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Contents

Project Idea Selection in an Automotive R&D Center

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Abstract. R&D project selection is one of the most important issues for an R&D center. Evaluating more than one project in terms of different criteria, selecting and implementing the most appropriate project is very critical for both the company's profit and the sustainability of the project. The project selection process is handled by different processes in companies. Due to the importance of this issue, companies adopt a selection process in line with their own strategies. In this study, an application was carried out with the fuzzy TOPSIS method to evaluate alternative project ideas that will be an R&D project in the R&D center of an automotive company. 4 different criteria were evaluated by experts for 6 different project ideas. With the implementation realized as a result of expert evaluations, a priority order was obtained for 6 project ideas. In practice, as a result of the evaluation, the alternative project P5 with the highest value in the ranking is selected as the next R&D project to be started.

Keywords: Project selection · fuzzy TOPSIS · R&D · automotive

1 Introduction

Nowadays, large-scale companies should attach importance to R&D activities in order to achieve growth in market shares and to be a leading company by following the agenda in line with the dynamics of the sector in which they operate [1]. While determining the strategies of the companies, it is very important to ensure the right distribution of resources, especially in terms of labor and financial resources, to the right projects [2]. In order to make this evaluation correctly, the company must analyze the resources it has correctly, evaluate the details of alternative projects correctly, and then make choices among these alternatives, taking into account the available resources. R&D project selection and financing decisions are critical for the firm [2].

The difficult part in these elections; ensuring that the organization chooses projects that will lead it to success, projects with a positive cost/benefit, and keeping a priority list of projects for future technologies that will increase the organization's chances of success. Scope and strategic alignment will help stakeholder engagement especially for these projects. In the project evaluation, many different criteria such as strategic suitability, technical feasibility, capacity, project cost and risks are considered. The risks in

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the selection of these projects are quite high, as the selection of unsuitable projects in the wrong evaluation results will cause significant financial, temporal and human resource losses for the companies [1]. Decision-making can be considered as a complex process, since there are multiple stages in this process, different decision-making groups are involved, and there are conflicting goals for different purposes [3]. Various studies have been conducted on the way organizations make these decisions [3–6]. Due to the uncertainty and different criteria in the projects, Golabi [7] conducted a study related to the maximization of the total values of the projects by using the multi-featured utility theory with integer linear programming. Bard et al. [8] worked on a decision support system to evaluate projects. Stewart [9] introduced a decision support system for a nonlinear optimization in portfolio planning. Traditionally, net present value (NPV), internal rate of return (IRR), and payback period have been used extensively as investment valuation techniques. Iyigium [10] proposed a decision support system for project selection using the Delphi technique. Additionally, Turner and Cochrane [11] published a study of well-defined projects and methods. Chui and Chan [12] proposed a method that evaluates the conditions for the success or failure of an R&D project and uses the net present value. However, there has always been a need to add non-quantitative criteria to the studies in addition to the mathematical studies carried out. For this reason, the multi-criteria decision-making technique started to be used for project selection in the following years. Saaty [13] introduced Analytical Hierarchy Process (AHP) for a method of multi-criteria decision-making. Liberatore [14] created a spreadsheet for project evaluation based on AHP. Brenner [15] proposed a method using the systematic project selection process using AHP for Air Products.

Considering these studies, classification has been made for decision models in project selection; scoring, mathematical programming, economic model, decision analysis, artificial intelligence, and portfolio optimization [4]. However, since the R&D project selection process is a decision-making problem that requires considering many interrelated and contradictory criteria, the use of multi-criteria decision-making methods has taken its place in the literature in order not to overlook the situations that may cause errors, to manage uncertainties correctly, and to evaluate more than one alternative criterion [16].

In this study, an application is conducted to evaluate the ideas of the R&D projects that will be started in the R&D center of an automotive company and the project selection. This application uses the fuzzy TOPSIS method, which is one of the multi-criteria decision-making methods. The linguistic equivalents of the evaluation of the criteria used in the selection of the projects by the experts were shown with fuzzy triangular numbers and the project selection is utilized with the fuzzy TOPSIS method. The main reason for the use of fuzzy triangular numbers in practice is that these numbers are easier to respond to linguistic evaluations, the sensitivity of the numbers is higher, and they provide ease of operation in terms of real application compared to other fuzzy numbers.

