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A study on Laptop Computers Selection Problem Using the Grey Relational Analysis (GRA) Technique

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Abstract. *Many individuals nowadays find it difficult to envision their lives without computer systems. This circumstance demonstrates how crucial a functioning laptop plays in society because using laptops to "search and save data, create tables and graphs, edit images, music, video, and perform other tasks" makes people's lives simpler and more pleasant. The aggregate functionality of an informational system can be significantly impacted by the computer infrastructure. Choosing equipment with the right qualities without increasing expenses is a significant and difficult decision. This issue becomes prominent when selecting laptops and desktops, as a greater proportion of assessment criteria should be considered. In a "Multi-criteria decision-making (MCDM)" situation, the most preferred laptop needs to be selected from a range of available options. The laptop selection problem is analyzed in this study using strategies focused on "the Grey Relational Analysis (GRA) method." The rankings for the laptops are as follows: HP 17- ck1023TX is ranked 1, ASUS ROG Zephyrus M16 (2022) is ranked 2, MSI Raider GE78HX 13VH-088IN is ranked 3, ASUS ROG Strix SCAR 16 (2023) is ranked 4, Dell Alienware x17 R2 is ranked 5, HP ENVY 15-ep1087TX is ranked 6, ASUS ROG Zephyrus M16 is ranked 7, Acer Predator Helios 300 is ranked 8, and ALIENWARE m15R3 is ranked 9. The ranking order is as follows: "HP 17-ck1023TX > ASUS ROG Zephyrus M16 (2022) > MSI Raider GE78HX 13VH-088IN > ASUS ROG Strix SCAR 16 (2023) > Dell Alienware x17 R2 > HP ENVY 15-ep1087TX > ASUS ROG Zephyrus M16 > Acer Predator Helios 300 > ALIENWARE m15R3." According to the "Grey Relational Analysis (GRA) technique" used in this study, "HP 17-ck1023TX, ASUS ROG Zephyrus M16 (2022), and MSI Raider GE78HX 13VH-088IN" are the three most preferred laptops in recent times. The capacity of the SSD, RAM, graphics quality, and price of the laptop had a dominant effect on customers' preference when selecting the product.*

Keywords: *Computer hardware, laptop, SSD Capacity, RAM, Dedicated Graphic Memory, MCDM, Laptop selection.*

1. INTRODUCTION

Year after year, more people are using computers due to technical advancements. Meanwhile, new features and models for computers are continually being developed. Three basic categories can be used to assess computers: tablets, laptops, and desktop PCs [1]. Sales of desktop and personal computers have been declining, while sales of laptops and tablets have experienced temporary decreases followed by surges. It is evident how commonplace computer sales are when one considers that the average lifespan of a computer is five years. Every year, a commodity with such strong market demand introduces new qualities that require judgment to act upon. Due to the availability of various brands, models, and integrated features [2,3], this screening process is challenging. Nowadays, many individuals find it impossible to imagine their lives without computers. This circumstance demonstrates the crucial role that computers play in our daily lives, as they simplify and enhance tasks such as data search and storage, table and diagram creation, and image, audio, and video editing, among other things [4]. Individuals can communicate with millions of people around the world simultaneously, regardless of their location. The sizes and casings of individual computers are typically used for classification. One such type is the laptop, which is more popular due to its versatility, portability, and mobility. There are several laptops available on the market from various manufacturers, each with different capabilities [5]. However, they often resemble one another, making the selection of a functional laptop that meets the buyer's needs both crucial and challenging. In many technical, business, and other challenges, competing goals must be simultaneously

