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A Comprehensive Review of AI Applications in Quran Recitation and Tajweed Learning

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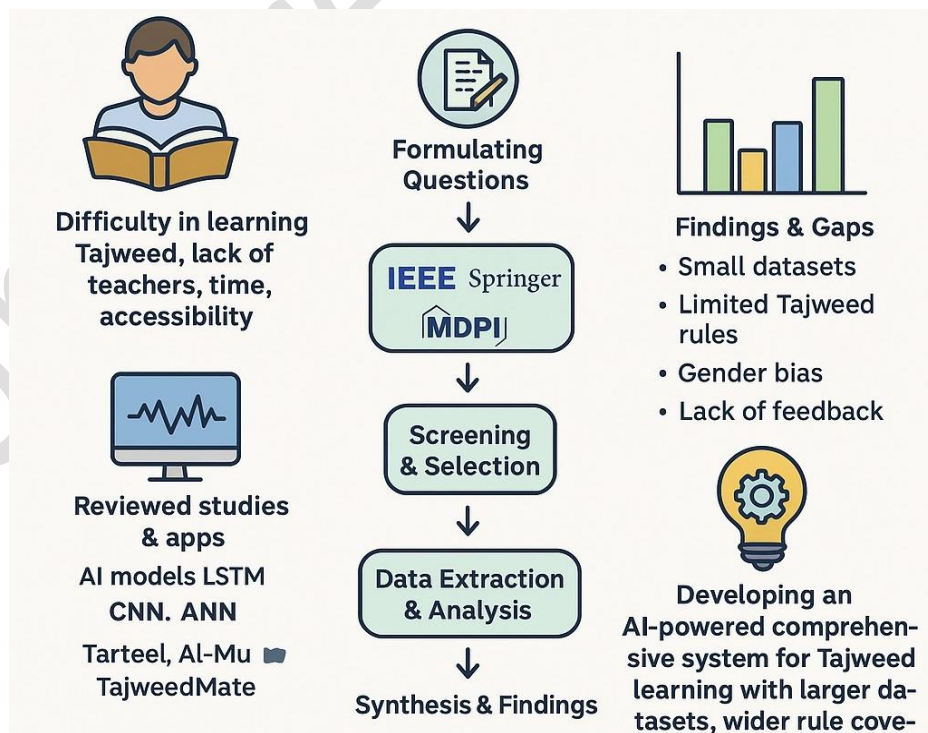
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ABSTRACT

The Holy Quran is the holy book for Muslims; reciting it is considered one of the most important and best forms of Islamic worship. Reciters of the Quran must apply a set of pronunciation rules called Tajweed, which dictate how to correctly pronounce letters and words. Learning Tajweed rules is essential yet challenging for many Muslims because it requires a qualified teacher, and access to them is limited due to lack of time, distance from educational centres, or other reasons. This paper presents a Literature Review on how to apply Artificial Intelligence (AI) to automate the process of learning Tajweed rules in Recitation, listening to, and learning the Holy Quran. We also review existing Quran learning applications and research papers on the detection of Quran Recitation mispronunciation using AI tools. The analysis of the literature review identifies limitations such as small datasets, gender bias, a limited set of Tajweed rules, and the evaluation of short Surahs or single verses. It suggests filling a research gap to facilitate Tajweed learning and improve Quran Recitation in an effective way. Future work will include developing and evaluating a new prototype based on enhancing the limitations of previous works.

Graphical abstract



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1. Introduction

Muslims attach great importance to the Arabic language, as it is the language in which the Holy Quran. The Holy Quran, the holy book for Muslims, was revealed to the Messenger of Allah Muhammad. The Arabic language is known as the 'Language of Quran' because the Quran was revealed in Arabic over 1400 years ago [1].

Muslims believe that reciting the Holy Quran is one of the best acts of worship for them. The Holy Quran must be recited in Arabic and be free from obvious errors, such as errors in letters and related matters.

To recite the Quran correctly, the reader must understand the rules of Tajweed. Tajweed is the science that governs the pronunciation and articulation of Quranic words [2]. It includes principles such as Idgham, Idhar, Iqlab, Ikhfaa, and Mad [3]. Tajweed rules are vital for ensuring accurate reading.

Many Muslims face challenges in learning Tajweed, including difficulty detecting mistakes during recitation, limited access to Quranic programs or teachers, time constraints preventing participation in classes, and a lack of tools that offer personalized feedback for self-learners. Researchers are working to address these issues by making Tajweed education more accessible, allowing Muslims to improve their recitation independently from anywhere.