2 Material and Methods

2.1 Fuzzy Approach

Classical sets are not always sufficient when it comes to linguistic variables in decision-making. Linguistic variables are very useful in situations where there is complexity and there are no clear results [17]. It is not entirely clear what these expressions will mean quantitatively. In this case, fuzzy logic comes into play and dealing with fuzzy numbers can meet the situation.

In classical sets, an object is either a member of a set or not. In fuzzy sets, on the other hand, there are different degrees of membership to the set. In this way, objects can provide membership to sets. In classical set concept, if an object is a member of a set, its membership degree is evaluated as 1, otherwise it is evaluated as 0. No value other than these two values can be considered. In fuzzy sets, it is possible to talk about different values between 1 and 0 values. In fuzzy sets, the membership degree is the name given to each value between 0 and 1. The changes given under each of these are called membership functions. Objects gathered under membership functions have different membership degrees according to their importance.

In this study, triangular membership function is used. In Fig. 1, the triangular membership function and the elements of the triangular fuzzy set are defined as $\tilde{A} = (a, b, c)$ function [18]. Accordingly, the membership function $\tilde{A}$ is determined as $\mu\tilde{A}: x \rightarrow [0,1]$.

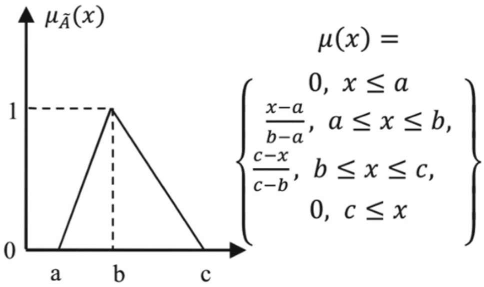

Fig. 1. Triangle Membership Function [19]

2.2 Fuzzy TOPSIS

TOPSIS is one of the most widely used multi-criteria decision-making techniques developed by Hwang and Yoon [20]. The method provides the evaluation of alternatives according to ideal solutions with the Euclidean distance approach. While looking at ideal solutions, it aims to choose the solution closest to the positive ideal solution and the farthest from the negative ideal solution. Fuzzy TOPSIS, on the other hand, is a method used in the evaluation of fuzzy environment developed by Chen [17]. The fuzzy TOPSIS method is useful for solving problems where there are uncertainty and more than one decision maker. In this method, as mentioned before, linguistic expressions are mostly used because there is uncertainty. Decision makers make their evaluations using linguistic expressions, and then these evaluation results are processed by converting them into trapezoidal or triangular fuzzy numbers. The fuzzy TOPSIS steps are as follows [17];

Step 1: The criteria and alternatives clusters are created by the decision makers. Linguistic expressions are used in the evaluation of alternative criteria and determination of weights. The five-point Likert-type linguistic scale used in this study is as shown in Table 1 [20].

Table 1. Fuzzy Evaluation Scores for Alternatives [21].

Linguistic Scale	Triangular Fuzzy Scale
Very unimportant	(0, 0, 0,25)
Unimportant	(0, 0.25, 0,5)
Moderately important	(0.25, 0.5, 0,75)
Important	(0.5, 0,75, 1)
Very important	(0.75, 1, 1)

Step 2: The evaluation results of the decision makers using linguistic expressions are converted into fuzzy numbers using Table 1. Then, using Eq. (1), alternative evaluations of the decision makers are made according to each criterion.

$$\widetilde{x_{ij}} = \frac{1}{K}[\tilde{x}_{ij}^1(+)\tilde{x}_{ij}^2(+)\ldots(+)\tilde{x}_{ij}^K] \tag{1}$$

Step 3: The alternative weights, and fuzzy degrees are obtained according to each criterion, and the fuzzy multi-criteria decision-making matrix is as in Eq. (2).

$$D = \begin{bmatrix} \widetilde{x_{11}} & \ldots & \widetilde{x_{1n}} \\ \ldots & \ldots & \widetilde{x_{2n}} \\ \widetilde{x_{m1}} & \ldots & \widetilde{x_{mn}} \end{bmatrix} \tag{2}$$

The linguistic expressions $\left(\widetilde{X_{ij}}\right)$ are expressed with triangular fuzzy numbers like $\left(\widetilde{X_{ij}}\right) = \left(a_{ij}, b_{ij}, c_{ij}\right)$.

