MJFAS
Malaysian Journal of Fundamental and Applied Sciences

Bahri *et al.* | Malaysian Journal of Fundamental and Applied Sciences, Vol. 20 (2024) 678-690

RESEARCH ARTICLE

Changing Active to Passive Sentence in Indonesian using Graph Theory and Pascal

Susila Bahri*, Aulia Rahmayu Firdaus

Department of Mathematics, Faculty of Mathematics and Natural Sciences, Andalas University, Limau Manis, 25163, Padang, Indonesia

Abstract This study discusses how graph theory is employed to changes four types of active sentence patterns into passive sentences in Indonesian. By considering 12 types of words as vertices, a weighted active sentence graph is constructed. The graph is then converted into an adjacency matrix. Furthermore, by using the transformation, the adjacency matrix is converted into a passive sentence adjacency matrix. The adjacency matrix is converted back into a passive sentence graph. From this graph, a passive sentence is generated. In the end, the Pascal program for converting active sentence to passive sentence is also used.

Keywords: Graph, matrix, transformation, active sentence, passive sentence

Introduction

Language plays an important role in the social life of humans as it serves as a means of expression and communication [1]. Formally, language is organized in units, such as words, groups of words, clauses, and sentences expressed verbally and textually in writing. A sentence is the smallest unit of language in oral or written forms that expresses a concept of thought or feeling [2]. Sentence elements in Indonesian are Subject (S), Predicate (P), Object (O), Adjunct (K), and Complement (PEL) [3,4]. Based on the elements, a sentence is called complete if it has at least two elements, which are the Subject and Predicate [5]. Sentences in Indonesian have several basic sentence patterns, including sentence patterns that have Object elements (O) such as SPO, SPOK, SPOPel and SPOPelK. Sentences with such patterns are categorized as active sentences because the Subject (S) performs actions against the Object (O). Generally, these sentences have predicates in the form of active verbs. Active verbs are usually marked with the prefix “me-”or “memper-” and can be converted into passive sentences whose predicate is in the form of passive verbs. Passive verbs are marked with prefixes “di-” or “diper”.

In Indonesian, an active sentence can be converted into a passive sentence by turning the subject in the active sentence into an object in the passive sentence and changing the prefix “me-”or “memper-” to “di-” or “diper” in the predicate [6]. The rules of such changes can easily be applied to simple sentences with SPO pattern, sentences whose subjects are not pronouns. For example, in the active sentence with the SPO pattern “Ani memasak ikan”, the sentence can be converted to a passive sentence by replacing the previous subject “Ani” to “ikan”, replacing the object that was previously “ikan” to “Ani”, and replacing the prefix “me-masak” to “di-masak” in the predicate so that the passive sentence “Ikan dimasak Ani” is formed. In other sentence patterns, the sentence change rules result in many possibilities of passive sentences.

Mathematics as an exact science has been widely applied in various fields of science, including the field of linguistics. Marcus conducted research on the separation of natural language from cultural and social problems and viewed language as a collection of structured mathematical objects [7]. Pandey and Dhami constructeds mathematical models to convert active sentences into passive sentences in English [8], and Pandey employed graph applications for translating sentences from English to Hindi [9]. These studies demonstrate, that mathematics can be used in research related to linguistics. Therefore, this study applies graphs to change active sentences into passive sentences which have different patterns in Indonesian, and uses the Pascal program to construct applications for changing active sentences into passive sentences.

***For correspondence:**
susilabahri@sci.unand.ac.id

Received: 30 Sept. 2021
Accepted: 13 May 2024

The Process of Applying Graph to Indonesian Sentences

Specifying the Set of Vertices V for a Sentence Graph

Conceptually, a graph is formed by the vertices and the edges connecting the vertices [10]. A graph G is a pair of sets (V, E), where V is a finite non-empty set of elements called vertices, and E is a set of unordered pairs of distinct vertices called edges. The sets V and E are the vertex-set and the edge-set of G, often denoted by $V(G)$ and $E(G)$. The standard notation for the vertex-set is $V = \{v_1, v_2, \dots, v_n\}$ and for the edge-set is $E = \{e_1, e_2, \dots, e_m\}$ [11].

In the research, the vertices set on the graph consists of the types of words in Indonesian. In Indonesian, the types of words are: (a) Noun which refers to something (concrete or abstract). Nouns serve as subject, object, complement, and adverb. (b) Verb, which is a word that expresses an action, or a process. Verbs have a primary syntactic function as predicates. (c) Adjectives, which refer to words that give descriptions to the noun. The description can reveal certain qualities of the nouns described, such as qualities related to color, size, and distance. (d) Pronouns or "*pronomina*", which are words used to refer to other nouns. There are several pronouns in Indonesian, namely: *Pronamina Persona* like "*aku, saya, mereka, kita, dia, ia, beliau,*anda" and *Pronomina Penunjuk* like "*ini, itu, begini,sini,sana*" (e) Adverbs, (f) Numbers "*numeralia*", (g) Prepositions, (h) Conjunctions, which are words that connect two linguistic units that are equal, such as word by word, phrase by phrase, or clause by clause. Some examples of words that belong to conjunctions are "*dan, jika,seperti, dengan,tanpa,maka,sehingga*", (i) Interjection which is, a word that expresses the feeling of the speaker's heart like "*bah, cis, cih,amboi,astaga, astagfirullah, ayo, nah*" (j) Articles, which refer to a word that limits the meaning of a noun like "*sang, sri, hang, dang, para, umat, si, yang*" and (k) Particles, comprising of four types of particles, namely "*-kah, -lah, -tah, pun*" [3,12].

Defined as an additional verb that is passive, a passive verb, the addition of one type of passive verb aims to distinguish between active and passive verbs. So the set of vertices in the sentence graph can be defined as: $V = (v_i),\ i = 1,2,..,12$. The description is shown in Table 1.

