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YILDIZ TECHNICAL UNIVERSITY
DEPARTMENT OF COMPUTER ENGINEERING

PRODUCTION OPTIMIZATION INFORMATION SYSTEM

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SENIOR PROJECT

Advisor
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ACKNOWLEDGEMENTS

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Yiğit DEMİRKO
Sait YALÇIN

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ABSTRACT

PRODUCTION OPTIMIZATION INFORMATION SYSTEM

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Senior Project

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In this study, an information system that aims to increase production performance and production efficiency by systematically improving techniques in the industrial environment with optimization methods has been implemented. The focus of this study is implementing an information system with using genetic algorithm and gradient descent optimization methods and linear programming and dynamic programming operations research methods to determine how to make production more efficient and successful for a ready-mixed concrete factory when considering orders and raw material stocks.Production optimization is crucial for being competitive in today's fast-paced, always changing, and dynamic manufacturing industry. Within the scope of this study, it was emphasized that the parameters in this dataset, such as cement, slag, ash, water, superplastic, coarse aggregate, fine aggregate, and time, determine the quality of concrete, and these parameters were tried to be optimized with various methods, thus increasing the production capacity. and it was determined whether the concrete's quality might be improved.During the project, the data set was thoroughly analyzed and reported on, and the methodologies were validated and evaluated. At the end of this study, manufacturing optimization can be evaluated in general, and concrete production may be accomplished in a more optimal manner. This increases the efficiency of manufacturing systems and more production can be achieved.

Keywords: Production, optimization, cement, information system, dynamic programming, linear programming, gradient descent, genetic algorithm

ÖZET

ÜRETİM OPTİMİZASYONU BİLGİ SİSTEMİ

Yiğit DEMİRKO
Sait YALÇIN

Bilgisayar Mühendisliği Bölümü
Bitirme Projesi

Danışman: Prof. Dr. Oya KALIPSIZ

Bu çalışmada, endüstriyel ortamda tekniklerin optimizasyon yöntemleriyle sistemli bir şekilde iyileştirilmesiyle üretim performansın ve üretim verimliliğinin arttırılmasını hedefleyen bir bilgi sistemi gerçeklenmiştir. Bu çalışmanın odak noktası bir hazır beton fabrikası için siparişleri ve hammadde stokları ele alındığında üretimini nasıl daha verimli ve daha başarılı hale getireceğinin tespiti için genetik algoritma ve gradient descent optimizasyon yöntemleri; lineer programlama, dinamik programlama yöneylem araştırması yöntemlerini barındıran bir bilgi sisteminin gerçeklenmesidir. Günümüz hızlı ve sürekli değişen ve gelişen üretim ortamında rekabetçi kalmak için üretim optimizasyonunun kritik önemi vardır. Bu çalışma kapsamında bir beton üretimi veri kümesi kullanılarak bu veri kümesi içeriğindeki çimento, cüruf, kül, su, süperplastik, kaba agregan, ince agregan, süre gibi parametrelerin betonun niteliğini belirlediği vurgulanmış ve bu parametrelerin çeşitli yöntemlerle optimize hale getirilmesi çalışılmış, bu sayede üretimin kapasitesinin ve betonun niteliğinin daha iyi hale gelip gelemeyeceği gözlenmiştir. Proje süresince veri kümesi detaylı olarak incelenmiş ve raporlanmış, yöntemlerin gerçeklenmesi ve değerlendirilmesi yapılmıştır. Bu çalışma sonunda üretim optimizasyonu genel olarak değerlendirilebilir ve daha optimize bir şekilde beton üretimi sağlanabilir. Bu sayede üretim sistemlerinin verimliliğinin artması ve daha çok üretim yapılması sağlanabilir.

Anahtar Kelimeler: Üretim, optimizasyon, çimento, bilgi sistemi, dinamik programlama, lineer programlama, gradient descent, genetik algoritma

1
Introduction

The notion of optimization is a cornerstone for achieving excellence in the industrial and corporate environments. The systematic improvement of procedures and techniques with the ultimate objective of improving overall performance is what optimization includes. It is possible to improve efficiency and effectiveness by fine-tuning various parts of a system, organization, or project.

1.1 Optimization

Optimization, being a multidimensional topic, has several applications. Optimization techniques are used to simplify operations, minimize expenses, and increase production [1]. They range from mathematical models to computational approaches. This part will investigate the theoretical underpinnings and practical applications of optimization, shining light on its importance in decision-making processes in a variety of sectors.

1.2 Production

The manufacturing sector is the beating heart of the economy, comprising the development and transformation of raw materials into completed goods or services. Analyzing supply networks, manufacturing processes, and quality control methods is required for a thorough knowledge of production dynamics. This section will dissect the complexities of production, revealing the problems and possibilities that characterize this core part of business.

1.3 Production Optimization

As industries change in response to technical breakthroughs and market needs, the importance of production optimization grows. This section will look into innovative processes and cutting-edge technology aimed at optimizing every stage of the manufacturing process. The pursuit of production optimization is critical for remaining competitive in today's fast-paced and ever-changing business landscape, from lean manufacturing concepts to the incorporation of Industry 4.0 technology [2]. This section seeks to provide readers with the information they need to transform their manufacturing processes by examining real-world case studies and current trends [3].

2
Preliminary Investigation

In this chapter, a preliminary analysis of the project was carried out in order to define the roadmap. The resources and datasets of the project have been assessed in order to set the framework for the next phases. As our project focuses on the optimisation of cement production, research on cement production has been conducted and information on the raw materials available in our dataset has been analysed. The content of the dataset is mentioned in the requirements analysis section.

A series of information is provided on the current challenges related to the production optimisation information system and how to overcome them. Firstly, concerns about the data collection and processing methods used in production facilities can be addressed. Data accuracy, velocity and integrity issues can all have a detrimental impact on system performance.

Organisations should also be aware that supply chain issues, changes in production techniques and demand fluctuations can prevent them from achieving their optimisation goals. Solutions currently in use include a variety of tactics such as the use of industrial sensors, real-time data processing, predictive models driven by artificial intelligence, and automation technologies.

Furthermore, by focussing on the application areas of these systems and providing examples from various industry sectors, insights into the effectiveness and adaptability of existing solutions can be provided.

2.1 Project Steps for Production Optimization Information System

2.1.1 Step 1: Project Inception and Planning

The project team sets the broad goals, scope, and major deliverables of the Production Optimization Information System at this early phase. Among the planning activities are:

- Identifying stakeholders and understanding their requirements.
- Defining project objectives and success criteria.
- Creating a detailed project timeline with resource allocation.

2.1.2 Step 2: Preliminary Investigation and Dataset Exploration

Investigating the state of production processes at the moment by doing a thorough preliminary inquiry and looking through the datasets that are available regarding the manufacture of concrete. Among the activities are:

- Reviewing current resources and data sources.
- Evaluating the usefulness and quality of possible datasets.

2.1.3 Step 3: Study of Operations Research Methods.

Operations research methods. It has many application areas such as production planning, productivity analysis, project management, cost analysis, quality management, which are within the scope of our project. Research has been done on which of these methods we can use and it has been decided that Linear programming and Dynamic Programming methods can be used.

- Reviewing current resources and data sources.
- Evaluating the usefulness and quality of possible datasets.

2.1.4 Step 4: Obtaining and Cleaning Datasets

Obtaining the chosen dataset, which includes characteristics like cement, slag, ash, water, superplastic, coarse aggregate, fine aggregate, age, and strength. Among the data cleansing activities are:

- Handling missing values and outliers.
- Ensuring data consistency and integrity.

2.1.5 Step 5: Model Training and Evaluation

Using the preprocessed dataset, create the optimization algorithms and create the regression models and evaluate the regression models with using mean squared error and r-squared value.

2.1.6 Step 6: Insights and Analysis of Results

Analyzing the outputs of the training models in order to generate useful insights. Among the activities are:

- Optimization suggestions interpretation.
- Identifying areas for improvement in the manufacturing process.

2.1.7 Step 7: Documentation and Reporting

The entire project is being documented, including techniques, outcomes, and suggestions.

3
Feasibility

3.1 Technical Feasibility

3.1.1 Software Feasibility

Python was used to build optimization algorithms and the flask library used to communicate with java spring boot backend application. While React used to enhance user interaction.

3.1.2 Hardware Feasibility

Table 3.1 shows the hardware requirements. Google Colab will also be used for severe hardware requirements.

Table 3.1 Hardware features planned for model training

Display card	MX250
Ram	16 GB RAM
CPU	Intel i7-10510U

3.2 Economic Feasibility

The programming languages and libraries used in software development are all free. Google Colab Pro costs 162.84TL a month since it is utilized for hardware needs.

Table 3.2 Economic Feasibility

Description	Price	Duration	Total
Languages and libraries used	0TL/month	2 months	0TL
Google Colab Pro	162,84TL/month	2 months	325,68TL

By using fewer raw materials, organizations may improve efficiency, increase production capacity, and optimize operational procedures through production optimization. In other words, more efficient manufacturing processes and lower costs can help to cover project expenses, thus enhancing the company's total profitability.

3.3 Legal Feasibility

The dataset utilized is publicly available and does not include any personally identifiable information. A consent statement will be displayed to the user. The user will be able to use the application after accepting the consent statement.

3.4 Labor and time feasibility

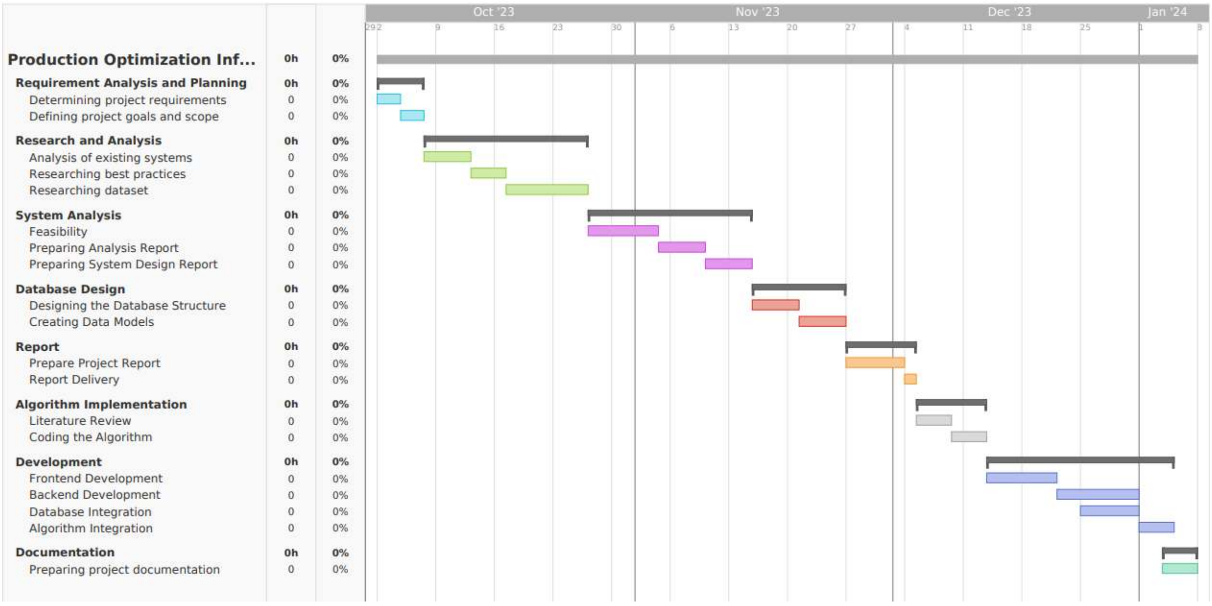


Figure 3.1 Gantt Diagram

4
System Analysis

The system's requirements, objectives, and performance criteria have been discussed in this section.

4.1 Requirements

- The system should allow access to the data required to monitor, evaluate, and improve manufacturing operations.
- All stakeholders' needs, from workers to top-level executives, should be considered during requirements analysis.
- The system should have a user-friendly interface that allows users to easily input and output data.

4.1.1 Dataset

This production optimization project's dataset includes essential parameters linked to concrete manufacture. These criteria are critical in defining the qualities and quality of the manufactured concrete. The following fields are included in the dataset:

1. **Cement:** The quantity of cement used in the concrete mix, measured in kilograms.
2. **Slag:** The amount of slag, a byproduct of metal smelting processes, included in the concrete mix (in kilograms).
3. **Ash:** The quantity of ash, which may be sourced from various industrial processes, utilized in the concrete mix (in kilograms).
4. **Water:** The amount of water added to the concrete mix, a critical factor influencing the mixture's workability and strength (in liters).

5. **Superplastic:** The dosage of superplasticizer, a chemical additive enhancing the fluidity of the concrete, measured in kilograms.

6. **Coarse Aggregate:** The volume of coarse aggregate (e.g., gravel) in the concrete mix, measured in kilograms.

7. **Fine Aggregate:** The volume of fine aggregate (e.g., sand) in the concrete mix, measured in kilograms.

8. **Age:** The curing time of the concrete, indicating the duration since its preparation (in days).

9. **Strength:** The compressive strength of the concrete specimen, a critical performance indicator (measured in megapascals - MPa).

4.1.2 Significance of Parameters

1. **Cement, Slag, Ash:** These components contribute to the composition of the concrete, influencing its durability, setting time, and environmental impact.

2. **Water:** Affects the workability and strength of the concrete mixture; the right balance is crucial for optimal performance.

3. **Superplasticizer:** Enhances the fluidity of the concrete mix, promoting easier placement and reducing water requirements.

4. **Coarse and Fine Aggregate:** Provide structural stability and influence the overall strength and texture of the concrete.

5. **Age:** The curing time is a critical parameter, impacting the concrete's long-term strength and durability.

6. **Strength:** The ultimate compressive strength of the concrete, a key metric in assessing its performance in structural applications.

This dataset serves as the basis for our optimization efforts, allowing us to investigate correlations, trends, and ideal combinations of these characteristics in order to improve the efficiency and quality of the concrete manufacturing process. The next sections of the project report will go into the methodology used, the outcomes achieved, and the insights acquired from analyzing this dataset.

4.2 Objectives

- The system should be designed to meet the bare minimum of needs, avoiding needless complexity while increasing user productivity.
- Ensure that the system creates dependable and steady outputs so that users may get accurate and trustworthy data.
- The system should be able to provide a generic solution that is adaptable to various manufacturing processes and sectors.

4.3 Performance Criteria

- **Data Processing Speed:** Large datasets should be processed rapidly and efficiently by the system.
- **Optimization Success:** The system should track the success of manufacturing process optimization model.
- **User Satisfaction:** User feedback should be used to assess the degree of satisfaction of system users.

5
System Design

5.1 Software Design

Python was used to implement optimization methods in our work. The Flask library was used for the java spirng boot backend application and optimization method communication operations, while the React, React Semantic UI, and Bootstrap libraries were used for the front end. The outputs were shown, the inputs were gathered, and the users were provided with a user-friendly interface.

5.2 Database Design

This section focuses on the database design phase of the Production Optimization Information System. This stage establishes the foundation for data management, creating a database structure to store the necessary information for analysis.

The designed database aims to meet the analytical needs of the project and provides room for future expansions.

The descriptions and schemas of the database tables are detailed in the following sections.

5.2.1 Data Types and Relationships

The basic data types needed for the project were identified, and relationships among them were designed to meet the project's goals and analysis requirements. Key data types include:

- **Production Information:** Basic details about production (e.g., production quantity, process steps, materials used).
- **Raw Material Status:** Information about the condition and maintenance history of production equipment, if applicable.

- **Employee Information:** Details about employees working in the production optimization process.

5.2.2 Database Tables

Tables selected for the database design include:

- **t_order:** This table is orders table and contains information about orders. It contains information such as order number and order date, that helps in the administration of business operations.
- **t_order_planned_production:** This table provides data about planned production. It contains information such as the number of items to be produced based on orders, production dates, and is used to organize production procedures.
- **t_order_planned_production_raw_material:** This table contains information on the raw materials that will be used in manufacture. It provides information on which raw materials will be utilized to make certain goods and in what amounts, with the goal of optimizing manufacturing processes.
- **t_product:** This table contains general information about the company's items that it manufactures or sells. It contains product numbers, names, strength range informations and is required for product management.
- **t_raw_material:** This table presents data on the raw materials utilized in the company's manufacturing operations. It contains data such as raw material codes and stock levels, that helps in material management.
- **t_user:** This table contains general information about the system's registered users. It contains information such as usernames, passwords for the purposes of system security and user administration.

Database schema shown in Figure 5.1.

5.3 Input-Output Design

- Input: Manifacturing durations, order quantity, amount of consumables required.
- Output: Planning of the production line and planning of the consumables usage.

