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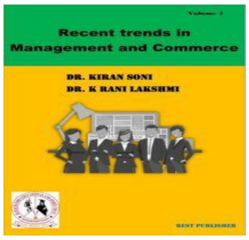

Assessment of Industrial Robots Selection in Manufacturing Industries Using the EDAS Method

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Abstract

Robots commonly utilized in manufacturing applications in industries are referred to as industrial robots. Robots are used to execute repetitive, difficult, and dangerous tasks with greater precision, accuracy, and speed. The main reason why businesses use industrial robots is to increase manufacturing productivity and reduce operational expenses. The choice of an appropriate robot necessitates careful consideration of their needs. An inappropriate robot could eventually hurt a company's ability to compete in the market. A commercial robot has several different characteristics, including mechanical weight, payload capacity, repeatability, etc. It is an MCDM challenge because of these parameters. The EDAS approach, a relatively new and mathematically powerful tool of MCDM (Multi-Criteria Decision Making), has been employed in this research. Here Industrial Robot1 (IR1) is ranked fifth, Industrial Robot2 (IR2) is ranked second, Industrial Robot3 (IR3) is first ranked, Industrial Robot4 (IR4) is fourthranked, Industrial Robot5 (IR5) is ranked seventh, Industrial Robot6 (IR6) is sixth-ranked and Industrial Robot7 (IR7) is ranked third. The result of this paper shows the best robot for industrial purposes is industrial robot 3 and industrial robot 2 and followed by industrial robot.

Keywords: Industrial robot, MCDM, maximum tip speed (MTS), repeatability (RE), and manipulator reach (MR).

Introduction

Industrial robots are crucial elements of advanced manufacturing technologies because they allow manufacturing companies to generate high-quality products affordably. All features are completed with extreme endurance, speed, and accuracy. [1]. Industrial robots, however, if considered, related to production Concerns about automation within an industry-More focus on driving systems It is clear that they are paying. Pause Without repetition it would be time-consuming for automation that can perform operations with help we can achieve our goals. [2]. In today's technologically advanced society, most professions Productivity to increase productivity Automation-driven to reduce costs Focus on improving systems are paying. High accuracy and repeat in various conditions with precision Due to the ability to repeat tasks, Robots in a wide range of fields are widely used. [3]. Industrial robots are more accurate than humans at repetitive, difficult, and risky tasks, which results in higher-quality products and more efficient production. As a result, businesses have used industrial robots in a variety of processes, including welding, spray painting, machine loading, and assembly. Industrial robots are typically pricy and diversified. [4]. With today's technological breakthroughs, the majority of industries are working to improve automated-driven systems to boost productivity and cut production costs. The choice of an appropriate robot necessitates careful consideration of their needs. An inappropriate robot could eventually hurt a company's ability to compete in the market. As a result, choosing the best robot from a variety of robots to fulfil a certain requirement and manufacturing environment has become an important and difficult task for industrial enterprises. [5]. Manufacturing Industrial Robots A long history in the field have, usually constant A considerable number of contexts Functions and tasks Quickly and efficiently, Accurate and efficient. The usage of industrial robotics is suggested by trends in the oil and gas industry to increase safety and efficiency, and reduce environmental impact. [6]. The ability to maintain, examine, and repair industrial robots remotely could enable new advancements in places that are hazardous or difficult for people to work in. This new application field emphasizes some issues with today's robots, including their poor ability to adapt to changing circumstances, lack of rich human-robot interaction, and complexity of end-user programming. [7]. There are various robots with varying capabilities and specifications for various uses. It can be challenging to choose the right robot for a certain application and industrial need. There are many robot selection techniques available. [8]. When choosing a robot, experts and credible sources weigh the decision-makers by taking their prior experiences into account. Both the decision maker's subjective preferences and objective weights that represent the relevance of the trait are taken into account. [9]. There are robots for a variety of applications with a wide range of capabilities and specifications. The variety of applications and the number of industrial robots on the market have both significantly expanded during the past few years. Given that potential users are likely to have no prior experience with a robot, the topic of robot selection is extremely pertinent. Industrial robots are frequently expensive and have a variety of features, so choosing one requires a detailed analysis and assessment of the needs. [10]. For a particular production system Choosing the best robot, Difficult for manufacturing companies is the task. by various manufacturers, Robots will continue to be added Complex, advanced features and because of the facilities, it is still has grown complex.

