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Implementation of Long Short-Term Memory for Traditional Medicine Information Retrieval System

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ABSTRACT Indonesia is the second most biologically diverse country in the world. Spices and herbs are one of the many forms of biodiversity in Indonesia. The diversity of herbs and spices plants is important for traditional herbal medicine because they have many potential health benefits. Indonesian herbal medicine continues to develop and many innovations in the formulation, many various of traditional herbal medicine small and medium enterprises have emerged. It makes difficulties in finding appropriate traditional herbal medicine that suitable with user. However, this development requires an information retrieval system for traditional herbal medicine. A system that can store, retrieve, and maintain information is called an information retrieval system. An information retrieval system's overarching goal is to reduce the effort required for a user to find the information they need. Information retrieval (IR) systems have generally performed much better because to the development of deep learning techniques, which have allowed them to manage the complexity of natural language queries. Long Short-Term Memory (LSTM) can be used in Information Retrieval (IR) systems. LSTM can be used to understand user queries better by predicting related or expanded queries. They help improve recall by generating semantically similar queries and to model the semantic similarity between a query and a document. They are useful for ranking documents based on relevance scores.

KEYWORDS Information retrieval system; traditional herbal medicine; Indonesia; long short-term memory; small and medium enterprises.

I. INTRODUCTION

The World Health Organization (WHO) has recently defined traditional herbal therapy as a set of medicinal techniques that had often existed for hundreds of years, before the emergence of modern medicine. The combination of generations of indigenous medical practitioners' therapeutic experiences is known as traditional herbal medicine [1]. The number of patients pursuing herbal and alternative therapies is rapidly increasing. Because they are more culturally acceptable, more compatible with the human body, and have less negative effects, traditional herbal medicines are becoming increasingly popular in the poor countries for primary healthcare, not just because they are less expensive [2]. Whether or not they can be explained, traditional herbal medicine, according to the World Health Organization, is the sum of all knowledge, skills, and practices drawn from indigenous theories, beliefs, and experiences in diverse cultures. It is used to prevent, diagnose, treat, or improve physical and mental illness as well as to maintain health [3]. 90% of developing countries utilize traditional herbs as their primary source of healthcare, and 88% of the world's population uses traditional herbal medicine, according to the WHO [4]. Indonesia as a developing country, used to take "jamu," a traditional herbal remedy from Indonesia that is inherited as an alternative treatment. Jamu is still widely used for illness treatment and health maintenance. This is further supported by Indonesia's tropical climate, which contributes to its abundance of natural resources. Around 9.600 of the more than 30.000 plant species that occur in Indonesia are known to have pharmacological properties [5]. Traditional medicine is part of the cultural heritage that is passed down from generation to generation in Indonesia, especially on Madura island. There are many different kinds of Madura herbs, from those for married couples to those for women's health. Given the variety of Madurese herbal medicine, an inventory encompassing location, content, side effects, etc., is required. Given that Madura herbs are not only used as a remedy but also as part of Madura's

cultural legacy, this is crucial [6]. Most Madurese people currently choose to use traditional herbal medicine as a treatment option. Because it has various benefits. In addition, the price is quite affordable and the raw materials are easy to obtain. The population uses traditional medicine to preserve their health and treat ailments including fever, cough, and pain. This ancient medicine has been kept to this day and has become the wisdom of the Madura people [7]. Madurese herbal medicine has a unique characteristic, namely its bitter herbal medicine, different from Javanese herbal medicine which tastes slightly sweet. The Madurese's devotion to maintaining traditional customs is seen in their use of traditional herbal medicine, which symbolizes their valued indigenous knowledge [8]. Traditional herbal medicine reflects the richness of nature and local wisdom by mixing herbal concoctions to treat and maintain body balance. Although, Indonesia has the potential to make herbal concoctions, there are several problems that can be identified. First, the difficulty for users who want to choose herbal medicine that suits their health needs because of the many types of herbal medicine and their various properties. Second, the lack of easily accessible information regarding the description and properties of traditional herbal medicine makes it difficult for users to understand the benefits of each type of herbal medicine. Because of this, an information retrieval is needed to make it easier for users to find herbal medicine that suits their preferences. Previously, existing solutions helped users select herbal medicine by querying databases and manual guides or consulting traditional herbalists. However, these solutions were not always practical and could be time-consuming.

