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PREDICTIVE ANALYTICS IN HUMAN RESOURCES USING MACHINE LEARNING AND DATA MINING

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ABSTRACT

Human resource management information systems (HRIS) are rapidly evolving as a result of today's technologies and global technological developments. With the digitalization of businesses, it is widely used in predictive applications in human resources (HR) and HRIS. HR and HRIS, better managing human resources data and making more accurate and reliable decisions are of critical importance for businesses. In this field, data mining and machine learning approaches are used to reveal meaningful relationships and trends between data in management decisions through predictive analysis. Both approaches are very important in the field of HR and are very effective for businesses to transform data sets into useful information. It helps businesses understand trends that can lead to more accurate and reliable business decisions by using analytical capabilities. Within the scope of this study, research was conducted on the use of the HRIS system with white-collar employees of a company in the automotive sector in Bursa. The cost, time saving and strategic impact of the human resources information system on the company and information technology infrastructure, its differences and relationships according to the department worked, age, gender and education level were investigated through statistics and data mining. Knime and SPSS Statistics programs, which are machine learning tools, were used in the research. HRIS results were evaluated and suggestions were made for future planning.

Keywords: Human Resources Management, Human Research Information System, Data Mining, Machine Learning**,** Automotive, Classification, Knime, IBM SPSS Statistics

1. INTRODUCTION

Due to global technological developments, businesses prefer to work technology-oriented in human resources management and informatics, as in all sectors and fields. Today, human resources (HR) has undergone a significant transformation, from employment and business processes to the implementation of applications on construction sites, requiring the use of human resources information systems (HRIS). HRIS is an integrated computerized system that includes obtaining, storing, analyzing and distributing valuable information regarding the human resources of the enterprise [1]. Carrying out the administrative processes of businesses with HRIS also increases the reliability of the decisions taken [2]. It is important not only to monitor and manage HRIS human resources functions and processes on a technological basis, but also to make the right decisions by considering the social qualities in the system and to take policies accordingly [3].

1.1.Human Resources Management, Information Systems and History

In the 21st century global economies, HR has undergone great change and development. It is a critical element for businesses to compete. In this process, the labor market structure has changed, leading to increased interaction with developed countries and institutions due to economic and social developments, and workforce quality and management have improved [4-5].

The concept of Human Resources Management dates back to 1950. This concept first began to

develop in America and did not attract much attention until the 1980s. It has become quite popular after 1980 [6].

Finance and accounting departments in the HR department emerged in the 1960s [7]. Since the 1970s, the Human Resources Department has been officially established to carry out the staff works. The association of HRs dates back to 1971. Between 1971 and 1980, HR departments increased rapidly, but their job descriptions did not change and were generally limited to tax, social security, and wage payments [8]. After 1980, HR was used as an advantage by institutions in global competition due to the free economy. Therefore, the transformation of "personnel departments" into HR departments took place towards the end of the 1980s. [9], The concept of HR was fully understood by organizations and began to become widespread in the 1990s. [10].

HRM, which brings significant innovations to the management of employee-related issues, is called "modern management" in organizations. Although the big scale downsizing which followed the economic crisis in the 2000s had a negative impact on Human Resources Departments and institutions in general [4-5], the proportion of enterprises that involve a Human Resources Department has increased to 65% [7]. The term and concept of HR has developed in Turkey by adapting it from foreign country practices [5,11-12]. The companies that operate in Turkey carry out benchmarking in order to maintain competitive advantage. Introduction of new practices modeled from abroad and the increase in academic interest in HR systems have been the driving force for the progress of HRM in Turkey [5,9].

The purpose of HRIS is to improve employee performance. This system has turned into a computerized system in which social, economic, demographic and performance management information such as social, economic, demographic and performance management information is collected and monitored for the employees of the administrative departments of institutions, analytically predictive analysis is made and constantly updated [13]. HRIS is a decision support system that includes all processes from data management system into management information system, and it has been developing for the last 40 years [14]. The HRIS overview graph is shown in Figure 1 below.

