Sponsored by

COMPUTER SCIENCE
UNIVERSITAS KLABAT

IEEE INDONESIA SECTION

ICORIS 2020

The 2nd International Conference on Cybernetics and Intelligent System

Proceedings of ICORIS 2020

HOST

Universitas Klabat

Jalan Arnold Mononutu, Airmadidi, Airmadidi Bawah, Kec. Airmadidi, Kabupaten Minahasa Utara, Sulawesi Utara 95371

ISBN: 978-1-7281-7257-6

27th -28th October 2020
Virtual Conference

Organized by:

Supported by:

2020 2nd International Conference on Cybernetics and Intelligent System (ICORIS) | 978-1-7281-7257-6/20/$31.00 ©2020 IEEE | DOI: 10.1109/ICORIS50180.2020.9320804

Structural Similarity Measurement using Graph Edit Distance-Greedy on State chart Diagrams

Hidayatul Munawaroh
Department of Informatic
Institut Teknologi Sepuluh Nopember
Surabaya, Indonesia
hidayatul15@mhs.if.its.ac.id

Daniel Oranova Siahaan
Department of Informatic
Institut Teknologi Sepuluh Nopember
Surabaya, Indonesia
daniel@its.ac.id

Reza Fauzan
Department of Informatic & Department of Electrical Engineering
Institut Teknologi Sepuluh Nopember & Politeknik Negeri Banjarmasin
Surabaya & Banjarmasin, Indonesia
reza.fauzan@poliban.ac.id

Evi Triandini
Department of Information System
Institut Teknologi dan Bisnis STIKOM Bali
Denpasar, Indonesia
evi@stikom-bali.ac.id

2020 2nd International Conference on Cybernetics and Intelligent System (ICORIS) | 978-1-7281-7257-6/20/$31.00 ©2020 IEEE | DOI: 10.1109/ICORIS50180.2020.9320764

***Abstract*--With the emergence of the need for online learning, the automatic grading system is inevitable requirements in an e-learning system. The automatic grading system in software design courses requires a method for measuring similarity between the key-answer design and student-answer designs. There have been several efforts to develop methods for measuring the design similarity. The similarity measurement that has been developed based on semantic or structural aspects of the design. Nevertheless, the purpose of those methods is to reuse software designs. This study proposes a graph representation of the State chart diagram. The graph models the structural aspects of the State chart diagram. This study also proposes the use of Graph Edit Distance (GED) greedy for calculating the structural similarity between two graphs. Graph representation of the State chart diagram is used as input to the GED-greedy method. The results show that all parameters used can determine the structural similarity between two State chart diagrams with graph representation of the State chart diagram as input. State chart similarity results obtained were 0.83.**

Keywords–State chart diagram similarity, structural similarity, Graph Edit Distance (GED), greedy, graph similarity.

I. INTRODUCTION

As technology develops, teaching and learning are no longer limited to traditional classrooms. At present, the use of e-learning in higher education is becoming increasingly popular and becoming an important component. E-learning is an electronic learning media to support the delivery and assessment of learning materials [1]. The use of e-learning requires less space or time restrictions, and recording is easier when compared to traditional classrooms.

Evaluation is the process of assigning value to an object by referring to a certain size, such as high or low. Whereas measurement is a process of giving a number to a measuring object. Measurements are made by comparing the object to be measured with the facts [2]. Measurements always provide quantitative results while assessment results can be qualitative. The measurement results can be taken into consideration or the basis for the assessment.

The assessment system on e-learning is divided into two types, selected response and constructed response [3]. Selected responses include true/false answers, matching, multiple-choice, and a list of answer choices. The constructed response includes answer answers and descriptions [4], [5]. Description answer is the answer that is written in the form of description, different from the description problem. Description problem is a question that is written in the form of a story or description with the type of answer that varies according to needs, can be in the form of a selected response or constructed response. This e-learning model allows a greater number of students compared to conventional classes, consequently driving the need for automation of the evaluation process. Automation in the constructed response that has been up to now is for answers to text contents. The assessment of answers to the contents of the existing text is reliable for the assessment of the subjects [6]–[8].

