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FACULTY OF ENGINEERING AND NATURAL SCIENCES

CAPSTONE FINAL REPORT

PROJECT 1010603

Use of Machine Learning in Resource Planning Application in the Textile Industry

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- they have not falsely assigned credit for work to another student in the group, and not take credit for work done by another student in the group.

ABSTRACT

RESOURCE PLANNING AND SALES PREDICTION WITH MACHINE LEARNING TECHNIQUES

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In this study, it was tried to calculate the amount of fabrics to be used during that year by estimating the annual sales amounts of the clothes offered for sale by a company providing services in the textile industry in the locations where it is located. In order to create sales forecasts, XGBoost Regression Algorithm modeling is based on machine learning algorithms. The elaboration of this algorithm is the location of the store, the visibility of the product, the amount of fabric, the cut of the product, the amount of the product in the warehouse, etc. parameters are based on. All these parameters and modeling results will help companies with material resource planning

Key Words: MRP, Material Resource Planning, Sales Prediction, Textile Industry, Fabric

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1. OVERVIEW

In this study, we will use a sales forecasting algorithm for institutions and organizations serving in the textile industry using a machine learning algorithm. With this algorithm, we will help material resource planning by calculating the stock for the fabrics from which the products are produced.

Our system will generally collect data from the textile industry and use machine learning to perform optimization etc. for the companies. After the parameters and data are determined and processed into the system, the system will run continuously and fast. It will improve itself by processing the collected data one after another. It's going to reduce the workforce and save costs for companies. As 'Management Engineering' students (Cem, Aysu, Eda) we will take over the strategies, analysis, data collection and operation (etc.) of the project. As 'Computer Engineering' students (Sedef, Fatih) we will take over collecting data, processing the collected data, creating the system, etc.

1.1. Identification of the need

It is becoming increasingly difficult for institutions to plan how much stock they should keep for their fabrics in growing and developing textile factories.

Since too many processes and materials are handled at once, and rapid response timings for orders are crucial, material resource planning is an essential application in the textile industry.

Due to this, the development of applications for material resource planning for the textile industry has gained attention recently, and research into the topic has a tendency to grow daily. The implementation of a fundamental application for the planning of material resources in the textile industry with the use of machine learning will be carried out in this project.

1.2. Definition of the problem

Sales forecasting is the process of predicting the future sales amount of a product or service. By making sales forecasting, businesses can make more informed decisions about inventory management, marketing strategies and planning operations. There are several common methods for making sales forecasting;

- Methods Based on Historical Data: You can use these methods to predict future sales based on historical sales data:
- Simple Moving Average (Simple Moving Average): To predict future sales by taking the average of sales over a certain period of time.
- Weighted Moving Average (Weighted Moving Average): Calculating the moving average by giving different weights to different time periods and making sales forecasts.
- Exponential Moving Average (Exponential Moving Average): Making a forecast by giving more weight to more recent sales.

All these methods support institutions by forming around several parameters. However, institutions need comprehensive parameters in order to manage their inventories more efficiently.

Our problem that we aim to solve in this project is to eliminate the inventory management problem that occurs when institutions do not make sales forecasts.

When sales forecasting is not performed, businesses cannot accurately predict product or service demands. In this case, the problem arises of keeping stocks in the wrong quantities or at the wrong time. While an excess of inventory may increase storage costs, a lack of inventory may negatively affect customer satisfaction.

1.2.1. Functional requirements

The functional requirements of the use of machine learning in the textile industry can be listed as follows:

- Users should be able to log in to the system.
- Accounts for users should be able to be created by authorized individuals.
- Users' data entry permissions should be limited to their own departments.
- Login information for newly created users should be sent via email.
- Users should be able to change their own passwords.
- Users should not be able to change their demographic information. Only authorized individuals should be able to do so.
- Authorized users should be able to enter data.
- Authorized users should be able to edit data.
- The system to be established should be suitable for users to enter parameters and see the prediction with the best machine learning algorithm.

1.2.2. Performance requirements

- The speed of the system should not vary according to the number of users.
- The system should not slow down when data entry is made.
- The system should work continuously in sync.
- The result/response should be given to the user within a maximum of 5 seconds.
- If the user forgets their password, an email should be sent to the authorized person for password reset within a maximum of 3 minutes.
- The system should run smoothly on all operating systems.

1.2.3. Constraints

In terms of scheduling, we have more than one academic semester which is enough for gathering the necessary data and evaluating the results. The team consists of five people from two departments. Gathering five people together for a meeting is pretty difficult.

About cost of this project can be examined in the short-term and long-term. To examine in the short term, the investment in technology may be high, but in the long term, the investment in the application may seem reasonable because the labor cost will decrease.

The tool price may seem expensive at first, but after the workers are well-trained and if we reduce the number of workers, it may seem that there is less expense over time. However, it can never be reduced to 0 personnel/workers for the implementation of machine learning because it needs personnel to use the tool.

Generally, for the operation the company makes a contract for this machine learning/resource planning tool. The fee is calculated over the time that the development will take (man/day). Service fee is such as monthly subscription, so the concept is constantly recurring (machine learning cost, database is rent cost, server is rent cost etc.)

The implementation can be relatively costly but also we will see in the further parts of the report if it is reasonable or not. So, collecting and processing data has very strict legal requirements in general. Our project is not an exception. Furthermore, in order to not violate these requirements, we are willing to find some open source data and contact some textile factories. But in further parts in this report all the legal restrictions will be considered and come up with an applicable solution.

In terms of sustainability, labor sustainability can be added as a negative effect. As the workforce will decrease, which will reduce the number of personnel, workers may be left out. Unfortunately, this may cause some socio-economic problems.

1.3. Conceptual solutions

Our first concept in this project is to find the appropriate data to be used. Then we will clean up this data, edit it and make it suitable for modeling. Our second concept will be to apply machine learning algorithms. After that, the third concept is the technical review, the appropriate parameters(product type, the type of fabric from which the product is produced, the amount of sales of the product, etc.) we will do a technical review analysis for. Our fourth concept can be emotion analysis. After this stage, we plan to conduct a joint analysis of Machine Learning and Technical Review analyses and use these two points together. After these steps, we aim to make stock management of institutions in accordance with sales forecasting.

1.3.1. Literature Review

Machine learning is a branch of artificial intelligence. Machine learning applications are basically based on past data and can be used to predict the future accordingly. If we look at the benefits of machine learning models, it has been seen in the research that machine learning models give the same result with the real result at a high rate and increase the accuracy of the result. [1]. Machine learning is a form of artificial intelligence that uses a learning process based on data or data sets to solve problems. These methods are based on models that use past examples from the database and are then used to predict future events.

In material resource planning, machine learning techniques can be used to predict the material needs of a production facility by using past production data. [2]. These predictions can be used to optimize the material procurement process of the facility. For example, machine learning techniques can be used to analyze past production data of the facility and predict the facility's future material needs. These predictions can be used to organize the material procurement process of the facility and increase its efficiency. [3].

Machine learning techniques can also be used to optimize the material storage system of a production facility. For example, machine learning techniques can be used to analyze past production data of the facility and predict the facility's future material needs [4]. These predictions can be used to organize the material storage system of the facility and increase its efficiency. However, the use of machine learning techniques in material resource planning requires a large amount of data and it is important that this data is accurate and up-to-date.

There are many models of machine learning. The method to be used must be determined according to the application to be made and the outputs desired from this application. These models include linear models, decision tree models, neural networks, support vector machines, etc. In resource planning, regression-based algorithms are generally used to use past data to plan for the future. [5].

1.3.2. Concepts

There are three different concepts that we can evaluate within the framework of our project. The first is to continue with the SAP system, the second is to continue with machine learning, and the third is to continue in the traditional way without using machine learning and SAP. In the costs section of the continuation of the project, there are evaluations we made with the data we collected.

Table 1. Comparison of the three conceptual solutions.

	SAP	Machine Learning	Statistical Approach
Cost	**	***	**
Complexity	*	**	***
Performance	***	***	*
Features	**	***	*

[1 star (*) is bad, 2 star (**) is medium, 3 star (***) is good]

1.4. Physical architecture

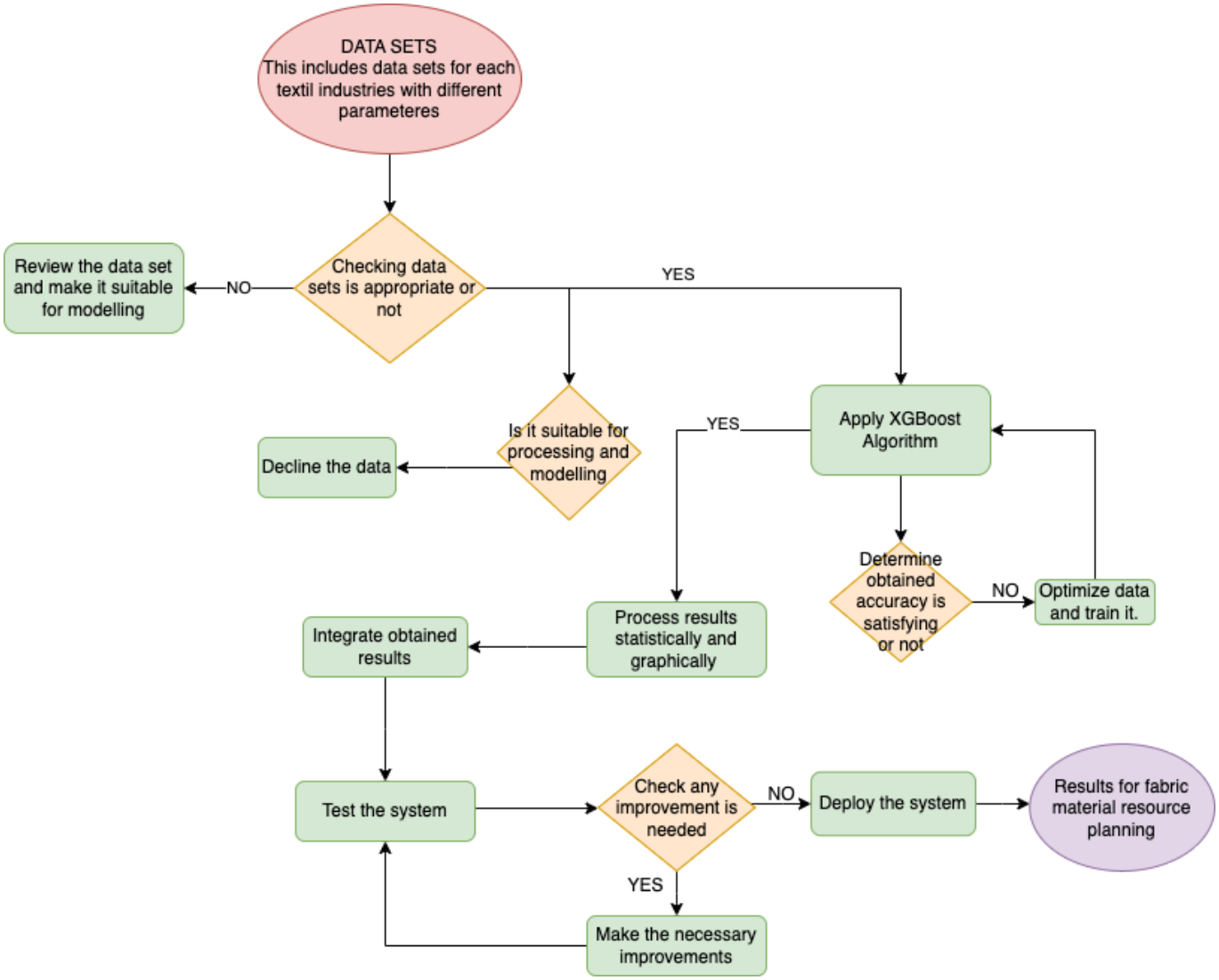


Figure 1. Physical Model

The algorithm decision table will be made in the following processes. We are continuing the algorithm training related to machine learning.