Table 1. Set of Vertices by Type of Words in Indonesian

Type of Words	Vertices
Noun	v_1
Active verbs	v_2
Passive verbs	v_3
Adjectives	v_4
Pronouns	v_5
Adverbs	v_6
Numbers (*numeralia*)	v_7
Prepositions	v_8
Conjunctions	v_9
Interjection	v_{10}
Articles	v_{11}
Particles	v_{12}

Constructing a Sentence Graph

A sentence graph is a graph representing a sentence that has direction and weight. In a sentence graph, the edges of the graph connect the types of consecutive words in the sentence. The weights are given based on the order of the edges [9]. To understand the sentence graph, it is presented using an example:" *Ibu memasak nasi*". In the sentence *"Ibu memasak nasi*", the sentence can be grouped by type of word: (noun + active verb + noun). From Table 1, it is known that noun = v_1, active verb = v_2. The sentence graph for "*Ibu memasak nasi*" is shown in Figure 1.

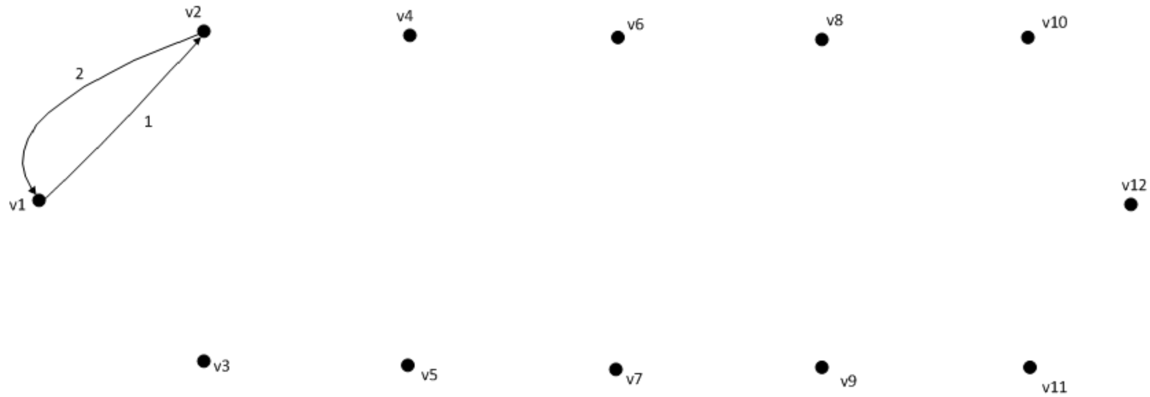


Figure 1. Sentence Graph for the Sentence "*Ibu memasak nasi*"

Determining the Adjacency Matrix for the Sentence Graph and Constructing Passive Sentence

The adjacency matrix is a square matrix that is used to represent a finite graph. Entry from an adjacency matrix is a means for representing which vertices of a graph are adjacent to which other vertices [13]. Suppose that $G = (V, E)$ is a simple graph. Suppose that the vertices of G are listed arbitrarily as $\{v_1, v_{2,} v_3, \dots, v_n\}$. The adjacency matrix A of G, with respect to this listing of the vertices, is the $n \times n$ zero one matrix with 1 as its $(i, j)th$ entry when v_i and v_j are adjacent, and 0 as its $(i, j)th$ entry when they are not adjacent [14]. However, in this study, the entry of the adjacency matrix is the weight of edge from vertex i to vertex j. In other word, if its adjacency matrix is $A = [a_{ij}]$ then

$$a_{ij} = \begin{cases} k, if \; \{v_i, v_j\} \; are \; adjacent \\ 0, otherwise \end{cases}$$

Since the sentence graph is a finite graph, it can be represented using an adjacency matrix. For the sentence graph, "*Ibu memasak nasi*" which can be seen in Figure 1, then the graph of the sentence can be represented by the following adjacency matrix.

$$\begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \quad (1)$$

The sentence graph is represented by a 12×12 adjacency matrix and the set of all 12×12 matrices forming a space vector W over a field of integers for ordinary multiplication and addition. Based on the rules of changing to passive sentences in Indonesian, by setting a vector space for active sentences (W_1) and passive sentences (W_2), vector elements of W_1 can be transformed into W_2 elements with the following rules:

$$T_1(A_1) = P_1 \;, \; T_2(A_2) = P_2 \;, \; so \; on$$

Therefore, the adjacency matrix of the sentence "*Ibu memasak nasi*" in a matrix (1) can be transformed into an adjacency matrix for passive sentences as follows:

$$T\begin{bmatrix}0&1&0&0&0&0&0&0&0&0&0&0\\2&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\end{bmatrix}=\begin{bmatrix}0&0&1&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\2&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\end{bmatrix}$$

The transformed adjacency matrix is represented in a sentence graph shown in Figure 2.

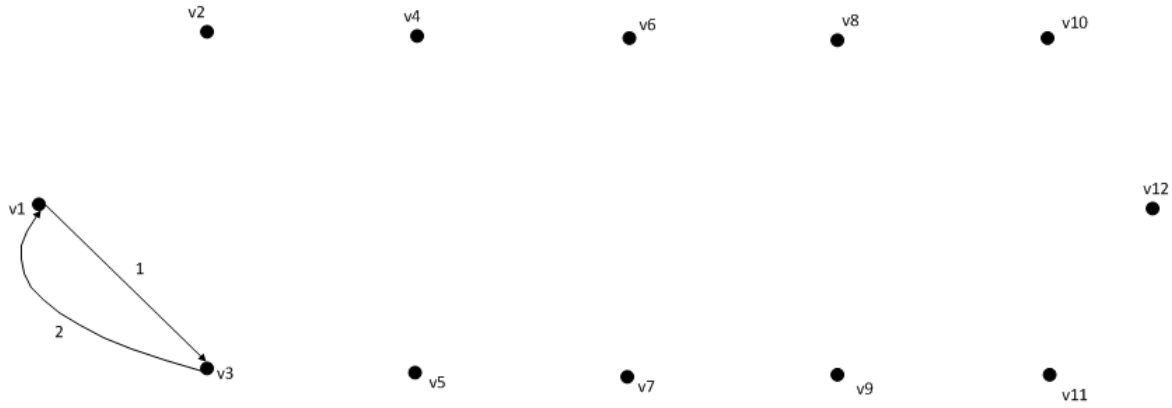


Figure 2. Sentence Graph for Adjacency Matrix Transformation Results for Sentence "*Ibu memasak nasi*"

From the sentence graph in Figure 2, the passive sentence "*Nasi dimasak ibu*" is obtained.

