do not say that Alif-Lam-Mim ***(ألم)*** is one letter, but Alif أ is a letter, Lam ل is a letter and Mim م is a letter".

The virtues of reading Quran are numerous, such as:

- ten rewards for every recited letter,
- the people who used to recite Quran are the best and last but not least,
- a Muslim position and rank in *Jannah* (paradise) is determined based on the amount of Quran that was memorized in his life [1].

Recitation of the Quran with ***Tajweed*** is an essential task as a Muslim. In fact, it is an important means for fulfilling other worship such as praying, ***zikr*** (remembrance) and ***hajj*** (pilgrimage). Recitation of the Quran should be as close to the way that our Prophet Muhammad (pbuh) did it as possible. To do it in such a way, learning ***Tajweed*** becomes a necessary education in Islam. The word ***Tajweed*** means "to improve" or "to make better". It is also the rules and knowledge that help people to recite the Holy Quran in a similar manner to that of the Prophet Muhammad (pbuh) [2]. Moreover, an important part of ***Tajweed*** is to pronounce the letters or alphabets from its correct articulations (***Makharij***) and by giving each alphabet its inherent characteristics (***Sifaat***) and dues in conditional characteristics. Characteristics (***Sifaat***) of Quranic alphabets help in differentiating alphabets that have similar points of articulations, where they are divided into two groups; characteristics with opposites and characteristics without opposites. The pronunciation of Quranic alphabets from their correct articulations points and characteristics is considered a challenging task for people from non-Arab background or even among children. They need much effort to learn the right way of pronouncing the Quranic alphabets [3]. As the pronunciation of Quranic verses is part and parcel of a general speech production process, thus, the implementation of speech recognition techniques can be beneficial with regard to the pronunciation of the Quranic alphabets for supporting its teaching and learning.

In the recent years, the utilization of computers in the process of second language teaching and learning has gained considerable attention from researchers. As an example, the systems that use computers in teaching a second language are called Computer Aided Language Learning (CALL) [4]. CALL systems have gained popularity due to their flexibility in empowering students to develop their language more efficiently and quickly than traditional ways. In fact, the traditional and prevalent method of teaching ***Tajweed*** rules in Quranic teaching and learning is mainly based on face-to-face. In this method, the process of teaching ***Tajweed*** rules requires extensive practice sessions with a teacher where the student is trained by looking at the way the teacher pronounces it. Indeed, it is quite a tough task to learn the actual pronunciation of any foreign language without the presence of the teacher. This process must be repeated until the student manages to recite the Quranic verses correctly, and to achieve this, extensive training time from both teacher and student is required [4].

Nowadays, computers are smart enough to mark the student's effort based on the predetermined answers; give instant feedback, and record the student's speech or text. However, computers must be trained in advance to be able to do the aforementioned tasks, [5], and eventually be able to replace the teacher. The process of teaching languages using computers is improved significantly due to the combination between images, texts, videos, and sounds. These combinations facilitate the integration of the four basic skills of listening, speaking, reading, and writing [6]. Visual-based articulatory feedback has been given to the learners of the second-language in order to correct their pronunciations. These feedbacks were the tongue position and shape [7]. On the other hand, a Computer Aided Quranic Recitation Training system has been developed to detect errors in continuous reading of the Quran. The system integrates both Automatic speech recognition and a classifier-based approach [4]. Most of the designed systems deal with the full verses and words, but they do not consider the basic structure of the languages: the alphabets. In order to learn another language, the person must learn how to pronounce the alphabets of this language correctly from the right articulation with the right characteristics.

The integration of acoustic and visual cues in speech recognition systems has led to a promising area of research: audio-visual or multimodal speech recognition systems. This type of system can be used to improve the system performance in noisy environments [8]. Naturally, the perception of human speech is a multimodal system, which consists of the ears and eyes, integration between acoustic and visual information that significantly improves the communication between people. Due to this, introducing visual cues in speech recognition systems is believed to give high impact in terms of improving the performance and to reduce the error rates.

Lip and speech reading are the ability to understand uttered words without hearing. These are well-known practices to help people with hearing impairments to understand speech via movement of the lips. Facial expressions and gestures are used as well in this method [9-10]. Recently, the process of lip reading has been automated and this opens a wide area of research. This new area comes under many names such as visual speech recognition, silent speech recognition or automated lip/speech reading [11]. Introducing visual information to an audio-based speech recognition system results in a novel system called Audio-Visual Speech recognition system. These visual cues are used widely to enhance the performance of speech recognition system. The lip plays a vital role in speech, where it moves about 80% of the time during speech, so it is considered as the best visual cues in speech perception [12]. In the recent years, the researchers have shown a significant interest in the field of Audio-Visual Speech recognition systems due to its importance in improving the accuracy of speech recognition systems [13-15].

This study aims to investigate the mouth shape of the Quranic alphabets or letters during pronunciation. The pronunciation was done based on the unique but correct method of pronouncing the Arabic alphabets; i.e. based on ***Tajweed*** methods - by putting a ***Sukun*** (◌ْ

) on the alphabets and preceding it by ***Hamzah*(أ)** with ***Fathah*** (َ), [3], i.e. (أَجْ) for testing the alphabet (ج). This paper is organized as follows; Section 2 represents the Quranic alphabets' pronunciation rules. The experiment and the implementation are discussed in Section 3. The results are discussed in Section 4 and finally the conclusion was written in Section 5.

2. THE CORRECT PRONUNCIATIONS OF QURANIC ALPHABETS

Quranic letter or alphabet pronunciations rely on two major things: (1) points of articulation, exit or in Arabic, it is called ***(Makharij)*** and (2) attributes/characteristics or in Arabic it is called ***(Sifaat).*** There are 5 main places of articulations in the vocal tract; the empty space in the mouth and throat, the throat, tongue, two lips and the nasal passage. Figure 1 shows the chart of the articulation points and the alphabets that are related to these points. These articulation points have been part of the Quranic teaching and learning for many years and were developed based on the experiences of the old Islamic scholars. Some alphabets share the same point of articulations or its articulations are close to each other as shown in Fig. 2, which can cause difficulties in the pronunciation of these alphabets. Therefore, the Quranic alphabet's attribute ***(Sifaat)*** is the next attribute that plays a key role in differentiating the alphabets that share the same points of articulation. Thus, the correct pronunciation of Quranic alphabet can be achieved by giving the alphabets their due. The vowel ***"Harakat"***, the points of articulation and the manner of articulation. We can categorize the Arabic alphabets based on their equivalents in the English language into two groups. Group 1 consists of 16 alphabets of that can be linked to similar alphabets in the English language. On the other hand, Group 2 consists of 11 letters that do not have any equivalent alphabets in the English language. In order to achieve the correct pronunciation of Quranic alphabets, a ***SUKUN*** (ْ) should be used on the alphabets and it should be preceded by ***Hamzah*(أ)** with ***Fathah*** (َ), [3], i.e (أَبْ) for testing the alphabet (ب) .