2. WORK PLAN

2.1. Work Breakdown Structure (WBS)

We made the work breakdown structure as deliverable oriented. You can see the major and minor deliverables required for the final product. In the '**Identification and beginning**' and '**Definition and Planning**' section, there is a general planning, how the works will be carried out through this planning, and the preparation of documents, files, etc. required to start the project. In the '**Research and Data**' part, the data required for our project will be collected. A data set will be prepared for computer engineers and they will work on this data set. In the '**Coding and Implementation**' section, computer engineers will create the codes of our system and perform implementation. In the '**Testing and Completion**' section, necessary tests will be made and presented to ensure the compatibility of the system. If the results of the tests are unexpected, the 'Coding and Implementation' section will be returned and any mistakes made will be tested and corrected.

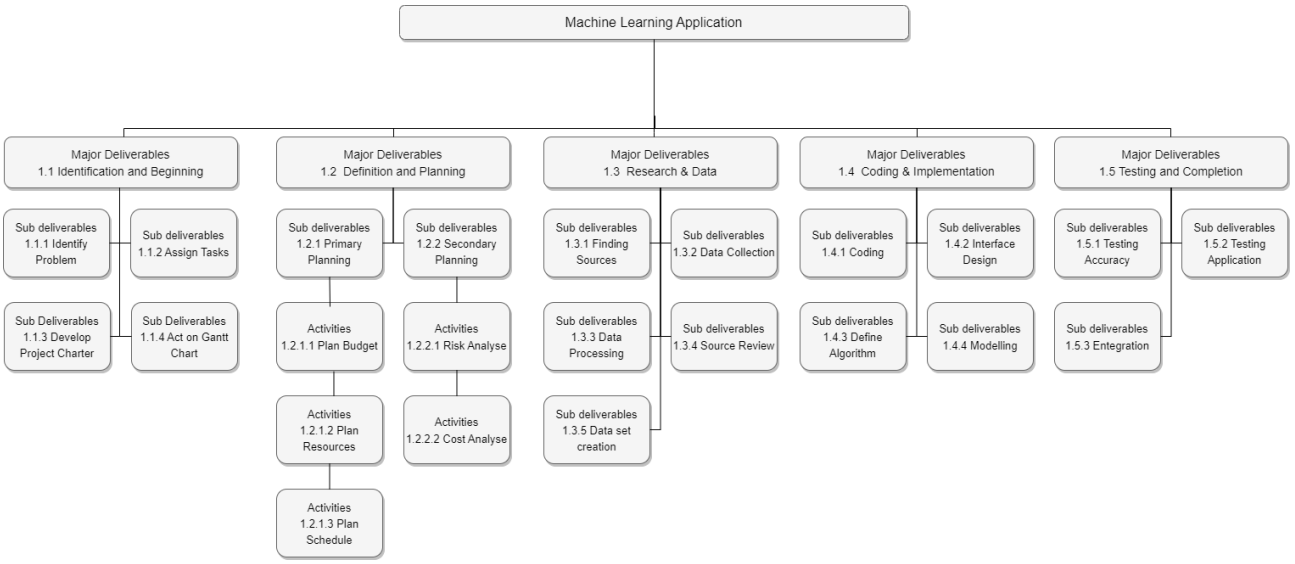


Figure 2. Work breakdown structure for the project.

2.2. Responsibility Matrix (RM)

In the Responsibility matrix, it is shown that any member of the team is responsible for which works and which works he or she will support throughout the project. In this way, it can be clearly seen who will do what and the distribution of the load is ensured.

Task	Eda	Aysu	Cem	Sedef	Fatih
Identification	R	R	R	S	S
Primary Planning	R	R	R	S	
Secondary Planning	R	R	R		S
Research	R	R	R	R	R
Data	S	S	S	R	R
Coding				R	R
Implementation	R	R	R	R	R
Testing			S	R	R
Reporting	R	R	R	S	S

Table 2

2.3. Project Network (PN)

Our project network demonstrates the interdependencies of the work to be implemented throughout the process.