Step 4: The normalized fuzzy matrix is expressed with $\tilde{R}$ using Eq. (3). Normalization process is performed using Eqs. (4)–(7). The aim here is to transform the numbers into triangular fuzzy numbers normalized between [0,1].

$$\tilde{R} = \left[\tilde{r}_{ij}\right]mxn \tag{3}$$

Decision criteria are divided into two as benefit and cost oriented. Here, it is assumed that B shows the benefit criteria and C shows the cost criteria;

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right), j \in B; \tag{4}$$

$$\tilde{r}_{ij} = \left(\frac{a_j}{c_{ij}^*}, \frac{a_j}{b_{ij}^*}, \frac{a_j}{a_{ij}^*}\right), j \in C; \quad (5)$$

$$c_{ij}^* = \max_i c_{ij}, j \in B \quad (6)$$

$$a_j^- = \min_i a_{ij}, j \in C \quad (7)$$

Step 5: After the normalization process, a weighted normalized fuzzy decision matrix is created by using different weights for each criterion, if any, or by using equal weights for each criterion.

$$\tilde{V} = \left[\tilde{v}_{ij}\right] mxn, \ \ i = 1, 2, 3, \ldots, m, \ \ \ j = 1, 2, 3, \ldots, n \quad (8)$$

$$\tilde{v}_{ij} = \tilde{r}_{ij}(x)\tilde{w}_j \quad (9)$$

Step 6: Considering the weighted normalized fuzzy decision matrix, the elements $\left(\widetilde{v_{ij}}\right)$, $\forall i, j$ normalized triangular positive fuzzy numbers are expressed in the range [0,1].

The fuzzy positive ideal solution $(FPIS, A^*)$ and the fuzzy negative ideal solution $(FPIS, A^-)$ are defined using Eqs. (10) and (11).

$$A^* = (\tilde{v}_1^*, \tilde{v}_2^*, \ldots, \tilde{v}_n^*) \quad (10)$$

$$A^- = (\tilde{v}_1^-, \tilde{v}_2^-, \ldots, \tilde{v}_n^-) \quad (11)$$

$$\tilde{v}_j^* = (1, 1, 1) \text{ and } \tilde{v}_j^- = (0, 0, 0), j = 1, 2, 3, \ldots, n$$

Step 7: The distances of each alternative from A* and A$^-$ are calculated (d_i^* and d_i^-) using Eqs. (12) and (13).

$$d_i^* = \sum\nolimits_{j=1}^{n} d(\tilde{V}_j, \tilde{V}_j^*), i = 1, 2, \ldots, m \quad (12)$$

$$d_i^- = \sum\nolimits_{j=1}^{n} d(\tilde{V}_j, \tilde{V}_j^*), i = 1, 2, \ldots, m \quad (13)$$

Step 8: The closeness coefficients of each alternative are calculated using Eq. (14) to determine the alternative ranking.

$$cc_i = \frac{d_i^-}{d_i^- + d_i^*}, \ \ i = 1, 2, \ldots, m \quad (14)$$

According to these calculated values, the one with the highest closeness degrees in the ranking can be considered as selected.

3 Case Study

This application was carried out for the selection of projects to be started in the R&D center of an automotive company established in Türkiye. The fuzzy TOPSIS method was used for problem solving. The use of linguistic expressions and the absence of clear values in the fuzzy TOPSIS method made it easier for the experts to evaluate the projects during the implementation. In this way, the selection was made by obtaining objective evaluations by the experts.

Project evaluation criteria used in practice are expressed by the set K, $K = \{K_1, K_2, K_3, K_4\}$. As the evaluation criteria of the projects; the impact of the project (K1), the cost of the project (K2), the feasibility of the project (K3) and the added value (K4) in terms of innovation, which is considered as the innovative aspect of the project, were taken into consideration. The set of alternative projects is denoted by P, $P = \{P_1, P_2, P_3, P_4, P_5, P_6\}$. In this application, 6 new project ideas were evaluated in total.

The evaluation of the relationship between alternative project ideas and the criteria was performed by 7 experts working in different fields in the R&D center for a long time, using the linguistic expressions in Table 1. Evaluations of experts in linguistic variables is given in Table 2.

