Complexity prediction model: a model for multi-object complexity in consideration to business uncertainty problems

Rahmad B. Y. Syah, Habib Satria, Marischa Elveny, Mahyuddin K. M. Nasution
Excellent Centre of Innovations and New Science-PUIN, Faculty of Engineering, Universitas Medan Area, Medan, Indonesia
Data Science and Computational Intelligent Research Group, Medan, Indonesia

Article Info

Article history:

Received Dec 1, 2022
Revised May 28, 2023
Accepted Jun 5, 2023

Keywords:

Business metric
Hybrid model
Multi-criteria decision making
Multi-objectives genetic algorithm complexity prediction model

ABSTRACT

In a competitive environment, the ability to rapidly and successfully scale up new business models is critical. However, research shows that many new business models fail. This research looks at hybrid methods for minimizing constraints and maximizing opportunities in large data sets by examining the multivariable that arise in user behavior. E-metric data is being used as assessment material. The analytical hierarchy process (AHP) is used in the multi-criteria decision making (MCDM) approach to identify problems, compile references, evaluate alternatives, and determine the best alternative. The multi-objectives genetic algorithm (MOGA) role analyzes and predicts data. The method is being implemented to expand the information base of the strategic planning process. This research examines business sustainability along two critical dimensions. First, consider the importance of economic, environmental, and social evaluation metrics. Second, the difficulty of gathering information will be used as a predictor for making long-term business decisions. The results show that by incorporating the complexity features of input optimization, uncertainty optimization, and output value optimization, the complexity prediction model (MPK) achieves an accuracy of 89%. So that it can be used to forecast future business needs by taking into account aspects of change and adaptive behavior toward the economy, environment, and social factors.

Corresponding Author:

Rahmad B. Y. Syah
Excellent Centre of Innovations and New Science-PUIN, Faculty of Engineering, Universitas Medan Area
Medan, Indonesia
Email: rahmadsyah@uma.ac.id

1. INTRODUCTION

Increasing the productivity of business processes has become a major issue, both in academia and in business, because organizations must provide effective and efficient results [1], [2]. The impact of commercial digital business actors' characteristic patterns varies greatly and is highly competitive for users with diverse desires [3]. This is demonstrated by the continued expansion of business actors by prioritizing profit-oriented, revenue-generating activities, as well as consideration in increasing the competitiveness of the number of merchants obtained electronically, thereby providing users with a plethora of options for facilitating their transactions [4], [5].

There must be anticipation for business actors by preventing disruptions in order for the business to be sustainable, specifically by providing a significant social impact caused by business actors and users [6], [7]. The current issue is that people have a variety of digital shopping options that business actors must consider; as a result, business metrics are used in determining investment in long-term business opportunities [8], [9]. Multi criteria decision making (MCDM) is a decision making technique that chooses the best optionamong several alternatives based on specific criteria. Criteria are commonly used decision making measures, rules, or standards [10]–[12].

One of the MCDM methods is the analytical hierarchy process (AHP), which works to decompose complex multi factor or multi criteria problems into a hierarchy [13]. The first level represents the goal, and the subsequent levels represent factors, criteria, and sub criteria [14], [15]. To select individuals with the same rank, a split mechanism is used. It plans to investigate several business process model variants that will be processed using the AHP. As a basis for decision making, such as alternatives,attributes, conflicts between criteria, and decision weights [16], [17]. Multi-objectives genetic algorithm (MOGA) is a multi-objective optimization algorithm that, by allowing the user to explore different regions of the solution space, is particularly well suited to solving multi-objective optimization problems [18], [19]. As a result, a more diverse set of solutions can be sought, with more variables that can be optimized concurrently [20], [21].

2. METHOD

The first step is to collect data from e-metrics. Furthermore, the data is processed using the AHP method, namely special weighting by determining alternatives, criteria, and attributes. The examination results were re-tested for each alternative using the MOGA combinatorial algorithm approach. MOGA is used to find populations through selection, crossover, and mutation. The research steps can be seen in Figure 1.