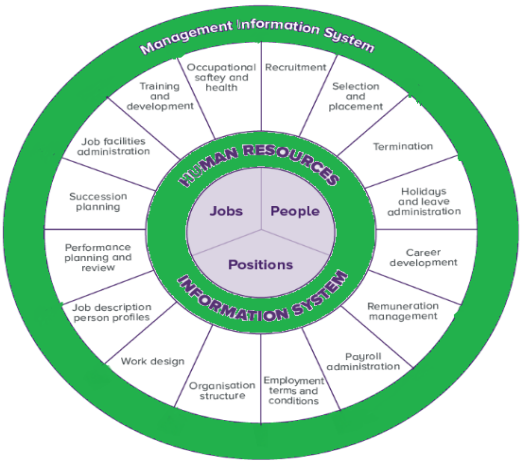

Figure 1. Digital HR practice worldwide and its percentage of utilization [15]

1.2. Data Science, Statistics, Data Mining and Machine Learning Concepts and Their Relationships

Machine learning can be defined as an applied artificial intelligence in a computer system. Data mining and machine learning algorithms serve the same purpose in that they predict the patterns and relationships of the data. In machine learning and data mining, clustering and decision tree algorithms are the same and their names vary for different purposes. In machine learning and data mining, clustering and decision tree algorithms are the same, but their names vary according to different purposes. For example, if the researcher achieves his goals only by running algorithms in an artificial intelligence-based system, he will prefer the term machine learning, but if the researcher monitors all processes from data acquisition to knowledge discovery and performs analytical operations with various machine learning algorithms, he will prefer the term data mining. On the other hand, statistics are used to read and explore data and is at the heart of machine learning/data mining methods.

On looking at the history of machine learning and data mining techniques, we would see that its origins are based on the disciplines of statistics and mathematics. Probability and statistics first began with the mathematical treatment of games of chance and the systematic examination of death data in the years 1650-1700. Bayes' theorem emerged in the 1700s, and the regression method, one of the most

important topics of probability and statistics, started with the least squares method introduced by Legendre in 1805 [16] and by Gauss [17] in 1809. The term 'machine learning' was coined by Arthur Samuel in 1952. Arthur Samuel of IBM designed a computer program to play checkers in the 1950s. The design included a scoring function that used the positions of the pieces on the checkerboard and sought to measure both sides' chances of winning. The program chose to use the minimax strategy in its next move in the theory of operations, and the minimax algorithm emerged as a result of this strategy.

In 1957, Frank Rosenblatt, who worked at the Cornell Aeronautical Laboratory, combined Donald Hebb's brain cell interaction model with Arthur Samuel's machine learning program and created the Perceptron. Before 1970, machine learning was used as a training program for artificial intelligence, but between 1970-1980, the research on artificial intelligence adopted approaches based on logical knowledge other than algorithms. In 1965, it became the first "*Data Science (Decision Science*)" company to apply evolutionary computing specifically to solve evolutionary programming applications and real-world problems by Lawrence J. Fogel [18]. The sensor was originally installed as a machine (IBM 704) for image recognition, not as a program. Later, these software and algorithms could be transferred to other machines and made usable.

Data mining and machine learning have something in common with the Knowledge Discovery in Databases (KDD). The term KDD was first coined by Piatetsky-Shapiro in 1989 and became popular with artificial intelligence and machine learning [19].

Although sensors are an important discovery, neural network/machine learning research has been successful in recognizing visual pattern (faces) after the 1990s. The concepts of machine learning and artificial intelligence were separated. In the early 1990s, data mining was defined as Knowledge Discovery in Databases (KDD), and today it is defined as "Knowledge Discovery in Data Science" and accepted as a sub-process of KDD. However, data mining and its process were defined by Fayyad et al. as the extraction of useful and understandable patterns from unimportant and potential data [19]. It was seen that the term 'data mining' was first used in Lovell's study (Lovell, 1983). Data mining, which started as a coding process, has brought out experts who have coding skills and are defined as "data miners" in cleaning, analyzing and evaluating data. Data mining is the process of extracting important and meaningful information by performing many operations from seemingly meaningless data [20].