In its application, some design subjects, such as Software Engineering (SE), the given description answer sometimes involves answers in the form of design diagrams, for example, Unified Modeling Language (UML) diagrams. So there needs to be development related to the evaluation of these answers. Previous research has developed a method for measuring the similarity of UML diagrams for the assessment of the breakdown answers in diagram form. The UML diagram that has been handled is the class diagram [9], sequence diagram [10], and use case diagram [11]. While research related to the measurement of similarity of existing State chart diagrams has the aim of reusing software designs [12]. This research uses the Finite State Machine and Cuckoo Search Algorithm (CSA) to match and retrieve State chart diagrams from the repository. The experimental results show that this method is effective for retrieving the most similar State chart diagrams from a repository against a given query.

In previous studies, there have been several methods for calculating the similarity of UML diagrams. But the main focus of these methods is to reuse software designs or considering only one aspect of either semantics [9]–[11] or structural [13]–[16]. Measurement of similarity of UML diagrams to reuse software designs is done by comparing one UML diagram with several UML diagrams that exist in the repository. Even though the software has a different domain, the software design can be reused for new software development.

The similarity rating is determined from the similarity value of the diagram obtained. Whereas the measurement of the similarity of UML diagrams for the assessment of the answer to the questions is done by comparing several diagrams of answers with key diagrams. The answer and key diagram must have the same domain and the judgment given are not necessarily the same as the similarity value obtained. So that the effect of aspects of UML diagram similarity measurement will be different depending on the objectives to be achieved.

Measurement of similarity using Graph Edit Distance (GED) method needs to be calculated from each of the existing permutations, so it needs to be calculated as many $(m+n)!$. m is the number of nodes in graph 1 and n is the number of nodes in graph 2. To reduce the number of experiments performed the greedy algorithm is used in research. This study proposes a graph representation of the State chart diagram. The graph models the structural aspects of the state-chart diagram. This study also proposes the use of Graph Edit Distance (GED) greedy for calculating the structural similarity between two graphs.

II. Literature Review

Structural similarity is a similarity of the structural aspect of a diagram. For example, the relation between state and state components in a State chart diagram. The structural similarity that has been done in previous studies uses two approaches, namely the use of lexical information from neighbours [17] and the use of graphs [13]. Research conducted by Yuan [13] uses a class diagram case study. The similarity measurement is done by giving priority to structural aspects using UML Class Graph (UCG) and overriding the semantic aspects between diagrams. The results of the study stated that UCG can effectively measure the similarity of diagrams in the same or different domains.

III. Methodology

This research includes several stages of research consisting of 1) state chart diagram data collection, 2) data preprocessing, 3) formulation of structural similarity measurement methods.

A. State chart Diagram Data Collection

The data collected is a software design from the description of the software provided in the form of questions. The problem given is a description of an object and the conditions experienced by the object. There are three types of questions given, each respondent only receives one type of question. Each respondent will answer the questions in the form of a State chart diagram. The answers will then be a measured similarity with the answer key that has been made previously.