Figure 5.1 Database Schema

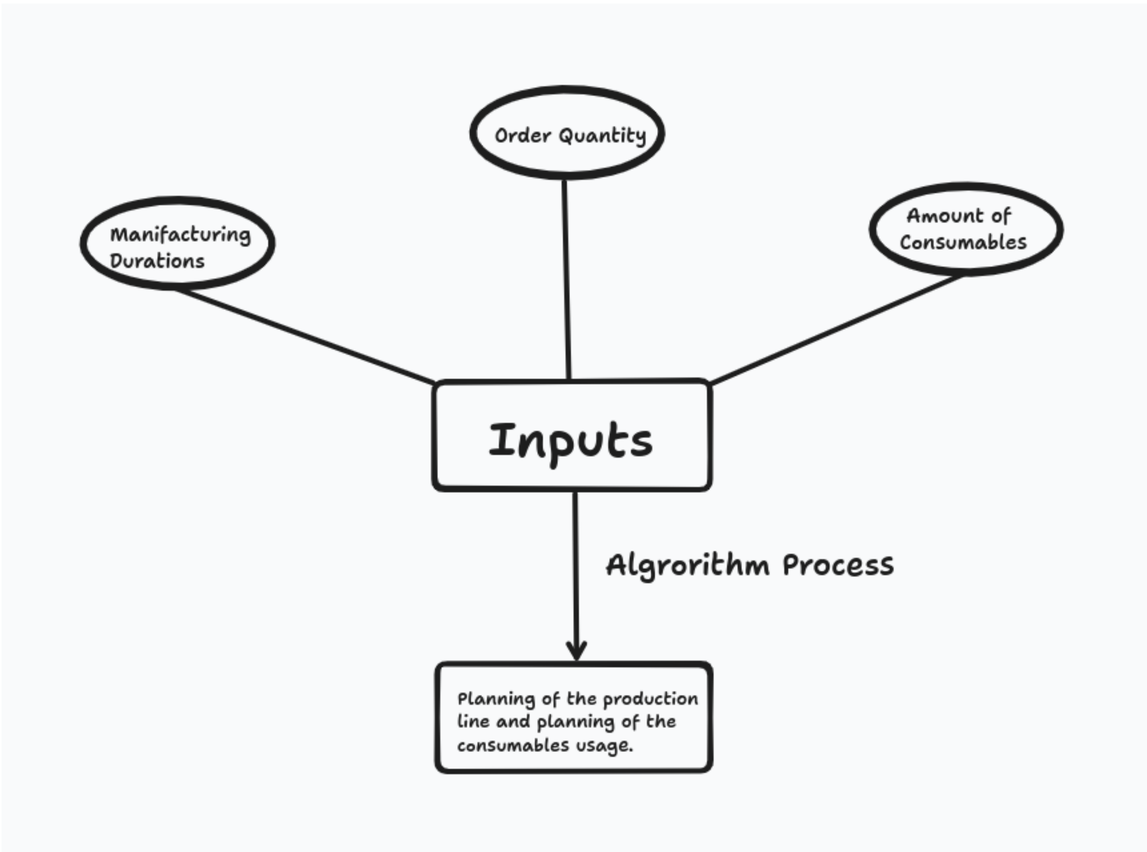


Figure 5.2 Input-Output Diagram

6
Implementation

The Production Optimization Information System is a project that aims to control and optimize manufacturing operations. The system's goal is to give users the opportunity to observe production processes and optimize the production line, resulting in a more structured and efficient production process.

6.1 Technologies Used

The following technologies were used.

- Front-end Development
  - React.js
  - Semantic UI
  - Bootstrap libraries
- Backend Development
  - Java Spring Boot
- Implementation of Optimization Algorithms
  - Python
- Interaction Between Optimization Algorithms and Backend
  - Flask

6.2 Production Process Management

The program will enable production process management and assure consumable material management for the enhancement of production operations.

6.2.1 Planning

Production process management schedules the items that will be manufactured in a given amount of time. It takes into account things like resource evaluation, demand forecasting, and needs analysis.

6.2.2 Resource Management

Raw material supply controlled successfully. This method relies heavily on capacity planning, efficiency studies, and raw material management.

6.2.3 Quality Standarts

Quality standarts ensures that the items manufactured meet the defined requirements.

6.3 Optimization System

Models and algorithms are found in this section. We can define it as the part that performs the optimisation process. The operations in this section are described in detail below. Before that, a diagram is given below for overview. The diagram shows 2 different methods in each step. These methods are used separately.

6.3.1 Optimization Algorithms

Optimization algorithms are important in many disciplines because they provide sophisticated answers to complicated issues by systematically refining and enhancing processes. These algorithms, which are based on mathematical and computational approaches, seek the best feasible result within a given set of limitations. Optimization algorithms attempt to improve efficiency, minimize costs, and optimize desired outcomes whether applied to resource allocation, scheduling, or other decision-making scenarios. The diverse range of optimization algorithms, from linear programming to genetic algorithms and machine learning-based techniques, enables them to address a wide range of challenges, making them indispensable tools in the pursuit of operational excellence and strategic decision-making across industries.

Python is used to execute optimization algorithms. Algorithms analyze production data and provide recommendations to improve the process.

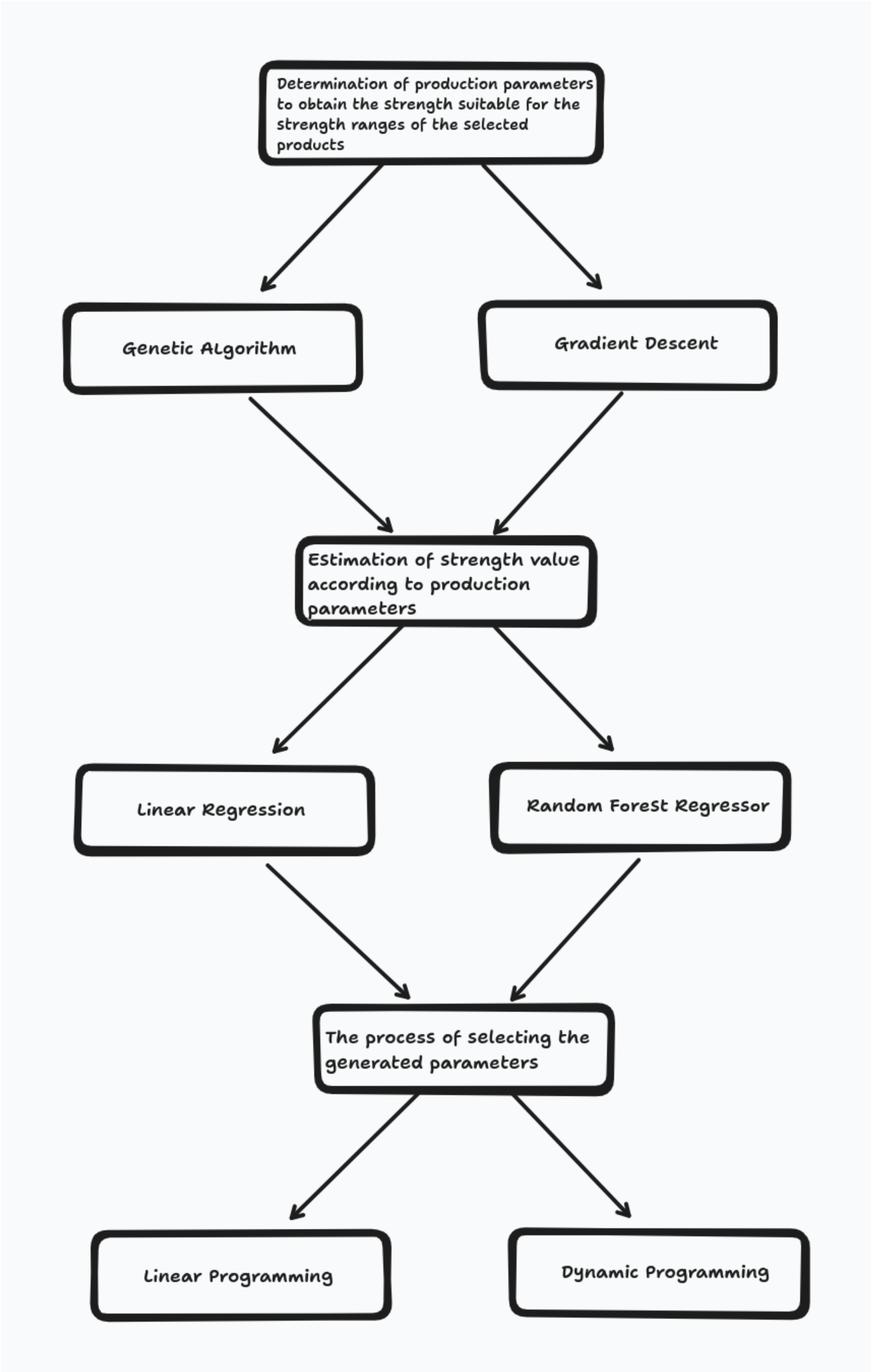


Figure 6.1 Optimization System Overview

6.3.2 Genetic Algorithm

Genetic algorithm is based on the notion of constructing chromosomes with variables that entail genetic processes performed to an originally random population, similar to biology. Genetic algorithm seeks to develop solutions for future generations. Individual production success is directly related to the fitness representing its solution, ensuring an improvement in quality in subsequent generations. When genetic algorithm is most appropriate for concerns related to optimization in a computable system, the procedure finishes [4].

The following steps are often included in algorithm implementation:

- **Initialization of the Population:** The initial step is usually to construct a population of randomly chosen chromosomes. These chromosomes may hold solutions to the problem.
- **Fitness Evaluation:** Each chromosome in the produced population indicates a solution to the target challenge in terms of fitness. A fitness function, which quantifies how excellent a solution is, is used to evaluate each chromosome.
- **Allocation of Reproductive Opportunities:** The population's chromosomes are ordered based on their fitness. Better-performing chromosomes are given more "reproductive" possibilities in the next generation. This includes chromosomal selection for genetic crossover and mutation procedures.
- **Allocation of Reproductive Opportunities:** The population's chromosomes are ordered based on their fitness. Better-performing chromosomes are given more "reproductive" possibilities in the next generation. This includes chromosomal selection for genetic crossover and mutation procedures.
- **Genetic Operators in Action:** Genetic crossover and mutation procedures are performed on chosen chromosomes, resulting in the formation of new chromosomes. This stage improves the population's genetic variety and enables for the investigation of possible solutions.
- **New Population Generation:** Following the application of genetic operators, the newly acquired chromosomes create the next-generation population.

These phases reflect a genetic algorithm's iterative process. By repeating these stages, the algorithm optimizes solutions within the population over time. While genetic algorithms are often used to improve a function, they may also be used to a variety of other problems.

6.3.3 Gradient Descent

Gradient descent is one of the most widely used optimization methods [5]. Gradient descent is an iterative optimization algorithm that approaches a function's minimal point. The function's gradient points in the direction where the function grows the fastest. The objective is to approach or near the function's minimal point. The method starts from a starting point and progresses towards a new position by subtracting a percentage of the negative gradient from the current position at each step. These procedures guarantee that the function is kept to a bare minimum. The learning rate is often used to calculate the size of the steps.

Gradient descent is a popular method for optimizing model parameters, particularly when dealing with big datasets or complicated models. The algorithm's success is determined by criteria such as the beginning point, learning rate, and function topography.

6.4 Operations Research Methods

Operations research is a subject that uses mathematical and analytical approaches to optimize an organization's or business's operations and choices. It entails mathematically modeling issues in order to comprehend, analyze, and optimize them. Operations research often utilizes mathematical programming techniques to solve optimization issues, with the goal of maximizing or minimizing a target function under certain restrictions. Decision analysis is used to make optimum judgments under uncertainty, whereas simulation simulates system behavior in real time. Stochastic models deal with unpredictable conditions, whereas queueing theory examines the performance and capacity of service systems. Operations Research, which is widely used in industries such as manufacturing, logistics, finance, healthcare, and transportation, focuses on managing and improving complex systems via the application of quantitative and analytical methodologies to improve decision-making processes.

6.4.1 Linear Programming

Linear programming is a mathematical optimization approach that seeks the optimal result in a mathematical model with linear connections. The goal of linear programming is to maximize or reduce a linear objective function while adhering to a set of linear equality or inequality constraints. The decision variables, which represent undetermined values, are modified to optimize the objective function while meeting the provided constraints. Linear programming is widely used in many domains, including operations research, economics, finance, manufacturing, and logistics, where resources are few and effective resource allocation is critical. The simplex technique and the interior-point approach are two frequently used methods for addressing linear programming problems, and they provide optimum answers to decision-makers for improved resource allocation and decision-making.

6.4.2 Dynamic Programming

Dynamic programming is a mathematical optimization technique for solving problems that may be divided into overlapping subproblems, allowing for a more efficient solution. The approach entails solving and storing subproblem solutions in a table or memoization array, such that when a subproblem is encountered again, the answer may be obtained immediately rather than recomputing. This method is especially useful for issues with optimum substructure, where the optimal solution to the overall problem may be built from optimal solutions to its subproblems. Dynamic programming is frequently used in domains such as computer science, economics, and operations research to solve complicated problems and enhance computing performance by eliminating duplicate computations.

6.5 Interaction Between Optimization Algorithms and Backend

Flask python library is used to facilitate communication between backend and optimization algorithms. Java spring boot application communicates with Flask API, to get algorithm outputs and save to database and serve the inputs like raw material and order informations.

6.6 Backend Development

Backend application, which was built with Java Spring Boot and JPA, is linked to a PostgreSQL database. This application sends API requests to a Python Flask optimization service. The optimization service runs production optimization algorithms and returns optimized outcomes. Spring Boot program gets these results, stores them in the database, and makes any necessary changes. As a result, the optimization algorithms used to improve manufacturing processes update and save their results in the database.

6.7 Front-end Development

The front-end, which was built with React.js, Semantic UI, and Bootstrap, provides a user-friendly experience. It has an interactive interface that allows users to enter data and view optimization outcomes.

Production Optimization Information System is a software tool used to improve production efficiency. It leads to a better structured and streamlined manufacturing process by integrating optimization algorithms with a user-friendly interface.

7
Emprical Results

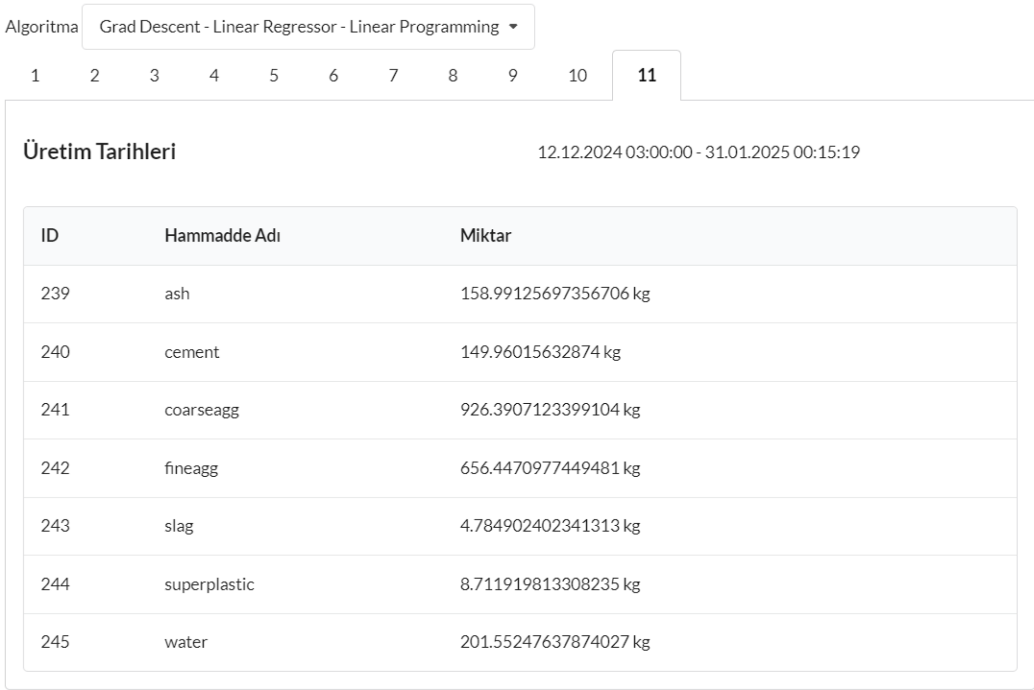
The raw material inputs in Table 7.2 and the order informations in Table 7.1 are critical components of our production optimization information system. Figure 7.1 clearly shows the system's output, where you can see the optimum outcomes for these raw materials and order-related data. Our production optimization system uses advanced algorithms, such as regression models, genetic algorithms, and gradient descent methods, to fine-tune parameters and improve overall performance. The order selection approaches of dynamic programming and linear programming contribute to the overall optimization strategy.

