F O U N D A T I O N S O F C O M P U T I N G A N D D E C I S I O N S C I E N C E S
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Determination of Criteria Priorities and Interactions in ChatGPT by a Fuzzy Model

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Abstract. Today, technology is advancing much more and faster than in the past. The technological revolution is progressing so fast that people can now communicate with pre-programmed computers through Artificial Intelligence (AI). This study aims to evaluate the priorities and interactions of the criteria that stand out in the use of ChatGPT-4, using Fuzzy-Analytical Hierarchy Process (F-AHP) and Fuzzy-DEMATEL (F-DEMATEL) methods. Eight critical criteria in the use of ChatGPT are determined by the expert opinions obtained from the focus group. Among the criteria, this study found that reliability 23.1% and security 21.2% were the most important criteria by F-AHP calculations. This study also found that the criteria of appearance and functionality were generally influencing criteria, and the criteria of speed was generally influenced by other criteria.

Keywords: ChatGPT, Artificial Intelligence, Fuzzy AHP, Fuzzy DEMATEL

1. Introduction

Artificial Intelligence (AI) technologies are constantly evolving and becoming more visible in different areas of human life. Nowadays, software technologies have developed to such an extent that AI support is carried out in computers, tablets and smartphones, in every technological moment of daily life, and even in the Internet world and social media, and it is useful to explain this situation as the "AI effect" phenomenon. Recently, Generative Pre-trained Transformer-ChatGPT, a chatbot with a chat-based AI interface developed by OpenAI, has been quite popular. ChatGPT has attracted great attention from societies around the world as one of the AI applications with an advanced background [5, 26, 40]. ChatGPT can be used as a more effective chatbot over time, using machine learning algorithms and natural language processing approaches that learn from previous conversations to provide appropriate responses to future questions, thereby improving language skills [16].

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ChatGPT is trained on a dataset of conversational text and generates human-like text based on a given prompt or context for a variety of languages and formats [26]. Users can ask ChatGPT questions, and ChatGPT responds with interesting results and relevant topic answers. ChatGPT is growing rapidly in the Internet world and is used by people for various purposes [13]. Moreover, ChatGPT is used in various fields by academicians, researchers and mostly students to complete their assignments, essays, scientific abstracts, summarize literature and generate new ideas [32].

It should be noted that ChatGPT has been defined as an "artificial intelligence-based conversational large language model" by [36]. This implies that it contains a structure to enable mutual communication with more than one user. ChatGPT is capable of engaging in convincing conversations with users in a multitude of languages on a vast range of topics. Furthermore, it is free, user-friendly, and continues to learn and teach [43]. The principal advantages of AI-based language models are manifold. They provide a platform for asynchronous communication that increases participation and collaboration, facilitate collaboration to form groups, and enable distance learning [7]. The GPT model learns languages, syntax, grammar, and semantics with a large structure of text data. The initial GPT architecture, designated GPT-1, was created with 117 million parameters in 2018. The subsequent GPT-2 model, announced in 2019, featured 1.5 billion parameters. In 2020, the GPT-3 model was introduced with 175 billion parameters.

ChatGPT is developed on a large structure of text data and generates responses that are perceived as human-like. ChatGPT was released in 2022 with 175 billion parameters, enabling a mutual dialogue with humans. Finally, GPT-4 was produced in 2023 with a much newer and greater vision, using 100 trillion parameters. This was trained with both text prediction and reinforcement learning from human feedback [33]. The continued growth, development, and evolution of speech-based AI models like ChatGPT will determine the future of human-computer interaction [25]. AI technologies that develop and change at a dizzying pace are designed to provide optimum benefits for people.

The motivation for this study is the need to examine ChatGPT, which is one of the AI and machine learning-based systems developed in a user-friendly way to meet human needs. ChatGPT has recently become popular and is emerging in many areas. The objective of this study is to evaluate the relative importance and interactions of the criteria that emerge during the use of ChatGPT-4, which has emerged as an AI-based mutual dialogue robot and has been very popular recently. This will be achieved using Analytical Hierarchy Process (Fuzzy-AHP, F-AHP) and Fuzzy Decision Making Trial and Evaluation Laboratory (Fuzzy-DEMATEL, F-DEMATEL) methods. The research objectives are to provide guidance to future researchers working in this field, outlining the methods, subjects, and findings of this study. The originality and contribution of this study can be explained by the fact that it is the first study investigating the usage structure of ChatGPT and using multi-criteria decision-making (MCDM) methods. The remainder of the study is organised as follows. In the second part, the literature is reviewed. In the third section, the materials and methods employed in the study are elucidated. In the fourth section, the data analysis and results are presented. In the fifth section, the discussion is presented. Finally, in the concluding section, the most significant conclusions about the study are highlighted.

2. Literature Review

In the past, academic studies have typically employed time-consuming manual methods to research, analyse and draw inferences from large volumes of texts. Recent advances in natural language processing technology have the potential to streamline the work of researchers by automating numerous tasks. ChatGPT represents a promising technology in the field of academic research. The advent of ChatGPT can be attributed to the remarkable advancements in AI technologies over the past decade [9]. Given that ChatGPT is a relatively new technology, it is challenging to ascertain the underlying realities. There is a great deal of interest and a plethora of studies on it. The majority of these studies focus on the innovations and contributions of ChatGPT, as well as its application areas. It is beneficial to present a summary of studies investigating the structure, characteristics, history, strengths and weaknesses, and usage areas of ChatGPT.

In [5] discussed the potential of AI to enhance various research methods with the ChatGPT, with a particular focus on its utility in management research. [7] examined the opportunities, challenges, potential risks, and rewards of using ChatGPT in higher education. [8] discussed the benefits, challenges, applications, and limitations of ChatGPT. [11] employed the SWOT analysis to identify ChatGPT's strengths and weaknesses and to assess its potential benefits and drawbacks for education. [12] investigated how ChatGPT performs on the US medical licensing examination. Furthermore, the performance of ChatGPT is compared to that of GPT-3 and InstructGPT in [12] study. [9] examined the prospects and potential threats of ChatGPT in academic writing. [16] implemented the ChatGPT for healthcare services. [26] studied ChatGPT's ability to generate scripts in cybersecurity. [32] highlight the application of ChatGPT in academic research by showing a practical example with some recommendations. [33] examines the potential applications of ChatGPT in scientific research, highlighting the challenges and ethical concerns that may arise in the process, including data processing, hypothesis generation, and public outreach. [36] utilises the ChatGPT for utility in healthcare education, research, and practice. [40] present a three-stage case study on the use of chatbots in education. [34] provide an overview of OpenAI and ChatGPT, outlining their functionality, strengths, and limitations. [31] aim to contribute to the ongoing discussion on the application of AI in the learning process of higher education students through ChatGPT.