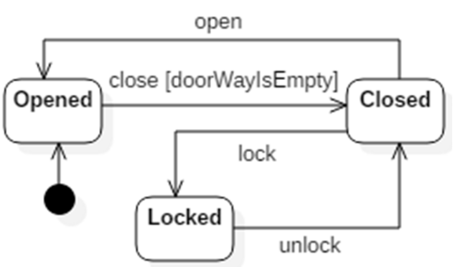

Fig. 1. State chart diagram 1 (SC1).

```
...
<subvertex xmi:id="AAAAAAFwd/JD/8EzeYo=" name="Opened" visibility="public"
 xmi:type="uml:State"/>
<subvertex xmi:id="AAAAAAFwd/JiMcFZaUY=" name="Closed" visibility="public"
 xmi:type="uml:State"/>
<subvertex xmi:id="AAAAAAFwd/JvxcF/Og8=" name="Locked" visibility="public"
 xmi:type="uml:State"/>
...
<transition xmi:id="AAAAAAFwd/LYtMG6/Dk=" visibility="public" xmi:type="
uml:Transition" source="AAAAAAFwd/JD/8EzeYo=" target="AAAAAAFwd/JiMcFZaUY=
" kind="external">
    <guard xmi:id="AAAAAAFwd/3L2cIc6g0=" xmi:type="uml:Constraint"
    specification="doorWayIsEmpty"/>
    ...
    <trigger xmi:id="AAAAAAFwd/3L6MIdT5Q=" xmi:type="uml:Trigger" name="
    close" event="AAAAAAFwd/TCeMIOKLg="/>
    ...
</transition>
```

Fig. 2. Example of the XMI file cut from SC1.

B. Data Preprocessing

Before a similarity measurement is made, each diagram is processed into the form of XMI (XML Metadata Interchange). The following is an example of an XMI file cut from one of the State chart diagrams (SC1).

From the example at Fig. 2. it can be interpreted that there is an element with the name “Opened” of type State, an element with the name “Closed” of type State, an element with the name “Locked” of type State. Then there are elements of type Transition that have the source “AAAAAAFwd/JD/8EzeYo=”, target “AAAAAAFwd/JiMcFZaUY=”, guard “doorWayIsEmpty” and have a trigger “close”. Where the element “AAAAAAFwd/JD/8EzeYo=” is named “Opened” and the element “AAAAAAFwd/JiMcFZaUY=” is named “Closed”. So it can be concluded that there is a transition from state “Opened” to state “Closed” with the trigger “close” and guard “doorWayIsEmpty”.

C. Structural Similarity Measurement Method between Two State chart Diagrams

The structural similarity of a State chart diagram is measured by modelling a State chart diagram in the form of a graph. The designation used to graph the State chart diagram can be seen in Table 1.

TABLE 1. Labelling of State chart Diagrams Graph Elements

No	Element Type	Name	Label
1	Node	State Node	Vs
2	Node	Transition Node	Vt
3	Node	Entry Activity Node	Ven
4	Node	Do Activity Node	Vdo
5	Node	Exit Activity Node	Vex
6	Node	Trigger Node	Vtr
7	Node	Guard Node	Vgr
8	Node	Action Node	Vac
9	Edge	Transition Edge	e_t
10	Edge	Entry Activity Edge	e_{en}
11	Edge	Do Activity Node	e_{do}
12	Edge	Exit Activity Node	e_{ex}
13	Edge	Trigger Edge	e_{tr}
14	Edge	Guard Edge	e_{gr}
15	Edge	Action Edge	e_{ac}

Measurement of structural similarity of State chart diagrams is divided into two components, namely inter-structure and intra-structure. Inter-structure is a

$V_2^+ =$
$\{Vs_1, Vs_2, Vs_3, Vs_4, Vt_1, Vt_2, Vt_3, Vt_4, Vt_5, \varepsilon, \varepsilon, \varepsilon, \varepsilon, \varepsilon, \varepsilon, \varepsilon, \varepsilon, \varepsilon\}$

measurement of similarity between two State chart diagrams based on the relationship between states in each diagram. Whereas intra-structure is a measurement of similarity between two State chart diagrams based on the attributes possessed by each state or transition in each diagram. Calculation of structural similarity between two State chart diagrams ($strucSim(d_1, d_2)$) can be seen in Equation (1).

$$strucSim(d_1, d_2) = w_{inter} \times interSim(d_1, d_2) + w_{intra} \times intraSim(d_1, d_2) \quad (1)$$

notes:
d_1 = first State chart diagram,
d_2 = second State chart diagram,
w_{inter} = weight of an inter-structural similarity,
w_{intra} = weight of intra-structural similarity,
$interSim$ = inter-structure State chart diagram similarity,
$intraSim$ = intra-structure State chart diagram similarity.