Table 7.1 Orders

Order Title	Product Name	Quantity	Product Strength Range
order 1	product name 1	$3\,m^3$	40 MPa-60 MPa
order 2	product name 2	$2\,m^3$	60 MPa-80 MPa
order 3	product name 3	$5\,m^3$	70 MPa-90 MPa
order 4	product name 1	$3\,m^3$	40 MPa-60 MPa
order 5	product name 2	$2\,m^3$	60 MPa-80 MPa
order 6	product name 3	$2\,m^3$	70 MPa-90 MPa
order 7	product name 1	$2\,m^3$	40 MPa-60 MPa
order 8	product name 2	$2\,m^3$	60 MPa-80 MPa
order 9	product name 3	$2\,m^3$	70 MPa-90 MPa
order 10	product name 1	$2\,m^3$	40 MPa-60 MPa
order 11	product name 2	$2\,m^3$	60 MPa-80 MPa
order 12	product name 3	$3\,m^3$	70 MPa-90 MPa
order 13	product name 1	$5\,m^3$	40 MPa-60 MPa
order 14	product name 2	$2\,m^3$	60 MPa-80 MPa
order 15	product name 3	$2\,m^3$	70 MPa-90 MPa
order 16	product name 1	$3\,m^3$	40 MPa-60 MPa
order 17	product name 2	$3\,m^3$	60 MPa-80 MPa
order 18	product name 3	$3\,m^3$	70 MPa-90 MPa

Table 7.2 Raw Materials

Material Name	Quantity
Slag	10000 kg
Cement	10000 kg
Ash	10000 kg
Water	10000 kg
Superplastic	10000 kg
Coarseagg	10000 kg
Fineagg	10000 kg



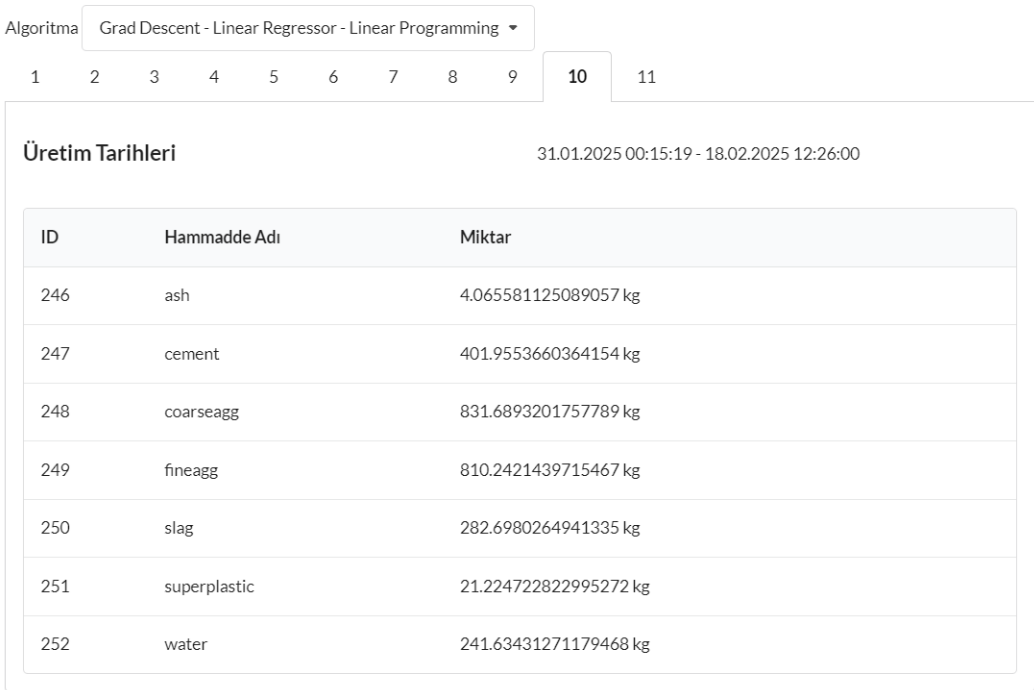
Algoritma Grad Descent - Linear Regressor - Linear Programming

1 2 3 4 5 6 7 8 9 10 **11**

Üretim Tarihleri 12.12.2024 03:00:00 - 31.01.2025 00:15:19

ID	Hammadde Adı	Miktar
239	ash	158.99125697356706 kg
240	cement	149.96015632874 kg
241	coarseagg	926.3907123399104 kg
242	fineagg	656.4470977449481 kg
243	slag	4.784902402341313 kg
244	superplastic	8.711919813308235 kg
245	water	201.55247637874027 kg

Figure 7.1 System Output 1



Algoritma Grad Descent - Linear Regressor - Linear Programming

1 2 3 4 5 6 7 8 9 **10** 11

Üretim Tarihleri 31.01.2025 00:15:19 - 18.02.2025 12:26:00

ID	Hammadde Adı	Miktar
246	ash	4.065581125089057 kg
247	cement	401.9553660364154 kg
248	coarseagg	831.6893201757789 kg
249	fineagg	810.2421439715467 kg
250	slag	282.6980264941335 kg
251	superplastic	21.224722822995272 kg
252	water	241.63431271179468 kg

Figure 7.2 System Output 2

Algoritma: Grad Descent - Linear Regressor - Linear Programming

1 2 3 4 5 6 7 8 **9** 10 11

Üretim Tarihleri 18.02.2025 12:26:00 - 08.03.2025 07:12:24

ID	Hammadde Adı	Miktar
258	superplastic	2.759973285696926 kg
253	ash	29.706000848131087 kg
254	cement	311.5773862213816 kg
255	coarseagg	809.7644936090755 kg
256	fineagg	610.9319454542182 kg
257	slag	125.04575106009679 kg
259	water	220.14854474286716 kg

Figure 7.3 System Output 3

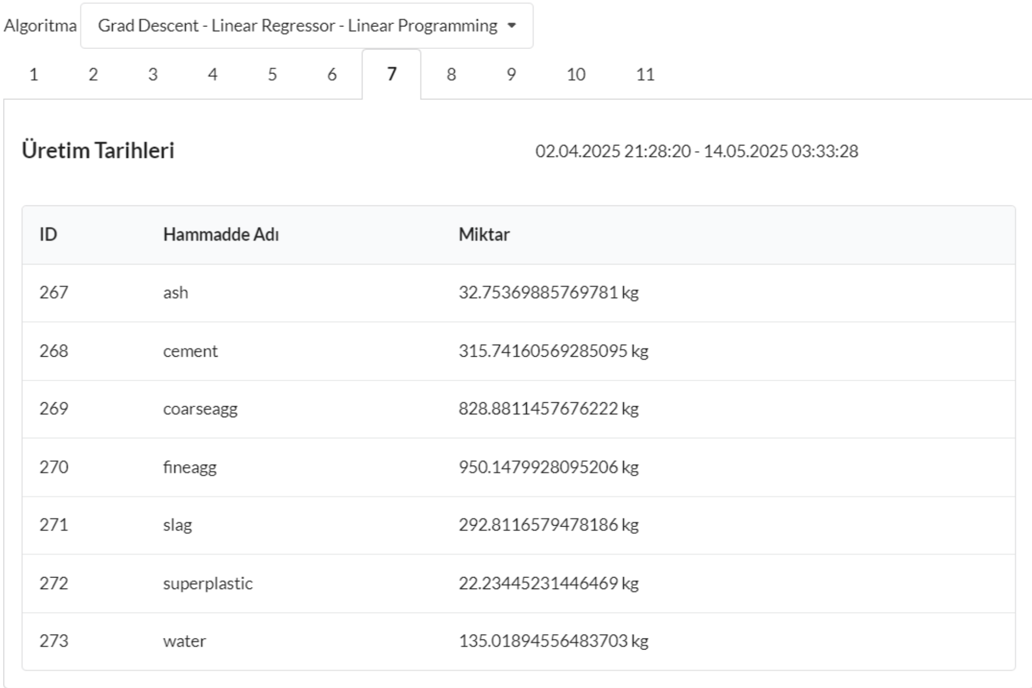
Algoritma: Grad Descent - Linear Regressor - Linear Programming

1 2 3 4 5 6 7 **8** 9 10 11

Üretim Tarihleri 08.03.2025 07:12:24 - 02.04.2025 21:28:20

ID	Hammadde Adı	Miktar
260	ash	104.52488152191255 kg
261	cement	166.62122610684108 kg
262	coarseagg	952.8053592863237 kg
263	fineagg	666.438440433785 kg
264	slag	124.38125366394594 kg
265	superplastic	25.522345222107194 kg
266	water	174.7199905647399 kg

Figure 7.4 System Output 4



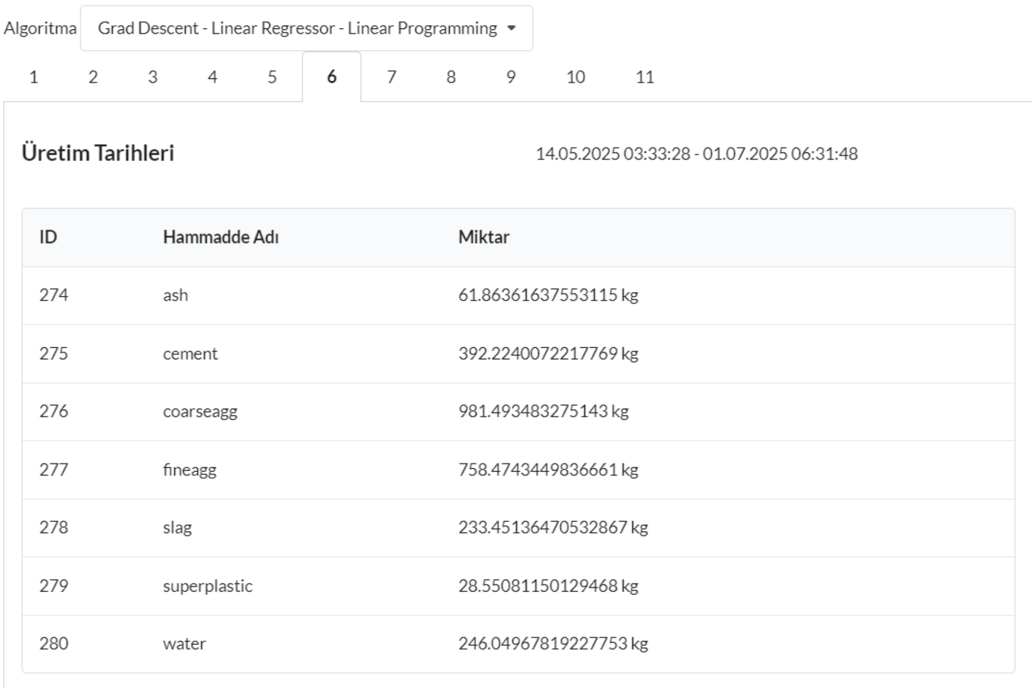
Algoritma Grad Descent - Linear Regressor - Linear Programming

1 2 3 4 5 6 7 8 9 10 11

Üretim Tarihleri 02.04.2025 21:28:20 - 14.05.2025 03:33:28

ID	Hammadde Adı	Miktar
267	ash	32.75369885769781 kg
268	cement	315.74160569285095 kg
269	coarseagg	828.8811457676222 kg
270	fineagg	950.1479928095206 kg
271	slag	292.8116579478186 kg
272	superplastic	22.23445231446469 kg
273	water	135.01894556483703 kg

Figure 7.5 System Output 5



Algoritma Grad Descent - Linear Regressor - Linear Programming

1 2 3 4 5 6 7 8 9 10 11

Üretim Tarihleri 14.05.2025 03:33:28 - 01.07.2025 06:31:48

ID	Hammadde Adı	Miktar
274	ash	61.86361637553115 kg
275	cement	392.2240072217769 kg
276	coarseagg	981.493483275143 kg
277	fineagg	758.4743449836661 kg
278	slag	233.45136470532867 kg
279	superplastic	28.55081150129468 kg
280	water	246.04967819227753 kg

Figure 7.6 System Output 6

Algoritma Grad Descent - Linear Regressor - Linear Programming

1 2 3 4 **5** 6 7 8 9 10 11

Üretim Tarihleri 01.07.2025 06:31:48 - 30.07.2025 02:43:47

ID	Hammadde Adı	Miktar
281	ash	131.8658374830578 kg
282	cement	401.1814862757666 kg
283	coarseagg	852.8365218157141 kg
284	fineagg	644.676814856824 kg
285	slag	338.4654010226352 kg
286	superplastic	4.440495527617902 kg
287	water	140.6309573218638 kg

Figure 7.7 System Output 7

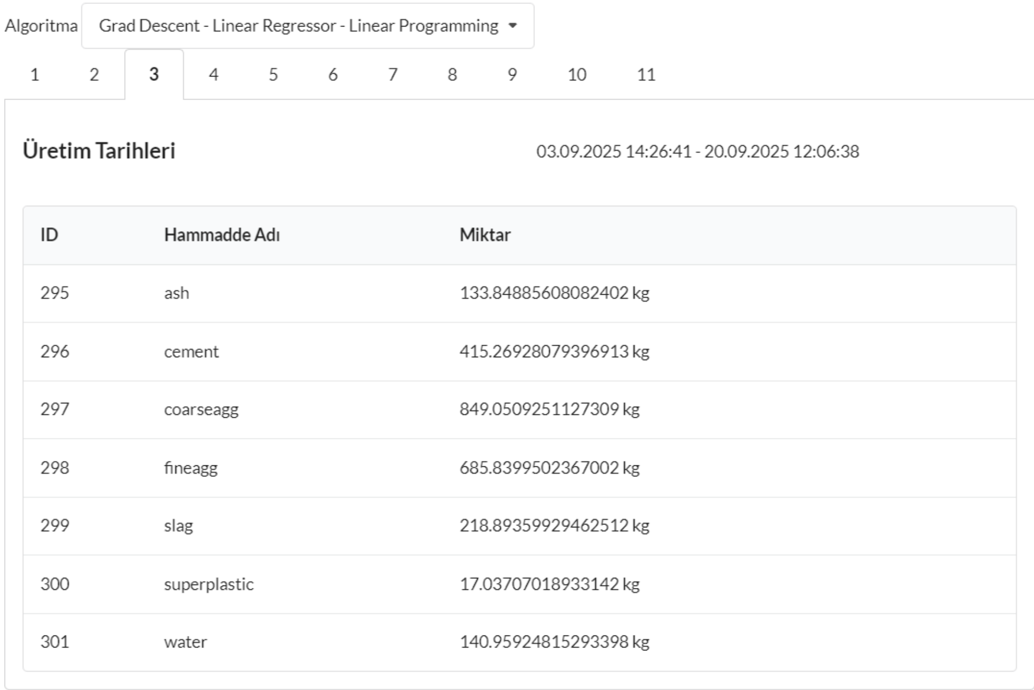
Algoritma Grad Descent - Linear Regressor - Linear Programming

1 2 3 **4** 5 6 7 8 9 10 11

Üretim Tarihleri 30.07.2025 02:43:47 - 03.09.2025 14:26:41

ID	Hammadde Adı	Miktar
288	ash	55.69119037263894 kg
289	cement	399.5737756795058 kg
290	coarseagg	905.8189118867444 kg
291	fineagg	870.0505370045577 kg
292	slag	244.91231102656178 kg
293	superplastic	10.887413620623391 kg
294	water	168.9855510364771 kg

Figure 7.8 System Output 8



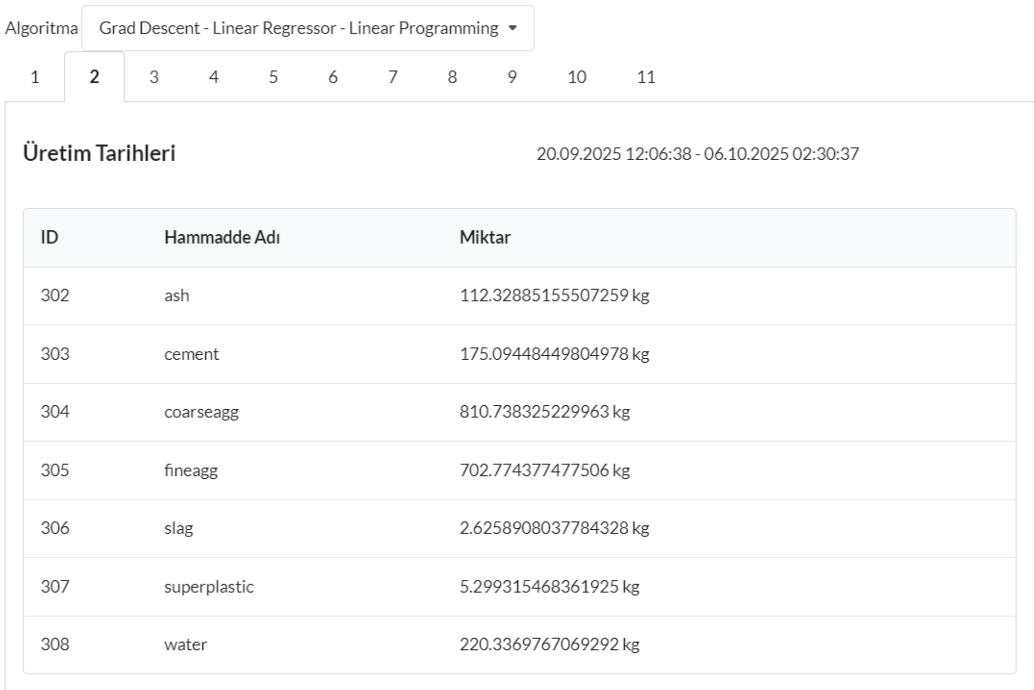
Algoritma Grad Descent - Linear Regressor - Linear Programming