A search of the Web of Science database using the keyword "ChatGPT" yielded 3,690 studies conducted up to March 2024. Approximately 36% of the studies were conducted in the field of computer science, approximately 18% in the field of educational research, approximately 12% in the field of general internal medicine, and approximately 12% in the field of healthcare sciences services. The majority of the 3,690 studies (approximately 67%) are articles, with the majority of these studies belonging to the years 2023 and 2024. A search of the current studies with the keyword MCDM yielded only one publication. This feature enables our current study to make a contribution to the existing body of literature and to address a gap in the existing knowledge base.

3. Material and Methods

In [26] posited that ChatGPT represents a significant advancement in language modelling, citing its scale, pre-training, versatility, efficiency, and quality as key advantages. However, no study has yet addressed the criteria for evaluating ChatGPT that are emerging in the field. In this study, it was deemed more appropriate to determine the criteria that will emerge in the use of ChatGPT through a focus group interview. In a study by [2], a focus group discussion was conducted with the ChatGPT-4 in the context of pediatric palliative care. [29] proposed that interviews or focus groups would be employed as a means of obtaining in-depth insights and explanatory methods, including ethical considerations. These would be used to develop strategies for mitigating bias in ChatGPT-generated responses, to assess consumer well-being and ChatGPT, to develop new applications for ChatGPT, and to personalise the experience for stakeholders, developers, users, and experts. As the problem to be solved comprises several distinct stages, a flow chart can be employed to illustrate the proposed methodology in a more systematic manner.

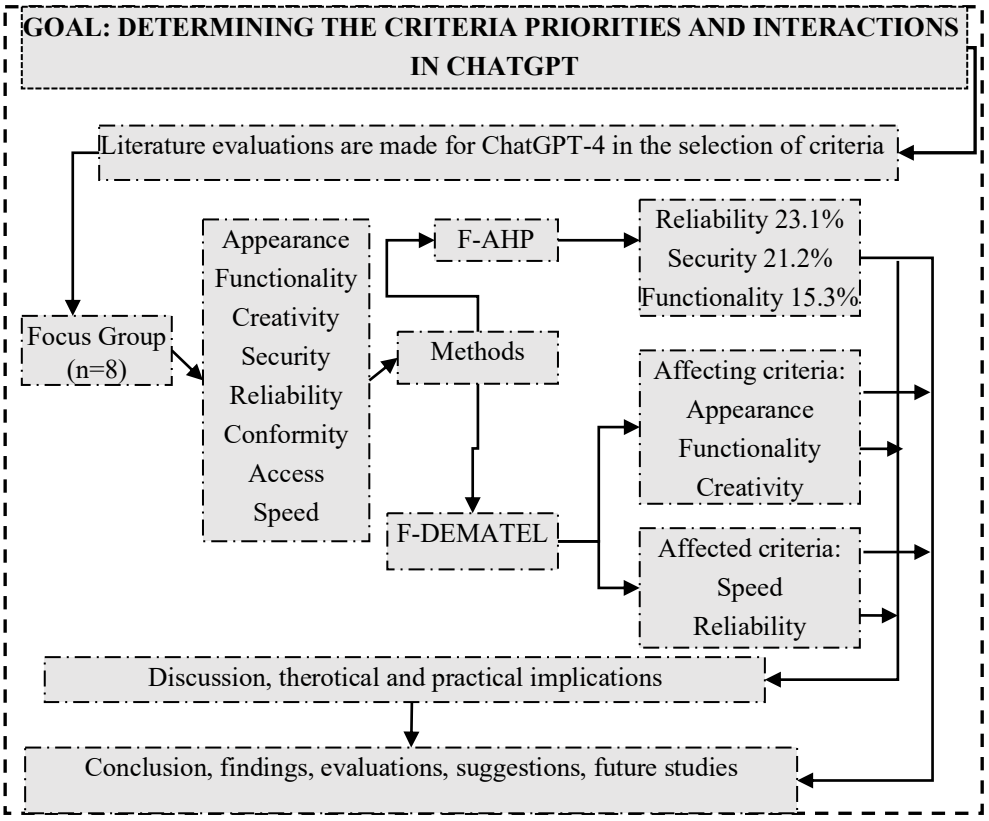

Figure 1. Flowchart of the paper

The procedures are carried out in accordance with the methodology depicted in Figure 1. The subsequent stages of the study are as follows. A focus group interview was conducted with eight experts (n=8) in this field. A responsible specialist facilitated the discussion and encouraged the other experts to participate. The experts are employed in academic, software development, and computer programming roles. The age range of the experts is between 28 and 47 years old. Two of them are female, while the others are male. The interview was conducted with the experts and lasted for a total of 43 minutes. These criteria were established by focus group members, who are experts in the field, to enable the evaluation of the ChatGPT-4 chatbot using MCDM methods. Consequently, it was determined that certain key criteria should be employed, which are presented in Table 1.

