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Analysis of Autonomous Maintenance Activities Using FUZZY ARAS Method

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Abstract. Automated maintenance is a maintenance strategy where machine operators monitor their equipment and make changes and perform minor maintenance tasks. The ultimate goal of total production maintenance is to improve the efficiency of a company's overall equipment. That's why it starts with autonomous maintenance. This efficient maintenance is simple and frees employees from worrying about routine maintenance tasks, allowing them to focus on specialized care programs, alternative database management, data storage, data analysis, and sensor technology. The evaluation options are preventive maintenance, condition-based maintenance, and predictive maintenance. The fuzzy ARAS method determines the optimal solution at a short range from the analysis and the negative-optimal solution at a long distance from the solution, but the relative importance of these distances is not significant. The results show that condition-based maintenance ranks first, while predictive maintenance has the lowest rank.

1. Introduction

The first pillar of a total manufacturing maintenance strategy is autonomous maintenance. If an operator is trained in autonomous maintenance, they will have thorough knowledge of routine tasks such as cleaning, lubrication, and inspection. Operators must take ownership of their equipment and the surrounding area. Before starting up a machine, regular inspections should be conducted, and operators should be trained in technical skills. An autonomous inspection schedule should be standardized. The fuzzy ARAS method is a complex world that uses comparisons of events to achieve understanding. The performance of the Fuzzy ARAS substitution method determines each alternative rate and also calculates the best alternative. The fundamentals of the fuzzy ARAS method involve the decision-making body using numerical values to consider criteria-based assessment and the relative importance of the criterion to provide evaluations of possible alternatives. In real-world problems, determining accurate weights for dependent criteria and the use of alternatives can be difficult to consider.

2. Autonomous Maintenance

The ultimate goal of autonomous maintenance is to improve the overall equipment productivity of the company, which is the main objective of maintenance. It is an efficient way to avoid worrying about routine maintenance tasks for maintenance staff, allowing them to focus on specialized maintenance plans. The maintenance training pillar aims to enhance ownership and autonomy for the pilot crew through OEE measurement and education on operator skill levels. TPM (Total Productive Maintenance) is a creative way to reduce downtime and improve productivity by helping operators deal with daily increases. It consists of six cores, which focus on solving equipment downtime, setup and repair time, idle and minimal interruptions, reduced speed, defects in performance, and reduced yield. This case study focuses on the Autonomy and Equipment Effectiveness (OEE) of a research institute in the automobile industry, explaining how autonomous maintenance reduces downtime and increases machine efficiency. Maintenance is generally considered a support system, and it is productive but does not directly make money. The main objective of this case study is to consider the current maintenance system of the company and the overall equipment productivity using a self-maintenance competency framework. Autonomous maintenance plays an important role in increasing productivity and quality in a manufacturing department by focusing on preventing major losses. The pillars of TPM use primarily six major losses to reduce the overall equipment losses and improve operational efficiency (OEE). The key to equipment performance is minimizing these losses while improving working conditions, which in turn improves productivity, quality, and profitability. High-level management implements total production maintenance, while autonomous maintenance (AM) is usually given more importance. When implementing TPM in industries, autonomous maintenance is the most important function to perform. It is an internal function implemented within the TPM to reduce the cost of maintenance. Tools and machinery require proper maintenance, and autonomous maintenance provides the right kind of help to the operator, ensuring that the machine has minor failures and continues production even if malfunctions occur, which can lead to energy losses and speed losses. The Autonomous Maintenance (AM) audit standardization sheet is established in section 4.7 to measure the effectiveness of autonomous maintenance audit work and assess the AM work. Autonomous Maintenance, also known colloquially as jitsu-hosen, is a Japanese concept that is critical to the success of Practical TPM. In practice, operators can avoid unplanned machine downtime by checking their respective devices, cleaning, lubricating, adjusting, and taking simple countermeasures. The role of production operators in AM ensures that tasks are planned, and easy daily maintenance can be performed without maintenance actions. In other words, AM is designed to allow production operators to maintain their own equipment independently without notice or instruction from the maintenance department [2]. Before proceeding with the fuquai (abnormality) detection and remediation program, 5s operations and autonomous maintenance team formation should be established. The effectiveness of autonomous maintenance can be determined by measuring Line-wide equipment effectiveness (OEE) production before and after processing. This detects and measures equipment losses based on CNC availability, efficiency, and quality ratio in an automated parts manufacturing line for machining. Continuous improvement is achieved through the Kaizen process, which is used to restore damaged components and equipment. Earlier OEE results were compared with records received and processed after each day of processing. However, the final result still fell short of the organization's goal. In practice, the average OEE results ranged from 65.8% to 80.4%, which suggests a need for wider improvement. The main objective is to formalize the target OEE rate of the corporation, as the engine is old and gradually reaches the degradation factor along the tank curve. Autonomous alignment games are completed using operators with technical assistance from security personnel. Operator's autonomous routine maintenance, which includes a thorough evaluation of the other pillars of Productivity Maintenance (TPM), is carried out by operators independently and is referred to as renewals. Autonomous Maintenance is one of the pillars of TPM, recognized in Japanese as jishu hosan. This self-contained maintenance work brings people together in teams to stabilize production and maintenance conditions and prevent equipment wear and tear. These duties are for post-shift operators, so security personnel can perform different dynamic security tasks. The focus is on achieving the goals of autonomous maintenance, program production, and implementation of projects [3]. Manufacturing firms operate in a competitive market where productivity output is key to survival. Improving production efficiency is critical as it has a direct relationship with process control and device performance. The absence of accurate productivity measurement indicators is a challenge for manufacturing companies as they cannot determine whether their production line is operating optimally. An unstable and uncontrolled process can result in non-conforming products, which ultimately affects overall production efficiency. The integration of manufacturing processes can improve productivity. This study focuses on evaluating manufacturing productivity in the tiles manufacturing industry through continuous improvement of equipment performance and process control. The Overall Equipment Effectiveness (OEE) is proposed as an indicator for measuring equipment performance. The Defining, Measuring, Analyzing, Improving, and Controlling (DMAIC) approach is used to analyze and improve performance. Statistical Process Control (SPC) is recommended as a function for monitoring process quality performance, and the seven basic tools are used to cope with manufacturing process variations. Autonomous maintenance (AM) is used to empower operators to perform additional improvement and preventive measures on their own machines, which includes polishing to improve mechanical performance. "Make in India" is a slogan that emphasizes India's growing manufacturing sector, particularly the Micro, Small, and Medium Enterprise (MSME) sector, which contributes approximately 33% to the Gross Value Output (GVO) of production. Maintenance cost can account for 15%-70% of the total cost of operating a complex system, making the implementation of autonomous maintenance in the MSME sector an important cost reduction strategy. Engineering and manufacturing autonomous maintenance involves the participation of all employees in the planning, equipment design, use, and maintenance. Encouraging maintenance autonomy through management activities promotes employee participation in maintenance. An optimal level of autonomous maintenance is scheduled to reduce inventory, taking into account capacity constraints, demand, and service requirements. The decision maker chooses the stock level to maximize equipment efficiency and safety. Autonomous maintenance (AM) is a maintenance approach that involves empowering operators to carry out routine maintenance tasks on their own equipment. The main objective of AM is to reduce the maintenance workload on technicians and improve equipment reliability and availability. However, implementing an AM program can be challenging, as it requires a significant organizational change and may face resistance from employees. One of the benefits of AM is the reduction in maintenance costs and inventory savings generated through maintenance. By comparing the relevant fixed costs with the savings generated by AM, a decision can be made on whether to implement a Total Productive Maintenance (TPM) system. A case study of a semiconductor company in Malaysia showed that implementing an AM program helped reduce technician workload and improve productivity. However, implementing AM requires a significant organizational change that may face resistance from employees. To enable AM, organizations need to consider factors such as organizational structures, worksite management systems, personnel responsibilities, performance incentive systems, competency development, and the use of information technology. Some of the difficulties faced in implementing AM include resistance to change, insufficient resources, inadequate understanding of the methodology and philosophy of AM, and sectoral barriers within a business unit. Additionally, some employees may view AM as a threat to job security, as it involves additional work or responsibilities. However, with proper planning and implementation, AM can significantly improve equipment reliability and availability, reduce maintenance costs, and improve productivity. [8].