1 2 3 4 5 6 7 8 9 10 11

Üretim Tarihleri 03.09.2025 14:26:41 - 20.09.2025 12:06:38

ID	Hammadde Adı	Miktar
295	ash	133.84885608082402 kg
296	cement	415.26928079396913 kg
297	coarseagg	849.0509251127309 kg
298	fineagg	685.8399502367002 kg
299	slag	218.89359929462512 kg
300	superplastic	17.03707018933142 kg
301	water	140.95924815293398 kg

Figure 7.9 System Output 9



Algoritma Grad Descent - Linear Regressor - Linear Programming

1 2 3 4 5 6 7 8 9 10 11

Üretim Tarihleri 20.09.2025 12:06:38 - 06.10.2025 02:30:37

ID	Hammadde Adı	Miktar
302	ash	112.32885155507259 kg
303	cement	175.09448449804978 kg
304	coarseagg	810.738325229963 kg
305	fineagg	702.774377477506 kg
306	slag	2.6258908037784328 kg
307	superplastic	5.299315468361925 kg
308	water	220.3369767069292 kg

Figure 7.10 System Output 10

Algoritma Grad Descent - Linear Regressor - Linear Programming

1 2 3 4 5 6 7 8 9 10 11

Üretim Tarihleri 06.10.2025 02:30:37 - 04.11.2025 09:10:13

ID	Hammadde Adı	Miktar
314	superplastic	2.4615302028008337 kg
309	ash	73.21016044060356 kg
310	cement	138.6308287604308 kg
311	coarseagg	818.0550699572402 kg
312	fineagg	804.2200518916554 kg
313	slag	316.6954022108586 kg
315	water	140.4203928923114 kg

Figure 7.11 System Output 11

Algoritma Grad Descent - Linear Regressor - Dynamic Programming

1 2 3 4 5 6 7 8 9

Üretim Tarihleri 12.12.2024 03:00:00 - 14.02.2025 01:31:34

ID	Hammadde Adı	Miktar
321	superplastic	0.9491055226515499 kg
316	ash	32.60008009880144 kg
317	cement	199.65976058105653 kg
318	coarseagg	1065.5032934942824 kg
319	fineagg	650.4900803048652 kg
320	slag	283.40550964103335 kg
322	water	227.77330745609737 kg

Figure 7.12 System Output 12

Algoritma Grad Descent - Linear Regressor - Dynamic Programming

1 2 3 4 5 6 7 **8** 9

Üretim Tarihleri 14.02.2025 01:31:34 - 12.04.2025 16:57:55

ID	Hammadde Adı	Miktar
323	ash	171.41000502623527 kg
324	cement	517.8450698250814 kg
325	coarseagg	1131.8101169280817 kg
326	fineagg	887.2889068573078 kg
327	slag	257.42150964361286 kg
328	superplastic	21.999608318664496 kg
329	water	180.0464571175079 kg

Figure 7.13 System Output 13

Algoritma Grad Descent - Linear Regressor - Dynamic Programming

1 2 3 4 5 6 **7** 8 9

Üretim Tarihleri 12.04.2025 16:57:55 - 27.05.2025 17:39:36

ID	Hammadde Adı	Miktar
330	ash	166.2143485507178 kg
331	cement	427.19568584965555 kg
332	coarseagg	1129.452936310248 kg
333	fineagg	970.1703961426562 kg
334	slag	90.80242443942839 kg
335	superplastic	21.06179679115668 kg
336	water	194.86295457323536 kg

Figure 7.14 System Output 14

Algoritma Grad Descent - Linear Regressor - Dynamic Programming

1 2 3 4 5 **6** 7 8 9

Üretim Tarihleri 27.05.2025 17:39:36 - 03.06.2025 08:45:56

ID	Hammadde Adı	Miktar
337	ash	145.57717171342978 kg
338	cement	498.2950861573978 kg
339	coarseagg	1100.2426061435126 kg
340	fineagg	915.7704298079002 kg
341	slag	141.041194305296 kg
342	superplastic	3.0304066528563247 kg
343	water	169.3746699919754 kg

Figure 7.15 System Output 15

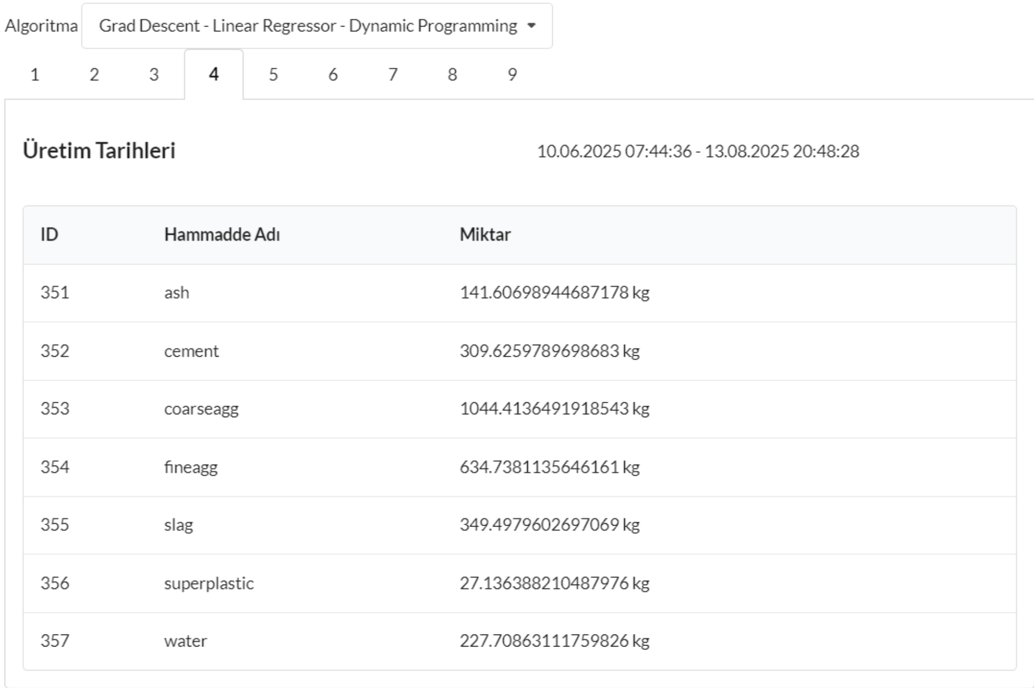
Algoritma Grad Descent - Linear Regressor - Dynamic Programming

1 2 3 4 **5** 6 7 8 9

Üretim Tarihleri 03.06.2025 08:45:56 - 10.06.2025 07:44:36

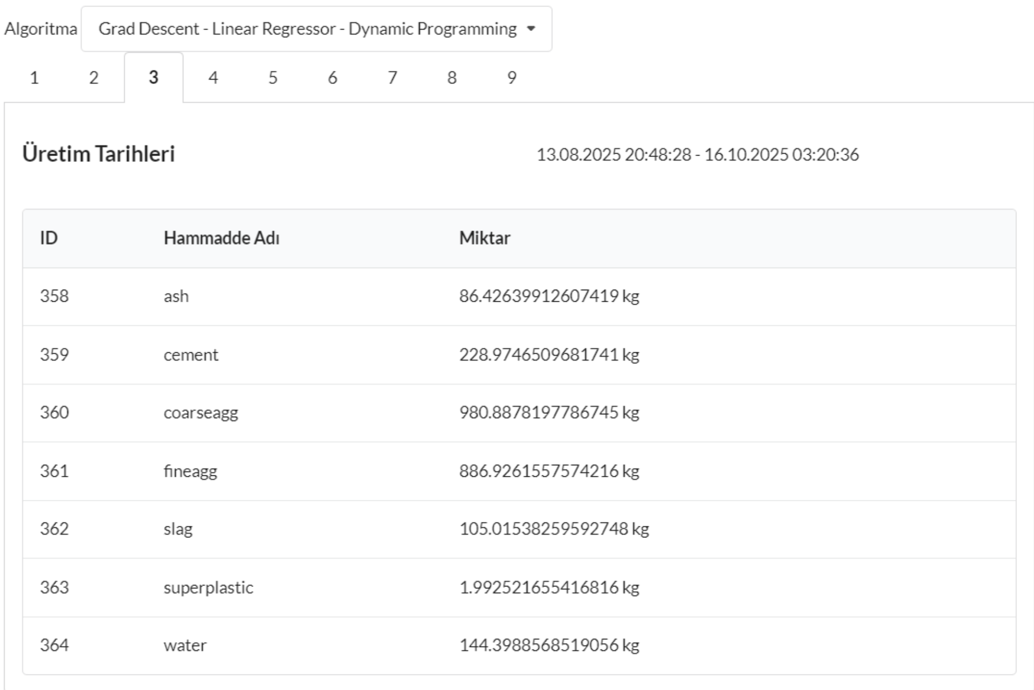
ID	Hammadde Adı	Miktar
344	ash	119.13953238612254 kg
345	cement	272.18705925302777 kg
346	coarseagg	993.3388363678474 kg
347	fineagg	830.7238161215034 kg
348	slag	174.49626880201464 kg
349	superplastic	10.760102665621162 kg
350	water	124.24395118175858 kg

Figure 7.16 System Output 16



ID	Hammadde Adı	Miktar
351	ash	141.60698944687178 kg
352	cement	309.6259789698683 kg
353	coarseagg	1044.4136491918543 kg
354	fineagg	634.7381135646161 kg
355	slag	349.4979602697069 kg
356	superplastic	27.136388210487976 kg
357	water	227.70863111759826 kg

Figure 7.17 System Output 17



ID	Hammadde Adı	Miktar
358	ash	86.42639912607419 kg
359	cement	228.9746509681741 kg
360	coarseagg	980.8878197786745 kg
361	fineagg	886.9261557574216 kg
362	slag	105.01538259592748 kg
363	superplastic	1.992521655416816 kg
364	water	144.3988568519056 kg

Figure 7.18 System Output 18

Algoritma Grad Descent - Linear Regressor - Dynamic Programming

1 **2** 3 4 5 6 7 8 9

Üretim Tarihleri 16.10.2025 03:20:36 - 19.12.2025 01:19:50

ID	Hammadde Adı	Miktar
365	ash	120.47792527738575 kg
366	cement	268.29222751447224 kg
367	coarseagg	1088.9947570444415 kg
368	fineagg	613.3924799935686 kg
369	slag	0.7265121281706457 kg
370	superplastic	14.08729096769785 kg
371	water	211.2497544532899 kg

Figure 7.19 System Output 19

Algoritma Grad Descent - Linear Regressor - Dynamic Programming

1 2 3 4 5 6 7 8 9

Üretim Tarihleri 19.12.2025 01:19:50 - 24.12.2025 22:00:19

ID	Hammadde Adı	Miktar
372	ash	169.32767393163877 kg
373	cement	478.91279652697864 kg
374	coarseagg	1003.2661567857235 kg
375	fineagg	804.5356355026535 kg
376	slag	303.1301553380283 kg
377	superplastic	15.28323769420016 kg
378	water	185.31233570608117 kg

Figure 7.20 System Output 20

Algoritma Grad Descent - Random Forest Regressor - Linear Programming

1 2 3 4 5 6 7 8 9 10 **11**

Üretim Tarihleri 12.12.2024 03:00:00 - 20.01.2025 19:23:58

ID	Hammadde Adı	Miktar
379	ash	167.1050591735825 kg
380	cement	443.9664752136026 kg
381	coarseagg	807.1541175095911 kg
382	fineagg	845.0353758118981 kg
383	slag	167.07404347200898 kg
384	superplastic	23.194848371705064 kg
385	water	185.00215749995655 kg

Figure 7.21 System Output 21

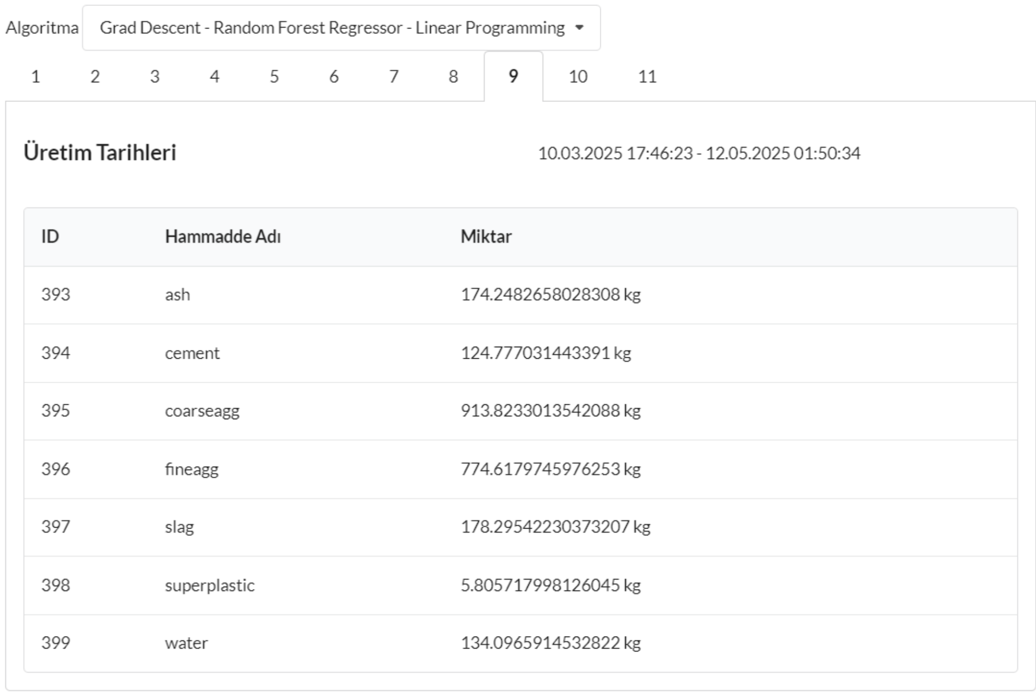
Algoritma Grad Descent - Random Forest Regressor - Linear Programming

1 2 3 4 5 6 7 8 9 **10** 11

Üretim Tarihleri 20.01.2025 19:23:58 - 10.03.2025 17:46:23

ID	Hammadde Adı	Miktar
386	ash	155.2317462177173 kg
387	cement	467.082744988957 kg
388	coarseagg	926.4463722306847 kg
389	fineagg	607.9250080160813 kg
390	slag	332.4154740332101 kg
391	superplastic	25.236143333216496 kg
392	water	136.7649123317966 kg

Figure 7.22 System Output 22



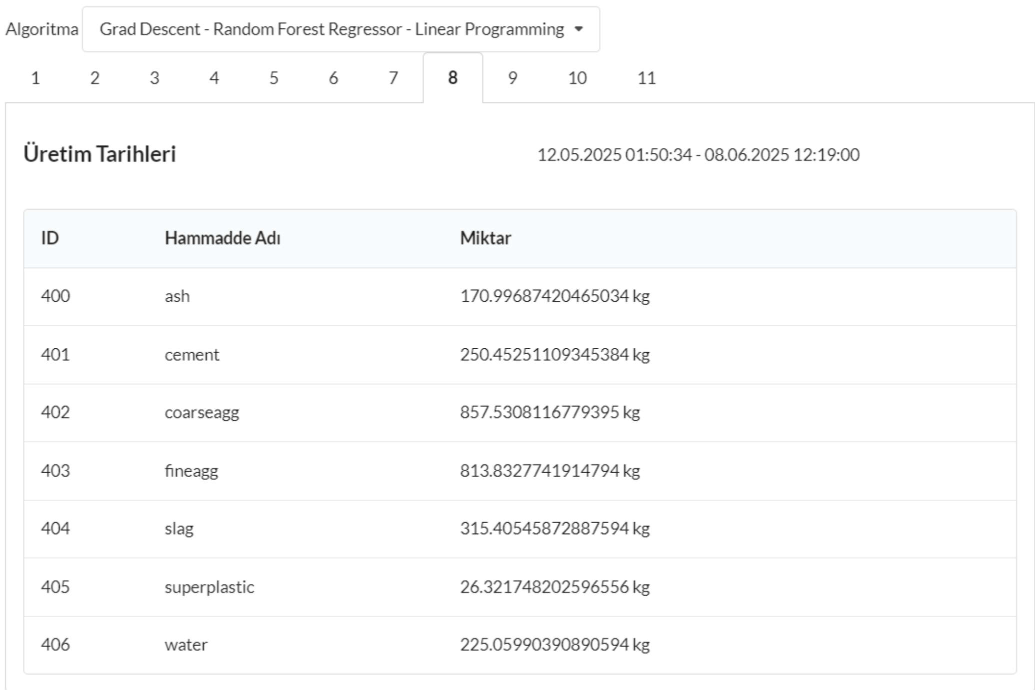
Algoritma: Grad Descent - Random Forest Regressor - Linear Programming

1 2 3 4 5 6 7 8 9 10 11

Üretim Tarihleri 10.03.2025 17:46:23 - 12.05.2025 01:50:34

ID	Hammadde Adı	Miktar
393	ash	174.2482658028308 kg
394	cement	124.777031443391 kg
395	coarseagg	913.8233013542088 kg
396	fineagg	774.6179745976253 kg
397	slag	178.29542230373207 kg
398	superplastic	5.805717998126045 kg
399	water	134.0965914532822 kg