Table 2. Evaluations of Experts in Linguistic Variables

Alternative/Criteria	K1	K2	K3	K4
P1	Very important	Unimportant	Moderately important	Very important
P2	Moderately important	Moderately important	Very important	Unimportant
P3	Moderately important	Moderately important	Moderately important	Unimportant
P4	Important	Moderately important	Moderately important	Important
P5	Moderately important	Unimportant	Moderately important	Important
P6	Moderately important	Moderately important	Moderately important	Important

Table 2 shows the degree of importance of the project alternatives according to the criteria. To apply this to fuzzy TOPSIS, the equivalent of the alternative-criteria evaluation with linguistic language for fuzzy numbers is given in Table 3.

As a result of the comparison of the criteria used in the project evaluation with each other, it was decided that their weights were equal and it was taken as 0.25 for each criterion. Equations (8) and (9) are calculated to obtain weighted fuzzy decision matrix. Then, the weighted fuzzy normalized decision matrix is obtained by the weighting process (see Tables 4–5).

Table 3. Equivalent of Table 2 for Fuzzy Numbers

Weight	0,25			0,25			0,25			0,25		
	K1			K2			K3			K4		
P1	0,75	1	1	0	0,25	0,5	0,25	0,5	0,75	0,75	1	1
P2	0,25	0,5	0,75	0,25	0,5	0,75	0,75	1	1	0	0,25	0,5
P3	0,25	0,5	0,75	0,25	0,5	0,75	0,25	0,5	0,75	0	0,25	0,5
P4	0,5	0,75	1	0,25	0,5	0,75	0,25	0,5	0,75	0,5	0,75	1
P5	0,25	0,5	0,75	0	0,25	0,5	0,25	0,5	0,75	0,5	0,75	1
P6	0,25	0,5	0,75	0,25	0,5	0,75	0,25	0,5	0,75	0,5	0,75	1

Table 4. Weighted Fuzzy Normalized Decision Matrix for K1-K2

	K1			K2		
P1	0.090951	0.156174	0.242536	0	0.058926	0.25
P2	0.030317	0.078087	0.181902	0.066815	0.117851	0.375
P3	0.030317	0.078087	0.181902	0.066815	0.117851	0.375
P4	0.060634	0.11713	0.242536	0.066815	0.117851	0.375
P5	0.030317	0.078087	0.181902	0	0.058926	0.25
P6	0.030317	0.078087	0.181902	0.066815	0.117851	0.375

Table 5. Weighted Fuzzy Normalized Decision Matrix for K3-K4

	K3			K4		
P1	0.032009	0.083333	0.032009	0.083333	0.032009	0.083333
P2	0.096028	0.166667	0.096028	0.166667	0.096028	0.166667
P3	0.032009	0.083333	0.032009	0.083333	0.032009	0.083333
P4	0.032009	0.083333	0.032009	0.083333	0.032009	0.083333
P5	0.032009	0.083333	0.032009	0.083333	0.032009	0.083333
P6	0.032009	0.083333	0.032009	0.083333	0.032009	0.083333

Equation (10)–(13) was used to measure the distances of the weighted fuzzy normalized decision matrix from the ideal negative and ideal positive solutions. As a result of calculating the relative closeness to the ideal solutions, the values were calculated by using Eq. (14) for the closeness coefficient values of the alternatives for the ranking. The closeness coefficients and rankings of the alternatives are given in Table 6.

As can be seen from Table 6, the P5 was found to be the first project to be initiated by the R&D department.

Table 6. Closeness Coefficient of Alternatives and Ranking

Alternative	c_i	Ranking
P1	0.582059	2
P2	0.456326	6
P3	0.459195	5
P4	0.504535	4
P5	0.620146	1
P6	0.551704	3

4 Conclusion

In this study, Fuzzy TOPSIS method was conducted to select the best R&D projects in the R&D center of an automotive company. The feasibility of the project, the cost of the project, the impact of the project and the contribution of the project to the innovation criteria are evaluated by experts for 6 projects that were considered as alternatives in practice. Since these evaluation results are expressed linguistically, their equivalents with fuzzy numbers are taken into account in the application of the method. With the ranking obtained as a result of the application, the P5 was found to be the first project to be initiated by the R&D department.

R&D project selection evaluation can be performed with other decision-making methods such as fuzzy TOPSIS method in future studies. Project selections can be utilized by using 7-likert-type different scales instead of the 5-point likert scale.