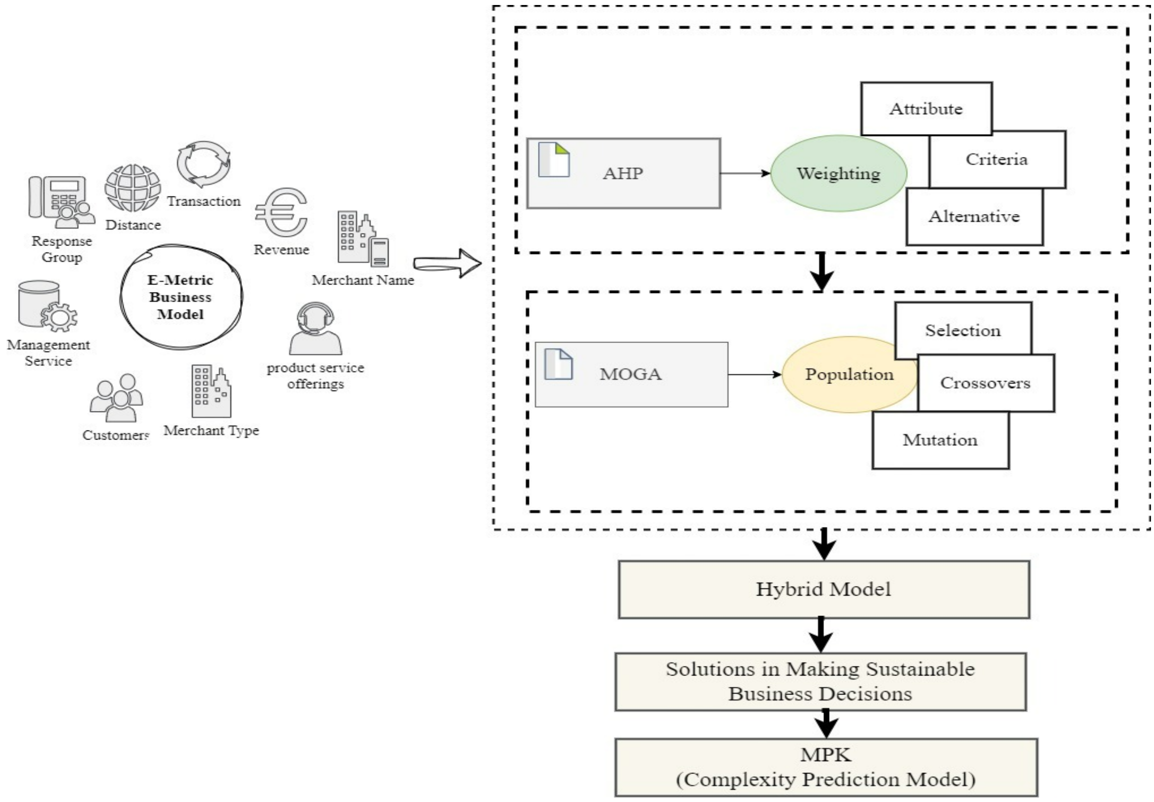


Figure 1. State of the art research

2.1. Multi-criteria decision making

MCDM is a systematic procedure for changing complex problem decisions with a predefined sequence of steps that can be followed and used to aid in rational decision making [22]: i) create a model that describes a structured system, including component relationships and interactioncriteria; ii) goals must be established; iii) develop relevant criteria for differentiating between desirable and undesirable goals; iv) construct and evaluate potential alternatives; v) experiment with various options to see if they meet your objectives; vi) consider the consequences of the alternatives; and vii) weighing and sorting alternative options based on the decision maker's preferences.

2.2. Concept analytic hierarchy process

AHP algorithms provide structured and systematic work assignments for problem solving, particularly in situations when there are several criteria and alternatives to consider. This aids in the completion of subordinate tasks, allows for the comparison of monetary factors, and provides a clear process for evaluating and prioritizing priorities. The AHP method has a hierarchical structure that divides complicated decision issues into smaller pairwise comparisons. The AHP algorithm is explained in detail in Figure 2.

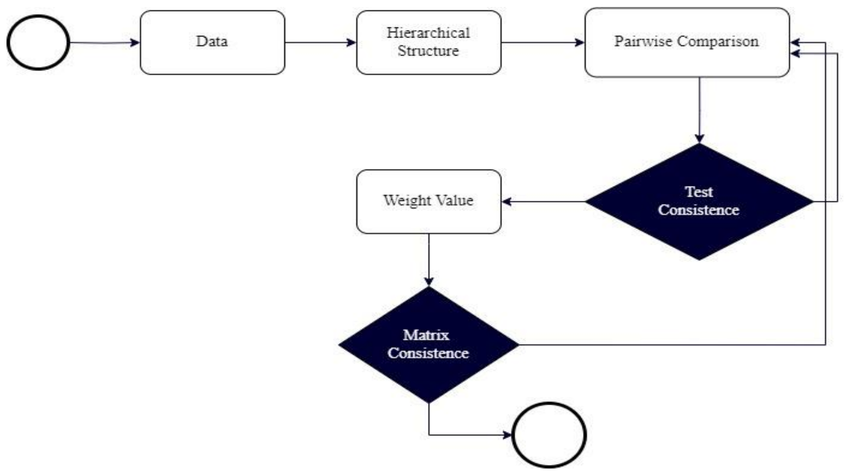


Figure 2. Hierarchy process AHP

A matrix is used to implement the AHP model [23]. For example, suppose an operating subsystem has n elements, i.e. operating elements C_1, C_2,..., C_n. The comparisons shown in the Table 1 are the resultsof pairwise comparisons of the operating elements [24], [25]. Matrix $C(n \times n)$ is a reciprocal matrix with n elements i.e., $C_1, C_2, \dots, C_n$ to be compared. As shown in (1), the results of the pairwise comparisons between (W_i, W_j) can be represented as a matrix [26]:

$$\frac{W_i}{W_j} = a, i; I, J = 1,2, \dots n \quad (1)$$

A comparison matrix with intensity values represents pairwise comparisons of items using numerical intensity values. This intensity number represents the importance or preference given to one aspect above another as in Table 2.

