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Application of the Rule-Based Pattern Matching Method to Detection of Types of Mujarrad and Mazid Verbs in the Qur'an Based on Arabic Morphology Patterns

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ABSTRACT

Arabic has a complex morphological system, particularly in the formation of fi'il (verbs), which in sharaf are classified into fi'il mujarrad and fi'il mazid. Fi'il mujarrad refers to basic verbs without additional letters, while fi'il mazid involves added letters that form specific wazan (patterns). The main problem addressed in this study is the similarity of morphological patterns between fi'il and non-fi'il, which affects classification accuracy. This study aims to identify fi'il in Surah Al-Baqarah and classify them into mujarrad and mazid, along with their wazan patterns, automatically using a rule-based pattern matching approach. The method applies rules based on Arabic morphological patterns, such as fi'il mudhari' prefixes, word length, and the presence of additional letters in accordance with sharaf principles.The data consist of Qur'anic text processed through preprocessing stages, including load data and tokenization. The system detected 916 candidate fi'il, of which 468 data points were used for evaluation by comparison with manual annotations using a confusion matrix.The results show that the system achieved an accuracy of 75% for fi'il type classification, with precision, recall, and F1-score of 0.77, 0.75, and 0.75, respectively. For wazan classification, the system achieved an accuracy of 69.23%, with weighted average precision of 0.66, recall of 0.69, and F1-score of 0.65. These findings indicate that the rule-based approach is sufficiently effective in detecting fi'il mujarrad and mazid, although performance for certain wazan patterns remains limited due to structural similarities. Therefore, further development of more specific rules and integration with machine learning methods are recommended to improve system accuracy.

I. INTRODUCTION

Arabic as the language used in the Qur'an has a unique and complicated morphological system, where the meaning and function of a word is determined by the root of the word and its formation pattern. In the study of Arabic morphology ('Ilmu Sharaf), changes in word form occur through the process of adding letters, changing patterns (wazan), or a combination of both. These morphological changes have a direct effect on the meaning of words, so that understanding morphology becomes an important aspect in understanding the text of the Al-Qur'an correctly[1]. Therefore, the ability to analyze the morphological structure of words is a basic competency in learning Arabic and studying the Qur'an.

In line with this, Arabic language learning in Indonesia also emphasizes the importance of morphological literacy, because understanding vocabulary and text structure is very dependent on the ability to recognize patterns of change[2]. In addition, religious education policies and madrasah curriculum place the study of the Qur'an and Arabic as an important part of formal education[3]. Thus, strengthening the ability to analyze Arabic morphology is not only theoretically

relevant, but also supports improving the quality of Qur'an learning in Indonesia.

However, difficulties in distinguishing between mujarrad and mazid verbs can also be encountered in Arabic language learning in Islamic boarding schools (pesantren) or Islamic boarding schools (dayat). Based on the author's experience while studying sharaf at a dayah, many students experience difficulty identifying verb forms that have undergone additional letters or changes in pattern (wazan). Students generally still have to memorize various patterns manually and match them one by one with words found in the Qur'anic text. This process often takes quite a long time and often results in errors in determining whether a verb is a mujarrad or mazid verb. This condition shows that although the rules of Arabic morphology have been systematically compiled, the identification process remains a challenge for learners, so an approach is needed that can help recognize these morphological patterns more systematically and efficiently. Furthermore, the morphological analysis process is still often carried out manually, which is relatively time-consuming and prone to error [4]. For example, in Surah Al-Baqarah, there are several verb forms that show the difference between fi'il mujarrad and fi'il mazid. One example is the word خلقَ in the verse ٱلَّذِي خلقَ لكُم مَّا فِي ٱلۡأَرۡض جمِيعًا (QS. Al-Baqarah: 29). The word خلقَ is included in fi'il mujarrad because it is composed of three basic letters خ-ل-ق without any additional letters. On the other hand, there are also forms of verb mazid, such as the word أَنْزَلَ in the verse وَأَنْزَلَ مِنَ السَّمَاءِ مَاءً (QS. Al-Baqarah: 22). The word أَنْزَلَ comes from the root word ن-ز-ل, but has the addition of the letter أ at the beginning so that it follows the pattern أَفْعَلَ, which is one form of verb mazid. The difference in morphological structure shows that the addition of letters and changes in patterns can affect the form and meaning of verbs in Arabic.