3. Fuzzy ARAS Method

The additional charge (ARAS) introduced by Zavatskas and Zavatskas (2010) can be understood as the use of comparisons based on simple relationships of complex world phenomena (Turskis and Zavatskas, 2010). The ARAS method is used to determine the overall performance of options by calculating each trade fee for the best opportunity. According to the simple ideas of the ARAS technique, the selection panel uses numerical values on rating scales to measure the criticality of possible options and their importance in real-world problems. Determining the accuracy of substitutions and weights is largely up to the test manufacturer (Yazdani-Chamzini and Yakhchali, 2012). The fuzzy method applicability should be suitable for real-world cases; therefore, the Fuzzy Logic and ARAS Technique Fuzzy ARAS method have the shape of most real-world problems.

To demonstrate the ARAS approach, a real case study of the assessment of microclimate in confined work rooms is presented. According to the newly proposed ARAS technique, the main point of project evaluation is that the capacity complexity of the alternative determines the cost of the performance utility function [9]. State-of-the-art photo-fuzzy MCDM analysis is presented to validate nine novel photo-fuzzy ARAS techniques. Finally, Spearman's rank correlation coefficients are used to test the stability of the developed image blurring ARAS technique and PFS-based MCDM strategies [10]. A Fuzzy ARAS Approach for Locating Logistics Centers: A fuzzy level AHP method is used to find the weights. Supplier selection disturbed Turskis and Zavatskas' gray ARAS technique, and Zavatskas used the primary installment ARAS approach to find the most suitable and safe alternative. According to Keršuliene and Turskis' wise weight ratio analysis (Svara) and labor selection method, they overcome the difficulties in fuzzy ARAS techniques. A Fuzzy ARAS method is used to assess the overall performance of Lithuanian financial sectors by Baležentis et al. The state method is used to solve the employee selection problem by Dudlow et al. The ARAS machine was adopted to determine the most suitable technology for erecting pile-columns by Zavatskas et al. A combined AHP-ARAS approach was used to evaluate project managers on techniques using Zavatskas et al. Combined AHP and gray-based ARAS strategies were used for traditional projects with the help of Darskis et al. Keršuliene and Turskis proposed AHP and fuzzy weighted product version combined with ARAS techniques to evaluate fuzzy accounting authorities. The AHP-ARAS method was used to prioritize cultural historic houses by Kudut et al. Zamani et al. coordinated methods for a dairy food company brand extension strategy selection problem in ANP and Fuzzy ARAS. A sophisticated building block of AHP-ARAS using Medinekin et al. was used to solve the certification problem technique. Stanujic proposed the ARAS approach based on valued fuzzy units. Combined AHP and Fuzzy ARAS techniques were used for ranking port locations by Zavatskas et al. Liao et al.'s AHP-ARAS technique for solving the dealer selection problem is an integrative multi-phase goal programming. Note: I made a few corrections based on grammar and syntax. However, there were some parts of the text that were unclear or lacked context. Please let me know if you need further assistance. The additional charge (ARAS) introduced by Zavatskas and Zavatskas (2010) can be understood as the use of comparisons based on simple relationships of complex world phenomena (Turskis and Zavatskas, 2010). 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A state-of-the-art photo-fuzzy MCDM analysis is presented to validate nine novel photo-fuzzy ARAS techniques. Finally, Spearman's rank correlation coefficients are used to test the stability of the developed image blurring ARAS technique and PFS-based MCDM strategies [10]. A Fuzzy ARAS approach for locating logistics centers uses a fuzzy level AHP method to find the weights. Supplier selection disturbed Tarskis and Zavatskas gray ARAS technique used the primary installment ARAS approach to find the most suitable and safe alternative. According to Keršuliene and Turskis' wise weight ratio analysis (Svara) and labor selection method, it overcomes the difficulties in fuzzy ARAS techniques. A Fuzzy ARAS method is used to assess the overall performance of Lithuanian financial sectors by Baležentis et al. The state method is used to solve the employee selection problem by Dudlow et al. 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Liao et al.'s AHP-ARAS technique for solving the dealer selection problem is an integrative multi-phase goal programming. A fuzzy AHP-ARAS approach was used by Nguyen et al. to solve the conveyor selection problem. The AHP-ARAS method was used to evaluate the technologies of power generation in Lithuania by Streamkine et al. A fuzzy ARAS approach was used to assess overall performance measures of supply chain control in small and medium enterprises by Rostamzadeh et al. [11]. Fuzzy ARAS ranks the alternatives, and then the Fuzzy ARAS method is used to rank the alternatives based on their performance [16]. In another study, the fuzzy ARAS method was used to evaluate and prioritize the sustainability of green supply chain management practices in the construction industry. The criteria and sub-criteria for evaluation were determined using the Delphi method and the weights were determined using the fuzzy AHP method. The fuzzy ARAS method was then used to rank the alternatives based on their sustainability performance. The study showed that the fuzzy ARAS method is an effective tool for evaluating the sustainability of green supply chain management practices in the construction industry [17]. Overall, the fuzzy ARAS method is a useful tool for evaluating and ranking alternatives in complex decision-making problems where there are multiple criteria to consider and uncertainty is present. The method can be combined with other techniques such as fuzzy AHP and Delphi to determine criteria and weights, and can be applied in various industries such as oil and gas, shipping, and construction. [16].