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Societies Becoming the Same: Visual Representation of the Individual via the Faceapp: Application

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Abstract. Standardized perceptions of beauty have always existed through bodies, which are expressions of our characters and identities. As societies have changed, these perceptions have changed shape along with societies. But in a globalizing world with social media, beauty standards also tend to go global. In this direction, the sense of beauty and the way of life of Western societies have been positioned as the goal sought to be reached in the whole world. Therefore, having slanted eyes or black skin has been declared ugly, beyond racism, because it does not fit the ideal perception of beauty.

In this study, this ideal beauty, which is about the whole body and self, is evaluated through the face editor applications applied to the portraits in which identities and characters are revealed. In this context, FaceApp: Face Editor application, one of the most popular face-changing and editing applications, is taken as an example.

Such applications based on machine learning and artificial intelligence take advantage of the user's location, which is also data for them.

The issue of protecting personal data, which is one of the biggest problems, and the possibility of it, as well as the fact that it is becoming increasingly difficult to distinguish between real and fake in a world centered on commodification, will be discussed.

This study, in which the descriptive analysis method is used by examining the data, aims to draw attention to the current problems of the society that has become identical in the effort of differentiation and the causes of these problems.

Keywords: FaceApp · face editor · machine learning · Homogeneous Society

1 Introduction

Standardized perceptions of beauty have always existed through bodies, which are expressions of our characters and identities. As societies have changed, these perceptions have changed shape along with societies. But in a globalizing world with social media, beauty standards also tend to go global. In this direction, the sense of beauty and the way of life of Western societies have been positioned as the goal sought to be reached in the whole world. Therefore, having slanted eyes or black skin has been declared ugly, beyond racism, because it does not fit the ideal perception of beauty.

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As Kaşıkara points out, the desire to be admired, which is defined as the desire of individuals to receive positive feedback from others in many areas of their lives to transform their perceptions about themselves into positive ones, to feel good about themselves, to satisfy their needs for love and respect, has turned into an effort to create visual satisfaction through their bodies (Kaşıkara 2017, p. 53). Social tastes have always existed and influenced people's individual tastes. This common understanding, which is shaped by many factors, continues to transform with the effect of globalization (Gürler 2018, p. 143).

2 Admiration Instinct of Societies and Portraiture

Nowadays, sharing on social media, especially selfies, has become a daily routine and this situation has been positioned as a result of our age. However, in the past, people who first competed to have their portraits drawn then tried to make their self-portraits permanent by having their photographs taken. The self-portrait is considered a reflection of one's character. Therefore, self-portraits and selfies are self-presentations used to reveal oneself.

Today, being admired, applauded, and approved by people becomes even more important, and presenting a complete human image stands out as dominant behavior (Kaşıkara 2017, p. 52). In the past, people proved their reputation by becoming visible with the portraits they had drawn and the photographs they had taken to gain acceptance and respect in front of society. Today, social media sharing is carried out for similar purposes. People whose only purpose is to be visible, create new identities, and take on other identities while doing this. Photography and especially 'selfie' have an important place in the creation of all these identities (Gök 2016, p. 42). "It is no accident that the portrait was the focal point of early photography. The cult of remembrance of loved ones, absent or dead, offers a last refuge for the cult value of the picture. For the last time, the aura emanates from the early photographs in the fleeting expression of a human face" (Benjamin 1969, p. 7).

The use of social media, which takes advantage of these needs, has expanded more and more. As the possibility of editing images becomes easier while sharing, more people are going to correct (!) and change what they see as defects in their photos. The desire to be liked has turned into a race to ingratiate oneself with everyone over time, causing unreal content to be produced and shared. Especially these edits made for face photos can cause self-comparison and excessive criticism by the viewer who perceives them as real.

3 The Objectified Body

In his book The Consumer Society, Baudrillard writes, "We are living in an age in which it has become imperative to look beautiful. Beauty became a religious commandment. Being beautiful is neither a natural gift nor an addition to moral qualities. It is the basic, commanding quality of those who take care of their faces and contours as well as their souls. Being beautiful, like success in the business world, is a sign of being chosen at the level of the body" (Baudrillard 2008, p. 168).

As Goffman emphasizes, first impressions are very important as the first link of interaction (Goffman 2014, pp. 24–25). For this reason, people try to create a perfect first impression, creating images that are far from reality and therefore from themselves. “In today’s world, determined by the principle of simulation, the real can only be a copy of the model.” (Baudrillard 2008, p. 150). This is what W. Benjamin calls “By making many reproductions it substitutes a plurality of copies for a unique existence.” (Benjamin 1969, p. 4).

