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DIGITAL HADITH AUTHENTICATION: A LITERATURE REVIEW AND ANALYSIS

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ABSTRACT

Hadith is the second source of reference for Muslim all over the world after the Holy Al-Quran. Plenty of Muslims used the internet as primary knowledge sources including when searching for religious texts such as Hadith. Due to the vast amount of data being transferred on the Internet, there is exists many fabricated Hadiths, and these produce many problems in distinguishing between authentic or fabricated Hadiths for Muslim and non-Muslim who are interested in Hadiths. Therefore, Hadiths accessed from the internet needs to be researched to get its authenticity and originality.

Hadith has three parts that are *Sanad*, *Matn*, and *Taraf*. Referred to Hadith science, an authentic Hadith can be seen from the status of its *Sanad* and *Matn*. Based on the literature review of previous research on Hadith authentication, it exists 14% of the studies were using the authentication concept of *Sanad* and *Matn*, almost 33% of studies were using only the authentication concept of *Sanad*, and 6% of studies were using only the authentication concept of *Matn*. Most of the prior studies done manually and fewer utilized any machine learning methods, and the performance is still unable to measured or standardized.

Keywords: *Hadith, Sanad, Matn, Hadith Authentication, Hadith Authentication Methods*

1. INTRODUCTION

Islam is large religion in the world with a number of all Muslim individuals more than 2.14 billion in the year 2016, roughly 28.26% of the global population [1]. Currently, Indonesia is the country with the world's largest Muslim population with more than 228.68 million Muslims at the year 2016 [2]. The Quran and Hadith are two essential resources in the Islam world, the Qur'an and Hadith present the key principle of the Islamic doctrine [3][4][5]. The Holy Al-Quran is the first source of reference, and the Hadith is the second source of reference [6][7][8]. Allah granted the Holy Quran, as the absolute revelation from Him to all human beings [9] while Hadith notably purports the words and the memoirs of the Prophet Muhammad (PBUH) [9][10][11]. Hadith has four concerning the provisions of The Holy Qur'an, which includes [12]:

1) Hadith serves to support and strengthen The Holy Qur'an (بَيَانُ التَّقْرِيْرِاَوِالتَّأْكِيْدِ).
2) Hadith serves to provide interpretation and details on things that have been described by The Holy Quran (بَيَانُ التَّفْسِيْرِى).
3) Hadith serves to establish laws that are not in the Holy Quran or already exist but only staples things (بَيَانُ التَّشْرِيْعِ اَوْالزِّيَادَة).
4) Hadith serves to alter the substance that has been determined by the verses of the Holy Quran. There are different opinions from the hadiths experts on this subject (بَيَانُ التَّغْيِيْرُاَوْالنَّسْخ).

Since the mortality of the Prophet (PBUH), false hadith began appearance from groups and sects to legitimize theirs believes [13]. A false hadith is a hadith that has been created, fabricated or falsified in the name of Prophet (PBUH), either intentionally or otherwise. The dissemination of falsified hadith has an adverse impact on the Aqedah and Shariah. It could raise questions about the authenticity of the hadith and also raise doubts when accepting the hadith as a source of legal reference [14]. Muslims scientist starts out to provide high concern to Hadiths since it considered as the second legitimation source after the Holy Quran. They wrote hundreds of books to serve Hadith science, and they initiated many specialist sciences under Hadith science such as the science of "*Al-Jarh wa at-Ta'dil*" and "*Musthalah Al-Hadith*". These

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efforts running over the centuries, and the Muslim scientist determine of valuable regulation and principles related to Hadith science [13]. Safeguard the authentic Hadith from the fabricated is the most significant of Hadith preservation aim, as well as to comply the necessity for the continuity of Hadith research and protection among Muslim scientist. [15].

Essentially, Hadiths are being examined not to dispute the Prophet's (PBUH) words, but it is rather to consider whether the avowed Hadiths comes directly from the Prophet (PBUH) or being distorted by other people [7]. Currently, with the existence of the internet and the popularity of social media, there are various sources of al-Hadith. Regrettably, these diverse sources of information expose Muslim to both authentic and fabricated Hadith, and the threat to the access of false Hadith are more likely than ever [16]. There exists considerable of false Hadiths being spreading on the internet distributed by immoral people [8][16] and these produce many problems in identifying between true and false Hadiths for Muslim and non-Muslim who are interested in Hadiths. Saleh and Mai (2015) told that if the Internet is the major source of information, then how do users know whether it is authentic and original data. Although the Internet is widely used and has become the most effective communication tool and information provider, the major focus is on the quality of the information given by it. People can provide information as many as they wanted on the Internet but there is no rules or regulation regarding the publication of information, and there is no control who creates the information or how the information is displayed. Therefore, Hadiths accessed from the internet needs to be researched to get its authenticity and originality [8].

2. HADITH SCIENCE

Hadith science (عِلْمُ الحَدِيْثِ) is one of Islamic knowledge which used to examining and classifying the correctness of existing hadith [17]. The hadith science is classified into two sections [12]:

1) Hadith Science *Riwayah*

   Science (which in its discussion) includes the words and deeds of the prophet saw, both concerning the problem of transmission, maintenance, and writing or bookkeeping-pronunciation.

2) Hadith Science *Dirayah*

   The science of hadith which discusses the principles to discover the state of *Sanad* and *Matn*, the procedure of receiving and narrating, the nature of the narrator and so forth.

Hadith science has several branches, including [12]:

1) *Rijal al-Hadits* (عِلْمُ رِجَالِ الْحَدِيْثِ)

   Science to know the hadith narrators in their competence as a transmitter of hadith.

2) *Tarikh ar-Ruwwat* (عِلْمُ تَا رِيْخ الرُّوَّاةِ)

   Science to understand the hadith narrators from their effort to transmit the hadith.

3) *Al-Jarh wa at-Ta'dil* (عِلْمُ الْجَرحِ وَالتَّعْدِيْلِ)

   Science that examines the narrators of hadith from the point of view accepted and denied of their transmission.

4) *Asbab al-Wurud* (عِلْمُ اَسْبَابِ الْوُرُوْدِ)

   Science to study the causes of the prophet (PBUH) delivered his word at the time it was spoken.