optimized, much like the laptop selection problem [6]. Contemporary computers, particularly laptops, include a variety of features that should be considered when selecting a computer for a specific task. Additionally, it is well recognized that more expensive hardware enables improved results, making the selection of an acceptable laptop an even more difficult decision [7]. In our everyday lives, people have numerous choices for themselves, their households, or their jobs. Occasionally, these choices involve selecting between several options or making a decision on a single one. Making choices and analyzing them is as old as humanity's history, and new methods are being developed daily [8]. The availability of options or possibilities makes the process of making judgments more challenging. In the past, people relied on their understanding to choose among options with various attributes. However, technological advancements, expanding commercial partnerships, and an abundance of similar products have made these choices more complex. To assist in decision-making, various models have been created, distinguished by different methodologies and analysis techniques [9]. The ability of "multi-criteria decision-making (MCDM) procedures" to address information overload problems makes them popular. MCDM is also a modeling tool used to tackle challenging engineering issues [10]. This study aims to identify and assess the most important factors for the "laptop selection dilemma." We have conducted these studies to shed light on the selection dilemma by using an analytical technique to determine the priority of these parameters and reveal the interrelationship between them. The laptop selection problem is analyzed in this study using strategies based on "the Grey Relational Analysis (GRA) method."

2. MATERIALS AND METHOD

"A grey system" is one that merely has the smallest number of identifiable details. The five primary pillars of the grey systems approach are "grey relational analysis (GRA), grey decision, grey programming, and grey control". "The grey systems approach," which helps address issues involving complex interactions between multiple elements and numbers, includes GRA [11]. Therefore, the GRA technique has been extensively employed to address uncertainty issues arising from discontinuous data and partial knowledge. Additionally, the GRA approach is one of the most widely used techniques for examining numerous associations between discrete data collections and for making conclusions when dealing with several attributes. The main benefits of the GRA technique are that it is one of the best ways to make judgments in a corporate context, the computations are easy to understand, and the conclusions depend on the raw data [12]. There has been extensive application of "Deng's (1982) grey systems method" in many fields. It is useful for dealing with incorrect, insufficient, and unclear information. A variation of the grey systems technique called "grey relational analysis" (GRA) can be utilized to resolve problems with intricate relationships between numerous different components and aspects [13]. Numerous MADM issues, including "hiring decisions (Olson & Wu, 2006), restoration planning for power distribution systems (Chen, 2005), inspection of integrated circuit marking processes (Jiang, Tasi, & Wang, 2002), modeling of quality function deployment (Wu, 2002), defect detection in silicon wafer slicing (Lin et al., 2006)," etc., have been effectively addressed using GRA [14]. By incorporating all the achievement similarity measures considered for each option into a fixed value, GRA can help address MADM troubles. As a result, the original issue is reduced to a judgment issue involving a single attribute. Consequently, following the GRA procedure, solutions with numerous characteristics can be simply evaluated [15]. Furthermore, a comparison sequence is created by converting the behaviors of each possibility into the primary step of GRA (Grey Relational Analysis). This phase is referred to as "grey relational generating." Based on these sequences, a "standard sequence" (ideal target sequence) is defined. Finally, the grey relational correlation between all similarity variants and the benchmark pattern is determined [16,17]. The "grey relational grade" between each comparable pattern and the benchmark pattern is then generated based on the "grey relational coefficients." The optimal variant will be the one whose converted comparable sequence has the greatest grey relational grade among the "reference sequence and itself [18].

Step 1. Design of decision matrix and weight matrix

For an MCDM problem consisting of "m alternatives and n criteria, let $D = x_{ij}$ be a decision matrix, where$x_{ij} \in R$"

$$D = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \qquad 1$$

Step 2. "Normalization of decision matrix"

Formula 2 and 3 are used, respectively, to analyze whether normalizing two data sets is better whenever the higher type is assessed or stronger when the lesser type is. The information after normalization varies from zero to one.

$$M_{ij} = \frac{N_{ij} - \min(N_{ij})}{\max(N_{ij}) - \min(N_{ij})} \quad 2$$

$$M_{ij} = \frac{\max(N_{ij}) - N_{ij}}{\max(N_{ij}) - \min(N_{ij})} \quad 3$$

Where $i, j = 1,2,3,\cdots,n$

Step 3. "$Deviation = the \max value\ after\ normalization - value\ of\ the\ current\ row$" 4

