Halimah Badioze Zaman · Peter Robinson · Alan F. Smeaton · Renato Lima De Oliveira · Bo Nørregaard Jørgensen · Timothy K. Shih · Rabiah Abdul Kadir · Ummul Hanan Mohamad · Mohammad Nazir Ahmad (Eds.)

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Selangor, Malaysia, November 15–17, 2023
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Preface

The International Visual Informatics Conference (IVIC) 2023 once again brought together experts from academia and industries in a multidisciplinary field that encompasses Computer Science, Information and Communications Technology and Computing Engineering. The conference took place amidst tremendous challenges of the post-COVID-19 pandemic, Energy Transition, Climate Change, Digital Transformation, Wars, Security, low education standards, unemployment and corruption. Despite these challenges, nations are braving it through and embracing opportunities that come their way. Emphasizing its multidisciplinary nature, this time the conference returned to its original home, Universiti Kebangsaan Malaysia (UKM) and was hosted once again by the Institute of Visual Informatics (IVI). Together with other institutional partners of this conference, research findings in various specialized areas of Visual Informatics integrated into various fundamental domains were shared together at this conference. We have seen the areas of Visual Informatics grow since the conference first began in 2009. We are grateful to all our partners, locally and internationally, for making this 8th IVIC a specially exciting and meaningful one.

The Eighth International Visual Informatics Conference (IVIC 2023) was conducted for the first time face-to-face after more than three years of not being able to have physical meetings but only virtual ones. For the first time after a long time too, participants could meet co-researchers from different institutions and different countries; and interact with potential partners from different institutions and industries physically. Participants were also able to appreciate exhibitions and discuss with the respective researchers the works exhibited to get first-hand explanations on matters that they did not understand or were concerned about. Like the previous conferences, the main objective of this conference was to bring together experts and researchers from academia and industry to discuss and share new knowledge, ideas and innovations through internationalization and industrialization. Like the previous IVIC conferences, this conference was organized collaboratively by the Visual Informatics fraternity from various public and private universities, professional institutions and industry players from various parts of the world (their names are listed in the proceedings). The conference was co-sponsored by the Malaysian Information Technology Society (MITS), Malaysia Chapter MyAIS, Institute of Informatics and Computing for Energy (IICE), UNITEN, ARB Berhad and MatrixStreams Sdn. Bhd. The conference was co-chaired by six (6) Professors from Cambridge University, MIT Sloan Management School/ABS, Dublin City University, University of Southern Denmark, National Central University and Universiti Tenaga Malaysia (UNITEN).

The theme of the conference mentioned earlier reflects the importance of the need for organizations and nations to create innovations to achieve Energy Transition efforts and digital transformation for societal well-being. All these innovations were undertaken at a time when disruptive technologies, Climate Change, Sustainability and Generative

AI had brought about interesting emerging visual technologies such as Electric Vehicles; Autonomous and semi-autonomous vehicles, Smart Energy Efficient Chat-bots, as well as Internet of things (IoT) and Blockchain for various domains such as smart buildings, healthcare, agriculture and education. The human-centric future smart society and citizenry of the various nations required new digital innovations that were adopting advanced AI such as Generative Artificial Intelligence (GAI) and data-driven AI and secured AI; they also required digital transformation through strategic digital adoption and sustainable technologies for better technological and economic growth of their respective countries. Thus, the theme of the conference was relevant, apt and timely.

The conference focused on six (6) tracks: *Modeling & Simulation, Mixed Reality & HCI, Systems Integration & IoT, Cybersecurity, Energy Informatics* and *Intelligent Data Analytics,* which lasted for two days (15th and 16th November 2023) and ended with four (4) half-day workshops (17th November 2023) that ran concurrently online entitled: *Data Development for Information Visualisation; Designing Questionnaires for Product, Process, Organizational & Marketing Innovation; Introduction to Deep Learning;* and *Advanced Techniques in Cybersecurity- Safeguarding your Digital Assets* respectively. There were five keynote speakers and 51 paper presentations based on topics covered by the six (6) main tracks. The reviewing of the papers was conducted by experts who represented the Programme Committee locally and internationally from Asia, Europe, and Oceania. Each paper was single-blind by three reviewers and the acceptance rate was 50%. The reviewing process was managed using the system Conference Bay. The conference also included an exhibition portraying research and innovations by academia and industry.