5) *An-Nasikh wa al-Mansukh* (عِلْمُ النَّاسِخُ والْمَنْسُوْخُ)

   Science to study the contradictory hadiths, which between them are impossible to reconcile because there is an opposite matter, whereas the essence is erasing each other.

6) *'Ilal al-Hadits* (عِلْمُ عِلَلِ الْحَدِيْثِ)

   Science that examines the hidden stuff that causes the Hadith *Sahih* was contaminated.

7) *Gharib al-Hadits* (عِلْمُ غَرِيْبِ الْحَدِيْثِ)

   Science to understand the expression of the meaning of *matn* of hadith that is challenging and complicated to comprehend because the vocabulary is unfamiliar and unknown.

8) *Mukhtalif al-Hadits* (عِلْمٌ مُخْتَلِفِ الْحَدِيْثِ)

   Science that discusses the hadiths that are outwardly contradictory then eliminated its contradiction, or both are compromised.

9) *At-Tashhif wa at-Tahrif* (عِلْمُ التَصْحِيْفِ وَالتَّحْرِيْف)

   Science to examine the nature of the hadiths which its dots or *syakal* (مُصَحَّفْ) and its form (مُحَرَّفْ) have changed.

According to language, Hadith means new or word. Meanwhile, the term hadith is anything that comes from Prophet Muhammad (PBUH), whether in the form of speech, deed, judgment or nature [18][19].

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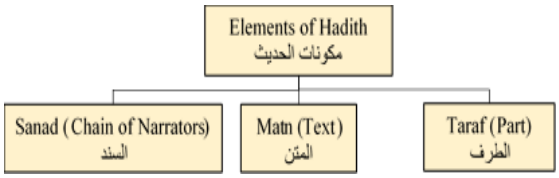

Figure 1: Elements of Hadith

Each hadith is contained three elements [3] as presented in Figure 1, namely:

1) *Sanad* (اَلسَّنَدُ)

   Sanad (synonym: *Isnad*) is the chain of narrators (اَلرِّجَالُ) that points to the text of the Hadith. The *Sanad* composed of all those who narrated the text, starting with the last narrator and ending to the Prophet (PBUH). Among the initial and the final narrator, long or short, there are amounts of narrators who were skipping the hadith from one to the other [17] [18][20][21].

2) *Matn* (اَلْمَتْنُ)

   Text or content of hadith conveyed by *sanad* [21][22].

3) *Taraf* (الطرف)

   The section, or opening of the sentence, of the *Matn* which point to the sayings, actions or characteristics of the Prophet (PBUH), and his consent to others deed [23].

In the science of hadith [18], hadith is classified into three main principles as shown in figure 2. Hadith classification becomes the basis for Hadith authentication framework. According to the status of accepted or rejected, Hadith is received (*Maqbûl*) in case comply with some criteria that are [5][12]:

1) All of the narrators that involved in Hadith *Sanad* were qualified (*'Adil* and *Dhabith*).
2) The Hadith *Sanad* is continued.
3) The Hadith *Matn* was free from the *syadz* aspect.
4) The Hadith *Matn* was free from *'illat*.

Supposing one criterion of the *Maqbûl* Hadith is not fulfilled, it made the Hadith status change over into rejected (*Mardûd*).

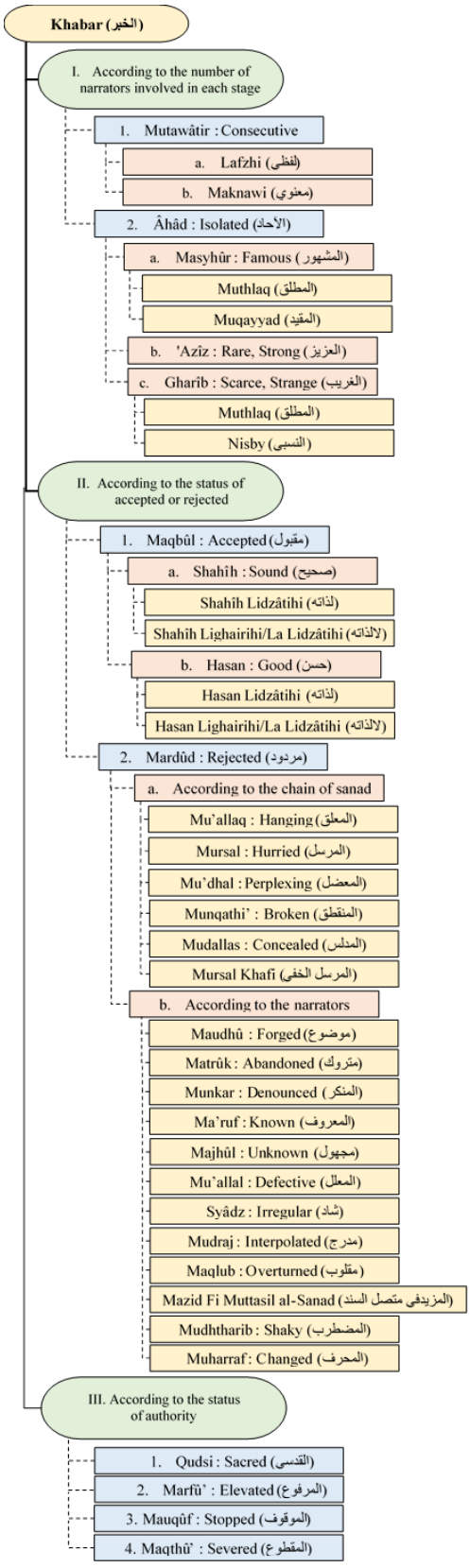

Figure 2: Hadith Classification

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3. LITERATURE REVIEW

The strategy to guard the review focus was by defining the research question (RQ). RQ was composed using the assist of the Population, Intervention, Comparison, Outcomes, and Context (PICOC) framework criteria for setting scope [24]. Table 1 represents the PICOC fabric of the research questions.

Table 1: Summary of PICOC.

Population	Hadith Authentication
Intervention	Method, Techniques, Dataset
Comparison	n/a
Outcomes	- Kind of methods or techniques used in the study areas of Hadith Authentication - Kind of dataset used in the study area of Hadith Authentication
Context	Studies in academia

The research questions addressed by this literature review is shown in Table 2.

