**ABSTRACT**

In a master's thesis, when a new task come to a software testing group, it was discussed how to finish the job in the most efficient way. Since task was new, it was difficult to predict which individuals in the group would finish in how much time and with how much efficiency. For this, test cases were determined by the expert group related to the task and the test suite was written. The testers will complete the task according to the test steps here and return the result. Thus, in line with the criticality of bugs entered into the system, the right people will be identified according to the scores they receive from the relevant assessment.

According to the characteristics of the people in the test group, a proposal will be made according to the features of the people in the test group to determine the new employees to be hired. Rather than having each new applicant apply this task one by one, the system will offer us the ability to do this job according to the features of the existing workers.

Keywords: Task Assignment, Naive Bayes, Regression, Decision Tree

1. **INTRODUCTION**

Previously, each tester had a fixed task that was on a weekly basis. In each new software, the tester would start this test under the name of a regression test and finish it weekly. So he could feel bored for doing the hard work. Based on this, the testers will make a bug entry into the system with the test suite specified by the engineers. They will receive points according to the criticality of the bug they entered. If the bug is not resolved, they will have no effect on the score. If the majority of the bug entered is high and solved, they will get a high score. If the bug entered was entered by mistake or in the case of re-test, the user will have a negative score. It will contribute to the score in inverse proportion to the end time of the test. After the test is finished and the software is approved, the quality assurance department is commissioning the test. The testers in this group are trying to catch the bugs escaping from the testers in the said test group. According to bug's priority, there will be a return of minus points according to the number of testers in the quality group. After the results are announced, these assignments will be made as needed.

When recruitment is needed for the task, the following criteria are used.

Features:

* Gender
* Age
* Experience
* Maritial status
* Number of chldren
* Education status
* Number of previous job
* Seniority
* Title
* Estimated time of arrival

The above features are determined by domain experts and non-domain experts. The persons consulted here are sociologist, test group manager and test group chief. If tester get the passing grade, he or she is successfull. According to the available data, when the new candidate is wanted to be introduced to the system, it presents the result that the new worker can or cannot do this job according to the propositions determined by certain machine learning algorithms.

1. **FEATURES of WORKERS**

The features will role in suggesting whether new testers will be able to do the job. Based on the skills of existing workers, certain dependent-independent features were created. A dependent variable is a boolean value that indicates whether the user can do that job. It returns us as 1 or 0 according to the arguments entered in the system. Independent variables were determined by taking the opinions of many people.

First, the success rate is determined by inserting the relevant algorithms between 1 and 0 for each feature. If the value is 0.5 or less, the user is unsuccessful. Between 0.5 and 1 will be considered successful. The values ​​obtained from all the latest features will be summed and divided by the number of features. If the value is greater than 0.5, it will result in successful, otherwise unsuccessful. In the final thesis we will compare the results of the algorithms returned to us.

1. **BUG TRACKER SYSTEM and SUCCESS CRITERIA**

Software group designs and implements all requirements of system. R&D test group’s task is to find bugs of the system. Their bugs are resolved by software group and software is released again. Until R&D group don’t see, this loop goes on. Then the software that there is no issue delivers quality department. Quality assurance tests the same parts. When they see any issues, R&D software group evaluate those bugs in their side. If it’s major or can be reproducable, it will be resolved by software group. After test is finished, software group releases new version. R&D test group re-test again, then quality assurance group re-test again.

Bugs entered into the R & D test group vary according to severity, duration and resolution status. The success criteria of the testers is affected by these variables. Testers's expectations are that the bugs are solved by the developers. If the bug entered into the system is resolved and the criticality of the bug is high, the tester gets a high score per bug entered. The task finish time determined by the engineer who wrote the test suite affects the success rate in inverse proportion. If the tester completes the task in a shorter period of time, the score will be positively reflected. Else, if it finishes longer, it will be inversely proportionally negative. Bugs entered by the testers but which are re-tested shall be interpreted as exhausting the system and scored as negative.

At the approval stage, the testers of the quality assurance unit will test the same test as end user. The bugs found by quality group testers and will be solved will negatively affect the score of the R & D testers.