Table 1. Suggested criteria for the use of ChatGPT' evaluating

No	Criterion	Explanation
C1	Appearance	Design view on attracting the user
C2	Functionality	To be able to access and use past conversations
C3	Creativity	The ability of the desired answers to respond to the need creatively
C4	Security	Concern that conversations might be accessed by others
C5	Reliability	The information given may be biased, inappropriate, and inaccurate
C6	Conformity	Ability to correspond in accordance with mutual user language
C7	Access	The ability to access the site anytime from anywhere and access it as the same user on laptop/tablet/mobile
C8	Speed	Expected fast response time during peer-to-peer

The primary objective of this study is to elucidate the interrelationship between the specified criteria and their respective priorities. Firstly, a comprehensive literature review was conducted, and a list of experts and criteria was compiled. The criteria priorities were determined using the F-AHP. The F-DEMATEL method is employed to ascertain the interaction between the criteria and to construct the interaction diagram. This method is a commonly employed approach in the literature for identifying causal relationships between criteria [6, 1, 30]. The F-DEMATEL method is applied to both methods. This is because expert opinions are inherently subjective, and some decisions lack complete certainty. One of the main functions of this study is to contribute to the existing literature on the subject. This is because a study in which the criteria are determined and the methods mentioned are not included in the existing literature. MCDM methods are preferred due to the high number of criteria and their potential for conflict or complementation with each other. In the study, eight criteria were identified for evaluating ChatGPT.

3.1. F-AHP Approach

The initial steps and dissemination of AHP are initiated with the publication titled "The Analytic Hierarchy Process" authored by [35]. This method is a widely used method among those engaged in MCDM and is based on pairwise comparisons and criteria prioritisation logic. The AHP employs a scale ranging from 1 to 9, with which experts assign scores to two principal criteria, in comparison through pairwise comparisons. [45] established the

foundations of fuzzy logic, which subsequently led to its application in various fields. While decision-making in a fuzzy environment is highly influenced by subjective judgments that are often uncertain, sources of uncertainty can include inaccurate and unquantifiable information collected from the decision-makers being evaluated [28]. The fuzzy logic approach is an effective solution to decision problems characterised by uncertainty and complexity. The initial steps and operations are identical in both AHP and F-AHP. The stepwise sequence of F-AHP transactions can be conducted as follows [21, 38].

Step 1. The initial step in the problem-solving process is to determine the nature of the problem and to identify the criteria that can be used to formulate a solution. Once this has been done, the next step is to establish the hierarchical model. In this phase, the problem is structured in a hierarchical manner, with the target at the top and the criteria, sub-criteria, and alternatives at successive levels [35].

Step 2. The decision matrix was created in the following manner: A decision matrix is constructed for each criterion and, if applicable, sub-criteria. This is achieved through pairwise comparisons conducted by experts. If the 1-9 scale is employed at this stage, the matrix is constructed in accordance with the AHP method. If these numerical values are converted to fuzzy equivalents, a matrix for F-AHP will be formed. There are a variety of fuzzy number equivalents, but the fuzzy numbers presented in Table 2 were employed in the current study.

Table 2. Fuzzy triangle scale

Value	Definition	Fuzzy Triangle Scale
1	Equal importance	(1, 1, 1)
3	Moderate importance	(2, 3, 4)
5	Strong importance	(4, 5, 6)
7	Very strong importance	(6, 7, 8)
9	Extreme importance	(9, 9, 9)
2;4;6;8	Intermediate values	(1, 2, 3); (3, 4, 5); (5, 6, 7); (8, 8, 9)

The equivalent values are formed by taking their inverses. To illustrate, if the AHP score of 5 (Strong importance) is given in the comparison of the first criterion and the second criterion, the value of 1/5 should be entered for the comparison of the second criterion and the first criterion for AHP. The F-AHP equivalent of 5 (Strong importance) scoring is (4, 5, 6). If the value (4, 5, 6) was entered when comparing the first and second criteria, the values (1/6, 1/5, 1/4) should be entered when comparing the second and the first criteria. In the event that there are multiple experts, matrices are created for each expert, and a single matrix is obtained by combining them.

Step 3. Using equation (1), the fuzzy geometric mean ($\tilde{r}_i$) is calculated.

$$\tilde{r}_i = \left(\prod_{j=1}^{n} \tilde{d}_{ij} \right)^{1/n} \quad i = 1, 2, ..., n \tag{1}$$

Step 4. Using equation (2), fuzzy criterion weights can be defined.

$$\tilde{w}_i = \tilde{r}_i x \left(\tilde{r}_i + ... + \tilde{r}_n\right)^{-1} \quad (2)$$

Step 5. The criteria average (M_i) and normalized (N_i) weight can be calculated using equations (3) and (4).

$$M_i = (\tilde{w}_1 + ... + \tilde{w}_n) / n \quad (3)$$

$$N_i = M_i / (M_1 + ... + M_n) \quad (4)$$

It is also necessary to verify the consistency of the pairwise comparison values provided by the experts during the process. The inconsistencies of the decision matrices responded to by the experts can be calculated in the AHP method [30]. The F-AHP method has been employed in a number of academic studies, including those on renewable energy dissemination program evaluation [14], performance evaluation [39], supplier selection [3], human resource management [1], risk analysis [24], risk assessment [23], laptop selection problem [38], evaluation of e-service quality [4], freight village efficiency criteria evaluation [30], etc. have been applied in a variety of fields. A further application area has been identified, namely the evaluation of ChatGPT.

3.2. F-DEMATEL Approach

The DEMATEL technique enables the presentation of interactions between criteria in the form of diagrams or digraphs [6]. It can be observed that the opinions of five or more experts are sufficient to interpret the results obtained with DEMATEL when the studies in the literature are examined [17, 18]. The number of experts involved in this study is eight, which is sufficient to draw conclusions and make interpretations. Eight participating experts were presented with a pairwise interaction table of the eight existing criteria and were asked to indicate the effect size of the first criterion on the second criterion. The scale employed and the fuzzy equivalents of these values are presented in Table 3.

Table 3. Linguistic scale for influential score and triangular fuzzy numbers

Value	Definition	Fuzzy Triangle Scale
0	No influence	(0, 0, 0.25)
1	Low	(0, 0.25, 0.50)
2	Moderate	(0.25, 0.50, 0.75)
3	High	(0.50, 0.75, 1)
4	Very High	(0.75, 1, 1)

The working steps of the DEMATEL and F-DEMATEL methods are similar to each other. These stages can be listed as follows [28, 17, 38, 18, 30].

Step 1. A direct interaction matrix is constructed for each expert, utilising the pairwise comparison values presented in Table 3. No items are represented by a negative sign in this matrix.