Unnecessary aesthetic operations are resorted to because the ideal image obtained with over-edited portrait photographs is desired to be made permanent as the first place to look when interacting with people.

False needs have multiplied so much that the distinction between them and real needs has disappeared. The greatest need has become to provide a social status and visual satisfaction. With capitalism, the average age of individuals who are dissatisfied with their bodies and constantly in search of a better image is gradually decreasing. The body and soul of the individual are now objects of consumption. In this process of emphasizing the individuality and difference of people, sameness, and objectification have ironically become normal.

It can be said that individuals who have an idealized self-perception by the environment, who have objectified their bodies, become alien to their essence. Objectification has always existed. However, the acceleration of globalization, which has brought many benefits, has also ensured that the targeted person can be easily managed. New desires and dissatisfactions are introduced to the market (Bauman 1999, p. 43) to ensure the continuous sale of consumer goods that are no longer merely intended to satisfy needs (Asıl 2017, p. 5). People who seek emotional satisfaction try to resemble the ones they think are most liked to be liked. “While the individual’s area of freedom on his body expands through choices; gender norms, cultural codes, images and symbols that create social inequality through the body have continued to exist.” (Varga 2005, p. 227).

4 FaceApp Working Principle

In addition to editing photos and videos through simple but powerful apps like FaceApp, artificial intelligence, and machine learning can be easily used by ordinary people. By using machine learning to train artificial intelligence, operations that can be extremely complex for even the most experienced digital artists can be easily performed at the push of a button (Gerstner 2020, p. 2). For example, when a face swap was shared by a Reddit user for the first time in 2017, face swap spread through social media and began to attract people’s attention and was practiced by more and more people every day (Peipeng Yu 2021, p. 608). Later, companies that noticed the demand developed new applications. One of them, FaceApp: Face Editor, can produce realistic images with the Deepfake principle. In addition, “Many applications offered by ‘Smart-Android’ phone manufacturers allow consumers to quickly process and share photos and selfies, and receive notifications through the application for likes or comments on shared photos.” (Gök 2016, p. 43). Therefore, the user prefers applications where he can easily share edited photos on social platforms.

FaceApp: Face Editor and similar applications, which were produced in line with these demands, have added entertainment to the business over time and have increased the methods of use. Applications must ask the user for permission to send notifications, use the phone's microphone and camera, and access photo albums. However, since the application cannot be used without granting these permissions, the user continues to use the application by granting all permissions without question.

FaceApp, whose reliability is questioned more with the increase in its use, has announced that personal data is not shared with third parties. In a statement, FaceApp said that only photos selected for editing can be accessed, and other photos in your gallery cannot be accessed.

However, videos created with recent deep fake approaches are becoming extremely realistic and can hardly be distinguished from the human eye (Peipeng Yu 2021, p. 608). Recognizing the distinction between fake and real is becoming more difficult as machine learning improves. The public can be misled and manipulated by unreal sounds and images. Although the editing of unauthorized fake pornographic images of people has become widespread, deep fake videos of people who have a guiding influence on public opinions, such as political leaders, have also been produced, and some laws and rules have been enacted afterward. For this, new programs that work like deep fakes are used to capture images produced with deep fakes.

5 Conclusion

Social media has become an intermediary element representing the new face of the body; it mostly represents the face of the person that is not himself but wants to be (Kahraman 2020, p. 1211). With the increase in the speed of social media sharing and the audience that can reach it, new applications and facial effects that interact with media such as FaceApp also collect data that belongs to us and provide data to companies and machine learning. The protection of personal data is becoming increasingly difficult. Companies that come to the fore with a new lawsuit every day expand their clarification texts and specify the information to be used, sometimes implicitly and sometimes explicitly. People who cannot give up on the promise of entertainment and a better image provided by the applications continue to download the applications.

With these practices and sharing habits, in addition to security problems, the door to major psychological and sociological changes is opened. Especially in adolescence, the desire to be liked, which is of great importance for the person, turns into an addiction. The excessive increase in the need to be liked and approved by others distances the person from himself and makes him dependent on the guidance of others. Is it really possible for an individual to exist in a healthy way in society with an externally dependent life model?