However, Tajweed rules can be intricate, even with AI assistance. Two particularly challenging rules for AI to detect are Idgham and Ghunna [4]. Idgham involves merging specific Arabic letters, resulting in a smooth transition that can be subtle and context-sensitive, making it difficult for voice AI to recognize. Ghunna further complicates accurate Tajweed detection by AI.

The science that studies how to pronounce the words of Quran, and the differences in their pronunciation that are attributed to their transmitter, is called the science of recitations [5]. There are a lot of Quran recitation methods, such as Hafs and Warch. Each method has its own Tajweed rules according to it. The most famous recitation method, Asim, was passed down by Abdullah bin Masoud through his student Hafs. [6]. Because of the spread of the Quran recitation method "Hafs", most studies related to automatic Quran recitation recognition are based on using "Hafs reading".

There are various ways available to learn Quran Recitation and Tajweed rules, such as online resources like YouTube, mobile apps, or classes offered by mosques. Additionally, many apps provide different ways to learn Tajweed, including listening to recorded lessons or engaging in interactive practice. These resources can greatly assist anyone seeking to master Tajweed and enhance their recitation.

However, these programs and services may not be available to many people for various reasons or may not suit them. Quranic programs may not be available in many villages and even cities, let alone in non-Muslim countries. Also, many people, whether university students, employees, or others, may not have the opportunity to commit to specific times to attend educational programs. There are many reasons besides those mentioned. All these factors create obstacles for those wishing to learn Quran.

With technology advancing rapidly and AI becoming part of everyday life, AI is being used in all fields, such as the detection of Bean Leaf Diseases [7], improving gas prediction accuracy [8], and Offline signature verification

[9]. Quran recitation recognition using AI is important and complex. AI is used to enhance Quran Recitation and Tajweed learning. With speech recognition, AI can give real-time feedback on recitation, which allows users to improve their pronunciation and Tajweed skills. AI tools are used to help people learning Quran in many ways. For example, using machine learning for detecting errors in Quran Recitation [10].

Many applications, like AlMualim [11], Learn Quran Tajweed [12], and Tarteel [13] now use AI to make learning the Quran engaging and accessible. These tools guide learners in improving their recitation and understanding, making it easier to progress. With AI's support, Quranic learning has become a meaningful journey, helping people connect more deeply with its teachings [14]. But AI technologies have yet to be fully integrated into practical tools for everyday use by people.

This paper presents the related works on the development of Quranic learning applications and research papers on the detection of Quran Recitation mispronunciation by AI.

This paper is organized as follows: Section 1 begins with an introduction, providing insight into many aspects such as Arabic language, Quran Recitations, Tajweed rules, and AI technology. Section 2 presents a Literature Review approach to identify, search, evaluate, and analyze the relevant studies in the field. Section 3 presents an analysis of the relevant studies in the field. Section 4 presents a review that identifies existing gaps in the current knowledge. Finally, conclusion and further work.

2. Literature Review

This section discusses the literature review methodology, the results, and their analysis.

2.1. Methodology of Literature Review

The literature review methodology consists of five stages as illustrated in Fig. 1.

2.1.1. Question Formulation

During question formulation, a literature review must be well-planned to create the most suitable questions.

Literature Review questions (LRQs):

- ✓ LRQ1- Is there any AI model built to teach Tajweed and Quran Recitation?
- ✓ LRQ2- Is there any machine learning model built to teach Tajweed and Quran Recitation?
- ✓ LRQ3- Is there any deep learning model built to teach Tajweed and Quran Recitation?
- ✓ LRQ4- Is there any application that teaches the rules of Tajweed and Quran Recitation?
- ✓ LRQ5- Is there any application that allows the user to practice the rules of Tajweed?
- ✓ LRQ6- Is there any application that uses AI to teach Tajweed and Quran Recitation?
- ✓

2.1.2. Conducting the review phase

In this phase, we will outline the scope of the search strategy, including the keywords that are selected to filter papers from data sources, while also clarifying the criteria of inclusion and exclusion. And present the quality of those papers.