Application of Graph to the Four Basic Sentence Patterns in Indonesia

Grammatical sentences in Indonesian consist of subject elements and predicates that can be followed by objects, complement, or adjunct. The elements of the sentence are: (1) Subject, which is the part of the sentence that refers to the perpetrator,figure, or an issue that is the subject of conversation. The subject is usually located at the beginning of the sentence. Subjects are usually nouns, noun phrases, and pronouns. (2) Predicates, which refers to the part of a sentence that tells what the subject is doing. Predicates on transitive active sentences can be verbs or verbal phrases. (3) Objects, which are usually nouns or nominal phrases. Objects can take the subject's position when a transitive active sentence is converted into a passive sentence. (4) Complement, which are the part of the sentence that completes the predicate. (5) Adjunct, which is an element of a sentence that can occupy a position at the beginning or at the end of a sentence. Adjunct can be description of time, destination, place, cause, effect, and conditions.

Based on the role of the subject, sentences are distinguished into active sentences and passive sentences. An active sentence is a sentence whose subject executes an action, while a passive sentence is a sentence whose subject is subject to action. An active sentence that can be converted into a passive sentence is a sentence that has an object. The general formation rules from active sentence to passive sentences in Indonesian are as follows: (a) Using the prefix verb "*di–*". The change of sentence using the prefix "*di–*" is done by exchanging *S* and *O*, and replacing the prefix "*meng–*" with "*di–*"on the predicate, and the word "*oleh*" may be added in front of the element that was previously *S*. (b) Using verbs without prefixes "*di-*". This is done by moving *O* to the beginning of the sentence, removing the prefix "*meng–*", and then moving *S* to the right place before the verb.

In this study, because the sentence used is an active sentence, the basic sentence pattern used contains object elements (*O*), namely *SPO*, *SPOK*, *SPOPel*, and *SPOPelK*. Based on the change rules from active sentence to passive sentence, there are two possibilities in the change of sentence so that the four basic patterns of language used will also produce various possible changes in passive sentence

patterns. The possibilities of changing the patterns of active sentences to passive sentences based on the type of sentence pattern are as follows: Passive forms of *SPO* pattern sentences are *OPS* and *OSP*; passive forms of *SPOK* sentence patterns are *OPSK*, *KOPS*, and *OSPK*; passive forms of *SPOPel* pattern sentences are *OPSPel*, *OPelPS* and *OSPPel*; and passive forms of *SPOPelK* pattern sentences are *OPSPelK*, *KOPSPel*, *OPPelSK* and *OSPPelK*. Because of the many possibilities of changing the pattern of active sentences to passive sentences, this study is limited only to the change of active sentences to passive sentences that uses the first way, that is by using verbs with a prefix "*di-*" with provisions for sentences that have elements of adjunct. Then, in the process of changing the active sentence to passive sentences, the adjunct element remains in the previous position.

Based on the change of active sentences to passive sentences, the application of graphs on sentence changes is carried out on four basic patterns of sentences that have objects. From these steps before, it is applied to four active sentence patterns by providing an example for each sentence pattern:

(1) Active Sentence *SPO* Pattern
The example sentence for the *SPO* pattern: "*Ani mencuci mobil*". The sentence can be grouped by the type of word: (noun + active verb + noun). From Table 1, it is known that noun = v_1, active verb = v_2. Therefore, the sentence can be represented by the graph shown in Figure 3.

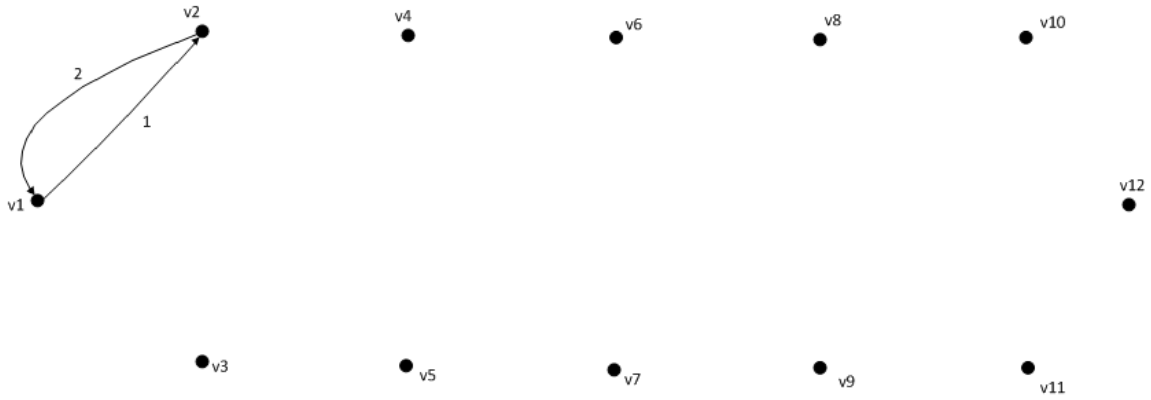


Figure 3. Sentence Graph for the Sentence "*Ani mencuci mobil*"

Then the graph of the sentence can be represented in the following adjacency matrix

$$T\begin{bmatrix}0&1&0&0&0&0&0&0&0&0&0&0\\2&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\end{bmatrix}=\begin{bmatrix}0&0&1&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\2&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\end{bmatrix}$$

The transformed adjacency matrix is represented in a sentence graph shown in Figure 4.

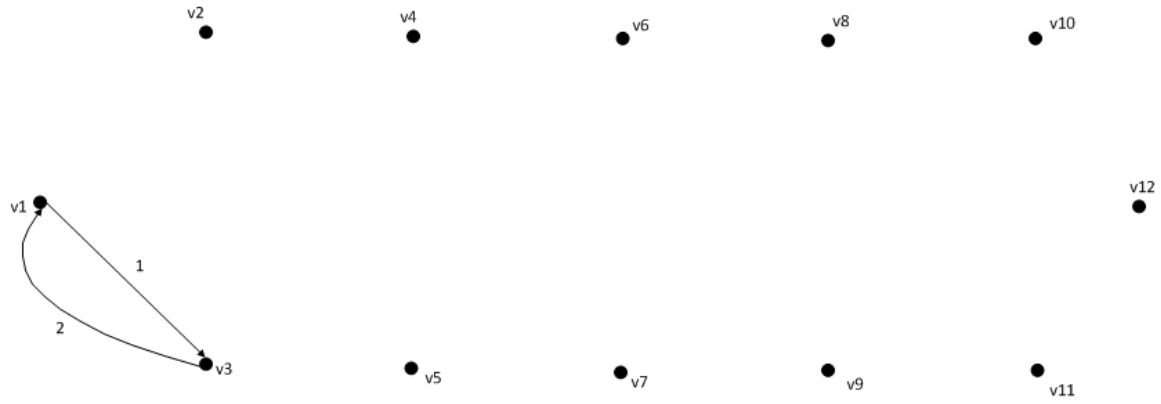


Figure 4. Sentence Graph for Adjacency Matrix Transformation Results for Sentences "*Ani mencuci mobil*"

From the sentence graph in Figure 2, the passive sentence"*Mobil dicuci Ani*" is obtained.