Social media, which is one of the biggest contributors to the increase in the need for admiration added to the list of harmful addictions, can ignore the health of individuals with its desire for visibility. Microsoft has fired a team that guides AI innovation that leads to ethical, responsible, and sustainable outcomes as part of a plan to cut 10,000 jobs (Ulukan 2023). The approach of companies such as Microsoft, one of the technology giants, that benefit from artificial intelligence and machine learning to the individual and ethical issues should be considered by the individuals who use the applications. The fact that the individual is aware of the negative effects of artificial intelligence while benefiting from the positive returns will protect him from being an object that is directed outside his own decisions.

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Modeling Electro-Erosion Wear of Cryogenic Treated Electrodes of Mold Steels Using Machine Learning Algorithms

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Abstract. Electro-erosion wear (EEW) is a significant problem in the mold steel industry, as it can greatly reduce the lifespan of electrodes. This study presents a machine-learning approach for predicting and modeling electrode and workpiece wear on an electrical discharge machining (EDM) machine. In the experimental design, EDM of CuCrZr and Cu electrodes of AISI P20 tool steel was carried out at different pulse currents and duration levels. In addition, CuCrZr and Cu electrodes used in the experiment were cryogenically treated at a predefined degree for multiple periods and then tempered. This study employed machine learning algorithms such as decision trees, random forests, and k-nearest neighbors to model the EEW of cryogenically treated electrodes made of mold steels. The results were compared according to the coefficient of determination (R^2), adjusted R^2, and root mean squared error. As a result, the decision trees outperformed the other algorithms with 0.99 R^2 performance. This study provides valuable insights into the behavior of EEW in mold steel electrodes and could be used to optimize the manufacturing process and extend the lifespan of the electrodes.

Keywords: electrical discharge machining · material removal rate · electrode wear ratio · machine learning

1 Introduction

Electric discharge machining (EDM) is a widely used non-traditional method. The amount of material removed from the workpiece per unit of time is called the material removal rate (MRR). In contrast, the mass loss in the electrode material is referred to as electrode wear rate (EWR). In an EDM method, improvement is desired in terms of higher MRR, lower EWR, and better surface quality [1]. EWR is the most important

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factor in determining the number of electrodes required to achieve the correct size and dimensions of the desired form. When considering that electrodes are processed by wire erosion, turning, or milling machines, it is seen that EWR is the most significant factor affecting electrode costs. Therefore, studies on higher chip removal and lower electrode wear have gained importance in the EDM process in recent years.

EDM method has been applied in recent years with traditional methods and machine learning studies such as artificial neural networks (ANNs) and soft computing techniques such as fuzzy logic for predicting output performance parameters such as MRR and EWR based on optimum processing parameters such as discharge current, pulse duration, and voltage. In their study investigating the machinability of EDM, Ramaswamy et al. [2] performed a variance analysis to determine the significance of test parameters on experimental results. In the second phase of their study, researchers identified optimal process parameters and used regression analysis and ANNs to predict MRR and EWR. Similarly, Sarıkaya and Yılmaz [3] developed a mathematical model based on ANNs that successfully predicted outputs. In another study, Balasubramaniam et al. [4] used different electrode materials, such as copper, brass, and tungsten, for EDM of Al-SiCp metal matrix composites. MRR, EWR, and circularity (CIR) were considered as performance metrics in their study. As a result of using artificial intelligence to optimize processing parameters such as current, pulse duration, and flushing pressure, the most important parameter was shown to be current, and Cu exhibited the best performance among the three electrodes. In EDM, the effect of processing parameters such as peak current, pulse interval, and pulse duration are important for the variation in MRR and EWR. Ong et al. [5] developed a model based on the prediction of radial basis function neural networks to predict the MRR and EWR of the EDM process. The researchers used the moth flame optimization algorithm to determine the optimal processing parameters that maximize MRR and minimize EWR [5]. Cakir et al. [6] investigated the capacity of adaptive neuro-fuzzy inference systems, genetic expression programming, and ANNs in predicting EDM performance parameters using experimental data. Arunadevi and Prakash [7] used artificial intelligence to perform a performance analysis of experimental values with five input parameters to increase the MRR value and reduce surface roughness (SR) in their study. The model was evaluated using the R-squared value.