Table 1. Pairwise comparison matrix

	C_1	C_2	…	C_n
C_1	C_{11}	C_{12}	…	C_{1n}
C_2	C_{21}	C_{22}	…	C_{2n}
:	:	:	:	:
C_n	C_{n1}	C_{n2}	…	C_{nn}

Table 2. Comparison matrix with intensity value

	C_1	C_2	…	C_n
C_1	W_1/W_1	W_1/W_2	…	W_1/W_n
C_2	W_2/W_1	W_2/W_2	…	W_2/W_n
:	:	:	:	:
C_n	W_n/W_1	W_n/W_2	…	W_n/W_n

Once a comparison matrix containing intensity values is created, it may be used as the foundation for additional calculations such as normalization to generate priority weights for components and make educated judgments based on their relative relevance or preference. Score W_i, W_j with $i, j = 1, 2, \dots, n$ obtained from a higher value. The eigen value of *A* is *n* when this matrix is multiplied by the column vector $w = w_1, w_2, \dots, w_n$ [27].

$$\begin{bmatrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \dots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & \frac{w_2}{w_2} & \dots & \frac{w_2}{w_n} \\ \frac{w_n}{w_n} & \frac{w_n}{w_2} & \dots & \frac{w_n}{w_n} \end{bmatrix} \times \begin{bmatrix} w_1 \\ w_2 \\ \dots \\ w_n \end{bmatrix} = n \times \begin{bmatrix} w_1 \\ w_2 \\ \dots \\ w_n \end{bmatrix} \quad (2)$$

In general, the variable n in the illustration can be substituted by a vector λ in [28]:

$$C_w = \lambda_w$$

where

$$\lambda = (\lambda_1, \lambda_2, \dots, \lambda_n) \tag{3}$$

Every λ_n satisfying in (3) is referred to as an eigen value, and every vector W satisfying the above equation is referred to as an eigen vector [29], [30]. The comparison matrix is said to be consistent in this case if the consistency index (CI) value is less than. CI parameter deviation λ_{max} from n is formulated as (4):

$$CI = \frac{\lambda_{max-n}}{n-1} \tag{4}$$

2.3. Multi-objective genetic algorithm

MOGA assesses individual survival of the fittest during executive generation. Each generation is made up of a population of character strings that function similarly to chromosomes [31], [32]. In general, the purpose can be defined as (5):

$$F_{max/min} = \sum_{a-1}^{x} J_i C_i \tag{5}$$

Where $F_{max/min}$ explains why functions, input variables, model coefficients, and constant coefficients should be maximized or minimized $J_i C_i$ [33], [34].

3. RESULTS AND DISCUSSION

The first step is to create an objective hierarchy of criteria and to identify alternative criteria. The second step is to compute the criteria and compare the alternatives. To begin, the criteria in hierarchical construction must be defined at three levels: top, middle, and bottom. The upper level defines the objectives, the middle level defines the criteria and sub criteria, and the lower level defines the lower alternatives. The third step is to rank the criteria, sub criteria, and alternatives in order of importance.

3.1. Criteria weighting measures analytical hierarchy process

A criterion weighting measure is used in the decision-making process to evaluate the relative value or priority of distinct criteria. Based on pairwise comparisons, AHP provides a structured approach for assigning priority weights to criteria. The criteria weighing steps in AHP involve the following steps:

a. Create a pairwise comparison matrix between weight criteria

Pairwise comparison: determining the relative importance or preference of two criteria. Each criterion is compared to the others, and an intensity score or rating is assigned to reflect its relative relevance based on (1). The elements compared in the matrix are shown in Table 3. The comparison value of each criterion element is shown in Table 4.

Table 3. Initial criteria element

Initials	Criteria
CS	Customers
MN	Merchant
TS	Transaction
DT	Date
TM	Time
LK	Location

Table 4. Criteria comparison matrix

Goal	CS	MN	TS	DT	TM	LK
CS	1.001	1.001	5.002	3.002	3.005	1.001
MN	1.002	1.001	5.002	3.002	3.005	1.001
TS	0.202	0.202	1.001	0.334	0.202	0.334
DT	0.334	0.334	3.005	1.001	0.334	0.334
TM	0.334	0.334	5.002	3.002	1.001	0.202
LK	1.001	1.001	3.005	3.005	5.002	1.001

b. Calculating the priority weight

Table 5 shows the calculations used to obtain the priority vector or total priority value (TPV). Priority vector or TPV refers to the set of priority weights assigned to elements in a decision hierarchy. These weights represent the relative importance of each element in the decision objectives shown in Table 6.