Step 4. Computation of "Gray relation coefficient"

$$C_{ij} = \frac{\Delta_{min} - \xi\Delta_{max}}{Current\ \ value - \xi\Delta_{max}}, where\ zeta\ (\xi)\ is\ distinguishing\ coefficient \quad 5$$

Step 5. Computation of "Gray relation grade"

It represents the Gray Relation Coefficient on average. After that, options are ordered using the "Gray Relation Coefficient's average" [19,20].The laptop selection problem is analyzed in this study using strategies focused on "the Grey Relational Analysis (GRA) method." Here we consider nine laptops "ASUS ROG Strix SCAR 16 (2023) (A1), MSI Raider GE78HX 13VH-088IN (A2), Acer Predator Helios 300 (A3), Dell Alienware x17 R2 (A4), HP 17-ck1023TX (A5), ASUS ROG Zephyrus M16 (A6), HP ENVY 15-ep1087TX (A7), ALIENWARE m15R3 (A8) and ASUS ROG Zephyrus M16 (2022) (A9)" as alternate options. After consideration, "SSD Capacity (MB) (C1), RAM (GB) (C2), Dedicated Graphic Memory Capacity (GB) (C3), Screen Resolution (inch) (C4), Cache (MB) (C5), Weight (kg) (C6) and Price (in rupees) (C7)" is to be used as evaluation parameters for laptop selection problem. Here "SSD Capacity, RAM, Dedicated Graphic Memory Capacity, Screen Resolution and Cache" are beneficial criteria. "Weight and Price" are taken as non-beneficial criteria.

3. ANALYSIS AND DISCUSSION

TABLE 1. The initial decision-making matrix

	C1	C2	C3	C4	C5	C6	C7
A1	1000	32	12	16	36	2.5	3,35,990
A2	2000	32	12	17	36	3.1	4,47,990
A3	1000	16	6	15.6	24	2.34	1,69,999
A4	1000	32	8	17.3	24	2.96	3,74,003
A5	2000	32	16	17.3	30	2.76	3,44,736
A6	1000	32	12	16	24	2.3	3,59,990
A7	1000	32	6	15.6	24	2.14	2,45,400
A8	1000	32	8	15.6	16	2.5	3,77,798
A9	2000	32	16	16	24	2	3,95,990

Table 1 shows the initial decision matrix for the laptop selection problem. Here we consider nine laptops "ASUS ROG Strix SCAR 16 (2023) (A1), MSI Raider GE78HX 13VH-088IN (A2), Acer Predator Helios 300 (A3), Dell Alienware x17 R2 (A4), HP 17-ck1023TX (A5), ASUS ROG Zephyrus M16 (A6), HP ENVY 15-ep1087TX (A7), ALIENWARE m15R3 (A8) and ASUS ROG Zephyrus M16 (2022) (A9)" as alternate options. After consideration, "SSD Capacity (MB) (C1), RAM (GB) (C2), Dedicated Graphic Memory Capacity (GB) (C3), Screen Resolution (inch) (C4), Cache (MB) (C5), Weight (kg) (C6) and Price (in rupees) (C7)" is to be used as evaluation parameters for laptop selection problem. Here "SSD Capacity, RAM, Dedicated Graphic Memory Capacity, Screen Resolution and Cache" are beneficial criteria. "Weight and Price" are taken as non-beneficial criteria.