Along with the development of technology, various computational studies on Arabic texts have focused on verse classification, stopword removal, or feature extraction in general [5]. Several studies have also studied wazan and fi'il forms in the Al-Quran. for example, analyzing the wazan fi'il in Surah Al-A'la using a semantic approach to understand the contextual meaning of the verse,not to identify its morpholo gical structure [6]. Meanwhile, Puspasari and Rusmin (2022) applied an NLP approach such as TF-IDF to analyze certain wazan patterns, but limited it to specific patterns and did not focus on distinguishing between mujarrad and mazid verbs. On the other hand, rule-based methods have been widely applied in NLP research in various contexts, such as information extraction, word search, and chatbots [7]. However, its application to identify the types of verbs in the text of the Qur'an is still rarely done.

Based on the review of previous studies, it can be concluded that although studies on wazan and the form of fi'il in Arabic have been conducted, these studies generally still focus on semantic analysis, manual studies, or general statistical and NLP approaches. To date, there has been no research that specifically develops an automatic system to detect mujarrad and mazid fi'il in the text of the Qur'an based on Arabic morphological patterns using a rule-based pattern matching approach. Therefore, there is a research gap in the form of the lack of systematic use of morphological rules ('ilmu sharaf) in computational form to detect these types of fi'il.

To address this gap, an approach capable of systematically recognizing Arabic morphological patterns based on established linguistic rules is needed. One suitable approach is rule-based pattern matching, a method that applies a set of rules to match morphological patterns in verbs. This approach uses if-then logic, whereby if a word meets a certain morphological pattern, the system will classify it into the appropriate category. Rule-based pattern matching is considered suitable for Arabic because its morphological structure is regular and can be formulated into clear rules, consisting of a root word, a pattern (wazan), and additional letters. This study was designed to extract verbs from Quranic verses, match them to predetermined morphological patterns, and automatically classify the type of verb.

Thus, this research is expected to help students understand Arabic morphology more effectively and reduce errors in analyzing verbs in the Quranic text. Furthermore, this research is also expected to support the development of technology-based Quranic studies.

II. METHOD

This study applies the rule-based pattern matching method to detect fi'il mujarrad and mazid in the Quran based on Arabic morphological patterns. The overall research process is illustrated in the flowchart shown in Figure 1.

Figure 1. Applying the rule-based pattern matching method to detect mujarrad and mazid

A. Data Collection

The data used in this study is secondary data obtained from the official Tanzil.net website, which provides digital text of the Quran in Arabic. The research dataset is limited to Surah Al-Baqarah, which consists of 286 verses, and is used in the form of a text file (.txt) as system input. The system receives

input in the form of a text file (.txt) containing verses from Surah Al-Baqarah obtained from digital sources of the Quran. This data serves as the main ingredient in the fi'il detection process. Surah Al-Baqarah was selected because it is the longest surah in the Qur'an and contains a diverse range of fi'il forms and morphological patterns. This diversity provides a representative dataset for evaluating the effectiveness of the proposed rule-based pattern matching method in detecting and classifying fi'il mujarrad, fi'il mazid, and their corresponding wazan patterns.

B. Preprocessing text

After receiving input of Quranic verses, the system will read and tokenize the data. The verses are read using UTF-8 format so that Arabic characters can be processed correctly, then each verse is broken down into words (tokens) so that they can be analyzed separately. Next, the data is cleaned and separated based on delimiters to obtain information on the surah number, verse number, and verse text. This research focuses on Surah Al-Baqarah so that only verses from that surah are processed. The data is then arranged in a table (DataFrame) to be more structured and facilitate processing in the next stage. Each tokenization result is stored along with information on the original surah and verse so that the context of the words is maintained and ready to be used for identification of verbs and classification of wazan. broken down into words (tokens) so that they can be analyzed separately.

C. Identification of verbs

Before entering the fi'il identification stage, it is necessary to understand first about fi'il mujarrad and fi'il mazid. Fi'il mujarrad is a verb that is composed of basic letters without additional letters, generally consisting of three letters. Examples include كتب (kataba) which follows the فعل pattern. Meanwhile, fi'il mazid is a verb that has letters added to form a certain pattern or wazan [8]. For example, استغفر (istaghfara) which has the additional letters alif, sin, and ta so it is included in the verb mazid.