Step 2. A general relationship matrix is generated, integrating the perspectives of all experts. During its construction, the equation presented in Eq. 5 is employed. Each value under the fuzzy numbers is ordered according to a low, medium, and upper hierarchy.

$$\tilde{x}_{ij} = \frac{\tilde{z}_{ij}}{r} = \left(\frac{l_{ij}}{r}, \frac{m_{ij}}{r}, \frac{u_{ij}}{r} \right) \tag{5}$$

where

$$r = \max_{i,j} \left\{ \max_{i} \sum_{j=1}^{n} u_{ij}, \max_{j} \sum_{i=1}^{n} u_{ij} \right\} \tag{6}$$
$$i, j \in \{1, 2, 3, ..., n\}$$

Step 3. The fuzzy total-relation matrix can be calculated by Eq. (7)

$$\tilde{T} = \lim_{k \to \infty} (\tilde{x}^1 \oplus \tilde{x}^2 \oplus \tilde{x}^3 \oplus ... \oplus \tilde{x}^k) \tag{7}$$

The fuzzy total-relation matrix can be calculated as follows in Eq. (8)

$$\begin{aligned} [l_{ij}^{"}] &= x_l \times (I - x_l)^{-1} \\ [m_{ij}^{"}] &= x_m \times (I - x_m)^{-1} \\ [u_{ij}^{"}] &= x_u \times (I - x_u)^{-1} \end{aligned} \tag{8}$$

Step 4. D_i+R_i and D_i-R_i values should be calculated. It is calculated with Eqs. (9 and 10)

$$D_i = \sum\nolimits_{1 \le j \le n}^{n} t_{ij} \tag{9}$$

$$R_i = \sum\nolimits_{1 \le i \le n}^{n} t_{ij} \tag{10}$$

Step 5. A defuzzified process is performed. Eqs. (11 and 12) are used for this calculation.

$$(D_i + R_i)_{def} = \frac{l + 2m + u}{4} \tag{11}$$

$$(D_i - R_i)_{def} = \frac{l + 2m + u}{4} \tag{12}$$

Step 6. Drawing a cause-effect relationship diagram

The DEMATEL and F-DEMATEL methods have been identified in the literature as useful tools for determining interactions and drawing diagrams. Previous studies have been conducted on the DEMATEL subject, including influence service innovation [11], machine tool selection [19], laptop selection [38] and recovery solutions for ecotourism centres [15]. Other studies have been conducted on the subject of supplier selection [27], sustainable

food consumption and production [22], freight village efficiency [30], and construction program manager selection [44]. As the ChatGPT topic is relatively new and there is no F-DEMATEL study on this subject, the use of this method will contribute to the existing literature.

4. Data Analysis and Results

This section commences with an overview of the F-AHP applications, which are then presented in stages, in conjunction with the F-DEMATEL applications.

4.1. F-AHP Results

Firstly, the F-AHP process is employed to ascertain the criteria weights and priorities. The operations are conducted in accordance with the steps outlined in the F-AHP explanation. Pairwise matrices are generated from the responses of eight experts who were consulted in the ranking process. These matrices are then combined using the geometric mean. The responses provided by the initial expert are presented in Table 4.

Table 4. Pairwise comparison values (Expert 1)

	C1			C2			C3			...	C8		
	l	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*	...	*l*	*m*	*u*
C1. Appearance	1.00	1.00	1.00	0.25	0.33	0.50	0.17	0.20	0.25		0.17	0.20	0.25
C2. Functionality	2.00	3.00	4.00	1.00	1.00	1.00	0.17	0.20	0.25		1.00	1.00	1.00
C3. Creativity	4.00	5.00	6.00	4.00	5.00	6.00	1.00	1.00	1.00		4.00	5.00	6.00
C4. Security	4.00	5.00	6.00	4.00	5.00	6.00	0.17	0.20	0.25		4.00	5.00	6.00
C5. Reliability	2.00	3.00	4.00	4.00	5.00	6.00	0.17	0.20	0.25	...	3.00	4.00	5.00
C6. Conformity	5.00	6.00	7.00	0.25	0.33	0.50	0.17	0.20	0.25		0.25	0.33	0.50
C7. Access	5.00	6.00	7.00	0.25	0.33	0.50	0.17	0.20	0.25		0.25	0.33	0.50
C8. Speed	4.00	5.00	6.00	1.00	1.00	1.00	0.17	0.20	0.25		1.00	1.00	1.00

The responses provided by the remaining seven experts were averaged together using the geometric mean, and the subsequent steps were conducted on these combined values. All values are presented in Table 5.

Table 5. Average and normalized criteria priority weights (all expert results)

Criteria	*Fuzzy geometric means*			*Fuzzy weights*			*Weights*		*Rank*
	l	*m*	*u*	*l*	*m*	*u*	*Mi*	***Ni***	
C1. Appearance	0.271	0.311	0.363	0.024	0.033	0.046	0.034	**0.033**	8
C2. Functionality	1.239	1.448	1.685	0.111	0.153	0.211	0.159	**0.153**	3
C3. Creativity	1.066	1.259	1.465	0.096	0.133	0.183	0.137	**0.133**	4
C4. Security	1.701	2.011	2.336	0.153	0.213	0.293	0.219	**0.212**	2
C5. Reliability	1.826	2.191	2.586	0.164	0.232	0.324	0.240	**0.231**	1
C6. Conformity	0.577	0.684	0.825	0.052	0.072	0.103	0.076	**0.073**	6
C7. Access	0.762	0.912	1.095	0.068	0.096	0.137	0.101	**0.097**	5
C8. Speed	0.542	0.642	0.770	0.049	0.068	0.096	0.071	**0.068**	7

Mi: Average priority weight, Ni: Normalized priority weight.