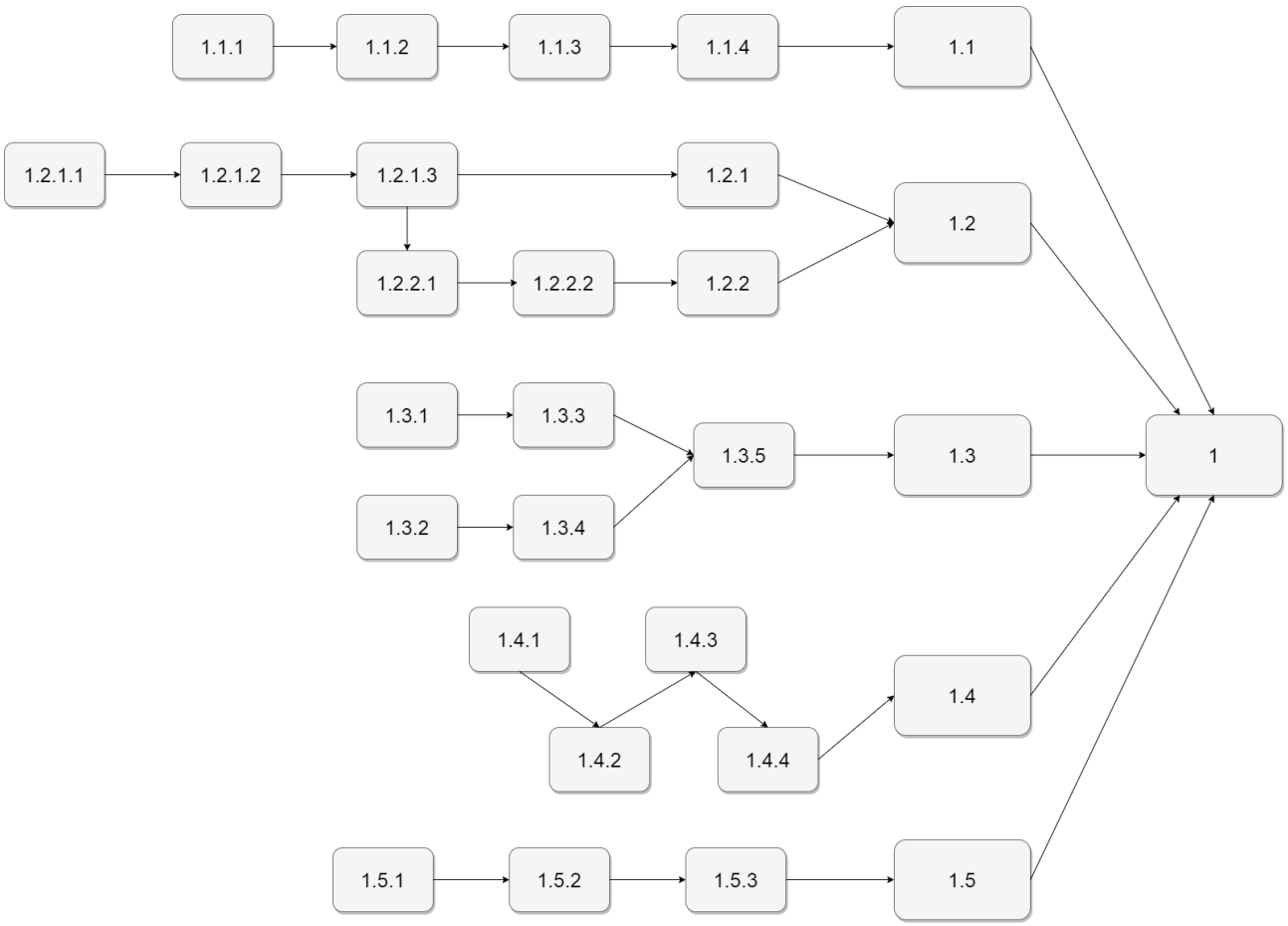


Figure 3. The project network

1.1 Identification and Beginning

1.1.1 Identify Problem

1.1.2 Assign Tasks

1.1.3 Develop Project Charter

1.1.4 Acting on Gantt Chart

1.2 Definition and Planning

1.2.1 Primary Planning

1.2.1.1 Plan Budget

1.2.1.2 Plan Resources

1.2.1.3 Plan Schedule

1.2.2 Secondary Planning

1.2.2.1 Risk Analyse

1.2.2.2 Cost Analyze

1.2.3 Report Analyzes

1.3 Research & Data

1.3.1 Finding Sources

1.3.2 Data Collection

1.3.3 Data Processing

1.3.4 Source Review

1.3.5 Data Set Creation

1.4 Coding & Implementation

1.4.1 Coding

1.4.2 Interface Design

1.4.3 Define Algorithm

1.4.4 Modelling

1.5 Testing & Completion

1.5.1 Testing Accuracy

1.5.2 Testing Application

1.5.3 Integration

2.4. Gantt chart

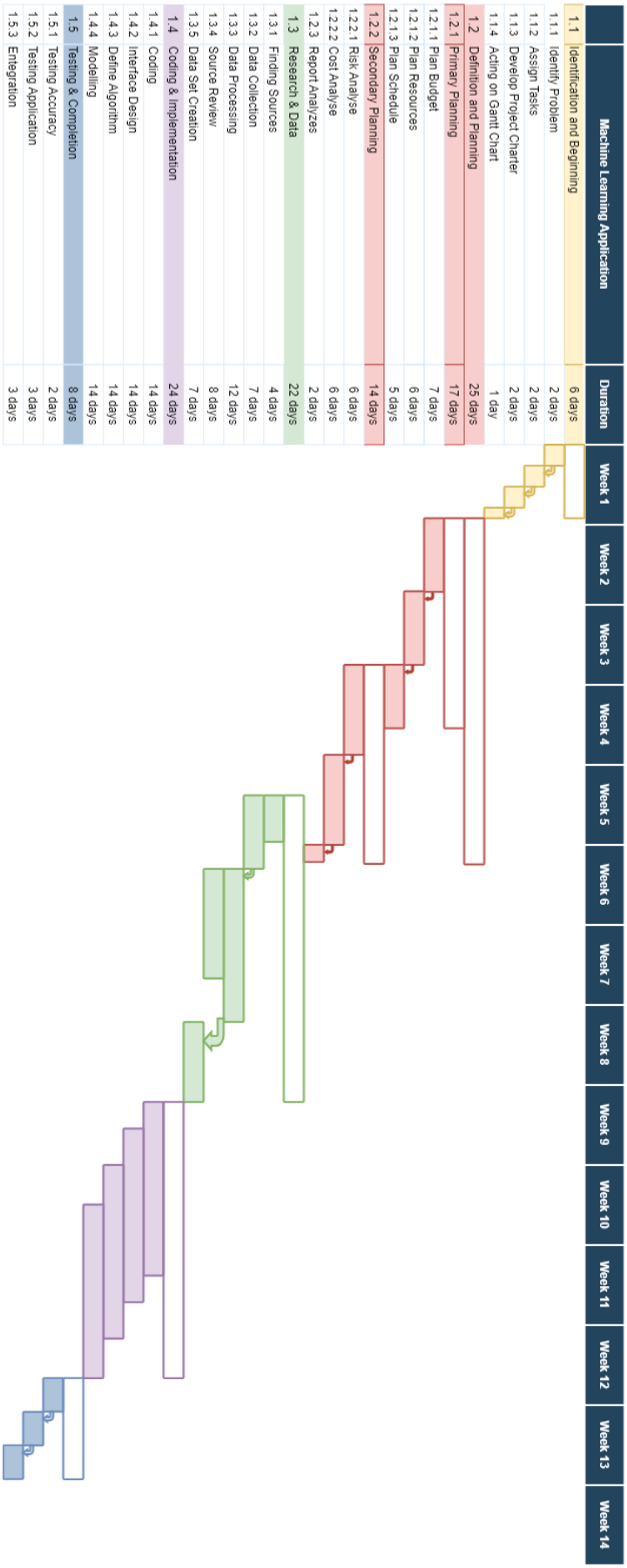


Figure 4. Gantt Chart

2.5. Costs

For our present research project, cost analysis and cost-performance analysis are crucial to the decision-making process. We are highly aware thet understanding a project's financial effects and performance results becomes crucial as organizations work to maximize their resources and achieve optimum efficiency. So, Cost analysis in this context refers to the methodical inspection and assessment of project-related expenses, whereas cost-performance analysis focuses on analyzing the link between project-related expenses and performance results. These evaluations will help us make informed decisions by giving us important information about the project's success and its financial sustainability which is one of our aims.

By defining and quantifying the major cost components, such as labor, materials, equipment, and overhead expenses, we can determine the entire project expenditure. This information is crucial for establishing reasonable budgetary objectives, figuring out our necessary funds, and making sure that financial resources are distributed properly throughout the project lifespan. Additionally, cost analysis enables us to identify possible cost-saving possibilities and develop our strategies to reduce expenses without risking our project's goals.

On the other hand, by analyzing the connection between project costs and performance results, cost-performance analysis will help us to assess the efficacy and efficiency of our project. We may evaluate the cost-effectiveness and value for money of our project by contrasting the actual expenses expended with the anticipated results. Moreover, these evaluations serve in identifying and choosing the most economical choice. The results of these studies additionally assist in successful stakeholder communication by helping them comprehend the costs and advantages related to the project's objectives which is very important for us.

In our quest to understand the textile industry, improve our service, and estimate project costs, we have reached out to several textile companies. We have had the opportunity to meet with some executives, individuals responsible for managing sales targets, conducting market research, handling cost accounting and so on.

To discuss the software aspect of our project, we have 11 different categories of information. Our first category represents the unique code assigned to each product we manufacture. Our next category indicates the amount of fabric needed to produce that particular product. Another category shows how visible the product is in our store, and yet another category reveals the store's location,

and so on.

By incorporating these 11 categories of data as parameters and employing machine learning techniques, our system generates a 12th column. This column predicts the annual sales volume for each desired product in a given store. Additionally, our system provides a 13th column, which reveals the required fabric quantity to produce the units mentioned in the 12th column. Utilizing machine learning, these two columns help us formulate an effective material plan based on the necessary fabric quantity.

As we develop this system, we will compare the cost analyses and performance evaluations of existing techniques and practices used by companies with the cost analysis and performance evaluation of the service we intend to provide.

Cost Analysis

First of all, as it was mentioned, we need to consider two types of analysis, one of them is Cost Analysis and the other one is Cost-Performance Analysis. These two analyses are utterly different from each other. The only common point of these two analyses is Cost.

For the Cost Analysis, we must determine all of the costs for the average company and our machine learning system. These costs include 'Direct Cost, Indirect Cost, and Variable Cost.' If we have to give an example for these three, Direct Cost includes; raw materials, labor cost, etc. Indirect Cost includes; energy expenses, rent, general expenses etc. Variable Cost includes; utilities, commission, distribution cost, etc.

So let us begin to calculate our variables.

First, the average Cost of some SAP Manufacturing systems setup cost is 250 USD per user/month. Assume that the company has 50 workers who use the SAP system. So we need to calculate the Cost of using the SAP system for all employees. 50 x 250 USD = **12.500 USD** is the total monthly fee.

Then we need to consider the salaries paid to the Material Resource Planning employees.

Presume that 15 of these workers use MRP. The salary of a material requirements planning (MRP) system depends on many factors and can be affected by various variables. These variables include factors such as level of experience, position responsibilities, and company size. During our sector analysis, we determine that a person who is working in the MRP department has a salary of **28.000TRY** on average. We assume that we fix the dollar rate as 20. When we calculate the salary in USD, 28.000TRY / 20 = 1.400 USD. Then we need to multiply this value by the number of employees; it is 1.400 USD x 15 = **21.000 USD**.

Besides all these, there are Indirect and Variable costs of this system, but in our analysis, we are basically comparing the costs and valuable points. So we do not need to calculate Indirect and Variable costs for the companies. It will be the same in any condition. That is why we will not specify these costs numerically.

On the other hand we need to calculate our Machine Learning System costs to continue our analysis. We have categorized the costs required to develop and maintain our system.
Lets calculate our costs;
For Needs Analysis and Design costs, we determine 1.000 USD as Salaries and expenses of analysts and business professionals and 4.000 USD as Needs analysis and design process. So a total of **5.000 USD.**
For Data Collection and Data Preprocessing Costs we determine 2.000 USD as Data set acquisition and cleaning, and 1.250 USD as Data storage and management. So a total of **3.250 USD**.
For Model Development and Training Costs we determine 1.500 USD as Salaries and expenses of data scientists and engineers, 2.000 USD as Algorithm selection and model development and 1.500 USD as Model training and optimization. So as a total **5.000 USD**
Another category is Testing and Verification Costs. We determine 1.250 USD as Test Data Set Creation and 2.500 USD as Evaluation of Performance Matrix. As a total of **3.750 USD**
For Distribution and Integration Costs; Salaries and expenses of software engineers: 6,000 USD and Integration of the software into the operating environment: 1,000 USD. So a Total of **7.000 USD.**
As Maintenance and Update Costs(annual), 1.500 USD as Maintaining and maintaining the software and 1.500 USD as Bug fixes and updates. So again as a total of **3.000 USD** we have here.

When we consider the costs of machine learning that we mentioned above, our first year cost is
5.000 + 3.250 + 5.000 + 3.750 + 7.000 + 3.000 = **27.000 USD**

Additionally, in the following year our Annual Continuing Cost will be **3.000 USD** / per year.

During our cost analysis, we analyzed the costs of SAP, an Enterprise Resource Planning system, and the Machine learning system, which is our final project. We accessed the data from information sources and kept parameters such as the number of workers the same for both systems. As a result, we saw that our Machine Learning system is much less costly than SAP, and the machine learning system seems much more profitable in terms of cost analysis.

Cost Performance Analysis

Cost performance analysis' main objective is to determine whether a project or process is achieving its cost targets and providing value for the resources used. Organizations can discover areas for improvement, make educated decisions, and implement corrective measures to improve efficiency and control costs by analyzing cost performance.

For the Cost-Performance analysis, we need to start with determining performance metrics. These metrics can change from situation to situation. In this part, the most important thing is what we expect from the tool, which we are going to use for the management and operations in the company.

Organizations can monitor project progress, identify cost drivers, evaluate the effectiveness of resource allocation, and make data-driven decisions to optimize costs and enhance overall performance by doing cost performance analysis.

Before starting the analysis, we must determine the metrics that are important to us and to the companies and we should do our analysis in the field of these metrics.
The metrics we determined are as follows;

- Integration
- Centralization
- Complexity
- Collaboration
- Customization
- User Interface
- Reliability and Accuracy
- Data Dependency

When we need to criticize, SAP is a common enterprise resource planning system and there are a lot of useful aspects of this system such as, Integration and Centralization. Organizations may consolidate their data, procedures, and operations thanks to SAP's broad and integrated platform. It makes it possible for diverse company operations, including finance, sales, procurement, production, and human resources, to integrate seamlessly with one another, facilitating effective departmental communication and data flow. Another useful aspect is ‘Enhanced Collaboration’. SAP solutions make it easier for teams to collaborate and communicate. They offer resources for

information exchange, teamwork, and workflow management.

Unfortunately, there are some challenges despite the useful aspects. For example, complexity. SAP systems are known for their complexity. It might be difficult to set up and administer because of the numerous modules, setup settings, and customization possibilities. There is always a requirement for skilled and experienced employees for all these. Another challenge of the SAP is 'Customization Challenges'. Despite the fact that SAP offers a wide range of customization possibilities, implementing modifications or creating new capabilities can be challenging and call for specialist knowledge. It could entail coding, system integration, and potential compatibility problems with modifications to the system in the future. A different challenge of SAP is 'User Interface'. In comparison to more recent software, some users regard SAP's user interface to be less intuitive and user-friendly. For casual or non-technical users, the system's intricacy and wealth of options may be too much to handle.

In terms of performance of our machine learning system, Automating repetitive operations, difficult computations, and data processing with machine learning systems will boost production and efficiency. Organizations may dedicate resources to more strategic and value-added operations by minimizing manual intervention. The accuracy of machine learning algorithms may be constantly increased over time by learning from data. They can spot trends and anomalies that would be hard for people to see, which improves the accuracy of jobs like fraud detection, picture recognition, and natural language processing. Also systems that use machine learning can scale to manage vast amounts of data and meet rising demand and one last thing Machine learning systems are able to continually adapt and learn from new data. Organizations may take advantage of the newest insights and trends by updating their models, improving forecasts over time, and improving performance.