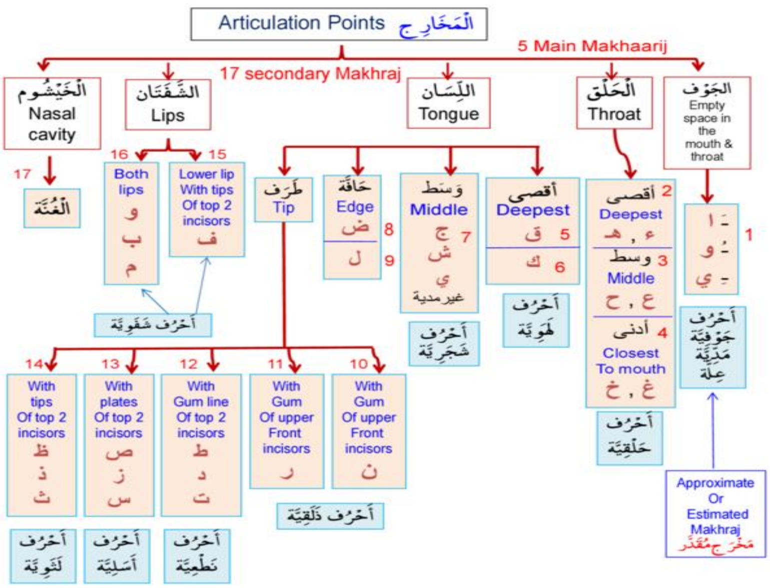


Fig. 1: Chart of the articulation points and the alphabets that are related to these points [16].

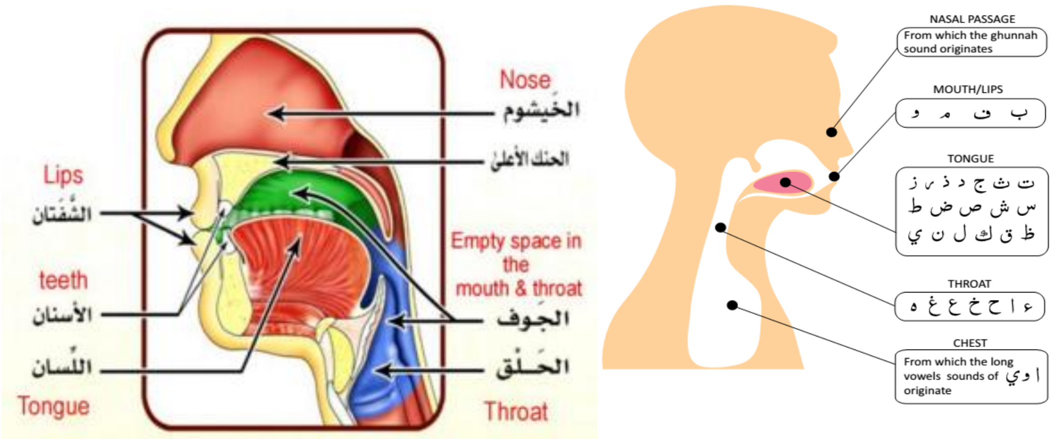


Fig. 2: Chart of the articulation points and the alphabets that are related to these points [16].

An important point to be addressed here is that of the confusion between two concepts "***Tajweed*** Rules" and "***Qira'at*** Rules". ***Tajweed*** is more concerned about the alphabets and their emissions from their points of articulation, and holding their characteristics. While ***Qira'at*** is concerned with the way of pronouncing the full words from the Quran. Thus, the 'points of articulation' topic is under ***Tajweed*** rules. In addition to that, the differences with ***Qira'at*** do not affect the points of articulation topic because it deals with the alphabets individually.

3. VISUAL-BASED DATA COLLECTION

As in any speech analysis research, the process of data collection plays a key role in the overall system's performance. In this paper, visual data is collected in an audio-visual (AV) studio room at the Center for Professional Development (CPD), at the International Islamic University Malaysia (IIUM) to provide a standard and low noise environment for recording video and audio. The professional reciter's mother tongue is Malay, and he is an expert in Quranic recitation, a Ph.D holder in Quranic teaching and holder of a ***sanad***. The Quranic alphabet pronunciations have been recorded audio-visually for each alphabet and for each Arabic vowel ***[Fathah, Kasrah, Dammah and sukun]*** ie.***, (بُ ,بِ ,بَ ,أبْ)***. For this paper, the visual data was used to track the lip movement when pronouncing the correct Quranic alphabets.

The 28 alphabets of the Quran were recorded 4 times using a high speed camera for the professional reciter. The high speed recording capable of recording the skin vibration of the subject's face was used and able to record voice information [17]. In this research, a Casio EX-100 premium high speed camera has been used to record the face area of the reciter during the pronunciation. The recording speed of high-frame rates between 120 to 1000 frames per second (fps), where it was used to record and detect the details of the lip movements. It has 5-axis image stabilization that allows very clear recordings during handheld recording [18]. The recording was conducted in an AV studio equipped with sound mixer and soundproofed walls to reduce unwanted background noise, as shown in Fig. 3. A Casio ex-100 premium high speed camera was fixed in front of the face of the reciter at a distance of 1.5 m. The experimental setup of recording the data is shown in Fig. 4.

Fig. 3: The Center for Professional Development AV studio, IIUM.

Fig. 4: Data acquisition process [video recording].