Table 5. Calculating the priority weight

Goal	CS	MN	TS	DT	TM	LK	TPV
CS	1.001	1.001	5.002	3.002	3.005	1.001	14.12/6
MN	1.002	1.001	5.002	3.002	3.005	1.001	14.12/6
TS	0.202	0.202	1.001	0.334	0.202	0.334	2.2/6
DT	0.334	0.334	3.005	1.001	0.334	0.334	5.2/6
TM	0.334	0.334	5.002	3.002	1.001	0.202	9.8/6
LK	1.001	1.001	3.005	3.005	5.002	1.001	14/6

Table 6. TPV

Weight	TPV
CS	2.3
MN	2.3
TS	0.36
DT	0.86
TM	1.63
LK	2.3

c. Test the consistency
Divide each element in the row number column by the criterion weight of TPV to get λ_{max}:

$$\begin{bmatrix} 2.3 \\ 2.3 \\ 0.36 \\ 0.36 \\ 1.63 \\ 2.3 \end{bmatrix} \div \begin{bmatrix} 14.12 \\ 14.12 \\ 2.2 \\ 5.2 \\ 0.3 \\ 1 \end{bmatrix} = \begin{bmatrix} 0.16 \\ 0.16 \\ 0.16 \\ 0.069 \\ 5.4 \\ 2.3 \end{bmatrix}$$

$$\lambda_{max} = \frac{0.16+0.16+0.16+0.069+5.4+2.3}{6} = 8.249$$

Next, compute the CI by adding λ_{max} minus n (number of criteria) and then subtracting n minus 1 as show in (4).

$$CI = \frac{8.249-6}{6-1} = 0.44$$

Calculate the value of the consistency ratio from the value of random 6 elements then choose 2.3 then the value of CR is:

$$CR = \frac{0.44}{5.4} = 0{,}08$$

The criterion matrix's consistency ratio is 0.08 (0.08 0.1), showing good consistency, because a value of 0.08 implies that the consistency ratio of the comparative research outcomes is 8%. Because it is less than 0.1 (10%), the value is acceptable.

3.2. Stages multi-objectives genetic algorithm

The MOGA algorithm continues iterating until the termination condition is met. It aims to converge toward a set of solutions representing trade-offs or Pareto fronts between conflicting goals. The final output of the MOGA algorithm is a set of non-dominant solutions that represent the best trade-off solutions for multi-objective optimization problems in (5). Table 7 shows the lower and upper threshold values as the basis for finding versatile values for various scenarios.

Table 7. Lower and upper bounds for the optimization problem

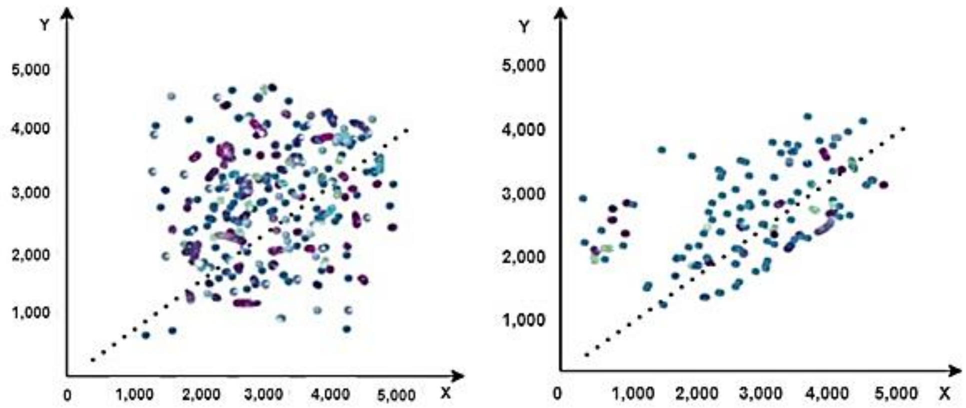
Input parameters	Lower bound	Upper bound
Customers	60	4,000
Merchant	600	1,200
Transaction	1,200	40,000
Date	900	1,200
Time	900	1,200
Location	250	500

In multi-objective optimization, fitness is determined by evaluating each individual's performance across multiple objective functions. The objective function is usually defined based on the specific problem being addressed. In the Table 8 several scenarios were carried out to evaluate each individual in several objective functions.

