Automatic Tajweed Rules Recognition using k-Nearest Neighbour (k-NN)

Shafaf Ibrahim, Farah Afiqah Abdul Rahim, Zaaba Ahmad

Abstract*— Tajweed refers to a pronunciation rule for Al-Quran recitation in Islam. It acts as guidance for Muslims in reciting the Al-Quran in a correct manner. Yet, Tajweed rules could be complicated as it consists of various types of laws. It could also be confusing, and difficult to remember particularly for the people who have less knowledge in Tajweed rules. Thus, a study on automatic tajweed rules recognition using image processing technique is proposed. The scope of this study is limited to Idgham laws only. Initially, the input image went through the pre-processing process which includes four sub-processes which are greyscale conversion, binary conversion, thinning and flip, and word segmentation. Next, six attributes of shape descriptor which are major axis length, minor axis length, eccentricity, filled area, solidity, and perimeter were extracted from each input image. A technique of k-Nearest Neighbour (k-NN) is employed to recognize the two types of Idgham Laws which are Idgham Maal Ghunnah and Idgham Bila Ghunnah. The performance of the proposed study is evaluated to 180 testing images which returned 84.44% of classification accuracy. The outcome of this study is expected to recognize the Tajweed rules automatically and may assist the user on a proper recitation of Al-Quran.

***Index Terms*: Automatic recognition, k-Nearest Neighbour (k-NN), regionprops, tajweed.**

I. INTRODUCTION

Al-Quran is the holy book for Muslims revealed by God to Prophet Muhammad progressively over 23 years, through the angel Jibreel as the medium. It is generally meant as “That which is read” [1]. Recitation of the Al-Quran is controlled by many laws that contain in "Tajweed rules" which is referring to the right pronunciation of the Al-Quran [2]. Tajweed is an Arabic word that is derived from the root word ‘jawwada’ meaning to make well, make better and improve which refers to correct pronunciation during recitation [3].

The correct pronunciation of Al-Quran recitation had been ensured by Tajweed rules at a moderate speed, without changing the meaning [4]. It is compulsory for Muslims to read the Al-Quran in the correct way as it can change the actual meaning if there are any mistakes happen in Tajweed rules. Thus, reading Al-Quran in appropriate way is necessary in Islamic worship besides of prayers [5].

Presently, the problem of poor Al-Quran reading skills is always being an issue in the field of Islamic education [6]. It seems to be a serious problem that the Muslims should aware as it is compulsory for them to recite the Quran properly by following the Tajweed rules. A problem that had contributed to Tajweed mistakes is a low frequency in reciting the Al-Quran lead to the Muslims to have misreading the Holy Book properly [7]. The incorrect recitation of certain Al-Quran’s verses will cause to incorrect understanding [6]. So, it is obligatory for the Muslims to implement Tajweed rules whenever they recite any Al-Quran verses as to avoid wrong understanding and spreading a wrong message which contains in the Al-Quran.

The traditional learning session for Tajweed rules is called as a Talaqqi Musyafahah method [8]. However, the teacher’s skills and their ability could be suspicious. There are possibilities of mishearing and prone to errors due to environmental disturbances such as noise and attention [4]. Additionally, learning hours are also limited.

The Tajweed rules cover nine areas of Nun Sakinah and Tanwin, rules of Mim Sakinah and rules of Mad Asli. Thus, it could be confusing, and difficult to remember particularly for the people who have less knowledge in Tajweed rules [6]. This supported by a survey conducted by [9] on testing tajweed knowledge which revealed astonishing result where only 16.3% of the participants have good knowledge in Tajweed rules, 37.5% of moderate, and 46.3% are still weak.