4. LIP MOVEMENT DATA ANALYSIS

The system is set up to extract the movement data from the professional reciter and the novice reciter and compare these data to check whether the novice utterance is correct or not. The experiment was first conducted in concurrent flow for extracting the movement data, and then these data sets were used to compare the pronunciation performance of other reciters. The recorded videos were analyzed frame by frame to extract the position of the points on the lips and determine the width, height, and shape of the mouth using MATLAB software. The lip movement data was first extracted from the professional reciter then from the public reciter. A friendly Graphical User Interface (GUI) has been designed and programmed using C# to be used by any user, as shown in Fig. 5.

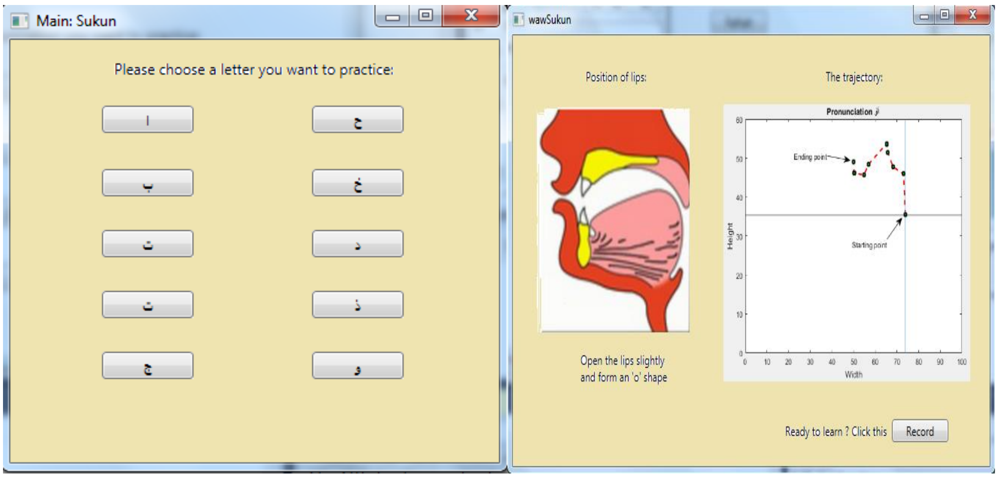


Fig. 5: The designed graphical user interface.

Displacement was used to measure the movement between the two aligned points, to accommodate for various mouth shapes. In addition, if any pronunciations exist that are not symmetrical with the movement between the two parallel points, either height or width, the displacement can be used to measure from a single isolated point to increase the accuracy of the performance.

There were two features studied in this paper: width and height of the lips from the initial position (*time* = *0*) until the end of the pronunciation time (*time* = *t*). The width and height of the lips are selected between points 1, 2 and 3, 4 respectively as shown in Fig. 6. The lip movement can be extracted by analyzing each frame and calculating the width and height for that frame. This movement provides information about the starting point, end point, and the behavior between these two points. Note that, there are limits for both the opening and closing of the mouth, which are considered boundaries. Thus, the width and height of the lips may vary within the boundaries as can be referred to in Fig. 7. The lips' final position during the pronunciation was categorized into 4 possible shapes; (i) OpenMuzzle, (ii) OpenAgape, (iii) ClosedStretched, and (iv) ImpossibleShape. The last mentioned shape is impossible to be reached when both the width and height of the lips are decreased, as can be referred to in Fig. 8.

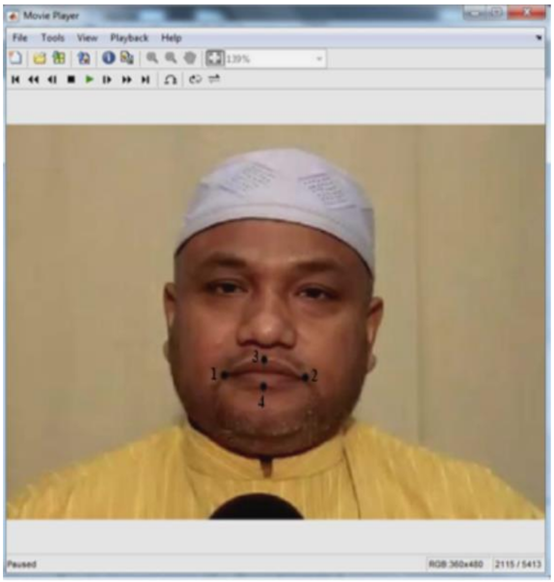


Fig. 6: The points used to determine the width and height for each frame in the video.

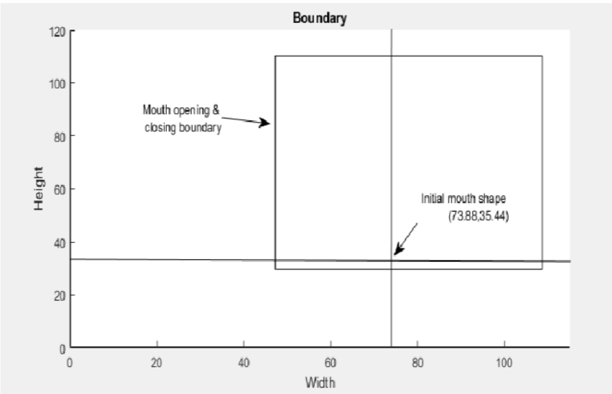


Fig. 7: Mouth opening & closing boundary.

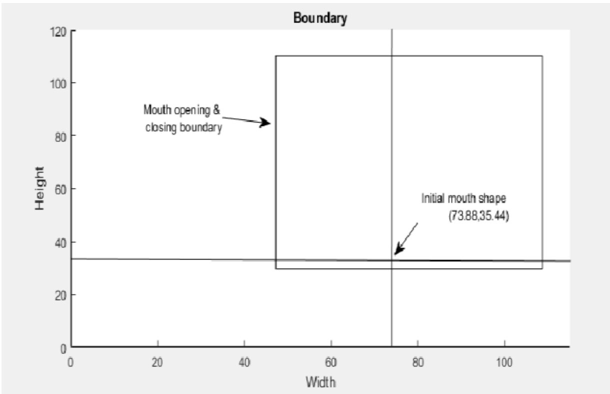


Fig. 8: Mouth shapes when pronouncing Quranic alphabets.

