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Fast Building Identification Using Fuzzy Soft Set Based on Rapid Visual Building (RVS)

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Abstract

Building damage can be caused by disasters such as earthquakes, landslides, etc. To minimize the fatality, the identification of buildings is needed to know the condition of buildings and whether the construction of buildings is able to endure if the disasters happen. This research uses the Rapid Visual Building (RVS) method to identify the building condition. The data are collected from Kalirejo, Kulon Progo. The survey is conducted by taking a simple building evaluation form (typical of the walls) based on RVS data. The field assessment results are distinguished into several factors that affect the condition of typical building walls: the foundations, structures, walls, and roofs of the 11 categories on the assessment form. From the data obtained, it is used to classify the building condition using Fuzzy Soft Set. The results show that the classification has been made with good performance in terms of accuracy, precision and time response. The accuracy and recall are close to 100% with above 50% of prevision average and time response is quite 0.0051 second. Thus, it can be used to predict the condition of buildings accurately.

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INTRODUCTION

Landslides are natural disasters that can change the land order and cause significant economic losses, so it is necessary to process disaster mitigation (Uhlemann et al., 2015). Landslide mitigation efforts can be made by knowing the subsurface structure of landslide-prone areas (Coccia et al., 2010; Piegari et al., 2009; Nasharuddin, 2018; Uhlemann et al., 2015) and knowing the condition of buildings above landslide-prone areas with Rapid Visual Screening (RVS) or building assessment through direct observation.

Rapid Visual Screening (RVS) in buildings is an assessment process of areas vulnerable to earth-quakes by defining safety conditions through direct (Demartinos & Dritsos, 2006). Rapid Visual Screening (RVS) is formulated by FEMA 154 in earthquake-prone areas (Ningthoujam & Nanda, 2018). This method provides information about the characteristics of building structures evaluated with a score so that there is a classification of possible damage in the event of an earthquake (Demartinos & Dritsos, 2006).

Building assessment can be done in two ways: direct observation assessment or often called Rapid Visual Screening (RVS), and structural assessment that is assessing in terms of strength in the building in detail. Assessment of buildings is also still a lot of consequences of earthquake disasters. There has not been a special assessment for landslide disasters, so in this study, the observation assessment form directly uses the Simple Building Evaluation form (typical of walls) (Harirchian et al., 2020).

Identification using RVS is needed for lay people whose home position is in landslide or disaster prone areas. Knowing the house is occupied in a good position in construction allows the homeowner to act on what should be done (Bektaş, N and Brassai, O, K., 2022). The lay people do not yet know how to assess a building, the easiest way to use Rapid Visual Screening (RVS) on a simple building typical of this wall because it only sees from the visual construction that the building has. Predictions are made to facilitate in analyzing, so that decision makers that can be done by homeowners or the government become faster and can be done in other regions accurately (Kumari et al., 2022).

One of the functions of Rapid Visual Screening (RVS) in this simple building typical of this wall to evaluate the mitigation of earthquake disaster structures, evaluation of earthquake disaster mitigation structures on Doom Island is intended to observe directly whether the houses of residents have met the provisions for earthquake resistant houses (Bawoleh et al., 2019). From this evaluation it can be known that almost all buildings on Doom Island have not met the requirements specified in the technical requirements of earthquake-resistant buildings, so in the event of a disaster the possibility of damage to the building becomes greater (Sari, 2020).

From the explanation above, one of the mitigations of pre-disaster is to conduct a simple building assessment, so it takes a classification of simple buildings typical of wall in kalirejo area, Kokap subdistrict, Kulon Progo, Yogyakarta regency using fuzzy logic. Before classifying buildings need to be assessed buildings using a simple building evaluation form (typical wall), adopted from FEMA that has been modified by Satyarno, I (2011) in which has been adapted to the condition of buildings in Indonesia (Bawoleh et al., 2019).

This simple building evaluation form (typical wall) has 11 minimum categories of buildings that must be present in the structure building. Classification of building safety using weights. The answer to the question on the Simple Building Evaluation form (Typical Wall) is yes and no. Classifying by multiplying the weight of the on the number of yes and no answers. The results of precision building classification are expected with the aim to provide minimal disaster impact. Precise reclassification can be done with fuzzy logic models (Zedadra et al., 2019; Demartinos & Dritsos, 2006).