(2) Active Sentence *SPOK* Pattern
The example sentence for the *SPOK* pattern: "*Ibu memasak ikan di dapur*". The sentence can be grouped by the types of word: (noun + active verb + noun + prepositions + noun). From Table 1, it is known that noun = v_1, active verb = v_2, and prepositions = v_8 So that the sentence can be represented as a graph shown in Figure 5.

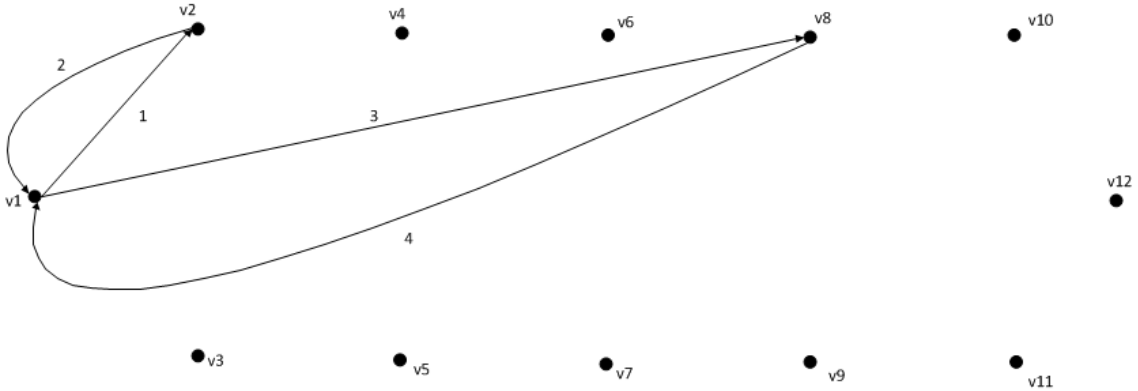


Figure 5. Sentence Graph for the Sentence "*Ibu memasak ikan di dapur*"

Then the graph of the sentence can be represented in the following adjacency matrix

$$T\begin{bmatrix}0&1&0&0&0&0&0&3&0&0&0&0\\2&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\4&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\end{bmatrix}=\begin{bmatrix}0&0&1&0&0&0&0&3&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\2&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\4&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\\0&0&0&0&0&0&0&0&0&0&0&0\end{bmatrix}$$

The transformed adjacency matrix is represented in a sentence graph shown in Figure 6.

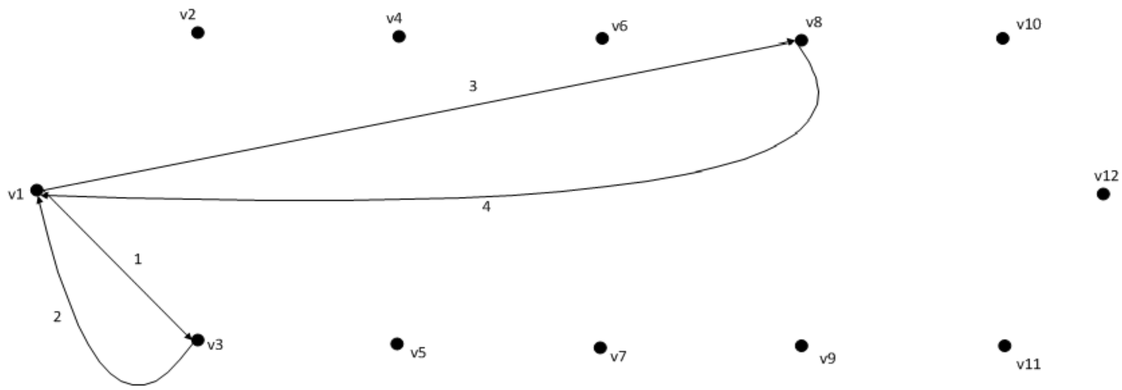


Figure 6. Sentence Graph for Adjacency Matrix Transformation Results for the Sentence "*ibu memasak ikan di dapur*"

From the sentence graph in Figure 6, the passive sentence "*ikan dimasak ibu di dapur*" is obtained.

(3) Active Sentence *SPOPel* Pattern

The example sentence for the *SPOPel* pattern: "*Ari membelikan Rani coklat*". The sentence can be grouped by the types of word: (noun + active verb + noun + noun). From Table 1, it is known that noun = v_1, and active verb = v_2. From the word order in the sentence, there is noun repetition so that the graph has a cycle. Therefore, the sentence can represented by a graph shown in Figure 7.

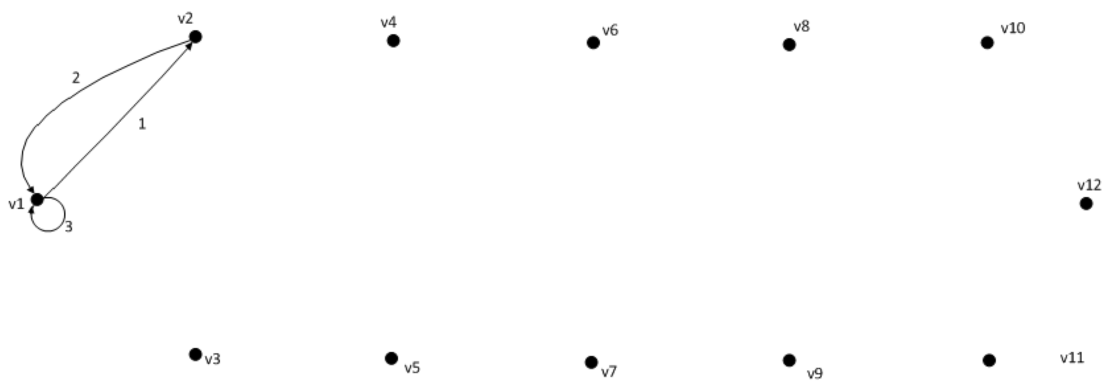


Figure 7. Sentence Graph for the Sentence "*Ari membelikan Rani coklat*"