5. RESULTS AND DISCUSSION

5.1 The Correct Lip Movement Extraction

The first step in the analysis was to extract and plot the lip movements from the professional reciter, where this movement helps in deciding the final shape of the mouth and in categorizing the letters into 5 groups.

The selected pairs of points represent the width and height of the lips while pronouncing the Arabic alphabets. Therefore, by achieving the width and height of the lips, it is easy to describe the shape of the mouth that can be categorized into 4 basic shapes (i) OpenMuzzle, (ii) OpenAgape, (iii) ClosedStretched, and (iv) ImpossibleShape based on the end position of the points. Figure 9 shows the four possible shapes of the mouth during pronunciation of Quranic alphabets. Although there will be differences between reciters' mouth sizes, this will not affect the results because the proposed method is conducted based on the behavior of the mouth, not its size. The behavior is same regarding the size of the user's mouth width and height.

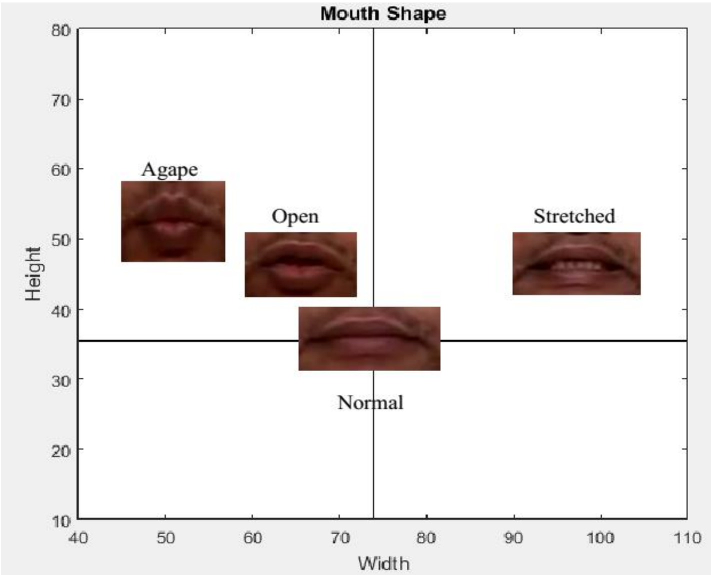


Fig. 9: Four basic Mouth shapes when pronouncing Quranic alphabets.

In addition to the shape of the lips, the analysis of the extracted frames from the video may provide us the position of the mouth when we start uttering the alphabet, the end position, and the behavior of the mouth during the pronunciation. By plotting the width and the height of the lips in one graph and extracting the relation between them, we can create another category of the groups based on the shape of the mouth. These groups are categorized based on the movement of the lips and the end position. Figure 10 shows the movement graphs of Group 1, in which the height is linearly increased, the width is decreased, and the final shape is small but open. Group 2 forms a loop and is closed during the pronunciation as shown in Fig. 11. Group 3 is where the width is decreased while the height is increased and then decreased to form an *O*-shape, as illustrated in Fig. 12. Group 4 is where both height and width change their positions. The width decreases, then increases, while the height that is opposite to the width increases and then decreases. In Group 4, the final shape of the mouth is stretched a little, as shown in Fig. 13. Lastly, Group 5 follows the movement of Group 4 but with larger change that results in a wider stretched mouth, as shown in Fig. 14. Table 1 illustrates the groups, final shape and the associated alphabets for each group. The dots in Fig.10 to Fig.14 represent the extracted frames. However, it is observed that it is not necessary to have exactly 12 dots (representing 12 frames), but rather that the important thing is the changes from one frame to another must be significant. That is why some figures have 5 and 6 dots instead of 12 dots. The reason is that some frames do not have significant differences from one dot to another so the system ignores the similar frames that are near to each other and plots only the frames that have significant jumps.

Table 1: Groups of mouth shapes and the associated alphabets

Group No.	Mouth behavior/shape	Alphabets
1	Open a Bit	ق, ح, ع, خ, ل, ن
2	Open and Close	م, ب
3	Form an ‘o’ shape	غ, ش , و, ر, ص, ط, ظ
4	Open the mouth and then stretch a bit	ك, ي, ت, ج, د, س, ف
5	Open the mouth and stretch wider	ز, ث, ذ