In order to obtain Table 5, fuzzy geometric averages were calculated using Eq. 1, criterion weights were obtained using Eq. 2, criteria average (Mi) and normalized (Ni) weight values were calculated with the help of Eqs. 3 and 4. The calculated values were then ordered and the relative importance of the criteria was determined. The 'Reliability' criterion was identified as the most crucial criterion, with a weight of 23.1%. The Security (C4-21.2%) and Functionality (C2-15.3%) criteria, collectively representing the first criterion, correspond to a total weight of 59.6%, which is greater than half of the total. The following criteria are of lesser importance: Creativity (C3: 13.3%), Access (C7: 9.7%), Conformity (C6: 7.3%), Speed (C8: 6.8%), and Appearance (C1: 3.4%). The value of 0.231 represents a higher priority than that of 0.033. For instance, when purchasing a house or a car, individuals invariably seek to procure a superior item according to a variety of criteria. In such instances, the price may be of greater importance than the economic life. As in decision-making problems, the relative importance of the criteria must be considered when evaluating an alternative. The greater the weight assigned to a criterion, the more significant it is. In this problem, reliability was identified as the most important criterion, while appearance was found to be the least important. It can be observed that reliability is perceived as a more significant criterion than others by the collective opinion of experts. The reason why reliability and security criteria are more important than others may be because people seek to search, find, and communicate what they want in a more secure and private environment in the confusing internet world. Although there were inconsistencies in the comparison matrices of some experts, the fuzzy consistency ratio (CR) in the group judgment calculations was found to be 0.044, which is less than 0.1 and therefore at an acceptable level. The experts have demonstrated consistent and reliable judgments.

4.2. F-DEMATEL Results

In this stage, the F-DEMATEL applications are initiated, during which the interaction between the criteria is determined. The experts were requested to compare the eight criteria

presented to them in pairs and to indicate the degree of influence exerted by each criterion on the others. The decision matrices were constructed using the fuzzy expressions provided in Table 3, in accordance with the responses provided by the experts. The decision matrix generated by the initial expert is presented in Table 6.

Table 6. Pairwise comparison values (Expert 1)

Criteria	C1			C2			C3			…	C8		
	l	***m***	***u***	***l***	***m***	***u***	***l***	***m***	***u***	…	***l***	***m***	***u***
C1. Appearance	0.00	0.00	0.25	0.00	0.25	0.50	0.25	0.50	0.75		0.50	0.75	1.00
C2. Functionality	0.00	0.25	0.50	0.00	0.00	0.25	0.00	0.00	0.25		0.00	0.25	0.50
C3. Creativity	0.25	0.50	0.75	0.00	0.00	0.25	0.00	0.00	0.25		0.00	0.25	0.50
C4. Security	0.25	0.50	0.75	0.00	0.00	0.25	0.00	0.00	0.25		0.50	0.75	1.00
C5. Reliability	0.00	0.00	0.25	0.00	0.25	0.50	0.00	0.25	0.50	…	0.00	0.25	0.50
C6. Conformity	0.00	0.00	0.25	0.00	0.00	0.25	0.00	0.00	0.25		0.00	0.00	0.25
C7. Access	0.00	0.00	0.25	0.00	0.00	0.25	0.00	0.00	0.25		0.00	0.00	0.25
C8. Speed	0.50	0.75	1.00	0.00	0.25	0.50	0.00	0.25	0.50		0.00	0.00	0.25

The fuzzy decision matrix of the first expert is normalized and given in Table 7. For all other experts, normalized matrices were found and combined with the arithmetic mean.

Table 7. Normalized pairwise comparison values (Expert 1)

Criteria	C1			C2			C3			…	C8		
	l	***m***	***u***	***l***	***m***	***u***	***l***	***m***	***u***	…	***l***	***m***	***u***
C1. Appearance	0.00	0.00	0.04	0.00	0.04	0.09	0.04	0.09	0.13		0.09	0.13	0.17
C2. Functionality	0.00	0.04	0.09	0.00	0.00	0.04	0.00	0.00	0.04		0.00	0.04	0.09
C3. Creativity	0.04	0.09	0.13	0.00	0.00	0.04	0.00	0.00	0.04		0.00	0.04	0.09
C4. Security	0.04	0.09	0.13	0.00	0.00	0.04	0.00	0.00	0.04		0.09	0.13	0.17
C5. Reliability	0.00	0.00	0.04	0.00	0.04	0.09	0.00	0.04	0.09	…	0.00	0.04	0.09
C6. Conformity	0.00	0.00	0.04	0.00	0.00	0.04	0.00	0.00	0.04		0.00	0.00	0.04
C7. Access	0.00	0.00	0.04	0.00	0.00	0.04	0.00	0.00	0.04		0.00	0.00	0.04
C8. Speed	0.09	0.13	0.17	0.00	0.04	0.09	0.00	0.04	0.09		0.00	0.00	0.04

The responses provided by all the experts were subjected to a pairwise comparison matrix with fuzzy number values and subsequently averaged. The values are presented in Table 8.

Table 8. Normalized pairwise comparison values (all experts)

Criteria	C1			C2			C3			…	C8		
	l	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*	…	*l*	*m*	*u*
C1. Appearance	0.00	0.00	0.04	0.03	0.07	0.11	0.06	0.10	0.14		0.05	0.10	0.13
C2. Functionality	0.04	0.08	0.11	0.00	0.00	0.04	0.06	0.10	0.13		0.06	0.11	0.13
C3. Creativity	0.07	0.11	0.14	0.05	0.09	0.12	0.00	0.00	0.04		0.06	0.10	0.13
C4. Security	0.05	0.08	0.12	0.03	0.06	0.10	0.03	0.05	0.09		0.06	0.09	0.13
C5. Reliability	0.01	0.03	0.06	0.05	0.08	0.12	0.05	0.09	0.12	…	0.04	0.08	0.11
C6. Conformity	0.02	0.05	0.09	0.06	0.08	0.12	0.04	0.05	0.09		0.05	0.08	0.11
C7. Access	0.04	0.07	0.10	0.03	0.06	0.09	0.04	0.05	0.09		0.06	0.10	0.13
C8. Speed	0.04	0.07	0.11	0.05	0.08	0.12	0.04	0.07	0.10		0.00	0.00	0.04

The collective opinions of all experts were aggregated using the arithmetic mean. Subsequently, the third and subsequent stages of the F-DEMATEL process were initiated. Firstly, the fuzzy total-relation matrix was calculated utilising Eqs. (7) and (8). At these stages, the unit matrix must be subtracted from the matrix, the matrix must be inverted, and the matrix must be multiplied with the normalized decision matrix. The combined decision matrix was obtained by combining the values obtained in the previous step. The combined matrix is presented in Table 9.