[11]. Before choosing a suitable robot, Product design, manufacturing process and taking into account many factors including economics should be taken. A company its Productivity of facilities and is Based on the quality of products Competitiveness, Improperly of Robots will be negatively affected by the selection. in the market, since there are so many robots, a certain one is Perfect for application and production environments Choosing one is a challenge developed as a process. [12]. In the present work, the alternatives and the attributes considered are Industrial Robot1 (IR1), Industrial Robot2 (IR2), Industrial Robot3 (IR3), Industrial Robot4 (IR4), Industrial Robot5 (IR5), Industrial Robot6 (IR6) and Industrial Robot7 (IR7). The attributes are considered load capacity (LC), maximum tip speed (MTS), repeatability (RE), memory capacity (MC) and manipulator reach (MR) and purchase cost (PC).

Materials and methods

MCDM has been a useful tool for decision-making during the past few decades. Researchers are focusing on this topic to improve MCDM techniques and close any gaps left by earlier approaches. Additionally, to make decisions that are more precise and accurate, researchers have created new, creative MCDM models. MCDM techniques are becoming more and more popular because of their innate capacity to evaluate several possibilities. [13]. The EDAS method ranks the available options based on positive and negative distances from the average solution. Based on several helpful and non-beneficial criteria, measurements of positive and negative distances were computed. The option with higher PDA (positive distance from average) values or lower NDA (negative distance from average) values is deemed preferable. [14,15]

- The decision matrix X, which displays how various options perform with certain criteria, is created.

$$D = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ x_{31} & x_{32} & \cdots & x_{3n} \end{bmatrix} \quad (1)$$

- Weights for the criteria are expressed in equation 2.

$$w_j = [w_1 \quad \cdots \quad w_n], \text{ where } \sum_{j=1}^{n}(w_1 \quad \cdots \quad w_n) = 1 \quad (2)$$

- Next criteria vice average solutions are calculated

$$AV_j = \frac{\sum_{j=1}^{n} k_{ij}}{n} \quad (3)$$

- PDA is expressed in equation 4

$$PDA_{ij} = \begin{cases} \frac{\max(0,(x_{ij}-AV_{ij})}{AV_{ij}} & | \ j \in B \\ \frac{\max(0,(AV_{ij}-x_{ij})}{AV_{ij}} & | \ j \in C \end{cases} \quad (4)$$

- The NDA is expressed in equation 5

$$NDA_{ij} = \begin{cases} \frac{\max(0,(AV_{ij}-x_{ij})}{AV_{ij}} & | \ j \in B \\ \frac{\max(0,(x_{ij}-AV_{ij})}{AV_{ij}} & | \ j \in C \end{cases} \quad (5)$$

- Using equation 2 multiplied by factors 4 and 5, respectively, the weighted sum of the positive and negative distances from the average solution for all options is normalised.

- Weighted sums of the positive and the negative distance are calculated by the equation

$$SP_i = \sum_{j=1}^{m} w_j \times PDA_{ij} \quad (6)$$

$$SN_i = \sum_{j=1}^{m} w_j \times NDA_{ij} \quad (7)$$

- Equations 8 and 9 are used to normalise the weighted sum of the positive and negative distances from the average solution for all alternatives.

$$NSP_i = \frac{SP_i}{max_i(SP_i)} \quad (8)$$

$$NSN_i = 1 - \frac{SN_i}{max_i(SN_i)} \quad (9)$$

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- The final appraisal score (ASi) for each alternative is calculated as the normalised weighted average of the positive and negative distances from the average solution for all alternatives.

$$AS_i = \frac{(NSP_i + NSN_i)}{2} \quad (10)$$

where 0 ≤ ASi ≤ 1. The alternative with the highest appraisal score is selected as the best choice among the other selective alternatives [16].

In the present work, the alternatives considered are Industrial Robot1 (IR1), Industrial Robot2 (IR2), Industrial Robot3 (IR3), Industrial Robot4 (IR4), Industrial Robot5 (IR5), Industrial Robot6 (IR6) and Industrial Robot7 (IR7). The attributes are considered load capacity (LC), maximum tip speed (MTS), repeatability (RE), memory capacity (MC) and manipulator reach (MR) and purchase cost (PC). LC, MTS, MC and MR are beneficial attributes, and PC and RE are non-beneficial attributes. The load capability of a robot refers to how much weight it can support on its wrist. The weight of any end-of-arm tooling (EOAT) and bracketing fastened to the robot wrist is also included in the definition of "payload," despite the misconception held by some that it only relates to the weight of the workpieces the robot is handling [17].The tip speed is the maximum speed at which a robot can travel in an inertial reference frame. how swiftly the robot's arm can move. The speed of the arm's end while all axes are moving, the compound speed or the angular or linear speed of each axis are all possible ways to express this. Speed is used to quantifying an axis' ability to accelerate [18].The robot's ability to repeatedly strike the same stance is known as repeatability. The term "repeatability" in robotics, as used by all industrial robot manufacturers, simply refers to the ability to return to the same location from the same direction. Thus, the effects of blowback are reduced. Multidimensional repeatability can be twice as bad or even worse than unidirectional repeatability [19]. A robot's memory capacity is defined by how many points or steps it can keep in mind while following a predetermined path [20].In robotics, a manipulator is a device that is used to move objects without the operator directly touching them. The applications were initially used to handle radioactive or biohazardous goods with robotic arms or inaccessibly. The manipulator reach operation with n places refers to the distance that a robotic manipulator can traverse to locate and pick up an object. [21]. The term "purchase cost" refers to the overall price paid for the industrial robots, including all applicable taxes, shipping charges, additional fees, and contingencies.