The classification of simple buildings will be grouped into 3 zone sections according to the scale of the index of building conditions from bad, medium and very good. Building predictions using fuzzy are done so that what has been done in the field is strengthened by fuzzy analysis and improved accuracy.

METHOD

The method carried out in this study was to survey the field, taking simple building objects typical of the walls of the kalirejo Kulon Progo area. The survey assessed buildings located in Kalirejo, Kokap District, Kulon Progo, Regency of Yogyakarta by using a simple building evaluation form (typical of walls). The field assessment results are distinguished into several factors that affect the condition of typical building walls: the foundations, structures, walls, and roofs of the 11 categories on the assessment form.

Identification of Existing Buildings

Location observations are carried out to assess the building following a simple building evaluation form (typical of walls). Surveyors will come to the house in the Kalirejo area and ask whether the building is following the requested form. Buildings that corre-spond to the form will be in the checklist section "Yes," buildings that do not exist according to the dining form will be on the checklist "No" and existing buildings according to the form, but different sizes or forms of eating will be on the checklist "Yes" but with a note. Once the assessment is done, 11 cate-gories are on the form will be divided into 4 to be analyzed using fuzzy logic. The four factors are foundation, structure, walls, and roof. To get the results of building conditions in the form of safe, less safe, and unsafe, it takes four stages: the formation of the Fuzzy set, the application of implication functions, the composition of rules, and affirmations. The typical simple building assessment category is done based on the existing form, 11 categories of assessment can be seen in **Figure 1**.