1. **SUGGESTION MECHANISM**

Scores that have been collected is classified as successfully and failed. For once, dependent variable is our decision. If testers succeed in their task, the dependent variable will be updated as “yes”. In order to be successfull, they should get min 50 points in each task. Starting from this, the system will recommend us with different algorithms to assign new employee.

Different regression and classification algorithms were used to find a good recommendation. Decision tree regressor, support vector regressor and naive bayes algorithms have been selected. After user enters inputs in the system, the application will say that whether new employee can do this task or not. I will work through in the following.

The common feature of the algorithms used in the thesis is that they all deal with the same dependent variable. Arguments are entered into the system respectively. The model is trained according to the algorithm to be used. Estimates are taken for each argument individually. From this result, values are obtained (between 0 and 1) as to whether or not the candidate can perform the job per independent variable. The arithmetic average of these values obtained from all the latest features is obtained and a proposal is made as to whether or not the candidate will start this job.

1. **NAIVE BAYES ALGORITHM**

Naive Bayes is a simple machine learning and supervised algorithm. It is a classification algorithm and is extremely fast. It uses Bayes theory of probability. This is called 'naive' because the algorithm assumes that all attributes are independent of each other. It is used widely used in text classifications with multiple classes. The data presented for teaching must have a class / category. With the probability operations performed on the taught data, the new test data submitted to the system is operated according to the probability values obtained previously and it is tried to determine in which category the given test data belongs. Of course, the greater the number of taught data, the more accurate it is to determine the actual category of test data.

The Naive Bayes classification method can be used in many ways, but it is important that what is classified here rather than how it is classified. In other words, the data to be taught can be binary or text data, where the proportional relationship between these data becomes more important than the data type and what it is.

The basis of the algorithm is based on Bayesian Theory. It is found probabilities “yes” and “no” in the below.

For example, if the decision variable is “yes”:

P( Independent Feature| Yes ) =               P( Yes| Independent Feature) P(Independent Feature)

                 —————————————————————————

P( Yes| Independent Feature) P(Independent Feature) +

P( Yes|not Independent Feature) P( not Independent Feature)

All probabilites of independent features are calculated according to “yes” and “no” selection. The system gives us that recommendation, whichever probability is greater.

As we have seen, the Naive Bayes classification has determined the class or category of data presented to the system by a series of calculations defined according to probability principles.

1. **DECISION TREE REGRESSION**

Decision tree regression algorithm returns a result according to arithmetic mean of the related feature. If the value of feature is not in this range,