On behalf of the organizing and program committee of IVIC 2023, we thank all authors for their submissions and camera-ready copies of papers, and all participants for their thought-provoking ideas and active participation at the conference. We also thank the Vice-Chancellor of UKM (host university), and Vice-Chancellors and Deans of all Computer Science & IT and Business faculties and Research Institutes of the IHLs and Industry for their support in organizing this conference. We also acknowledge the sponsors, members of the organizing committees, program committee members, support committees and individuals who gave their continuous help and support in making the conference a success. We believe that IVIC will grow from strength to strength and will one day be hosted by not only different institutions in Malaysia but also in different host countries around the world.

November 2023

Halimah Badioze Zaman
Peter Robinson
Alan F. Smeaton
Renato Lima De Oliveira
Bo Nørregaard Jørgensen
Timothy K. Shih
Rabiah Abdul Kadir
Ummul Hanan Mohamad
Mohammad Nazir Ahmad

Organization

The 8th International Visual Informatics Conference (IVIC 2023) was organized by the Institute of Visual Informatics, Universiti Kebangsaan Malaysia (UKM), in collaboration with local public and private Universities in Malaysia, Multimedia Development Corporation (MDEC), and ICT Cluster of the National Professors' Council (MPN).

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Contents

Mixed Reality and Human-Computer Interaction

Fuzzy Soft Set Based Classification for Rock Dataset

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Abstract. One of the main tasks in geological studies is rock classification. To examine rock samples in this classification usually requires a human expert. Thus, the igneous rocks' classification task will become challenging because of igneous rocks' diverse composition. One data mining technique based on Fuzzy soft set can be used for classification. Several similarity measures have been proposed on the fuzzy soft set. In this paper, we conduct an experiment to explore the fuzzy soft set classifier applying several measurement to calculate the similarity, i.e., generalized fuzzy soft sets, similarity based on matching function, similarity based on set theoretic approach, similarity measure based on distance. The classification of igneous rocks is carried out in this experiment based on their chemical composition and compared it in terms of accuracy, precision, and recall. According to our simulation results, the Euclidean distance still outperforms to another measure in terms of classification accuracy, precision, and recall.

Keywords: Fuzzy soft set · similarity measures · igneous rocks · chemical composition

1 Introduction

The study of igneous rocks is one of the fundamental branches of geology [1]. In geology there are three main rocks, namely sedimentary, metamorphic, and igneous rocks [2]. Formation of igneous rock from molten material through a compacted process. In its past history, all rocks on the Earth's surface should have had a freezing process, although igneous rock deposits in some areas were not abundant. Therefore, Understanding the composition of the earth's interior is very important. This can be done through the study of igneous rocks. Both within and between rock bonds, igneous rock is not homogeneous. This is possible due to differences in rock and mineral composition. The place and time at which rocks form is sometimes related to the diversity of these igneous rocks [3]. In addition, differences in the origin of rocks result in the elemental composition of igneous rocks from one place to another. The diversity of chemical and mineral compositions results in a diversity of igneous rocks. In igneous rock, chemical analysis is expressed

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as weight percent oxides (wt%) for the main elements (SiO_2, TiO_2, Al_2O_3, FeO, Fe_2O_3, MnO, MgO, CaO, Na_2O, K_2O, and P_2O_5) and parts per million (ppm) for trace element [3]. In quantitative classification, the classification of igneous rocks can be carried out on the basis of their chemical or mineralogical composition. The category of silicate or felsic rock, ultramafic rock, mafic rock, and intermediate rock is a classification of igneous rock based on its mineral composition. Meanwhile, the category of intermediate rock, acid rock, ultrabasic rock, and bare rock are classified as igneous rocks based on their chemical composition [4]. The diversity in the composition of igneous rocks presents a challenge in classifying these rocks.