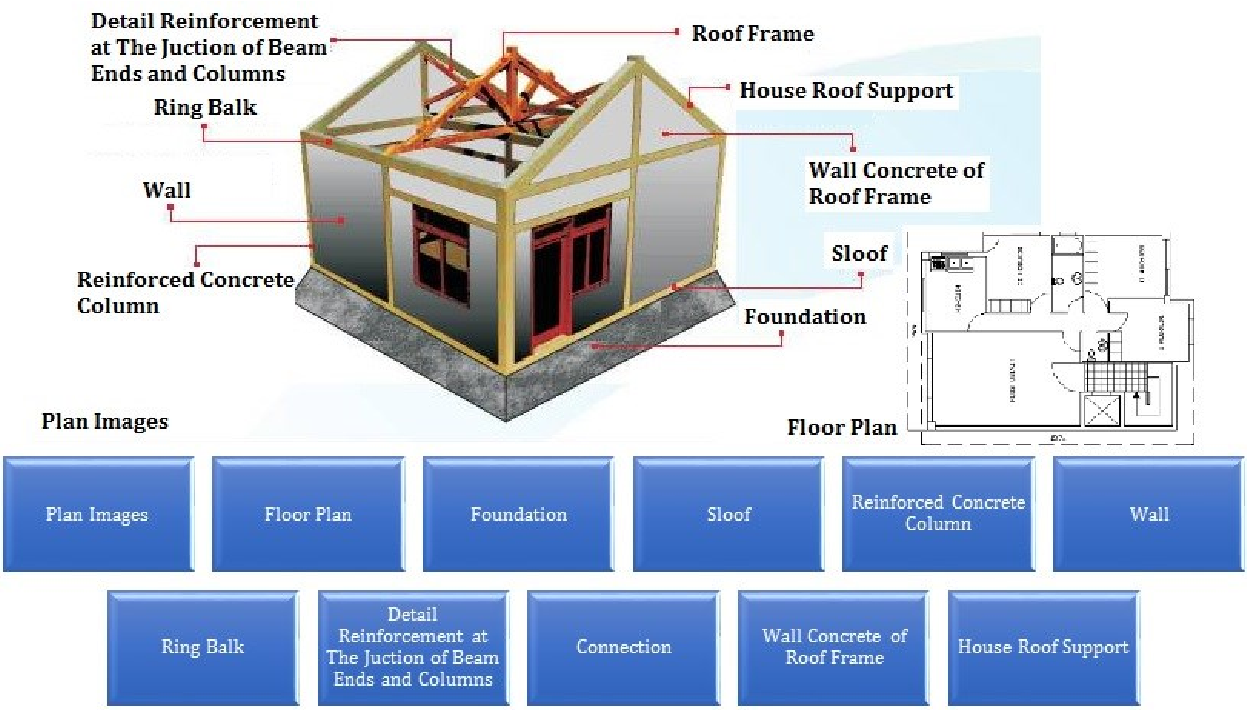

Figure 1. Categories of typical simple building assessment

Data Collection

This research started by conducting field surveys. Surveys were conducted to identify simple building conditions using a Rapid Visual Screening (RPS) system using a simple building evaluation form (typical of walls). The survey is planned to be con-ducted four times in the village papak kalirejo District Kokap Kulon Progo Yogyakarta. From the field survey, 144 simple buildings were assessed in 3 hamlets, namely 51 buildings in sangon I hamlet, 51 buildings in kalibuko I and II hamlets and 42 buildings in papak hamlet. The research area carried out continued the previous (Prastowo et al., 2018). The surveyor team coordinated to determine the building's survey point in the value to match the potential soil break map in the previous research.

The building's assessment using a simple building evaluation form (typical wall) (Satyarno, 2011) carried out at an agreed coordination point—the simple building evaluation form (typical wall), di-vided into 11 assessment categories. The categories are 40 questions that must be filled out by the field survey team following the existing state of the existing building.

An example of filling out a simple building evaluation form (typical of walls) is to check the YES column if the building has the question performed, check the column NO if the building does not have the requested part formulated, and fill in the LESS section if the building has the requested part but does not meet the specifications written on the form. The field survey team must see the condition of the building directly by asking the homeowner for per-mission by filling in the owner's bio and information about the building; this filling can be done by directly interviewing the owner of the building and conducting Rapid Visual Screening (RVS) directly with the guidelines of the simple building evaluation form (typical of the wall).

Simple Building Condition Analysis

The field survey team collected rapid screening visual assessment (RVS) of simple buildings (typical of walls). The results of the assessment will be analyzed following the assessment of existing buildings. A simple building evaluation form (typical wall) that has been filled in according to the building's condition becomes the basis of analyzing the condition of the simple building.

They analyzed a simple building (typical wall) by giving a value of 1 for a YES answer. Giving a value of 0 for a NO answer and giving a value of 0.5 for a LESS answer. All answers to the 40 questions will be suited to get the amount of value. The number of values divided by 40 and then used as a percentage by multiplying 100% then obtained the building's score. To get a Building Score can be seen from formula one below.

$$Building\ Score\ =\ (total\ value)/40\ x\ 100\% \qquad (1)$$

The score of the building is divided into three classifications, namely safe buildings with a percentage of 70-100% with green markings, buildings less safe with a percentage of 40-69% with yellow markings, and unsafe buildings with a percentage of 0-39% with red markings. Classification of building conditions is taken from the condition index scale, divided into three (Bintarto, 2007) The condition index scale can be seen in **Table 1**.

Table 1. Condition Index Scale

Zone	Condition Index	Condition Description	Handling Action
1	85 – 100	Very Good (No visible damage	Immediate action still not needed
	70 - 84	Good (Only minor deterioration or damage)	
2	55 - 69	Moderate (Deterioration or damage is starting to occur but does not affect the overall function of the building structure	It is necessary to make an economic analysis of alternative improvements to determine the appropriate/appropriate action
	40 - 54	Adequate (Deterioration or damage occurred but the building is still quite functional	
3	25 – 39	Bad (There is a critical enough damage, so the function of the building is disrupted)	Detailed evaluation is needed to determine repair, rehabilitation, reconstruction actions and evaluation is needed for safety
	10 – 24	Very Bad (Severe damage and barely functional building)	
	0 - 9	Collapse (The main component of the building is damaged)	

(**Source :** The concept of this study)

Classification Based on Soft Set Theory

The software classifier learns by calculating each parameter's average value (attribute or feature) or instants with the same class label to build a soft set model with a universe consisting of all classes (Mushrif, M, M et al., 2006). This algorithm is divided into two stages, namely the training stage and the classification stage.

However, high complexity is still a significant issue in the classification stage. Fuzzy Soft Set Classifier (FSSC) is an algorithm to classify numerical data, a modification of the SSC (Handaga, B et al., 2012) to classify the features of general numeric data, it replaces the second stage at the training stage and the SSC classification by taking a fuzzy number so that all parameters have a value in the interval [0.1]. The complete algorithm is as follows Algorithm and Fuzzy Soft Set Classifier (FSSC).

