

The Purpose of Bellman-Ford Algorithm to Summarize the Multiple Scientific Indonesian

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The Purpose of Bellman-Ford Algorithm to Summarize the Multiple Scientific Indonesian Journal Articles

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Abstract

Text is a one of huge type data in the big data era today. It can be processed to be valuable information with Natural Language Processing approach, such as Automated Text Summarization. This study aims to purpose the text summarization automatically for multiple text documents with graph approach at once. The graph approach that purposed in this research as methodology is Bellman-Ford algorithm. This research uses scientific journal articles documents in Indonesian language as the case study. The result of this research is the logical framework based on literature review and analysis of Bellman-Ford algorithm for automated text summarization. This framework can be implemented and evaluated in the further works.

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The Purpose of Bellman-Ford Algorithm to Summarize the Multiple Scientific Indonesian Journal Articles

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Abstract—Text is a one of huge type data in the big data era today. It can be processed to be valuable information with Natural Language Processing approach, such as Automated Text Summarization. This study aims to purpose the text summarization automatically for multiple text documents with graph approach at once. The graph approach that purposed in this research as methodology is Bellman-Ford algorithm. This research uses scientific journal articles documents in Indonesian language as the case study. The result of this research is the logical framework based on literature review ana analysis of Bellman-Ford algorithm for automated text summarization. This framework can be implemented and evaluated in the further works.

Keywords— *Bellman-Ford algorithm, extractive summarization, multiple documents, natural language processing, text summarization*

I. INTRODUCTION

Digital data is growing with large amounts, fast, and various variations. In fact, according to the International Data Corporation, the total amount of digital data circulating annually around the world will grow from 4.4 zettabytes in 2013 to 180 zettabytes in 2025 [1], and text document is one of digital data type. In the research field, scientific journal article is the main source to produce the latest (up-to-date) research. Based on The World Bank data about scientific and technical journal articles, there are more than 2.5 million recent value articles from all around the world in 2018 [2], and has continued to increase since 2000 (Figure 1). This data refers to the number of scientific and engineering articles published only in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences.

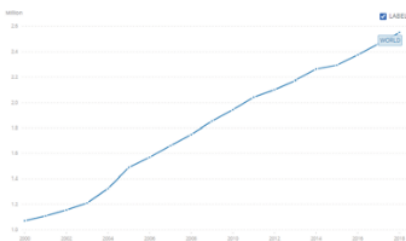


Fig. 1. Scientific and technical journal articles data [2]

In Indonesia itself, the publication of scientific journal articles increases significantly (Fig. 2 and Fig. 3). Based on the World Bank data, until 2018, Indonesia has 26,947 recent value article in the field of physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences [2]. More than one hundred thousand articles that indexed by Scopus and more than 2,7 million articles that indexed by Google Scholar from Indonesian scholars and researches [3].

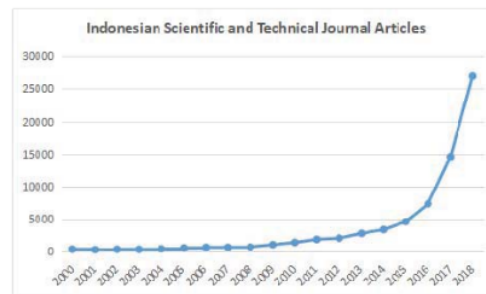


Fig. 2. Scientific and technical journal articles data in Indonesia [2]



Fig. 3. Scientific journal article in Indonesia based on Scopus and Google Scholar [3]

The problems arise when many research topics are similar or intersect, so it is often difficult to find differentiators for different studies. To solve this problem, automatic text summarization technique can be used to make it easier to find the essence of many scientific article documents. So that the summary results can reduce time and make it easier to find similar topics from multi-document of scientific articles at once. Text summarization is one part of

Natural Language Processing which is the process of reducing text documents by computer programs to create a summary that maintains the most important points of the original document [4], [5], with extraction and abstraction approaches.

There are many methods and algorithms that can be used for automatic text summarization, either for single document or multi documents. Begin from simple sentence scoring method [6]–[8], graph theory [9], [10], machine learning [11], [12], until deep learning [13]–[15]. This study focused on automatic text summarization using graph theory. The previous related works that used graph for text summarization, among others: (1) Automatic summarization of Indonesian text using Dijkstra's algorithm, this application is built using the concept of virtual graphics, calculation of sentence weight and the weight of the relationship between sentences, the Deductive - Inductive method in Indonesian and the Shortest Path Algorithm (Dijkstra) to provide a summary path from the first sentence to the the last sentence of each paragraph in the article [16]; (2) Automatic summarization of news text documents uses the TextRank algorithm, where sentences in the text are represented in a graph, then calculates the value of each sentence using the similarity between sentences to determine the summary results [17]; (3) Indonesian news text summarization using Graph Convolutional Networks that use word embedding sequence and sentence relationship graph [10]; and (4) Semantic graph (graph based ranking algorithm) also used for abstractive text summarization [18].