Figure 7.23 System Output 23



Algoritma: Grad Descent - Random Forest Regressor - Linear Programming

1 2 3 4 5 6 7 8 9 10 11

Üretim Tarihleri 12.05.2025 01:50:34 - 08.06.2025 12:19:00

ID	Hammadde Adı	Miktar
400	ash	170.99687420465034 kg
401	cement	250.45251109345384 kg
402	coarseagg	857.5308116779395 kg
403	fineagg	813.8327741914794 kg
404	slag	315.40545872887594 kg
405	superplastic	26.321748202596556 kg
406	water	225.05990390890594 kg

Figure 7.24 System Output 24

Algoritma Grad Descent - Random Forest Regressor - Linear Programming

1 2 3 4 5 6 **7** 8 9 10 11

Üretim Tarihleri 08.06.2025 12:19:00 - 10.07.2025 14:48:55

ID	Hammadde Adı	Miktar
407	ash	174.5695451806494 kg
408	cement	334.150083140459 kg
409	coarseagg	1019.6329109948874 kg
410	fineagg	792.8309681867609 kg
411	slag	21.803067260100196 kg
412	superplastic	3.4677850785781636 kg
413	water	152.54269941811668 kg

Figure 7.25 System Output 25

Algoritma Grad Descent - Random Forest Regressor - Linear Programming

1 2 3 4 5 **6** 7 8 9 10 11

Üretim Tarihleri 10.07.2025 14:48:55 - 23.07.2025 13:18:36

ID	Hammadde Adı	Miktar
414	ash	53.23021971833026 kg
415	cement	332.8133278912909 kg
416	coarseagg	887.9141178387308 kg
417	fineagg	659.6758626838902 kg
418	slag	312.4684041553728 kg
419	superplastic	28.22642433013855 kg
420	water	231.43090664575237 kg

Figure 7.26 System Output 26

Algoritma: Grad Descent - Random Forest Regressor - Linear Programming

1 2 3 4 **5** 6 7 8 9 10 11

Üretim Tarihleri 23.07.2025 13:18:36 - 11.08.2025 21:55:21

ID	Hammadde Adı	Miktar
421	ash	193.06762365293574 kg
422	cement	290.0337082769986 kg
423	coarseagg	904.172650748024 kg
424	fineagg	952.8901661106429 kg
425	slag	122.32174577992004 kg
426	superplastic	26.524319725321337 kg
427	water	188.03345885039857 kg

Figure 7.27 System Output 27

Algoritma: Grad Descent - Random Forest Regressor - Linear Programming

1 2 3 **4** 5 6 7 8 9 10 11

Üretim Tarihleri 11.08.2025 21:55:21 - 08.09.2025 18:48:31

ID	Hammadde Adı	Miktar
428	ash	122.78605272999252 kg
429	cement	150.64020542634043 kg
430	coarseagg	827.1077786016356 kg
431	fineagg	849.014089549667 kg
432	slag	160.012417244952 kg
433	superplastic	15.66155970507426 kg
434	water	174.35367624800296 kg

Figure 7.28 System Output 28

Algoritma Grad Descent - Random Forest Regressor - Linear Programming

1 2 **3** 4 5 6 7 8 9 10 11

Üretim Tarihleri 08.09.2025 18:48:31 - 09.10.2025 04:47:50

ID	Hammadde Adı	Miktar
435	ash	46.01292747592929 kg
436	cement	374.3078416855019 kg
437	coarseagg	932.4821244214319 kg
438	fineagg	879.6959357088214 kg
439	slag	270.868722951472 kg
440	superplastic	29.816202799235192 kg
441	water	229.46379690096921 kg

Figure 7.29 System Output 29

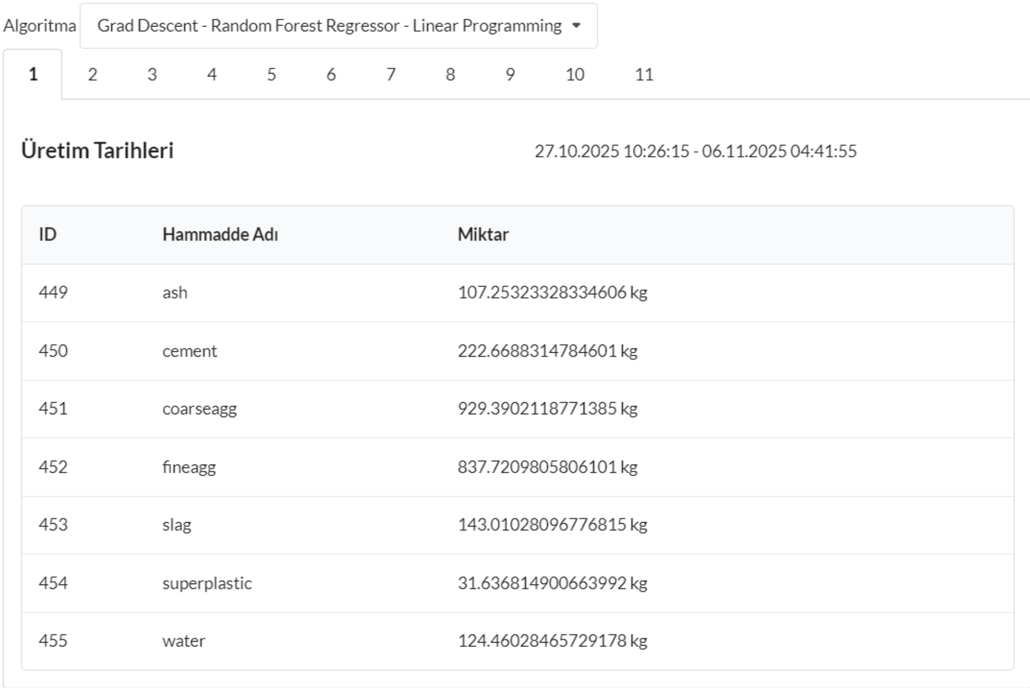
Algoritma Grad Descent - Random Forest Regressor - Linear Programming

1 **2** 3 4 5 6 7 8 9 10 11

Üretim Tarihleri 09.10.2025 04:47:50 - 27.10.2025 10:26:15

ID	Hammadde Adı	Miktar
442	ash	16.528425455887707 kg
443	cement	114.58620474639588 kg
444	coarseagg	965.4823772665593 kg
445	fineagg	945.7269676402716 kg
446	slag	114.8871521463535 kg
447	superplastic	3.279525942069796 kg
448	water	241.8025256651237 kg

Figure 7.30 System Output 30



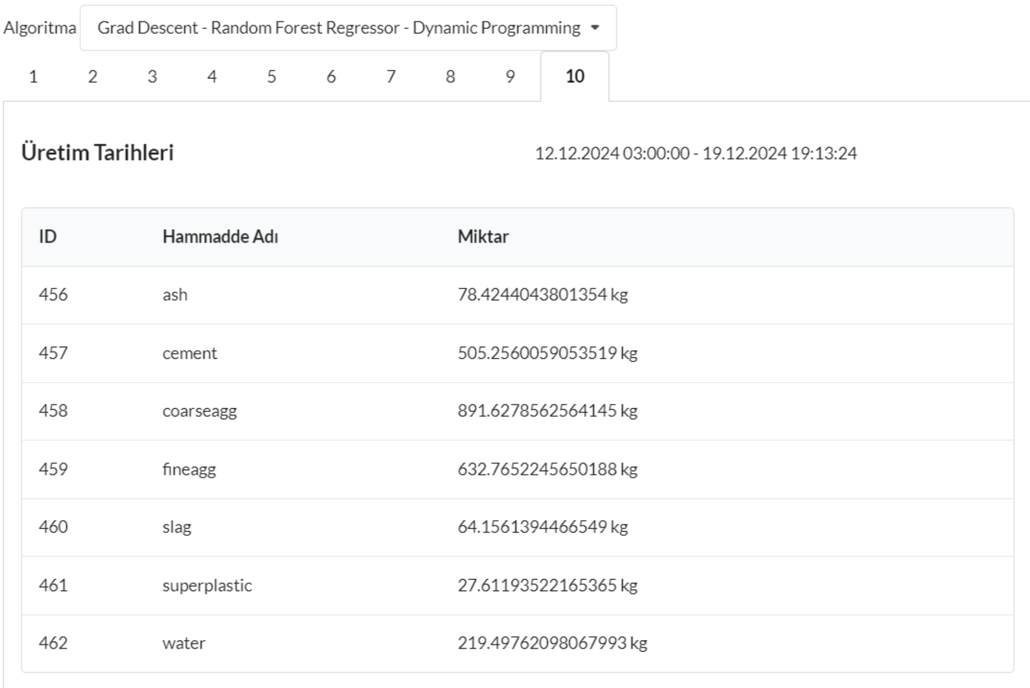
Algoritma: Grad Descent - Random Forest Regressor - Linear Programming

1 2 3 4 5 6 7 8 9 10 11

Üretim Tarihleri 27.10.2025 10:26:15 - 06.11.2025 04:41:55

ID	Hammadde Adı	Miktar
449	ash	107.25323328334606 kg
450	cement	222.6688314784601 kg
451	coarseagg	929.3902118771385 kg
452	fineagg	837.7209805806101 kg
453	slag	143.01028096776815 kg
454	superplastic	31.636814900663992 kg
455	water	124.46028465729178 kg

Figure 7.31 System Output 31



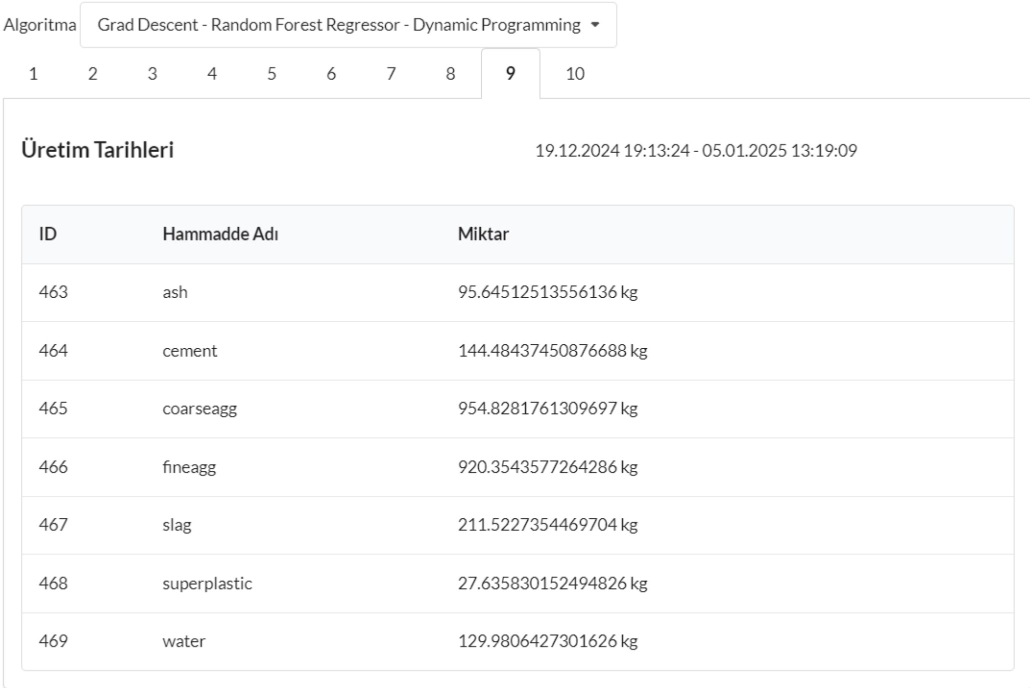
Algoritma: Grad Descent - Random Forest Regressor - Dynamic Programming

1 2 3 4 5 6 7 8 9 10

Üretim Tarihleri 12.12.2024 03:00:00 - 19.12.2024 19:13:24

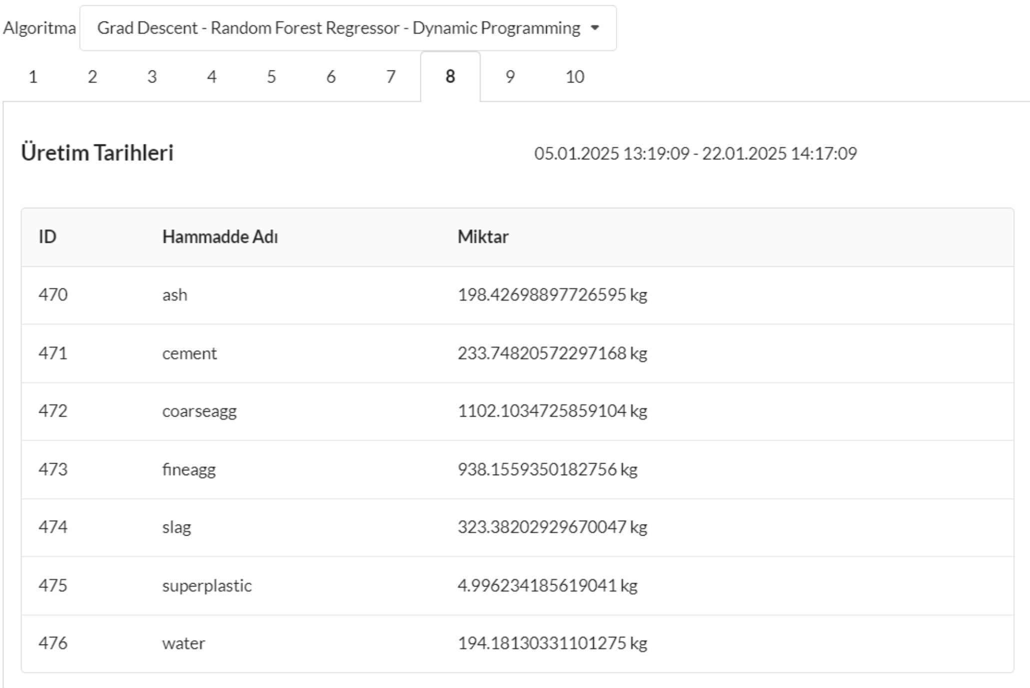
ID	Hammadde Adı	Miktar
456	ash	78.4244043801354 kg
457	cement	505.2560059053519 kg
458	coarseagg	891.6278562564145 kg
459	fineagg	632.7652245650188 kg
460	slag	64.1561394466549 kg
461	superplastic	27.61193522165365 kg
462	water	219.49762098067993 kg

Figure 7.32 System Output 32



ID	Hammadde Adı	Miktar
463	ash	95.64512513556136 kg
464	cement	144.48437450876688 kg
465	coarseagg	954.8281761309697 kg
466	fineagg	920.3543577264286 kg
467	slag	211.5227354469704 kg
468	superplastic	27.635830152494826 kg
469	water	129.9806427301626 kg

Figure 7.33 System Output 33



ID	Hammadde Adı	Miktar
470	ash	198.42698897726595 kg
471	cement	233.74820572297168 kg
472	coarseagg	1102.1034725859104 kg
473	fineagg	938.1559350182756 kg
474	slag	323.38202929670047 kg
475	superplastic	4.996234185619041 kg
476	water	194.18130331101275 kg

Figure 7.34 System Output 34

Algoritma: Grad Descent - Random Forest Regressor - Dynamic Programming

1 2 3 4 5 6 **7** 8 9 10

Üretim Tarihleri 22.01.2025 14:17:09 - 02.03.2025 22:50:50

ID	Hammadde Adı	Miktar
477	ash	189.27265471033644 kg
478	cement	234.4742678904451 kg
479	coarseagg	836.5490069516757 kg
480	fineagg	682.8799540878006 kg
481	slag	345.45405862778745 kg
482	superplastic	26.555728948501752 kg
483	water	214.48978232296548 kg

Figure 7.35 System Output 35

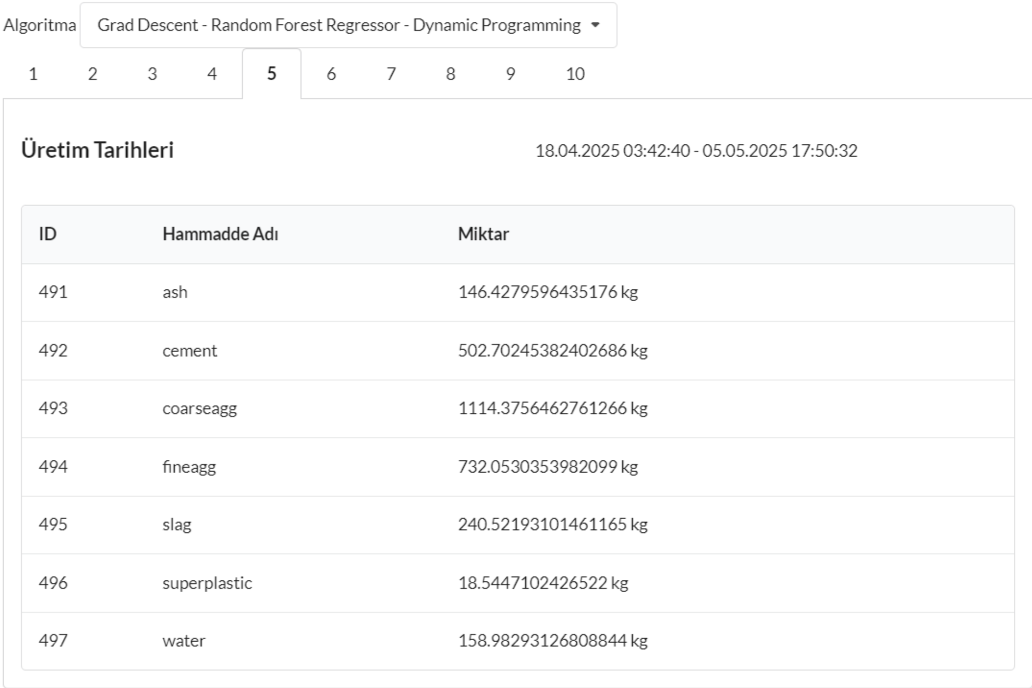
Algoritma: Grad Descent - Random Forest Regressor - Dynamic Programming