1) Measurement of State chart Diagram Inter-structure Similarity

State chart diagram modelling in the form of graphs for the measurement of similarity of structures is only concerned with the relationship between states and ignores the attributes that exist in the state and transition. First, do the diagram modelling in the form of graphs. Then the similarity measurement is done using GED-greedy. The stages carried out in GED-greedy are.

a) Cost matrix C formation The cost C matrix is a matrix containing the costs needed to change the first graph) into the second graph. Cost is the step needed to change from node to node ‘. The matrix has the size

$$(m + n) \text{ x } (m + n) \quad (2)$$

notes:
m = the number of vertices in graph 1
n = the number of vertices in graph 2

For example, graph 1 has a set of vertices

$$V_1 = \{Vs_1, Vs_2, Vs_3, Vs_4, Vt_1, Vt_2, Vt_3, Vt_4, Vt_5\},$$

and graph 2 has a node-set

$$V_2 = \{Vs_1, Vs_2, Vs_3, Vs_4, Vt_1, Vt_2, Vt_3, Vt_4, Vt_5\}.$$

So we get m = 9 and n = 9.

Next obtained V_1^+ which is the set of vertices of graph 1 that has been added by an empty node of number n, such that

$$V_1^+ = \{Vs_1, Vs_2, Vs_3, Vs_4, Vt_1, Vt_2, Vt_3, Vt_4, Vt_5, \varepsilon, \varepsilon, \varepsilon, \varepsilon, \varepsilon, \varepsilon, \varepsilon, \varepsilon, \varepsilon\}$$

Next obtained V_2^+ which is a set of vertices of graph 2 that has been added to an empty node of m, so that

If a member of V_1^+ and V_2^+ already totalled $m + n$ then made a cost matrix C. Cost matrix C is divided into four parts, i.e.

$$C = \left[\begin{array}{c|c} Q_1 & Q_3 \\ \hline Q_2 & Q_4 \end{array}\right] \quad (3)$$

notes:
Q_1 = price obtained for substitution from V_i to V_j'
Q_2 = the price obtained to delete V_i (from V_i to ε)
Q_3 = price obtained to add V_j' (from ε to V_j')
Q_4 = price obtained for substitution from ε to ε
V_i = node in graph 1
V_j' = node in graph 2.

Calculation of total cost using greedy The similarity calculation is done by adding the greedy algorithm to the Graph Edit Distance (GED) method. The greedy algorithm is used in the selection of permutations to find the minimum cost needed to convert graph 1 to graph 2. To find the minimum cost in GED it is necessary to calculate the respective permutations so that the GED needs to be done calculation as much $(m + n)!$. To reduce the number of experiments performed the greedy algorithm is used at this stage. By using greedy the number of calculations that need to be done is O(m2) when value $m \geq n$.

The greedy algorithm is done twice, the first one is: If $m > n$ then the first cost selection in matrix C of quadrant 2 (Q_2). If $m < n$ then the first cost selection in matrix C of quadrant 3 (Q_3). If $m = n$ then the first cost selection in matrix C of quadrant 1 (Q_1). The second cost selection from Q_4, this is done because in Q_4 consists of “0” which is the minimum value. The cost selection in Q_4 is done until all values in Q_4 have nothing to choose from. Next, the cost is selected from the remaining cost value in matrix C.

2) Measurement of State chart Diagram Intra-structure Similarity

Intra-structural similarity is divided into two components namely state and transition. To get the value of intra-structural similarity ($intraSim(d_1, d_2)$) carried out by following Equation (4).

$$intraSim(d_1, d_2) = w_{st} \times stSim(d_1, d_2) + w_{tr} \times trSim(d_1, d_2) \quad (4)$$

notes:
d_1 = first State chart diagram,
d_2 = second State chart diagram,
w_{st} = weight of state similarity,
w_{tr} = weight of transition similarity,
$stSim$ = State chart diagram state similarity,
$trSim$ = State chart diagram transition similarity.