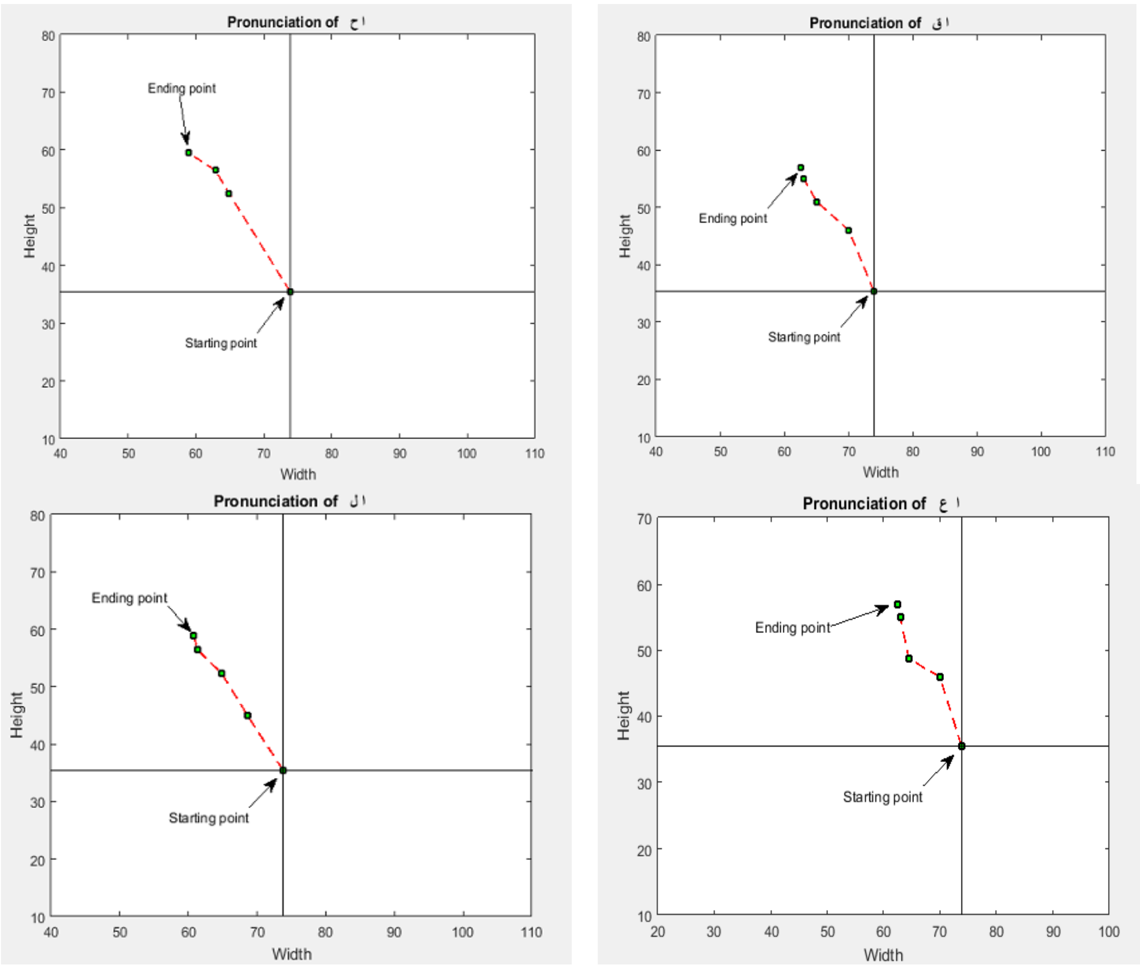


Fig. 10: Lip movement for alphabets in Group 1.

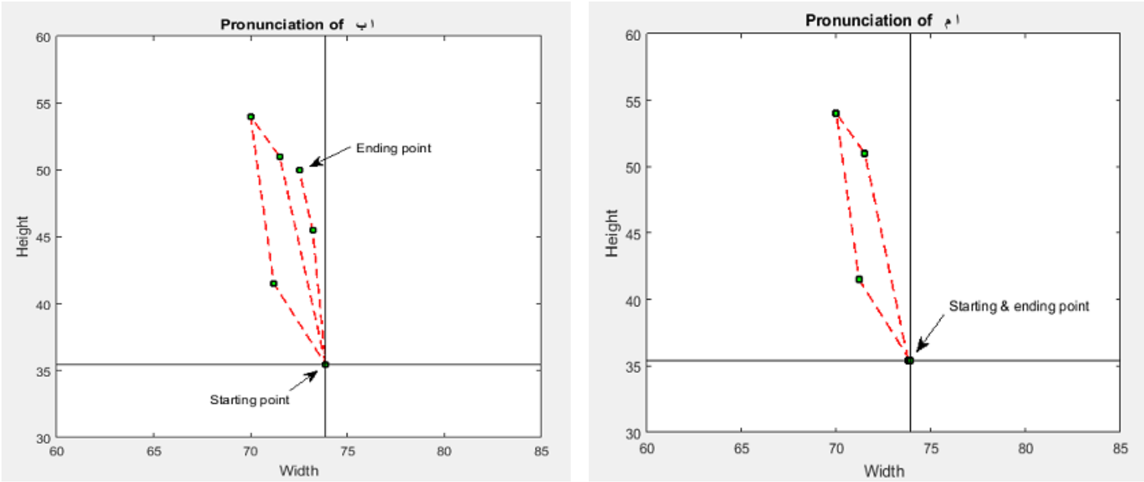
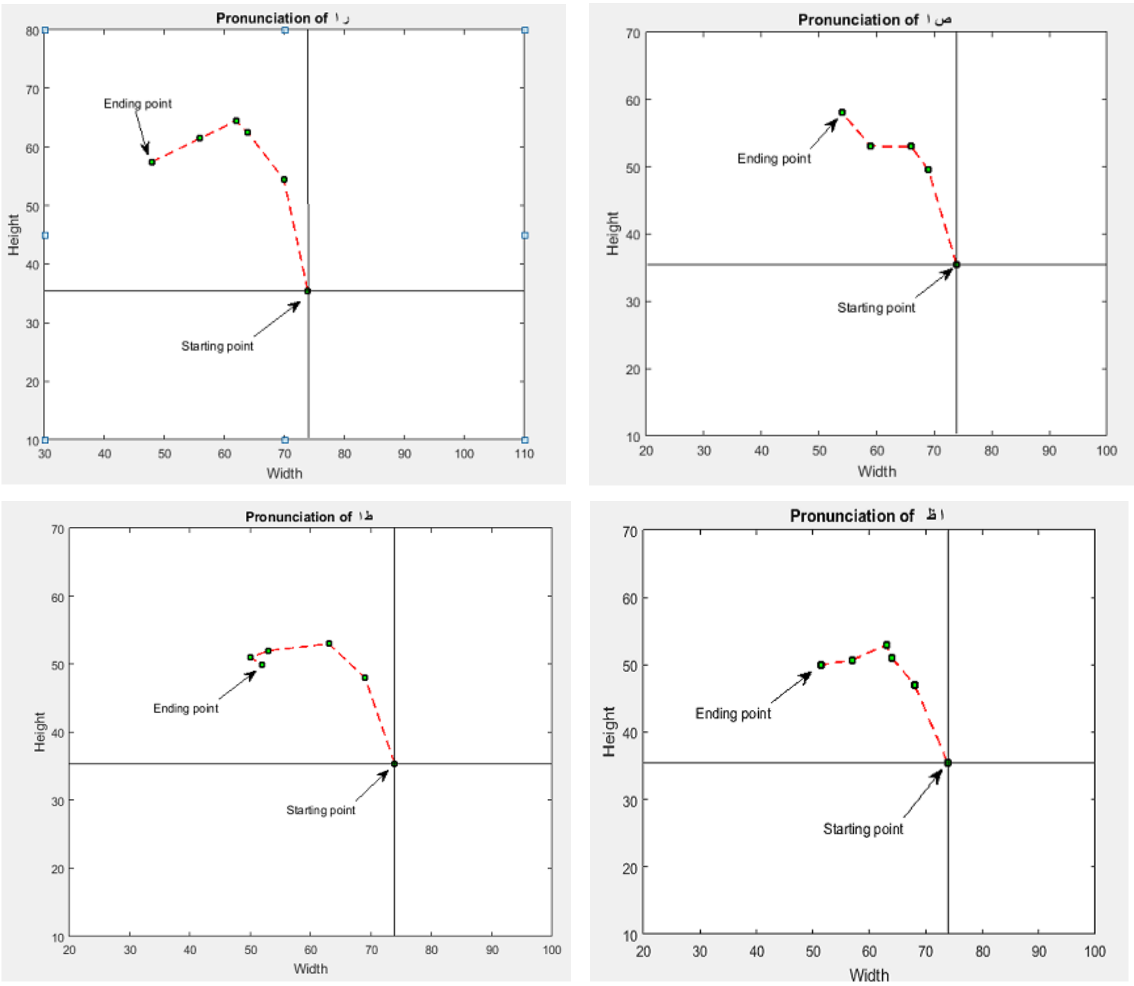