Unfortunately, as in everything, Machine learning systems also have disadvantages. One of them is 'Data Dependency'. For the purpose of building precise models, machine learning systems largely rely on high-quality, diversified, and well-labeled data. Predictions may be wrong or skewed as a result of incomplete or biased data. When working with huge datasets, data collection and preparation may be time- and resource-intensive. There may be problems in terms of 'Model Robustness and Reliability'. Machine learning models could have trouble delivering consistent results outside of their training data distribution. They may exhibit unexpected behavior or poor performance if the input data is altered because of their sensitivity. To keep resilience and dependability, regular monitoring, model validation, and adaptability to changing situations are required.

There is also the traditional MRP system, carried out with paper or Excel without using either SAP or Machine learning. The traditional approach involved manually calculating inventory levels and production needs using spreadsheets or paper-based techniques. This procedure took a long time and was prone to mistakes. Making decisions based on immediate needs or inventory shortages was a common reactive planning strategy. It was difficult to efficiently utilize resources because there needed to be more visibility into future demand or production requirements. Since the information was dispersed among several departments, it took time to comprehensively understand the requirements for production, inventory, and procurement. Departmental coordination and communication could have been more cohesive. Traditional approaches could not analyze comprehensive data and depended on crude calculations and estimates. This made it difficult to spot patterns, predict demand, or manage inventory levels. The manual generation of purchase and manufacturing orders caused delays and additional administrative work. Manual follow-up and communication were required to coordinate the manufacturing teams and suppliers.

We evaluated the performances of our systems on the basis of the metrics we determined, and in the meantime, we need to make an evaluation by comparing these performance analyzes with their costs.
In terms of metrics, although the SAP system has certain advantages, it also has many disadvantages. In addition, although our system has disadvantages, it has disadvantages that are closer to the solution when compared to SAP. Especially from the disadvantages of the SAP system, Complexity and Customization Challenges are definitely not the kind of problems that can be fixed by the companies that use it. Also Machine learning systems can continually learn and adapt based on new data. This feature of machine learning makes it preferable despite its disadvantages.

When we combine all these performance analyzes with cost analyses, in short, the startup fees of the two systems we compare;

SAP system = 33.500 USD

Machine Learning System = 21.000 USD

Being able to reach a system with better performance with less expense is definitely an option that should be preferred. As a result of our Cost-Performance analysis, we think that a better cost-performance is more beneficial for companies, and we can see this in our Machine Learning System.

Conclusion for the Analyses

As a Management Engineering team, we carried out a cost analysis and cost-performance analysis of our machine learning system as well as the commonly used enterprise resource planning system SAP. Calculating different expenses, including direct, indirect, and variable costs related to both systems was part of the cost analysis. When compared to the SAP system, we discovered that the machine learning system was substantially less expensive.

Additionally, we carried out a cost-performance study by assessing the most important indicators regarding data dependency, integration, centralization, complexity, collaboration, customization, and user interface. The SAP system had advantages in areas like centralization and integration, but it also had downsides in terms of complexity, customization, and user interface. On the other side, the machine learning system showed benefits in operation automation, accuracy improvement, scalability, and adaptability. However, data dependencies and model robustness were two of its weaknesses.

We came to the conclusion that our machine learning system offered a more cost-effective and promising solution than the SAP system after taking the cost-performance analysis into account along with the cost analysis. The machine learning system is an appealing option for businesses looking to optimize their operations and resource allocation since it offers higher performance at a cheaper cost.

In conclusion, this study emphasizes the significance of performing in-depth cost analysis and cost-performance inspections when comparing different options. The results highlight the potential advantages of putting machine learning systems into use across a range of businesses, while also highlighting the necessity to deal with issues like data quality and model stability. Future businesses may benefit from increased productivity, better decision-making, and cost optimization thanks to this study and the use of machine learning systems.

2.6. Risk assessment

Table 5. Risk matrix

RISK LEVEL	Severity of the event on the project success: Minor	Moderate	Major
Probability of the event occuring: Unlikely	VERY LOW	LOW	MEDIUM
Possible	LOW	MEDIUM	HIGH
Likely	MEDIUM	HIGH	VERY HIGH

VERY LOW	This event is very low risk and so does not require any plan for mitigation. In the unlikely event that it does occur there will be only a minor effect on the project.
LOW	This event is low-risk; a preliminary study on a plan of action to recover from the event can be performed and noted.
MEDIUM	This event presents a signficant risk; a plan of action to recover from it should be made and resources sourced in advance.
HIGH	This event presents a very signficant risk. Consider changing the product design/project plan to reduce the risk; else a plan of action for recovery should be made and resources sourced in advance.
VERY HIGH	**This is an unacceptable risk. The product design/project plan must be changed to reduce the risk to an acceptable level.**

Table 6. Risk assessment

FAILURE EVENT	PROBABILITY	SEVERITY	RISK LEVEL	PLAN OF ACTION
The system may crash	Possible; It can be experienced when more data is loaded into the system than the storage space or processing capacity.	Major; When the estimation algorithm does not work for a long time, resource planning is disrupted and the need for raw materials cannot be met. There may be a disruption in the production line.	High	Support should be obtained by contacting the company that offers the software and the software development technical team.
Data can be stolen	Likely; It can happen when data sources are not protected correctly or data sharing is not managed correctly.	Major; If the data gets into the hands of competing companies with the operation of the data, the possible sales amounts may be revealed, which will harm the company.	Very High	It should find the sources that stole the stolen data, prevent it from falling into the hands of rival companies, and take the necessary security measures to prevent data theft ever again.
Not enough data to successfully train the Machine Learning system	Doubtful; It can be experienced when there are no 11 parameters required for data prediction.	Major; If the necessary data set is not provided for prediction, accurate results cannot be obtained and the machine cannot draw accurate conclusions. The correct resource planning cannot be done.	Very High	11 parameters must be completed.
Lack of Experience	Possible; That can be experienced due to the fact that everyone in the team is young.	Moderate; Lack of experience causes some basic mistakes while producing the product and these mistakes are overlooked.	Medium	Training will be given to inexperienced people. These people will learn the job and gain experience by working with experienced employees.
Lack of Capital	Likely; Due to the changing economic conditions, the existing capital determined may be insufficient.	Major; It increases borrowing, may cause a decrease in investments, difficulty in purchasing raw materials, and production balance may deteriorate.	Very High	In the new system integration, the process of transitioning directly to the system will be slowed down. Money will be obtained by borrowing money from the bank. The number of employees will be reduced.
Exchange rate	Possible; Exchange rates are constantly changing in current economic conditions.	Major; An increase in the exchange rate will cause a huge increase in the prices of the goods to be purchased and at the same time an increase in the selling price. There will be a decrease in purchasing power and difficulty in purchasing materials.	High	Since the exchange rate is constantly increasing, the necessary materials will be bought in bulk and will be affected by the exchange rate at a minimum level.
Occupational Accident	Possible; It consists of moving parts in machines used in all parts of the textile industry.	Major; Occupational accidents may occur in the form of crushing, breaking, breaking, etc. of the employees' arms, hands, fingers, or other parts of the body by being caught between the moving parts.	High	Employees will be given occupational safety training. Such accidents will be prevented by taking safety precautions in the machines.
Electrical hazard from installations	Likely; A deformation in the installation or electrical cables pose a risk.	Major; Injury and death can occur as a result of electric shock.	Very High	Panels should be checked, old cables and circuit elements should be replaced with new ones.
Material logistics	Likely; It is a viable problem due to the high supply of the product at the initial stage of production. Due to variables such as increasing electricity prices, the supplier may not willingly supply the price of the products.	Major; Due to the problems in supply, there is a problem in finding materials and production cannot be made in the planned number. There is a possibility that the lead time may be extended due to possible problems with the suppliers.	Very High	In case of problems in logistics, alternative supply routes and suppliers will be found and production will be prevented from stopping.

3. SUB-SYSTEMS

3.1. Sales Prediction for Material Resource Planning

3.1.1. Requirements

We have examined the requirements of the material resource planning application to be carried out within this project's scope under two sub-headings: cost and in terms of employees. Our primary goal is to increase production efficiency by optimizing companies' budgets and following up the production. We plan to realize this optimization by integrating Machine Learning applications into the company.

When we consider it from the point of view of the employee, the employee's loyalty to the company will be reduced. At the same time, in parallel with the new system integration, the competencies of the personnel will be increased, and possible errors will be minimized by training them on this system.

3.1.2. Technologies and methods

Cost performance analysis will be used when examining the operating system. In the further stages of the project, when machine learning and employee performance are compared, we will choose the option that will be efficient for us by using AHP (decision making) as a decision mechanism, as well as the analyzes we have made. While collecting data for machine learning applications, the accuracy and operability of these data will be analyzed.

3.1.3. Conceptualization

We intend to investigate the data of the textile yarn business within the parameters of this study due to the scale of the textile industry. For example, by keeping track of the inventory, we can restrict the project's scope to cotton utilized in the spinning business.We intend to employ the supervised learning structure from machine learning techniques to achieve this goal.

3.1.4. Evaluation

In the project scope, it will investigate whether it is more advantageous for the company when Machine Learning is used. This practice's long and short-term effects on the company will be evaluated from different perspectives using certain methods. After this evaluation, it will be decided whether it is reasonable to use machine learning or not.

3.2. Modeling with Machine Learning Algorithms

In this section, machine learning related requirements, planned algorithms to follow, technologies used in machine learning, etc. information will be mentioned.

3.2.1 Data Collection & Preparation and Visualization

In this system, contact was established with multiple textile industries to gather information about the functioning of the textile industry and initiate data collection. Information was gathered about the applications used in their resource planning systems through discussions with major companies such as Koton, İpekyol, and Sharabati Denim. Based on this information, parameters were created to be used in the dataset. Subsequently, open-source websites containing the dataset were scanned according to these parameters. The targeted parameters found in the collected dataset include product code, fabric quantity of the product, cutting style of the product, product visibility, type of fabric used in the product, quantity of the product in stock, establishment date of the store where the product is sold, location and area of the store, store size, and the previous sales of that product in the store.

The product code is a unique identifier for the product, similar to an identification number. The fabric quantity of the product refers to the amount of fabric used in the production of 100 units of the product. The product visibility is the visibility ratio of the product in the store where it is sold.

3.2.2. Requirements

By estimating the amount of product sales to be realized within the scope of this project, we examined the requirements of raw material or material resource planning application under two subheadings as functional and non-functional. At the very beginning of the functional requirements, the user should be able to create an inventory record using the application. In order to make a sales forecast in this inventory record, the mandatory 11 columns must be filled with complete and accurate data. The data entered into the system should not be processed manually. In order for the

machine learning algorithm to develop and learn more, data set should be uploaded to the system at regular intervals. The MRP system of the relevant industry should be fed with the output received for machine learning. It should be able to display discounted products in the inventory register. It should have an easy interface. The user should be able to search specifically about the material he wants to decipher.

For non-functional requirements, the database must be up-to-date and running simultaneously. The application should be able to accommodate a large number of users at the same time. The application should not allow it to run without filling in 11 columns, it should give a warning if there is a missing column.