Based on the problem discussed, it was found that there is a need to improve the current way of learning Tajweed. A study of automatic recognition of Tajweed rules using image processing is proposed. The image processing technique is very effective and dependable day by day. It is very well known for its ability to significantly increase the interpretation accuracy of pictorial information [10]. Feature extraction techniques of shape were implemented to analyze the characteristics of the tajweed letters. Whereas, a k-Nearest Neighbour (k-NN) technique is used to recognize the two types of Idgham Laws which are Idgham Maal Ghunnah and Idgham Bila Ghunnah. The outcome is believed to automatically detect the Tajweed rules and may assist the user on proper recitation of Al-Quran.

II. METHODOLOGY

The aim of this study is to automatically recognize the tajweed rules using k-NN, and to evaluate the tajweed rules recognition performance. Fig. 1 depicts the proposed process flow of the tajweed rules recognition.

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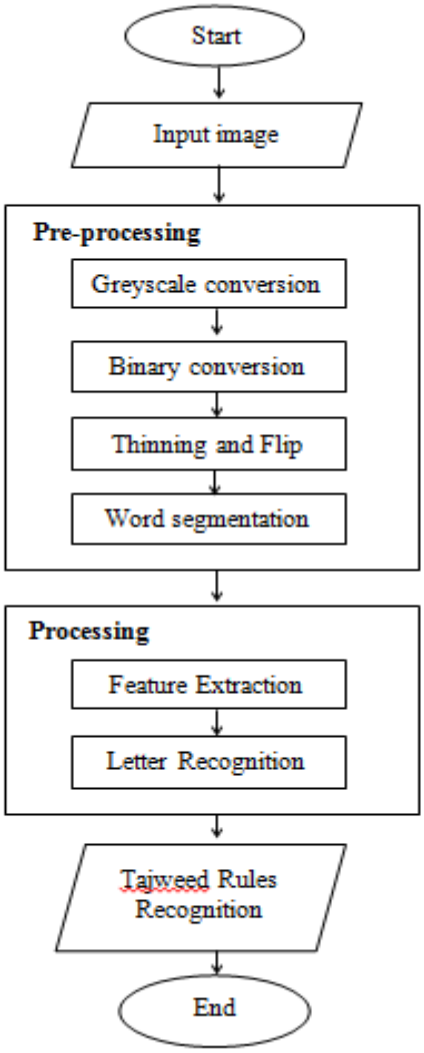


Fig. 1: Proposed process flow of tajweed rules recognition

The proposed process flow of tajweed rules recognition begins with the input image. The image will then go through the image pre-processing processes which comprise of four sub-processes which are greyscale conversion, binary conversion, thinning and flip, and word segmentation. Next, the processing consists of two sub-processes which are feature extraction and recognition. The feature extraction is used to extract the shape feature properties of the tajweed letters in the input image. Whereas, the recognition is used to recognize the tajweed letters and determine which tajweed rule that the image belongs to. After the image is recognized, the system will produce the final result which is the tajweed rule recognition.

A. Input image

This study is only focusing on Idgham Laws. There are two types of tajweed rules for Idgham Laws which are Idgham Maal Ghunnah and Idgham Bila Ghunnah. A total of hundred and eighty testing images were collected. There are four tajweed letters for Idgham Maal Ghunnah which are "Ya", "Wau", "Mim", and "Nun". Whereas, there are two types of tajweed letters for Idgham Bila Ghunnah which are "Ra" and "Lam". Table 1 tabulates the sample images for each type of tajweed letters and rules as mentioned.

Table 1: Sample images of tajweed rules

Image	Tajweed Rules	Tajweed Letters	No. of Sample Images
مَنْ يَشاء	Idgham Maal Ghunnah	Ya 'ي'	30
مِنْ وَاقٍ		Wau 'و'	30
مِنْ مَحِيْصٍ		Mim 'م'	30
مَنْ نَشَاء		Nun 'ن'	30
مِن رِّزْقٍ	Idgham Bila Ghunnah	Ra 'ر'	30
مِن لَّدُنْهُ		Lam 'ل'	30

B. Pre-processing

Image pre-processing is a process where the input image is improved by suppresses the disfigurement or enhances some image features that are important for further processing [11]. The pre-processing includes four sub-processes which are greyscale conversion, binary conversion, thinning and flip, and word segmentation.