Fig. 11: Lip movement for alphabets in Group 2.



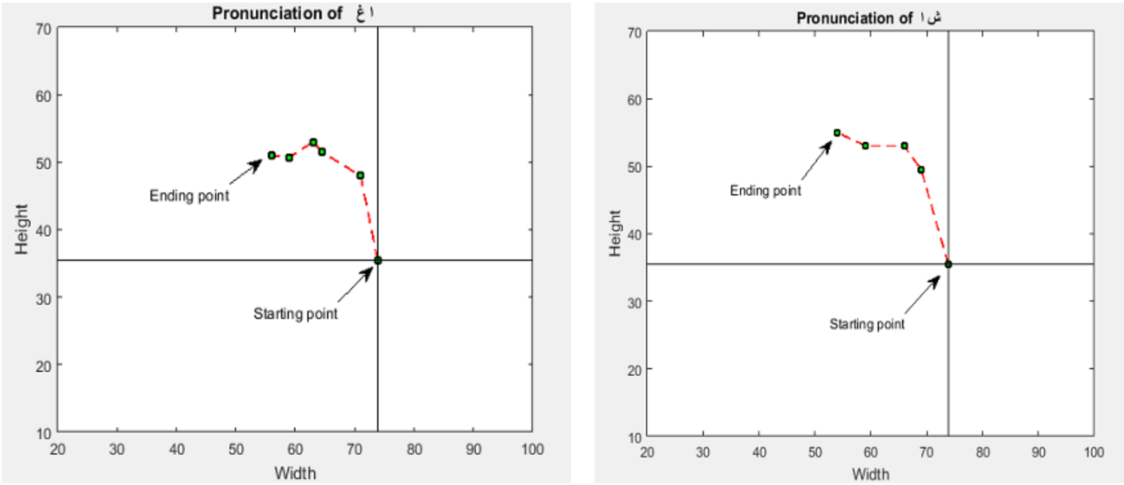
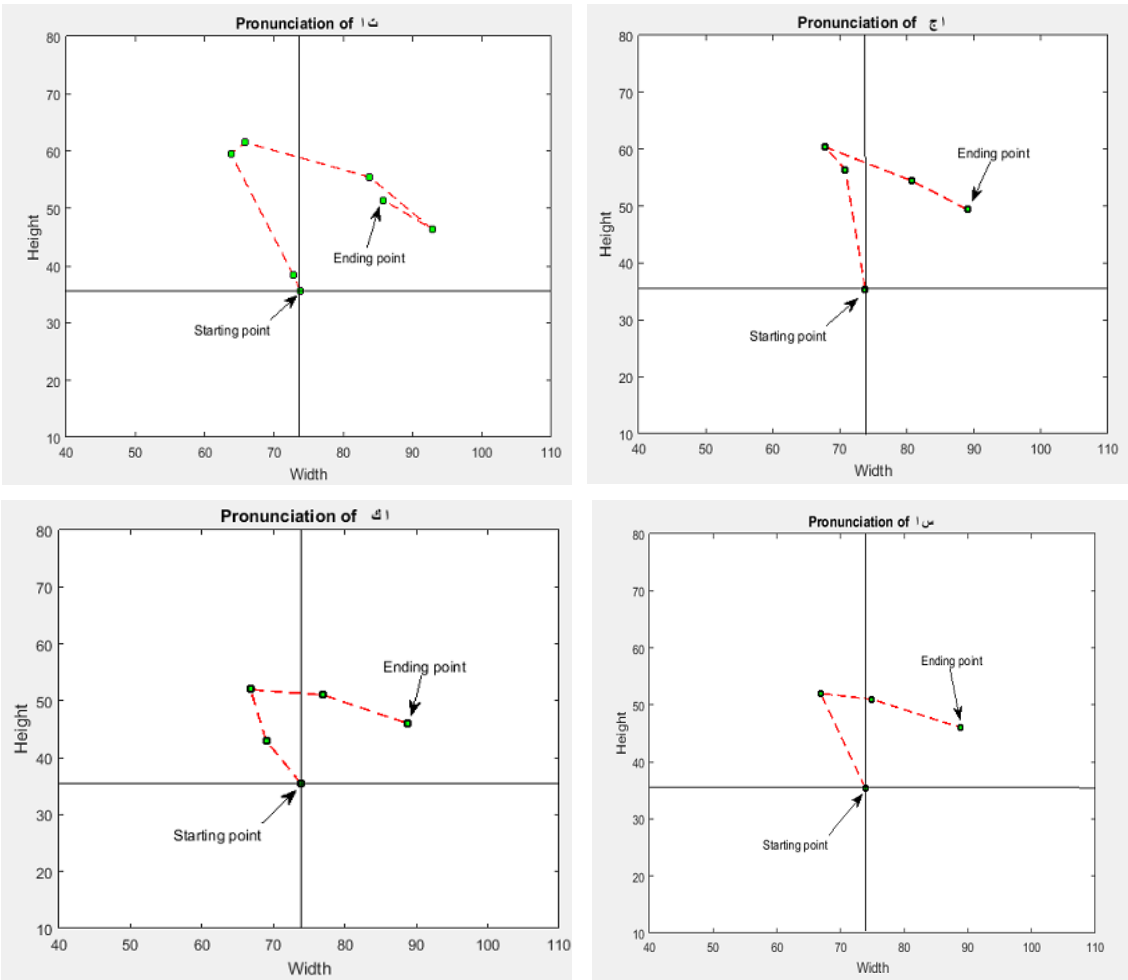


Fig. 12: Lip movement for alphabets in Group 3.