TABLE 1. Alternative factors

C1	Database Management
C2	Data Storage
C3	Data Analysis
C4	Sensor Technology

Table 1 shows the Alternative factors of the C1- Database Management, C2- Data Storage, C3- Data Analysis, C4- Sensor Technology.

TABLE 2. Parameter factors **(**Evaluation Preference)

M1	Preventive Maintenance
M2	Condition Based Maintenance
M3	Predictive Maintenance

Table 2 shows the parameter factors **(**Evaluation Preference) of the M1- Preventive Maintenance, M2- Condition Based Maintenance, M3- Predictive Maintenance.

TABLE 3. Criterion Weights

Medium	**(0.4,0.6,0.7)**
High	**(0.5,0.3,1.0)**
Very High	**(0.9,0.8,1.0)**

Table 3 shows the Criterion Weights scale value of Medium, High, Very High stands for fair.

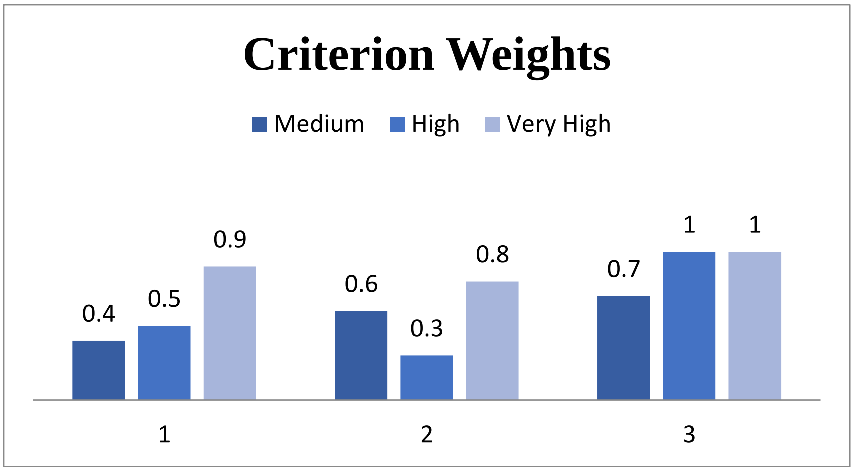

FIGURE 1. Criterion Weights

Figure 1 shows the Criterion Weights of scale value of Medium **0.4, 0.6, 0.7**; High **0.5, 0.3, 1.0**, Very High **0.9, 0.8, 1.0** stands for fair.

TABLE 4. Formula for criterion weight

	C1	C2	C3	C4
M1	H	M	H	M
M2	M	H	H	H
M3	VH	H	VH	M

Table 4 above shows the code for C1, C2, C3, and C4. Here C1 stands for Database Management, C2 stands for Data Storage, C3 stands for Data Analysis, C4 stands for Sensor Technology. Parameter factors **(**Evaluation Preference) code for M1 Stands for Preventive Maintenance, M2 Stands for Condition Based Maintenance and M3 Stands for Predictive Maintenance. H- High, M- Medium, VH- Very High.

TABLE 5. solved value of l', l, m, u', u

	l	l'	m	u'	u
C1	0.4	0.564622	0.524148	0.887904	1
C2	0.4	0.464159	0.377976	0.887904	1
C3	0.5	0.60822	0.416017	1	1
C4	0.4	0.430887	0.47622	0.788374	1

Table 5 shows the value that the table 3 substituted in table 4. The **l** column mentions that minimum of first value of all the criterion weight which the value substituted in the table 4. As same as the **l'** mention cube root of product of the first value substituted in the table 4. **m** mentions the cube root of product of the second value substituted in the table 4. **U'** mentions the cube root of product of the third value. **U** mentions that maximum of third value of all the criterion weight which the value substituted in the table 4.

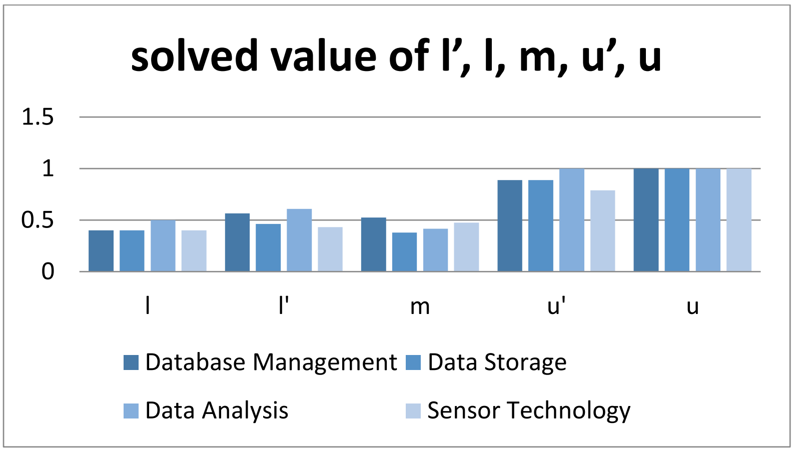

FIGURE 2. solved value of l', l, m, u', u

Figure 2 shows the graphical representation solved value of l', l, m, u', u of Database Management, Data Storage, Data Analysis, Sensor Technology Showing the l ,l', m, u', u values.

TABLE 6. Performance Rating

Performance Rating			
MG	0.4	0.6	0.7
G	0.5	0.3	1
VG	0.9	0.8	1
F	0.3	0.5	0.7

Table 6 shows the performance rating of F, MG, G, and VG. F represent fair, MG represent medium good, G represent good, VG represent the Very good. All the above value mentions the rating of the performance.