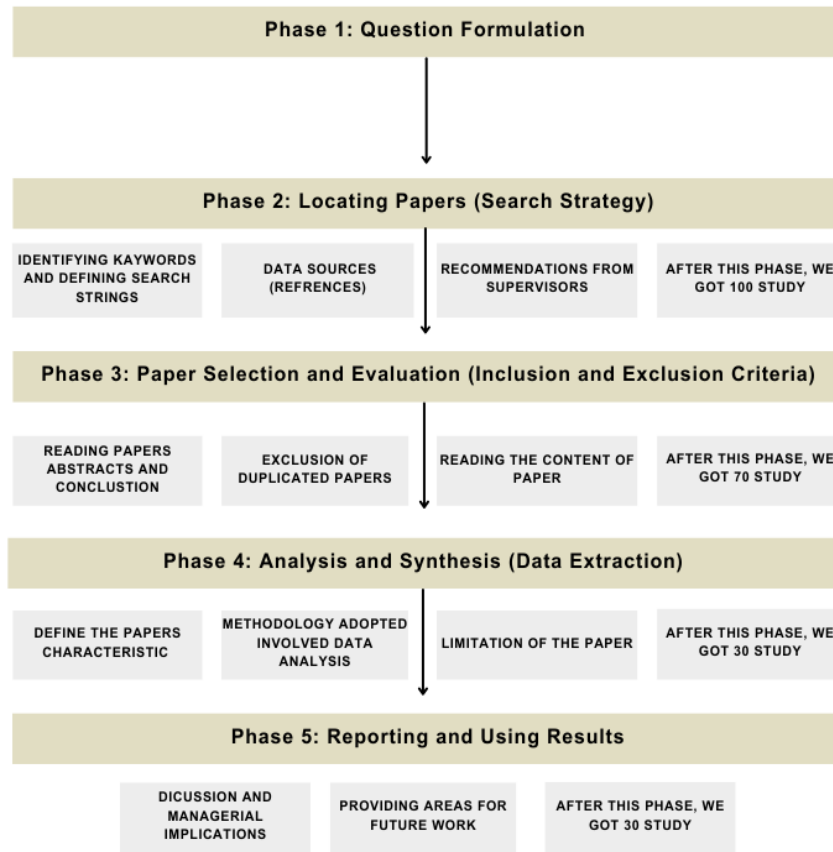


Fig. 1. Methodology of Literature Review

2.1.2.1. Search strategy

During our search, we limited the search scope by setting a primary keyword focused on Tajweed and Quran Recitation. We defined a search string, identified data sources, reviewed the search results, and finally conducted a structured search within those data sources.

2.1.2.1.1. Identifying keywords and defining a search string

The primary goal of setting a main keyword is to narrow the search results to find specific studies related to Quran Recitation, focusing on the correct method of recitation, error prevention, and evaluation techniques.

The search process included the following main keywords: "Quran Recitation" to capture studies related to the proper method of Quran reciting, avoiding errors, and evaluating recitation accuracy. "Speech recognition" to identify studies on speech recognition and its various applications, including its use in Quran Recitation. "Tajweed rules" to find in-depth resources on the main rules of Tajweed, ensuring recitation accuracy. "Tajweed learning", "Tajweed recognition", and "Tajweed detection using AI" to explore approaches to learning Tajweed, as well as relevant algorithms, models, and AI-based methods for Tajweed recognition, and how these technologies can be applied.

2.1.2.1.2. Data sources

The digital databases that were used to search for the keywords are Science Direct, Springer, MDPI, IEEE, and others.

2.1.2.2. Inclusion/Exclusion criteria for selecting studies

After searching for literature studies, using previously identified keywords, the researchers analyzed 44 studies, according to specific criteria as shown in Table 1.

After each researcher completed their review, the results were collectively reviewed to ensure their suitability and sufficiency. This process resulted in a final total of 30 studies (15 papers and 15 applications) out of 44. This process did not exclude applications due to the scarcity of applications in the field of learning Tajweed, and because this study aims to build an application that includes most of the features of other applications as a future work.

Table 1: Criteria of studies analysis

Category	Criteria
All Papers	Use AI to build innovative solutions.
	Provides solutions that detect mispronunciation of words from audio files using Voice Recognition technology.
	The proposed solutions were trained and tested on an Arabic language dataset.
	The papers were published after 2017.

2.1.2.3. Quality assessment

A set of four questions was created to evaluate the quality of the shortlisted papers. Each question is scored as follows: Y = 1 (Yes): The paper fully and clearly addresses the question; M = 0.5 (Medium): The paper provides a partial or somewhat adequate response; and N = 0 (No): The paper does not address the question at all. The following questions make up the evaluation criteria:

- ✓ Q1. Are the research motives clearly stated?

- ✓ Q2. Did the study achieve its aims?
- ✓ Q3. Are the development estimation techniques in the paper well-defined?
- ✓ Q4. Are the estimation accuracy measures soundly construed?

The authors have executed the quality assessment of all the carefully chosen primary studies. Eleven out of fifteen research papers achieved a high and comprehensive evaluation, while four papers received an average rating.