Grayscale conversion

Grayscale conversion is an approach to deal with a procedure and change the picture into dim or gray based color as the result [12]. Grayscale image simplifies and reduces computational requirements as colour can introduce unnecessary information that could raise the amount of training data required in achieving good performance. A grayscale image contains black and white colour only. Conversion of grayscale image from the Red Green Blue (RGB) image would carry out the intensity information of an image, compiled from black with the weakest intensity to white with the strongest intensity.

Binary conversion

In contrast, a binary image is a digital image that has only two possible values for each pixel either 1 or 0 [13]. The colour that is being used in binary image are black and white.

Thinning and flip

Next, the thinning is an erosion morphological operation which is used to shrink an image [14] and it only could be applied on a binary image. This method is chosen as it produced the best result in retrieving the characteristics of the input image as well as reducing the noise in the image. It is done by converting the image into inverse binary format beforehand as to preserve the feature of the image. The thinning is done by deleting the pixels inside the shape iteratively in order to shrink it without breaking it apart. Due to the condition of the Arabic word which is starting order from right to left, it is necessary to do the flip as the subsequent segmentation process will only perform its

function accurately on an image from left to right order

Word segmentation

The word segmentation is performed to detect the space between the words and segment it into two different images. The histogram projection method is used to compute the sum of white pixels in every column which consequently construct the corresponding histogram. The vertical histogram for the image constructed and the white pixel which known as pixel 1 in each column be measured. By using the histogram, the columns which containing no white pixel will be labeled as pixel 0, where the other column is replaced to pixel 1. Throughout the process, it will cut the 0-pixel and remain the 1-pixel. The separated images are then being used as input in the subsequent process. Table 2 portrays the sample of outcomes for each process in pre-processing until the tajweed letter recognition.

C. Processing

The processing consists of two sub-processes which are feature extraction and recognition.

Feature extraction

The feature extraction is used to study the characteristics of each tajweed letter which consequently produce the summary table. The shape feature properties value of the segmented tajweed letter is extracted from the input image. The r*egionprops* function is used to retrieve the feature value of the input image by computing the properties of each region within the image [15]. There are six shape feature properties extracted which are major axis length (MJAL), minor axis length (MNAL), eccentricity (ECC), filled area (FA), solidity (SLD) and perimeter (PRMT) of the desired area. Table 3 tabulates the summary table of the extracted feature properties. These values will then be compared with the same feature values of testing data before being recognized by the k-NN algorithm.

Recognition

The recognition is done using the k-NN classifier. It is a mature algorithm and it is widely used in text classification [16]. The algorithm is simple, effective, easy interpretation, and low calculation time [17]. In this part of study, the k-NN is used to compare both data value into two categories of Idgham Maal Ghunnah or Idgham Bila Ghunnah. The Euclidean distance is used to find the difference between two distances. Fig. 2 depicts the process flow of k-NN using Euclidean distance. In (1) presents the calculation of two different distances.

$$\sqrt{\sum_{i=1}^{k}(x_i - y_i)^2} \quad (1)$$

where:
k = number of neighbour
x = value of plane x
y = value of plane y

Table 2: Sample of outcomes for pre-processing and tajweed letter recognition

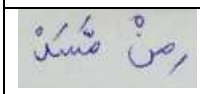
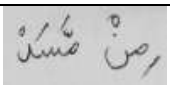
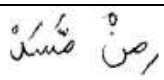
Input Image	Greyscale Conversion	Binary Conversion	Thinning, Inverse Binary Conversion, and Flip	Word Segmentation	Tajweed Letter Recognition
					