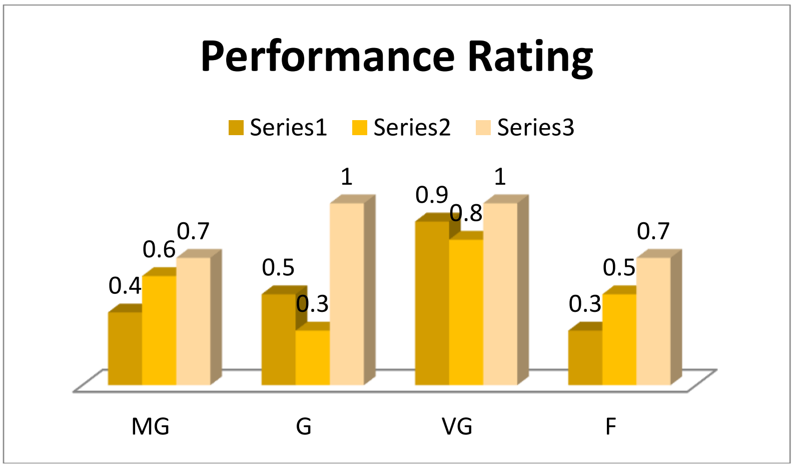

FIGURE 3. Performance Rating

Figure 3 shows the graphical representation Performance Rating of F, MG, G, and VG. F represent fair, MG represent medium good, G represent good, VG represent the Very good.

TABLE 7. Number for place which represent the column and row of the above tabulation

Optimal	C1	C2	C3	C4
M1	1,1	1,2	1,3	1,4
M2	2,1	2,2	2,3	2,4
M3	3,1	3,2	3,3	3,4

Table 7 shows the number of the place which represents the column and row of the above tabulation.

TABLE 8. Formula to calculate the Performance rating

	C1	C2	C3	C4
M1	G,VG,MG	VG,VG,MG	G,MG,G	VG,MG,VG
M2	VG,VG,VG	MG,MG,G	MG,MG,VG	G,G,MG
M3	MG,G,VG	G,VG,G	F,G,MG	VG,G,G

Table 8 represent the formula for each box in the table by substituting the table 7 value in table 8. By continuing this process for each row and column the next value will be found.

TABLE 9. solved value of l', l, m, u', u for Performance rating

	l	l'	m	u'	u
1,1	0.4	0.564622	0.524148	0.887904	1
1,2	0.4	0.686829	0.726848	0.887904	1
1,3	0.4	0.464159	0.377976	0.887904	1
1,4	0.4	0.686829	0.726848	0.887904	1
2,1	0.9	0.9	0.8	1	1
2,2	0.4	0.430887	0.47622	0.788374	1
2,3	0.4	0.524148	0.660385	0.788374	1
2,4	0.4	0.464159	0.377976	0.887904	1
3,1	0.4	0.564622	0.524148	0.887904	1
3,2	0.5	0.60822	0.416017	1	1
3,3	0.3	0.391487	0.44814	0.788374	1
3,4	0.5	0.60822	0.416017	1	1

Table 9 shows the value that the table 7 substituted in table 8. The **l** column mentions that minimum of first value of all the criterion weight which the value substituted in the table 8. As same as the **l'** mention cube root of product of the first value substituted in the table 8. **M** mentions the cube root of product of the second value substituted in the table 8. **u'** mention the cube root of product of the third value. **U** mentions that maximum of third value of all the criterion weight which the value substituted in the table 8.

TABLE 10. sum of solved value of l', l, m, u', u

A01	0.9	0.9	0.8	1	1
A02	0.5	0.686829	0.726848	1	1
A03	0.4	0.524148	0.660385	0.887904	1
A04	0.5	0.686829	0.726848	1	1

Table 10 shows the Maximum of each box with respect to the table 7. The maximum of all row and column are considered.

TABLE 11. Normalized Matrix C1

	Normalized Matrix				
A0	0.1	0.107722	0.119055	0.197093	0.25
M1	0.1	0.141155	0.131037	0.221976	0.25
M2	0.225	0.225	0.2	0.25	0.25
M3	0.1	0.141155	0.131037	0.221976	0.25

Table 9 shows the Normalized matrix of C1. In Normalized matrix the sum of u of the C1, this sum is divided for each value normalized matrix. From the normalized matrix is calculated by the weighted normalized matrix.

TABLE 12. Normalized Matrix C2

	Normalized Matrix				
A0	0.1	0.107722	0.119055	0.197093	0.25
M1	0.1	0.11604	0.094494	0.221976	0.25
M2	0.1	0.131037	0.165096	0.197093	0.25
M3	0.075	0.097872	0.112035	0.197093	0.25

Table 12 shows the Normalized matrix of C2. In Normalized matrix the sum of u of the C2, this sum is divided for each value normalized matrix. From the normalized matrix is calculated by the weighted normalized matrix.

TABLE 13. Normalized Matrix C3

	Normalized Matrix				
A0	0.1	0.107722	0.119055	0.197093	0.25
M1	0.1	0.171707	0.181712	0.221976	0.25
M2	0.1	0.107722	0.119055	0.197093	0.25
M3	0.125	0.152055	0.104004	0.25	0.25

Table 13 shows the Normalized matrix of C3. In Normalized matrix the sum of u of the C3, this sum is divided for each value normalized matrix. From the normalized matrix is calculated by the weighted normalized matrix.

TABLE 14. Normalized Matrix C4

	Normalized Matrix				
A0	0.1	0.107722	0.119055	0.197093	0.25
M1	0.1	0.171707	0.181712	0.221976	0.25
M2	0.1	0.11604	0.094494	0.221976	0.25
M3	0.125	0.152055	0.104004	0.25	0.25

Table 14 shows the Normalized matrix of C4. In Normalized matrix the sum of u of the C4, this sum is divided for each value normalized matrix. From the normalized matrix is calculated by the weighted normalized matrix.

TABLE 15. Weighted Normalized Matrix

	Weighted Normalized Matrix				
A0	0.09	0.12704	0.10483	0.221976	0.25
M1	0.04	0.079699	0.068683	0.197093	0.25
M2	0.09	0.12704	0.10483	0.221976	0.25
M3	0.04	0.079699	0.068683	0.197093	0.25

Table 15 represent the value calculation of the C1 from all the other calculation done on the above. It shows the weighted normalized matrix of C1 which represent Economic distribution.