The first step carried out to measure the intra-structure similarity of a State chart diagram is to model each state and transition of a State chart diagram in the form of a graph. State and transition modelling in State chart diagrams in graphical form for the measurement of intra-structural similarity does not pay attention to relations between states and pay attention to the attributes that exist in the state and transition. Furthermore, the similarity measurement is performed on each pair of vertices and transition pairs using GED-greedy.

To get the value of state similarity ($stSim(d_1, d_2)$) carried out by following Equation (5).

$$stSim(d_1, d_2) = \frac{(n \times maxCostSt) - costS}{n \times maxCostSt} \quad (5)$$

notes:
d_1 = first State chart diagram,
d_2 = second State chart diagram,
n = the number of cost values taken from the cost matrix S,
$maxCostSt$ = maximum cost that might occur in the cost matrix S,
$costS$ = GED cost taken from the cost matrix S.

State similarity value ($costS$) is obtained by applying the greedy algorithm to find permutations with a minimum amount of cost from a set of state pair cost values. This value is stored in the form of a cost matrix S with rules

$$S = \begin{bmatrix} Vs_1Vs_1 & \cdots & Vs_tVs_j \\ \vdots & \ddots & \vdots \\ Vs_tVs_j & \cdots & Vs_xVs_y \end{bmatrix} \quad (6)$$

notes:
x = number of state nodes in the first State chart diagram
y = number of state nodes in the second State chart diagram.

To get the value of transition similarity ($trSim(d_1, d_2)$) carried out by the following Equation (7).

$$trSim(d_1, d_2) = \frac{(n \times maxCostTr) - costT}{n \times maxCostTr} \quad (7)$$

notes:
d_1 = first State chart diagram,
d_2 = second State chart diagram,
n = the number of cost values taken from the cost matrix T,
$maxCostTr$ = maximum cost that might occur in the cost matrix T,
$costT$ = GED cost taken from the cost matrix T.

Transition similarity value ($costT$) is obtained by applying the greedy algorithm to find permutations with a minimum amount of cost from a set of transitional pair cost values. This value is stored in the form of a cost matrix T with rules

$$T = \begin{bmatrix} Vt_1Vt_1 & \cdots & Vt_tVt_j \\ \vdots & \ddots & \vdots \\ Vt_tVt_j & \cdots & Vt_uVt_v \end{bmatrix} \quad (8)$$

notes:
u = number of transition nodes in the first State chart diagram
v = number of transition nodes in the second State chart diagram.

IV. Result and Analysis

This study uses two State chart diagrams as examples to measure similarity using the proposed method. Both diagrams can be seen in Fig. 1. and Fig. 3.

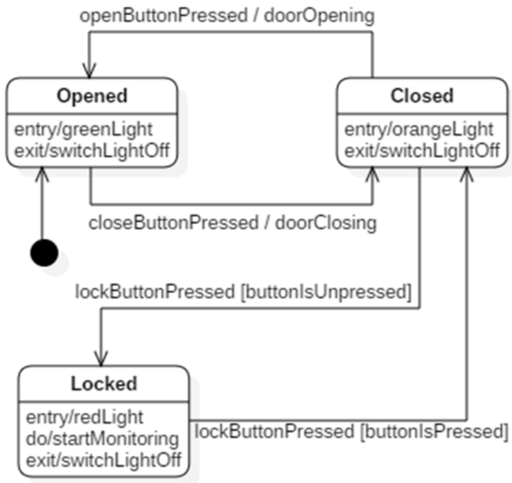

Fig. 3. State chart diagram 2 (SC2).

1) *Measurement of State chart Diagram Inter-structure Similarity*

The first step carried out to measure the inter-structure similarity of a State chart diagram is to model a State chart diagram in the form of a graph. Examples of modelling from SC1 can be seen in Fig. 4. and SC2 can be seen in Fig. 5.