Once the pre-processing process is complete and the data is in the form of word tokens, the system enters the fi'il identification stage. At this stage, the system determines whether a word is a fi'il or not. The identification process begins with word normalization, which removes vowels (harakat) to focus the analysis on the basic letter structure without being influenced by spelling variations. Next, the system performs initial filtering using a list of non-fi'il words, such as pronouns and certain letters, to reduce the possibility of misidentification.

After the filtering stage, the system applies several conditions for the possibility of verbs, which aim to identify the morphological characteristics of verbs in Arabic. Some of the conditions used include:

1. Word length:
   Words with a length of less than three letters are not categorized as fi'il.
2. Checking for specific prefixes
   Words beginning with the letter ال (alif lam) are eliminated because they are generally nouns or nouns.
3. Filtering for connecting prefixes
   Words beginning with letters such as ك, ب, ف, و, and ل with short lengths are not considered as verbs.
4. Detection of mudhari' verbs
   Words beginning with the letters ن, ت, ي, and أ with a minimum length of four letters are considered candidates for mudhari' verbs.
5. Detection based on letter length and pattern
   a. Words with a length of three letters have the potential to be mujarrad verbs.
   b. Words with a length of four letters are analyzed for the presence of additional letters such as ا, و, ت, or ي.
   c. Words with a length of more than four letters are checked based on certain prefixes such as است، ان، ت، ي، and أ which indicate the fi'il mazid form.

After applying the *fi'il* identification rules to all tokenized words in Surah Al-Baqarah, the system generated 916 candidate *fi'il*. These candidates represent all words that fulfilled at least one morphological condition defined in the identification stage. Since the identification process prioritizes recall, some non-*fi'il* words may still be included as candidates and are filtered during later evaluation stages.

D. Manual Annotation (Ground Truth)

Ground truth data were obtained through manual annotation based on Arabic morphology (sharaf) rules. Each candidate fi'il was examined and labeled according to its type (mujarrad or mazid) and corresponding wazan pattern. The annotation process was performed manually by the researcher using established Arabic morphology references and served as the benchmark for evaluating system performance. Only data that could be consistently matched between system output and manual annotation were included in the final evaluation dataset.

E. Morphological rules (Rule based)

The rule-based method is an approach that uses a set of pre-determined rules or logic to analyze data [9]. In general, this approach can be expressed by the formula:

$$Match(w,R) = \begin{cases} True, jika\ w\ sesuai\ dengan\ pola\ R\_i \in R \\ False, jika\ tidak\ ada\ R\_i \in R\ yang\ cocok \end{cases}$$

Information:
W = word or token fro the input text

R = set of rules or patterns
Ri = i-th rule in the rule set

Match(w,R) returns True if there is a matching pattern between the word and the defined rule.The formula above shows that a word (w) will be declared a match (true) if it meets one of the defined pattern rules (R_i). Conversely, if the word does not match any of the available patterns, the match result will be false [10].

Once a word is identified as a fi'il, the system continues the process to the stage of applying morphological rules using a rule-based method. At this stage, the system does not immediately perform pattern matching, but first applies predetermined morphological rules to recognize the wazan pattern and type of fi'il. Rules. And the application of morphological rules in the system is represented in the form of a rule table (rule-based) that contains the relationship between word conditions, fi'il types, and the resulting wazan pattern. These rules form the basis for the system in recognizing mujarrad and mazid fi'il forms.