Table 2: Research Questions on Literature Review.

Id	Research Question
RQ1	What kind of methods or techniques was used in the study field of Hadith Authentication?
RQ2	What kind of method or technique was the most used in the study field of Hadith Authentication?
RQ3	What kind of datasets was used in the study field of Hadith Authentication?
RQ4	What kind of dataset was the most used in the study field of Hadith Authentication?

There are considerable of research that focuses on studying the authentication of Hadiths manually. However, there is also some number of research that concentrates on the Hadiths Authentication based on machine learning or other various techniques. Table 3 listed some of the previous research related to Hadith Authentication.

Table 3: Previous Researches Related to Hadith Authentication.

Citation	Scope	Language	Hadith Science
[6]	Authentication	Malay/ Indonesia	*Matn, Sanad*
[5][20] [25][26] [27]	Authentication	English	*Matn, Sanad*
[28][29]	Authentication	Malay/ Indonesia	*Sanad*
[7][9][15] [30][31] [32][33] [34][35] [36][37] [38][39] [4][40]	Authentication	English	*Sanad*
[14][41]	Authentication	English	*Matn*
[42]	Authentication	Malay/ Indonesia	*Matn*
[10][11] [13][43] [44][45] [46][47] [48]	Narrators Extraction/ Visualization/ Authentication	English	*Sanad*
[3][49] [50]	Classification	English	*Matn, Sanad*
[51][52] [53][54]	Classification	English	-
[17]	Extraction	English	*Matn, Sanad*
[16][21] [55][56] [57][58] [59][60]	Compilation/ Retrieval	English	-

2.1 Trends in Hadith Authentication

In this literature review and analysis, 51 previous research that related to Hadith authentication are employed. Figure 3 manifested the number of prior research over the years. It is provided to point out how the concern in Hadith authentication has shifted over time. Figure 3 reveals that there has been a slight growth in the number of research in Hadith authentication and still very relevant to do. Table 3 shows that previous studies according to the scope and the utilized level of Hadith science may be divided into eleven types as seen in Figure 2.

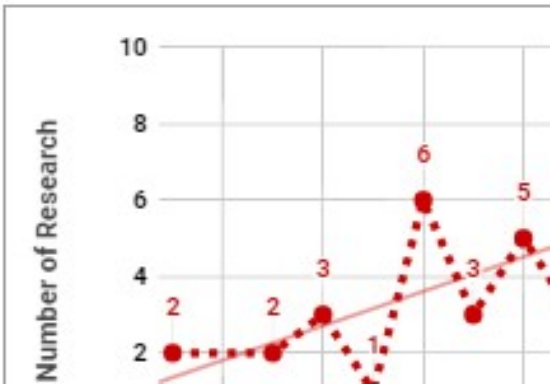

Figure 3: Number of Previous Research over the Years

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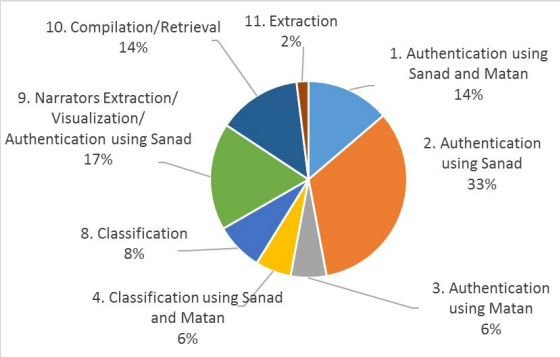

Figure 4: Types of the Previous Research According to the Scope and the Utilized Level of Hadith Science

2.2 Methods or Techniques Used for Hadith Authentication

Based on Figure 4, 14% of previous research in type 1 that work in Hadith authentication was using the concept of *Sanad* and *Matn*. Table 4 describes method or technique and output for each study in previous research type 1.

Table 4: Methods or Techniques used in Prior Research Type 1 (Hadith Authentication using Sanad and Matn).

Citation	Method/Technique	Output
[5]	*Takhrij Hadith* manually, partially research on the main Hadith using one *Sanad*, simultaneous research on the Hadith using multiple *Sanad*	Authentication status of Hadith of Rajab fasting
[6]	Study literature to analyze the *Takhrij Hadith* in conceptual and theoretical methods.	Description of Recent *Takhrij Hadith* Methodology
[20]	The computerization of manuscripts, Modeling a generic chain of narrators using Set Theory, Modeling the relationships of multiple chains of narrators using Directed Acyclic Graph (DAG), Constructing the rules to evaluate Narrator and *Matn*.	Hadith class according to the status of links, Hadith class according to the number of narrators, Hadith class according to the result of narrators evaluation
[25]	*Takhrij Hadith* manually	Authentication status of Hadith used by Shihab in interpreting the Qur'an.
[26]	A Quantitative Research and Content Analysis	Consistency status of application of the science of *Takhrij al-Hadith* on the scientific writings of master and doctoral study.
[27]	Literature Review Manually with analytical approach	Authentication Status for Hadith of *Raj'ah*

According to [5], [6], [25], and [26], *Takhrij Hadith* used in Hadith authentication that employed the concept of *Sanad* and *Matn*. Refers to [5], Hadith authentication cannot be done partially only from one *Sanad* way but must be done simultaneously by studying all of the *Sanad* lines from the same *Matn*, either the texts or the meaning. If Hadith authentication is done partially, it could not be applied as the basis of law policy takes. [5] provides a deeper understanding of five general reasons why Hadiths were needed to be checked its authenticity. The key strengths of this study offer valuable insights on three simultaneous steps to verify the authenticity status of Hadith although it is done manually.