3.2.3. Technologies and methods

In this project, the machine learning technology, a subfield of artificial intelligence, will be used. The main methods are machine learning algorithms and database integration. There are three main subfields of machine learning: supervised, unsupervised, and semi-supervised learning. To process output data patterns known by the system with labeled data, supervised learning algorithms will be used to use these data in a less complex way. Supervised machine learning creates a model that makes evidence-based predictions within uncertainty. A supervised learning algorithm takes a known input data set and known responses to the data, then trains a model to make reasonable predictions for new data. The main algorithms for this supervised learning approach are regression, CART (Classification and Regression Tree), Naive Bayes, and nearest neighbor. The appropriate algorithm technique will be selected based on the data set.

Within the scope of this project, the python language, which is open source, was used. XGBoost, Decision Tree and Random Forest machine learning algorithms were also used for sales prediction algorithms and modeling was done with this algorithm. In this section different python libraries are used.

3.2.4. Conceptualization

In this project, due to the size of the textile sector, we aim to examine the data of the textile fabric type sector. We limit the scope of the project with inventory records of cotton, etc. used in the yarn sector. When we start with these limitations, if we first use unsupervised learning methods; this method is suitable for finding relationships in data using labeled data and known answers. With this algorithm, we can group similar data points based on features or content; we can use it to show and represent data in a way that makes it easy to find patterns or connections in the data set; we can use

it to find patterns that show the relationship between variables in the data set. But these are not sufficient for resource management. The output of this method is prediction-oriented; the deviations are more. It gives outputs on uncertainty. Only prediction-oriented data in resource management can drag businesses into a spiral. For this reason, we looked at our other concept, the supervised learning mechanism. Supervised learning is an option that uses machine computers that are trained to predict results from labeled inputs. The goal of supervised learning is to train the model on labeled information and then use it to direct it later. Variables between these predictions are the correct predictors of prediction. Supervised learning structures use different prediction methods such as regression and thinking in the data set. With this concept, the machine works the data sets we give it and learns from them. Afterwards, it presents what it has learned to us based on the data we have given. With this modeling, we can learn a lot of data such as yarn needs, yarn stocks, seasonality, variables, etc. in the industry. This method seems to be the most efficient method in material resource management.

It is assumed that these concept reviews were created entirely by opting for the ML concept in 1.3.2

As a first step, we must perform the step of filling in the relevant 11 columns in order for the system to make a sales forecast. Then, steps such as filling in the empty fields in the relevant columns, clearing the excess fields, visualization should be performed. In short, this step is called Exploratory Data Analysis.

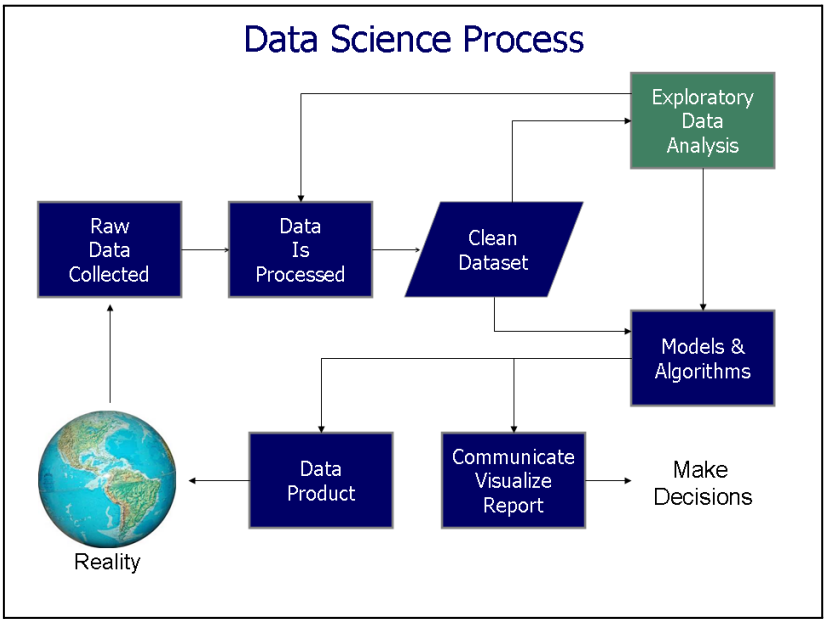


Figure 5. Data Science Process Algorithm

	Item_Id	Item_Visibility	Store_Id	Item_Store_Sales	Item_Fit_Type	Item_Fabric	Item_Fabric_Amount
3810	1282	0.034942	0	123.8388	2	9	19.85
2318	334	0.014577	6	2864.2716	1	7	17.75
242	724	0.020903	9	3098.6332	1	8	13.10
5528	1330	0.060805	5	3339.6528	1	0	10.80

Figure 6. Data Set Columns 1

Item_MRP	Store_Establishment_Year	Store_Size	Store_Location_Type	Store_Type
132.1968	1998	2	2	0
224772.0000	2004	2	1	1
231.1668	1999	1	0	1
118344.0000	1985	1	2	3

Figure 7. Data Set Columns 2

As the next step, table controls are performed by making a data visualization of the columns.