Table 9. The combined matrix

Criteria	C1			C2			C3			…	C8		
	l	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*	…	*l*	*m*	*u*
C1. Appearance	0.02	0.08	0.45	0.05	0.15	0.53	0.08	0.17	0.02		0.07	0.19	0.59
C2. Functionality	0.06	0.15	0.52	0.02	0.09	0.47	0.08	0.17	0.06		0.08	0.20	0.59
C3. Creativity	0.08	0.17	0.53	0.07	0.17	0.53	0.02	0.08	0.08		0.08	0.19	0.58
C4. Security	0.07	0.14	0.49	0.04	0.13	0.49	0.04	0.12	0.07		0.07	0.17	0.55
C5. Reliability	0.03	0.09	0.42	0.06	0.14	0.48	0.06	0.15	0.03	…	0.06	0.15	0.51
C6. Conformity	0.03	0.11	0.43	0.07	0.14	0.48	0.05	0.11	0.03		0.07	0.15	0.50
C7. Access	0.06	0.12	0.45	0.05	0.12	0.46	0.05	0.12	0.06		0.08	0.17	0.53
C8. Speed	0.05	0.14	0.48	0.07	0.15	0.50	0.06	0.14	0.05		0.02	0.09	0.47

Once the total relation matrix had been calculated, the next step was to identify the row and column totals in the fourth step. The row totals are designated as Di, while the column totals are designated as Ri. The values of Di+Ri and Di-Ri were calculated for low, medium, and upper values, and these values were transformed using the defuzzified equations given in Eqs. 11 and 12. Finally, the total interaction matrix was obtained. All criteria in the combined decision matrix were transformed with the defuzzified equations given in Eqs. 11 and 12, and Table 10 was obtained.

In order to construct interaction graphs, it is necessary to define threshold values. There is a plethora of literature on the subject of threshold values, with differing approaches proposed by various authors, including [20], [37], and [30]. The threshold value can be determined by the experts or derived from the decision matrix. If the threshold value is set

too low, the resulting map becomes excessively complex, making it difficult to display the requisite information. If the threshold value is set too high, a significant number of items will be shown to have overly complex relationships with other items. As the threshold value increases, it results in the removal of certain items or relationships from the digraph map [42]. Consequently, it is imperative to ascertain an accurate threshold value that accurately reflects the appropriate relationships. Some key threshold values have been identified, including maximum diagonal approach (0.168), matrix mean (0.201), and diagonal mean (0.149). Concurrently, the largest element in the matrix has a value of 0.268. Furthermore, the average of the largest value and the matrix mean value was calculated in order to enhance the clarity of the interactions, specifically the expert threshold (0.234). Graphs can be constructed according to the matrix mean and the defined expert threshold values.

Table 10. Total/net affecting/affected values and interaction matrix

	C1	C2	C3	C4	C5	C6	C7	C8	D	R	D+R	D-R	weight
1	0.155	**0.222**	**0.243**	0.186	**0.246**	**0.211**	**0.245**	**0.258**	1.765	1.539	3.304	0.227	0.127
2	**0.221**	0.167	**0.241**	**0.207**	**0.238**	**0.220**	**0.234**	**0.268**	1.796	1.642	3.439	0.154	0.129
3	**0.237**	**0.234**	0.158	0.196	**0.231**	0.196	0.199	**0.259**	1.710	1.610	3.320	0.101	0.127
4	**0.209**	0.196	0.188	0.136	**0.226**	0.181	0.194	**0.240**	1.570	1.484	3.054	0.087	0.122
5	0.158	**0.207**	**0.209**	0.186	0.142	0.186	0.178	**0.218**	1.484	1.662	3.146	-0.179	0.124
6	0.170	**0.208**	0.182	0.174	0.192	0.126	0.188	**0.217**	1.456	1.477	2.933	-0.022	0.119
7	0.188	0.190	0.184	0.195	0.184	0.177	0.138	**0.236**	1.491	1.596	3.087	-0.105	0.122
8	**0.201**	**0.218**	**0.204**	**0.203**	**0.204**	0.180	**0.220**	0.168	1.599	1.862	3.461	-0.263	0.130

Note: Underlined values are a threshold of 0.234, and bold values are a threshold of 0.201.

The row totals are indicated by Di, while the column totals are denoted by Ri. The D-R and D+R values are employed to ascertain the degree of influence exerted by each criterion on others and the strength of the relationship between them [41]. A positive D-R value indicates that the criteria have a greater influence and priority than others. These criteria are therefore considered to be influential criteria. Those criteria with negative D-R values are more influenced by other criteria and have a lower priority. These criteria are therefore considered to be influencing criteria. Conversely, D+R values indicate the relationship between each criterion and other criteria. Those with high D+R values are more related to other criteria, while those with low D+R values are less related to others [41].

The use of D-R and D+R scores enable the relative importance of each criterion in terms of effect-cause and the relationship between them to be determined. It can be observed that criteria with positive D-R scores have a higher effect and priority over others. In this MCDM problem, C1 (Appearance) has a higher effect on the others. In contrast, criteria with negative D-R scores are more susceptible to influence than other criteria. The C8-Speed criterion has a lower value and is more affected than the others. Those criteria with a high D+R value are more likely to interact with others. The Speed (C8) and Functionality (C2) criteria have high D+R values and are therefore more related to the others. The priorities of the criteria can be determined by calculating the vector sum of the D+R and D-R scores using the DEMATEL method. The F-DEMATEL weight calculations indicate that the most important criteria are C8 (13%), C2 (12.92%), C1 (12.69%), and C3 (12.68%). As the DEMATEL method is primarily concerned with interactions, the priority

degrees were found to be of a very similar value. The interaction diagram, which depicts the relationships between the values, is presented in Figs. 2 and 3.