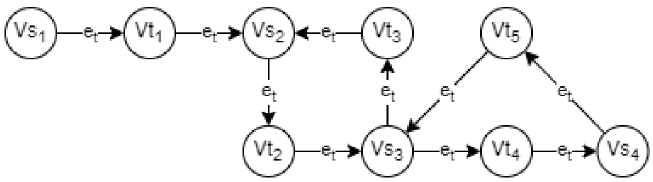

Fig. 4. Graf model of SC1.

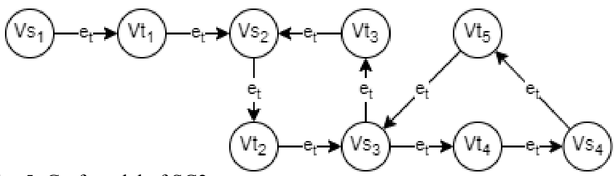

Fig. 5. Graf model of SC2.

Furthermore, the cost of each node is calculated, and the results are entered into the cost C matrix. After obtaining all the cost values, a cost C matrix is produced as follows.

$$C = \left[\begin{array}{ccccccccc|ccccccccc}
0 & 0 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & 2 & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty \\
0 & 0 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & \infty & 2 & \infty & \infty & \infty & \infty & \infty & \infty & \infty \\
1 & 1 & 0 & 1 & 2 & 2 & 2 & 2 & 2 & \infty & \infty & 3 & \infty & \infty & \infty & \infty & \infty & \infty \\
0 & 0 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & \infty & \infty & \infty & 2 & \infty & \infty & \infty & \infty & \infty \\
1 & 1 & 2 & 1 & 0 & 0 & 0 & 0 & 0 & \infty & \infty & \infty & \infty & 2 & \infty & \infty & \infty & \infty \\
1 & 1 & 2 & 1 & 0 & 0 & 0 & 0 & 0 & \infty & \infty & \infty & \infty & \infty & 2 & \infty & \infty & \infty \\
1 & 1 & 2 & 1 & 0 & 0 & 0 & 0 & 0 & \infty & \infty & \infty & \infty & \infty & \infty & 2 & \infty & \infty \\
1 & 1 & 2 & 1 & 0 & 0 & 0 & 0 & 0 & \infty & \infty & \infty & \infty & \infty & \infty & \infty & 2 & \infty \\
1 & 1 & 2 & 1 & 0 & 0 & 0 & 0 & 0 & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & 2 \\
2 & \infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\infty & 2 & \infty & \infty & \infty & \infty & \infty & \infty & \infty & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\infty & \infty & 3 & \infty & \infty & \infty & \infty & \infty & \infty & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\infty & \infty & \infty & 2 & \infty & \infty & \infty & \infty & \infty & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\infty & \infty & \infty & \infty & 2 & \infty & \infty & \infty & \infty & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\infty & \infty & \infty & \infty & \infty & 2 & \infty & \infty & \infty & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\infty & \infty & \infty & \infty & \infty & \infty & 2 & \infty & \infty & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\infty & \infty & \infty & \infty & \infty & \infty & \infty & 2 & \infty & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\infty & \infty & \infty & \infty & \infty & \infty & \infty & \infty & 2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{array}\right]$$

The minimum permutation obtained from the greedy algorithm is 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18 with the total cost is 0. Cost The GED needed to convert graph 1 to graph 2 is 0, so it can be concluded that the similarity of inter-structures between graph 1 and graph 2 is 1.

2) *Measurement of State chart Diagram Intra-structure Similarity* The first step carried out to measure the intra-structure similarity of a State chart diagram is to model each state and transition of a State chart diagram in the form of a graph. Graph representation of the SC1 diagram can be seen in Fig. 6. and graph representation of the SC2 diagram can be seen in Fig. 7.

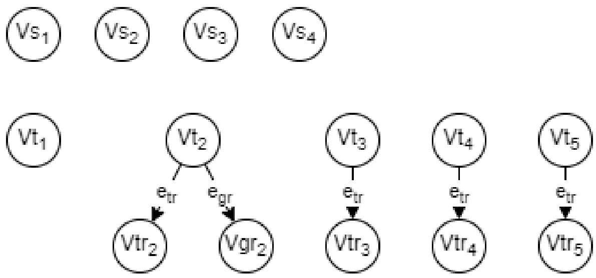

Fig. 6. Inter-structure graf model of SC1.