At the moment, computer technology is evolving quickly. High specifications at reasonable prices can solve issues of all kinds, from the easiest to the most challenging. Information has become one of the essential needs in everyday life. In the digital era like today, information can be easily and quickly accessed through the internet. However, with the abundance of available information, searching for specific information can be a challenge. The goal of information retrieval techniques is to effectively extract, process, and comprehend information from large amounts of data [9]. Therefore, an effective information retrieval system is needed to assist users in finding the required information. Because it is integrated into so many practical applications, including internet browsing, question-answering systems, personal assistants, chatbots, and digital libraries, information retrieval, or IR, it is becoming increasingly important in people's daily lives. Identifying and retrieving information related to the user's request is the main goal. The results are often sorted based on how closely the records match the user's query because several entries may be pertinent [10]. The study of finding information in documents, including manual document searching, descriptive metadata search, and databases containing text, images, or sound, is known as information retrieval (IR) [11, 12] An information retrieval system is designed to search for documents or information that matches the criteria entered by the user. One form of information retrieval system is searching for news documents based on user keywords. This system allows users to search for relevant news on specific topics by entering appropriate keywords or phrases [13]. The goal of information retrieval (IR), a crucial area of computer science, is to effectively extract data from a vast repository that is pertinent to user inquiries. Users typically submit their questions in text format while interacting with an IR system. Then, in order to make it easier to retrieve the most relevant results, IR systems match and rank these user-supplied queries against an indexed database [14]. It is the action of acquiring information from information system resources appropriate to the information requested. Full-text or other content indexing queries are both possible. Data overload can be lessened using an automated IR system. Index terms are a collection of terms that represent documents and can be used to clarify fundamental ideas in information retrieval [15].

Information retrieval (IR) systems have generally performed much better because of the development of deep learning techniques, which have allowed them to manage the complexity of natural language queries. This is due to large labeled datasets and powerful computers, but further research and development in this field is still needed [10]. There are various methods that can be used in information retrieval system, one of which is Deep Learning LSTM (Long Short Term Memory) method. Long Short-Term Memory (LSTM) is a variant of RNN that is explicitly designed to avoid or handle the problem of Long Term Dependencies. Remembering information for a long period of time is the standard behavior of LSTM. The LSTM network, a specific type of RNN network, has a memory unit that can store historical data. It works incredibly well for predicting time series data. The four fundamental parts of the LSTM network are the cell, input gate, output gate, and forget gate. Information is sent by the cell during random time intervals. The input and output data flow from the cell is traced by the gates. With the LSTM network, the gradient disappearing and exploding issues that arise with RNN can be lessened [16]. The LSTM model [17] is a strong recurrent neural system that was created specifically to get beyond the vanishing/exploding gradient issues that frequently occur while learning long-term dependencies, even when the minimal time lags are extremely lengthy [18]. In short, a collection of recurrently connected sub-networks, referred to as memory blocks, make up the LSTM architecture. The memory block's concept is to control the information flow using nonlinear gating units and preserve its state across time [19]. LSTM networks, a type of recurrent neural network, is well-suited for modeling the temporal aspects, for example, for health dynamics. The integration of game theory and LSTM-based predictive analysis offers a promising avenue for understanding and addressing the health impacts of industrialization. The proposed method is implemented in Python software and has an accuracy of about 99.12 % which is 3.1 % higher than other existing methods like HealthFog, Conv LSTM and GoogleNet- Deep Neural Network (DNN) [20]. A recurrent neural network called the long short-term memory (LSTM) model was created to circumvent the vanishing and expanding gradient issue. Usually, when sequential data is taken into consideration, the information from the prior moment is directly related to the current and next phases [21].

Some research has been already conducted in information retrieval by using another method. BERT and large language models were used to improve the comprehension of queries and the effectiveness of document retrieval in search engines. BERT records a relative gain of 47.0% in the value of NDCG@10 compared to the BM25 ranking algorithm and a 15.9% gain over the standard BERT model, thus suggesting the applicability of multi-stage neural architecture designs for the development of suitable technologies that aim to connect the user intent with the discovery of useful information [22]. Another research discussed transformer in information retrieval. Transformer architecture, known for its capabilities in natural language processing and managing complex contexts, offers

great potential to enhance search quality in the health care domain. BERT is a deep learning model that performs search based on specific queries and search results are sorted accordingly. Evaluation results show that the NDCG score for bi-encoder is 0.89, while for cross-encoder it is 0.9. The mAP score for bi-encoder is 0.7, and for cross-encoder, it is 0.89. Both bi-encoder and cross-encoder achieved an MRR score of 1.0 [23]. Research on information retrieval shows limited application of LSTM-CNN models; hybrid LSTM-CNN architectures are better suited for classification and prediction tasks.