Then the graph of the sentence can be represented in the following adjacency matrix

$$T\begin{bmatrix} 3&1&0&0&0&0&0&0&0&0&0&0\\ 2&0&0&0&0&0&0&0&0&0&0&0\\ 0&0&0&0&0&0&0&0&0&0&0&0\\ 0&0&0&0&0&0&0&0&0&0&0&0\\ 0&0&0&0&0&0&0&0&0&0&0&0\\ 0&0&0&0&0&0&0&0&0&0&0&0\\ 0&0&0&0&0&0&0&0&0&0&0&0\\ 0&0&0&0&0&0&0&0&0&0&0&0\\ 0&0&0&0&0&0&0&0&0&0&0&0\\ 0&0&0&0&0&0&0&0&0&0&0&0\\ 0&0&0&0&0&0&0&0&0&0&0&0\\ 0&0&0&0&0&0&0&0&0&0&0&0 \end{bmatrix}=\begin{bmatrix} 3&0&1&0&0&0&0&0&0&0&0&0\\ 0&0&0&0&0&0&0&0&0&0&0&0\\ 2&0&0&0&0&0&0&0&0&0&0&0\\ 0&0&0&0&0&0&0&0&0&0&0&0\\ 0&0&0&0&0&0&0&0&0&0&0&0\\ 0&0&0&0&0&0&0&0&0&0&0&0\\ 0&0&0&0&0&0&0&0&0&0&0&0\\ 0&0&0&0&0&0&0&0&0&0&0&0\\ 0&0&0&0&0&0&0&0&0&0&0&0\\ 0&0&0&0&0&0&0&0&0&0&0&0\\ 0&0&0&0&0&0&0&0&0&0&0&0\\ 0&0&0&0&0&0&0&0&0&0&0&0 \end{bmatrix}$$

The transformed adjacency matrix is represented in a sentence graph shown in Figure 8.

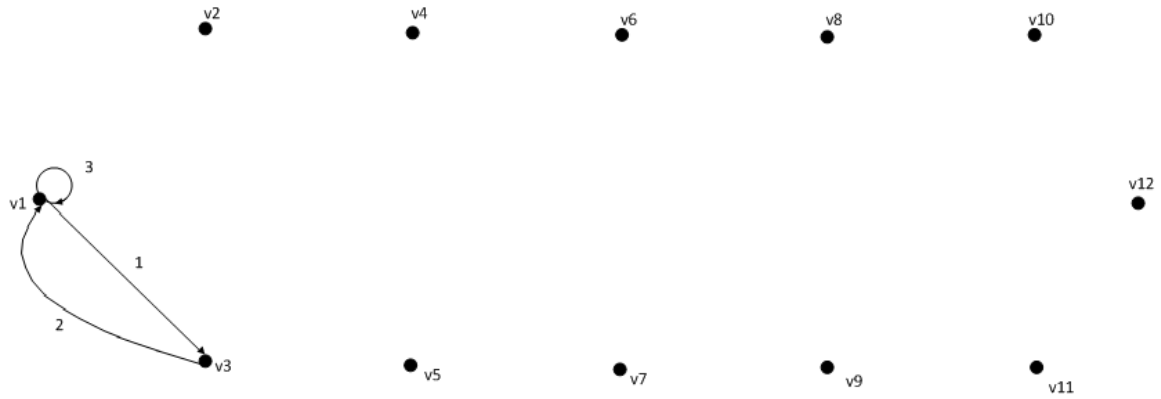


Figure 8. Sentence Graph for Adjacency Matrix Transformation Results for Sentence "*Ari membelikan Rani coklat*"

From the sentence graph in Figure 8, the passive sentence "*Rani dibelikan Ari coklat*" is obtained.

(4) Active Sentence *SPOPelK* Pattern
The example sentence for the *SPOPelK* pattern: "*Ani membelikan ibu sawah di kampung*". The sentence can be grouped by types of word: ((noun + active verb + noun + noun+ prepositions + noun). From Table 1, it is known that noun = v_1, active verb = v_2, and prepositions = v_8 . Therefore, the sentence can be represented by a graph shown in Figure 9.

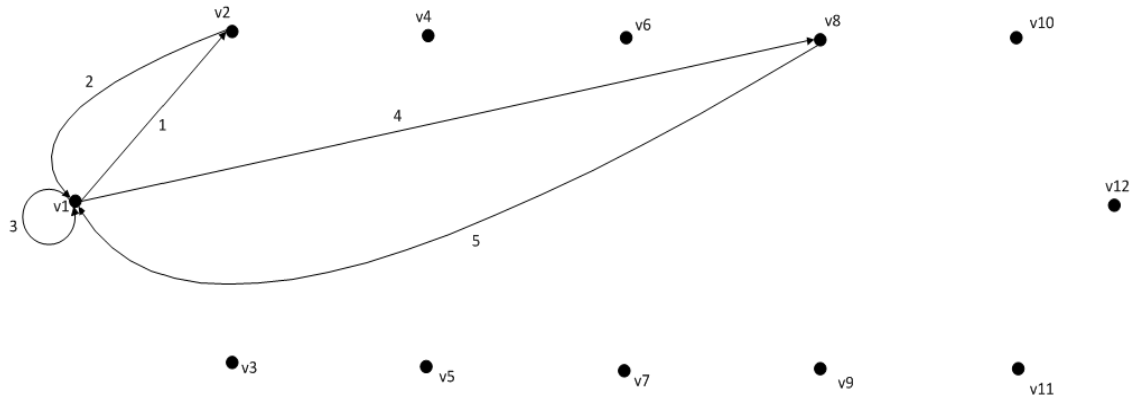


Figure 9. Sentence Graph for the Sentence "*Ani membelikan ibu sawah di kampung*"

Then, the graph of the sentence can be represented in the following adjacency matrix

$$T\begin{bmatrix} 3 & 1 & 0 & 0 & 0 & 0 & 0 & 4 & 0 & 0 & 0 & 0 \\ 2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 5 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} = \begin{bmatrix} 3 & 0 & 1 & 0 & 0 & 0 & 0 & 4 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 5 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

The transformed adjacency matrix is represented in a sentence graph shown in Figure 10.