Bana et al. proposed the fuzzy soft set (FSS) based on the generalized fuzzy soft set's similarity to classify the data numerically called FSSC [5]. In the pre-processing stage of the algorithm, a fuzzy approach is used to obtain the similarity of concepts and features in the classification process This process can not only be applied to binary valued datasets but can also be used to classify data consisting of real numbers. They compare the FSSC with the Soft Set Classifier on data set taken from UCI machine learning. The Algorithm is implemented for text classification and has a better performance than SVM and KNN [6]. Another fuzzy soft set has been proposed by Yanto et al. using hamming distance to measure the similarity called HDFSSC [7]. The HDFSSC technique consists of four phases: data acquisition (1st phase), feature fuzzification (2^{nd} phase), training (3^{rd} phase), and testing (4^{th} phase). The technique is evaluated by comparing with the baseline fuzzy soft set classifiers, including FSCC using the data taken from the Mammographic Image Analysis Society (MIAS) with good results.

Measurement of similarities has an essential role in the Classification using FSS [8, 9]. The similarity measure is a measure to find out how similar the two data objects are. The similarity measure in the context of data mining is the distance to dimensions that represent object features. If this distance is small, it can be interpreted that the two objects have a high degree of similarity, and if there is a considerable distance, then both objects have a low level of similarity. The similarity is subjective and is very dependent on the domain and application. There are many similarity measures of the soft set, and FSS have been studied, i.e., generalized fuzzy soft sets, similarity based on matching function, similarity based on set-theoretic approach, and similarity measure based on distance. Another distance is based on new similarity measures of FSS, where the usage of this distance measure in this research is more reasonable [10]. However, not all similarity measure has been exploration to know the performance for Classification. We conduct experiments to explore the similarity measure of generalized fuzzy soft sets, similarity based on matching function, similarity based on set-theoretic approach, and similarity measure based on distance on the rock dataset.

2 Fuzzy Soft Set (FSS)

Maji et al. define and apply the fuzzy soft set concept, hereinafter referred to as FSS in decision making problems. It is known that a convenient tool for representing concept uncertainty is provided by fuzzy sets using partial membership. In the definition of a FSS, substitute for sharp subsets uses fuzzy subsets. Thus, each soft set can be treated as a FSS [11]. In addition, on the basis of an analogy such as a soft set, it can be seen easily that each FSS can be viewed as a fuzzy information system. In such systems, data tables with entries included in the unit interval [0,1] represent the FSS. Suppose that E is the set of parameters that have relations with objects in a non-empty universe denoted by U, the set of powers of U is denoted by P(U) and A ⊆ E. Then, the parameterized family of the subset U is called the soft set [12, 13]. A soft set of U can also be interpreted as a pair of f:E → P(U) maps. The definition is based on the consideration that set of ε-approximate elements of the soft set or set ε-elements of the soft set, rather than a (crisp) set. Meanwhile, in FSS Theory, shows the power of all fuzzy subsets. Furthermore, a fuzzy soft set over is a pair, with is mapping represented by. Thus, the substitute for subset U is the fuzzy subset in universe U. Example 1 is given as an illustration.

Example 1. A description of the attractiveness of the shirt to be purchased is given against the given parameters stated in the FSS (F, E). Suppose that the set of all the shirts being considered is represented by $U = \{x_1, x_2, x_3, x_4, x_5\}$. Next, the aggregate of all fuzzy subsets of U is represented by $P(U)$ and the colorful, bright, cheap, and warm parameters are expressed in terms of the set $E = \{e_1, e_2, e_3, e_4\}$. Let

$$\underline{F}(e_1) = \{x_1/0.5, x_2/0.9, x_3/0.0, x_4/0.0, x_5/0.0\}$$

$$\underline{F}(e_2) = \{x_1/1.0, x_2/0.8, x_3/0.7, x_4/0.0, x_5/0.0\}$$

$$\underline{F}(e_3) = \{x_1/0.0, x_2/0.0, x_3/0.0, x_4/0.6, x_5/0.0\}$$

$$\underline{F}(e_4) = \{x_1/0.0, x_2/1.0, x_3/0.0, x_4/0.0, x_5/0.0\}$$

and the family $E(e_i)$ with $i = \{1, 2, 3, 4\}$ of $P(U)$. Table 1 is given as a form of FSS representation.