In a comprehensive study of the theoretical concepts of *Takhrij Hadith*, [6] found that it is essential for Islamic scientists to master the science of *Takhrij Hadith*. Especially now, more easily with ICT support. This study provides an exciting opportunity to advance our knowledge of *Takhrij Hadith*. The main strength of the present study was a comprehensive analysis and comparison of three different sources of *Takhrij Hadith* and seven types of Takhrij Hadith methodology. Similarly, [26] found 70.2% of studies in Islamic area has neglected *Takhrij* as a vital in dealing with the Hadith that may influence the reliability of the attention and the interaction with the Hadith. Total 1288 Hadiths from academic research documents were analyzed using three primary criteria as either 1) Level of write out reference to the authentic source of Hadith, 2) Level of write out the blueprint of an authentic source of Hadith, 3) Level of write out the statement of the status of Hadith. To minimize that matter, a normative model of *Takhrij al-Hadith* necessary to be produced and introduced to guarantee consistency of *Takhrij* practice in scholarly writing. One added value of this study is the actual result of the comparative analysis of the virtues and capacities of three Takhrij methods in scholarly research, i.e., 1) *Takhrij* towards *Sanad*,

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2) *Takhrij* towards *Matn*, and 3) *Takhrij* towards *Sanad* and *Matn*.

The study conducted by [25] utilized *Takhrij Hadith* to authenticate Hadith used by Shihab in *Tafsir* Al-Misbah. The result indicates that Shihab emphasizes the use of authentic Hadith but occasionally refers to a weak Hadith and rejects Hadith solely because of his tendency on a metaphor rather than the true meaning of the verses. One of the strengths of this study is that it presents a comprehensive description of the vital position of Hadith to support, strengthen, interpret and details on things that describe by The Holy Quran using *Tafsir* Al-Misbah by Shihab as a sample case.

The study conducted by [20] propose a systematic approach to modeling Hadith using relational database, algorithmic and data-warehouse technique. The strengths of this study are that it has a comprehensive approach to modeling a generic chain of narrators using Set Theory and a Directed Acyclic Graph (DAG) to modeling the relationships of multiple chains of narrators. The proposed models are completed with some set of the rules. Firstly, the rules to classify Hadith according to the status of links such as *Marfu'*, *Mauquf*, *Maqtu*, *Mursal*, and others. Secondly, the rules to classify Hadith according to the number of narrators such as *Mutawatir*, *Ahad*, *Gharib*, and others. Thirdly, the rules to group Hadith based on the evaluation of its narrators such as *Sahih*, *Hasan*, *Dha'if*, and others. All narrators biographical adopted from *Rijal Al-Hadith*. Both [20] and [27] defines similar step to evaluate Hadith, which are: 1) Narrators, Links and Chain Evaluation, 2) *Matn* (Content or Context) Evaluation. Most research on type 1 aside from study done by [20] has not adopted any machinery model.

Based on Figure 4, almost 33% of previous research in type 2 that work in Hadith authentication was using only the concept of *Sanad*. Table 5 describes method or technique and output for each earlier study of type 2.

Table 5: Methods or Techniques used in Prior Research Type 2 (Hadith Authentication using Sanad).

Citation	Method/Technique	Output
[28]	Manually *Takhrij Hadith* and *Tahqiq Hadith*	Authentication status of Hadith used in Tafsir Al-Azhar.
[29]	*Sanad* connection rate, *Jarh wa Ta'dil* Level, Hadith Classification	Status of Hadith authentication into *Maqbûl* and *Mardûd*
	Modelling using Naive Bayes (NB), Hadith Searching Modelling using Vector Space Model (SVM)	
[7]	Removing *Matn* (manually), Removing verbs (manually), Removing the word "عن" (manually), Names Standardization (manually), Feature extraction (TF-IDF), Document representation (VSM), Classification (LVQ)	Hadith Authentication into *Sahih*, *Hasan*, *Da'if* and *Maudhu'*
[9]	*Takhrij Hadith* using a Unicode centric string matching approach	Hadith Authentication into *Sahih*, *Hasan*, *Da'if*
[15]	*Takhrij Al-Isnad* combined with a new mechanism which inspired from a prophetic strategy the battle of Badr	Hadith Authentication into *Sahih* or not *Sahih*
[30]	Science of Hadith *Rijal al-Hadith* combined with Fuzzy Rule-Based System	Narrator Reliability and Hadith Validity Level
[31]	Appending Isnad (manually), Eliminating punctuation and diacritical signs (manually), Append specific character (manually), Classify Hadith (Decision Tree optimized using Missing Data Detector)	Hadith Authentication into *Sahih*, *Hasan*, *Da'if* and *Maudhu'*
[32]	Hadith Science combined with Associative Classification (AC)	Hadith Authentication into *Sahih* and *Da'if*
[34]	Rule-based Expert System	Hadith Class
[35]	Manually Literature Analysis on Hadith *Sanad*	Authentication Status of *Mursal* Hadith
[37]	*Takhrij Hadith* combined with Decision Tree (DT) classifier and Missing Data Detector (MDD)	Hadith Authentication into *Sahih*, *Hasan*, *Da'if* and *Maudhu'*
[38]	Decision Tree (DT) and Naïve Bayes	Hadith Authentication

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	Classifier with Missing Data Detector	into *Sahih*, *Hasan*, *Da'if* and *Maudhu'*
[39]	Hadith Science *Rijal al-Hadith* applying Multi Binary Classifier	Status of Hadith authentication into *Sahih*, *Hasan*, *Da'if*, *Maudhu'*
[40]	Ontology and Ontology Reasoning (rule-based)	*Sanad* authentication and Hadith authentication

As shown in Table 8, [29], [7], [9], [31], [32], [37], [38], [39] utilize machine learning method, [30], [34] exploit rule-based expert system and then [40] using ontology rule-based model on their studies on Hadith authentication using *Sanad*. Details are summarized in Figure 5.