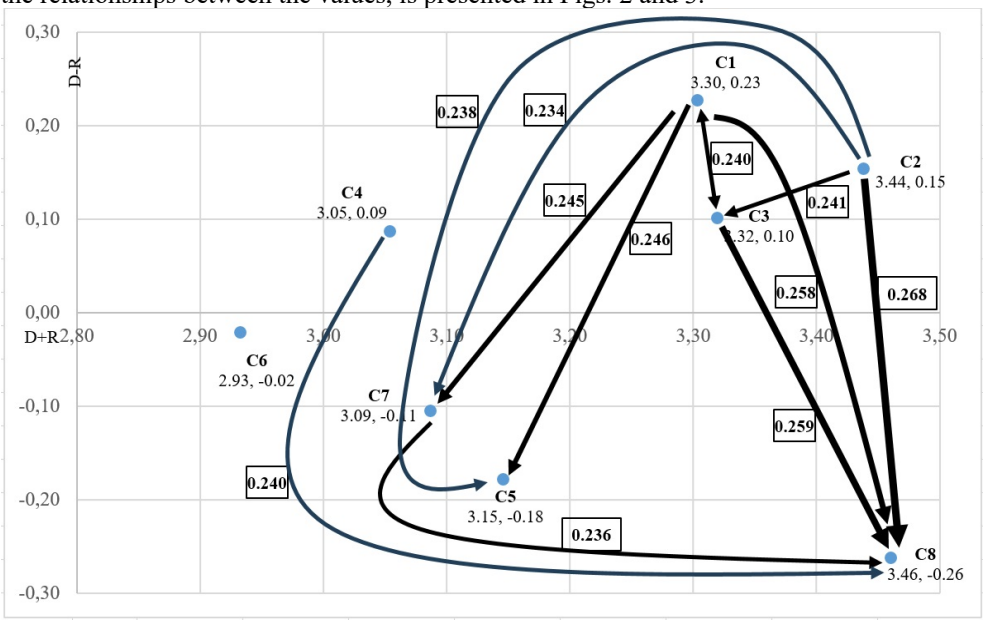

Figure 2. Interaction diagram for a threshold of 0.234

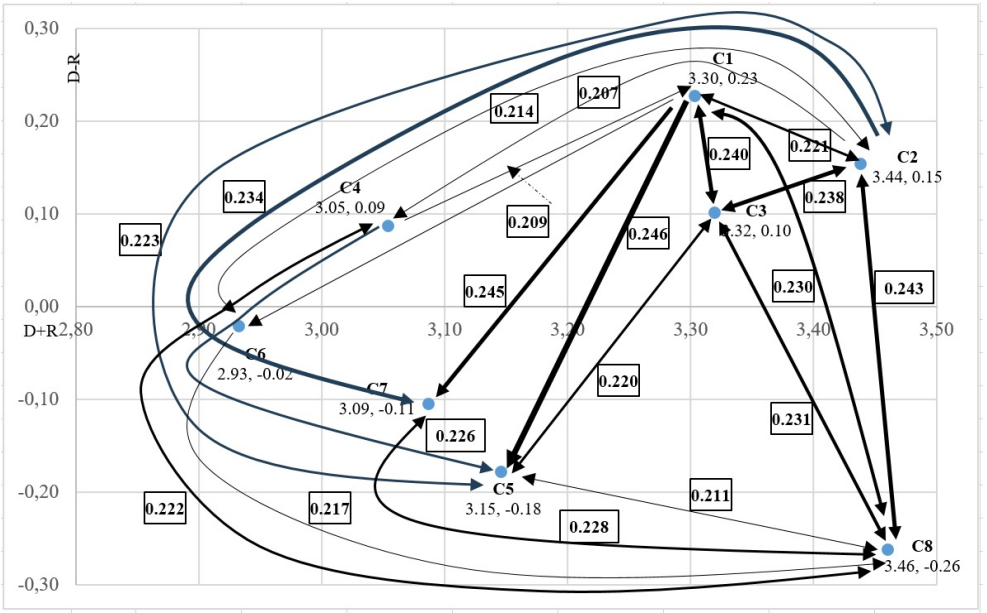

Figure 3. Interaction diagram for a threshold of 0.201

The thickness of the lines connecting the criteria in the figures has been increased in proportion to the size of the effect. Furthermore, the directions of the lines indicating the interaction between the criteria are shown on the digraph map. Concurrently, the number on the double-sided arrow between the C1 and C3 criteria, for instance, where there is mutual interaction, was determined by calculating the interaction averages (mean of 0.243 and 0.237 = 0.240). A digraph map with a reduced number of interactions and lines is generated in Figure 1 when the higher threshold value is employed. The C1-Appearance, C2-Functionality, C3-Creativity, and C8-Speed criteria are the primary actors in the interaction. Upon averaging the matrix with a slightly lower threshold value, the more complex Figure 2 is obtained. It can be posited that C1-Appearance, C2-Functionality, and C3-Creativity are essential criteria. Both figures indicate that C1-Appearance, C2-Functionality, and C3-Creativity are the primary criteria influencing the outcome. C8-Speed and C5-Reliability were identified as the criteria most affected by the aforementioned criteria.

5. Discussion

This study obtains important findings from the research and discussion of them contributes. We asked for results about working with a different method to ChatGPT in a dialog (19/07/2023).

Our question:

We did research related to ChatGPT. Our aim is to evaluate the priorities and interactions of the criteria that stand out during the use of ChatGPT, which has emerged as an artificial intelligence-based mutual dialogue robot and has been very popular recently, using Fuzzy-AHP and Fuzzy-DEMATEL methods. Eight crucial criteria are determined - Appearance, Functionality, Creativity, Security, Reliability, Conformity, Access, and Speed- in the use of ChatGPT according to the expert views made using the focus group. Reliability-23.1% and Security-21.2% were found to be more priority criteria by fuzzy AHP calculations. Appearance and functionality criteria were found to be generally affecting criteria, and speed criterion was found to be generally affected by other criteria using fuzzy DEMATEL calculations. What can you say about this research and its results?