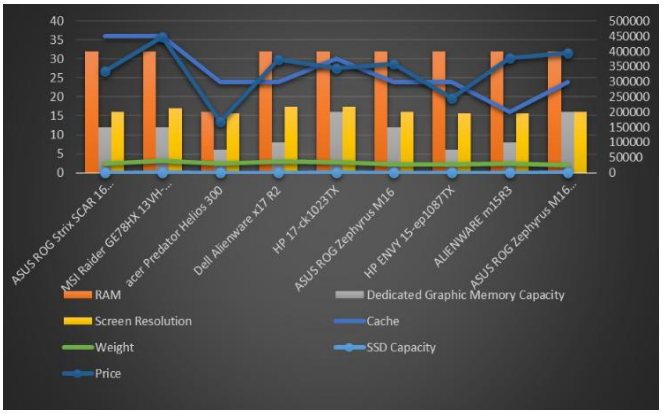

FIGURE 1. Quantitative data for alternative laptops

Figure 1 illustrates the initial decision matrix for the laptop selection problem. Here we consider nine laptops "ASUS ROG Strix SCAR 16 (2023) (A1), MSI Raider GE78HX 13VH-088IN (A2), Acer Predator Helios 300 (A3), Dell Alienware x17 R2 (A4), HP 17-ck1023TX (A5), ASUS ROG Zephyrus M16 (A6), HP ENVY 15-ep1087TX (A7), ALIENWARE m15R3 (A8) and ASUS ROG Zephyrus M16 (2022) (A9)" as alternate options. After consideration, "SSD Capacity (MB) (C1), RAM (GB) (C2), Dedicated Graphic Memory Capacity (GB) (C3), Screen Resolution (inch) (C4), Cache (MB) (C5), Weight (kg) (C6) and Price (in rupees) (C7)" is to be used as evaluation parameters for laptop selection problem. Here "SSD Capacity, RAM, Dedicated Graphic Memory Capacity, Screen Resolution and Cache" are beneficial criteria. "Weight and Price" are taken as non-beneficial criteria.

TABLE 2. Normalized matrix

0.0000	1.0000	0.6000	0.2353	1.0000	0.5455	0.4029
1.0000	1.0000	0.6000	0.8235	1.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.4000	0.6909	1.0000
0.0000	1.0000	0.2000	1.0000	0.4000	0.1273	0.2661
1.0000	1.0000	1.0000	1.0000	0.7000	0.3091	0.3714
0.0000	1.0000	0.6000	0.2353	0.4000	0.7273	0.3166
0.0000	1.0000	0.0000	0.0000	0.4000	0.8727	0.7288
0.0000	1.0000	0.2000	0.0000	0.0000	0.5455	0.2525
1.0000	1.0000	1.0000	0.2353	0.4000	1.0000	0.1871

Table 2 shows the normalized array for the laptop selection problem. This is calculated using equation 2 for beneficial criteria ("SSD Capacity, RAM, Dedicated Graphic Memory Capacity, Screen Resolution and Cache") and equation 3 for non-beneficial criteria ("Weight and Price").

TABLE 3. Deviation sequence

1.0000	0.0000	0.4000	0.7647	0.0000	0.4545	0.5971
0.0000	0.0000	0.4000	0.1765	0.0000	1.0000	1.0000
1.0000	1.0000	1.0000	1.0000	0.6000	0.3091	0.0000
1.0000	0.0000	0.8000	0.0000	0.6000	0.8727	0.7339
0.0000	0.0000	0.0000	0.0000	0.3000	0.6909	0.6286
1.0000	0.0000	0.4000	0.7647	0.6000	0.2727	0.6834
1.0000	0.0000	1.0000	1.0000	0.6000	0.1273	0.2712
1.0000	0.0000	0.8000	1.0000	1.0000	0.4545	0.7475
0.0000	0.0000	0.0000	0.7647	0.6000	0.0000	0.8129

Table 3 shows the Deviation sequence matrix for the laptop selection problem. This value is calculated using equation 4, that is Maximum value of the column of normalized value is subtracted from the current value of the normalized matrix.