Table 8. Multi object scenario

Object	Scenario 1	Scenario 2	Scenario 3	Scenario 4
A1	10,673	31,887	4,996	913
A2	3,188	2,275	8,424	815
A3	3,188	4,435	913	950
Total	17,049	38,597	14,333	2,678

The MOGA approach solves the majority of the issues. MOGA generates more decision information based on the AHP process, as shown in Figure 3, based on the scenarios generated in Tables 2 and 4. The MOGA algorithm performs convergence behavior analysis by tracking the development of Pareto front or non-dominance solutions from element to element. The convergence sign in Figure 3(a) is explained by the behavior problem of each larger element. Figure 3(b) the improvement mechanism is carried out by reducing the intensity of problems that occur as a result of behavior.



(a) (b)

Figure 3. Predicted output; (a) behavior of each element is greater and (b) behavior of each element is smaller

The optimization measure is calculated using the optimization method over the predicted range each time the e-metric data is sampled in this strategy [35]. The complexity prediction model (MPK) optimization model is shown (6):

$$x_{k+1} = A_{kxk} + B_{kuk} + E_{dk}$$
$$y_k = C_{xk} + D_{uk} \tag{6}$$

Modeling is generated based on input complexity (R), uncertainty (A), and output value (D). Therefore, it means:

$$D = 0.xk \in R$$
$$D = 0.xk \in R^n uk \in R^{nu} dk \in R^{nd} yk \in R^{ny} Ak \in R^{n\times n} Bk \in R^{n\times nu} E \in R^{n\times nd} C \in R^{ny\times n} \tag{7}$$

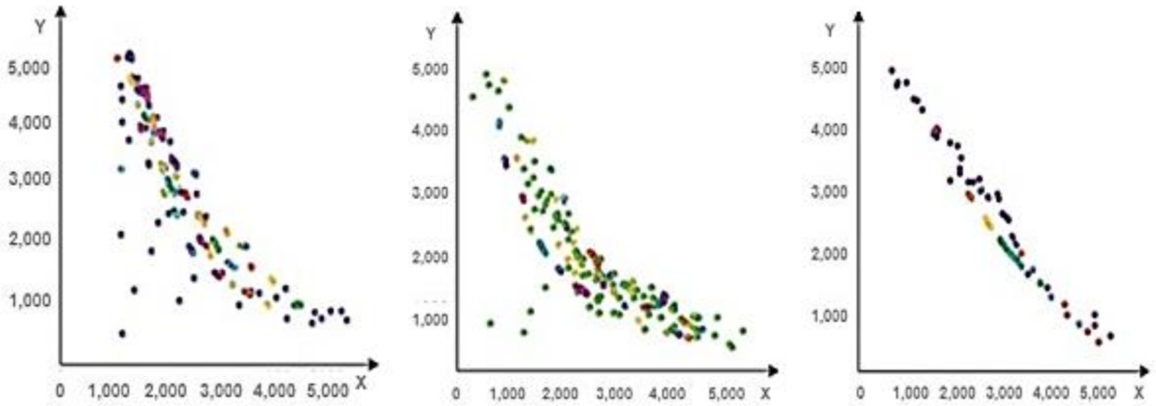
The derivative of the prediction model and the period complexity of the future state are as (8):

$$\begin{aligned} x_{k+1} &= A_{k\times k} + B_{kuk} + D_{dk} \\ x_{k+2} &= {A_k}^2 xk + A_k B_{kuk} + B_{kuk+1} + A_k E d_k + E d_k \\ x_{k+p} &= {A_k}^p xk + {A_k}^{p-1} B_{kuk} + {A_k}^{p-2} B_{kuk+1} + \cdots + {A_k}^{p-m} B_{kuk+m-1} \\ &+ {A_k}^{p-1} E_{dk} + {A_k}^{p-2} E_{dk+1} + \cdots \\ &+ A_k E d_{k+p-2} + E d_{k+p-1} \end{aligned} \tag{8}$$

Analysis of user behavior on e-metric data is done by looking at user habits in business metrics. The study that has been carried out is based on the estimated maximum limit based on the prediction results in Table 9. Figure 4 shows the results of the optimization model. Where the MPK approach optimizes 3 parts of e-metric data. Figure 4(a) optimizes the input, Figure 4(b) optimizes the uncertainty, and Figure 4(c) optimizes the output value. It can be concluded that the approach provides information about strategies and alternatives. The MCDM-MOGA hybrid model was developed into a MPK based on (6) to (8), which responds to predictions of future user behavior by producing the highest value accuracy of 89% at the output value optimization based on complexity results prediction Table 9.