ChatGPT's answer:

The research you conducted aims to evaluate the priorities and interactions of various criteria in the use of ChatGPT by employing Fuzzy-AHP (Analytic Hierarchy Process) and Fuzzy-DEMATEL (Decision-Making Trial and Evaluation Laboratory) methods. You have identified eight crucial criteria, namely Appearance, Functionality, Creativity, Security, Reliability, Conformity, Access, and Speed, based on expert opinions gathered through a focus group. According to your fuzzy AHP calculations, Reliability (23.1%) and Security (21.2%) emerged as the criteria with higher priority. This suggests that users consider these aspects as crucial factors when utilizing ChatGPT. Reliability refers to the system's ability to consistently provide accurate and dependable responses, while Security pertains to ensuring the confidentiality and protection of user information. Furthermore, your fuzzy DEMATEL calculations indicate that Appearance and Functionality criteria generally have a significant impact on other criteria. This implies that the perceived appearance and user interface of ChatGPT, as well as its overall functionality, play a substantial role in shaping

user experience and satisfaction. On the other hand, the Speed criterion is generally influenced by other criteria, suggesting that factors like reliability, functionality, and accessibility may affect the perceived speed of the system. Overall, this research provides valuable insights into the priorities and interrelationships of criteria in the use of ChatGPT. By employing fuzzy AHP and fuzzy DEMATEL, you have utilized robust decision-making methods that consider both subjective expert opinions and the interdependencies between criteria. The findings highlight the importance of reliability, security, appearance, functionality, and speed in the context of ChatGPT's usability and user satisfaction.

The response time was minimal, with ChatGPT providing an answer to the 127-word question in a few seconds with 252 words. However, the response provided was largely a reiteration of the original question. It has also been shown that, while the system stands out in terms of reliability, the answers it provides can be questioned regarding their absolute accuracy and realism. However, it can still be useful in terms of functionality, as it helps achieve the intended purpose and provides answers in the shortest possible time. It was not reasonable to anticipate that ChatGPT would provide a detailed, independent, and different interpretation and inference at this stage of its development. It is possible that more comprehensive and satisfactory comments will be forthcoming in the future.

Although the results were intended to be compared with the literature, this was not possible due to the absence of any previous ChatGPT study employing MCDM methods, apart from that of [31]. Indeed, this demonstrates that the study is highly original. It is also worth noting that [31] employed ChatGPT evaluation criteria (ease of use, flexibility, cost-benefit, content relevance, effectiveness, accuracy of answers, response complexity) in higher education with PROMETHEE and SAPEVO-M1 models. As the criteria employed are distinct from those utilised in the current study and the values and weights were not disclosed, a comprehensive comparison could not be conducted. All of these aspects reflect the originality of the study. Conversely, in a period when AI technologies are beginning to achieve a significant impact in every aspect of life, the ability to utilise these technologies effectively will be of value to all users. It is evident that as ChatGPT is developed, it will become increasingly useful for individuals engaged in business, engineering, education, and academia. Given that ChatGPT is capable of producing high-quality writing in a relatively short time, it has attracted considerable attention, particularly in the field of education. This has led to a great deal of excitement and some pessimistic predictions about its potential impact on other fields. In response, academic journals have recently taken action and are demanding statements declaring the use of AI. Despite its widespread popularity and acceptance, ChatGPT must also contend with certain challenges. These include the fact that it does not always produce correct answers, that it is unable to function when there is no internet, that it may harm research methods by providing convenience, and that it may endanger the jobs of some people working online. Furthermore, there are ethical and legal issues that must be considered.

6. Conclusion

The integration of artificial intelligence technologies and intelligent systems into every aspect of life is becoming increasingly prevalent. While the extent to which these

technologies can be developed is uncertain, new ones are continually being added to their capabilities, with advances being made on a daily basis. A study was conducted on ChatGPT, which is one of these systems and an application that has been frequently mentioned on every platform recently. The objective was to determine the criteria and criterion interactions in application selection, which had previously been overlooked. The study's primary focus is on the identification and analysis of criteria priority and interaction determination studies, with a particular emphasis on the utilisation of the fuzzy logic approach within the existing literature.

In the study, experts were asked to determine the criteria and select the most appropriate criteria. The selected criteria were then scored according to the methods used. In the F-AHP method, a scale of 1-9 was employed, a consistency checker was implemented, and the F-AHP results were obtained by converting the obtained values into fuzzy number equivalents. Consequently, the most significant criteria were identified as Reliability (C5-23.1%), Security (C4-21.2%), and Functionality (C2-15.3%). These three criteria correspond to a total weight of 59.6%, which represents more than half of the total. The consistency ratio (CR) was found to be 0.044, which is below the threshold of 0.1.

In studies on Internet applications, it is typical for reliability and security criteria to be given the highest priority. It is of paramount importance that individuals pay close attention to the reliability and security of the programs and applications they use on the Internet. The results of the F-DEMATEL method indicate that appearance has a greater impact on the others than speed. The criteria of appearance, functionality, creativity, and speed are of significant importance in the context of the interaction, and can be considered as essential and indispensable criteria. Thus, the initial aspect that emerges with regard to reliability is the visual appeal of the platform. The study revealed that the functionality criterion is also an important factor, given that it is a web-based application. In contrast, the speed criterion is affected by all other criteria to a degree below the threshold value. The interaction between the creativity and speed criteria with the functionality criteria demonstrates the importance of these criteria for the development of a more functional platform. The conformity criterion is only affected by other variables with a value below a low threshold. It can be posited that there is minimal interaction between this criterion and the others. Given that the F-AHP and F-DEMATEL methods employ distinct calculation procedures, no similarity was observed in the criteria weights and weight rankings. In future studies, it would be beneficial to evaluate the criteria with a range of MCDM methods, rather than solely with the F-AHP and F-DEMATEL methods. This would allow for a more comprehensive comparison of different chatbot applications. The findings of this study may be used to compare various chatbot applications, including Deepseek, Claude, Microsoft Bing, Google Gemini, Zapier, Pi, Poe, Perplexity, Youchat, Jasper Chat, HuggingChat, and Personal AI, with MCDM models.

Declaration of generative AI and AI-assisted technologies in the writing process During the preparation of this work the author(s) used [ChatGPT-3.5 / OpenAI] in order to [interpret and validate study findings]. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Declarations of competing interest Authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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