Data science; by extracting meaningful relationships from raw data using machine learning processes, complex tools and algorithms, math, statistics and other similar fields, customer behavior and trends, etc. It can also be defined as a discipline that deals with today. The concept of data scientist is about the bigger picture and should have good expertise in areas such as data mining, software and programming, visualization, analytics of big data, statistics [21]. The disciplines associated with data science are given in Figure 2 below.

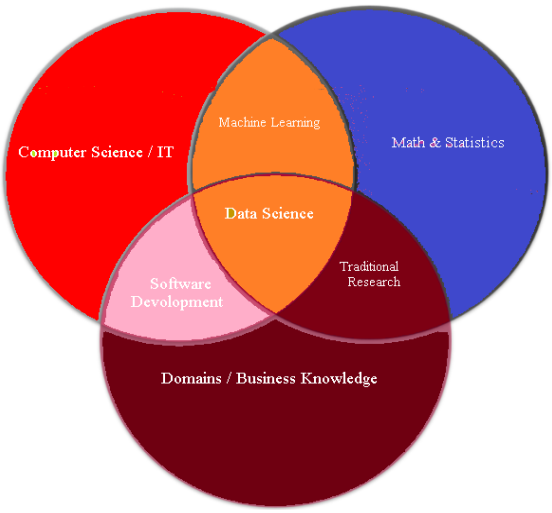

Figure 2. The disciplines associated with data science [38]

Statistics reads numbers, and definitions and inferences about probabilistic models are relevant. Data mining, on the other hand, explains the relationships and patterns among these data. Machine learning, on the other hand, makes predictions with models, and often the machine learning method can be formulated as a formal probability model. Therefore, machine learning is very similar to statistics and data mining in this sense and reveals the behavior and causes with artificial intelligence.

2. LITERATURE REVIEW

This transition must be made in HRIS, as in all technological innovations, in order for institutions to keep up with continuous development, solve potential problems and compete. Those who prefer the HRIS structure in businesses and institutions appear to be more effective and efficient than those who do not. The use of human resources information systems in the worksite and in the business structure [22,23] does not only function to meet current needs, but also lead to change. It also increases efficiency in HRM and across the organization. However, the use of HRIS can lead to a number of outcomes [24]. Recognizing that the reality might be different from what was expected, it is important to reflect on the current situation regarding the impact of HRIS on human resource management.

Human resources information systems, a modern product of HRM innovation, are the result of a set of interconnected new ideas that spread predictably and consistently within different communities [25]. HRM innovation can be measured by whether or not its new framework is seen as new and affects employee attitudes and behavior [26]. HRIS can also be defined as a systematic method to collect, organize, protect, access and verify data about the human resources department of an enterprise [2, 27-28].

Wang (2003) states in his study that data mining goes beyond data analysis on big data sets. In the study, he explains the steps of data mining with the Human Resources Information System. He also states that relationships and valuable patterns can be found about thousands of employees.

In the study by Shilpa and Gopal, the challenges associated with the implementation and maintenance of e-HRM systems are identified. The authors also offer suggestions to increase the effectiveness of e-HRM systems. In addition, the study includes a comparative table of the production and management sector according to the adoption of e-HRM systems in Indian companies [29].

Zeebaree et al. (2019) described the factors that lead to the adoption of E-HRM in human resources management in different companies and different countries. According to the results of the research, they determined that HRM played an important role in facilitating organizational processes and saving cost and time. They also encouraged adoption of E-HRM in making decision-taking easier for HR managers [30].

Masum et al. (2020) expressed that the Human Resources Information System (HRIS) played a strategic role in the decision-making process of companies. In this study, an intelligent human resources information (IDSS) framework is proposed. With the system that implements Intelligent Decision Support System (IDSS) together with a decision support system (i-HRIS), structured, especially semi-structured and unstructured data has improved the HR decision-making process. Recommended HR IDSS is a machine learning program that stores and processes information with a set of Artificial Intelligence (AI) tools, such as knowledge-based reasoning [31].

Ghazi et al. (2021) presented the data of the company's employees in their study, categories being the age, monthly income, working time, environmental satisfaction, etc. Data mining was carried out considering the characteristics. In the research, support vector machine, decision tree, linear regression, and random forest algorithms were applied and the accuracy rate was found as 88%. According to the results of the research, the most important factors affecting the employee turnover were determined as total years at work and satisfaction [32].