However, from many researches of automatic text summarization, it still wide opportunity to use graph theory or methods such as Bellman-Ford algorithm. There is a research that used Bellman-Ford's algorithm for single document of Hadith text with Indonesian language [19]. But the evaluation result is still low, because of many factors, including the availability of datasets for experiments is still limited. Therefore, this research purposes the Bellman-Ford algorithm with the availability of dataset that more complete and for the purpose of summarizing the multi-document of scientific journal articles.

II. METHODOLOGY

A. Multi-Document Pre-Processing

Text pre-processing is the important phase to prepare the input data and keep the quality of output from text processing [20]–[22], either in text mining, natural language processing, or text summarization. In this process, all of the scientific journal articles will be preparing with several text-pre-processing process, such as: case folding, tokenizing by the sentence and word, removing regular expression, removing stop-words, and stemming.

B. Graph Theory

Graph is a set of arcs and vertices that are finite in number and their arcs connect part or all of the pairs of vertices [23]. Graph $G(V, E)$ consists of a set of vertices represented by $V = \{v_1, v_2, v_3, \dots, v_n\}$ and a set of arcs denoted by $E = \{e_1, e_2, e_3, \dots, e_n\}$ where $e_i = (v_i, v_j)$ is the arc connecting vertex v_i and vertex v_j [24]. In this study, the process of summarizing the text from the document was carried out using the Graph method. After the text

preprocessing stage is carried out, the document text data is converted into numeric data. Each sentence in the document will be converted into a node (V). The value of Edge (E) will represent the similarity value between two sentences in the document.

C. Bellman-Ford Algorithms

Bellman-Ford algorithm is one of the shortest path algorithms to search based on graph theory. A graph is an infinite number of edges and vertices, and edges that link some or all of the vertical pairs [23], [25], [26]. Graph $G(V, E)$ consists of a set of vertices expressed with $V = \{v_1, v_2, v_3, \dots, v_n\}$ and edges contain set expressed with $E = \{e_1, e_2, e_3, \dots, e_n\}$ where $e_i = (v_i, v_j)$ is an edge that connects node v_i and node v_j . The Bellman-Ford algorithm determines the shortest path on a weighted graph [27]–[29]. This method measures all the shortest distances from a single node point onwards. The advantage that makes this algorithm better than other algorithms is that it allows weights to form negative numbers on the sides that connect between two vertices [30], [31]. Bellman-Ford will look for paths and count paths in tandem, implying that each node will do each operation at once (multi-thread) simultaneously. The measures for finding the shortest route using the Bellman-ford algorithm are [32]:

- a. Determine the origin and list all points and sides
- b. Give values for origin as equal to zero and other points with infinity.
- c. Starting iteration over all existing points starting with the origin. to determine the distance of all points associated with the origin with a formula like the following:
 $U = \text{origin}$
 $V = \text{destination point}$
 $UV = \text{side connecting U and V.}$
 If the distance V is greater than the distance $U + \text{weight}$ UV then the distance V is filled with distance $U + UV$ weight, carried out until all points are explored.
- d. Iterate for all sides to check whether there is a negative cycle in the graph, then check as below: For all UV sides, if the V distance is greater than the $U + \text{distance}$ of the UV weight, it is clear that the graph has a negative cycle.

The Bellman-Ford algorithm has strong accuracy and efficiency as shortest path finding algorithm based on several previous studies [27], [30], [32]. Then the Bellman-Ford algorithm was not yet used in the automatic summary of text. In this review, however, it is recommended that automated text summarization be performed utilizing the Bellman-Ford algorithm. After the pre-processing of text for multi-document as described in Section II, weighting of TF-IDF is used to determine the weight of each paragraph. TF-IDF has a formula (1) underneath:

$$W_{dt} = tf_{dt} * IDF_t \quad (1)$$

Where, d is a d^{th} document, t is a t^{th} word from the keyword, W_{dt} is the weight of the d^{th} document with the t^{th} word, tf is the number of words searched for in a document, IDF is Inverse Document Frequency where get from $\log(D/df)$, D is a total document, while df is the number of documents containing the searched word.