2.1.2.4. Data extraction

During the data extraction phase, information is gathered from the final selected studies that address the research questions. This data extraction for the chosen studies is conducted using an Excel sheet and starts by defining the aim, methodology, limitations, and results of the selected study. The sheet also contains a paragraph of LR of the papers and applications that have been studied.

2.1.3. Results reporting of the Literature Review

This section summarizes the selected studies according to the questions they answer.

2.1.3.1. Results reporting on LRQ1

In [15], the authors developed a Quranic Verses Recitation Recognition system, using Pocket Sphinx for accurate verse identification. They improved performance through noise reduction; Mel Frequency Cepstral Coefficients (MFCCs) feature extraction, and a custom matching algorithm. They achieved 100% accuracy in recognizing recitations.

In [16], the authors investigated Arabic speech recognition using the Soundflower tool, focusing on its audio routing effectiveness and recognition accuracy. Features extracted using MFCCs. These features were processed with machine learning models such as Deep Neural Networks (DNNs) and Hidden Markov Models (HMMs). The study analyzed 150 speech files from male speakers, achieving an accuracy range of 42.26% to 70.39% with an average Word Error Rate (WER) of 44.67%. For 104 female speech files, accuracy ranged from 46.52% to 68.73%, with an average WER of 43.03%.

In [17], the author designed a Unit Selection Speech Synthesis System in MATLAB for improving text-to-speech synthesis of Quranic recitations. The system converts Quranic verses into numeric codes and uses a database of 11,070 sound units from authentic recitations. It applies Contextual and Prosodic Selection techniques to ensure accurate and seamless recitations by optimizing factors like energy, F0, and MFCCs. With dynamic programming, the system achieved over 97% intelligibility while using only 3.85% of the total Quran recording storage, demonstrating its efficiency and effectiveness.

In [18], the authors explored the use of mobile technology to enhance Quranic recitation learning through Tajweed. They developed an application based on Dynamic Time Warping (DTW). The app addresses challenges in Quranic recitation, such as a lack of learning aids, limited self-evaluation, and low motivation.

In [19], Researchers developed a three-phase approach to improve Quranic learning for children using voice recognition. The first phase involves feature extraction with MFCC, Hamming window, FFT, and DCT. The second phase compares recitations using HMM. The third

phase focuses on an intuitive user interface to facilitate interaction, present results, and improve accessibility.

2.1.3.2. Results reporting on LRQ2

In [20], Researchers developed a Long Short-Term Memory (LSTM) model to detect mispronunciations in Tajweed rules, focusing on Separate Stretching, Tight Noon, and Hide. Using a public dataset with over 1,550 recordings of verse 109 of Surah Al-Ma'idah, the dataset was split into 90% training and 10% test data. Preprocessing included noise removal, followed by the extraction of MFCC features. The LSTM model identified errors in the Tajweed rules with high accuracy, achieving 96% for Separate Stretching, 95% for Tight Noon, and 96% for Hide, demonstrating its effectiveness in improving Tajweed learning.

Authors in [21] proposed two machine learning models, Artificial Neural Network (ANN) and K-Nearest Neighbor (KNN), to recognize reciters of the Holy Quran. Using audio recordings of Surah As-Sajdah and Surah Al-A'raf from ten reciters at the Holy Mosque, the dataset was divided into 70% training and 30% testing. Features were extracted using MFCC, and the resulting data were input into the ANN and KNN classifiers. Testing the models on the remaining 30% of recordings yielded accuracy results: 97.62% for ANN and 97.03% for KNN for Surah Al-A'raf, and 96.08% for Surah As-Sajdah, demonstrating the models' effectiveness in reciter recognition.

In [22], the authors introduced a smart Tajweed system to help students learn accurate Quranic recitation by applying Tajweed rules and distinguishing between different "Qira'ah" styles. They collected recordings from renowned Quran reciters and used MFCC for feature extraction. A Support Vector Machine (SVM) was employed to classify the recordings based on their "Qira'ah," while an ANN mapped input features to meaningful outputs. The ANN achieved a 96% success rate for "Qira'ah" recognition, outperforming other machine learning algorithms, and effectively supporting students in mastering Quran Recitation and Tajweed rules.

In [23], Researchers enhanced Quran learners' understanding of maqamat and Tajweed patterns using 478 audio files from two reciters. They analyzed the recordings with W-DFT and trained Convolutional Neural Networks (CNN), LSTM, and CNN+LSTM models. Utilizing 26 sound features, the system achieved 95.7% accuracy in recognizing maqamat and Tajweed patterns.