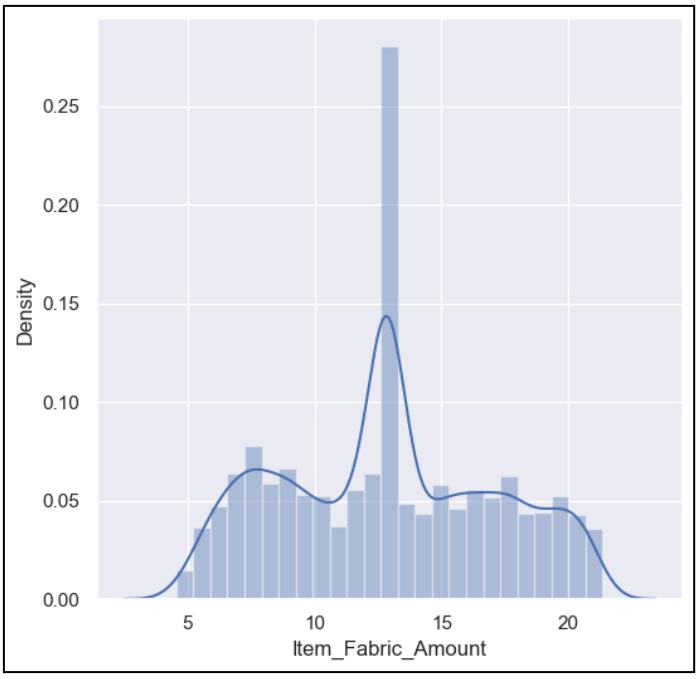


Figure 8. Item Fabric Amount Visualization

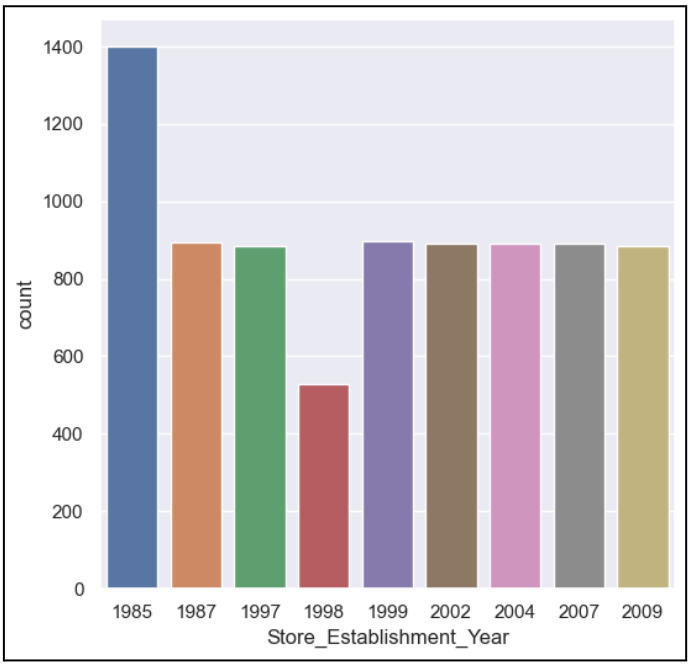


Figure 9. Store Establishment Year Visualization

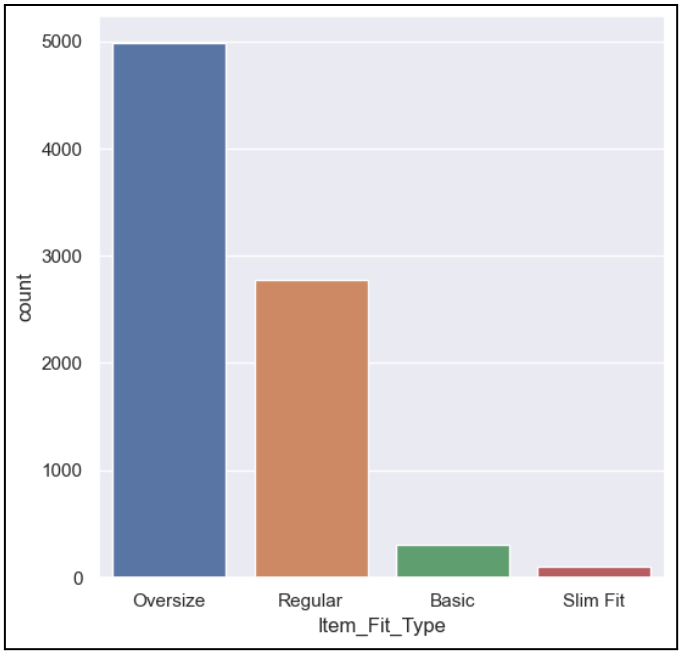


Figure 10. Item Fit Type Visualization

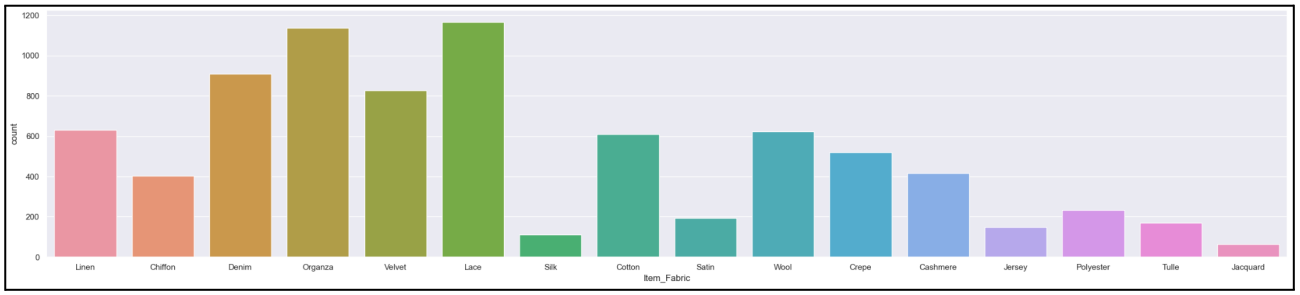


Figure 11. Item Fabric Type Visualization

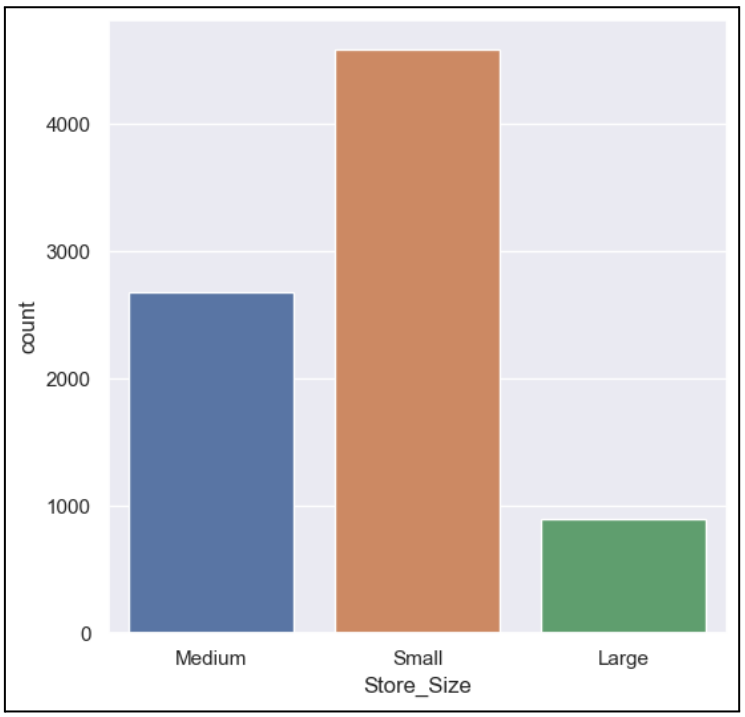


Figure 12. Store Size Visualization

Viewing these visualizations and charts is not mandatory. It is just a graphic visualization step that we do to control your data. After that, we can start using the models we have determined for our system. We worked with 3 main models with our research. These; The XGBoost algorithm is the Decision Tree algorithm and the Random Forest algorithm.

3.2.4.1. Decision Tree Algorithm

Decision tree algorithms divide the data sets into decision nodes and leaf nodes according to their properties or desired outcome target and bring them into tree form. With this method, it divides the data into small pieces and ensures that the data becomes the smallest pieces. A decision node can contain more than one branch.

This structure is easy to understand and interpret. Therefore, it can be easily visualized. In addition, there is no need to process the dataset too much. Data preparation takes a short time. But this model does not support data with missing values. The tree cost depends on the size of the dataset.

The downside of this algorithm is that as the data set grows, very complex trees can be produced. Therefore, tree branching may not be tracked.

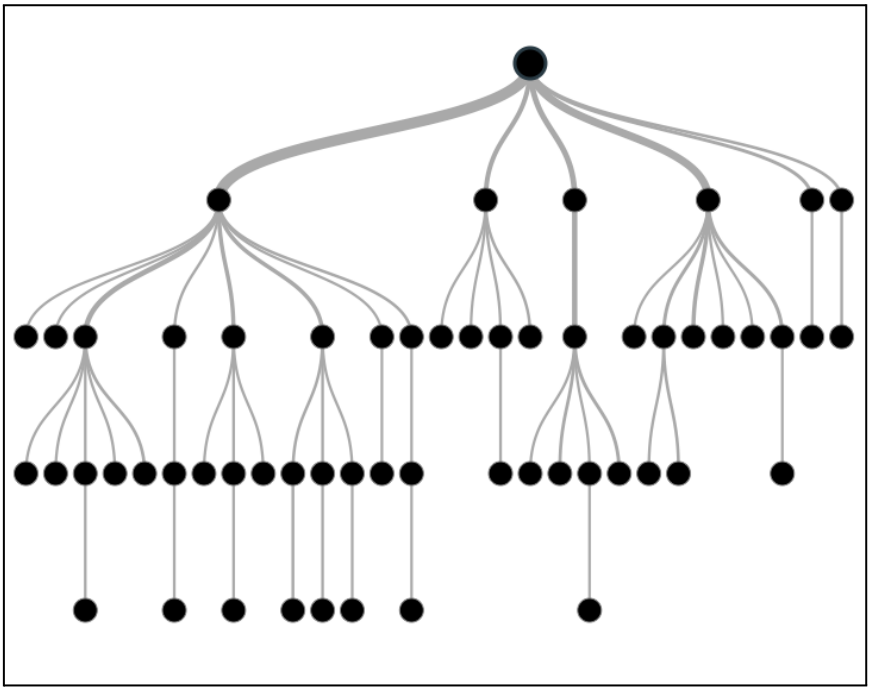


Figure 13. Decision Tree Algorithm Visualization

In this algorithm, there is a parameter called R square, which indicates the margin of error. This parameter must be between 0 and 1. If this margin of error is negative, it is understood that the relevant data does not work with this algorithm and produces incorrect results.

As you can see in Figure Decision Tree Algorithm Code with Python, the margin of error parameter of the algorithm we have applied to our data set has a negative value. In this way, we see that this algorithm is not suitable for our dataset.

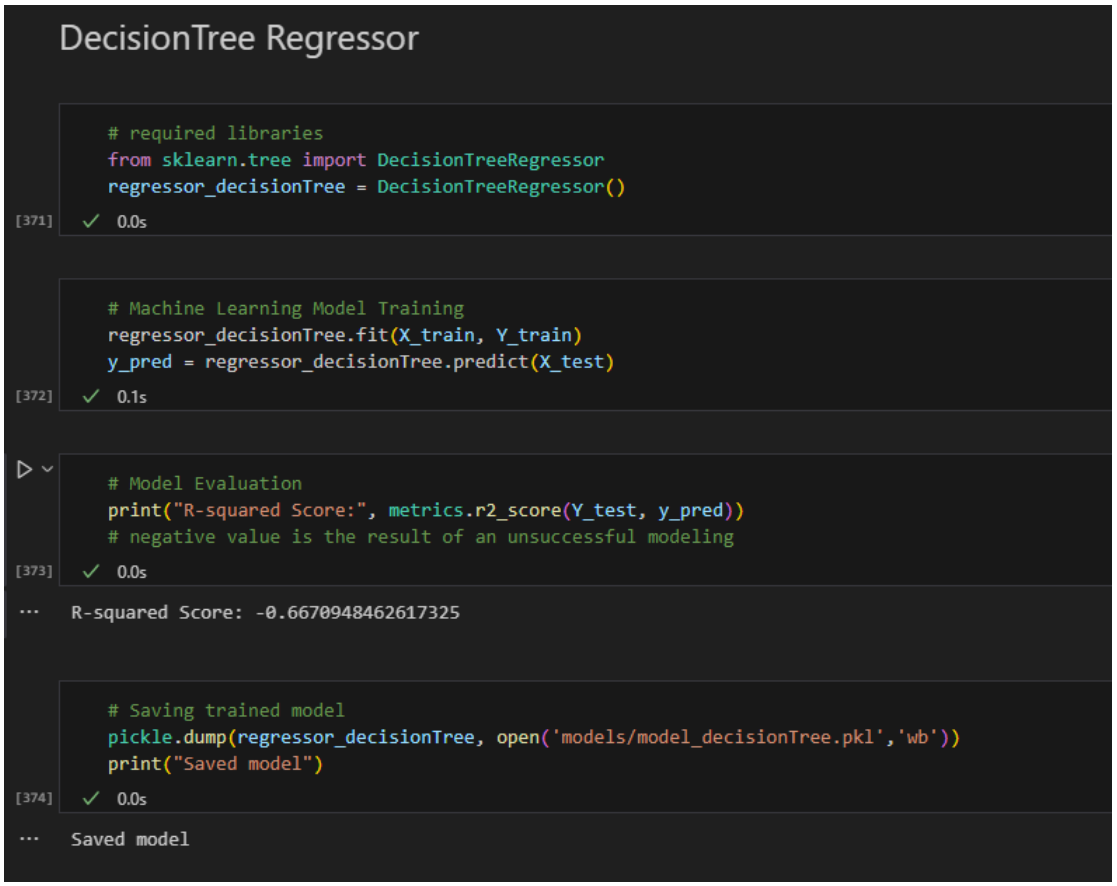


Figure 14. Decision Tree Algorithm Code with Python

3.2.4.2. Random Forest Algorithm

Random Forest is an ensemble method used for classification and regression problems in machine learning applications. We will use it for regression. The working steps of the algorithm are as follows;

1. The data set to be analyzed is prepared,

(The cluster to be analyzed is created, if necessary, data cleaning is performed.)

2. The algorithm creates a decision tree for each sample and the estimated value result of each decision tree is generated,

3. Voting is performed for each value formed as a result of the prediction,

(Mode for Classification problem, Mean for Regression problem)

4. Finally, the algorithm generates the result by choosing the most voted value for the final guess.

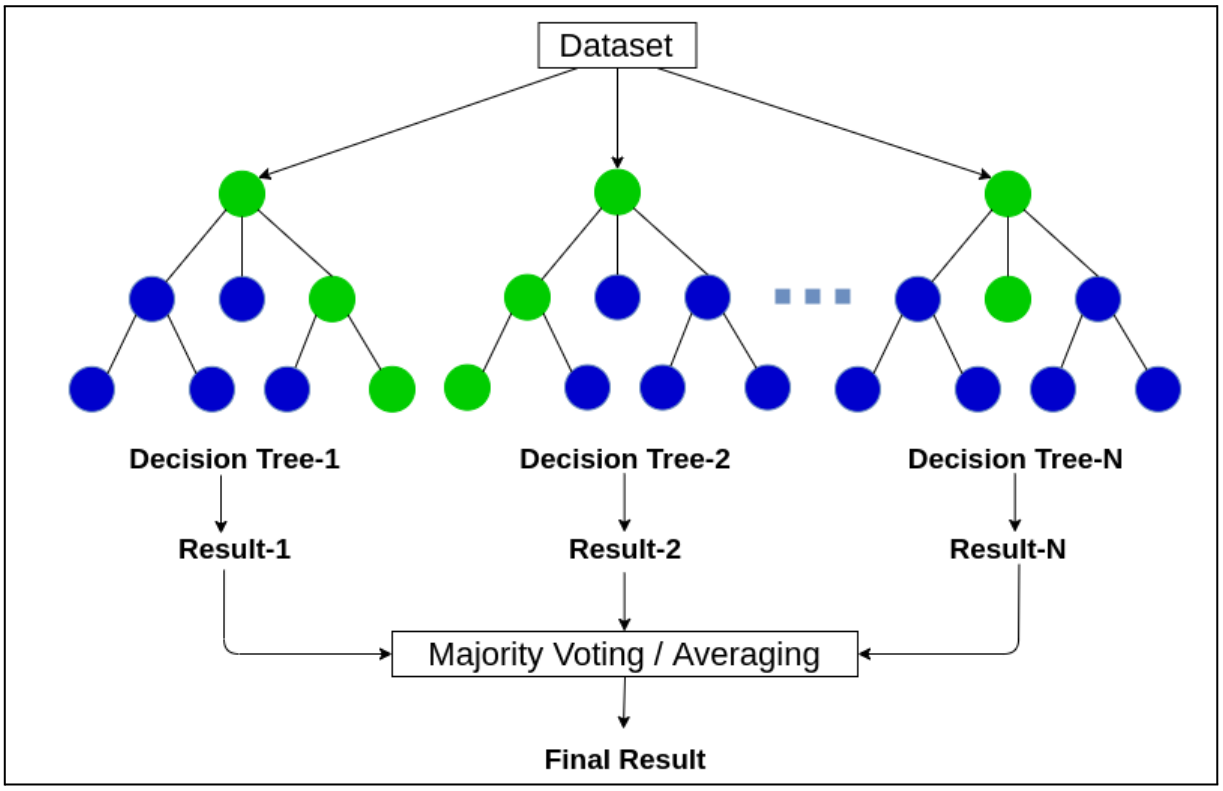


Figure 15. Random Forest Algorithm

As we mentioned in the algorithm above, we also have a parameter that calculates the margin of error called R Square. As you can see in Figure Random Forest Algorithm Code with Python, the margin of error parameter of the algorithm we applied to our data set has a value between 0-1. In this way, we see that this algorithm is suitable and usable for our dataset.