TABLE 4. Grey Relation Coefficient

0.3333	1.0000	0.5556	0.3953	1.0000	0.5238	0.4557
1.0000	1.0000	0.5556	0.7391	1.0000	0.3333	0.3333
0.3333	0.3333	0.3333	0.3333	0.4545	0.6180	1.0000
0.3333	1.0000	0.3846	1.0000	0.4545	0.3642	0.4052
1.0000	1.0000	1.0000	1.0000	0.6250	0.4198	0.4430
0.3333	1.0000	0.5556	0.3953	0.4545	0.6471	0.4225
0.3333	1.0000	0.3333	0.3333	0.4545	0.7971	0.6483
0.3333	1.0000	0.3846	0.3333	0.3333	0.5238	0.4008
1.0000	1.0000	1.0000	0.3953	0.4545	1.0000	0.3808

Table 4 shows the Grey Relation Coefficient matrix for the laptop selection problem. This value is calculated using equation 5 and the zeta value is 0.5. Table 3 Deviation sequence matrix is for calculating Grey Relation Coefficient.

TABLE 5. Grey Relation Grade

Laptops	GRG
ASUS ROG Strix SCAR 16 (2023)	0.60911
MSI Raider GE78HX 13VH-088IN	0.70876
Acer Predator Helios 300	0.48655
Dell Alienware x17 R2	0.56314
HP 17-ck1023TX	0.78398
ASUS ROG Zephyrus M16	0.54405

HP ENVY 15-ep1087TX	0.55714
ALIENWARE m15R3	0.47275
ASUS ROG Zephyrus M16 (2022)	0.74725

Table 5 shows the Grey Relation Grade value for alternate laptops taken for this paper. Its average values of the Grey Relation Coefficient using table 4. Here Grey Relation Grade value for ASUS ROG Strix SCAR 16 (2023) is 1.6882, MSI Raider GE78HX 13VH-088IN is 1.3473, Acer Predator Helios 300 is 3.1621, Dell Alienware x17 R2 is 1.9894, HP 17-ck1023TX is 0.74234, ASUS ROG Zephyrus M16 is 2.6555, HP ENVY 15-ep1087TX is 2.4018, ALIENWARE m15R3 is 3.29118 and ASUS ROG Zephyrus M16 (2022) is 1.04269.

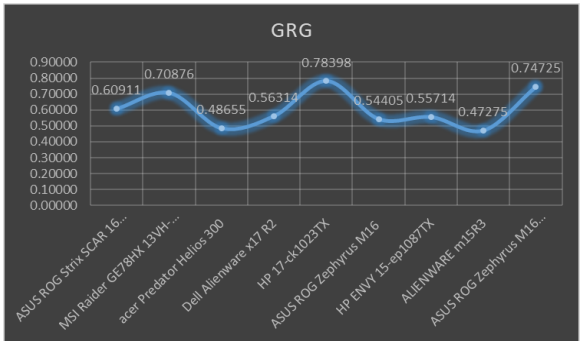

FIGURE 2. Grey Relation Grade

Figure 2 shows the graphical representation of the Grey Relation Grade value for alternate laptops taken for this paper. Its average values of the Grey Relation Coefficient using table 4. Here Grey Relation Grade value for ASUS ROG Strix SCAR 16 (2023) is 1.6882, MSI Raider GE78HX 13VH-088IN is 1.3473, Acer Predator Helios 300 is 3.1621, Dell Alienware x17 R2 is 1.9894, HP 17-ck1023TX is 0.74234, ASUS ROG Zephyrus M16 is 2.6555, HP ENVY 15-ep1087TX is 2.4018, ALIENWARE m15R3 is 3.29118 and ASUS ROG Zephyrus M16 (2022) is 1.04269.