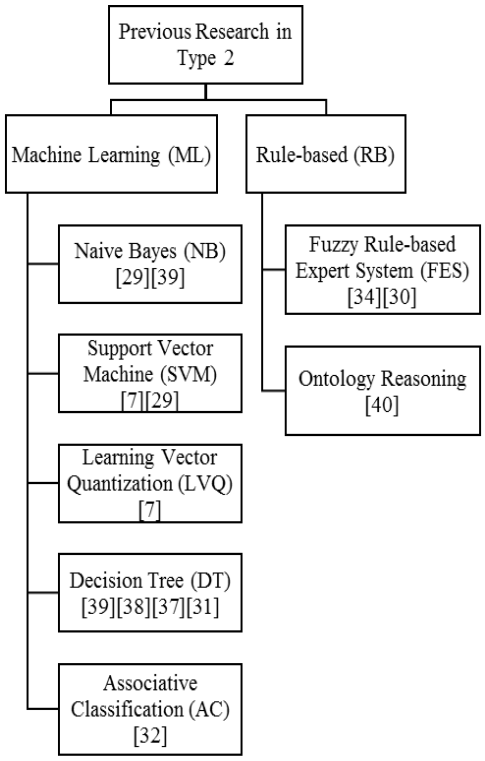

Figure 5: Method used in Prior Research Type 2

The study performed by [29] succeeds to define simple Hadith classification model using Naive Bayes (NB) machine learning method combined with the concept of *Jarh Wa-Ta'dil*. Two attributes used by Naive Bayes on authentication process, i.e. (1) Sanad's connection rate use formula SanadGrade = ConnectedSanad x gp, where gp is 1/NumberOfNarrator, (2) the Sanad multiplier (*Jarh wa Ta'dil* level). The result show level of accuracy 97%, 55%, 50% using 100, 20, 10 data testing. Moreover, the Vector Space Model (VSM) method is used to search the hadith based on its relevance and output indicate the accuracy is influenced by keywords. However, this study has only classified Hadith into two class that are *Maqbûl* or *Mardûd*. Further work is required to establish the quality of Hadith into more specifics status according to criteria of Hadith Science.

The research conducted by [7] using Vector Space Model (VSM) to represent the order of Hadith narrators also its frequency of occurrences in the form of a vector and Learning Vector Quantization (LVQ) used as a classification method. 160 Hadith were employed in the preprocessing step and resulting 455 narrators. As a result, Hadiths which have narrators who are not in the training set classified into *Da'if*. Hadiths which most narrators are seen for the first time arranged into *Maudhu'*. Others are classified into *Sahih* or *Hasan* based on the occurrences of its narrators.

The study that undertakes by [9] utilized a Unicode-centric string matching strategy to scheme and built the digital Quran and Hadith authentication system. [9] concentrate on proving whether a transcript of digital Quran is authentic or fake and also to form a database of Hadith that composed of authenticated texts of Hadith from authority sources, translated books of Hadith and elaborated lessons, injunctions and even conclusions that acquired from the Hadith. The Authentication of Hadith done by investigating the original characters of Arabic letters, the Arabic terms and its signing of textual Hadith that acquired from 6 major books of Hadith on al-Kutub al-Sittah. This research proves Hadith by deciding and inspect all texts of Hadith of those origin books of Hadith into the three measures of qualities, i.e., *Sahih* (authentic), *Hasan* (good) and *Da'if* (weak). As a result, these research outcomes are the forming of the standard translation of the texts of Hadith and the repository of the digital Hadith.

Research that carried out by [31] propose a new Hadith classifier model with a new way named missing data detector (MDD) to handle the missing attributes in the Hadith database. [31] focus on classifying Hadith according to the validity of its *Sanad* (*Sahih*, *Hasan*, *Da'if* and *Maudhu'*) using methods in Hadith Science. The target approach using a novel mechanism to deal with missing data in the Isnad attributes. The Hadith Classifier model with MDD was built through the learning process, Decision Tree (DT) classifier modeling applied the C4.5 algorithm, and the attributes of the instances initially were obtained from the source books. The

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result generated shows the performance of DT Hadith classifier had a significant effect with MDD, the Correct Classification Rate (CCR) was sharply increased from (50.1502%) to (97.597%). As seen on the result, one strength of this study is the MDD that can improve the performance of the model.

The study conducted by [32] publish a paper that describes investigation opportunity to innovate an automatic Hadith Isnad processing system to the automatic judgment of Hadith and distinguish between the accepted (*Sahih*) and rejected (*Da'if*) Hadith. [32] describe possibility to use one of the classification techniques such as Decision tree, Bayesian Classification, Artificial Neural Networks (ANN), Support Vector Machine (SVM). As a result, [32] investigation indicate that there is a significant opportunity to build an automatic information system to classify Hadith to *Sahih* or *Da'if* using Associative Classification technique. However, this study publishes a concept that still needs to be proven.

The study that performed by [37] proposed a new model to classify Hadith into *Sahih*, *Hasan*, *Da'if*, and *Maudhu'* that built through four phase. The first phase is three step of data pre-processing, i.e.: (1) attaching *Isnad*; (2) removing punctuation and diacritical marks; (3) adding a special character. The second phase is training stage to build the model using C4.5 and Naive Bayes. The third phase is Missing Data Detector (MDD). MDD validate *Sanad* based on three status, namely: (1) The status of reliability attribute in the Isnad chain; (2) The status of the narrators' retention or preservation in the *Sanad* chain; (3) The status of the link attribute in *Sanad* chain. The last phase is evaluation conducted using Correct Classification Rate (CCR), Error Rate (ER), Sensitivity and Specificity. The result shows the performance of proposed model had a significant effect on MDD, the Correct Classification Rate (CCR) was sharply increased from (50.1502%) to (97.597%).

The study conducted by [39] classifying Hadith to its categories using supervised learning classification that is Multi Binary classifier. The study runs using *Rijal Al-Hadith* with some assumptions, namely: (1) The narrator's reliability already determined, (2) The narrator Exactitude previously defined, (3) The continuity of the sand chain already established, and (4) The *Matn* is regular and free of defectives. This study provides new insights into how to automatically produce new knowledge or rule for Hadith authentication using data mining technique. However, this study has some weakness, which is not using Hadith text as input but using some predefined input values with some condition assumptions.

The study that undertakes by [30] build a Rule-based Fuzzy Expert System to determine the rate of the validity of a Hadith. [30] focus on validation of Hadith based on two parameters: (1) Hadith narrator's honesty and Reliability, (2) Continuous and discrete of a Hadith. These parameters were determined from "Rijal Science", a theoretical framework in the Islamic science that concentrates upon the examination of the characters of those who narrated the Hadith. As a result, a Fuzzy Expert System was built with accuracy 94% compared with expert viewpoints. System outputs were the level of Hadith Validity and level of Narrator Character. This study was limited in several ways. First, for input, this study does not utilize generic Hadith text but pre-defined parameters value. Second, for output, this study does not apply standard Hadith science terminology but use its private hadith validity level that still needs to map.