In [24], the authors developed a Quran Recitation recognition system with Tajweed. A dataset was collected from four individuals, reciting a single verse with two Tajweed pronunciations. Using wavelet packets for speech signal extraction and the Adaptive Network-based Fuzzy Inference System (ANFIS) for classification, the WPAN-FIS model achieved 100% accuracy after training.

In [25], the authors introduced a smart Tajweed system to assist learners, both native and non-native Arabic speakers, in reciting the Quran. The system analyzes audio signals and compares them to thresholds to detect correct pronunciation. Using SVM and filter banks, the system achieved 99% accuracy in validating Tajweed rules.

In [26], the authors developed the Samee'a system to aid memorization of texts like poems, speeches, and the Holy Qur'an. The system achieved a similarity score of

83.33% for Quranic files, increasing to 91.33% after pre-processing and 95.66% for the Holy Qur'an.

2.1.3.3. Results reporting on LRQ3

In [14], the Researchers proposed an end-to-end deep learning model for recognizing Holy Quran Recitation, using the Ar-DAD public dataset. The model consists of a CNN-BiGRU encoder that processes the spectrogram of audio clips and a character-based decoder that generates predictions. The performance was measured using Character Error Rate (CER) and WER, achieving a WER of 8.34% and a CER of 2.42%. However, the dataset's limitation to male reciters and a single recitation form reduced the model's generalizability.

In [27], Researchers emphasized the effectiveness of CNNs in recognizing Quranic recitation, particularly for addressing Qalqalah pronunciation issues using MFCCs for feature extraction. However, they noted challenges with small datasets, limiting the model's adaptability to various accents, especially for non-native speakers, and called for further research to enhance dataset diversity and model robustness.

In [28], Researchers compared two models for classifying Quran verses based on audio similarity. Model B used MFCC with a MaLSTM architecture, while Model C added delta features to Model B. The dataset consisted of 172,895 voice samples, with pre-processing steps including normalization and silence removal. Model B achieved a WER of 0.07 and an accuracy of 93.33% when tested with independent datasets, demonstrating its effectiveness in accurate predictions.

2.1.3.4. Results reporting on LRQ4

In 2021, Learn Quran Company launched its application: Learn Quran Tajwid [12], which aims to help Muslim users to study how to recite Quran with tarteel. The application is designed for anyone looking to learn Quran Recitation rules. It offers 21 Tajweed lessons with audio and visual examples, along with practice and tests for each lesson. While it doesn't use AI techniques, relying instead on auto-evaluation and user evaluations, it has been downloaded by over one million users and holds a 4.6 rating on Google Play, reflecting its success and user satisfaction.

In 2020, Quran Ona Inc. released the Quran Ona [29]. The application offers Quran listening, studying, readings, translations in 33 languages, 9 Tafsir options, and recitations by 103 reciters. It also includes Quranic stories with repeat and shares features. With a user-friendly interface, the app has a 4.1/5 rating on the App Store, based on 115 reviews.

In 2022, Holy Quran Academy Limited released Tajweed and Alphabet application [30]. It offers comprehensive lessons, starting with the Arabic alphabet, covering 12 lessons for all 28 letters, and providing audio examples. Subsequent lessons focus on letter connections and essential rules like Tanween, Hamza, Madd, and others. With a user-friendly interface, the app holds a 5/5 rating on the App Store, based on one review.

MSufara [31] is an application that helps users learn the Arabic alphabet and Quran Recitation rules. It offers audio examples, video explanations of Tajweed, and quizzes for practice. Available in multiple languages, it provides a wide reach for improving Quran reading skills.

2.1.3.5. Results Reporting on LRQ5

In late 2023, Wisdom-zone launched its application: Itqan Ayah: Quranic IQ Test [32], which aims to enhance understanding of the Holy Quran and master its memorization.

The application targets both beginners and experienced Quran memorizers, offering features like tests on Quranic surahs, progress tracking, and personalized settings for font size, color, and wallpaper. Despite fewer than a thousand downloads on the Google Store; it has received positive feedback with a 4.5-star rating from users, reflecting their satisfaction with the app.

Assistant App Teknologi AS launched an application: Quran 360 [33], which aims to help non-Arabic speakers read the Quran, offering features like full Quran coverage, the ability to choose a preferred reciter's voice, progress tracking, and detection of Tarteel mistakes. With an easy-to-navigate interface, the app has received a 4.7-star rating in the Apple Store.