3. MATERIAL AND METHOD

In this study, research was carried out between 01 April 2022 and 15 May 2022 with 90 white-collar workers working in a company operating as a provider of antivibration and sealing solutions in the automotive sector in Bursa, Turkey. The survey questions were created using the literature. The data were obtained by means of a questionnaire, and although it was not big enough for the data mining practice, some patterns related to the company were revealed.

A pilot study was conducted for the research questions and questions were asked with a small sample. According to the results obtained from the pre-test in which reliability and validity were investigated, the survey form was

finalized and questions were asked to all white-collar employees.

Cronbach's Alpha coefficient was calculated to investigate the internal consistency of the answers to all items of the questionnaire applied in the pilot study. Cronbach Alpha coefficient is a weighted standard change average found by dividing the sum of the variances of the questions in the scale to the general variance. The alpha coefficient varies between 0 and 1. The α value obtained for all questions shows the total reliability of that survey. According to some researchers, when alpha reliability coefficients for all elements are above 0.60, it is considered "good" reliability. Cronbach Alpha reliability coefficient was found to be 0.78 in the study. In addition, whether the questions in the scale were prepared to form an additive scale was evaluated with the "Tukey's test of additivity". It was seen that the model was compatible ($p=0.00<0.05$) and the questions in the scale were prepared to form an additive scale. Due to these statistical results, the pilot survey questions were found to be highly reliable.

Factor analysis was performed to examine the validity of the applied survey and the status of the sub-dimensions of the questions. The variables used in the research were found to be suitable for analysis ($p=0.00<0.05$). Similarly, in the KMO (Kaiser-Meyer-Olkin) test, a value close to 1 indicates that the samples are sufficient and suitable for factor analysis. In the study, KMO=0.693 and explained variance was found to be 64.136%. Considering the results obtained as a result of the pilot study above; It can be said that the survey used in the field study is a reliable and valid survey.

The obtained data were evaluated in IBM SPSS 25.0 package program and a survey method was used to reveal the factors related to human resources management of the human resources information system of the company employees. Descriptive and inferential statistics were used as the method in the study. Using HRIS in the workplace; Its differences in terms of time, cost savings, strategic impact and the role of human resources were investigated. These differences in the research; Employees' age, gender, education, marital status and employment were considered. Inferential statistics were based on the demographic characteristics of the participants, and since the samples were not distributed normally, non-parametric tests such as Mann Whitney U Test (MW-U) and Kruskal Wallis H Test (KW-H) were used.

Kolmogorov-Smirnov normality analysis was performed according to the total scores of the participants' answers in terms of cost savings ($p=0.00<0.05$), time savings ($p=0.00<0.05$) and the strategic impact of HRIS use on human resources ($p=0.00<0.05$), and it was determined that all three factors were not normally distributed.

The MW-U test is a non-parametric test and is an alternative to the independent two-sample t test, which is a parametric test. Also, it tests for differences between two main medians. KW-U is an alternative to ANOVA from parametric tests when parametric test assumptions are not met [33-35].

Data mining decision tree techniques were applied to determine which variables are the most important for employees in various departments of the automotive industry. Data mining is carried out in Knime machine learning. Out of data mining techniques, decision tree and Random Forest (RF) algorithm were used. In the RF algorithm, n random records are taken from the data set that contains k records. It generates an output by creating individual decision trees for each random sample [36]. Generating a RF algorithm is given in Fig. 3.

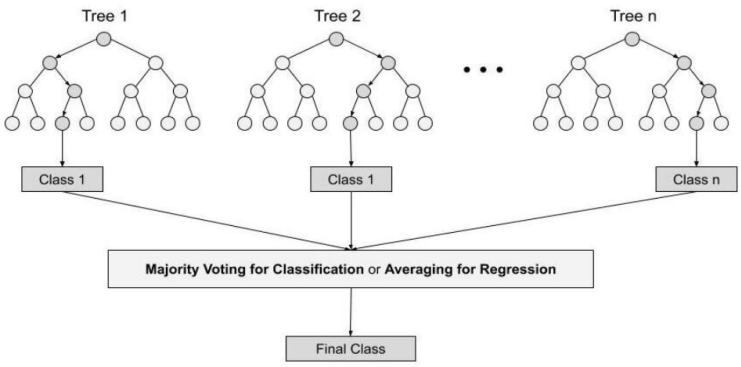

Figure 3. Random forest algorithm

Decision trees classify samples by ordering them in the tree from the root to some leaf/end node, the leaf/end node provides the sample classification [37]. Generating a decision tree algorithm is given in Fig. 4.