Table 9. Predictive complexity

	x=1	x=2	x=3	x=4	x=5	%
x=1, k=1	0	485.213	392.999	451.134	0	84
x=1, k=4	391.307	0	75.7144	0	391.307	85
x=5, k=1	916.733	213.896	0	116.567	224.061	89
x=5, k=4	151.842	867.871	789.288	123.639	171.377	87



(a) (b) (c)

Figure 4. Optimization model results; (a) input optimization, (b) uncertainty optimization, and (c) output value optimization

4. CONCLUSION

In this study, a complexity prediction model was developed to address the challenges posed by multi-object complexity on business uncertainty problems. This model aims to provide a comprehensive understanding of the factors contributing to complexity and offer insights for managing a dynamic business environment. research shows the importance of considering multiple objectives and the impact of uncertainty on complexity. The developed prediction model incorporates various factors such as organizational structure, resource allocation, technological advances, market dynamics, and external factors to assess and predict the level of complexity. The results show that the complexity prediction model is promising in capturing and predicting patterns of complexity, serving as a tool for organizations to assess the level of complexity, identify critical factors, and make decisions to optimize performance and reduce potential risks, where MCDM describes data by looking at opportunities in making decisions based on many criteria, the MOGA scenario looks for customer habits towards business metrics, resulting in an MPK method with an accuracy of 89% and can be used in predicting future business needs.

ACKNOWLEDGEMENTS

Thank you to DRTPM for the assignment research funds provided based on Grant Number 300/E5/PG.02.00.PT/2022,1652/LP2M/03.1.1/VIII/2022.

REFERENCES

[1] M. Geissdoerfer, D. Vladimirova, and S. Evans, "Sustainable business model innovation: A review," *Journal of Cleaner Production*, vol. 198, pp. 401–416, Oct. 2018, doi: 10.1016/j.jclepro.2018.06.240.

[2] D. Ibarra, J. Ganzarain, and J. I. Igartua, "Business model innovation through Industry 4.0: A review," *Procedia Manufacturing*, vol. 22, pp. 4–10, 2018, doi: 10.1016/j.promfg.2018.03.002.

[3] M. Rachinger, R. Rauter, C. Müller, W. Vorraber, and E. Schirgi, "Digitalization and its influence on business model innovation," *Journal of Manufacturing Technology Management*, vol. 30, no. 8, pp. 1143–1160, Dec. 2019, doi: 10.1108/JMTM-01-2018-0020.

[4] E. Y. Afeti and A. Owusu, "Mobile Payments Affordance as a Driver for End User Entrepreneurship," *International Journal of E-Entrepreneurship and Innovation*, vol. 12, no. 2, pp. 1–20, Nov. 2022, doi: 10.4018/IJEEI.314467.

[5] Y. Liu, J. Luo, and L. Zhang, "The effects of mobile payment on consumer behavior," *Journal of Consumer Behaviour*, vol. 20, no. 3, pp. 512–520, May 2021, doi: 10.1002/cb.1880.

[6] Y. Kahane, "New Metrics for a New Economy: The B2T by 2020 Project," 2019, pp. 101–113. doi: 10.1007/978-3-030-14199-8_6.

[7] R. Syah, M. K. Nasution, E. B. Nababan, and S. Efendi, "Sensitivity of shortest distance search in the ant colony algorithm with varying normalized distance formulas," *TELKOMNIKA (Telecommunication Computing Electronics and Control)*, vol. 19, no. 4, pp. 1251–1259, Aug. 2021, doi: 10.12928/telkomnika.v19i4.18872.

[8] A. Khowarizmi, R. Syah, M. K. M. Nasution, and M. Elveny, "Sensitivity of MAPE using detection rate for big data forecasting

crude palm oil on k-nearest neighbor," *International Journal of Electrical and Computer Engineering (IJECE)*, vol. 11, no. 3, pp. 2696–2703, Jun. 2021, doi: 10.11591/ijece.v11i3.pp2696-2703.

[9] M. Hossain, "Frugal innovation and sustainable business models," *Technology in Society*, vol. 64, pp. 1–7, Feb. 2021, doi: 10.1016/j.techsoc.2020.101508.

[10] M. Marczewska and M. Kostrzewski, "Sustainable Business Models: A Bibliometric Performance Analysis," *Energies*, vol. 13, no. 22, pp. 1–30, Nov. 2020, doi: 10.3390/en13226062.

[11] N. Bocken, L. Strupeit, K. Whalen, and J. Nußholz, "A Review and Evaluation of Circular Business Model Innovation Tools," *Sustainability*, vol. 11, no. 8, pp. 1–25, Apr. 2019, doi: 10.3390/su11082210.

[12] W. Sałabun and K. Urbaniak, "A New Coefficient of Rankings Similarity in Decision-Making Problems," *International Conference on Computational Science*, 2020, pp. 632–645. doi: 10.1007/978-3-030-50417-5_47.

[13] G. O. Odu, "Weighting methods for multi-criteria decision making technique," *Journal of Applied Sciences and Environmental Management*, vol. 23, no. 8, pp. 1449–1457, Sep. 2019, doi: 10.4314/jasem.v23i8.7.