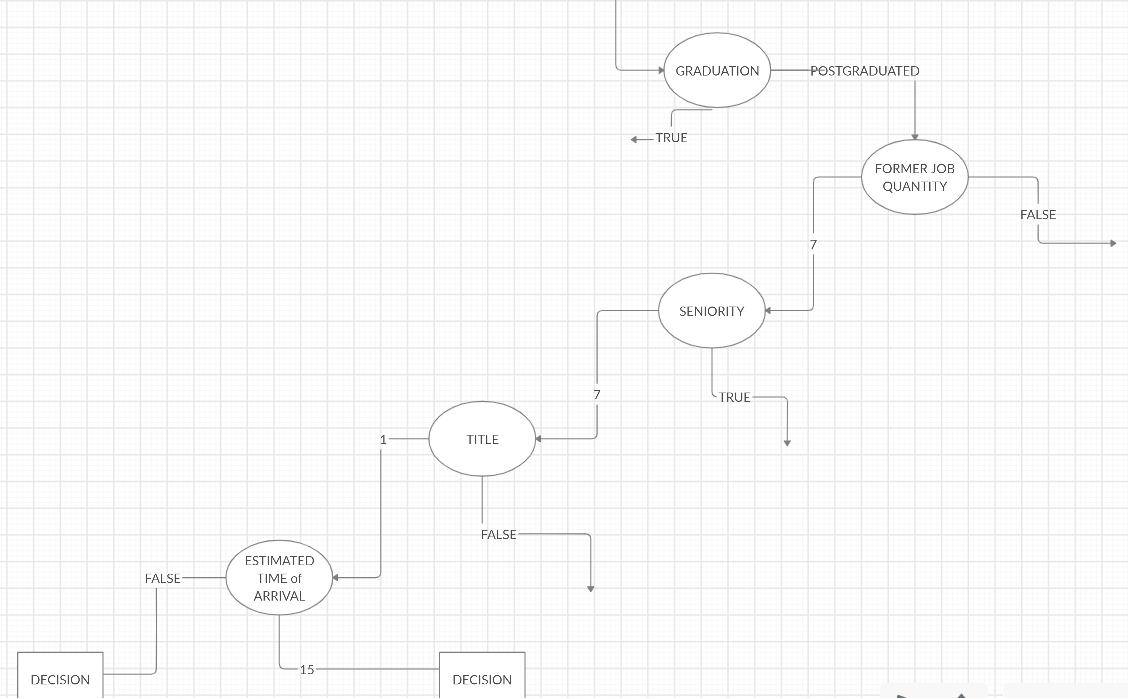
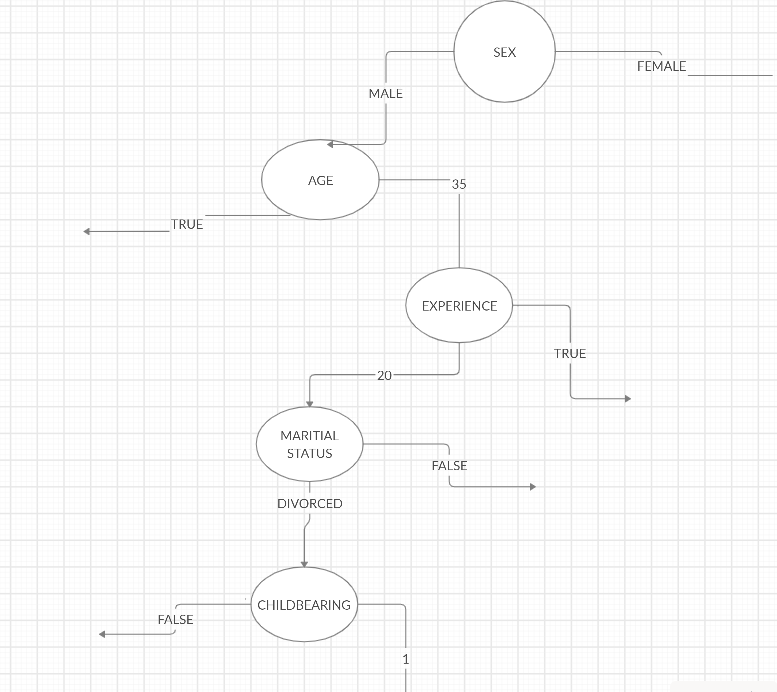
* If the value of feature that we enter in system is close to greater, it returns us the arithmetic mean of score of greater ones.
* If the value of feature that we enter in system is close to less, it returns us the arithmetic mean of score of less ones.
* If the value of feature that we enter in system is in the middle, it returns us the arithmetic mean of score of less ones.

Separates arguments into ranges based on information gain. When asked for a value from this range during the prediction, the answer is the average in this range (learned during training). For this reason, decision tree regression is discrete, not continuous, like other regression models. That is, it produces the same results for the desired estimates in a certain range.

The processes mentioned under Suggestion mechanism are as follow. All features are manually entered. Machine learning is performed for each feature. After the training part is completed, estimation is made according to the entered value. If the entered value is in this range, the arithmetic mean of the dependent variable corresponding to this range is taken. If not, the arithmetic mean of the dependent variable corresponding to the argument closest to this range is taken. If the corresponding argument is equal to the two ranges, it is rounded to the smaller one. This results in decimal values between 0 and 1 per feature. If we add these probabilities and divide by the number of arguments, if the value is between 0.5 and 1, the system suggests that the user can do this task. If it is between 0 and 0.5, the new employee cannot do the task. A value of 0.5 also indicates negativity.

GERÇEK VERİLERLE YAPTIĞIM KARŞILAŞTIRMALARI BURAYA YAZACAĞIM

**Decision Tree Regressor Data Structure**



1. **SUPPORT VECTOR REGRESSION**

The Support Vector Machine (SVM) is also used as a regression method, maintaining all the main features that characterize the algorithm (maximum margin). Support Vector Regression (SVR) uses the same principles as SVM for classification. It separates the datas as successful and failed. The working principle of this algoritm is that maximizes between the distances of two classes. It is a method that used to normalize the range of properties of arguments or data.