Table 3: Summary table of feature properties

Feature Properties	Tajweed Type					
	Idgham Maal Ghunnah				Idgham Bila Ghunnah	
	Ya ‘ي’	Wau ‘و’	Mim ‘م’	Nun ‘ن’	Ra ‘ر’	Lam ‘ل’
MJAL	1.15-123.85	1.15-69.06	5.187-59.8	3.46-86.1	2.56-52.58	2.59-91.1
MNAL	1.15-28.67	1.15-27.74	2.75-24.1	2.1-30.64	1.16-17.78	1.16-33.84
ECC	0-0.99	0-0.99	0.41-0.98	0-1	0.73-1	0.73-0.99
FA	1-1126	1-982	13-474	9-783	3-322	3-1176
SLD	0.314-1	0.34-1	0.31-1	0.24-1	0.25-1	0.545-1
PRMT	0-275.75	0-221.11	10.29-18.24	7.48-233.58	3.1-114.1	3.01-260.1

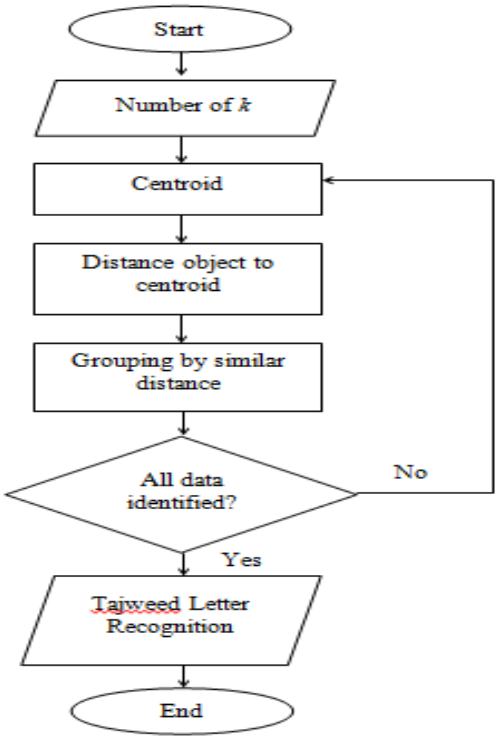


Fig. 2: Process flow of k-NN

Based on Fig. 2, the centroid is referred to the value of object of the extracted properties. Then, the distance is computed by using the Euclidean distance formula. The calculation halts when all data had been identified. The data is randomly divided into two groups which are training data and testing data. Table 4 tabulates the samples of the tajweed rules recognition of Idgham Law.

Table 4: Tajweed rules recognition

Image No.	Feature Properties Value	Letter Recognition	Tajweed Rule
1	MJAL: 26.99 MNAL: 4.53 ECC: 0.99 FA: 90 SLD: 0.84 PRMT: 52.48	Ya 'ي'	Idgham Maal Ghunnah
2	MJAL: 8.94 MNAL: 2.68 ECC: 0.95 FA: 13 SLD: 0.72 PRMT: 15.16	Wau 'و'	
3	MJAL: 59.8 MNAL: 18.79 ECC: 0.95 FA: 286 SLD: 0.38 PRMT: 143.72	Mim 'م'	
4	MJAL: 56.31 MNAL: 4.61 ECC: 1 FA: 195 SLD: 1 PRMT: 98.96	Nun 'ن'	
5	MJAL: 19.1 MNAL: 3.48 ECC: 0.98 FA: 48 SLD: 0.96 PRMT: 37.08	Ra 'ر'	Idgham Bila Ghunnah
6	MJAL: 6.33 MNAL: 2.98 ECC: 0.88 FA: 10 SLD: 0.71 PRMT: 11.98	Lam 'ل'	