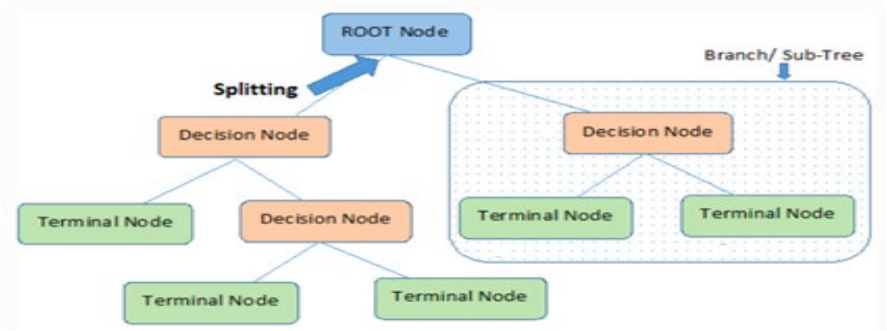

Figure 4. Decision tree algorithm

4. EXPERIMENTAL RESULTS

For the purposes of this study, descriptive and inferential (Hypothesis testing) statistics and data mining decision tree model results are given below.

4.1. Descriptive Statistics Results

In this study, data regarding employees in a company operating in the automotive sector was used. Descriptive statistics for the participants are given in Table 1.

Table 1. Descriptive Statistics

Variables	n	Percent (%)
Gender		
Female	39	43.3
Male	51	56.7
Marital Status		
Single	47	52.2
Married	43	47.8
Age Groups		
18-30	57	63.3
31-40	27	30.0
41-50	5	5.6
51-60	1	1.1
Departments		
Human Resources	5	5.6
IT	4	4.4
Quality	4	4.4
Financial Affairs	16	17.8
Production	10	11.1
Supply Chain	10	11.1
Sales and Marketing	5	5.6
R&D	36	40.0
Total	90	100.0

In the study, 56.7% of the sample was male, 52.2% was single, and 63.3% was between the ages of 18-30. The departmental distributions of the employees are given in Figure 5.

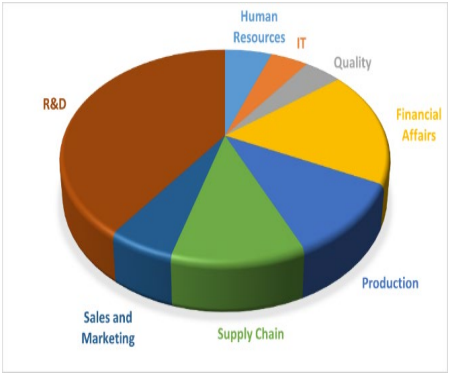

Figure 5. Distribution by department of the participants examined in the research.

It was determined that the department with the highest density of distribution of the participants was the "R&D" department with a rate of 40%.

4.2. Hypothesis and Results

Within context of the use of HRIS in the research; whether there is a difference according to the socio-demographic structures of the employees in terms of time, cost savings and strategic impact was investigated by hypothesis tests. The results of the hypothesis tests for the research are given in Table 2 below.

In this section, as related to the effect of HRIS on human resources management; it was investigated whether there was a statistical difference between employees in terms of gender, marital status, age, and department. For group comparisons, non-parametric techniques Mann Whitney U and Kruskal Wallis tests were applied. Since the data were not normally distributed, non-parametric statistical tests were used instead of statistical parametric tests. The results of the research in terms of any statistically significant difference are given in Table 2.