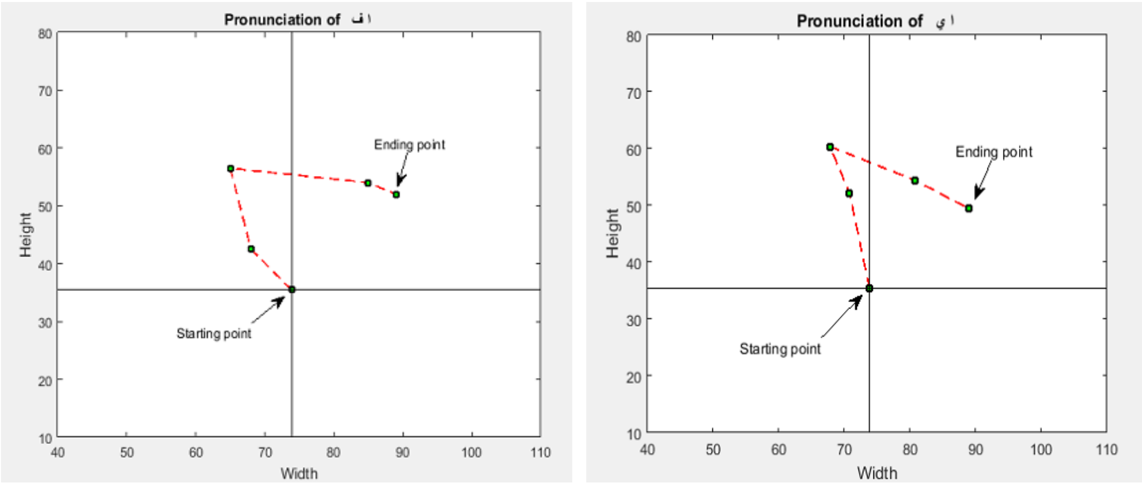


Fig. 13: Lip movement for alphabets in Group 4.

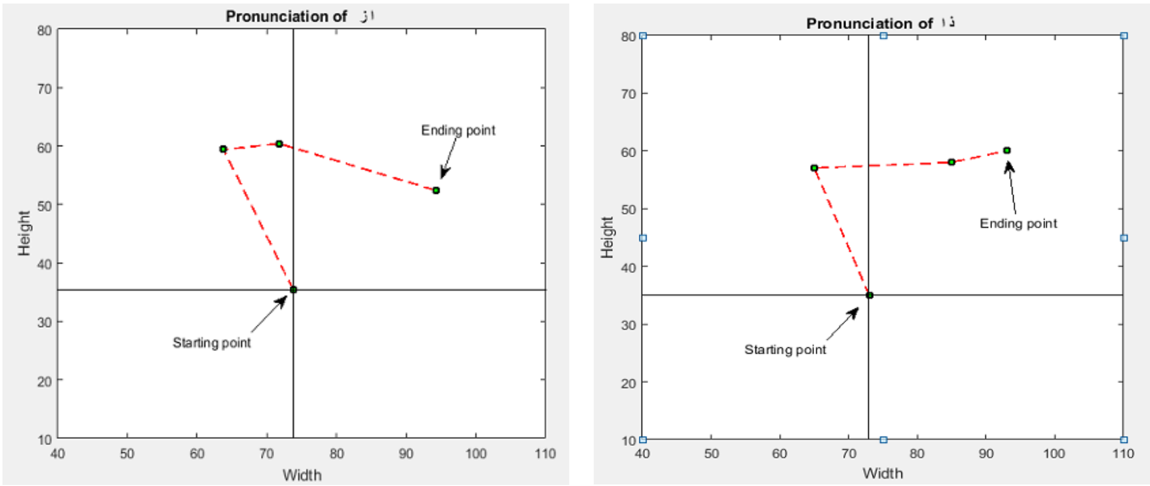


Fig. 14: Lip movement for alphabets in Group 5.

From another point of view, the displacement of the points on the lips can be used to evaluate the correct alphabet pronunciations instead of using the lip movements. Displacement can be calculated by considering the original point as (0, 0) and finding the displacement from that point. The displacement is calculated between each consecutive point. Displacement points in the *x*-axis and *y*-axis are calculated as follows;

- Difference between each subsequent frame as pairs (1 and 2, 3 and 4, etc.)
- Adding the differences between each two followed pairs.

Example 1: frame 1 and 2

73.88 - 73.06 = - 0.82

Example 2: frame 3 and 4

65.75 - 68.22 = - 2.47

Then the first displacement of the *x* axis between the above two pairs can be calculated by adding - 0.82 and - 2.47 which it is equal to - 3.29. Table 2 shows the displacement points calculation of the alphabet أَضْ. Figure 15 illustrates the displacement points of the same alphabet.

Table 2: Displacement points of the alphabet أَضْ

Frame	width *x*-axis	*x*-displacement	length *y*-axis	*y*-displacement
1 and 2	-0.82	-0.82	10.56	10.56
3 and 4	-2.47	-3.29	3.79	14.35
5 and 6	-0.01	-3.3	0.25	14.6
7 and 8	-2.26	-5.56	-2.76	11.84
9 and 10	-0.22	-5.78	0.11	11.95
11 and 12	-0.05	-5.83	0.05	12