Table 1. FSS representation

(U, E)	e_1	e_2	e_3	e_4
x_1	0.5	1.0	0	0
x_2	0.9	0.8	0	1.0
x_3	1	0.7	0	0
x_4	1	0	0.6	0
x_5	0	0	0	0.3

3 Similarity and Distance Measure

There are several measurement models within the scope of data clustering and grouping, one of which is the similarity between the two entities [12]. Several researchers have carried similarity measurement between fuzzy number, fuzzy sets, and vague sets.

Recently we found that the similarity measure of soft set and fuzzy fine set has also been investigated [13]. In this paper, the FSS was measured based on similarity, i.e., generalized fuzzy soft sets, similarity based on matching function, similarity based on the set-theoretic approach, and Similarity measure distance. Lets $U = \{x_1, x_2, \ldots, x_n\}$ be a universe set, $E = \{e_1, e_2, \ldots, e_m\}$ be a parameter set. Assume that the fuzzy soft set (F, A) and (G, B) have the same parameter set, $A, B \subset E$. The similarity between two generalized fuzzy soft set is defined as follows

$$d_1((F, A), (G, B)) = \max_{\mathrm{i}}\left(1 - \frac{\sum_{j=1}^{n}\left|F(e_i)(x_j) - G(e_i)(x_j)\right|}{\sum_{j=1}^{n}\left|F(e_i)(x_j) + G(e_i)(x_j)\right|}\right). \tag{1}$$

The following provides a definition of similarity based on the set-theory approach presented in the formula

$$d_2((F, A), (G, B)) = \max_{\mathrm{i}}\left(\frac{\sum_{j=1}^{n}F(e_i)(x_j) \bigwedge G(e_i)(x_j)}{\sum_{j=1}^{n}F(e_i)(x_j) \vee G(e_i)(x_j)}\right). \tag{2}$$

On the basis of the set-theory approach, similarities are also defined in terms of form

$$d_3((F, A), (G, B)) = \frac{\sum_{i=1}^{n}F(e_i) \cdot G(e_i)}{\sum_{i=1}^{n}(F(e_i)^2 \vee G(e_i)^2)}. \tag{3}$$

Meanwhile,on the basis of the distance, similarity measure by Munjandar et al. can be defined as

$$d_4((F, A), (G, B)) = \min T_i((F, A), (G, B)), \tag{4}$$

where $T_i((F, A), (G, B)) = \frac{1}{1+d_\infty^i}$, d_∞^i is the distance between the e-approximations $F(e_i)$ and $G(e_i)$ which is $d_\infty^i = \max_j\left|F(e_i)(x_j) - G(e_i)(x_j)\right|$.

Another distance-based similarity measure for the fuzzy soft set is explored by Feng et al. called new similarity measures of FSS based on hamming and Euclidean distance as a distance measure. The Hamming and normalize distance in FSS are using Eqs. (5) and (6).

$$d_5((F, A), (G, B)) = \frac{1}{mn}\sum_{i=1}^{m}\sum_{j=1}^{n}|F(e_i)(x_j) - G(e_i)(x_j)| \tag{5}$$

and

$$d_6((F, A), (G, B)) = \frac{1}{mn}\left(\sum_{i=1}^{m}\sum_{j=1}^{n}\left|F(e_i)(x_j) - G(e_i)(x_j)\right|^2\right)^{\frac{1}{2}} \tag{6}$$

4 Methodology

In this research, methodology consists are data collection, observation stage and laboratories stage. Data collection and observation stage is in the form of data collection in the field, in the form of lithology selected after detailed geological mapping of the meticulous area in Yogyakarta. Data collection in the form of igneous rock retrieval for petrographic analysis and chemistry. Laboratories stage is divided into sample preparation stages, in the form of making thin incisions of rocks for the study of petrography and chemical analysis of rocks (main oxides, trace elements, and rare soil elements) with XRF (X-ray fluoresces) and ICP-OES (Inductively Coupled Plasma optical emission spectrometry) devices by PT laboratories. Main Intertek Service. Petrographic observations were made in the Hard-rock Laboratory, with the Olympus CX-31P polarizing microscope.