TABLE I
MORPHOLOGICAL RULES (RULE-BASED) IN DETERMINING WAZAN FI'IL

No	Word Condition (System Logic)	Type	Direction
1	Diawali “ا” + huruf ke-3 = “ت”	Mazid	افتعل
2	Diawali “ت” + huruf ke-2 = huruf ke-3	Mazid	تفعّل
3	Huruf ke-2 = “ا” (pola alif internal)	Mazid	فاعل
4	Diawali “افعو”	Mazid	افعوعل
5	Diawali “افعن”	Mazid	افعنلل
6	Berakhir dengan tasydid (ّ)	Mazid	افعالّ
7	Diawali “تفعلل” / pola 5 huruf berulang	Mazid	تفعلل
8	Diawali “اف” + berakhir tasydid	Mazid	افعلّ
9	Panjang = 3 huruf (bukan huruf partikel awal)	Mujarrad	فعل
10	Diawali “ي” dan panjang ≥ 4	Mujarrad	فعل
11	Selain semua kondisi di atas	-	-

Table 1 shows the morphological rules used in the rule-based system. Each wazan is determined by matching the letter patterns of verbs (fi'il) based on the morphological structure of Arabic. The system applies a tiered approach, where more specific patterns are prioritized before general patterns (mujarrad).

The rules presented in Table 1 were constructed based on commonly used Arabic morphology patterns found in fi'il mujarrad and fi'il mazid forms. The system prioritizes specific patterns such as تفعّل ,افتعل, and فاعل before applying more general rules. This hierarchical strategy reduces ambiguity and improves pattern recognition accuracy by ensuring that more distinctive morphological patterns are evaluated first[11].

F. Pattern matching

After the morphological rules are defined, the system enters the pattern matching stage. Pattern matching is the process of matching word structures with morphological patterns defined in rule-based rules. The purpose of this process is to identify wazan patterns and classify the types of fi'il based on the suitability of the word form to the available rules. In this study, the system implements a wazan detection function to perform morphological analysis on words that have been identified as fi'il. The process begins with an initial filtering to ensure that the word meets the criteria as a candidate fi'il. Words are then normalized by removing harakat and performing form reduction through the removal of certain prefixes or suffixes to obtain the basic form of the word.

Next, the system performs a match against the established morphological rules. Matching is done based on certain characteristics, such as the presence of specific prefixes, internal letter patterns, word length, and letter repetition forms. For example, words beginning with "يست" ,"است", "تست", or "نست" are recognized as the pattern استفعل, while words beginning with "ان" are recognized as the pattern انفعل. In addition, the system also detects patterns based on the letter structure within the word, such as letter repetition indicating the pattern فعّل, the presence of an internal alif indicating the pattern فاعل, and certain prefix combinations that lead to the pattern افتعل or تفاعل. To expand the detection range, the system also applies several special rules to less common patterns, such as افعنلل ,افعوعل, and تفعلل. These additional rules serve as special handling for morphological variations that are not always found in common patterns.

If a word is three letters long and does not meet the letter addition indicator, then the word is classified as a mujarrad fi'il with the inflection of فعل. Conversely, words that indicate the addition of letters or meet a certain pattern are categorized as mazid fi'il. If all the rules are not met, the system assigns a default label in the form of a "-" sign to indicate that the pattern was not successfully identified. Based on the results of the pattern matching, the system then classifies the type of fi'il. Words with the inflection of فعل are categorized as mujarrad fi'il, while words with inflections other than فعل are categorized as mazid fi'il. The analysis results are then applied to all data using a DataFrame to produce additional attributes in the form of wazan and fi'il type. The successfully identified data is then used in the system evaluation stage.

III. RESULTS AND DISCUSSION

This section presents the results of detection and evaluation of the system's performance in identifying and classifying verbs in Surah Al Baqarah.

A. Detection Results

This research developed a Rule-Based Pattern Matching system to detect and classify fi'il in Surah Al-Baqarah into Mujarrad and Mazid categories based on Arabic morphological patterns. The system identified 916 candidate fi'il, of which 468 could be matched with the manually annotated ground truth data and were therefore used for evaluation. Samples of the detection results are presented in Table 2.