The study that performed by [34] propose a new cloud-based expert system called *Muhadith* that uses the Hadith science to classify hadith among 24 types from seven broad categories. *Muhadith* implemented using C#. Net and Asp.Net and SQL Server as a database management system. Service Oriented Architecture (SOA) is used for Cloud computing compatibility, and to solve the communication problems faced by the legacy Web-based distributed expert system. *Muhadith* has three modules that are *Muhadith* Inference Engine, *Muhadith* Knowledgebase, and *Muhadith* Explanation Module. The result shows that *Muhadith* can be successfully classified Hadith along with explanations. Fabricated Hadith can be easily distinguished from authentic ones. Some aspects of Hadith classification that depends on common sense are still not covered by the *Muhadith*. This study provides a better Hadith authentication expert system platform. However, this study is unable to encompass the entire rule of Hadith science, also insufficient data of reporters and Hadith.

The study that performed by [40] propose a new ontology-based Isnad Judgment System (IJS). The Isnad judgment has four steps, viz: (1) identify the narrator using the IJS ontology, (2) check the continuity of Isnad, and (3) applying the judgment rules. The results show that accuracy of the system according to Al-Albani scholar is 75% and according to Hadith specialist is 81%.

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The study conducted by [15] are proposing a different set of criteria for Isnad authentication compared to the existing research. The current rules are using four primary principles which expanded as (1) Reliability of the narrators, (2) Preservation of the narrators, (3) Defect of the chain of narration, (4) Connected chain, detailed out as DOD, Student of, Teacher of, and matched student-teacher. [15] add one new criterion in the principle which is the *tabaqat*, or the generation of the narrator. As a result, proposed model would categorize input hadith into its output status that is *Sahih* hadith or not *Sahih* hadith. It is highly important to note that the output produced from this partial theoretical authentication will not indicate the *hukm* or the status of the Isnad al-hadith. This note is because the authentication carried out in this research does not include all criteria to be validated for an Isnad al-hadith to be authentic, especially the criteria of the journey of narrators as well as the possibilities of unconnected chain to be occurring.

The study that undertakes by [35] focus on analyzing types and rules of *Mursal* Hadith and also the opinion of Muslim Scholars. Results show *Mursal* Hadith is to be rejected since it missed one of the conditions of Authenticity (The connection of the *Isnad*). However, some scholars have different opinions regarding the ruling of *Mursal* Hadith and there are three famous views; namely, (1) *Mursal* Hadith is *Da'if*, (2) *Mursal* Hadith is accepted and used as a proof and, (3) *Mursal* Hadith is accepted with some conditions.

Based on Figure 4, 6% of previous research in type 3 that work in Hadith authentication was using only the concept of *Matn*. Table 6 describes method or technique and output for each earlier study of type 3.

Table 6: Methods or Techniques used in Prior Research Type 3 (Hadith Authentication using Matn).

Citation	Method / Technique	Output
[14]	Manual Analysis using Imam Ibn Qayyim al-Jawziyyah guidelines	Authentic or fabricated Hadith
[41]	Manual using Quran as criterion	Authentic or fabricated Hadith
[42]	Manual Analysis using Hadith Science Criterion	*Matn* Hadith classification based on authenticity

The study that performed by [14] analyzing rules to identify a fabricated Hadith based on a view of Imam Ibn Qayyim al-Jauziyyah (IQJ). [14] focus on studying a view of IQJ from his book entitled Naqd al-Manqul which from previous work by Al-Salafi (1987) mentioned that IQJ provided thirteen brief rules for identifying falsified hadith. The result shows that thirteen concise rules were not explicitly referred to by ICQ but based on the examples given by ICQ. Among the thirteen rules or guidelines, there are some that are redundant; hence, it could be condensed into one. Consequently, this yields seven guidelines, as follows: (i) Hadith that contradict the Quran, (ii) Hadith That Contradicts a Definitive Sunnah, (iii) hadith that Contradicts a Confirmed Historical Fact, (iv) Hadith that Contradict the Basics of Religion, (v) hadith That Contradicts Logic and Contains an Incredulous Meaning, (vi) hadith that Contradict Reality, (vii) Hadith That Does Not Portray the Narration or Actions of the Prophet SAW.

Based on Figure 4, 17% of previous research in type 9 working with extraction, visualization, or authentication of Hadith narrators. Table 7 describes method or technique and output for each earlier study of type 9.

Table 5: Methods or Techniques used in Prior Research Type 9 Narrators Extraction/Visualization/Authentication using Sanad).

Citation	Method / Technique	Output
[10]	Hidden Markov Model (HMM)	Detect part of Hadith *Isnad*
[11]	Graph	Chain of Narrators Graph
[13]	Hadith Science *Jarh wa Ta'dil* combined with multi-agent system and arabic natural language processing	Graph of Narrators Chain (*Isnad* Tree)
[33]	Ontology and DL-Query	Hadith *Isnad* Ontology
[36]	Named entity recognition using three different classifiers, i.e., Naive Bayes (NB), Decision Tree (DT) and K-Nearest Neighbor (KNN)	Graph of Hadith narrators
[43]	Rule-based authentication algorithm	Hadith narrator name authentication
[44]	Ontology and Semantic Web	Graph of Narrators Chain (*Isnad* Tree)
[45]	Named Entity	Identify and

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	Extraction using Finite State Transducer	Extract Component of Hadith
[46]	Natural Language Processing (Lexical Analyzer, Shallow Parser)	Graph of Narrators Chain (*Isnad* Tree)
[47]	Information Visualization	Chain of Hadith Narrators Visualizer (CHN)
[48]	Manual Analysis for Rijal Biographical Literature based on *'Ilm al-Rijal*	Report and Comparison of Rijal Authentication Model