The developer Mohammad Nakhleh launched the Quran Teacher application [34]. This modern application helps children read and memorize the Quran (Juz' Amma), offering rewards for completing surah memorization tasks. With an enjoyable and simple interface, it allows children to record their Quran Recitations and share them with parents or teachers. The app has a 4.1/5 rating on the App Store.

The Quran Majeed application [35] helps Muslims learn Quran reading with Tajweed, featuring audio recitations, progress tracking, and group learning. With 65 million downloads and a 4.6 rating, it is widely used.

ZeroToHero Dev. has released an application called Al-Quran by Quran Touch [36]. The app allows users to record their recitations and provides feedback on their Tajweed, helping them improve pronunciation and adherence to rules. It includes color-coded explanations for each Quranic line according to Tajweed and features a Qari with excellent recitation. With a 4.8 rating and over 3,100 downloads, it offers a valuable learning experience.

In 2019, Quranic application [37] was launched to help users learn Quranic Arabic through interactive lessons, quizzes, flashcards, and activities. It focuses on the most used words and their meanings, aiding users in understanding the Quran's original text. With a user-friendly interface and organized lessons.

2.1.3.6. Results reporting on LRQ6

In 2021, the TajweedMate Team released an AI-powered application called TajweedMate [38], which aims to help Muslim users learn and practice Tajweed.

The app provides 33 Tajweed lessons, tests, and a memorization tool for 15 Surahs. It uses speech recognition for test evaluation but relies on self-evaluation for memorization. With over 100,000 downloads and a 4.7 rating, it's popular but could improve in design and AI accuracy.

In 2021, developer Muhammad Shaker released the Thurayya application [39]. The app is designed for children ages 4 and up. It features a colorful interface, covers most short Surahs, and includes a rewards system to encourage progress. Children can record their recitations, which are evaluated by the app. It won the 2021 Seedstars Award.

In 2014, Khaleef Technologies released the Al-Muallim application [11] Al-Muallim is an interactive app

designed to help Muslims learn and practice Quran Recitation with a focus on Tajweed. It uses AI voice recognition for real-time feedback on pronunciation and recitation accuracy. It has a 4.2/5 rating on the App Store from 634 users.

Tarteel application [13] is designed to enhance Quran memorization and recitation using AI-driven features that detect mistakes. It offers personalized memorization planning, goal-setting tools, and progress tracking. The app uses Automatic Speech Recognition to provide real-time pronunciation corrections. With a rating of 4.6, it has been downloaded by over 6,000 users.

Tasmee [40], was launched in 2016 by Eqra Tech, helps users practice Quran memorization by using speech

recognition. It also includes Tafsir and Tajweed explanations for each verse. With a 4.3 rating from 21,000 reviews.

3. Analysis of Literature Review

After studying 30 previous studies, researchers analyzed and compared the extracted results to identify their weaknesses and knowledge gap, as shown in Tables 2 and 3. This process was carried out in two stages: the paper analysis stage and the application analysis stage. In both stages, the researchers compared the methodologies used in each study to identify weaknesses that represent the knowledge gap.

Table 2. Comparison of the papers

Ref.	Aim	Dataset	Feature Extraction	Model	Results	Limitations
[20]	Detect mispronunciation of basic Tajweed rules.	1500 records	MFCC	LSTM	accuracy rate 95%, 96%	The dataset is small, and it contains only one verse. The model was trained in only three Tajweed rules
[14]	Quran Recitation recognition	1506 records	CNNBiGRU encoder	based decoder	Quran Recitation with WER of 8.34% and character error rate of 2.42%.	The dataset is not varied, and the study did not include any Tajweed rules.
[21]	Quran reciter recognition	2360 records for Surahs Al-A'raf and AsSajdah	MFCC	ANN and KNN	The accuracy rate is more than 96%.	The dataset is not varied. And, the model was trained to identify the reciter only, not to catch recitation errors.
[15]	Quranic Verses Recitation Recognition System	855 for training, 105 for testing	CMUSphinx, MFCC	---	105 audio samples were recorded, all correctly transcribed with zero errors, again achieving 100% accuracy.	The dataset contains recordings of Surah Al-Ikhlās, and there is no alarm or notification
[16]	Use Soundflower to test audio quality and recognition accuracy.	275 files recorded by 20 person	MFCC	---	Accuracy range: 42.26% to 70.39%, average WER for male speakers was 44.67%. For female speakers, the average WER is 43.03%.	A small data set was used.
[17]	Develop a text-to-speech system to reduce the errors of recitation.	11,070 sounds	MFCC	Rule-based scoring, USSS	The results conclude that the system intelligibility exceeds 97% with a reduction of memory size by using 3.85% of the total Quran recording.	The system does not focus on Tajweed rules or accurate recitation.
[22]	Learn accurate Quran Recitation	258 audio files, based on Hafs and Eldori readings, with	MFCC	SVM	The success rate of 96%, the SVM-based recognition model for "Qira'ah" outperforms other machine learning algorithms.	Limited Dataset.