TABLE 16. Weighted Normalized Matrix

	Weighted Normalized Matrix				
A0	0.04	0.065519	0.049529	0.197093	0.25
M1	0.04	0.09695	0.095244	0.197093	0.25
M2	0.04	0.060822	0.062403	0.175	0.25
M3	0.05	0.085854	0.054514	0.221976	0.25

Table 16 represents the value calculation of the C6 from all the other calculation done on the above. It shows the weighted normalized matrix of C6 which represent Economic distribution.

TABLE 17. Weighted Normalized Matrix

	Weighted Normalized Matrix				
A0	0.05	0.085854	0.054514	0.221976	0.25
M1	0.04	0.065519	0.049529	0.197093	0.25
M2	0.04	0.073986	0.086535	0.175	0.25
M3	0.03	0.05526	0.058723	0.175	0.25

Table 17 represent the value calculation of the C3 from all the other calculation done on the above. It shows the weighted normalized matrix of C3 which represent Economic distribution.

TABLE 18. Weighted Normalized Matrix

	Weighted Normalized Matrix				
A0	0.04	0.060822	0.062403	0.175	0.25
M1	0.04	0.09695	0.095244	0.197093	0.25
M2	0.04	0.065519	0.049529	0.197093	0.25
M3	0.05	0.085854	0.054514	0.221976	0.25

Table 18 represent the value calculation of the C4 from all the other calculation done on the above. It shows the weighted normalized matrix of C4 which represent Economic distribution.

TABLE 19. Si

	Si				
A0	0.22	0.339234	0.271275	0.816045	1
M1	0.16	0.339117	0.3087	0.788374	1
M2	0.21	0.327367	0.303296	0.769069	1
M3	0.17	0.306667	0.236433	0.816045	1

Table 19 shows the sum of all C1, C2, C3, C4 of all weighted normalized matrix with respect to all rows and column of each and every box in the tabulation.

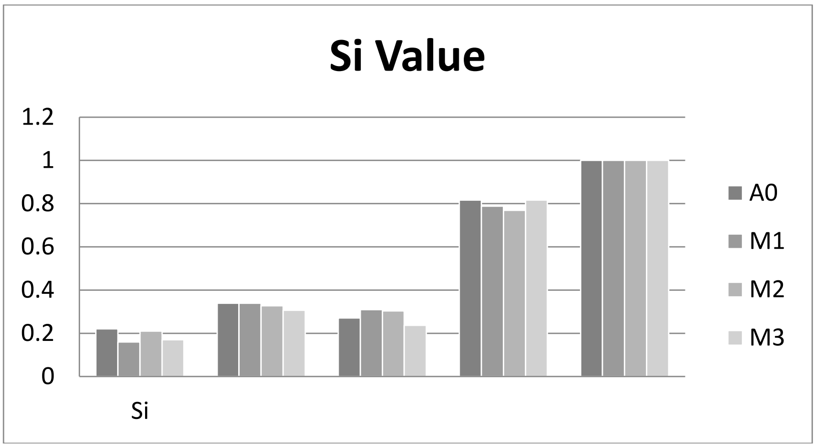

FIGURE 4. Si value

Figure 4 shows the graphical representation Si value A0, M1, M2, M3. The sum of all C1, C2, C3, C4 of all weighted normalized matrix with respect to all rows and column of each and every box in the tabulation.

TABLE 20. Si & Qi and Rank

	Si	Qi	Rank
A0	0.529311	1	
M1	0.519238	0.98097	2
M2	0.521946	0.986087	1
M3	0.505829	0.955637	3

Table 20 shows that the rank the Preventive Maintenance is in 2nd rank, Condition Based Maintenance is on 1st rank, Predictive Maintenance is on 3rd rank.

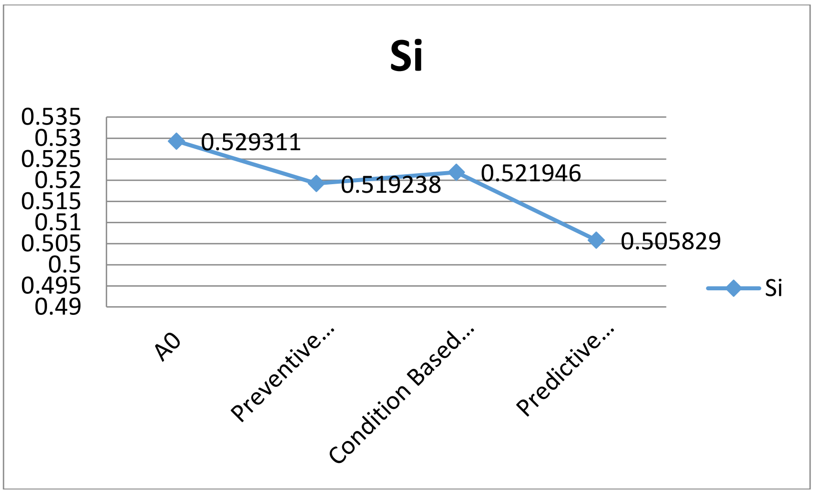

FIGURE 5. Si

Figure 5 shows the graphical representation Si value A0=0.529311, M1=0.98097, M2=0.521946, M3=0.505829.

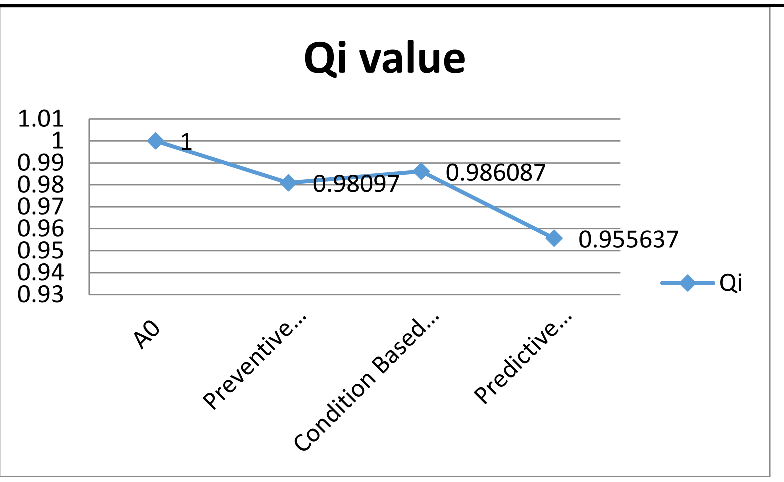

FIGURE 6. Qi

Figure 6 shows the graphical representation Qi value A0=1, M1=0.98097, M2=0.986087, M3=0.955637.