TABLE 2
FI'IL DETECTION RESULTS IN SURAH AL-BAQARAH

Surah	Verse	Words Fi'il	Direction	Type
2	2	ريب	فعل	Mujarrad
2	2	هدى	فعل	Mujarrad
2	3	يؤمنون	فعل	Mujarrad
2	3	ينفقون	فعل	Mujarrad
2	4	يؤمنون	فعل	Mujarrad
….	….	….	….	….
2	286	نسينا	فعل	Mujarrad
2	286	أخطأنا	أفعل	Mazid

B. *Evaluation*

The evaluation phase was conducted to determine the system's performance level in identifying and classifying verbs in Surah Al-Baqarah. The evaluation was conducted using a confusion matrix method that produces several measurement metrics, namely accuracy, precision, recall, and F1 score. The system evaluation was conducted by comparin g the system's classification results to ground truth data using a confusion matrix and a classification report. The test results showed that the system achieved an accuracy level of 75% in detecting and classifying the types of verbs mujarrad and mazid. These results indicate that the rule-based pattern matching approach is quite capable of recognizing the morphological patterns of verbs based on the designed rules, although there were still some classification errors due to similarities in morphological structure between words. and ground truth data for evaluation can be seen in table 3.

TABLE 3
FI'IL DETECTION RESULTS IN SURAH AL-BAQARAH

No	Surah	Verse	Word Fi'il	Direction	Type
1	2	3	يؤمنو	أفعل	Mazid
2	2	3	ينفقون	أفعل	Mazid
3	2	4	يؤمنون	أفعل	Mazid
4	2	4	أنزل	أفعل	Mazid
5	2	6	أأنذرتهم	أفعل	Mazid
6	2	6	يؤمنون	أفعل	Mazid
7	2	8	يقول	فعل	Mujarrad
8	2	9	يخادعون	فاعل	Mazid
9	2	9	يخدعون	فعل	Mujarrad
10	2	9	يشعرون	فعل	Mujarrad
…	…	…	…	…	….
467	2	286	تؤاخذنا	فاعل	Mazid
468	2	286	أخطأنا	أفعل	Mazid

Then testing is carried out by comparing the system detection results against ground truth data that has been manually annotated.

Before conducting the performance evaluation, the distribution of data across *fi'il* categories was analyzed to provide a clearer understanding of the evaluation dataset. Examining class distribution is important because an imbalance between categories may influence the interpretation of accuracy, precision, recall, and F1-score values. Therefore, the number of data instances in each fi'il category is presented to support a more comprehensive evaluation of the proposed system[12].

TABLE 4
DISTRIBUTION OF EVALUATION DATA

Fi'il type	Number of data
mazid	231
Mujarrad	237
Total	468

As shown in Table 4, the evaluation dataset consists of 231 Mazid verbs and 237 Mujarrad verbs. The relatively balanced distribution between the two classes helps reduce the risk of bias during evaluation and allows the reported accuracy, precision, recall, and F1-score values to better reflect the actual performance of the proposed system.

The performance of the proposed system was evaluated by comparing the classification results with the manually

annotated ground truth data. The evaluation results are presented in the form of a confusion matrix, as shown in Figure 2.

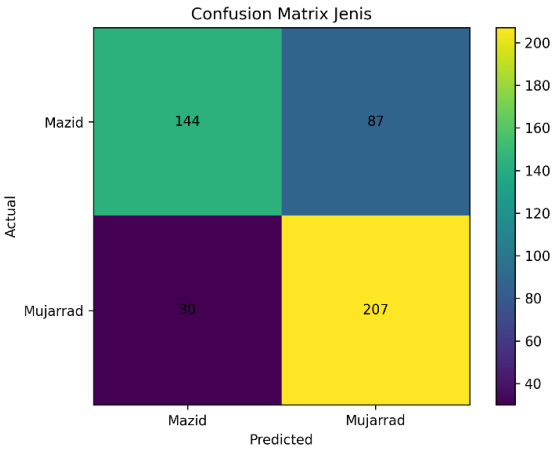

Figure 2. Confusion Matrix Classification of Fi'il Types

The results obtained from the confusion matrix show a TP (True Positive) value of 144, TN (True Negative) of 207, FP (False Positive) of 30, and FN (False Negative) of 87. The test results produce accuracy, precision, recall, and F1-score values as follows:

1. Accuracy

$$\text{Akurasi} = \frac{144 + 207}{144 + 207 + 30 + 87} \times 100\%$$

$$\text{Akurasi} = \frac{351}{468} \times 100\% = 75\%$$

2. Precision

$$Presisi = \frac{144}{144 + 30} = \frac{144}{174} = 0.83$$

3. Recall

$$Recall = \frac{144}{144 + 87} = \frac{144}{231} = 0.62$$

4. F1-score

$$F1 - Score = \frac{2 \times 0.83 \times 0.62}{0.83 + 0.62} = 0.71$$

Based on the calculation results, an accuracy value of 75% was obtained, indicating that the system has a fairly good lev el of accuracy in classifying the types of fi'il.The precision value of 0.83 indicates that most of the predictions for Mazid fi'il generated by the system are correct classifications. Mean while, the recall value of 0.62 indicates that the system has not been able to optimally detect all Mazid fi'il data because there are still some Mazid data that are predicted as Mujarrad. The F1-score of 0.71 indicates that the balance between precision and recall is in the fairly good category. However, there are still quite significant misclassifications in the Mazid category predicted as Mujarrad, indicating that the system still has difficulty consistently recognizing some Mazid verb patterns due to the similarity in morphological patterns between Mujarrad and Mazid verbs[13].

Error analysis shows that most classification errors occurred in wazan patterns with similar morphological structures. Several mazid forms were incorrectly classified as mujarrad because the additional letters were not sufficiently distinctive after normalization. In addition, certain verb forms share structural similarities with non-fi'il words, increasing the possibility of misclassification[14]. These findings indicate that additional morphological rules are still required to improve the discrimination of closely related patterns.

Figure 3. Performance Evaluation of the Rule-Based Pattern Matching Method in the Classification of Fi'il Mujarrad and

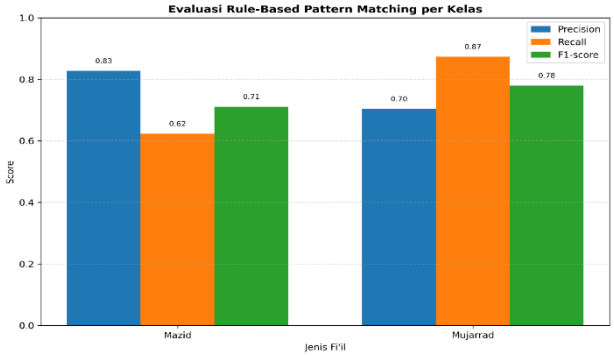

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Figure 3 shows the evaluation results of the Rule-Based Pattern Matching method in classifying Mujarrad and Mazid verbs based on precision, recall, and F1-score metrics. For the Mazid class, the system achieved a precision of 0.83, a recall of 0.62, and an F1-score of 0.71, indicating that Mazid's predictions were quite accurate, but some Mazid data remained unidentified. Meanwhile, for the Mujarrad class, the system achieved a precision of 0.70, a recall of 0.87, and an F1-score of 0.78, indicating that the system was better able to recognize Mujarrad verbs, although some classification errors still occurred. Based on the F1-score values, the system performed better in the Mujarrad class than in the Mazid class, thus concluding that the method used was more effective in identifying Mujarrad verbs than Mazid verbs[15].

IV. CONCLUSION

Based on the results of this research, the following conclusions can be drawn:

1) The developed system is capable of automatically identifying fi'il and classifying them into fi'il mujarrad and fi'il mazid categories, as well as determining their corresponding wazan patterns based on arabic morphological rules.
2) The rule-based pattern matching approach successfully recognizes many arabic verb patterns, particularly

those with distinctive morphological characteristics such as the prefixes "ان", "است", and "أ", as well as basic mujarrad patterns.

3) Based on the evaluation of 468 annotated data instances, the system achieved an accuracy of 75% for fi'il type classification, with a precision of 0.83, a recall of 0.62, and an f1-score of 0.71. for wazan classification, the system achieved an accuracy of 69.23%, with a weighted average precision of 0.66, recall of 0.69, and f1-score of 0.65.
4) The results indicate that the proposed rule-based pattern matching method can support the automatic identification of fi'il based on arabic morphological patterns. however, classification performance remains limited for several wazan patterns that exhibit similar morphological structures.
5) This study has several limitations. first, the evaluation was conducted only on surah al-baqarah, which may not fully represent all morphological variations found in the qur'an. second, the rule-based approach depends heavily on manually defined rules and has limited capability in handling morphological ambiguity. future research should evaluate the system using larger qur'anic corpora and explore machine learning or hybrid approaches to improve classification performance and generalization capability.

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