The implementation of Bellman-Ford algorithm for text data to give value between sentences can be conducted after counting TF-IDF value. Then, the similarity between sentence that given for edge weight in graph document is calculated using formula (2). Where, $Cost_{i,j}$ is sentence similarity value, i is the i^{th} sentence, j is the j^{th} sentence,

$overlap_{i,j}$ is number of words that are similar between the i -sentence and the j -sentence, while $weight_j$ is a sentence weight.

$$Cost_{i,j} = ((i-j)^2) / overlap_{i,j} * weight_j \quad (2)$$

The more similar the two sentences are, the lower the cost value between the two sentences. After the graph is formed, it will summarize the extraction by searching for the shortest path between the first sentence and the last sentence. In this study, the Bellman Ford algorithm is used to implement the shortest path search on document graphs

III. RESULT AND DISCUSSION

A. Proposed Framework of Bellman-Ford Algorithm for Multi Document Summarization

Fig. 4 provides the proposed framework that can be implemented for multi document summarization (in this case is scientific journal article) using Bellman-Ford algorithm. The first stage begins from users who access the automatic summarization with several documents of scientific journal articles. Those articles are inputted to the system and will be processed to the pre-processing stage.

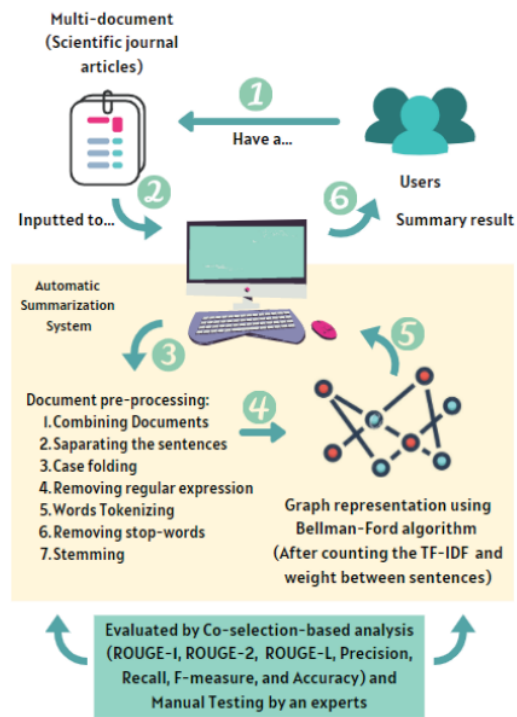


Fig. 4. Proposed Framework of Bellman-Ford Algorithm for Multi Document Summarization

The pre-processing that conducted in this case, among others:

1. Combining the documents
2. Separating the sentence from each document, because each sentence will be weighted [7], [8].
3. Case folding to uniform the text size.
4. Removing regular expression or unused characters.

5. Words tokenizing to count the TF-IDF, in this case use bag of words as text representation [33], [34].
6. Removing the stop-words or unused words [35].
7. Stemming process that used to return the word with affixes into the stem word [36]–[38]. There are many stemming algorithm that can be used for Indonesian language, such as Nazief-Adriani [39], Porter [40], and so on.

After pre-processing stage, the next process is counting the TF-IDF and weight between sentence using formula (1) and (2). Then, the graph representation will be formed using Bellman-Ford Algorithm. The candidate of sentence will be count using Bellman-Ford algorithm and the selected sentence will be issued as a summary result.

B. Analysis of Bellman-Ford Algorithm for Multi Document Summarization

Bellman-Ford algorithm will be used as graph representation that have the information about the pattern of closeness between sentences. Where the nodes are the representation of sentences with its weight, while edges are the representation of the similarity weight between sentence. As the as in the application of the shortest route, Bellman-Ford algorithm will be resulted the selected sentences that which has the smallest proximity to the total weight. Based on the previous works, Bellman-Ford algorithm has a better optimal result for the shortest route than the others shortest route algorithm such as Dijkstra [32], [41], [42]. Then, it is an opportunity to use Bellman-Ford as graph method for automatic text summarization.

The implementation of Bellman-Ford algorithm is conducted after text pre-processing, for example, there are 3 scientific journal articles with same topic below (provide in Indonesian language):

Document 1:

Pencarian rute terpendek saat melakukan perjalanan merupakan hal yang perlu dilakukan selain menemukan kota tujuan. Alasan pencarian rute terpendek adalah meringkas perjalanan dan menghemat biaya perjalanan.

(Finding the shortest route when traveling is another thing to do in addition to finding the destination city. The reason for finding the shortest route is to summarize the journey and save on travel costs.)

Document 2:

Dalam menemukan rute yang efektif dan efisien diperlukan suatu penerapan algoritma pencarian yang tepat sehingga rute yang disarankan akan benar-benar menjadi rute yang terbaik. Pencarian jalur terpendek (shortesh path) merupakan salah satu solusi dalam pencarian suatu lokasi yang terdekat jika terdapat beberapa jalur yang dapat dilaluinya.