D. Accuracy testing

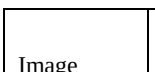
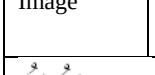
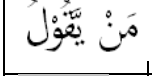
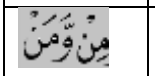
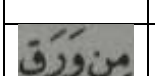
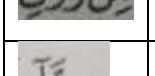
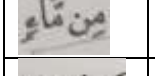
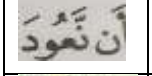
The performance of the tajweed rules recognition is evaluated using a truth table. It is performed by comparing the k-NN recognition result with the actual tajweed letters of the input image. Based on the truth table obtained, the recognition accuracy for each tajweed rules is calculated using (2):

$$\% \text{ of Accuracy } = \frac{No.of\ TRUE\ Recognition\ Result}{Total\ No.of\ Testing\ Images}\ x\ 100\% \qquad (2)$$

III. RESULTS AND DISCUSSION

Thirty testing images are tested for each tajweed rule. Table 5 displays some of the results plotted by the truth table from each tajweed rule.

Table 5: Samples of the truth table for tajweed rules recognition

Image	Actual Letter	k-NN Letter Recognition	k-NN Tajweed Rule Result	Accuracy Result
	Ya ’ي’	Ya ’ي’	Idgham Maal Ghunnah	TRUE
	Wau ‘و’	Ra ‘ر’	Idgham Bila Ghunnah	FALSE
	Wau ‘و’	Wau ‘و’	Idgham Maal Ghunnah	TRUE
	Mim ‘م’	Mim ‘م’	Idgham Maal Ghunnah	TRUE
	Nun ‘ن’	Nun ‘ن’	Idgham Maal Ghunnah	TRUE
	Ra ‘ر’	Ra ‘ر’	Idgham Bila Ghunnah	TRUE
	Ra ‘ر’	Wau ‘و’	Idgham Maal Ghunnah	FALSE
	Lam ‘ل’	Lam ‘ل’	Idgham Bila Ghunnah	TRUE

Subsequently, the accuracy performance of the tajweed rules recognition is demonstrated in Table 6.

Table 6: Recognition accuracy result

Tajweed Rules	Letter	No. of Testing Images	No. of TRUE Recognition	% of Accuracy
Idgham Maal Ghunnah	Ya ’ي’	30	28	93.33
	Wau ‘و’	30	22	73.33
	Mim ‘م’	30	28	93.33
	Nun ‘ن’	30	29	96.67
Idgham Bila Ghunnah	Ra ‘ر’	30	20	66.67
	Lam ‘ل’	30	25	83.33
			Mean	84.44

From the calculation of accuracy, it is observed that the study produced the highest percentage of accuracy for “Nun” which is 96.67%. Both “Ya” and “Mim” also returned a good percentage of accuracy which is 93.33%. The “Lam” is also cannot be underestimated which produced 83.33% of accuracy. However, “Waw” and “Ra” returned a moderate percentage of accuracy which is 73.33% and 66.67% respectively. It may cause by the confusion in recognizing the shapes between those two letters which seems slightly similar. The overall mean percentage of accuracy is found to produce a very good percentage of accuracy which is 84.44%.

IV. CONCLUSION

This paper proposed a study on automatic tajweed rules recognition using image processing technique. The study is focusing on the recognition of tajweed rules for Idgham Laws only which are Idgham Maal Ghunnah and Idgham Bila Ghunnah. Feature extraction techniques of shape were implemented to analyze the characteristics of the tajweed letters. In another note, a k-Nearest Neighbour (k-NN) technique is used to recognize four types of letters for Idgham Maal Ghunnah which are “Ya”, “Wau”, “Mim”, and “Nun”, and two types of letters for Idgham Bila Ghunnah which are “Ra” and “Lam”. The application to a variety of testing images has been successful. The performance of the tajweed rules recognition is evaluated using a truth table. The overall mean percentage of accuracy demonstrated a very good percentage of accuracy which is 84.44%. It can therefore be concluded that the proposed application of image processing techniques for tajweed rules recognition is found to be successful. Yet, implementation and incorporation of the current feature extraction and recognition techniques such as deep convolutional neural network are recommended.

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