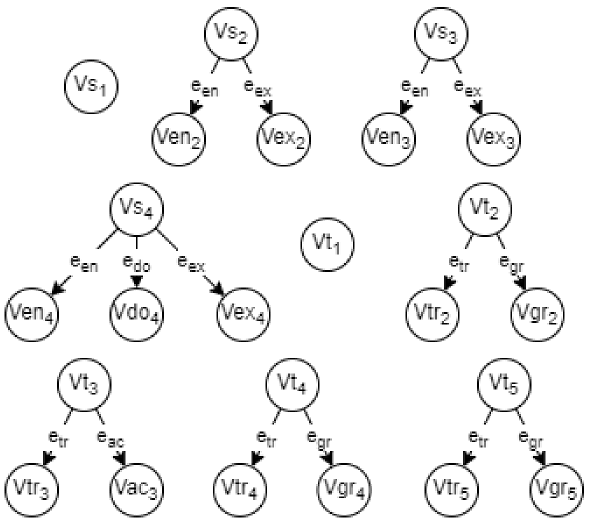

Fig. 7. Intra-structure graf model of SC2.

Graph 1 has 4 state vertices and 5 transition vertices, graph 2 has 4 state vertices and 5 transition vertices, because the state and transition from graph 1 to graph 2 are installed there will be 16 state pairs and 25 transition pairs that need to be calculated using the GED-greedy method. Calculations are carried out as in inter-structures, but in intra-structure calculations are performed in each state and transition pair. Obtained the cost matrix S:

$$S = \begin{bmatrix} 0 & 5 & 5 & 7 \\ 0 & 5 & 5 & 7 \\ 0 & 5 & 5 & 7 \\ 0 & 5 & 5 & 7 \end{bmatrix} \quad (9)$$

After permutation greedy is obtained is 4,3,2,1 with a total cost of 17, so the GED cost obtained is 17. The smaller the cost obtained, the greater the similarity value obtained. The state similarity ($stSim(d_1, d_2)$) value obtained is 0.47 by following Equation (3).

Obtained the cost matrix T:

$$T = \begin{bmatrix} 0 & 5 & 5 & 5 & 5 \\ 5 & 1 & 1 & 0 & 0 \\ 2 & 2 & 2 & 2 & 2 \\ 2 & 2 & 2 & 2 & 2 \\ 2 & 2 & 2 & 2 & 2 \end{bmatrix} \quad (10)$$

After the permutation greedy is obtained is 1,4,2,3,5 with a total cost of 6, so the GED cost obtained is 6. The state similarity ($trSim(d_1, d_2)$) value obtained is 0.85 by following Equation (4). State similarity value and transition similarity value then used to calculate intra-structure similarity value according to Equation (2). The results of intra-structural similarity measurements obtained by assuming state similarity weights (w_{st}) and transition similarity weights (w_{tr}) are assumed to be the same so that each has a value of 0.5. By using a state similarity value of 0.47 and a transition similarity value of 0.85, the intra-structure similarity value obtained using existing values is 0.66.

The results of structural similarity measurements obtained by assuming the inter-structural similarity weights (w_{inter}) and the intra-structural similarity weights (w_{intra}) are the same so that each has a value of 0.5. If the inter-structural similarity value is 1 and the intra-structural similarity value is 0.66, the structural similarity value obtained is 0.83.

V. Conclusion

The graph model can represent the structural aspects of the State chart diagram and can be used as input to measure the structural similarity of the State chart diagram. Measurement of the structural similarity of the diagram by dividing it into two aspects, inter-structure and intra-structure can be carried out. The structural similarity between the two State chart diagrams obtained is 0.83, the inter-structure similarity value obtained was 1 and the intra-structure similarity value was 0.66.