Analysis and Discussion

TABLE 1. Decision matrix for robot selection attributes

Robot	LC	MTS	MC	MR	RE	PC
IR1	60.000	2540.000	500.000	990.000	0.421	77.000
IR2	6.350	1016.000	3000.000	1041.000	0.151	8.200
IR3	6.800	1727.200	1500.000	1676.000	0.121	9.500
IR4	10.000	1000.000	2000.000	965.000	0.224	14.800
IR5	2.500	560.000	500.000	915.000	0.142	5.600
IR6	4.500	1016.000	350.000	508.000	0.084	7.100
IR7	3.000	1778.000	1000.000	920.000	0.124	7.400
AVJ	13.3071	1376.7429	1264.2857	1002.1429	0.1810	18.5143

Table 1 shows data for robot selection attributes. the alternatives considered are Industrial Robot1 (IR1), Industrial Robot2 (IR2), Industrial Robot3 (IR3), Industrial Robot4 (IR4), Industrial Robot5 (IR5), Industrial Robot6 (IR6) and Industrial Robot7 (IR7). The attributes are considered load capacity (LC), maximum tip speed (MTS), repeatability (RE), memory capacity (MC) and manipulator reach (MR) and purchase cost (PC). LC, MTS, MC and MR are beneficial attributes, and PC and RE are non-beneficial attributes.

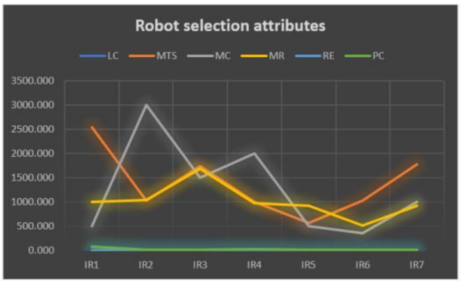

FIGURE 1. robot selection attributes

Figure 1 represents the data for robot selection attributes. the alternatives considered are Industrial Robot1 (IR1), Industrial Robot2 (IR2), Industrial Robot3 (IR3), Industrial Robot4 (IR4), Industrial Robot5 (IR5), Industrial Robot6 (IR6) and

Industrial Robot7 (IR7). The attributes are considered load capacity (LC), maximum tip speed (MTS), repeatability (RE), memory capacity (MC) and manipulator reach (MR) and purchase cost (PC). LC, MTS, MC and MR are beneficial attributes, and PC and RE are non-beneficial attributes.

TABLE 2. PDA

3.5089	0.8449	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	1.3729	0.0388	0.1657	0.5571
0.0000	0.2546	0.1864	0.6724	0.3315	0.4869
0.0000	0.0000	0.5819	0.0000	0.0000	0.2006
0.0000	0.0000	0.0000	0.0000	0.2155	0.6975
0.0000	0.0000	0.0000	0.0000	0.5359	0.6165
0.0000	0.2915	0.0000	0.0000	0.3149	0.6003

Table 2 displays the PDA. It is calculated using equation 4.

TABLE 3. NDA

0.000	0.000	0.605	0.012	1.326	3.159
0.523	0.262	0.000	0.000	0.000	0.000
0.489	0.000	0.000	0.000	0.000	0.000
0.249	0.274	0.000	0.037	0.238	0.000
0.812	0.593	0.605	0.087	0.000	0.000
0.662	0.262	0.723	0.493	0.000	0.000
0.775	0.000	0.209	0.082	0.000	0.000

Table 2 displays the NDA. It is calculated using equation 4.