Based on the previous research, the use of the LSTM method has fairly high accuracy results. In the study, conducted by Alvinus Cardova and Arief Hermawan entitled 'Implementation of the LSTM Method to Classify Fake News on PolitiFact', they obtained an accuracy result of 97% [24]. Another research that examined the LSTM method also showed fairly high accuracy results, such as in research conducted by Imran Ahmed et al. They carried out research in 2023 entitled 'A heterogeneous network embedded medicine recommendation system based on LSTM', in which they obtained an accuracy of 92% [25]. Furthermore, in research conducted by Wafa Shafqat and Yung-Cheol Byun in 2020 entitled 'A Context-Aware Location Recommendation System for Tourists Using Hierarchical LSTM Model', they obtained an accuracy of 94% [26]. According to the previous research that has been mentioned, the researchers decided to implement the LSTM method in traditional herbal medicine information retrieval system.

The following is how this article is structured. The dataset for traditional herbal medicine is provided in Section II, along with an introduction to the information retrieval models and their methodology. Results are discussed in Section III. Lastly, in Section IV, we conclude the research.

II. MATERIAL AND METHODS

Traditional medicine is a concoction of natural ingredients derived from plants that have been passed down from generation to generation. Some traditional medicines have been proven safe and controlled clinical research has demonstrated the safety and efficacy of certain traditional medicines. When utilized properly, traditional medicine can improve the health of the populations in resource-poor communities [27]. Indonesian traditional medicines are highly well-liked and frequently utilized to treat ailments and preserve wellness in Indonesian society [28]. Many generations in Indonesia have used herbal concoctions as traditional medicine for various diseases. Herbal medicine has become part of Indonesia's culture and natural wealth. Based on the 2010 Basic Health Survey, more than half of Indonesia's population uses herbal medicine. Herbal medicine can be one way to increase endurance. This is a traditional Indonesian medicine that has been used by the community for centuries to maintain health and treat various diseases [28]. Because it is thought to be safer than chemical pharmaceuticals, traditional Indonesian herbal medicine, which has been used for generations in Indonesian society, is still widely used for both illness treatment and health maintenance [29]. Some types of herbal medicine that are most widely produced are for beauty, health, and for husband and wife relations. An example of traditional herbal medicine produced by PT Firdaus Kurnia Indah can be seen in Figure 1.

Figure 1. Example of traditional herbal medicine

The research method contains the main materials used in the research and the methods used in solving problems including analysis methods. Flowchart system is a diagram that uses visual symbols to describe the steps or process flow of the system. In this research, the system process flow can be seen in Figure 2.

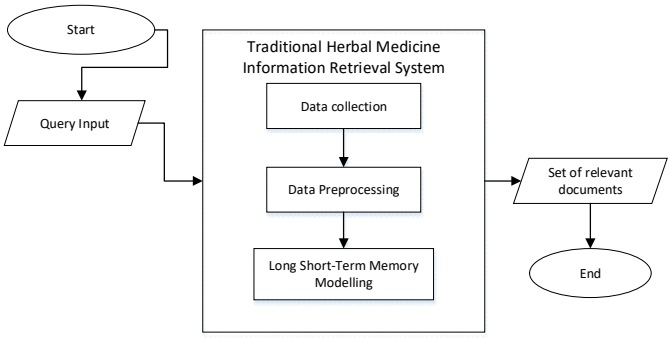

Figure 2. Traditional Herbal Medicine Information Retrieval System

A. DATA COLLECTION

In this study, data collection was carried out using primary and secondary techniques. Primary data collection was carried out by interviewing Madura herbal medicine small and medium enterprises (SME), where herbal medicine producers showed their products. Each product has been equipped with information such as efficacy and composition, which is then recorded or photographed. This information is then stored in Excel format along with a complete description of each product. Meanwhile, secondary data collection was carried out by taking existing or previously processed data from the small and medium Madura herbal medicine enterprises (SME). This dataset consists of several attributes, namely the name of the herbal medicine, efficacy, content, side effects, drinking rules, type, production location, marketing location, district and licensing. The data collected included 206 traditional herbal medicine data, which can be seen in Table 1.