1 2 3 4 5 **6** 7 8 9 10

Üretim Tarihleri 02.03.2025 22:50:50 - 18.04.2025 03:42:40

ID	Hammadde Adı	Miktar
484	ash	2.8845345311748316 kg
485	cement	478.33633659699433 kg
486	coarseagg	1132.5759957064038 kg
487	fineagg	903.1416447496588 kg
488	slag	155.91942616539532 kg
489	superplastic	2.190955918407255 kg
490	water	186.44228769327333 kg

Figure 7.36 System Output 36

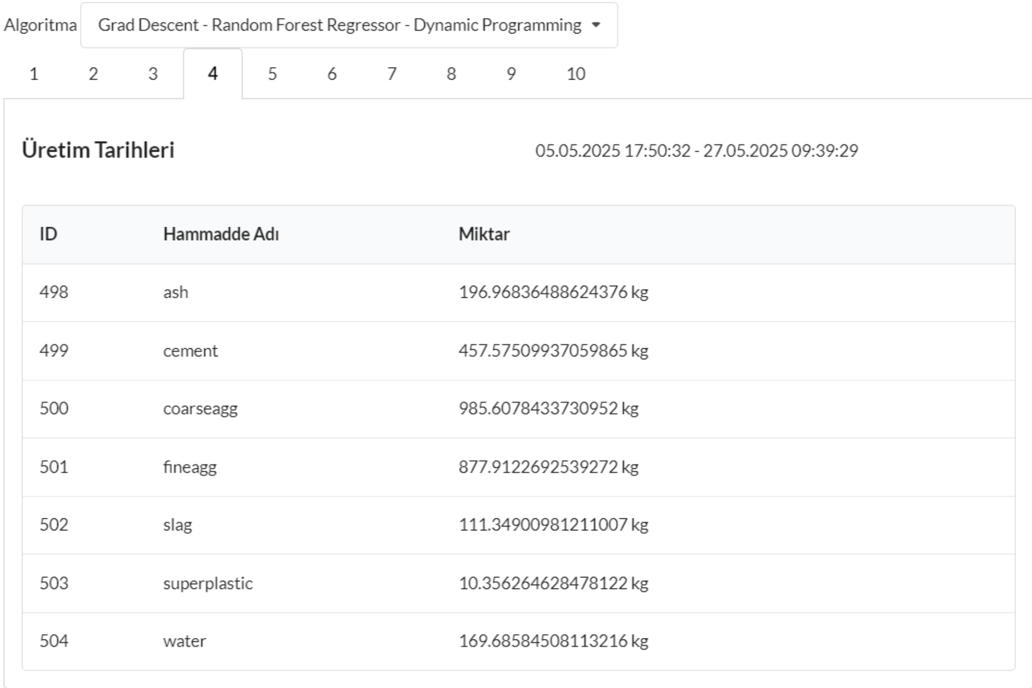

Algoritma Grad Descent - Random Forest Regressor - Dynamic Programming

1 2 3 4 5 6 7 8 9 10

Üretim Tarihleri 18.04.2025 03:42:40 - 05.05.2025 17:50:32

ID	Hammadde Adı	Miktar
491	ash	146.4279596435176 kg
492	cement	502.70245382402686 kg
493	coarseagg	1114.3756462761266 kg
494	fineagg	732.0530353982099 kg
495	slag	240.52193101461165 kg
496	superplastic	18.5447102426522 kg
497	water	158.98293126808844 kg

Figure 7.37 System Output 37



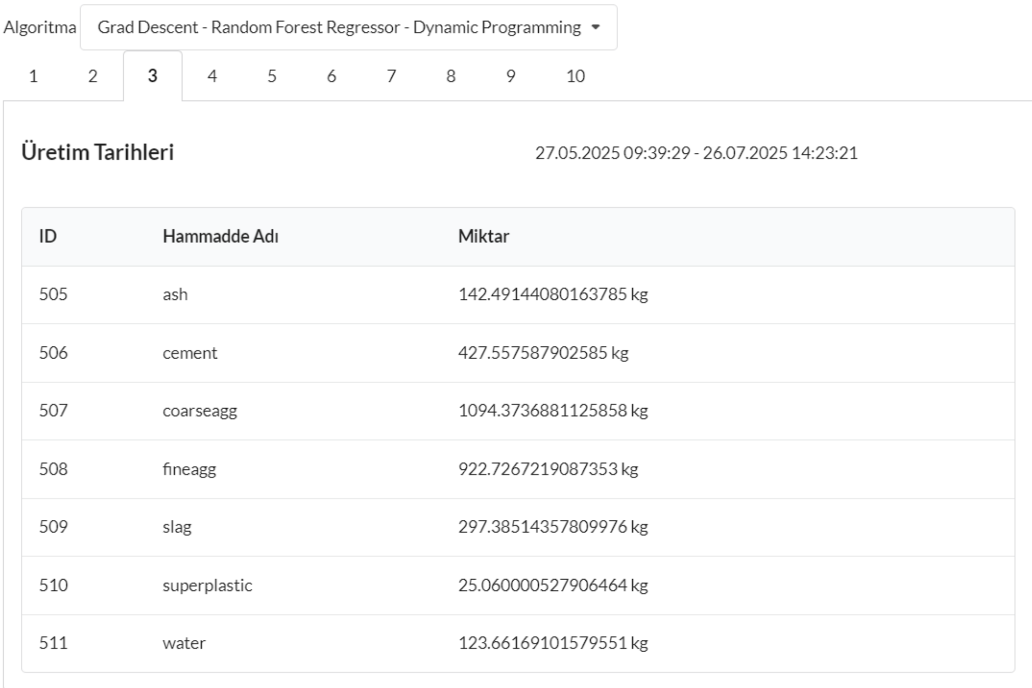
Algoritma Grad Descent - Random Forest Regressor - Dynamic Programming

1 2 3 **4** 5 6 7 8 9 10

Üretim Tarihleri 05.05.2025 17:50:32 - 27.05.2025 09:39:29

ID	Hammadde Adı	Miktar
498	ash	196.96836488624376 kg
499	cement	457.57509937059865 kg
500	coarseagg	985.6078433730952 kg
501	fineagg	877.9122692539272 kg
502	slag	111.34900981211007 kg
503	superplastic	10.356264628478122 kg
504	water	169.68584508113216 kg

Figure 7.38 System Output 38



Algoritma Grad Descent - Random Forest Regressor - Dynamic Programming

1 2 **3** 4 5 6 7 8 9 10

Üretim Tarihleri 27.05.2025 09:39:29 - 26.07.2025 14:23:21

ID	Hammadde Adı	Miktar
505	ash	142.49144080163785 kg
506	cement	427.557587902585 kg
507	coarseagg	1094.3736881125858 kg
508	fineagg	922.7267219087353 kg
509	slag	297.38514357809976 kg
510	superplastic	25.060000527906464 kg
511	water	123.66169101579551 kg

Figure 7.39 System Output 39

Algoritma Grad Descent - Random Forest Regressor - Dynamic Programming

1 **2** 3 4 5 6 7 8 9 10

Üretim Tarihleri 26.07.2025 14:23:21 - 09.08.2025 07:32:48

ID	Hammadde Adı	Miktar
512	ash	45.48007411414454 kg
513	cement	490.13220866615336 kg
514	coarseagg	925.5718027204795 kg
515	fineagg	698.2601832835506 kg
516	slag	356.4716019020245 kg
517	superplastic	19.875002141978936 kg
518	water	235.76712218138817 kg

Figure 7.40 System Output 40

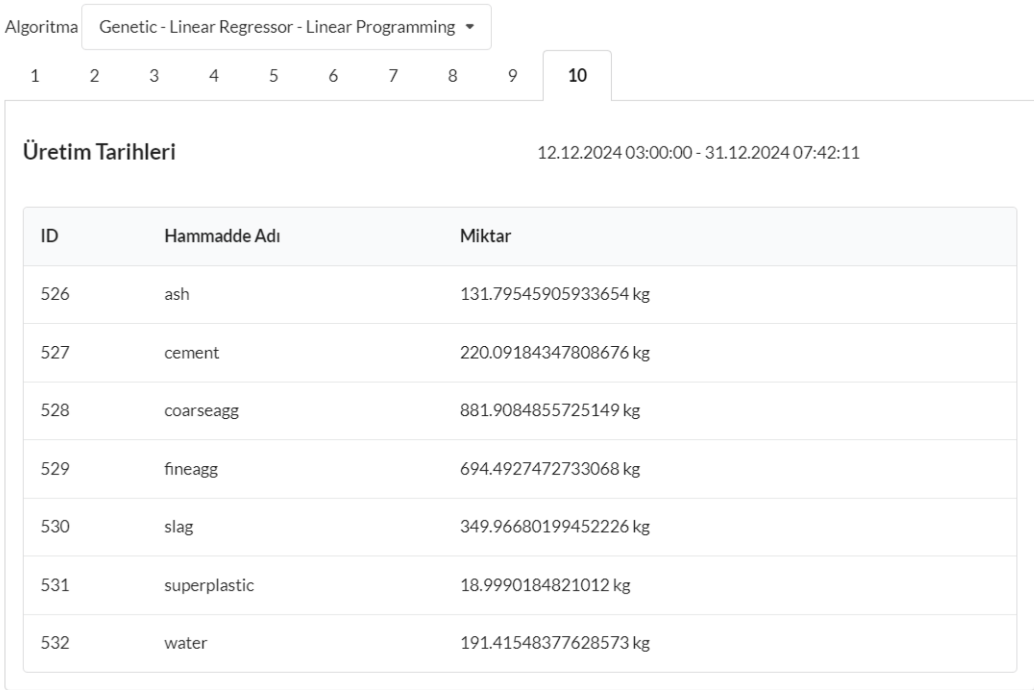
Algoritma Grad Descent - Random Forest Regressor - Dynamic Programming

1 2 3 4 5 6 7 8 9 10

Üretim Tarihleri 09.08.2025 07:32:48 - 17.09.2025 15:45:31

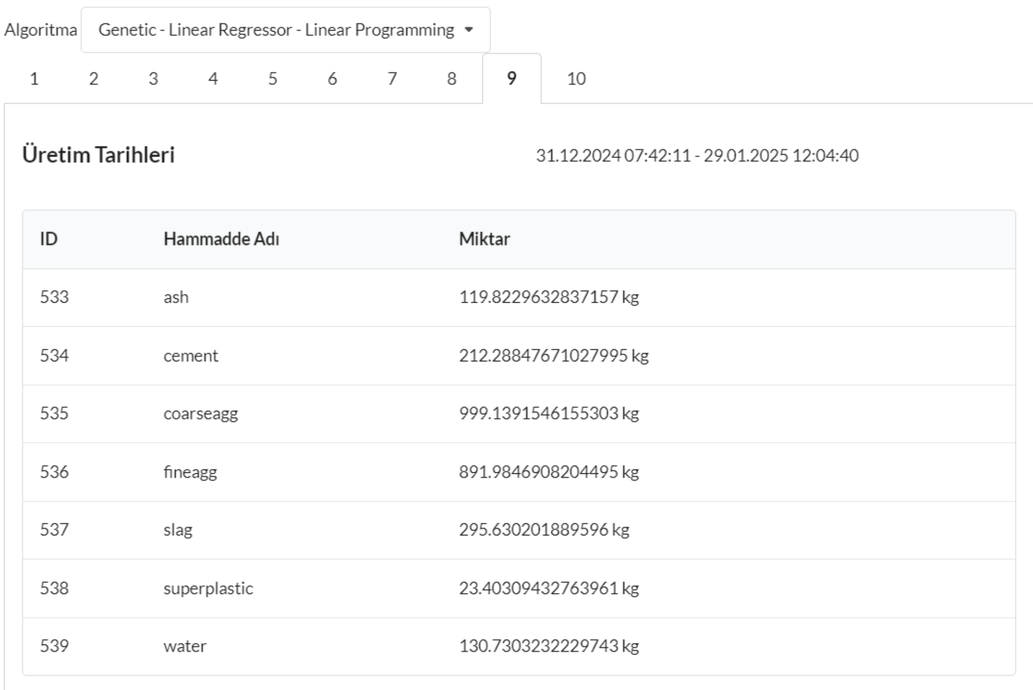
ID	Hammadde Adı	Miktar
519	ash	196.87884343674114 kg
520	cement	337.703070769663 kg
521	coarseagg	839.1897764031723 kg
522	fineagg	867.7092414457936 kg
523	slag	296.3694802927298 kg
524	superplastic	26.885660301841934 kg
525	water	189.98773619448366 kg

Figure 7.41 System Output 41



ID	Hammadde Adı	Miktar
526	ash	131.79545905933654 kg
527	cement	220.09184347808676 kg
528	coarseagg	881.9084855725149 kg
529	fineagg	694.4927472733068 kg
530	slag	349.96680199452226 kg
531	superplastic	18.9990184821012 kg
532	water	191.41548377628573 kg

Figure 7.42 System Output 42



ID	Hammadde Adı	Miktar
533	ash	119.8229632837157 kg
534	cement	212.28847671027995 kg
535	coarseagg	999.1391546155303 kg
536	fineagg	891.9846908204495 kg
537	slag	295.630201889596 kg
538	superplastic	23.40309432763961 kg
539	water	130.7303232229743 kg

Figure 7.43 System Output 43

Algoritma Genetic - Linear Regressor - Linear Programming

1 2 3 4 5 6 7 **8** 9 10

Üretim Tarihleri 29.01.2025 12:04:40 - 26.02.2025 21:58:51

ID	Hammadde Adı	Miktar
540	ash	168.06715378287421 kg
541	cement	256.5452854138262 kg
542	coarseagg	840.0281182843972 kg
543	fineagg	665.6813229571707 kg
544	slag	81.57520431750042 kg
545	superplastic	9.563991454782972 kg
546	water	168.94172564784225 kg

Figure 7.44 System Output 44

Algoritma Genetic - Linear Regressor - Linear Programming

1 2 3 4 5 6 **7** 8 9 10

Üretim Tarihleri 26.02.2025 21:58:51 - 19.04.2025 14:12:18

ID	Hammadde Adı	Miktar
547	ash	159.93046911585006 kg
548	cement	225.36337265855505 kg
549	coarseagg	930.9807944156898 kg
550	fineagg	910.1046743500146 kg
551	slag	288.80478044740045 kg
552	superplastic	10.572849932524548 kg
553	water	213.01636527215305 kg

Figure 7.45 System Output 45

Algoritma Genetic - Linear Regressor - Linear Programming

1 2 3 4 5 **6** 7 8 9 10

Üretim Tarihleri 19.04.2025 14:12:18 - 07.06.2025 12:45:04

ID	Hammadde Adı	Miktar
554	ash	144.36890252442402 kg
555	cement	220.6070631357368 kg
556	coarseagg	802.8721154822972 kg
557	fineagg	657.5128600519214 kg
558	slag	76.16369960347625 kg
559	superplastic	10.255715040751888 kg
560	water	133.98674425642105 kg