TABLE 4. Weight

0.17	0.17	0.17	0.17	0.16	0.16
0.17	0.17	0.17	0.17	0.16	0.16
0.17	0.17	0.17	0.17	0.16	0.16
0.17	0.17	0.17	0.17	0.16	0.16
0.17	0.17	0.17	0.17	0.16	0.16
0.17	0.17	0.17	0.17	0.16	0.16
0.17	0.17	0.17	0.17	0.16	0.16

Table 4 shows the weights distributed to the alternatives. Here beneficial criteria load capacity (LC), maximum tip speed (MTS), memory capacity (MC) and manipulator reach (MR) have 0.17 and non-beneficial criteria repeatability (RE), and Purchase Cost (PC) have 0.16 values. The sum of weight distributed among the evaluation parameters is one.

TABLE 5. Weighted PDA

Weighted PDA						SPi
0.5965	0.1436	0.0000	0.0000	0.0000	0.0000	0.7401
0.0000	0.0000	0.2334	0.0066	0.0265	0.0891	0.3556
0.0000	0.0433	0.0317	0.1143	0.0530	0.0779	0.3202
0.0000	0.0000	0.0989	0.0000	0.0000	0.0321	0.1310
0.0000	0.0000	0.0000	0.0000	0.0345	0.1116	0.1461
0.0000	0.0000	0.0000	0.0000	0.0857	0.0986	0.1844
0.0000	0.0495	0.0000	0.0000	0.0504	0.0960	0.1960

Table 5 shows the data values of the Weighted Positive Distance from the Average and the sum of the Weighted Positive Distance from the Average. It is calculated using equation 6.

TABLE 6. Weighted NDA

Weighted NDA						SNi
0.0000	0.0000	0.1028	0.0021	0.2122	0.5054	0.8224
0.0889	0.0445	0.0000	0.0000	0.0000	0.0000	0.1334
0.0831	0.0000	0.0000	0.0000	0.0000	0.0000	0.0831
0.0422	0.0465	0.0000	0.0063	0.0380	0.0000	0.1331
0.1381	0.1009	0.1028	0.0148	0.0000	0.0000	0.3565
0.1125	0.0445	0.1229	0.0838	0.0000	0.0000	0.3638
0.1317	0.0000	0.0355	0.0139	0.0000	0.0000	0.1811

Table 6 shows the data values of the Weighted Negative Distance from the Average and the sum of the Weighted Negative Distance from the Average. Equation 7 is used to calculate SNi.

TABLE 7. NSPi and NSNi value

Robot	NSPi	NSNi
IR1	1	0

IR2	0.480496	0.83777
IR3	0.432645	0.89892
IR4	0.177027	0.83818
IR5	0.197367	0.56656
IR6	0.249124	0.55762
IR7	0.264791	0.77974

Table 7 shows values of NSPi and NSNi values calculated from Tables 5 and 6 respectively. It is calculated using equations 8 and 9.

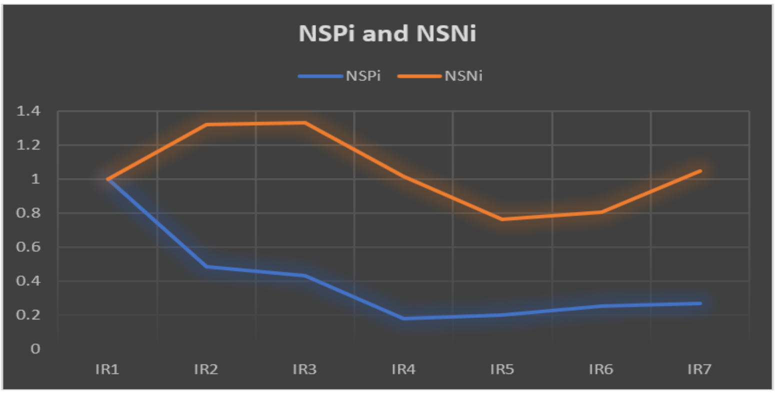

FIGURE 2. NSPi and NSNi value

Figure 2 shows a graphical representation of values of NSPi and NSNi values calculated from Tables 5 and 6 respectively. It is calculated using equations 8 and 9.

TABLE 8. ASi

Robot	**ASi**
IR1	0.5000
IR2	0.6591
IR3	0.6658
IR4	0.5076
IR5	0.3820
IR6	0.4034
IR7	0.5223

Table 8 shows the final appraisal score of alternative robots calculated by using equations 8,9 and 10. Here Industrial Robot1 (IR1) is 0.5000, Industrial Robot2 (IR2) is 0.6591, Industrial Robot3 (IR3) is 0.6658, Industrial Robot4 (IR4) is 0.5076, Industrial Robot5 (IR5) is 0.3820, Industrial Robot6 (IR6) is 0.4034 and Industrial Robot7 (IR7) is 0.5223.