We cannot always use linear models for our data. In such cases, we try to make sense of the data with other algorithms. One of these is support vector algorithms. When we apply support vector regression, it is to ensure that the range we will draw is within the maximum point. The points at which these maximum intervals are cut are called support points. Hence, Radial Basis Function (RBF) method was used to determine nonlinear range.

With this data set and the polynomial model it will be established, it will be possible to predict whether a tester can do this task according to the problem level it will be tried to solve. Thus, we can conclude that our target variable y is “Accept” and the remaining properties are independent variables.

Firstly, inputs are entered into system. Machine learning is performed for each feature. After the training part is completed, estimation is made according to the entered value. This results in decimal values between 0 and 1 per feature according to support vector regression. If we add these probabilities and divide by the number of arguments, if the value is between 0.5 and 1, the system suggests that the user can do this task. If it is between 0 and 0.5, the new employee cannot do the task. A value of 0.5 also indicates negativity.

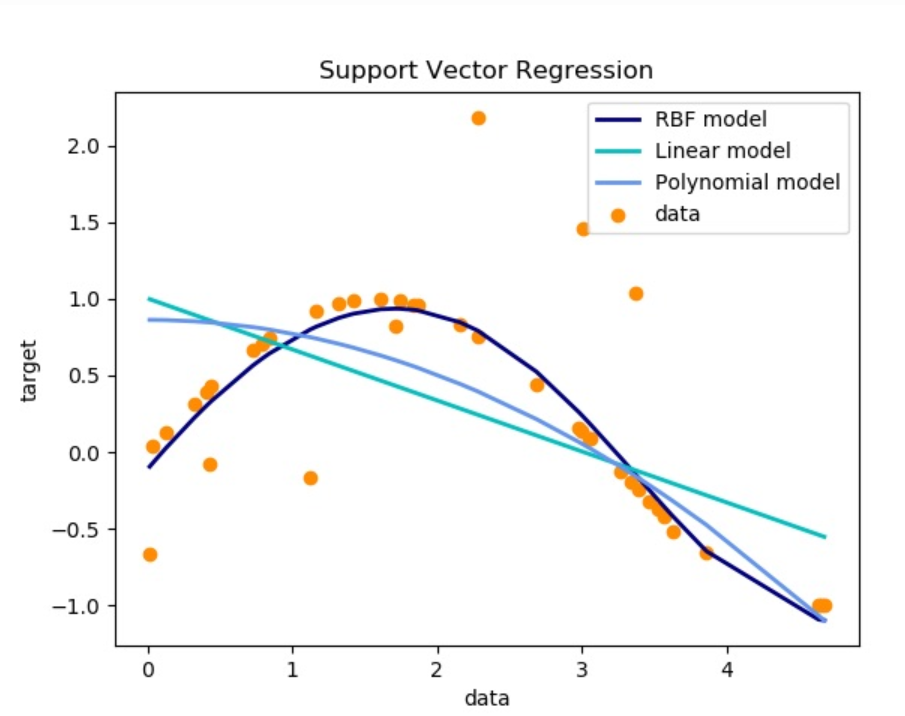
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Why do we need to scale datas?

* + It is used to use data under the same metric. Think of this process as roughly turning both of them into meters before processing the kilometer and millimeter. Data mining algorithms can not separate them.
  + It associates and normalizes similar datas.

WILL BE FILLED AFTER WE DECIDE WHICH DATAS NEED TO SCALING

**Comparison of SVR with Other Algorithms**



Linear and polynomial models have drawn a line for the data at hand, but the line drawn by the support vector algorithm seems much more efficient.