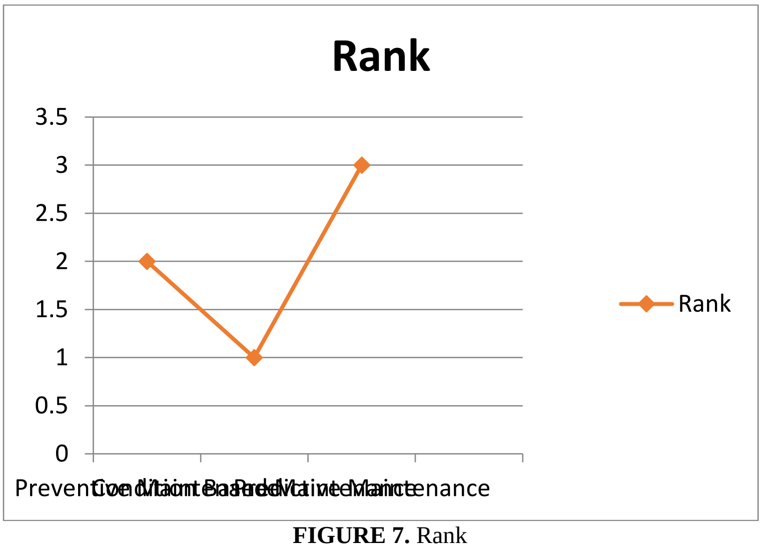

FIGURE 7. Rank

Figure 7 shows the graphical representation the Preventive Maintenance is in 2nd rank, Condition Based Maintenance is on 1st rank, Predictive Maintenance is on 3rd rank.

4. Conclusion

Auto maintenance is a maintenance strategy where mechanical operators follow their devices' monitors and make changes to their machines to perform minor maintenance tasks. The ultimate goal of care is to improve the overall equipment performance, which is essential for the company's total productivity. The reason for beginning autonomous care is unclear from the analysis. The ARAS method appears to be the best solution for short distances and negative values, but the comparison of these distances is not significant. From the results, Condition Based Maintenance ranks first, Preventive Maintenance ranks second, and Predictive Maintenance ranks third.

Reference

[1]. Acharya, A. S. E. E. M., D. H. A. I. R. Y. A. Garg, N. A. V. N. I. D. H. Singh, and U. T. K. A. R. S. H. Gahlaut. "Plant effectiveness improvement of overall equipment effectiveness using autonomous maintenance training:A case study." Int. J. Mech. Prod. Eng. Res. Dev 9 (2018): 103-112.

[2]. Min, Chen Shin, Rosmaini Ahmad, Shahrul Kamaruddin, and Ishak Abdul Azid. "Development of autonomous maintenance implementation framework for semiconductor industries." International Journal of Industrial and Systems Engineering 9, no. 3 (2011): 268-297.

[3]. Krishna Kumar TP, M. Ramachandran, Chinnasami Sivaji, Chandrasakar Raja, " Financing practices of Micro and Small Entrepreneurs using WSM MCDM Method", REST Journal on Data Analytics and Artificial Intelligence, 1(4), (2022):18-25.