Table 1. Sample of Indonesian Traditional Herbal Medicine Dataset

NO	Traditional Herbal Medicine (Local Name)	Efficacy	Ingredients	Type
1	ETABARI	for diabetes sufferers	Andrografis 30%, Ortosifon 20%, Rimpang Imperatae 20%,Rimpang Temulawak 20%, Ramuan Centellae 10%	Pill
2	TOLAK BATUK/ASMA	helps treat coughs, helps treat upper respiratory allergies and asthma, helps reduce fever caused by flu and sore throat.	Lada leaf 50 mg, rimpang turmeric 50mg, garlic 50 mg, Rimpang Temu Kunci 30 mg, adas 20mg	Pill
3	Susut perut Tresna	helps reduce body fat especially in the stomach area and helps lose weight	Guazuma leaf 30%, korteks parameria 20%, rimpang ginger 20%, Rimpang Boesenbegia 15%, rimpang turmeric 15%	Pill
4	PANYAMAN EMPOT-EMPOT	helps tighten female organs, tightens the muscles of the uterus and surrounding areas, makes the vagina dry and sensitive	adas 10%, alyxia stellata 10%,Parameria Berambut 15%, Temu Kunci Angustifolia Roscoe 40%, Temu Ireng Roxb	Pill
6	SEHAT L.M	improve blood circulation, increase energy and improve body resistance to disease, help overcome symptoms of aging, muscle pain, joint pain, aches, nearsightedness, prevent colds, dizziness and ulcers	Pegagan 15%, Kumis Kucing 15%, turmeric 50%, ginger 20%	Pill
7	Rapet Wangi	helps reduce excess mucus in the vaginal area	125mg Ek Quercus indica seed, 62,5mg Pinang seed (Areca catechu), 10mg orange peel, 41mg pure honey	Pill
8	sirih wangi	eliminates body and mouth odor, cures sore throat and gums, treats vaginal discharge, cures acne, smoothes skin, improves urine flow, increases energy/stamina, reduces excessive sweating, treats skin diseases/itching	Sirih seed (Piper betle), Sirih Hutan seed (Boesenbergia rotunda), turmeric seed (Curcuma longa), Kabesak seed (Piper cubeba)	Pill
9	super pria	Cures impotence and impotence in men, increases male libido.	Benalu seed,plant stem, pinang seed 20%, kulit kering 20%	Pill
10	GALIAN SEHAT / MONTOK	Madura herbal medicine pills for women / men who have poor appetite, are thin, have pale faces, are often sick, have a weak body and others. Drink this herbal medicine regularly so that the body becomes healthy, fresh and plump and solid.	Rimpang turmeric,Rimpang Temulawak, Rimpang Lengkuas, Kabesak fruit	Pill
11	Jaselang	Increase stamina, relieve aches and pains, fatigue, warm the body etc.	ginger emprit, seccang, akar alang-alang, pala seed, kapulaga, and sugar	Powder
12	sehat wanita	for vaginal discharge, women's stamina, more intimate husband and wife relations	temulawak, turmeric, manjakani, jelebi, jekkeleng	powder

B. DATA PREPROCESSING

Data preprocessing is done because the herbal medicine data obtained is text data and has noise. Preprocessing is done using libraries in python such as Regular Expression and NLTK. In preprocessing there are 6 stages, namely text data cleaning, tokenization, removing stop words, changing all words to basic words or commonly called stemming, transformation from text data to numeric representation, and padding. This process can help improve the accuracy and efficiency of the model used

C. LONG SHORT TERM MEMORY MODELLING

At this stage, researchers conducted modeling using the Long Short Term Memory (LSTM) deep learning method. Figure 3 shows that the stages in LSTM computation will be carried out through three stages, namely starting from the input gate which will determine the value to be updated, then the second stage forget gate which has the task of selecting information that will be used or not used, and the last stage output gate which is responsible for determining the context to be produced. A memory cell, a linear unit with a fixed weight self-connection, is the fundamental building block of an LSTM. In order to prevent them from being impacted by the disturbance brought on by irrelevant inputs or memory contents, multiplicative input and output gate units regulate the continuous error flow. The input and output gates are able to identify which faults they need to catch or scale [30].