Figure 7.46 System Output 46

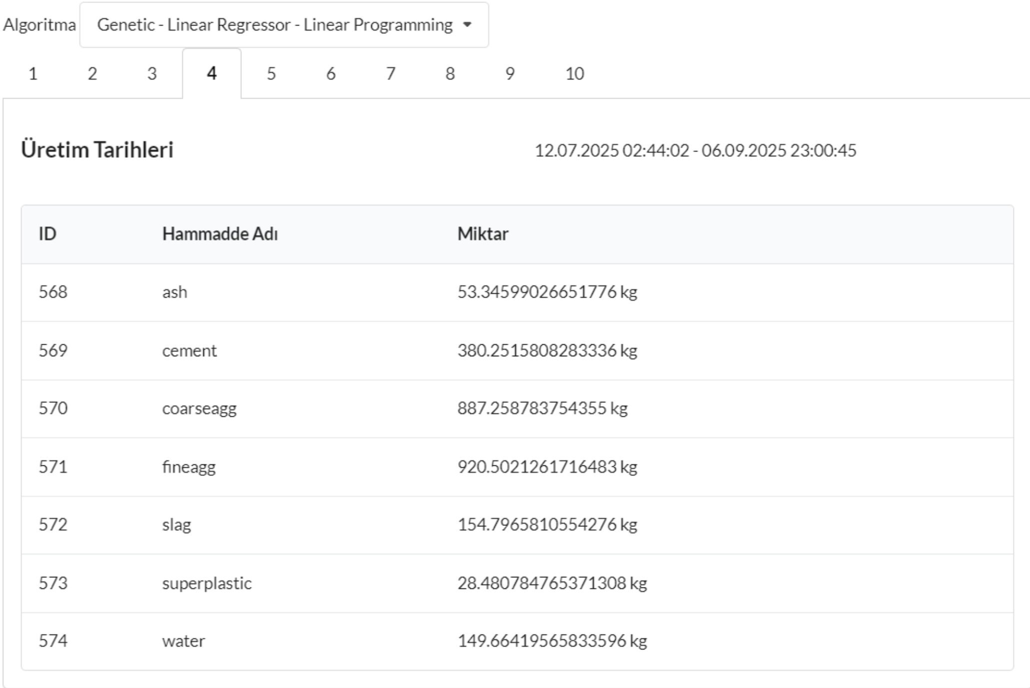
Algoritma Genetic - Linear Regressor - Linear Programming

1 2 3 4 **5** 6 7 8 9 10

Üretim Tarihleri 07.06.2025 12:45:04 - 12.07.2025 02:44:02

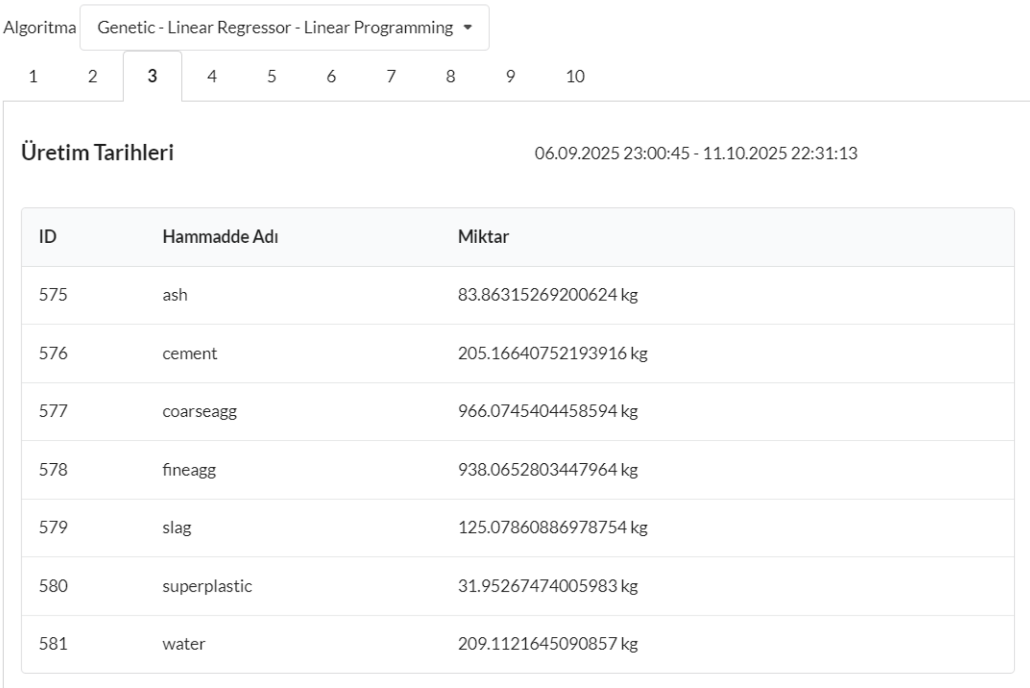
ID	Hammadde Adı	Miktar
561	ash	197.7246765154626 kg
562	cement	382.62607304396175 kg
563	coarseagg	958.5153251146626 kg
564	fineagg	698.0351172769007 kg
565	slag	87.64439005113785 kg
566	superplastic	30.24341398111314 kg
567	water	154.86067238320186 kg

Figure 7.47 System Output 47



ID	Hammadde Adı	Miktar
568	ash	53.34599026651776 kg
569	cement	380.2515808283336 kg
570	coarseagg	887.258783754355 kg
571	fineagg	920.5021261716483 kg
572	slag	154.7965810554276 kg
573	superplastic	28.480784765371308 kg
574	water	149.66419565833596 kg

Figure 7.48 System Output 48



ID	Hammadde Adı	Miktar
575	ash	83.86315269200624 kg
576	cement	205.16640752193916 kg
577	coarseagg	966.0745404458594 kg
578	fineagg	938.0652803447964 kg
579	slag	125.07860886978754 kg
580	superplastic	31.95267474005983 kg
581	water	209.1121645090857 kg

Figure 7.49 System Output 49

Algoritma Genetic - Linear Regressor - Linear Programming

1 2 3 4 5 6 7 8 9 10

Üretim Tarihleri 11.10.2025 22:31:13 - 24.10.2025 21:56:20

ID	Hammadde Adı	Miktar
582	ash	175.93219752256485 kg
583	cement	256.2386616568581 kg
584	coarseagg	934.5726484605862 kg
585	fineagg	728.5121210098246 kg
586	slag	89.07680922992975 kg
587	superplastic	30.563737885751742 kg
588	water	227.53083342398955 kg

Figure 7.50 System Output 50

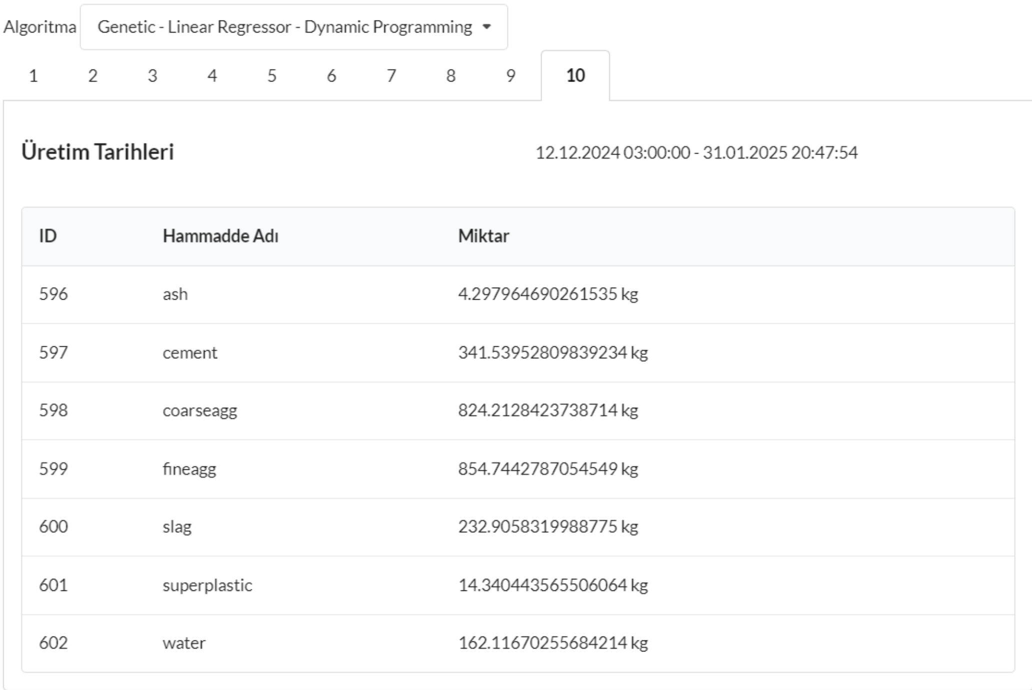
Algoritma Genetic - Linear Regressor - Linear Programming

1 2 3 4 5 6 7 8 9 10

Üretim Tarihleri 24.10.2025 21:56:20 - 30.10.2025 06:53:52

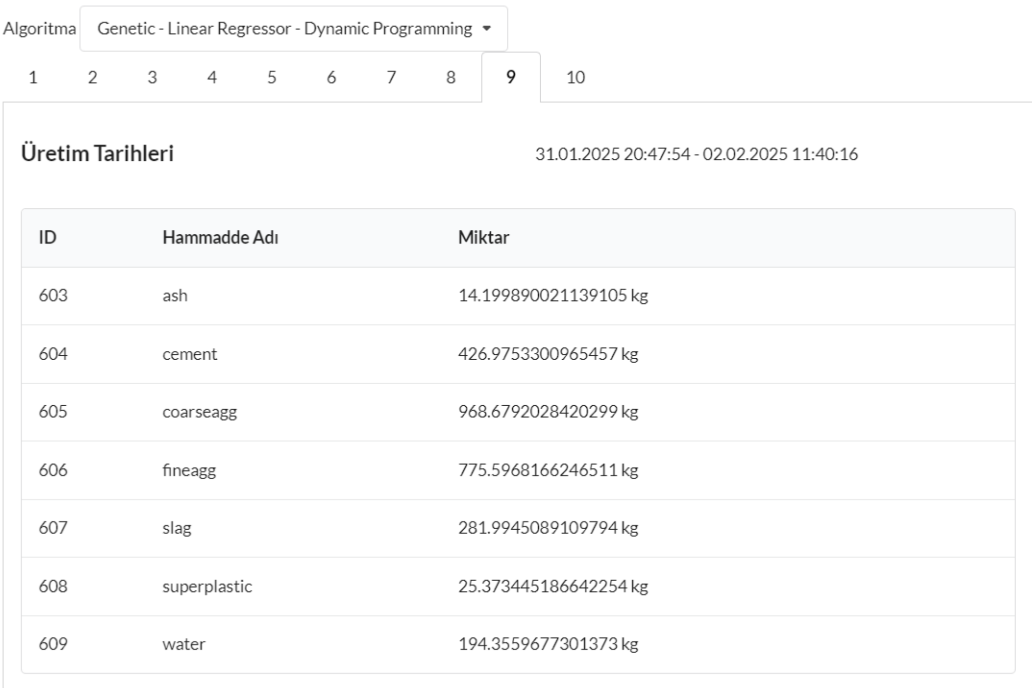
ID	Hammadde Adı	Miktar
589	ash	97.61365919712173 kg
590	cement	426.7516872016556 kg
591	coarseagg	977.182788080588 kg
592	fineagg	696.1508041004722 kg
593	slag	228.81057214238163 kg
594	superplastic	6.598109995002954 kg
595	water	229.60951684162535 kg

Figure 7.51 System Output 51



ID	Hammadde Adı	Miktar
596	ash	4.297964690261535 kg
597	cement	341.53952809839234 kg
598	coarseagg	824.2128423738714 kg
599	fineagg	854.7442787054549 kg
600	slag	232.9058319988775 kg
601	superplastic	14.340443565506064 kg
602	water	162.11670255684214 kg

Figure 7.52 System Output 52



ID	Hammadde Adı	Miktar
603	ash	14.199890021139105 kg
604	cement	426.9753300965457 kg
605	coarseagg	968.6792028420299 kg
606	fineagg	775.5968166246511 kg
607	slag	281.9945089109794 kg
608	superplastic	25.373445186642254 kg
609	water	194.3559677301373 kg

Figure 7.53 System Output 53

Algoritma Genetic - Linear Regressor - Dynamic Programming

1 2 3 4 5 6 7 **8** 9 10

Üretim Tarihleri 02.02.2025 11:40:16 - 05.04.2025 19:33:07

ID	Hammadde Adı	Miktar
610	ash	76.4357349288424 kg
611	cement	138.74260845248483 kg
612	coarseagg	1057.3049721958641 kg
613	fineagg	923.5773845189076 kg
614	slag	132.02516356957784 kg
615	superplastic	26.670125081568543 kg
616	water	176.10846882885113 kg

Figure 7.54 System Output 54

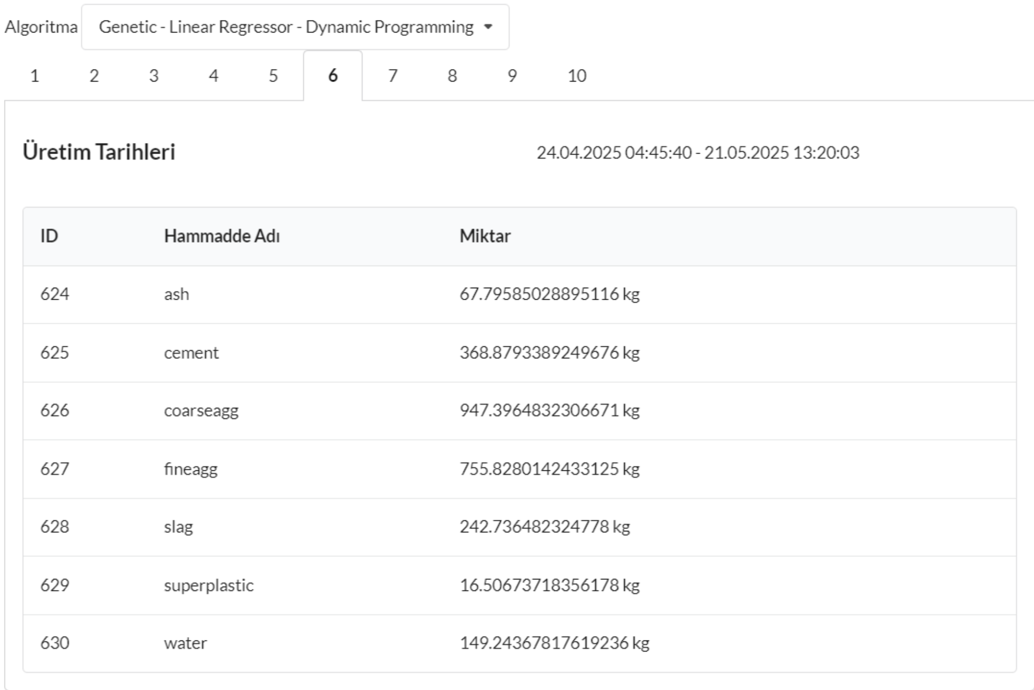
Algoritma Genetic - Linear Regressor - Dynamic Programming

1 2 3 4 5 6 **7** 8 9 10

Üretim Tarihleri 05.04.2025 19:33:07 - 24.04.2025 04:45:40

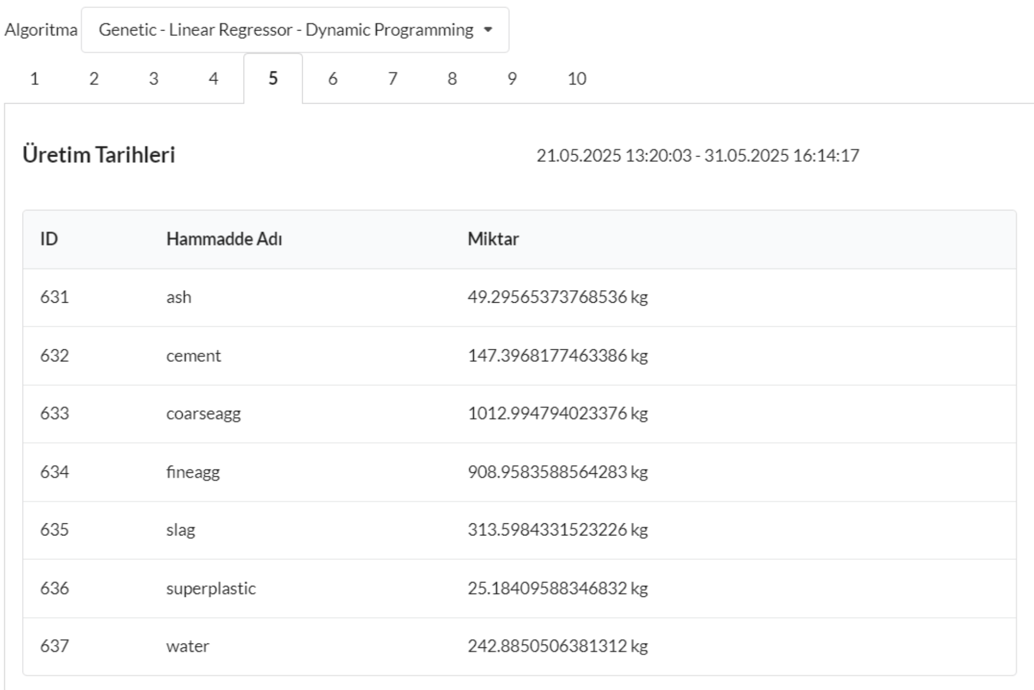
ID	Hammadde Adı	Miktar
617	ash	125.72161912038207 kg
618	cement	374.9571578466275 kg
619	coarseagg	1143.6299613666988 kg
620	fineagg	835.8954471261276 kg
621	slag	71.17244306250838 kg
622	superplastic	20.400830252650728 kg
623	water	171.11919731723432 kg

Figure 7.55 System Output 55



ID	Hammadde Adı	Miktar
624	ash	67.79585028895116 kg
625	cement	368.8793389249676 kg
626	coarseagg	947.3964832306671 kg
627	fineagg	755.8280142433125 kg
628	slag	242.736482324778 kg
629	superplastic	16.50673718356178 kg
630	water	149.24367817619236 kg