1. **LITERATURE REVIEW**

Kırmızı: atıf

Mor: atıfın atıfı

Sarı: yorum

Every workplace has many optimization efforts to increase productivity. Often, the first task is to identify wastes. In a study conducted in Chile, the undisciplined behavior of employees was addressed. Considering this type of behavior on the basis of thousands of workers, this type of behavior has caused a lot of damage to the company. These kinds of mishaps have been taken into consideration and actions have been taken primarily on job satisfaction. It was emphasized that it is quite difficult to satisfy the current workers. It was stated that measuring this difficulty is a problem. The difficulties here were classified and solved according to the skills of existing workers[1]. According to the researches, it is understood that the damage to the company and the country's economy increased after many years due to instability and problems caused by the inability of people to work[2]. Roberts and Escudero, on the other hand, evaluated the wasted time of employees in a workplace study[3]. In our paper, we used data from the current workplace to improve efficiency. First of all, it was predicted that each employee could be successful in other tasks. Everyone will have a specific score for the tasks they work outside their own tasks. The scoring criterion will be based on the bugs entered and resolved. Here the score will increase in proportion to the priority of the bug. Missed bugs and completion time of the task will be inversely proportional to the score. A lot of research has been done here about which features to choose. In the estimation system that deals with job satisfaction, features are examined in two groups. While more abstract features such as expectations, beliefs are used as organizational features, the more concrete ones such as age, gender, education are preferred as individual features[4]. According to the information obtained from the literature, age, gender, educational status features were added to the algorithms developed for comparison. In 2011, in the machine learning job suggestion system, people are proposed according to their job backgrounds. Features include experience, degree of education, title and frequency of job change. This system also learns when the new employee will leave work[5]. Among the features used in this article, the title of employee parameter was added to the paper to compare the algorithm. In a research conducted in 2010, skills were determined according to the current performance of the workers. In the first case, the current worker can be assigned to any job, whereas in the second case, the performance of the external workers is performed by the employer[6]. In another study on task assignment in 2009, a suggestion system was made based on task priorities[7]. Existing algorithms were used as the suggestion method in our own study. The relationship between them will be examined and the decision will be made. Based on this article, comparisons were made using existing algorithms, regardless of the single algorithm. The study of Nigerian scientists focused on the relationship between leadership intelligence and emotional intelligence. Gender, age, marital status, academic qualification data were used while collecting data from employees. As a result, it was revealed that there is a significant relationship between emotional intelligence and work efficiency and these independent variables play a positive role[8]. The marital status argument was added to the writing, inspired by this article. Thus, it will be focused on whether married people can work overtime due to their children and whether divorced people can be aggressive. The relationship between psychosocial characteristics and work performance in a workplace in Japan was examined. In this study, the age, gender, marital status, educational background, daily working hours, seniority of the workers were kept as independent variables. It has been observed that as the daily working hours increase, the work efficiency decreases, as the age increases, the performance increases proportionally, and that married people are more successful than singles. While the above conclusions have been made among men, a correct proportion has not been established among women[9]. According to the conclusions drawn from this article, some variables played an important role while others stood out as ineffective elements. Since the daily working hours will remain constant in our thesis, other independent variables are taken into consideration and included in the study. A study was conducted on the relationship between job satisfaction and performance in the United Arab Emirates. Here, many features of the employees are considered as independent variables and they are entered into the system before starting to work. These variables are gender, age, term of office, marital status, position and nationality. As a result of various regression and correlation analyzes, it was revealed that some variables were not really important. While nationality, which is one of the variables here, stands out as a feature that directly affects the process, it was observed that age, gender and marital status variables had no effect[10]. Before starting the regression analysis in my study, domain-expert received opinions about what features might be from many unrelated subjects and articles were scanned. As observed, it is noticeable that every feature does not directly contribute to performance. Studies will be carried out with the features we have determined for their extraction. After the study, single and multiple releases will be established.