Machine learning techniques like electro-erosion wear have become increasingly popular in modeling and optimizing complex material processing processes. Several recent studies have examined the relationship between electro-erosion wear and machine learning. For example, Ulas et al. [8] used machine learning methods to estimate the surface roughness of Al7075 aluminum alloy processed with wire electrical discharge machining (WEDM) using different parameters, such as voltage, pulse-on-time, dielectric pressure, and wire feed rate. They employed LM, W-ELM, SVR, and Q-SVR models to process the samples and estimate the surface roughness values. Similarly, Jatti et al. [9] investigated the prediction of material removal rate (MRR) using machine learning algorithms, including supervised machine learning regression and classification-based approaches. They found that gap current, voltage, and pulse on time were the most significant parameters affecting MRR. They concluded that the Gradient boosting regression-based algorithm was the most effective for predicting MRR.

Meanwhile, Nahak and Gubta [10] reviewed the developments and challenges of EDM processes in 2019, emphasizing optimizing process parameters for effective and economical machining. Finally, Cetin et al. [11] experimentally investigated the effect of cryogenic treatment on the performance of CuCrZr alloy and Cu electrodes during EDM of AISI P20 tool steel. They found that pulse current was the most effective parameter in the EDM process and using cryogenically treated electrodes resulted in less wear and decreased surface roughness values.

These studies have demonstrated the successful use of machine learning techniques for modeling and optimizing the electro-erosion wear process. However, no studies have been found on the evaluation of the performance of cryogenically treated and untreated Cu and CuCrZr electrodes or the use of the artificial neural network (ANN) predictions for material removal rate (MRR) and electro-erosion wear ratio (EWR). This study aims to evaluate the performances of cryogenically treated and untreated CuCrZr and Cu electrodes during the electrical discharge machining (EDM) of AISI P20 tool steel in terms of EWR and MRR. By comparing the electrodes under different processing parameters and applying cryogenic treatment in 10 different time intervals ranging from 1/4 - 24 h, the study aims to contribute to the existing literature. The study utilizes decision trees, random forests, and k-nearest neighbor algorithms from machine learning techniques for regression analysis. The best algorithm is determined based on the results obtained, and comments are developed accordingly.

2 Material and Methods

2.1 Test Materials

In this experimental study, CuCrZr and Cu electrode pieces with a diameter of 10 × 30 mm were used as tool material. The values of the chemical compositions of CuCrZr and Cu electrodes are given in Table 1. To observe the effects of CT (Cryogenic Treatment), the electrodes were divided into 11 groups as treated and untreated electrodes. Cryogenically treated electrodes were treated at −140 °C for 15, 30 min, and 0, 0.25, 0.5, 1, 2, 4, 8, 12, 16, 20, 24 h and then tempered at 175 °C for 1 h. For this study, a total of 176 experiments were tested.

Table 1. Chemical composition and some properties of electrode materials (wt.%)

Material		CuCrZr			Cu
Chemical Composition	Elements	Cu	Cr	Zr	Cu
	(wt.%)	Balance	1.00	0.10	100

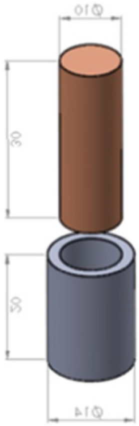

Fig. 1. AISI P20 and Electrode

AISI P20 tool steel, widely used in plastic injection molds, was chosen as the workpiece material of the experimental study. The diameter 14 × 20 mm AISI P20 material, tool electrode dimensions, and technical drawings drawn in 3D design programs are as in Fig. 1. Also, the chemical composition of AISI P20 tool steel is shown in Table 2.

Table 2. Chemical composition of AISI P20 steel (wt.%)

C	Si	Mn	Cr	Mo	Ni	S	Fe
0.40	0.25	1.5	1.9	0.2	1.0	0.001	Balance

2.2 EDM Tests

EDM tests were performed at pulse currents of 4, 8, 12, and 16 A and pulse times of 25 µs and 50 µs. In addition, the King ZNC K3200 model EDM machine seen in Fig. 2 was used in the experimental studies. At each parameter change, other processing parameters were kept constant for all tests.

Experimental conditions and parameters are given in Table 3. During the EDM tests, Petrofer dielectricum 358 mineral-based oil compatible with electro-erosion processing methods was used as the dielectric fluid. To obtain accurate values, EDM experiments were repeated three times for each combination of processing conditions, and the average values were considered the test result. EDM was performed for 20 min in each of the 176 experiments.