[4]. Musa, Mohd Azam, Nazrul Idzham Kasim, Akhtar Razul Razali, Wan Saidin, and Wan Ahmad Najmuddin. "Improvement of Overall Equipment Effectiveness (OEE) through implementation of autonomous maintenance in crankcase line." In *Applied Mechanics and Materials*, vol. 761, pp. 165-169. Trans Tech Publications Ltd, 2015.
[5]. Kumar, Ashish, Somenath Roy Chowdhury, Tulika Chakrabarti, Hemanta K. Majumdar, Tarun Jha, and Sibabrata Mukhopadhyay. "A new ellagic acid glycoside and DNA topoisomerase IB inhibitory activity of saponins from Putranjiva roxburghii." Natural Product Communications 9, no. 5 (2014): 1934578X1400900523.
[6]. Gali, Manvitha, and Aditya Mahamkali. "A Distributed Deep Meta Learning based Task Offloading Framework for Smart City Internet of Things with Edge-Cloud Computing." Journal of Internet Services and Information Security 12, no. 4 (2022): 224-237.
[7]. Sathiyaraj Chinnasamy, P.K.Chidambaram, M. Ramachandran, Malarvizhi Mani, "Performance Analysis of Sustainable Production Using VIKOR Method", REST Journal on Advances in Mechanical Engineering, 1(1), (2022):32-39.
[8]. Azizi, Amir. "Evaluation improvement of production productivity performance using statistical process control, overall equipment efficiency, and autonomous maintenance." *Procedia Manufacturing* 2 (2015): 186-190.
[9]. Gutu, Birhanu, Genene Legese, Nigussie Fikadu, Birhanu Kumela, Firafan Shuma, Wakgari Mosisa, Zelalem Regassa et al. "Assessment of preventive behavior and associated factors towards COVID-19 in Qellam Wallaga Zone, Oromia, Ethiopia: A community-based cross-sectional study." PloS one 16, no. 4 (2021): e0251062.
[10]. Manjunath, C. R., Ketan Rathor, Nandini Kulkarni, Prashant Pandurang Patil, Manoj S. Patil, and Jasdeep Singh. "Cloud Based DDOS Attack Detection Using Machine Learning Architectures: Understanding the Potential for Scientific Applications." International Journal of Intelligent Systems and Applications in Engineering 10, no. 2s (2022): 268-271.
[11]. Sinha, Ashish Kumar, Ananda Shankar Hati, Mohamed Benbouzid, and Prasun Chakrabarti. "ANN-based pattern recognition for induction motor broken rotor bar monitoring under supply frequency regulation." Machines 9, no. 5 (2021): 87.
[12]. Kumar, Ashish, Somenath Roy Chowdhury, Kumar Kalyan Jatte, Tulika Chakrabarti, Hemanta K. Majumder, Tarun Jha, and Sibabrata Mukhopadhyay. "Anthocephaline, a new indole alkaloid and cadambine, a potent inhibitor of DNA topoisomerase IB of Leishmania donovani (LdTOP1LS), isolated from Anthocephalus cadamba." Natural Product Communications 10, no. 2 (2015): 1934578X1501000221.
[13]. Mugwindiri, Kumbi, and Charles Mbohwa. "Availability performance improvement by using autonomous maintenance–the case of a developing country, Zimbabwe." In *Proceedings of the World Congress on Engineering*, vol. 1, no. 1, pp. 5-6. 2013.
[14]. Kumawat, Gaurav, Santosh Kumar Vishwakarma, Prasun Chakrabarti, Pankaj Chittora, Tulika Chakrabarti, and Jerry Chun-Wei Lin. "Prognosis of Cervical Cancer Disease by Applying Machine Learning Techniques." Journal of Circuits, Systems and Computers 32, no. 01 (2023): 2350019.
[15]. Sathiyaraj Chinnasamy, M. Ramachandran, Chinnasami Sivaji, "A Study on Ultraviolet Radiation and Its Effects", REST Journal on Advances in Mechanical Engineering, 1(2), (2022):1-9
[16]. Rathor, Ketan, Sushant Lenka, Kartik A. Pandya, B. S. Gokulakrishna, Susheel Sriram Ananthan, and Zoheib Tufail Khan. "A Detailed View on industrial Safety and Health Analytics using Machine Learning Hybrid Ensemble Techniques." In 2022 International Conference on Edge Computing and Applications (ICECAA), pp. 1166-1169. IEEE, 2022.
[17]. Mahamkali, Aditya. "Health Care Internet of Things (IOT) During Pandemic–A Review." Journal of Pharmaceutical Negative Results (2022): 572-574.
[18]. Tasisa, Yirgalem Bekele, and Kogila Palanimuthu. "Psychosocial Impacts of Imprisonment among Youth Offenders in Correctional Administration Center, Kellem Wollega Zone, Ethiopia." Medico-legal Update 21, no. 2 (2021).
[19]. Krishna Kumar TP, M. Ramachandran, Kurinjimalar Ramu, Ashwini Murugan, "Analysis of Reverse Logistics System using COPRAS MCDM Method", REST Journal on Banking, Accounting and Business, 1(4), (2022):31-37.
[20]. McKone, Kathleen E., and Elliott N. Weiss. "Analysis of investments in autonomous maintenance activities." *Iie Transactions* 32, no. 9 (2000): 849-859.
[21]. Kamali, Ali-Mohammad, Milad Kazemiha, Behnam Keshtkarhesamabadi, Mohsan Daneshvari, Asadollah Zarifkar, Prasun Chakrabarti, Babak Kateb, and Mohammad Nami. "Simultaneous transcranial and transcutaneous spinal direct current stimulation to enhance athletic performance outcome in experienced boxers." *Scientific Reports* 11, no. 1 (2021): 19722.
[22]. Ab-Samat, Hasnida, Poh Guat Khoe, Wai Shan Liau, Hsu Fen Tan, Wan Yee Yap, and Shahrul Kamaruddin. "Implementation of autonomous maintenance in semiconductor industry: a case study." In *Advanced Materials Research*, vol. 591, pp. 708-711. Trans Tech Publications Ltd, 2012.
[23]. Vimalarani, C. I., and M. Senthilkumar. "Energy Efficient PCP protocol for k-coverage in Sensor networks." Proc IEEE (2010).
[24]. Rathor, Ketan, Keyur Patil, Mandiga Sahasra Sai Tarun, Shashwat Nikam, Devanshi Patel, and Sasanapuri Ranjit. "A Novel and Efficient Method to Detect the Face Coverings to Ensurethe Safety using Comparison Analysis." In 2022 International Conference on Edge Computing and Applications (ICECAA), pp. 1664-1667. IEEE, 2022.