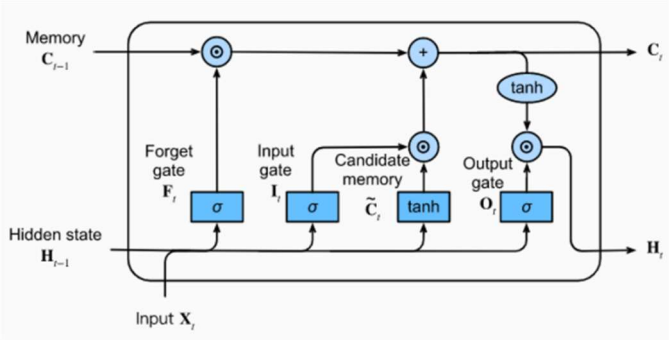

Figure 3. Long Short-Term Memory (LSTM) Architecture

III. RESULTS

The data that will be used for this example is data on the efficacy feature where the data will be preprocessed to remove noise in the text data and convert the text data into numbers. The data will be illustrated with 3 examples of data efficacy.

Table 2. Sample of Indonesian Traditional Herbal Medicine Dataset

Traditional Herbal Medicine	Efficacy
nafsu makan	menambah nafsu makan
ibu melahirkan	memperlancar ASI
ibu hamil	biar tidak mudah capek

Table 3. Sample of Preprocessing Result

Origin Dataset	Preprocessing Result
menambah nafsu makan	[0, 1, 2, 3]
memperlancar ASI	[0, 0, 4, 5]
biar tidak mudah capek	[6, 7, 8, 9]

And if the user enters a query input to search for traditional herbal medicine such as "nafsu makan" then:

Table 4. Sample of Query Preprocessing Result

Query Input	Preprocessing Result
Nafsu makan	[0, 0, 2, 3]

After getting the preprocessing results from the query input, it will be calculated using the LSTM model. With the initial assumption of the weight is 0.5 and the bias is 0. And with the initialization of the hidden state and cell state is 0. Then the calculation is obtained as follows.

1. Forget Gate Formula:

The LSTM unit chooses which data from its prior cell states c (t−1) should be eliminated in this stage.

$$f_t = \sigma(W_f \cdot [h_{t-1}, x_t] + b_f) \qquad (1)$$

2. Input Gate Formula:

This phase involves updating the input gate that combines the cell value c (t−1) from the previous iteration, the output of that LSTM unit y (t−1), and the current input x (t).

$$i_t = \sigma(W_i \cdot [h_{t-1}, x_t] + b_i) \qquad (2)$$

And

$$\tilde{C}_t = \tanh(W_c \cdot [h_{t-1}, x_t] + b_c) \qquad (3)$$

3. Cell State Update Formula:

In this phase, the cell value is calculated by combining the preceding cell value with the values of the block input z (t), input gate i (t), and forget gate f (t).

$$C_t = f_t \cdot C_{t-1} + i_t \cdot \tilde{C}_t \qquad (4)$$

4. Output Gate Formula:

This phase calculates the output gate, which combines the current input x (t), the output of that LSTM unit y (t−1) and the cell value c (t−1) in the last iteration.

$$o_t = \sigma(W_o \cdot [h_{t-1}, x_t] + b_o) \qquad (5)$$

And

$$h_t = o_t \cdot \tanh(C_t) \qquad (6)$$

Query input implementation:
Query Input = 0(padding):

Forget gate:

$$f_t = \sigma(0.5 \cdot [0 + 0] + 0) = \sigma(0) = 0.5$$

Input gate:

$$i_1 = \sigma(0.5 \cdot [0 + 0] + 0) = \sigma(0) = 0.5$$
$$\tilde{C_1} = \tanh(0.5 \cdot [0 + 0] + 0) = \tanh(0) = 0$$

Cell state update:

$$C_1 = 0.5 \cdot 0 + 0.5 \cdot 0 = 0$$

Output gate:

$$o_1 = \sigma(0.5 \cdot [0 + 0] + 0) = \sigma(0) = 0.5$$
$$h_1 = 0.5 \cdot tanh(0) = 0$$