The assessment by each lecturer has different standards so that a reliable similarity measurement result is needed with the similarity measurement result by the teacher (expert). In the future, further research is needed so that the measurement results by the method have reliability with the measurement results by experts.

Acknowledgment

This research was funded by the Ministry of Research and Technology/National Research and Innovation Agency of the Republic of Indonesia. This research is a collaboration amongst Institut Teknologi Sepuluh Nopember, Politeknik Negeri Banjarmasin, and ITB STIKOM Bali.

References

[1] D. R. Garrison, “E-learning in The 21st Century: A Framework for Research and Practice, ” Taylor & Francis, 2011.

[2] C. N. Qamari and M. R. Ridwan, “Implementation of android-based augmented reality as learning and teaching media of dicotyledonous plants learning materials in biology subject,” in 2017 3rd International Conference on Science in Information Technology (ICSITech), 2017, pp. 441–446.

[3] M. A. Hussein, H. Hassan, and M. Nassef, “Automated language essay scoring systems: A literature review,” PeerJ Comput. Sci., vol. 5, p. e208, 2019.

[4] T. Isaacs, C. Zara, G. Herbert, and S. Coombs, “Key Concepts in Educational Assessment,” London: Thousand Oaks: Sage Publications Ltd, 2013.

[5] B. Cope and M. Kalantzis, “E-learning Ecologies: Principles for New Learning and Assessment,” Taylor & Francis, 2017.

[6] H. Zhang and D. Litman, “Co-attention based neural network for source-dependent essay scoring,” arXiv Prepr. arXiv1908.01993, 2019.

[7] S. J. Haberman, “Use of e-rater in scoring of the TOEFL iBT writing test,” ETS Res. Rep. Ser., vol. 2011, no. 2, pp. i--13, 2011.

[8] S. Valenti, F. Neri, and A. Cucchiarelli, “An overview of current research on automated essay grading,” J. Inf. Technol. Educ. Res., vol. 2, pp. 319–330, 2017, doi: 10.28945/331.

[9] R. Fauzan, D. Siahaan, S. Rochimah, and E. Triandini, “Class diagram similarity measurement: A different approach,” in 2018 3rd International Conference on Information Technology, Information System and Electrical Engineering (ICITISEE), 2018, pp. 215–219.

[10] E. Triandini, R. Fauzan, D. O. Siahaan, and S. Rochimah, “Sequence diagram similarity measurement: A different approach,” in 2019 16th International Joint Conference on Computer Science and Software Engineering (JCSSE), 2019, pp. 348–351.

[11] R. Fauzan, D. Siahaan, S. Rochimah, and E. Triandini, “Use case diagram similarity measurement: A new approach,” in 2019 12th International Conference on Information & Communication Technology and System (ICTS), 2019, pp. 3–7.

[12] A. Adamu and W. M. N. W. Zainon, “Matching and retrieval of state machine diagrams from software repositories using Cuckoo Search Algorithm,” in 2017 8th International Conference on Information Technology (ICIT), 2017, pp. 187–192.

[13] Z. Yuan, L. Yan, and Z. Ma, “Structural similarity measure between UML class diagrams based on UCG,” Requir. Eng., 2019, DOI: https://doi.org/10.1007/s00766-019-00317-w.

[14] T. Weilkiens, “Systems Engineering with SysML/UML: Modeling, Analysis, Design,” Elsevier, 2011.

[15] J. Dick, E. Hull, and K. Jackson, “Requirements Engineering,” Springer, 2017.

[16] M. Debbabi, F. Hassaine, Y. Jarraya, A. Soeanu, and L. Alawneh, “Verification and Validation in Systems Engineering: Assessing UML/SysML Design Models,” Springer Science & Business Media, 2010.

[17] M. A.-R. Al-Khiaty and M. Ahmed, “Similarity assessment of UML class diagrams using a greedy algorithm,” in 2014 International Computer Science and Engineering Conference (ICSEC), 2014, pp. 228–233.