Table 2. Hypotheses and Status of Acceptance/Rejection of the Hypotheses

METHOD		HYPOTHESIS	P(<0,05)	ACCEPTANCE/REJECTION
MW - U	**H_1**	There is a significant gender difference in the use of HRIS in terms of time savings.	0.323	The hypothesis was rejected.
MW - U	**H_2**	There is a significant gender difference in the use of HRIS in terms of cost savings.	0.763	The hypothesis was rejected.
MW - U	**H_3**	There is a significant gender difference in the use of HRIS in terms of strategic impact and the role of human resources.	0.116	The hypothesis was rejected.
KW-H	**H_4**	There is a significant difference by marital status in terms of time savings in the use of HRIS.	0.450	The hypothesis was rejected.
KW-H	**H_5**	There is a significant difference by marital status in terms of cost savings in the use of HRIS.	0.694	The hypothesis was rejected.
KW-H	**H_6**	There is a significant difference by marital status in terms of strategic impact and the role of human resources.	0.860	The hypothesis was rejected.
KW-H	**H_7**	There is a significant difference according to age in terms of time saving in the use of HRIS.	0.131	The hypothesis was rejected.
KW-H	**H_8**	There is a significant difference according to age in terms of cost savings in the use of HRIS.	0.372	The hypothesis was rejected.
KW-H	**H_9**	There is a significant difference according to age in terms of strategic impact and the role of human resources.	0.540	The hypothesis was rejected.
KW-H	**H_{10}**	There is a significant difference between departments in terms of time savings in the use of HRIS.	**0.001***	**The hypothesis was accepted.**
KW-H	**H_{11}**	There is a significant difference between departments in terms of cost savings in the use of HRIS.	**0.018***	**The hypothesis was accepted.**
KW-H	**H_{12}**	There is a significant difference between departments in terms of strategic impact and the role of human resources in the use of HRIS.	**0.001***	**The hypothesis was accepted.**

*p<0.05

According to the hypothesis test results; except for the H_{10} H_{11} and H_{12} hypotheses, all hypotheses were rejected and there was no statistically significant difference.

In the H_{10} hypothesis, it has been revealed that the HRIS varies according to the departments in terms of time savings. In order to determine the department that created the difference, rank values were examined in the ranking test.

Accordingly, it has been determined that the employees of the "*Department of Financial Affairs*" have a higher degree of participation in the use of HRIS in terms of saving time, compared to other departments.

In the H_{11} hypothesis, it has been revealed that the HRIS system varies according to the departments in terms of cost savings. To determine the department that created the difference, rank values were examined in the ranking test. Accordingly, it has been determined that the employees of the "*Department of Sales and Marketing*" have a higher degree of participation in the use of HRIS in terms of cost saving, compared to other departments.

In the H_{12} hypothesis, it has been revealed that the HRIS system varies according to the departments in terms of strategic impact and the role of human resources. To determine the department that created the difference, rank values were examined in the ranking test. Accordingly, it has been determined that the employees of the "*Department of Sales and Marketing*" have a higher degree of participation in the use of HRIS in terms of strategic impact and the role of human resources, compared to other departments.

In terms of strategic impact and the role of human resources, it has been determined that the "*Department of Financial Affairs*" has the highest degree of participation, and the "*Department of Sales and Marketing*" has the lowest degree of participation.

4.3. Data Mining and Knime Machine Learning Results

The significance of the variables used in the study was processed according to the decision tree, random forest and Naive Bayes algorithm model infrastructure. The model variables are Age {18-30, 31-40, 41,50, 51-60}, Departments {Human Resources, IT, Quality, Financial Affairs, Production, Supply Chain, Sales and Marketing}, Information Technology Infrastructure, Time Savings of HRIS, Cost Savings of HRIS and HRIS' Strategic Impact are categorical values. The "department" variable was used as the target variable. Figure 4 shows the estimated workflow of human resources management. The workflow includes all nodes used for Knime machine learning and data mining. The workflow diagram in KNIME is given in Figure 6.