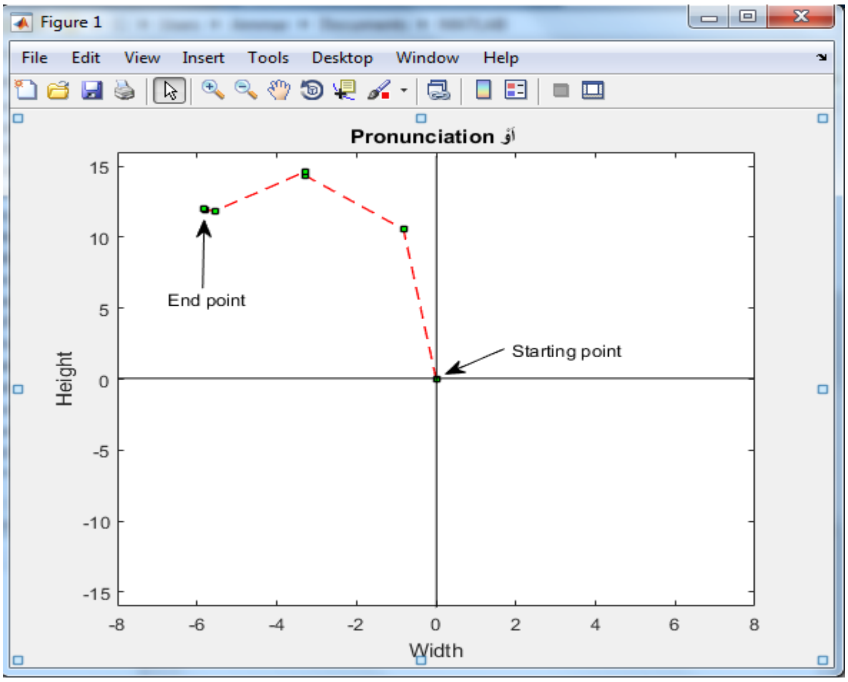


Fig. 15: Displacement points of the alphabet أَضْ

5.2 Testing with a Public Reciter

Random, ordinary people were selected to test the developed lip tracking system. The goal was to analyze the performance of the Quranic alphabet pronunciations from the percentage of similarity and thus the user could evaluate if the pronunciation was correct or not and potentially improve. The percentage of similarity was calculated by comparing the class extracted from the plotted lip movement. As an illustration, assume the user wants to learn how to pronounce أَشْ. Figure 16 shows the movement result for the first pronunciation. Similarly, Fig. 17 shows the second attempt at pronunciation. Note that the experiment was analyzed using displacement measurement. The expert Quran reciter graph was saved as the model reference and the system drew the recorded data on the same graph so the user could compare his graph with the expert graph and see that his pronunciation was not accurate.

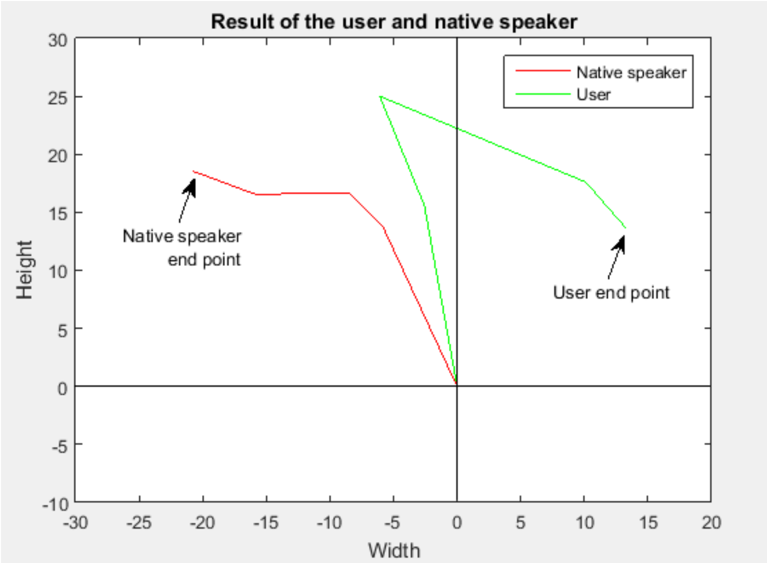


Fig. 16: First attempt of the random user for the alphabet أَشْ

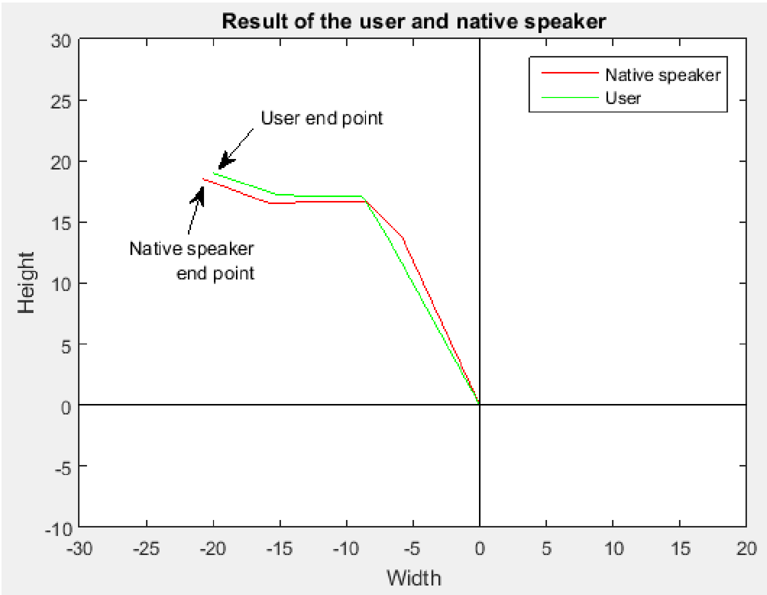


Fig. 17: Second attempt of the random user for the alphabet أَشْ

6. CONCLUSION

The movement of the lips while pronouncing the correct Quranic alphabets was extracted successfully from a recorded video of a professional Quranic reciter. The displacement between frames has been calculated from its initial point up to the completion of alphabet's pronunciation. A comparison between the pronunciation of the professional reciter and a novice subject has been conducted based on the displacement where at this level; the comparison can be done by the user himself. The system can be improved by considering more frames, and by providing real time feedback to the user in the very near future. A machine learning technique is to be included in the system so it will be able to calculate the percentage of similarity with the expert's recitation of Quranic alphabets and ways to improve the pronunciation. The main objective of this paper was to investigate the differences between Quranic alphabet pronunciations from the lip geometry and the movement of the points assigned to the lips. More investigations and tests are to be performed in the near future.

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