randomForest Regressor

```
# required libraries
from sklearn.ensemble import RandomForestRegressor
regressor_randomForest = RandomForestRegressor()
```

[250] ✓ 0.0s

```
# Machine Learning Model Training
regressor_randomForest.fit(X_train, Y_train)
y_pred = regressor_randomForest.predict(X_test)
```

[251] ✓ 4.3s

```
# Model Evaluation
print("R-squared Score:", metrics.r2_score(Y_test, y_pred))
```

[252] ✓ 0.0s

```
R-squared Score: 0.06831301643522014
```

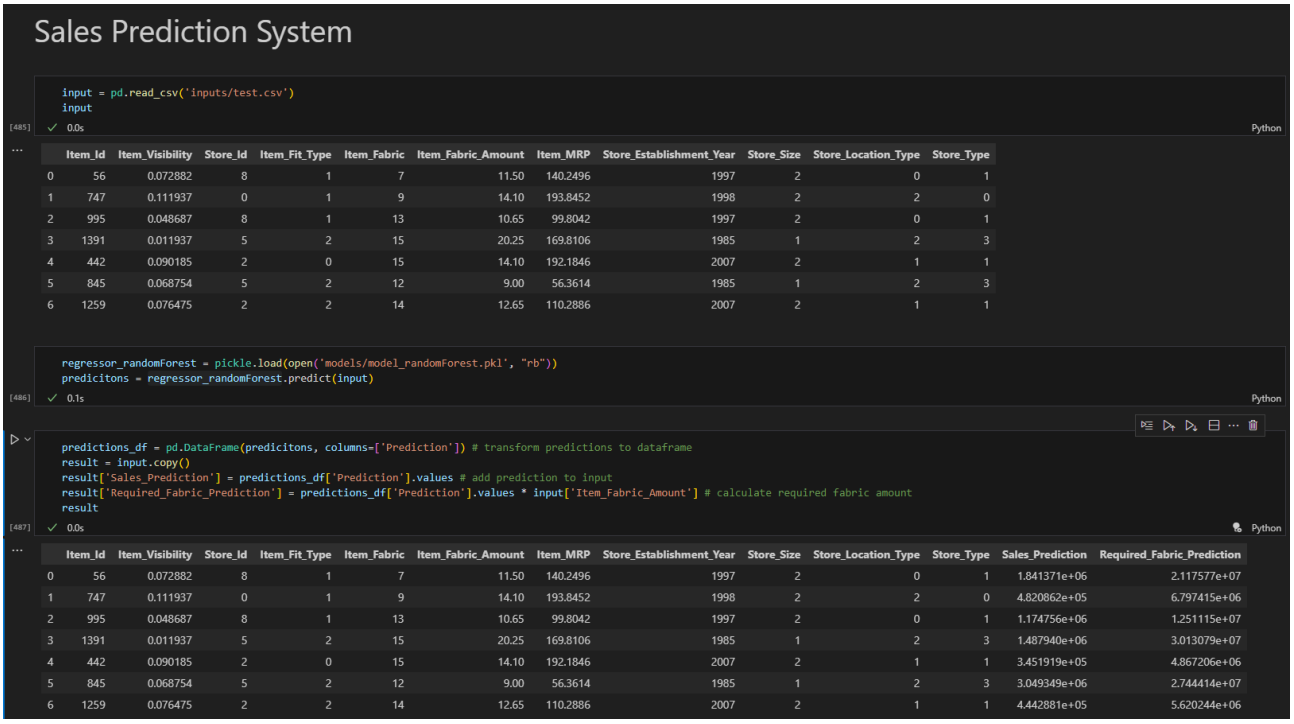
```
# Saving trained model
pickle.dump(regressor_randomForest, open('models/model_randomForest.pkl','wb'))
print("Saved model")
```

[253] ✓ 0.0s

```
Saved model
```

Figure 16. Random Forest Algorithm Codes with Python

You can see the result of running this code in Figure Sales Prediction System Results.



	Item_Id	Item_Visibility	Store_Id	Item_Fit_Type	Item_Fabric	Item_Fabric_Amount	Item_MRP	Store_Establishment_Year	Store_Size	Store_Location_Type	Store_Type
0	56	0.072882	8	1	7	11.50	140.2496	1997	2	0	1
1	747	0.111937	0	1	9	14.10	193.8452	1998	2	2	0
2	995	0.048687	8	1	13	10.65	99.8042	1997	2	0	1
3	1391	0.011937	5	2	15	20.25	169.8106	1985	1	2	3
4	442	0.090185	2	0	15	14.10	192.1846	2007	2	1	1
5	845	0.068754	5	2	12	9.00	56.3614	1985	1	2	3
6	1259	0.076475	2	2	14	12.65	110.2886	2007	2	1	1

	Item_Id	Item_Visibility	Store_Id	Item_Fit_Type	Item_Fabric	Item_Fabric_Amount	Item_MRP	Store_Establishment_Year	Store_Size	Store_Location_Type	Store_Type	Sales_Prediction	Required_Fabric_Prediction
0	56	0.072882	8	1	7	11.50	140.2496	1997	2	0	1	1.841371e+06	2.117577e+07
1	747	0.111937	0	1	9	14.10	193.8452	1998	2	2	0	4.820862e+05	6.797415e+06
2	995	0.048687	8	1	13	10.65	99.8042	1997	2	0	1	1.174756e+06	1.251115e+07
3	1391	0.011937	5	2	15	20.25	169.8106	1985	1	2	3	1.487940e+06	3.013079e+07
4	442	0.090185	2	0	15	14.10	192.1846	2007	2	1	1	3.451919e+05	4.867206e+06
5	845	0.068754	5	2	12	9.00	56.3614	1985	1	2	3	3.049349e+06	2.744414e+07
6	1259	0.076475	2	2	14	12.65	110.2886	2007	2	1	1	4.442881e+05	5.620244e+06

Figure 17. Sales Prediction System Results

3.2.4.3. XGBoost Algorithm (eXtreme Gradient Boosting)

Extreme gradient boosting, which is frequently used in regression, classification and ranking problems and is one of the best machine learning algorithms for these problems, is a scalable distributed decision tree machine learning algorithm.

Machine learning-based methods such as supervised machine learning, decision trees, ensemble learning and gradient boosting issues are important in making sense of the XGBoost algorithm.

Supervised machine learning uses various algorithms to train the model to identify patterns in a dataset containing various features and to use this model to predict the effects on the properties of new datasets.

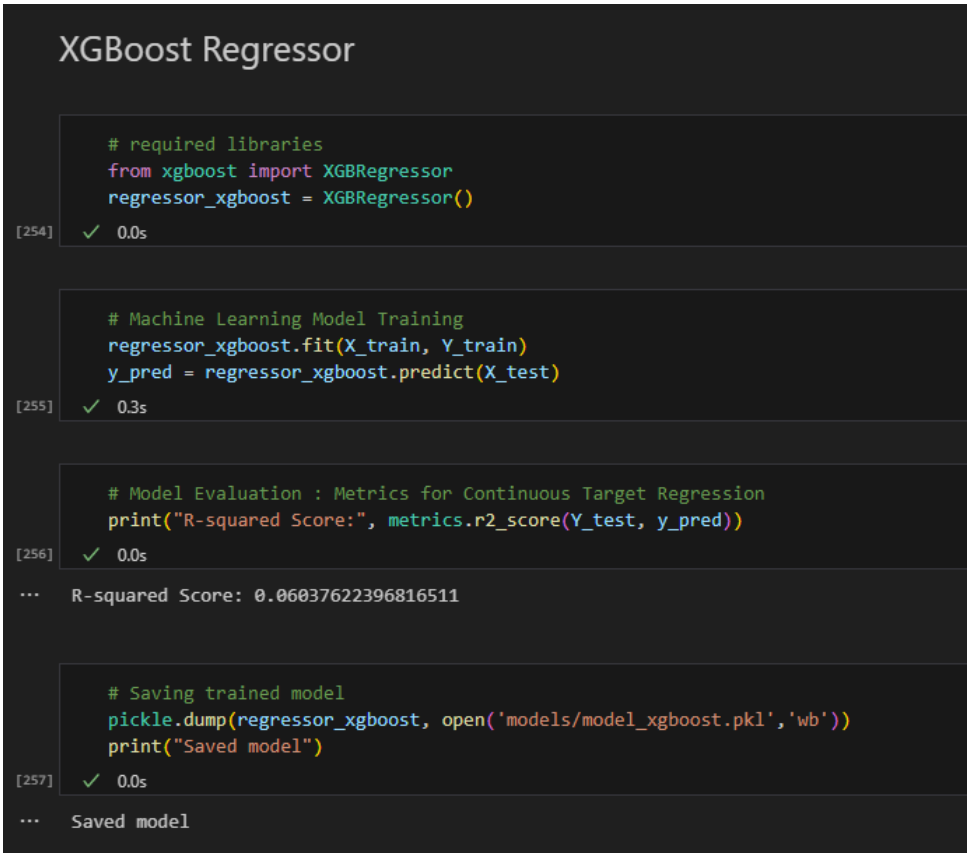


Figure 18. XGBoost Algorithm Code with Python

As you can see in the Figure XGBoost Algorithm Code with Python image, the R square parameter, which represents our margin of error, is between 0-1. By processing the data set we use with this algorithm, we can reach the results we want.