Query Input = 0(padding):
Forget gate:

$$f_t = \sigma(0.5 \cdot [0 + 0] + 0) = \sigma(0) = 0.5$$

Input gate:

$$i_2 = \sigma(0.5 \cdot [0 + 0] + 0) = \sigma(0) = 0.5$$

$$\tilde{C_2} = \tanh(0.5 \cdot [0 + 0] + 0) = \tanh(0) = 0$$

Cell state update :

$$C_2 = 0.5 \cdot 0 + 0.5 \cdot 0 = 0$$

Output gate:

$$o_2 = \sigma(0.5 \cdot [0 + 0] + 0) = \sigma(0) = 0.5$$
$$h_2 = 0.5 \cdot tanh(0) = 0$$

Query Input = 3("Nafsu"):
Forget gate:

$$f_t = \sigma(0.5 \cdot [0 + 2] + 0) = \sigma(1) = 0.731$$

Input gate:

$$i_3 = \sigma(0.5 \cdot [0 + 2] + 0) = \sigma(1) = 0.731$$
$$\tilde{C_3} = \tanh(0.5 \cdot [0 + 2] + 0) = \tanh(1) = 0.761$$

Cell state update:

$$C_3 = 0.731 \cdot 0 + 0.731 \cdot 0.761 = 0.556$$

Output Gate:

$$o_3 = \sigma(0.5 \cdot [0 + 2] + 0) = \sigma(1) = 0.731$$
$$h_3 = 0.731 \cdot tanh(0.556) = 0.369$$

Query Input = 4("makan"):
Forget gate +:

$$f_t = \sigma(0.5 \cdot [0.369 + 3] + 0) = \sigma(1.684) = 0.843$$

Input gate:

$$i_4 = \sigma(0.5 \cdot [0.369 + 3] + 0) = \sigma(1.684) = 0.843$$

$$\widetilde{C_4} = \tanh(0.5 \cdot [0.369 + 3] + 0) = \tanh(1.684) = 0.933$$

Cell state update:

$$C_4 = 0.843 \cdot 0.556 + 0.843 \cdot 0.933 = 1.255$$

Output gate:

$$o_4 = \sigma(0.5 \cdot [0.369 + 3] + 0) = \sigma(1.684) = 0.843$$

$$h_4 = 0.843 \cdot tanh(1.255) = 0.715$$

From the results of the calculations that have been carried out, the final output has a value of 0.751, while the last cell state is 1.255, so information retrieval system will output "nafsu makan" because during the 3rd and 4th calculations the results obtained are very similar to the hidden state calculations on the efficacy of traditional herbal medicine.

In the conducted experiment, the traditional herbal medicine dataset, comprising 206 samples, was split using a 70:30 ratio, allocating 70% for training and 30% for testing. Measuring the performance of a method is essential to assess the effectiveness of the model built using a specific algorithm. This study employed a confusion matrix as the evaluation method, with the resulting data used to calculate accuracy. Table 5 presents the confusion matrix evaluation results. Initial testing was conducted using a baseline LSTM model with default parameters and the aforementioned 70/30 data split. The evaluation yielded an accuracy of 91.33% on the test data, demonstrating the model's strong information retrieval capability in matching user queries with traditional herbal medicine remedies.

Table 5. Evaluation Results

Accuracy	Precision	*Recall*	*F1-Score*
0.9133	0.9194	0.9133	0.9130

For the traditional herbal medicine information retrieval dataset, which comprises only 206 records, the LSTM model is relatively lightweight. A reasonable approach involves using 50–100 epochs, with early stopping triggered between epochs 20 and 50. On a device with a standard CPU, training time is estimated to range from a few seconds to 1–2 minutes, whereas on a GPU, it typically takes anywhere from a few seconds to several tens of seconds. Given the small dataset size, employing 1–2 LSTM layers with 32–64 units is sufficient for experimentation. Scalability can subsequently be assessed by comparing training times as the dataset expands, for instance, increasing from 206 records to 500, 1,000, and 2,000. If computation time increases roughly in proportion while performance remains stable, the model can be considered to possess good efficiency and scalability.

IV. CONCLUSIONS

Information retrieval with long short-term memory algorithm can make easier for users to search for traditional herbal medicine quickly and accurately. The LSTM method provides different similarity values for each document stored in the database, where documents with the highest similarity values are placed in the highest list.

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