[14] M. Yazdani, P. Zarate, E. K. Zavadskas, and Z. Turskis, "A combined compromise solution (CoCoSo) method for multi-criteria decision-making problems," *Management Decision*, vol. 57, no. 9, pp. 2501–2519, Oct. 2019, doi: 10.1108/MD-05-2017-0458.

[15] Z. Chourabi, F. Khedher, A. Babay, and M. Cheikhrouhou, "Multi-criteria decision making in workforce choice using AHP, WSM and WPM," *The Journal of The Textile Institute*, vol. 110, no. 7, pp. 1092–1101, Jul. 2019, doi: 10.1080/00405000.2018.1541434.

[16] S. Hammami *et al.*, "Application of the GIS based multi-criteria decision analysis and analytical hierarchy process (AHP) in the flood susceptibility mapping (Tunisia)," *Arabian Journal of Geosciences*, vol. 12, no. 21, pp. 1–16, Nov. 2019, doi: 10.1007/s12517-019-4754-9.

[17] R. R. Patil and S. Kumar, "Priority selection of agro-meteorological parameters for integrated plant diseases management through analytical hierarchy process," *International Journal of Electrical and Computer Engineering (IJECE)*, vol. 12, no. 1, pp. 649–659, Feb. 2022, doi: 10.11591/ijece.v12i1.pp649-659.

[18] A. Koc, S. Turk, and G. Şahin, "Multi-criteria of wind-solar site selection problem using a GIS-AHP-based approach with an application in Igdir Province/Turkey," *Environmental Science and Pollution Research*, vol. 26, no. 31, pp. 1–13, Nov. 2019, doi: 10.1007/s11356-019-06260-1.

[19] T. T. Nguyen, "Optimization of distribution network configuration with multi objective function based on improved cuckoo search algorithm," *Bulletin of Electrical Engineering and Informatics*, vol. 9, no. 4, pp. 1685–1693, Aug. 2020, doi: 10.11591/eei.v9i4.1886.

[20] A. L. Achu, J. Thomas, and R. Reghunath, "Multi-criteria decision analysis for delineation of groundwater potential zones in a tropical river basin using remote sensing, GIS and analytical hierarchy process (AHP)," *Groundwater for Sustainable Development*, vol. 10, pp. 1–11, Apr. 2020, doi: 10.1016/j.gsd.2020.100365.

[21] N. A. Zolpakar, S. S. Lodhi, S. Pathak, and M. A. Sharma, "Application of Multi-objective Genetic Algorithm (MOGA) Optimization in Machining Processes," 2020, pp. 185–199. doi: 10.1007/978-3-030-19638-7_8.

[22] M. Al Mazaideh and J. Levendovszky, "A multi-hop routing algorithm for WSNs based on compressive sensing and multiple objective genetic algorithm," *Journal of Communications and Networks*, vol. 23, no. 2, pp. 138–147, Apr. 2021, doi: 10.23919/JCN.2021.000003.

[23] A. F. Mazlam, W. N. J. H. W. Yussof, and R. Mamat, "Estimation of fines amount in syariah criminal offences using adaptive neuro-fuzzy inference system (ANFIS) enhanced with analytic hierarchy process (AHP)," *International Journal of Electrical and Computer Engineering (IJECE)*, vol. 9, no. 6, pp. 5537–5544, Dec. 2019, doi: 10.11591/ijece.v9i6.pp5537-5544.

[24] T. Alfakih, M. M. Hassan, and M. Al-Razgan, "Multi-Objective Accelerated Particle Swarm Optimization With Dynamic Programing Technique for Resource Allocation in Mobile Edge Computing," *IEEE Access*, vol. 9, pp. 167503–167520, 2021, doi: 10.1109/ACCESS.2021.3134941.

[25] S. Sayadinia and M. A. Beheshtinia, "Proposing a new hybrid multi-criteria decision-making approach for road maintenance prioritization," *International Journal of Quality & Reliability Management*, vol. 38, no. 8, pp. 1661–1679, Jul. 2021, doi: 10.1108/IJQRM-01-2020-0020.

[26] G.-N. Zhu, J. Hu, and H. Ren, "A fuzzy rough number-based AHP-TOPSIS for design concept evaluation under uncertain environments," *Applied Soft Computing*, vol. 91, pp. 1–18, Jun. 2020, doi: 10.1016/j.asoc.2020.106228.

[27] O. M. Olabanji and K. Mpofu, "Appraisal of conceptual designs: Coalescing fuzzy analytic hierarchy process (F-AHP) and fuzzy grey relational analysis (F-GRA)," *Results in Engineering*, vol. 9, pp. 1–34, Mar. 2021, doi: 10.1016/j.rineng.2020.100194.