		only three surahs				
[23]	Classify the eight popular maqamat	478 audio files belonging to the 8 maqams	MFCC	CNN, LSTM, and deep ANN	An accuracy of 95.7% on the test set is obtained using a 5-layer deep ANN, which was trained using 26 input features	No diversity in the dataset; the research is limited to two Popular Quran reciters.
[24]	Recognize Al-Quran reading by recitation of Tajweed.	20 students taking the Al-Quran Tilawah	ANFIS	ANFIS	The WPANFIS classification model got 100% appropriate classification	None
[25]	Recognize correct recitation and Tajweed rules	657	Filter Banks	SVM	For the best results, SVM got 99% accuracy.	The dataset was limited to the Tajweed rules that were applied, which focused on four rules.
[18]	An Android mobile learning application using DTW to detect Tajweed rules.	42	MFCC	DTW	Applying DTW to analyze voice patterns, which got a 90.47% accuracy rate, recognizing 38 out of 42 voice samples correctly.	lack of appropriate learning tools, difficulty in evaluating ability, and a limited dataset.
[27]	Recognize and identify the Qalqalah rule in Quranic recitation.	Not mentioned	MFCC	CNN	CNN got an average of 92%, accuracy of Baa mini-model is 99%, accuracy of Daal mini-model is 93%, accuracy of Jeem mini-model is 95%, accuracy of Qaaf mini-model is 92%, accuracy of Taa mini-model is 83%	The dataset focused on only one rule and specific letters.
[19]	Propose an automated Tajweed Checking System for Children in Learning Surah Al-Fatiha in Quran	---	MFCC	HMM	-----	Small databases and did not provide feedback
[28]	Compare the performance of the two types of models used in the task of classifying Quran verses based on audio similarity	---	MFCC	MaLSTM	Model B has the lowest WER of 0.07 and the highest Accuracy at 93.33%, highlighting its effectiveness in delivering precise and efficient predictions.	reading the Quran using only three voices
[26]	Propose a new system to facilitate memorizing any kind of text, such as poems, speeches, and the Holy Qur'an.	---	MFCC	Distance Algorithm, Google Cloud Speech-to-Text API, HMM.	Text memorization with a similarity of 95.66% for the Holy Quran	Limited Dataset

3.1 Analysis of Reviewed Studies

After studying and extracting data from the studies, the researchers analyzed them to determine their limitations. They found six common limitations among them, which

list in Table 3. The most common limitation was the small size of the datasets, as nine of the papers used a small dataset of fewer than two thousand records. In contrast, the

least common limitation was focusing on one short Surah or verse, which applied to only two studies.

3.2 Analysis of Reviewed Applications

To determine the limitations of the applications, the researchers set seven characteristics or criteria to evaluate the applications. Criteria of the applications are: Completely free, playing audio, Voice recognition recitation, accurate recognition by AI, Active exercises, verse explanation, and educational app.

4. Gap of knowledge

This section highlights the gaps in current knowledge and explains why further investigation is necessary. The study aims to directly address these issues and fill the gaps identified in previous research and applications. Tables 3 and 4 show the limitations of the papers and applications, respectively.

In studies [16], [18], [20], [21], [22], [24], [25], [26], and [28] small dataset was used, which limits the reliability of the results and affects their accuracy. The results reflect the reader's assessments of the correctness of his recitation. In this study, a large data set will be collected and used, which will contribute to improving reliability and accuracy of the results.

In these studies: [14], [18], and [21] the sample used for recording readers was biased towards a specific gender, which negatively affected the validity of the results. The baseline voice will be compared with the voice of the reader, whether a child, a woman, or a man, which may lead to inaccurate results.

In study [15], the model was trained and tested on a dataset containing recordings of Surah Al-Ikhlās, a short surah consisting of approximately two lines. Also, in study [20], a public dataset was used containing recordings of verse 109 of Surah Al-Ma'idah, which consists of a line and a half. These verses do not contain all or most of the rules of Tajweed, which weakens the performance of the model.