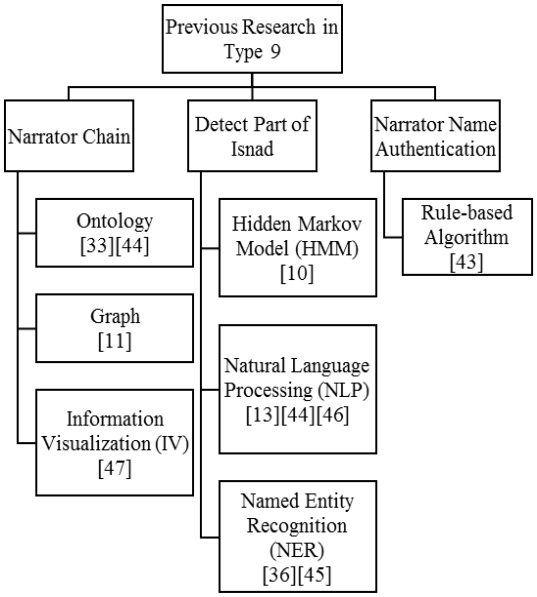

Figure 6: Method used in Prior Research Type 9

As can be seen from the Table 5 and Figure 6 (above), previous research on type 9 grouped under three model: (1) Build narrators chain ; (2) Detect Part of *Isnad*; and (3) Narrator name authentication. The study that undertakes by [10] proposes a new algorithm for Hadith Isnad processing using Hidden Markov Model (HMM) as one most important technique in natural language processing (NLP). [10] focus on detecting the Part-of-*Isnad* (not Part-of-Speech) which classifies the main phrases and words of *Isnad* to categories like narrator's name, a prefix of the narrator's name, received method, a prefix of receiving method, title, replacement, Prophet name. Sahih Muslim book is used as a Hadith source. This research does not classify Hadith into the correct or authentic Hadiths (*Sahih*) and the fake Hadiths (*Da'if*).

The study conducted by [11] developed a novel algorithm for representing and searching authentic chain of Hadith narrators. The representation of the chain of Hadith narrators' is built on a form of network graph, and the searching algorithm of an authentic chain of Hadith narrators is constructed by using Python programming language. Overall, 30 hadith texts from Sahih Bukhari is used to test the algorithm. Testing result shows that 18 Hadiths are accurate in the pre-processing process and network graph development and 12 Hadiths had an error in the pre-processing process and produced an error in the network graph development. This research does not categorize Hadith in any form.

The study that performed by [33] propose the design of Hadith *Isnad* Ontology, for *Isnad* judgment in the Hadith domain. [33] combine the ontology features with Hadith judgment rules (the clear steps Hadith scholars follow in the judgment of the Hadith *Isnad*) to identify the narrators so it can be used as the basis for the Isnad judgment process. As a result, Hadith *Isnad* Ontology was built and already evaluated, but Hadith *Isnad* judgment rules are still become the future work.

The study that undertakes by [36] put forward a model to create a network of Hadith narrators by automatically obtaining the sequence of narrators from Hadith through Named Entity Recognition and Classification (NERC) and transforms these sequences to the graph form. [36] focus on developing machine-learning models using Naive Bayes (NB), Decision Tree (DT) and K-Nearest Neighbor (KNN) for the NERC task and compares that. Total 7124 Hadiths from Sahih Bukhari Book were used as a training corpus and other Hadiths from *Musnad* Ahmed as a test corpus. NER performances evaluated using the correct entity type (TYPE) and the exact text boundaries (TEXT). Result show, the performance of different classifiers were able to achieve a 90% precision and 82% recall for the named entities. The classifiers were evaluated on a different corpus within the same domain that resulted in an 80% precision and 73% recall.

The study conducted by [43] propose a rule-based framework to recognize the narrators' names in the Malay hadith texts. This research focuses on the extraction and verification of a hadith narrator's name. The process of extraction hadith narrator's name features from its sources was done manually. The verification of a hadith narrator's name is

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crucial because it is the first step in the process of checking the authentication of a hadith. As a result, the extraction of narrators' names from the texts produced 455 names with different spelling and done for only one hadith book, the Shahih Bukhari's book. Moreover, the rule-based framework in Python programming to recognize the narrators' names for a single Malay hadith text had built.

2.3 Datasets Used for Hadith Authentication

Table 6: Datasets used in Prior Research Type 1, 2, 3, 9.

Citation	Datasets
[20][43][45][46][25][26][9]	Shahih Bukhari
[20][44][46][25][26][9]	Shahih Muslim
[25]	Ahmad
[25]	Al-Qurtubi
[25]	Al-Suyuti
[25]	Al-Tabari
[25]	Ibn Kathir
[47]	Hadith 40 of Imam Nawawi
[20]	Al-Maudu'at (Ibn al-Jauzi)
[9]	Sunan Abu Dawud
[9]	Sunan At-Tirmidzi
[9]	Sunan An-Nasa'i
[9]	Sunan Ibnu Majah
[15]	Al-Adab Al-Mufrad

Table 6 displays a summary of the dataset used in the previous Hadith authentication research. It showed that Sahih Bukhari and Muslim are most used hadith book. Muslim scholars verify that most of Hadith listed in the hadith book Sahih Bukhari and Sahih Muslim are valid (Sahih) [25]. Shahih al-Bukhari and Sahih Muslim are part six main books of Hadith known as al-Kutub al-Sittah. The others books are Sunan Abu Dawud, Sunan al-Tirmidhi, Sunan Nasa'i and Sunan Ibn Majah [9]. Some traditionists prefer Shahih Bukhari than Shahih Muslim because al-Bukhari looks for those narrators who had either accompanied or met each other, even if only once in their lifetime. On the other hand, Muslim would accept a reporter who is simply found to be contemporary to his immediate authority in reporting [20]. Al-Adab Al-Mufrad [15] is also the book of Imam Bukhari solely related to the subject of moral in Islam contain 1.322 Hadith *Sahih* and *Da'if*.

The Book of Sunan At-Tirmidhi used by [9] contains 3.956 hadiths. This book covering 158 Hadith *Sahih* (4%), 1.454 Hadith *Hasan Shahih* (36%), 8 Hadith *Sahih Gharib* (0.2%), 254 Hadith *Hasan Shahih Gharib* (6%), 705 Hadith *Hasan* (18%), 571 Hadith *Hasan Gharib* (14%), 412 Hadith *Gharib* (10%), 73 Hadith Dhaif (2%), and 344 Hadith not assessed (7,8%) [61]. Al-Maudu'at (Ibn al-Jauzi) [20] is Hadith book containing 1.847 Hadith which cannot correctly be declared maw.