TABLE 6. The rank

Laptops	Rank
ASUS ROG Strix SCAR 16 (2023)	4
MSI Raider GE78HX 13VH-088IN	3
Acer Predator Helios 300	8
Dell Alienware x17 R2	5
HP 17-ck1023TX	1
ASUS ROG Zephyrus M16	7
HP ENVY 15-ep1087TX	6
ALIENWARE m15R3	9
ASUS ROG Zephyrus M16 (2022)	2

Table 5 shows the rank of the alternate laptops taken for this paper by ranking Grey Relation Grade values using table 5. Here rank for ASUS ROG Strix SCAR 16 (2023) is four, MSI Raider GE78HX 13VH-088IN is 3, Acer Predator Helios 300 is 8, Dell Alienware x17 R2 is 5, HP 17-ck1023TX is 1, ASUS ROG Zephyrus M16 is 7, HP ENVY 15-ep1087TX is 6, ALIENWARE m15R3 is 9 and ASUS ROG Zephyrus M16 (2022) is 2. The ranking order is “HP 17-ck1023TX > ASUS ROG Zephyrus M16 (2022) > MSI Raider GE78HX 13VH-088IN > ASUS ROG Strix SCAR 16 (2023) > Dell Alienware x17 R2 > HP ENVY 15-ep1087TX > ASUS ROG Zephyrus M16 > acer Predator Helios 300 > ALIENWARE m15R3”.

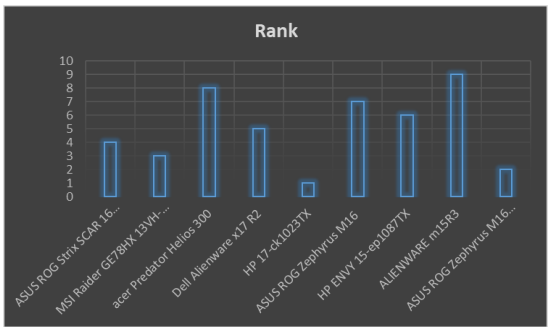

FIGURE 3. The rank of alternate materials

Figure 3 shows a graphical representation of the alternate laptops taken for this paper by ranking Grey Relation Grade values using table 5. Here rank for ASUS ROG Strix SCAR 16 (2023) is four, MSI Raider GE78HX 13VH-088IN is 3, Acer Predator Helios 300 is 8, Dell Alienware x17 R2 is 5, HP 17-ck1023TX is 1, ASUS ROG Zephyrus M16 is 7, HP ENVY 15-ep1087TX is 6, ALIENWARE m15R3 is 9 and ASUS ROG Zephyrus M16 (2022) is 2. The ranking order is "HP 17-ck1023TX > ASUS ROG Zephyrus M16 (2022) > MSI Raider GE78HX 13VH-088IN > ASUS ROG Strix SCAR 16 (2023) > Dell Alienware x17 R2 > HP ENVY 15-ep1087TX > ASUS ROG Zephyrus M16 > acer Predator Helios 300 > ALIENWARE m15R3".As per the GRA technique in this study, "HP 17-ck1023TX, ASUS ROG Zephyrus M16 (2022) and MSI Raider GE78HX 13VH-088IN" are the three most preferred laptops in recent times.

4. CONCLUSION

Due to their technological requirements for people and organizations, their value in both professional and personal settings, and their reduction of complication and error risk, laptops have become a necessity for everybody in our day and age. There are various models and capabilities available, including netbooks, ultrabooks, tablets, and smart devices. People find it more difficult to choose when more types and items diversify because of technological advancement.In "multi-criteria decision-making situations," making the proper selection between options is a key component. It is crucial to choose a product that can adapt to the needs that change quickly and consistently because of technological advancements. Several considerations and options should be considered into account while choosing a notebook, which is currently one of life's necessities.Throughout this research, the "multi-criteria decision-making technique known as the Grey Relational Analysis (GRA) approach" is utilized to solve "a laptop selection dilemma with seven criteria" that are useful in choosing a laptop between nine computers.Following the findings of the study, "HP 17-ck1023TX, ASUS ROG Zephyrus M16 (2022) and MSI Raider GE78HX 13VH-088IN" are found to be the most preferred laptops according to the evaluation based on the criteria with the GRA method.

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