Pre-processing stage

Fuzzification feature to get vector E_wi feature, amounting to i=1.2,...,N for all data, dataset training, and testing. The training phase as follows :

1. Given the example, N obtained from w class data.
2. Calculate vector cluster E_w with the equation below.

$$E_w = \frac{1}{N}\sum_{i=1}^{N} E\_wi \qquad (2)$$

3. Obtain a fuzzy soft set model for the ww class, where (F_w, E) (F_w, E), is the central vector cluster for the ww class with the D D feature.
4. Repeat steps (1), (2), and (3) for all classes.

While the classification phase as follows :
1. Get unknown class data
2. Obtain a fuzzy soft set model for unknown class data,
3. Calculate the equation between and for each w using the equation below.

$$S(F_\rho, G_\delta) = M_i\,(F, G) = 1 - \frac{\sum_{j=1}^{n}|F_{ij} - G_{ij}|}{\sum_{j=1}^{n}|F_{ij} + G_{ij}|} \quad (3)$$

4. Assign unknown data to class w if the similarity reaches the maximum

$$w = arg[max_{w=1}^{w}\, S(G, F_w)] \quad (4)$$

RESULTS AND DISCUSSION

The assessment of simple buildings will result in buildings' classification as safe, less safe, and unsafe buildings. This research proposes a simple building classification (typical wall) based on fuzzy based on rapid visual screening (RVS) building assessment using a simple building evaluation form (typical wall). In this study, the fuzzy soft set method is used to predict building classification accurately.

Results of Simple Building Assessment Analysis (Typical Wall)

From the results of the coordinate point, the per-centage of building conditions and categories of building conditions Papak Village Kalirejo District Kokap Kulon Progo district obtained the percentage of buildings in the safe category there are 25 build-ings or 59.52%, building categories are less safe there are 13 buildings or 30.95% and buildings with unsafe categories there are four buildings from 42 buildings Papak Village Kalirejo District Kokap Kulon Progo district surveyed then obtained a percentage is 9.52%. So there are about 9.52% of the buildings of Dusun Papak Desa Kalirejo District Kokap Kulon Progo Regency that must be considered because in conditions of the resilience of buildings are lacking and are in landslide-prone areas. Furthermore, the condition of existing buildings will be analyzed using the fuzzy soft set method to strengthen building classification determination accuracy. The results of the Analysis of Simple Building Assessment (Typical Tembokan) Of Village Papak Kalirejo District Kokap, Kulon Progo can be seen in **Table 2**.

Table 2. Results of Analysis of Simple Building Assessment (Typical Tembokan) Hamlet Papak Kalirejo Village Kokap District, Kulon Progo.

Point	Coordinate		Aspect of Building structure assessment											Percentation of building condition (%)	building condition
	Northing	Easting	A	B	C	D	E	F	G	H	I	J	K		
B2-01	9134314	398277	1	0,5	0,6	0,75	0,9	0,833	0,7	1	1	0,333	0,3	65	less safe
B6-01	9133724	398185	0	0,5	0,8	0,75	0,7	0,833	0,8	1	1	0,167	0	56,25	less safe
B6-02	9133651	398060	0	0,5	0,8	0,667	1	0,833	1	1	0	0,667	0	67,5	less safe
B6-03	9133562	398275	1	1	1	1	1	1	1	1	1	1	0	85	safe
B6-04	9133456	397799	0	1	1	1	1	0,833	1	0	0	1	1	95	safe
B6-05	9133431	397939	1	1	0,8	1	1	1	1	0	1	0,833	0	85	safe
B6-06	9133426	397935	1	1	1	1	1	1	1	0	1	1	0	87,5	safe
B6-07	9133383	397790	0	0,5	0,3	0,667	0,8	0,833	0,8	0	0	0,833	0	75	safe