Table 7: Summary of Method used for Detect Part of Isnad

Citation	Task/Method	Strength	Weakness
[10]	Task: Detect Part of Isnad Method: Hidden Markov Model (HMM) and Viterbi Algorithm	Statistical classification model that provides probability phrase/word occurs in a particular position of the array.	Classification performance result depends on number and quality of training data. Possibly emerge Out Of Vocabulary.
[36]	Task: Detect Part of Isnad Method: Named Entity Recognition (NER)	Automatic Machine Learning based-NER, comparing three classification algorithm (Naïve Bayes, Decision Tree, K-Nearest Neighbour)	Good performance cannot be achieved without a large enough of training data.
[45]	Task: Detect Part of Isnad Method: Named-Entity Extraction (NEE)	Employ Finite State Transducer (FST) that better for representation of linguistic knowledge particularly for smaller scale grammars and show specific linguistic phenomena	Within a programming context, FST encounter some severe restriction, the most significant is an absence of abstraction and bad in incremental processing.
[13]	Task: Detect Part of Isnad Method: Natural Language Processing (NLP)	Employ Multi-Agent System (MAS) that has strength in parallelism, scalability, and robustness.	The deficiency using MAS is the communication cost, which the effect of parallelism that perhaps causes the performance to be slower.
[44] [46]	Task: Detect Part of Isnad Method: Natural Language Processing (NLP)	On the Syntactic Analysis, employ Shallow parsing with memory-based learning (MBL) and Information Gain Tree (IGTree) model that has the high measure of precision and recall for a sentences parsing.	MBL have difficulty possibility in handling large numbers of features.

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4. DISCUSSION

This paper was undertaken to review previous research on Hadith authentication and analyze its method or techniques and dataset. Overall, this article strengthens the idea that Hadith authentication defines by the condition of its *Sanad* and *Matn*. Review and analysis show that 51 previous Hadith authentication research classified into four essential types. The first type is 14% of previous research that works in Hadith authentication was using the concept of *Sanad* and *Matn*. The second type is 33% of prior research that works in Hadith authentication was using only the concept of *Sanad*. The third type is 6% of previous research that works in Hadith authentication was using just the concept of *Matn*. Furthermore, the fourth type is 17% of prior research that works with various kind of research as a part of Hadith authentication, such as build narrator chain; detect part of *Sanad*; narrator name authentication.

Table 8: Summary of Method used for Built Narrator Chain and Narrator Name Authentication

Citation	Task/Method	Strength	Weakness
[11]	Task: Narrator Chain Method: Graph	Employ graph theory that powerful in text representation as it can be worthwhile in most of processing and analysis on the text.	Probably hard to find and note relation between nodes of Narrator on a large graph
[47]	Task: Narrator Chain Method: Information Visualization (IV)	Utilizing IV that focuses on datasets lacking inherent 2D or 3D semantics and has power for data exploration on relatively small and low-dimensional datasets.	Possibility loss of information (entropy) throughout the visualization process than the entire information content of a dataset.
[33] [34]	Task: Narrator Chain Method: Ontology	Utilize ontology that is valuable for developing systematic and coherent terminological resources, and reducing subjectivity and discrepancies.	A domain ontology does not represent a broad conceptual model, except only a model that is authentic for a particular domain.
[43]	Task: Narrator Name Authentication Method: Rule-Based Algorithm	Each rule could act as a unit of knowledge and a native format to represent knowledge in a domain. Entire the knowledge is expressed in the same way.	Possibly happen infinite chaining, knowledge modification can be complicated, occurs contradiction rules, inefficiency, opacity, and complex domains.
[29]	Task: Hadith Authentication Using Sanad Method: Naïve Bayes (NB)	Employ NB which although the conditional independence assumption infrequently exists, NB models perform surprisingly great in the field, mainly for a simple case. NB is easy to execute and may scale with a dataset.	Due to its simplicity, NB models are frequently defeated by models properly trained and tuned practicing the other machine learning algorithms.
[39]	Task: Hadith Authentication Using Sanad Method: Decision Tree (DT)	DT is robust to outliers, scalable, and able to naturally model non-linear decision boundaries thanks to its hierarchical structure.	DT is robust to outliers, scalable, and able to model non-linear decision boundaries effortlessly due to its hierarchical structure.
[7]	Task: Hadith Authentication Using Sanad Method: Learning Vector Quantization (LVQ) and Support Vector Machine (SVM)	SVM could mold non-linear decision boundaries. SVM is also reasonably strong toward overfitting, particularly in high-dimensional space.	SVM needs to use more memory, complicated to fit because of the importance of choosing the appropriate kernel, and do not scale well to large datasets.
[32]	Task: Hadith Authentication Using Sanad Method: Associative Classification	AC can efficiently cope with non-binary problems that contain more than two different class labels, mainly when the names are not mutually exclusive to each other.	Possibly does not optimum working for the poor-quality training and test datasets (conceive noise and missing values, frequently updated).
[34] [30]	Task: Hadith Authentication Using Sanad Method: Fuzzy Expert System (FES)	An expert system has some benefits to a hybrid system. For permanent, well-defined knowledge, a fuzzy system is a suitable and effective way to realize the solution to a problem.	The fuzzy system is hard to design for complex and large systems. The fuzzy system performance can be susceptive to the particular values of the parameters.

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Table 7 and Table 8 present summary of methods used and its strength and weakness. The final goals of most prior research are to authenticate Hadith. Others model of study such as detect part of the *Isnad*, narrator name authentication, built narrator chain are intermediate objectives. Mostly used Natural Language Processing (NLP) and its subset as a processing method. Furthermore to classify Hadith based on the condition of Sanad, look like any machine learning or rule-based model was used. It is hard to define which method is best for each work because there exist various Hadith datasets that used, and does not live enough information on result validation and its way. Based on all existing practices, the future work is needed to define a standard dataset, evaluation method, and its baseline as a foothold to improve the works on Hadith Authentication.

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