Literature Review: Smart Quran Recitation

Background and Importance of Smart Quran Recitation

Quran recitation is a central religious practice for Muslims, and correctness in pronunciation and application of Tajweed rules is essential to preserve the intended meaning of the text. Traditionally, correct recitation is learned through face-to-face instruction with qualified teachers. However, factors such as limited access to experts, large learner populations, time constraints, and geographical barriers have created a need for automated and intelligent Quran recitation systems, commonly referred to as Smart Quran Recitation. Advances in speech processing, artificial intelligence (AI), and mobile computing have enabled the development of systems that can automatically analyze recitation, detect errors, and provide feedback to learners.

Challenges in Smart Quran Recitation Systems: Despite technological progress, several challenges persist in developing effective smart recitation systems. First, accurate detection of Tajweed rules is difficult because Quranic recitation involves subtle phonetic variations such as elongation (madd), nasalization (ghunnah), and assimilation (idgham). Second, speaker variability (age, accent, recitation style, and melodic modes) affects system accuracy. Third, many systems suffer from limited datasets, often relying on small or private corpora, which reduces generalization. Finally, there is a trade-off between accuracy and explainability: while deep learning models offer high recognition performance, they often fail to explain why a recitation is incorrect, which is crucial for learning.

Review of Empirical Studies and Solutions

Early work by Tabbaa (2015) introduced a computer-aided training system focused on automatic error detection in Quran recitation. The study used classical signal processing and rule-based comparisons between learner recitation and reference audio. This approach addressed the challenge of automated feedback but struggled with speaker variability and lacked scalability due to its dependence on handcrafted rules.

To improve explainability, Elsayed and Fathy (2019) proposed integrating ontology-based knowledge representation with Automatic Speech Recognition (ASR). By modeling Tajweed rules using OWL ontology, their system could identify specific rule violations rather than only detecting mismatches. This approach directly addressed the challenge of pedagogical feedback by providing interpretable results. However, its effectiveness was limited by ASR errors and the complexity of building comprehensive Tajweed ontologies.

In response to the need for more data-driven solutions, SMARTAJWEED (2020) applied traditional machine learning techniques, particularly Support Vector Machines (SVM), to classify Tajweed rules from extracted acoustic features. This method improved detection accuracy over purely rule-based systems and demonstrated measurable performance. Nonetheless, it could not effectively model long-term temporal dependencies in recitation and relied on limited datasets.

More recently, Harere et al. (2023) proposed an end-to-end deep learning approach using CNNs and bidirectional GRUs with Connectionist Temporal Classification (CTC). This system addressed several previous challenges by modeling recitation as a sequence problem, improving robustness to speaker variation and continuous recitation. Deep learning significantly enhanced recognition accuracy and scalability. However, the model lacked explainability and required large annotated datasets, which remain scarce for Quranic Tajweed analysis.

In conclusion, research on Smart Quran Recitation has evolved significantly from basic rule-based systems to advanced deep learning models. While recent approaches achieve higher accuracy, challenges related to explainability, data availability, and educational effectiveness remain. Addressing these gaps will be crucial for developing intelligent, reliable, and learner-friendly Quran recitation systems.