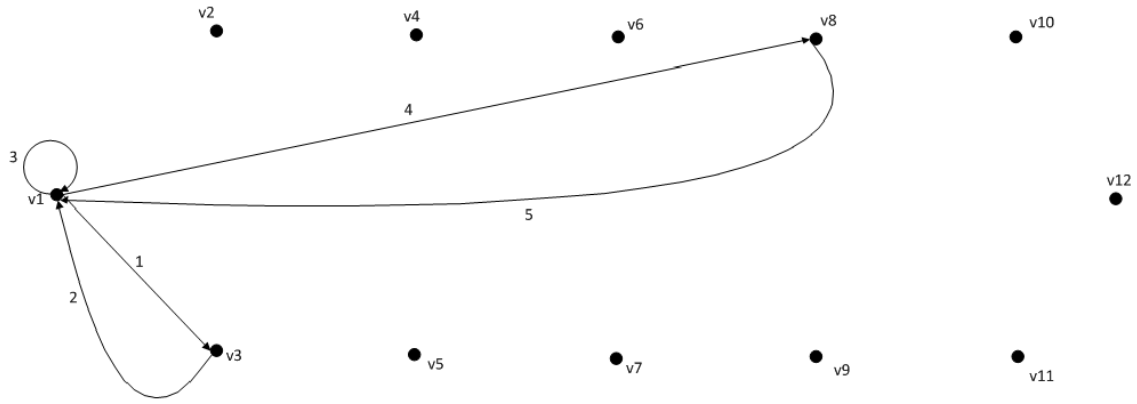
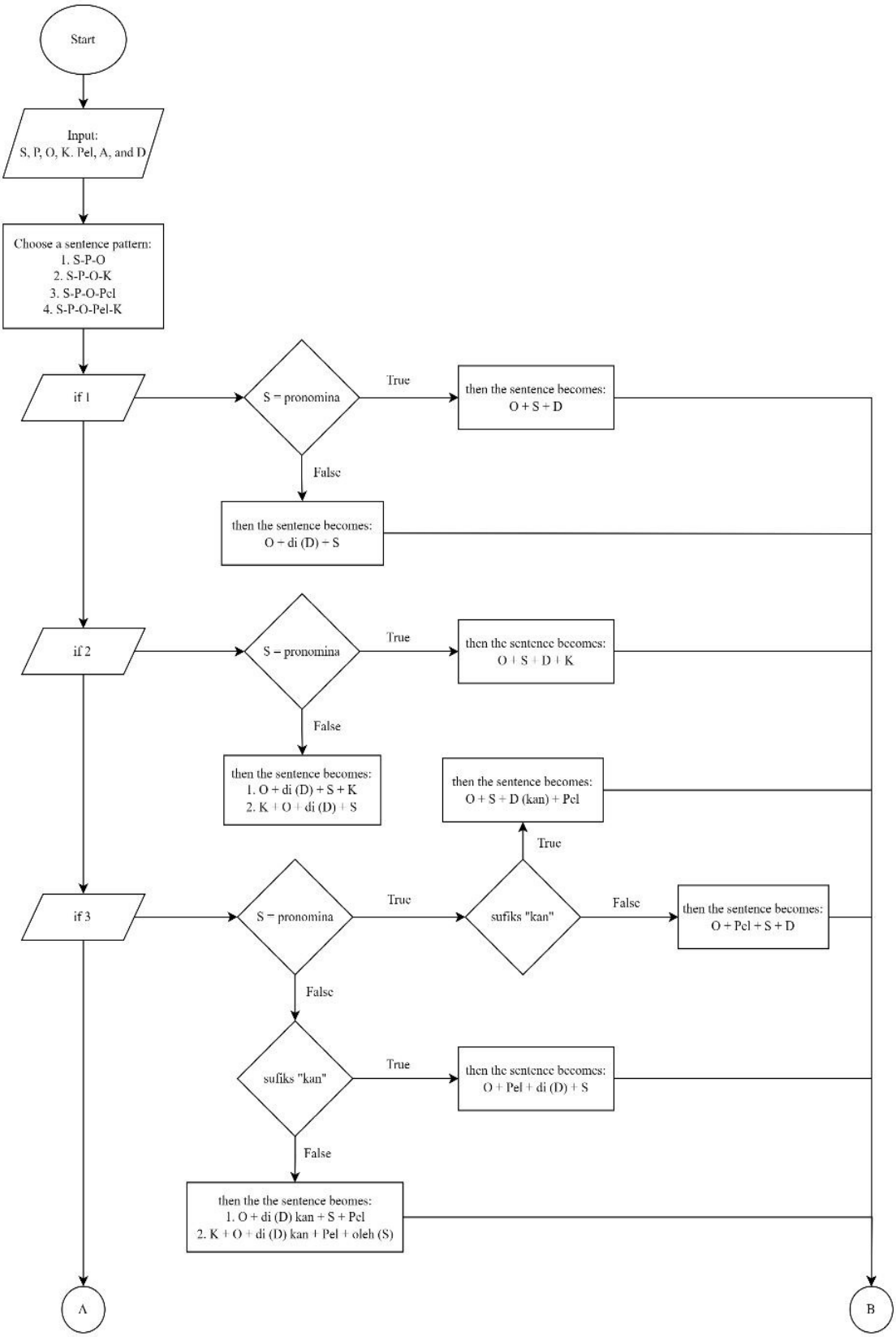


Figure 10. Sentence Graph for Adjacency Matrix Transformation Results for Sentences "*Ani membelikan ibu sawah di kampung*"

From the sentence graph in Figure 10, the passive sentence "*Ibu dibelikan Ani sawah di kampung*" is obtained.

Pascal Program to Convert Active Sentences into Passive Sentences

Pascal is goal-oriented, high-level language designed by Professor Niklaus Wirth of Technical University in Zurich, Switzerland.This software is easy to learn and use compared to other software because it has a simple structure and is very close to human language [15, 16]. The Pascal Programming Language is also used in various fields of research such as Solving the Traveling Salesman Problem [17], and research on Translating Indonesian into Source Code in Pascal Language [15]. This study also uses the Pascal programming language for the process of changing active sentences into passive sentences in Indonesia. Any possible changes in active sentence pattern to passive sentence are displayed in the pascal program. The steps in Pascal programming for sentence changes are presented in the flowchart shown in Figure 11.