B6-08	9133381	397790	0	0,5	1	0,667	0,8	0,667	0,8	1	0	0,667	0	77,5	safe
B6-09	9133674	398174	0	0,5	0,9	0,75	0,8	0,833	0,8	1	1	0,833	0	68,75	less safe
B6-10	9133732	398218	1	1	0,6	0,5	1	1	1	0	0	0,583	0	66,25	less safe
B6-11	9133594	398022	1	1	1	1	1	1	0,8	0	0	0,5	0,4	80	safe
B6-12	9133483	398023	0	0,5	0,6	0,667	0,8	1	0,8	0	1	0,667	0,4	65	less safe
B6-13	9133410	397585	0	0,5	1	1	1	1	1	1	1	0,667	0	77,5	safe
B6-14	9133365	397762	0	0,5	1	1	1	1	1	1	1	0,833	0,6	90	safe
B6-15	9133439	397777	0	0,5	1	1	1	1	1	1	1	0,667	0,4	85	safe
B6-16	9133437	397787	0	0,5	1	1	1	1	0,8	1	1	0,833	0,4	82,5	safe
B6-17	9133446	397806	0	0,5	0,8	0,833	0,8	1	0,8	1	1	0,667	0,4	72,5	safe
B11-01	9133094	397353	0	1	1	0,75	0,7	1	0,8	1	0,5	0,833	0	72,5	safe
B11-02	9133104	397256	0	1	1	0,667	0,8	1	0,8	0	0	0,667	0	65	less safe
B11-03	9132953	397152	0	0	0,5	0,667	0,8	1	0,8	0	0	0,667	0	53,75	less safe
B11-04	9132877	397055	0	0,5	1	0,167	1	1	1	0	1	1	0	67,5	less safe
B11-05	9132857	397038	0	0,5	0,7	0,833	0,7	0,833	0,7	1	0	0,833	0	65	less safe
B11-06	9132751	397092	0	0,5	0,9	0,583	0,7	0	0,7	0	0	0,833	0	62,5	less safe
B11-07	9132551	396779	0	1	0,4	0,667	0,7	0,5	0,7	0	0	0,667	0	57,5	less safe
B11-08	9132554	396850	1	0,5	0,8	0,75	0,7	1	0,7	1	1	0,667	0	66,25	less safe
B11-09	9132522	396765	0	1	1	0,5	0,8	1	0,8	0	0	0,167	1	75	safe
B11-10	9132539	396845	0	0	0	0	1	0	1	0	0	0,833	0	37,5	not safe
B11-11	9133182	397473	0	0,5	0,4	0,333	0,4	0,667	0,4	0	1	0,167	0,4	37,5	not safe
B11-12	9133154	397394	0	0,5	1	1	1	1	1	1	1	0	0,4	75	safe
B11-13	9133149	397341	0	0,5	0	0	0	0	0	0	1	0,833	0,4	22,5	not safe
B11-14	9133150	397343	0	0,5	0	0	0,2	0,667	0,2	0	0	0	0	12,5	not safe
B11-15	9133120	397321	0	0,5	1	1	1	1	1	1	1	0,833	0,2	82,5	safe
B11-16	9133111	397299	0	0,5	0,8	0,917	0,9	1	0,9	1	1	0,833	0,4	78,75	safe
B11-17	9132953	397112	0	0,5	0,9	1	1	1	1	1	1	0,833	0,6	86,25	safe
B11-18	9132827	397007	0	0,5	1	1	1	1	1	1	1	0,833	0,4	85	safe
B11-19	9132736	397070	0	0,5	0,8	1	1	1	1	1	1	0,833	0,4	82,5	safe
B11-20	9132673	396913	0	0	1	1	1	1	1	1	1	0,667	0,4	80	safe
B11-21	9132593	396865	0	0,5	1	1	1	1	1	1	1	0,917	0,4	83,75	safe
B11-22	9132538	396852	1	0,5	1	1	1	1	1	1	1	0,833	0,8	92,5	safe
B11-23	9132539	396851	0	0,5	1	1	1	1	1	1	1	0,833	0,2	82,5	safe
B11-24	9132530	396786	0	0,5	0,8	1	0,9	1	0,9	1	1	0,667	0,2	85	safe

***information :**

A	: Plan Images	**E**	: Reinforce Concrete Column	**I**	: Connection
B	: Floor Plan	**F**	: Wall	**J**	: House Roof Support
C	: Foundation	**G**	: Ring Balk	**K**	: Wall Concrete of Roof Frame
D	: Sloof	**H**	: Detail Reinforcement at the Juction of Beam Ends and Columns		

(**Source :** Data of this study)

Simple Building Classification (Typical Wall)

Simple building assessment of typical walls can evaluate the performance of this classification al-gorithm. The building's assessment is divided into 11 kinds of assessment activities: drawing plans, floor plans, foundations, sloof, columns, walls, ring balk, meeting joints of columns and beams, joints, and mountains (of concrete), and horses. This building's assessment data was obtained from The Village Papak Kalirejo District Kokap Kulon Progo Regency Yogyakarta.