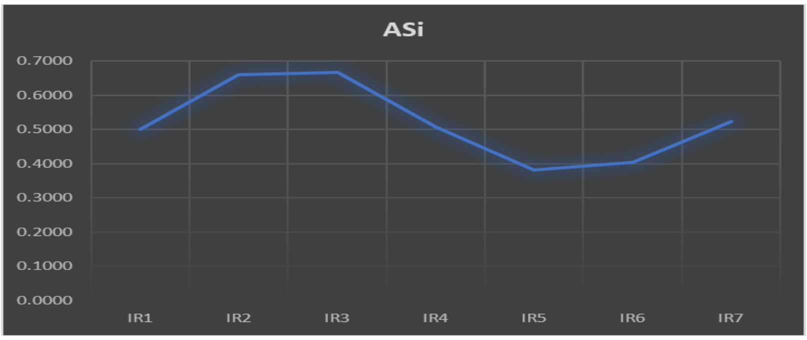

FIGURE 3. final appraisal score of alternative robots

Figure 3 illustrates the final appraisal score of alternative robots calculated by using equations 8,9 and 10. Here Industrial Robot1 (IR1) is 0.5000, Industrial Robot2 (IR2) is 0.6591, Industrial Robot3 (IR3) is 0.6658, Industrial Robot4 (IR4) is 0.5076, Industrial Robot5 (IR5) is 0.3820, Industrial Robot6 (IR6) is 0.4034 and Industrial Robot7 (IR7) is 0.5223.

TABLE 8. Rank

Robot	Rank
IR1	5
IR2	2
IR3	1
IR4	4
IR5	7

IR6	6
IR7	3

Table 9 shows the final rank of alternative robots calculated by using equations 8,9 and 10. Here Industrial Robot1 (IR1) is ranked fifth, Industrial Robot2 (IR2) is ranked second, Industrial Robot3 (IR3) is first ranked, Industrial Robot4 (IR4) is fourthranked, Industrial Robot5 (IR5) is ranked seventh, Industrial Robot6 (IR6) is sixth-ranked and Industrial Robot7 (IR7) is ranked third.

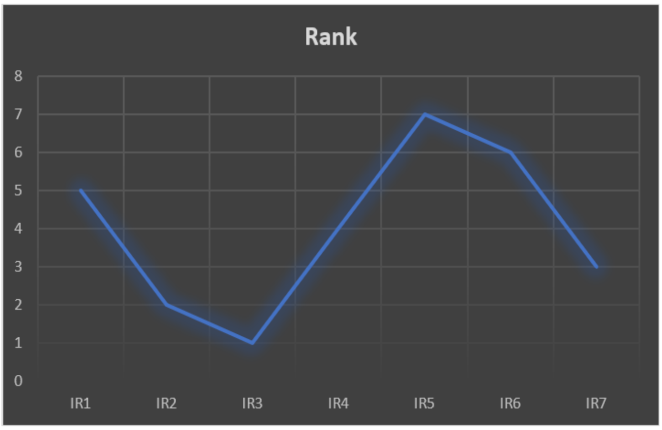

TABLE 4. The rank of alternative robots

Figure 4 shows a graphical representation of the final rank of alternative robots calculated by using equations 8,9 and 10. Here Industrial Robot1 (IR1) is ranked fifth, Industrial Robot2 (IR2) is ranked second, Industrial Robot3 (IR3) is first ranked, Industrial Robot4 (IR4) is fourthranked, Industrial Robot5 (IR5) is ranked seventh, Industrial Robot6 (IR6) is sixth-ranked and Industrial Robot7 (IR7) is ranked third. The result of this paper shows the best robot for industrial purposes is industrial robot 3 and industrial robot 2 and followed by industrial robot 7.

Conclusion

Since more than five decades ago, industrial robots have been widely used in the manufacturing industry to perform operations including stacking, casting, painting, sorting, welding, component soldering, and others. The primary benefit of an industrial robot, as highlighted by this use scenario, is its ability to consistently and precisely accomplish jobs at scales that are challenging for humans. Specialized engineers programme the robots for their upcoming tasks at the commissioning of a factory or when the line is re-tasked. It can take up to two years to commission a system, and the first year of production following that requires thorough fine-tuning. There are robots for a variety of applications with a wide range of capabilities and specifications. The variety of applications and the number of industrial robots on the market have both significantly expanded during the past few years. It can be challenging to choose the right robot for a certain application and industrial need. The EDAS approach, a tool of MCDM has been employed in this research. The findings of this study demonstrate that Industrial Robot 3 and Industrial Robot 2 are the best robots for industrial applications, with Industrial Robot 7 coming in second.

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