In this section, we will discuss the prediction and recommendation algorithms in the literature. In the article written in the literature, the suggestion algorithm deals with wind energy. The estimated value is the wind speed. Forecasting in this area is more difficult than in other areas of study. Because there are continuously variable parameters such as air pressure and temperature. The uncertainty here has been overcome by using data from previous days. This was achieved by using the SVR algorithm. Small sample size has been observed to be a problem with wind speed estimation made easier by SVR[11]. Since the number of employee data I use in my thesis is less than 100, I added the SVR algorithm to my article for comparison. Sales amount estimation was made with Walmart brand, which is famous for its supply chain. In this article, regression algorithms and time series analysis methods are applied to sales data. The algorithms and methods currently used are: Linear Regression, Decision Tree Regression, Neural Network Regression and Naive Method. As a result of the study, the performance and consistency of the regression was higher. Naive Method was used when it was good in economic and financial time series. The accuracy of the regression algorithms was higher than the time series analysis methods[12]. As you can see, the performance of regression algorithms is higher than the time series algorithms. While making comparisons, regression algorithms were preferred because analysis will be made according to the features of the employees. In a study in which health expenditures were estimated, multiple regression models were established. Comparisons were made between 2 algorithms by giving different hyper parameter values. These algorithms are Random Forest Regression and SVR. With the first algorithm, it was possible to approach the optimum by generating a large number of trees. At the maximum level, similar subclasses were created. In SVR algorithm, the largest linear function of the margin was determined in order to differentiate linearly classifiable data. Hyper planes were created with these functions. According to the hyperplane, the data was assigned to classes. In fact, the aim here was to classify. At the end of the study, it was found that Random Forest Algorithm gave better results[13]. Based on this article, it was observed that success was achieved by deriving trees in complex data, and SVR algorithm gave positive results with small data. Using SVR for the company data that has 80 to 100 employees will show us better results.

In this section, studies on task assignment are researched. In a research conducted in a health center, it has been revealed that the increase in the number of patients from time to time causes problems. Lack of staff and failure to meet the needs of patients were reported as problems. Based on this, it was thought that the personnel should be appointed correctly. Assignment types were determined under 2 titles, depending on the need and the type of the disease. Of course, the number of patients has not remained constant day by day and exceptional situations have also been considered. In unplanned situations, the appointment of plenty of experienced staff is systematically indicated[14]. In another workplace, all datasets are divided into shifts. The same proportion of occupational groups was assigned for each shift. The works to be performed by each staff are systematically defined and genetic algorithms are used to perform these operations. Minimization was applied to the break times and it was aimed to meet the monthly target working hours of the employees. Employees' psychology was also considered, and no more than 1 shift was given per employee per day. The target is the optimization of the company with the eyes of both the worker and the employee[15]. In a workplace that uses optimization methods with another method, it is aimed to work with a certain number of workers in a short time. It is striking that not every worker has a high skill here. So they find the cure with task assignment methods. Firstly, attention was paid to resource planning. Besides, different experiences and abilities, task repetition, priority constraints, resource limitation are another important points. In fact, it would not be wrong to say that this company was also affected by Toyota's optimization [16]. Calculating the tenure of the staff has not been easy. Therefore, the FS theorem was used to represent imprecise information. Genetic algorithms were preferred when the problems were clearly identified by the system. Optimization was tried to be achieved by making appointments according to the skill levels of the employees[17]. In another company that uses optimization methods to target high efficiency, the salary given to the personnel is minimized. Another limitation is to have at least one task among the employees and to maximize the efficiency. When using these constraints, scheduling algorithms were used. The algorithm here works as long as the judgment below is correct, using the attributes of the workers. Task and number of workers should always exist in the system. The entire task list is loaded, respectively. The best assignment is made where the efficiency is maximized. The utility function is updated at the end of the decision interval. In case of delay, due dates are updated. The task status of the worker to be assigned is updated. The most recently completed task is updated and the first task list loading step is resumed[18].

Finally, a hybrid heuristic algorithm will be written by adding the common good properties of all algorithms.

1. **MODELLING THE PROBLEM**

The cost function was minimized based on the data used.

Min z = QA feedback + Customer feedback + Re-test Bugs + Completion Period – Degree of Difficulty – Fixed Bugs

QA and customer feedbacks, number of re-test bugs, completion period affect the process negatively. After R&D approval, QA group tests the software. One of the tasks of the R&D group is to deliver less faulty software to the quality team. QA group should also deliver less faulty software to customer. Thus, so these 2 responses are quite an important factor for R&D tests. A good R&D tester must enter less re-test bug into system. Re-test bugs exhaust the system, but cause time loss. Of course, the tester who completes the test as soon as possible will contribute to the operation. The success rate of the tester will increase in direct proportion to how many bugs are corrected on a task basis. At the end of the test, all testers will vote the difficulty level from 1 to 10 per task. Here we will consider whether the testers are doing the tasks with pleasure, as well as their degree of happiness.

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