The steps of the classification algorithm that is learning (training) and classification step. Before the two steps are done, first applied fuzzification and formation of the FSS. This step is used to obtain the feature vector for all data, be it training and testing datasets. The set model for each class in fuzzy soft is obtained at the training step The data will be learned based on the data class group [7]. The Learning step is to determine the center of each class that exists. If data $U = \{u_1, u_2, \ldots, U_N\}$, there is C class of data with n_r; $r = 1, 2, \ldots, K$ data of each class where $\sum_{r=1}^{K} n_r = N$, and E be the set of parameters, $A \subseteq E, A\{e_i, i = 1, 2, \ldots, m\}$. Suppose F_{C_r} is the set of fuzzy soft sets of the r-th class. Then the center vector of the class is denoted as $P_{C r}$ can be defined as

$$P_{C_r} = \frac{1}{n_r} \sum\nolimits_{j=1}^{n_r} \mu_{C_r(e_i)}(u_1), \tag{7}$$

where $i = 1, 2, \ldots, m$ and $r = 1, 2, \ldots, k$.

The classification is used to label the unknown data to the target class. The new data of the training step results will be used to determine the classes in the new data measuring the similarity of two sets of fuzzy soft sets acquired in the class center vector and new data. This comparative study uses the formula for similarity measure as follows:

$$S\left(F_{P_{C_r}}, \mathrm{F}_G\right) = 1 - d_i\left(F_{P_{C_r}}, \mathrm{F}_G\right). \tag{8}$$

where d_i is the similarity and distance measure that have been discussed i.e., generalized fuzzy soft sets, similarity based on matching function, similarity based on set-theoretic approach and similarity measure based on distance, respectively.

After the value of the similarity for each class is obtained then it will look for which class label is appropriate for new data F_G by determining the maximum value of the result of measuring similarity for all classes. The class label is;

$$label_{clas} = \arg\left[\max\nolimits_{r=1}^{k} S\left(F_{P_{C_r}}, \mathrm{F}_G\right)\right]. \tag{9}$$

5 Result and Discussion

There are 11 features in this real world dataset collected from Mount Wungkal, Godean, Yogyakarta, Indonesia.namely Titanium dioxide (TiO_2), Silicon dioxide (SiO_2), Iron (II) oxide + Iron(III) oxide ($FeO + Fe_2O_3$), Aluminum oxide (Al_2O_3), Magnesium oxide

(MgO), Manganese(II) oxide (MnO), Sodium oxide (Na_2O), Calcium oxide (CaO), Phosphorus pentoxide (P_2O_5), Class Label, and Potassium oxide (K_2O). MATLAB version 7.14.0.334 (R2012a) was used to develop this experiment. Windows 10 operating system with an Intel Core i3-3217U CPU @ 1.80Ghz, and a total main memory of 8G RAM is used to run this algorithm. The dataset is divided into two sets of data used for training and testing where each experiment is carried out randomly in the process of separating the dataset. A total of 80 times were carried out in this experiment, with the percentage of training and testing being 80% and 20%, respectively. With this algorithm, the experiments conducted focus on calculation (precision, accuracy, recovery), and the experimental results are presented in Table 2. Based on Table 2 it can be seen that in igneous rock classification, fuzzy soft set has good performance.

Table 2. The experiment results

Methods	Accuracy	Precision	Recall
set theoretic approach	0.5833	0.7000	0.6000
Similarity distance	0.3667	0.4500	0.6000
Matching function	0.6000	0.5500	0.7500
Generalized fuzzy soft set	0.8000	0.8000	0.7500
Euclidean distance	0.8667	1.0000	0.8500

6 Conclusion

In this research, we conducted experiments on six different similarity-deductors to obtain the classification accuracy of the fuzzy soft set classification algorithm. In terms of which algorithm is better used to classify igneous rock based on its chemical analysis. This is done on the basis of the chemical composition of the igneous rock which is a fundamental characteristic. Furthermore, the classification will become a quantitative classification. It is clear from the simulation results that the best performance is for fuzzy classifier based on the Euclidian distance. The more generalized Euclidian distance of fuzzy soft set is one of the Future works.

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