(In finding an effective and efficient route, it is necessary to apply an appropriate search algorithm so that the suggested route will really be the best route. The search for the shortest path (shortesh path) is a solution in finding the closest location if there are several paths that can be passed.)

Document 3:

Seperti halnya dalam pencarian rumah sakit di kota Bogor. Pencarian lokasi klinik kesehatan dengan menggunakan rute yang signifikan untuk membantu calon pasien klinik kesehatan mendapatkan rute terdekat.

(Such is the case in searching for hospitals in the city of Bogor. Health clinic location search using significant routes to help prospective health clinic patients get the closest route.)

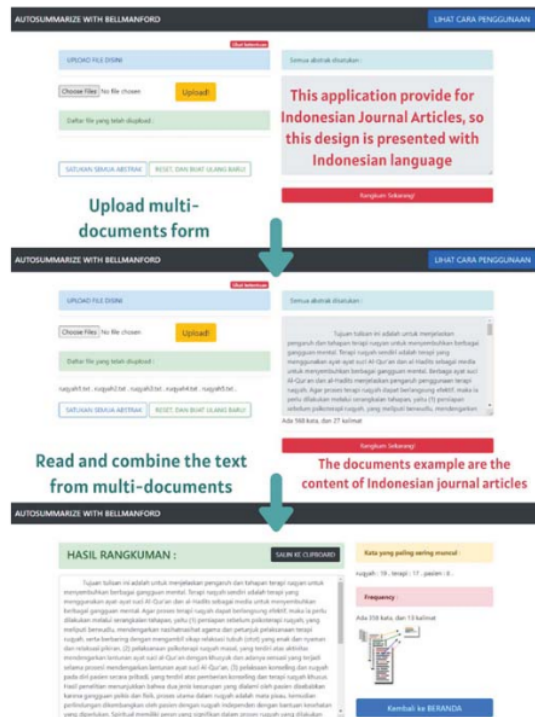
After text pre-processing:

<cari, rute, pendek, laku, jalan, perlu, laku, temu, kota, tujuan>, <alasan, cari, rute, pendek, ringkas, jalan, hemat, biaya, jalan>, <temu, rute, efektif, efisien, perlu, terap, algoritma, cari, tepat, rute, saran, benar, benar, jadi, rute, baik>, <cari, jalur, pendek, shorthesh, path, salah, satu, solusi, carian, suatu, lokasi, dekat, dapat, jalur, lalu>, <hal, cari, rumah, sakit, kota, bogor>, <cari, lokasi, klinik, sehat, guna, rute, signifikan, bantu, calon, pasien, klinik, sehat, dapat, rute, dekat>

In this case, the result of test pre-processing is the text representation that tokenize every word in every sentence from multi-documents. Then, those words will be counted by the TF-IDF formula (in formula (1)) and the similarity between sentence using formula (2). Then, the Bellman-Ford algorithm will be conducted to produce the best sentence for summary result.

C. Proposed Implementation and Evaluation of Bellman-Ford Algorithm for Multi Document Summarization

Because of every language is unique, including Indonesian Language, so that the implementation of this research is limited for Indonesian language. Fig. 5 describes the design of implementation Bellman-Ford algorithm for multi-documents summarization with Indonesian language. There are three main function, among others: (1) the form for upload the multi document; (2) the process of read and combine the documents; and (3) the automatic summarization process using Bellman-Ford algorithm that appear in the summary result form.



Summary result of Indonesian journal articles using Bellman-Ford algorithm

Fig. 5. Proposed Application Design of Bellman-Ford Algorithm for Multi Document Summarization

This proposed research has several evaluation scenarios besides the black box testing that used for evaluate the functionality of the system or application, among others:

1. Collected the scientific journal articles and classify based on the topic.
2. Prepare the manual summary result of those scientific journal article that involve the experts or readers.
3. Evaluate all of the summary result using co-selection-based analysis such as ROUGE-1, ROUGE-2, ROUGE-L, Precision, Recall, F-measure, and Accuracy [43]. Then, count the average.
4. Evaluate all of the summary result using manual testing by an expert or a reader.

IV. CONCLUSION

Finding the main idea from document, especially scientific journal article is the important thing in the research. Moreover, find the main idea from many scientific journal articles need more time and effort. Automatic text summarization technique can be used to extract the main idea from multi document easily. This research proposed the automatic text summarization for multi document using Bellman-Ford algorithm. For the further works, this concept can be implemented and evaluated to know the quality of the summary result using Bellman-Ford algorithm.

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