This study aims to classify the condition of simple buildings (typical walls) in landslide-prone are-as/ground movements. Classification of building conditions obtained three criteria: safe buildings, less safe buildings, and unsafe buildings. An example of the classification of simple building conditions (typical of walls) is shown in **Table 3**.

Table 3. classification of simple building conditions (typical of walls)

Building point coordinates	Assessment of simple building components (typical of walls)											Percentage of Building Condition (%)	Building Condition
	A	B	C	D	E	F	G	H	I	J	K		
	Plan Images	Floor Plan	Foundation	Sloof	Column	Wall	Ring Balk	Detail reinforcement at the juction of beam ends and columns	Connection	Wall concrete of roof frame	House roof support		
B6-03	1	1	1	1	1	1	1	1	1	1	0	85	Safe
B6-02	0	0.500	0.800	0.667	1	0.833	1	1	0	0.667	0	67.5	Less Safe
B11-10	0	0	0	0	1	0	1	0	0	0.833	0	37.5	Not safe

(**Source :** Data of this study)

Fuzzification can be done by dividing each attribute value by the most considerable value of each attrib-ute. After that, the dataset is broken down into two datasets, one is used for training, and the other is used for testing. Dataset splitting is done randomly in each experiment. The experiment was conducted seven times, with 7 percent different training and testing datasets for each experiment. Comparison of dataset composition of training and testing are as follows, 60% training and 40% testing, 65% training and 35% testing, 70% training and 30% testing, 75% training and 25% testing, 80% training and 20% testing, 85% training and 15% testing and 90% training and 10% testing.

To test the proposed algorithm, the experiment was developed using MATLAB version 7.14.0.334 (R2012a). Experiments were conducted on the Fuzzy Soft Set Classifier algorithm (Handaga et al., 2012; Palupi et al., 2021), which focuses on calculating accu-racy, precision, recall, specificity, and MEAN_TIME. Accuracy is calculated using total Overall Classifier Accuracy (OCA) and F measures (micro average and macro mean). The experiment results are summarized in **Table 4**, the results showed that the classification of fuzzy software for simple building conditions (typical of walls) has good per-formance. It can be seen that this technique has a good value if the average precision value is above 0.5; the average accuracy and recall is 1.

Tabel 4. Fuzzy Soft Set method classification experiment results

Training (%)	Testing (%)	Accuracy	Precision	Recall	Times response
60	40	1	0.7689	1	0.0051
65	35	0.9900	0.7786	0.8833	0.0022
70	30	0.9900	0.8412	0.9250	0.0021
75	25	1	0.7583	0.8500	0.0021
80	20	1	0.8033	0.9500	0.0022
85	15	1	0.8250	0.8000	0.0017
90	10	1	0.8250	0.9000	0.0026
Average		**1**	**0.7689**	**1**	**0.0051**

(**Source :** Data of this study)

Moreover, the response time is quite 0.0051 seconds. So the prediction of simple building classification (typical wall) that has been analyzed before proves the results of these predictions are more accurate with the addition of calculation of this fuzzy soft set method. The calculation of classification of similar simple building conditions can be used to predict the condition of buildings accurately.

CONCLUSION

This paper presents the use of a Fuzzy Soft Set Classifier (FSSC) to classify simple buildings (typical walls) based on the potential of ground movement. The assessment is obtained from the survey results using a simple building evaluation form (typical wall). The experiment was conducted seven times, with 7 percent different training and testing datasets for each experiment. The results showed that the Fuzzy Soft Set Classifier could predict simple buildings' classification (typical walls) more accurately based on precision, recall, and response time. The results showed that the Fuzzy Soft Set Classifier could predict simple buildings' classification (typical walls) more accurately based on precision, recall, and response time. It can be seen that this technique has a good value if the average precision value is above 0.5 the average accuracy and recall is 1.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest concerning the publication of this article. The authors also confirm that the data and the article are free of plagiarism.

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