In studies [14], [20], [25] and [27] researchers focused on fewer than four Tajweed rules, with some limiting themselves to only one rule. The proposed solution would

be unable to identify the rest of the rules. For this reason, the researchers in this study will seek to identify a larger set of rules so that the future model can identify the largest possible number of Tajweed rules.

In studies, [17], [19], [27] and [28], the authors did not focus on Tajweed rules or accurate recitation. But instead, it focused only on word and letter pronunciation, which is not sufficient to determine whether the recitation was accurate or not.

Based on the applications identified in previous studies, which total fifteen, we created the table that highlights the key differences and features among them, as shown in Table 4. The two most commonly recurring features are the provision of an educational environment, offered by fourteen applications, and audio playback for lessons, available in thirteen applications. Additionally, some features are less commonly provided. For instance, four applications include the accurate use of AI. Among the fifteen applications, only eight offer completely free experience. However, most applications lack features that actively engage users in practicing Quran Recitation, such as exercises to improve recitation skills or verse recognition. Furthermore, only five applications utilize AI technology, which limits the ability to provide accurate evaluations of users' recitation through voice recognition or other advanced tools. These findings emphasize a gap in comprehensive AI-powered tools for accurate evaluations and enhanced user engagement, pointing to opportunities for improvement in future applications.

5. Conclusion

This paper presents a review of the current landscape of papers and applications dedicated through AI to enhance Quran Recitation and Tajweed learning. The investigation reveals 30 research applications for automating the process of enhancing the accessibility and effectiveness of Quran Recitation. These papers and applications have been developed to make Quran Recitation and Tajweed learning easier, contributing to both religious and educational development. AI technologies are increasingly being used to offer real-time feedback, helping learners detect errors and enhancing the learning process for a wider audience.

Table 3. Limitations of the previous studies

Limitations	Description	Number of papers	Papers
Small dataset	Dataset size is less than 2,000 records.	9	[16], [18], [20], [21], [22], [24], [25], [26], [28]
Lack of dataset diversity	Lack of diversity in readers in the dataset (e.g., all readers in the dataset are men).	2	[14], [18], [21]
Lack of error correction	Failure to correct recitation mistakes is detected.	6	[15], [16], [17], [19], [20], [21]
Focus on one short surah or verse	The dataset contains recordings of a single surah or verse of less than two lines.	2	[15], [20], [24],
Focus on a small number of Tajweed rules	Focus on three or fewer Tajweed rules.	4	[14], [20], [25], [27]
Did not focus on any of Tajweed rules	Lack of Tajweed rules in detecting mistakes.	4	[17], [19], [21], [27]

Table 4. Comparison of the Applications

Application	fully free	Audio play lessons	Accurate Recognition using AI	Voice recitation recognition	Active exercises	Verse explanation	Educational
Learn Quran Tajweed [12]		√			√		√
Tajweedmate: Learn Quran [38]	√	√		√	√		√
Itqan Ayah [32],	√				√	√	
Al-Mullim [11]	√		√	√		√	√
Quran Ona [29]	√	√				√	√
Tajweed And Al-phabet [30]	√	√					√
Quran 360 [33]		√			√		√
Thurayya [39]		√			√		√
Tarteel [13]	√	√	√	√	√		√
Al-Quran By Quran Touch [36]		√				√	√
Quran Majeed [35]		√	√	√		√	√
Tasmee تسميع [40]		√	√	√		√	√
Quranic [15]		√			√		√
Quran Teacher [34]	√	√			√		√
Msufara [31]	√	√			√		√

Various AI models were used, including Machine Learning algorithms like SVM, KNN, and ANN, as well as deep learning architectures such as CNN, LSTM, and hybrid models, which have been employed with promising results, often utilizing MFCC for feature extraction.

Through the review process, we also found several limitations that constrain the current state of Tajweed learning applications. Some of these limitations are: small datasets, gender bias, a limited set of Tajweed rules, and the evaluation of short Surahs or single verses.

Gaps in the current knowledge underscore the need for more comprehensive AI-powered solutions to enhance Tajweed learning and Quran Recitation.

Finally, the ideal Tajweed learning system must be trained on a large, gender-balanced dataset encompassing a wide variety of Tajweed rules applied to the largest number of the Quran surahs'. It must leverage advanced AI techniques to provide precise, real-time feedback that is pedagogically sound and accessible to all learners.

Therefore, future work will focus on addressing these limitations. It will involve the development and rigorous evaluation of a new prototype. This will entail curating a larger, more diverse dataset and building a model capable of accurately detecting Tajweed errors. This will contribute to a more effective, scalable, and intelligent solution for Quran learning.

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