Start
Input:
S, P, O, K. Pel, A, and D
Choose a sentence pattern:
1. S-P-O
2. S-P-O-K
3. S-P-O-Pel
4. S-P-O-Pel-K
if 1
S = pronomina
True
then the sentence becomes:
O + S + D
False
then the sentence becomes:
O + di (D) + S
if 2
S = pronomina
True
then the sentence becomes:
O + S + D + K
False
then the sentence becomes:
1. O + di (D) + S + K
2. K + O + di (D) + S
if 3
S = pronomina
True
sufiks "kan"
True
then the sentence becomes:
O + S + D (kan) + Pel
False
then the sentence becomes:
O + Pel + S + D
False
sufiks "kan"
True
then the sentence becomes:
O + Pel + di (D) + S
False
then the the sentence beomes:
1. O + di (D) kan + S + Pel
2. K + O + di (D) kan + Pel + oleh (S)
A
B

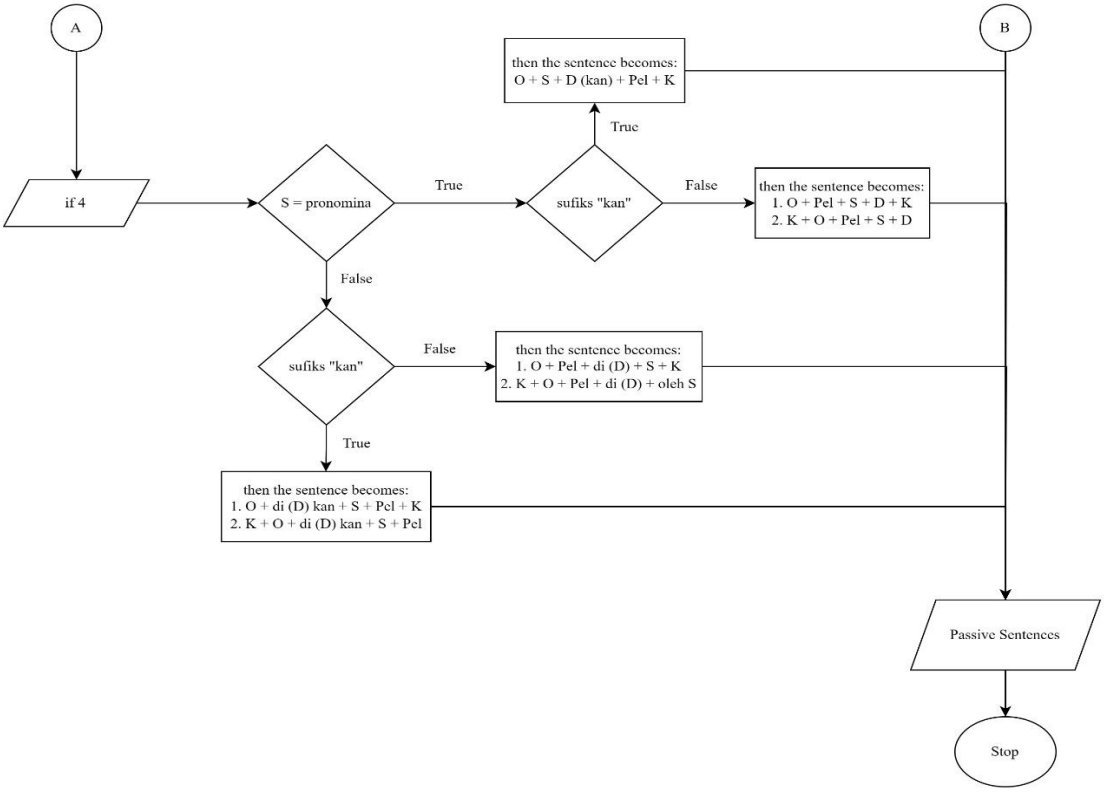


Figure 11. Flowchart for Changing Active Sentences to Passive Sentences

From the flowchart, it is known that changing active sentences to passive sentences is done with the input of subject, predicates, objects, complement, and adjunct based on the user's desired sentence pattern. Furthermore, users can choose which pattern sentences will be converted into passive sentences. The program display is shown in Figure 12 below.

Figure 12. Pascal Program Output

Figure 12 shows, the parts of the sentence that have been filled, which are the subject(*S*), predicate(*P*), object(*O*), adjunct(*K*), and basic word. Based on the basic sentence pattern in Indonesian, the sentence has an *SPOK* pattern, so the type of sentence pattern that selected is 2. Subprogram coding, changing active sentences into passive sentences with the selected sentence pattern 2 is shown in Figure 13.

```
If Pilihan = 2 then
if (S='saya') or (S='aku') or (S='daku') or (S='kamu') or (S='anda')
   or (S='kau') or (S='ia') or (S='dia') or (S='beliau') or (S='kita')
   or (S='kami') or (S='kalian') or (S='kamu sekalian') or (S='mereka') then
      begin
           writeln('Kalimat aktifnya adalah: ', S , ' ' , P , ' ' , O , ' ', K
           write('Kalimat pasifnya adalah :');
           writeln( O, ' ', S , ' ', D , ' ',K);
      end
   else
       begin
            writeln('Kalimat aktifnya adalah :', S , ' ', P , ' ', O , ' ',K);
            writeln('Kalimat pasifnya adalah:');
            writeln('1. ', O , ' ', 'di',D, ' ', S , ' ', K);
            writeln('2. ', K , ' ', O , ' ', 'di',D, ' ', S);
       end;
```

Figure 13. Program Coding for Changing Active Sentences to Passive Sentences

Figure 13 presents the code for changing the active sentence to passive with *SPOK* pattern. From Figure 13, it is known that if the choice is sentence pattern 2, then the program will separate first whether the sentence is a subject in the form of noun or pronoun. If the sentence inputs subject in the form of a noun, then the program will form a passive sentence based on the first way of realization that uses a verb with a prefix "*di-*", while if the subject entered is a pronoun, then the program will form a passive sentence based on the second way, that is without using the prefix "*di-*". The output of choice 2 is shown in Figure 14.