3.2.5. Software architecture

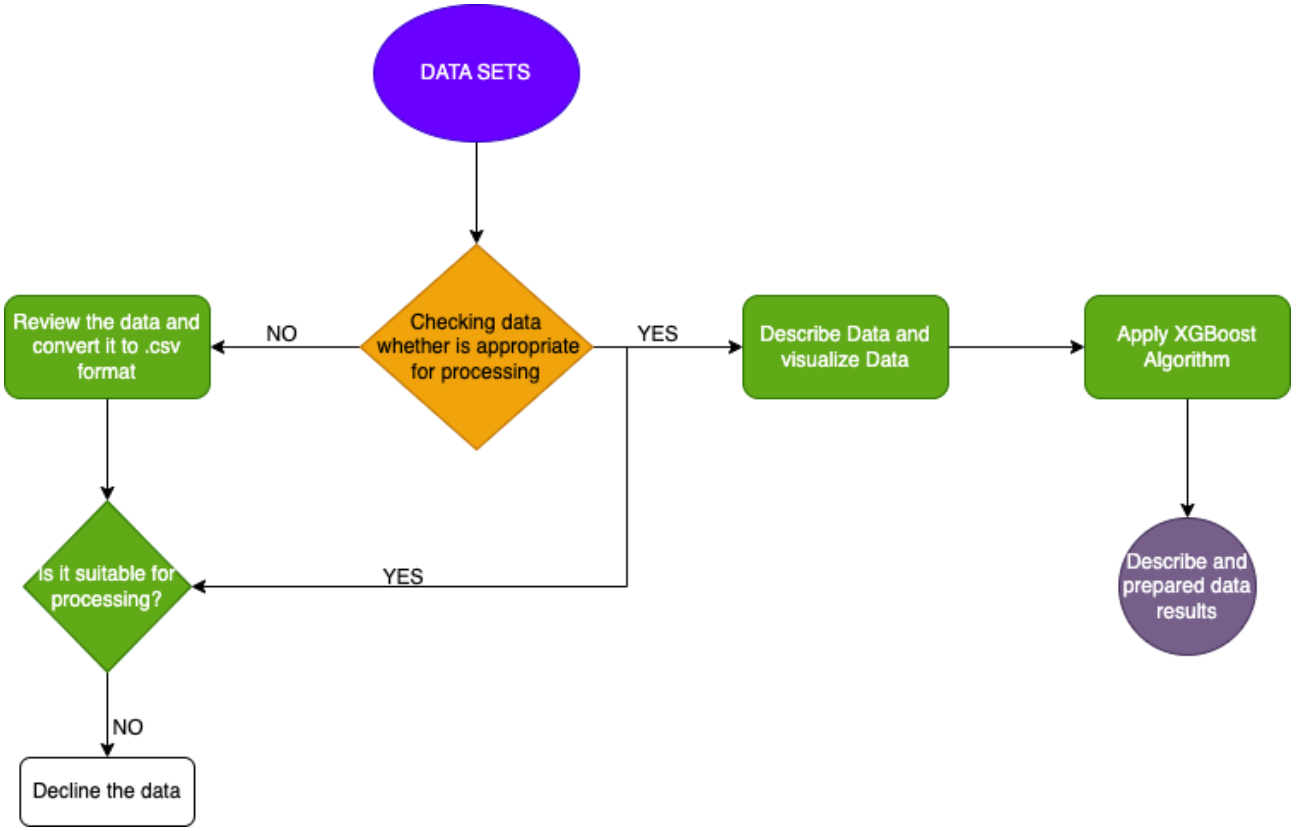


Figure 19. Physical architecture of the data collection, preparation & visualization sub-system

3.2.6. Evaluation

When the targeted objectives are achieved within the scope of the project, a technology-based and synchronous working inventory record of the companies using the service will be formed. These inventory records will reveal the inventory that is likely to be needed in the future, both in using historical data, in managing the inventory available today.

Apart from all these positive evaluations, negative factors may also occur. In any negative situation that occurs on the developed technology, the company may be badly affected. Data loss may occur.

4. INTEGRATION AND EVALUATION

4.1. Integration

As the Computer Engineering department, we first subjected the data we found together with the management engineering team to data cleaning and preprocessing steps before training them with machine learning techniques. We researched various algorithms to find the best algorithm for sales forecasting and, accordingly, resource planning. These are Random Forest Algorithm, XGBoost Regression Algorithm, Extra Trees Regression Algorithm, Support Vector Regression Algorithm, Linear Regression Algorithm. Among these algorithms, we chose the most suitable XGBoost Regression Algorithm for sales forecasting. We have developed a data upload and results area for users for sales forecasting. The management engineering team did the necessary tests and we did not encounter any faults. We plan to place our product in the production environment in the coming periods.

As the Management Engineering department, after acquiring the necessary data, we started researching the existing systems currently being used by companies and their associated costs, in addition to the service we will be offering. Based on the information obtained from these researches and our own estimations based on service costs, we conducted cost analysis and cost-performance analysis of the compared systems.

For the Cost Analysis, we had to determine all of the costs for the average company and our machine learning system which were 'Direct Cost, Indirect Cost, and Variable Cost.'

For the Cost performance analysis' our main objective was to determine whether our project is achieving its cost targets and providing value for the resources used. For the Cost-Performance analysis, we needed to start with determining performance metrics. In this part, the most important thing was what we expected from the tool, which we are going to use for the management and operations in the company.

We examined the expenses of SAP, an enterprise resource planning system, and the machine learning system, which is our capstone project, during our cost study. We retrieved the data from information sources and maintained constants for both systems, such as the number of workers. As a consequence, we discovered that our machine learning system is much more affordable than SAP, and the machine learning system appears to be far more effective when considering costs.

4.2. Evaluation

In this project, a machine learning algorithm was used to examine, organize and process datasets. First, we manually examined the datasets we found through various sources and determined whether they were suitable for machine learning. Then, we preprocessed the data in order to fill in the blank cells in the relevant data set and make sense of the data. Afterwards, we applied a visualization (chart and table creation) step in order to visually see the relevant data columns and increase their memorability. After that, we chose the XGBoost algorithm, one of the machine learning algorithms that we decided to be suitable for sales forecasting, and taught the data set to the machine. We made the sales estimation of the product with 11 parameters in the data set we taught. We output this sales forecast as the 12th column. In the light of all the data, using the sales forecast of the products, we found the amount of fabric planned to be used in that year and the approximate values of the fabric types. With these approximate values, we enabled the company to determine its sales volume and also supported it to make resource planning. In the light of this information, machine learning can be developed by adding different parameters to the relevant data set and support can be obtained from different algorithms. For example, in addition to 11 parameters, parameters such as color, season, etc. By adding parameters, it is possible to determine which color will sell the most in which season. In this way, logistics management, warehouse need, etc. It can also contribute to the planning of operational processes.

We carried out a cost analysis and cost-performance analysis of our machine learning system as well as the commonly used enterprise resource planning system SAP.We conducted a thorough cost study of two systems as part of our project: our own Machine Learning system and SAP, a popular Enterprise Resource Planning (ERP) system used by businesses.

We initially calculated the average activation cost for SAP, which came to $250 USD per person per month. So given that 50 employees in our business use the SAP system, we determined that the total monthly cost would be $12,500 USD. We also considered the wages of the Material Resource Planning (MRP) personnel. Our detailed industry research showed the typical MRP employee earns 28,000 TRY per year, which, at a 20 percent rate of exchange, translates to $1,400 USD. So we can accept that the overall cost of salaries for MRP's 15 workers comes to $21,000 USD.

Moreover, we divided the expenses related to the development and maintenance of our machine learning system into different categories. In addition, we budgeted $5,000 USD for the needs analysis and design phase, of which $4,000 USD was set aside for the process and the remaining

$1,000 USD for the wages and costs of analysts and business experts. For the data set collection and cleaning expenses we assessed $2,000 USD, while data storage and administration costs were projected at $1,250 USD, for a total of $3,250 USD.

For our model development and training, we budgeted $5,000 USD, which included $1,500 USD for the wages and costs of data scientists and engineers, $2,000 USD for the choice of algorithms and model development, and $1,500 USD for model training and optimization. Additionally, the Testing and Verification phase incurred expenditures of $3,750 USD for the evaluation of performance indicators and $1,250 USD for the creation of test data sets.

A total of $7,000 USD was spent on distribution and integration expenditures, which included $6,000 USD for software developers' salary and related charges and $1,000 USD for integrating the program into the operating environment. Last but not least, the cost of yearly maintenance and upgrades was expected to be $3,000 USD ($1,500 USD for software maintenance and $1,500 USD for bug fixes and updates).

Taking into account the previously mentioned expenses, our machine learning system had a first-year cost of $27,000 USD. The next year's predicted yearly ongoing expense was also estimated to be $3,000 USD.

We compared the expenses of SAP and our Machine Learning system through our thorough cost analysis, while maintaining constants like the number of workers between the two systems. In essence, the beginning costs of the two systems we compare when we integrate all performance assessments with cost analyses are ; 33.500 USD for SAP system and 21,000 USD for machine learning system. An alternative that deserves to be selected is one that allows for the development of a system with superior performance at a lower cost. In light of our examination of cost-performance, we believe that higher cost-performance is more advantageous for businesses, and our machine learning system reflects this.

5. SUMMARY AND CONCLUSION

It is possible to make accurate resource planning by using machine learning for sales forecasting. This method first offers the potential to increase sales by making accurate predictions. Machine learning models can analyze large datasets to discover trends, patterns, and relationships. By using this information, it becomes possible to predict future sales. Accurate predictions enable better results in business decisions such as inventory management, marketing strategies, and operational planning.

Furthermore, using machine learning for sales forecasting provides a time-saving advantage. Manual data analysis and making predictions can be time-consuming. Machine learning models, on the other hand, can process large amounts of data quickly and generate meaningful results. This allows companies to make faster decisions and adapt to changes in the market more quickly.

However, there are some potential drawbacks to using machine learning for sales forecasting. Firstly, if the model makes incorrect predictions, it can lead to misguidance. This can result in the implementation of incorrect strategies and wastage of resources. Additionally, for the model to make accurate predictions, it requires up-to-date and accurate data. If there are errors or gaps in the data, the predictions may not be accurate. Therefore, high data quality and continuous updates are important.

Furthermore, larger businesses that have rich resource pools and substantial user bases may utilize this service to boost operational effectiveness, achieve considerable company development, and acquire a competitive edge. In contrast, the cost of implementing and maintaining such a service may cause financial challenges for smaller businesses with fewer users/employees. To ensure that decisions about its adoption are well-informed, it is necessary to assess the long-term profitability and scalability that this service can provide to various companies.

In summary, using machine learning for sales forecasting has many benefits for resource management, but it also comes with some risks. These risks can be mitigated by ensuring high data quality, selecting appropriate models, and implementing proper management strategies.

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APPENDIX A

Following link includes source codes for data collection and modeling.

https://github.com/yarliganfatih/Machine-Learning-App-in-the-Textile-Industry