[25]. Mukherjee, Tulika, Tapas Sarkar, Piyali Paul, Ajit K. Chakraborty, Parasuraman Jaisankar, and Siba Brata Mukhopadhyay. "Putralone, a novel 10α-hydroxy-25-nor D: A friedo-oleanane triterpenoid from Putranjiva roxburghii." Natural Product Communications 7, no. 4 (2012): 1934578X1200700424.
[26]. Palanimuthu, Kogila, Eshetu Fikadu Hamba Yigazu, Gemechu Gelalcha, Yirgalem Bekele, Getachew Birhanu, and Birhanu Gutu. "Assessment of Stress, Fear, Anxiety and Depression on COVID-19 Outbreak among Adults in South-Western Ethiopia." Prof.(Dr) RK Sharma 21, no. 1 (2021): 440.
[27]. Nayeemuddin, M. Ramachandran, Chinnasami Sivaji, Prabakaran Nanjundan, "A Study on Renewable Energy and Wind Power", REST Journal on Advances in Mechanical Engineering, 1(2), (2022):10-18.
[28]. Krishna Kumar TP, M. Ramachandran, Chandrasekar Raja, Ashwini Murugan, "Understanding of E-Learning Programs using WPM MCDM Method", REST Journal on Banking, Accounting and Business, 1(2), (2022):13-19
[29]. Tugengol'd, A. K., V. P. Dimitrov, L. V. Borisova, M. V. Grankov, and R. N. Voloshin. "Autonomous maintenance of digital equipment." *Russian engineering research* 39, no. 6 (2019): 510-515.
[30]. Zamani, Mahmoud, Arefeh Rabbani, Abdolreza Yazdani-Chamzini, and Zenonas Turskis. "An integrated model for extending brand based on fuzzy ARAS and ANP methods." *Journal of Business Economics and Management* 15, no. 3 (2014): 403-423.
[31]. Nielsen, Steen. "Management accounting and the concepts of exploratory data analysis and unsupervised machine learning: a literature study and future directions." Journal of Accounting & Organizational Change (2022).
[32]. Palanimuthu, Kogila, Birhanu Gutu, Leta Tesfaye, BuliYohannis Tasisa, Yoseph Shiferaw Belayneh, Melkamu Tamiru, and Desalegn Shiferaw. "Assessment of Awareness on COVID-19 among Adults by Using an Online Platform: 26 Countries View." Medico-legal Update 21, no. 1 (2021).
[33]. Fulmare, Nilima Salankar, Prasun Chakrabarti, and Divakar Yadav. "Understanding and estimation of emotional expression using acoustic analysis of natural speech." International Journal on Natural Language Computing (IJNLC) 2, no. 4 (2013): 37-46.
[34]. Asmita Mahajan, M. Ramachandran, Sathiyaraj Chinnasamy, Ashwini Murugan, "Evaluating sustainable transportation systems using Weight Product method", REST Journal on Advances in Mechanical Engineering, 1(2),(2022): 33-40
[35]. Soares, Giselle A., Tanima Bhattacharya, Tulika Chakrabarti, Priti Tagde, and Simona Cavalu. "Exploring pharmacological mechanisms of essential oils on the central nervous system." Plants 11, no. 1 (2022): 21.
[36]. Kumar, M. Senthil, and Ashish Chaturvedi. "Energy-Efficient Coverage and Prolongs for Network Lifetime of WSN using MCP." (2012).
[37]. Kumar, Ashish, Ketan Rathor, Snehit Vaddi, Devanshi Patel, Preethi Vanjarapu, and Manichandra Maddi. "ECG Based Early Heart Attack Prediction Using Neural Networks." In 2022 3rd International Conference on Electronics and Sustainable Communication Systems (ICESC), pp. 1080-1083. IEEE, 2022.
[38]. Jovčić, Stefan, Vladimir Simić, Petr Průša, and Momčilo Dobrodolac. "Picture fuzzy ARAS method for freight distribution concept selection." *Symmetry* 12, no. 7 (2020): 1062.
[39]. Aswini, S., S. Tharaniya, RJ Joey Persul, B. Avinash Lingam, and P. Kogila. "Assessment of Knowledge, Attitude and Practice on Immunization among Primi Mothers of Children." Indian Journal of Public Health Research & Development 11, no. 3 (2020): 583-587.
[40]. Krishna Kumar TP, Vimala Saravanan, M. Ramachandran, Manjula Selvam, "A Market Segmentation Assessment Weighted Scoring for Using WSM Method An Study for Different Market", REST Journal on Banking, Accounting and Business, 1(3), (2022):1-8
[41]. Karagöz, Selman, Muhammet Deveci, Vladimir Simic, and Nezir Aydin. "Interval type-2 Fuzzy ARAS method for recycling facility location problems." *Applied Soft Computing* 102 (2021): 107107.
[42]. Soni, Rajkumar, Prasun Chakrabarti, Zbigniew Leonowicz, Michał Jasiński, Krzysztof Wieczorek, and Vadim Bolshev. "Estimation of life cycle of distribution transformer in context to furan content formation, pollution index, and dielectric strength." IEEE Access 9 (2021): 37456-37465.
[43]. Chinnasami Sivaji, P.K.Chidambaram, M. Ramachandran, Ashwini Murugan, "Performance Analysis of Facade Materials using VIKOR Method", REST Journal on Advances in Mechanical Engineering, 1(2), (2022):41-49.
[44]. Nguyen, Huu-Tho, Siti Zawiah Md Dawal, Yusoff Nukman, Achmad P. Rifai, and Hideki Aoyama. "An integrated MCDM model for conveyor equipment evaluation and selection in an FMC based on a fuzzy AHP and fuzzy ARAS in the presence of vagueness." *PloS one* 11, no. 4 (2016): e0153222.
[45]. Jisha, L., P. Jayaprabha, S. Gnanawel, K. Gowtham Kumar, and P. Kogila. "Assessment of the Prevalence of Febrile Seizure and Associated Factors among Children: A Retrospective Study." EXECUTIVE EDITOR 11, no. 03 (2020): 3179.
[46]. Jayalakshmi VA, M. Ramachandran, Chandrasekar Raja, Prabakaran Nanjundan, "Investigating Human Resource Practice in a Major Company Using GRA Method", REST Journal on Data Analytics and Artificial Intelligence, 1(2), (2022):15-23.
[47]. Kumar, M. Senthil, and Ashish Chaturvedi. "A novel enhanced coverage optimization algorithm for effectively solving energy optimization problem in WSN." Research Journal of Applied Sciences, Engineering and Technology 7, no. 4 (2014): 696-701.
[48]. Rathor, Ketan, Anshul Mandawat, Kartik A. Pandya, Bhanu Teja, Falak Khan, and Zoheib Tufail Khan. "Management of Shipment Content using Novel Practices of Supply Chain Management and Big Data Analytics."

In 2022 International Conference on Augmented Intelligence and Sustainable Systems (ICAISS), pp. 884-887. IEEE, 2022.

[49]. Krishna Kumar TP, M. Ramachandran, Sathiyaraj Chinnasamy, "Investigation of Public Transportation System Using MOORA Method", REST Journal on Emerging trends in Modelling and Manufacturing, 6(4), (2020):124-129.

[50]. Jaukovic Jocic, Kristina, Goran Jocic, Darjan Karabasevic, Gabrijela Popovic, Dragisa Stanujkic, Edmundas Kazimieras Zavadskas, and Phong Thanh Nguyen. "A novel integrated piprecia–interval-valued triangular fuzzy aras model: E-learning course selection." *Symmetry* 12, no. 6 (2020): 928.

[51]. Amol Lokhande, M. Ramachandran, Chinnasami Sivaji, Manjula Selvam, "A Study on GFRP Drilling Composites Using SPSS Statistical Analysis", REST Journal on Advances in Mechanical Engineering, 1(3), (2022):1-6.

[52]. Büyüközkan, Gülçin, and Fethullah Göçer. "An extension of ARAS methodology under interval valued intuitionistic fuzzy environment for digital supply chain." *Applied Soft Computing* 69 (2018): 634-654.

[53]. Jovčić, Stefan, Vladimir Simić, Petr Průša, and Momčilo Dobrodolac. "Picture fuzzy ARAS method for freight distribution concept selection." Symmetry 12, no. 7 (2020): 1062.

[54]. Asifulla A, M. Vijayakumar, M. Ramachandran, Prabakaran Nanjundan, "Analysis of Enterprise Resource Planning system using VIKOR Method", REST Journal on Data Analytics and Artificial Intelligence , 1(2), (2022):1-6.

[55]. Kumar, R. Dinesh, C. Sridhathan, and M. Senthil Kumar. "Performance Evaluation of Different Neural Network Classifiers for Sanskrit Character Recognition." Business Intelligence for Enterprise Internet of Things (2020): 185-194.

[56]. Khan, Zuhaib Ashfaq, Hafiz Husnain Raza Sherazi, Mubashir Ali, Muhammad Ali Imran, Ikram Ur Rehman, and Prasun Chakrabarti. "Designing a wind energy harvester for connected vehicles in green cities." Energies 14, no. 17 (2021): 5408.

[57]. Ghadikolaei, Abdolhamid Safaei, and Saber Khalili Esbouei. "Integrating Fuzzy AHP and Fuzzy ARAS for evaluating financial performance." *Boletim da Sociedade Paranaense de Matemática* 32, no. 2 (2014): 163-174.