[28] S. Djenadic, D. Ignjatovic, M. Tanasijevic, U. Bugaric, I. Jankovic, and T. Subaranovic, "Development of the Availability Concept by Using Fuzzy Theory with AHP Correction, a Case Study: Bulldozers in the Open-Pit Lignite Mine," *Energies*, vol. 12, no. 21, pp. 1–18, Oct. 2019, doi: 10.3390/en12214044.

[29] M. K. Ghorbani, H. Hamidifar, C. Skoulikaris, and M. Nones, "Concept-Based Integration of Project Management and Strategic Management of Rubber Dam Projects Using the SWOT–AHP Method," *Sustainability*, vol. 14, no. 5, p. 2541, Feb. 2022, doi: 10.3390/su14052541.

[30] A. A. Khan, M. Shameem, M. Nadeem, and M. A. Akbar, "Agile trends in Chinese global software development industry: Fuzzy AHP based conceptual mapping," *Applied Soft Computing*, vol. 102, pp. 1–24, Apr. 2021, doi: 10.1016/j.asoc.2021.107090.

[31] Q. Liu, J. Chen, W. Wang, and Q. Qin, "Conceptual Design Evaluation Considering Confidence Based on Z-AHP-TOPSIS Method," *Applied Sciences*, vol. 11, no. 16, p. 7400, Aug. 2021, doi: 10.3390/app11167400.

[32] A. Metiaf, Q. Wu, and Y. Aljeroudi, "Searching With Direction Awareness: Multi-Objective Genetic Algorithm Based on Angle Quantization and Crowding Distance MOGA-AQCD," *IEEE Access*, vol. 7, pp. 10196–10207, 2019, doi: 10.1109/ACCESS.2018.2890461.

[33] Q. Zhou, J. Wu, T. Xue, and P. Jin, "A two-stage adaptive multi-fidelity surrogate model-assisted multi-objective genetic algorithm for computationally expensive problems," *Engineering with Computers*, vol. 37, no. 1, pp. 623–639, Jan. 2021, doi: 10.1007/s00366-019-00844-8.

[34] J. Echanobe, K. Basterretxea, I. del Campo, V. Martinez, and N. Vidal, "Multi-Objective Genetic Algorithm for Optimizing an ELM-Based Driver Distraction Detection System," *IEEE Transactions on Intelligent Transportation Systems*, vol. 23, no. 8, pp. 11946–11959, Aug. 2022, doi: 10.1109/TITS.2021.3108851.

[35] L. Falahiazar and H. Shah-Hosseini, "Optimisation of engineering system using a novel search algorithm: the Spacing Multi-Objective Genetic Algorithm," *Connection Science*, vol. 30, no. 3, pp. 326–342, Jul. 2018, doi: 10.1080/09540091.2018.1443319.

BIOGRAPHIES OF AUTHORS

Rahmad B. Y. Syah is an Associate Professor in Universitas Medan Area and received head of Excellent Centre Innovations and New Science (PUIN) Universitas Medan Area. His research interests are modeling and computing, artificial intelligence, data science, business intelligent, metaheuristics hybrid algorithm and computational intelligent. He is a member of the IEEE, institute for system and technologies of information, control, and communication, International Association of Engineers (IAENG). He can be contacted at email: rahmadsyah@uma.ac.id.

Habib Satria received B.Sc. degree in electrical engineeringeducation from Padang State University in 2016, and M.T. degree in electrical engineering from University Andalas, Indonesia, in 2018. He is currently a lecture in Department of Electrical Engineering, Universitas Medan Area, Medan, Indonesia. His researchinterests are new and renewable energy, concerning about solar power plant,automatic control system, real-time simulation, green computing, and power system.He is a member of the International Association of Engineers (IAENG) and the institution of engineers Indonesia. He can be contacted at email: habib.satria@staff.uma.ac.id.

Marischa Elveny received TI (bachelor's) degree in information technology at the Universitas Sumatera Utara and earned her magister degree in informatics engineering, University of Sumatera Utara. She earned her doctorate (Ph.D) at the University of Sumatera Utara. Currently working as a lecturer in the faculty of computer science and information technology at the Universitas Sumatera Utara. Research interests are artificial intelligence, analytics and business intelligence, data science, modelling computation, and information technology. She is a member of international association of engineers (IAENG). She can be contacted at email: marischaelveny@usu.ac.id.

Mahyuddin K. M. Nasution is a Professor from Universitas Sumatera Utara, Medan Indonesia. Worked as a Lecturer at the Universitas Sumatera Utara, is an Drs. Mathematics (USU Medan, 1992); MIT, Computers and Information Technology (UKM Malaysia, 2003); Ph.D. in Information Science (Malaysian UKM). Fields: mathematics, computer science, data science, artificial intelligence, modelling and computation, new science, and information technology. He can be contacted at email: mahyuddin@uma.ac.id.