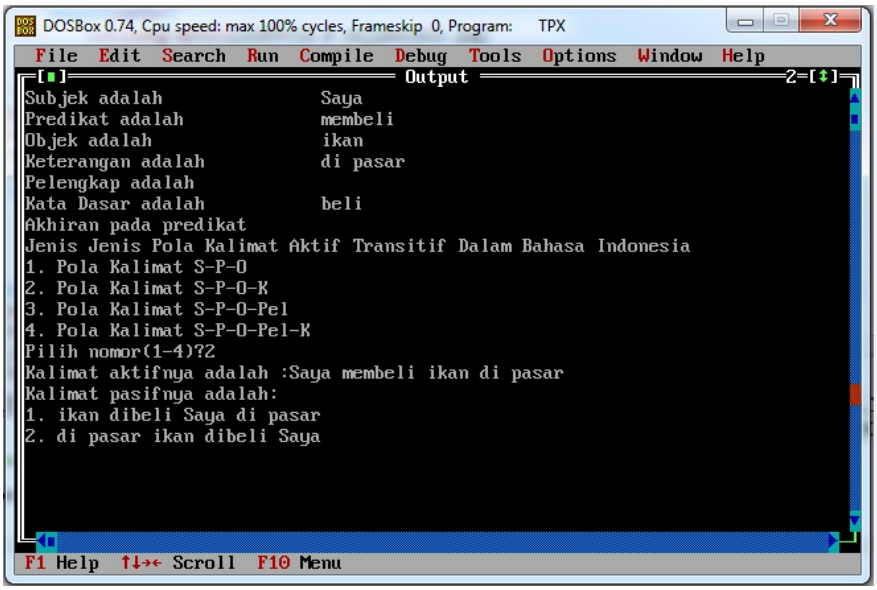


Figure 14. Output Results After Selecting Sentence Patterns for Changing Active Sentences to Passive Sentences

Figure 14 shows the final result of programming where active and passive sentences are obtained from the words that have been inputted. There, are two possible passive sentences for *SPOK* pattern sentences, because adjunct (*K*) is an element of a sentence that can occupy a position both at the beginning or at the end of a sentence.

Conclusions

A sentence graph is a graph representing a sentence that has direction and weight. The vertice on a sentence graph are a set of types of words, while the edges on the graph show the relationship between types of words in a sentence. After the sentence graph is formed, then the sentence graph is represented in an adjacency matrix. The adjacency matrix is then transformed to the adjacency matrix of passive sentences based on the rules of changing active sentences to the following passive sentences: $T_1(A_1) = P_1$, $T_2(A_2) = P_2$. Furthermore, the passive sentence adjacency matrix is expressed in a sentence graph. The sentence graph is then stated in passive sentences in Indonesian. These steps are applied in the process of changing each of the four basic patterns of active sentences into passive sentences in Indonesian. Pascal program for sentence change is able to convert active sentences into passive sentences in accordance with the rules of Indonesian sentence change. This is expected to help users in changing active sentences to passive sentences.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Acknowledgment

We would like to express our deepest gratitude to the Faculty of Mathematics and Natural Sciences, Andalas University, for the financial support and research facilities that have been provided.

References

[1] Tribus, A. C. (2017). The communicative functions of language: an exploration of roman Jakobson's theory in tesol. *MA TESOL Collection*, 723.
[2] Caterina, Y., Yaqin, M. A., & Zaman, S. (2021). Pengukuran kemiripan makna kalimat dalam Bahasa Indonesia menggunakan metode path. *Fountain of Informatics*, *6*(2), 45-50.
[3] Alwi, H., Dardjowidjojo, S., Lapoliwa, H., Moeliono, A. M. (2003). *Tata bahasa baku bahasa Indonesia.* Jakarta: Balai Pustaka.
[4] Finoza, L. (2009). *Komposisi bahasa Indonesia.* Jakarta: Diksi Insan Mulia.
[5] Ermanto, E. (2016). *Bahasa Indonesia: Pengembangan kepribadian di Perguruan Tinggi*. Padang: UNP Press.
[6] Suprato, D. (2012). Analisis kontrastif kalimat pasif bahasa Indonesia dengan bahasa Inggris. *Humaniora*, *3*(1), 290-298.
[7] Kracht, M. (2003). *The Mathematics of Language*. Mouton de Gruyter.
[8] Pandey, R., & Dhami, H. S. (2009). Mathematical model for transformation of sentences from active voice to passive voice. *arXiv preprint arXiv:0903.5168*.
[9] Pandey, R. (2016). Application of graph theory to translation from English to Hindi. *Global Journal of Computational Science and Mathematics*, *6*(1), 19-38.
[10] Samanta, Sovan, *et al.* (2021). A Study on semi-directed graphs for social media networks. *International Journal of Computational Intelligence Systems*, *14*(1), 1034-1041.
[11] Beineke, L. W., & Wilson, R. J. (2004). *Topics in algebraic graph theory*. Cambridge University Press.
[12] Wardana, H. K., Swanita, I., & Yohanes, B. W. (2019). Sistem pemeriksa pola kalimat bahasa Indonesia berbasis algoritme left-corner parsing dengan stemming. *Jurnal Nasional Teknik Elektro dan Teknologi Informasi (JNTETI)*, *8*(3), 211-217.
[13] Singh, H., & Sharma, R. (2012). Role of adjacency matrix & adjacency list in graph theory. *International Journal of Computers & Technology*, *3*(1), 179-183.
[14] Carnia, E., Suyudi, M., Aisah, I., & Supriatna, A. K. (2017). A review on eigen values of adjacency matrix of graph with cliques. *AIP conference proceedings* (Vol. 1868, No. 1, p. 040001). AIP Publishing LLC.
[15] Kohar, M. (2019). *Penerjemah bahasa alami dalam bahasa Indonesia ke source code dalam bahasa pascal*. Doctoral Dissertation. Universitas Komputer Indonesia.
[16] Hapsari, S. A. M. S. (2018). Algoritma dan program pascal untuk mencari luas dan volume bangun ruang secara cepat dan benar. *Research Fair UNISRI*, *2*(1).
[17] Sirait, D. E., & Simarmata, J. E. (2020). Penyelesaian masalah travelling salesman problem dengan menggunakan bahasa pemrograman pascal. *MES: Journal of Mathematics Education and Science*, *6*(1), 10-15.