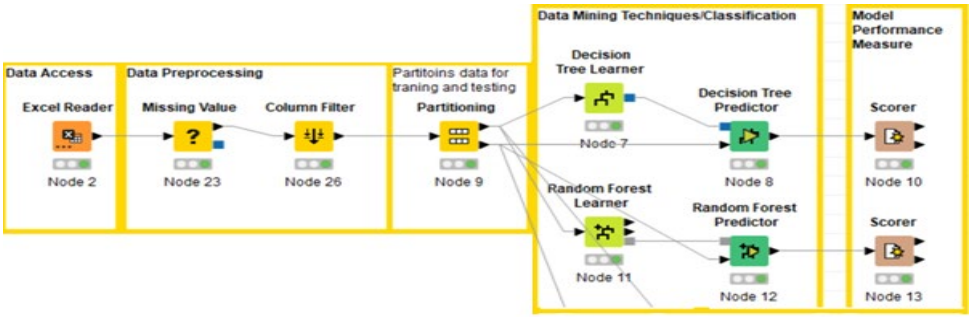

Figure 6. Workflow in KNIME

The filter node column is used to define the variables that should be included in the model. Special nodes are used in the implementation of the KNIME classification model. After these special nodes learn how to classify the data in model building, they classify the new data using Decision Tree and Random Forest Learner prediction node. Model performance and model accuracy values were examined. The accuracy rate of the Decision Tree and Random Forest algorithm was the same and was determined as 72.22%. Research results were evaluated according to the Random Forest algorithm results. In the research, 80% of the data was used as a training dataset in the decision tree learner operator and the remaining 20% was used as test data by all algorithm estimators. In addition, the "Gini" measurement was used, as the one which gives the highest accuracy among the quality criteria. The Random Forest algorithm results are given in Figure 7.

Figure 7. Random Forest algorithm results in KNIME

The most important variable for the staff employed in various departments of the automotive business is the HRIS strategy. This was followed by the IT infrastructure and time savings of HRIS. The involvement level of the finance department in the HRIS strategy is good, while the involvement level in the IT infrastructure is low. It is seen that the Human Resources and Quality departments evaluated the saving of time of HRIS positively. Employees in the department of Production and Sales evaluated the saving of time and cost of HRIS positively.

5. CONCLUSION

Human resources information system about all employees and organizational department-related data enables conversion and storage of documents such as reports, tables, forms, rulers, and extracting information about the business. This system, which reports all the processes of the business, is therefore very important in terms of human resources. In this study, as to the effect of HRIS on human resources management; it was investigated whether or not there was a statistical difference in terms of gender, marital status, age, and department. For group comparisons, non-parametric statistical techniques and tests were applied. According to the results of the research, it was seen that there was a statistical difference in terms of the department. When the strategic impact of human resources was investigated on a departmental basis, it has been determined that the department with the highest degree of participation was the "Department of Financial Affairs" and the department with the lowest degree of participation was the "Department of Sales and Marketing".

With the use of HRIS in the research; it was investigated by hypothesis tests whether or not there is a difference according to the socio-demographic structures of the employees in terms of time, cost savings and strategic impact. As a result of the research hypotheses, it was determined that it differed only according to the departments.

Data mining techniques were applied by taking the department variable as the target variable. The most important variable found as a result of the decision tree method was the HRIS strategy and this was followed by the IT infrastructure and HRIS's saving of time, respectively. Considering the outcomes of this study; it is aimed to guide the companies that operate in the automotive sector and companies that are engaged in other sectors on HRIS. As it is clear that HRM will serve more companies in the future; research in terms of time, cost and strategic impact and HR role will provide a competitive advantage. This study puts light on the obvious benefits to be well enjoyed by the HR workers when fulfilling HR functions using HRIS.

In the future, the role of artificial intelligence in the human resources functions and processes of businesses will gradually increase. Artificial intelligence in HRIS systems will increase the ability to analyze large volumes of data accurately and reliably in the system. By utilizing machine learning algorithms in analysis processes, traditional HR processes can be run on an optimization basis, making their functions easier. Especially in employment, testing the recruitment criteria, process and planning, it can automatically review the CVs of the candidates, provide many benefits to the participants with the help of personalized training materials and virtual assistants. Business human resources managers; Encouraging people to benefit from artificial intelligence technologies, data mining and machine learning, and advanced data analytics will enable them to obtain valuable, accurate information and make reliable decisions, saving time and money.

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