Figure 7.56 System Output 56



ID	Hammadde Adı	Miktar
631	ash	49.29565373768536 kg
632	cement	147.3968177463386 kg
633	coarseagg	1012.994794023376 kg
634	fineagg	908.9583588564283 kg
635	slag	313.5984331523226 kg
636	superplastic	25.18409588346832 kg
637	water	242.8850506381312 kg

Figure 7.57 System Output 57

Algoritma Genetic - Linear Regressor - Dynamic Programming

1 2 3 **4** 5 6 7 8 9 10

Üretim Tarihleri 31.05.2025 16:14:17 - 18.07.2025 00:01:07

ID	Hammadde Adı	Miktar
638	ash	190.45089673323844 kg
639	cement	188.588467847524 kg
640	coarseagg	1065.0092578646595 kg
641	fineagg	980.3052713620531 kg
642	slag	177.06851804959135 kg
643	superplastic	8.721855790958216 kg
644	water	142.7782319300744 kg

Figure 7.58 System Output 58

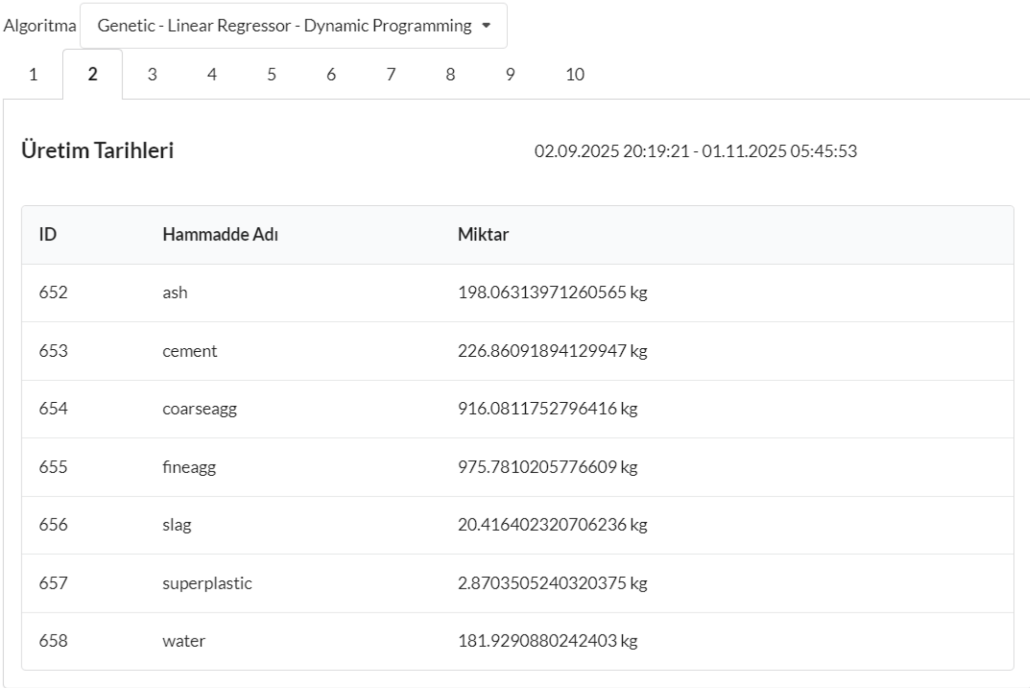
Algoritma Genetic - Linear Regressor - Dynamic Programming

1 2 **3** 4 5 6 7 8 9 10

Üretim Tarihleri 18.07.2025 00:01:07 - 02.09.2025 20:19:21

ID	Hammadde Adı	Miktar
645	ash	65.05534829184762 kg
646	cement	472.0073479326507 kg
647	coarseagg	978.4013871055879 kg
648	fineagg	706.0246164055076 kg
649	slag	141.6265524021315 kg
650	superplastic	9.23266779801602 kg
651	water	157.73694397214055 kg

Figure 7.59 System Output 59



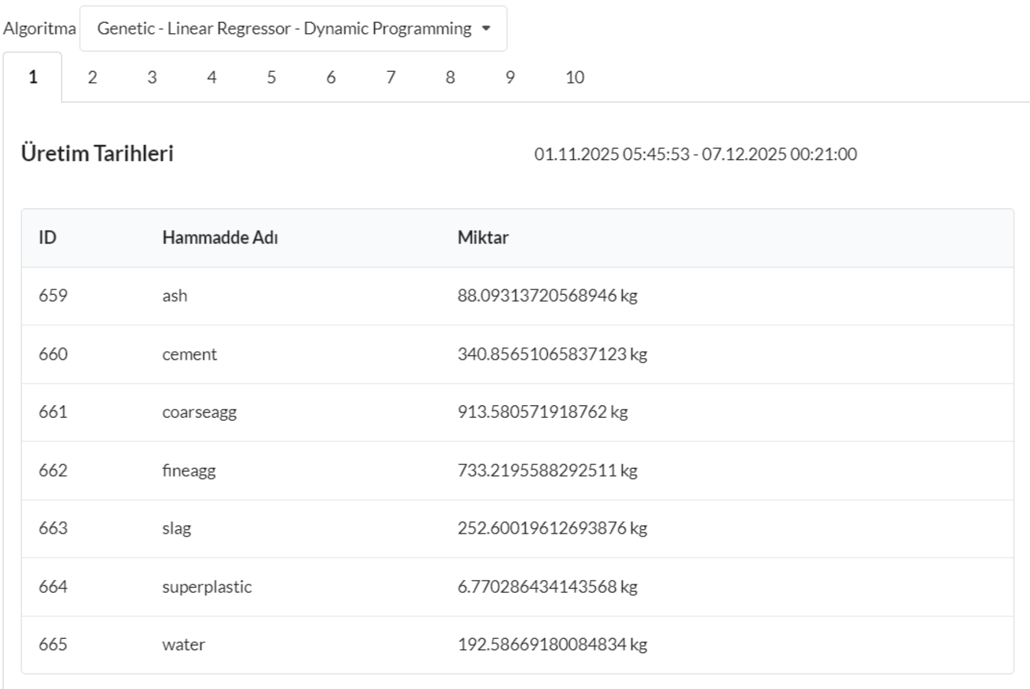
Algoritma Genetic - Linear Regressor - Dynamic Programming

1 2 3 4 5 6 7 8 9 10

Üretim Tarihleri 02.09.2025 20:19:21 - 01.11.2025 05:45:53

ID	Hammadde Adı	Miktar
652	ash	198.06313971260565 kg
653	cement	226.86091894129947 kg
654	coarseagg	916.0811752796416 kg
655	fineagg	975.7810205776609 kg
656	slag	20.416402320706236 kg
657	superplastic	2.8703505240320375 kg
658	water	181.9290880242403 kg

Figure 7.60 System Output 60



Algoritma Genetic - Linear Regressor - Dynamic Programming

1 2 3 4 5 6 7 8 9 10

Üretim Tarihleri 01.11.2025 05:45:53 - 07.12.2025 00:21:00

ID	Hammadde Adı	Miktar
659	ash	88.09313720568946 kg
660	cement	340.85651065837123 kg
661	coarseagg	913.580571918762 kg
662	fineagg	733.2195588292511 kg
663	slag	252.60019612693876 kg
664	superplastic	6.770286434143568 kg
665	water	192.58669180084834 kg

Figure 7.61 System Output 61

Algoritma Genetic - Random Forest Regressor - Linear Programming

1 2 3 4 5 6 7 8 9 **10**

Üretim Tarihleri 12.12.2024 03:00:00 - 03.01.2025 06:46:55

ID	Hammadde Adı	Miktar
666	ash	88.05287001640818 kg
667	cement	339.33101268256553 kg
668	coarseagg	826.0475736476558 kg
669	fineagg	625.7233261042234 kg
670	slag	249.25559839348037 kg
671	superplastic	22.176629967601055 kg
672	water	194.98841472693474 kg

Figure 7.62 System Output 62

Algoritma Genetic - Random Forest Regressor - Linear Programming

1 2 3 4 5 6 7 8 **9** 10

Üretim Tarihleri 03.01.2025 06:46:55 - 11.03.2025 07:36:21

ID	Hammadde Adı	Miktar
673	ash	140.16367621862636 kg
674	cement	514.7279687281474 kg
675	coarseagg	926.0089651778296 kg
676	fineagg	742.0911555592693 kg
677	slag	186.9427569927492 kg
678	superplastic	15.183000587578977 kg
679	water	150.2759571149129 kg

Figure 7.63 System Output 63

Algoritma Genetic - Random Forest Regressor - Linear Programming

1 2 3 4 5 6 7 **8** 9 10

Üretim Tarihleri 11.03.2025 07:36:21 - 23.03.2025 08:03:01

ID	Hammadde Adı	Miktar
680	ash	17.76862497579106 kg
681	cement	350.58140695889597 kg
682	coarseagg	1000.426255055351 kg
683	fineagg	610.1553788809734 kg
684	slag	47.02705149701262 kg
685	superplastic	10.60561675066602 kg
686	water	207.5770929146865 kg

Figure 7.64 System Output 64

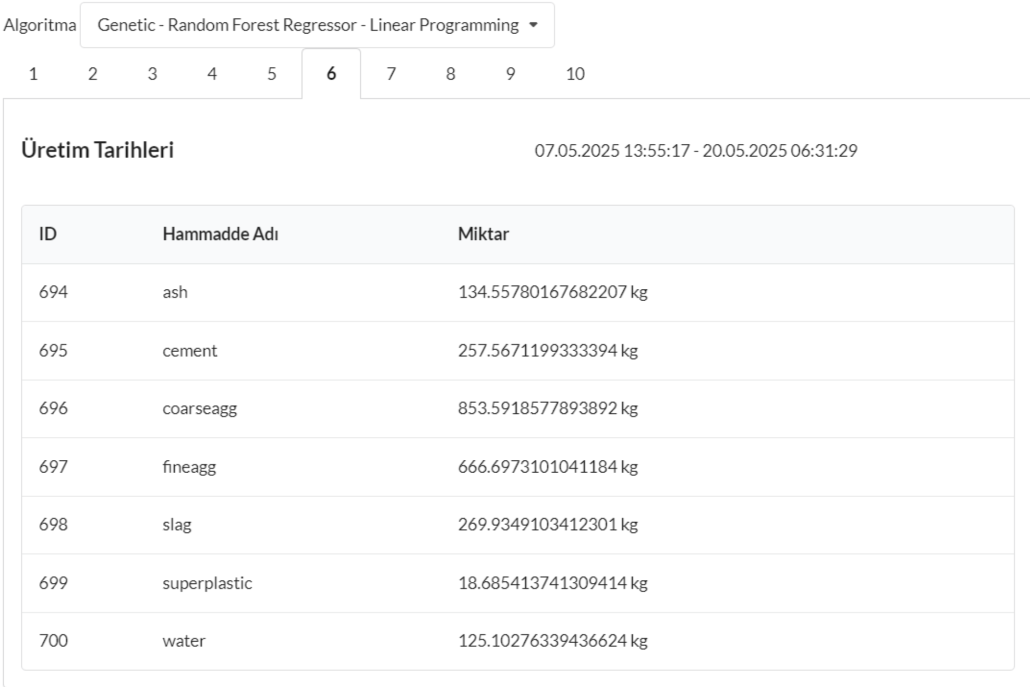
Algoritma Genetic - Random Forest Regressor - Linear Programming

1 2 3 4 5 6 **7** 8 9 10

Üretim Tarihleri 23.03.2025 08:03:01 - 07.05.2025 13:55:17

ID	Hammadde Adı	Miktar
687	ash	25.473599341584396 kg
688	cement	374.2169932377459 kg
689	coarseagg	985.7501651089138 kg
690	fineagg	949.7797023986232 kg
691	slag	202.20558395937996 kg
692	superplastic	16.713356957081732 kg
693	water	157.01044815018085 kg

Figure 7.65 System Output 65



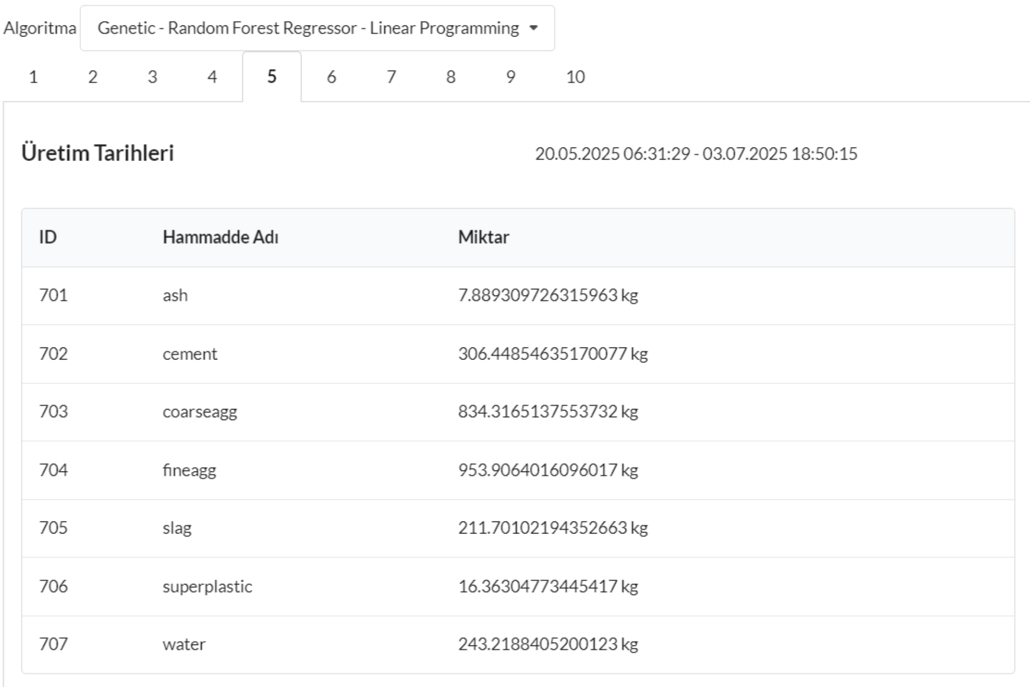
Algoritma Genetic - Random Forest Regressor - Linear Programming

1 2 3 4 5 6 7 8 9 10

Üretim Tarihleri 07.05.2025 13:55:17 - 20.05.2025 06:31:29

ID	Hammadde Adı	Miktar
694	ash	134.55780167682207 kg
695	cement	257.5671199333394 kg
696	coarseagg	853.5918577893892 kg
697	fineagg	666.6973101041184 kg
698	slag	269.9349103412301 kg
699	superplastic	18.685413741309414 kg
700	water	125.10276339436624 kg

Figure 7.66 System Output 66



Algoritma Genetic - Random Forest Regressor - Linear Programming

1 2 3 4 5 6 7 8 9 10

Üretim Tarihleri 20.05.2025 06:31:29 - 03.07.2025 18:50:15

ID	Hammadde Adı	Miktar
701	ash	7.889309726315963 kg
702	cement	306.44854635170077 kg
703	coarseagg	834.3165137553732 kg
704	fineagg	953.9064016096017 kg
705	slag	211.70102194352663 kg
706	superplastic	16.36304773445417 kg
707	water	243.2188405200123 kg

Figure 7.67 System Output 67

Algoritma Genetic - Random Forest Regressor - Linear Programming

1 2 3 **4** 5 6 7 8 9 10

Üretim Tarihleri 03.07.2025 18:50:15 - 08.09.2025 06:05:16

ID	Hammadde Adı	Miktar
708	ash	24.23928024758364 kg
709	cement	456.20645559620266 kg
710	coarseagg	885.128877601042 kg
711	fineagg	744.9634836291516 kg
712	slag	297.2374012746721 kg
713	superplastic	24.38167119123042 kg
714	water	174.45462551208058 kg

Figure 7.68 System Output 68

Algoritma Genetic - Random Forest Regressor - Linear Programming

1 2 **3** 4 5 6 7 8 9 10

Üretim Tarihleri 08.09.2025 06:05:16 - 01.11.2025 18:01:33

ID	Hammadde Adı	Miktar
715	ash	2.557122897130304 kg
716	cement	301.00810607839355 kg
717	coarseagg	948.427668082158 kg
718	fineagg	677.5216362344422 kg
719	slag	228.48838710198487 kg
720	superplastic	28.567702702232683 kg
721	water	149.89240300771712 kg

Figure 7.69 System Output 69

Algoritma Genetic - Random Forest Regressor - Linear Programming

1 **2** 3 4 5 6 7 8 9 10

Üretim Tarihleri 01.11.2025 18:01:33 - 06.12.2025 22:37:40

ID	Hammadde Adı	Miktar
722	ash	56.92891117647974 kg
723	cement	457.1891961555314 kg
724	coarseagg	978.2813373851761 kg
725	fineagg	989.6846512403922 kg
726	slag	326.47949802031246 kg
727	superplastic	14.095727593014189 kg
728	water	153.75406527597713 kg

Figure 7.70 System Output 70

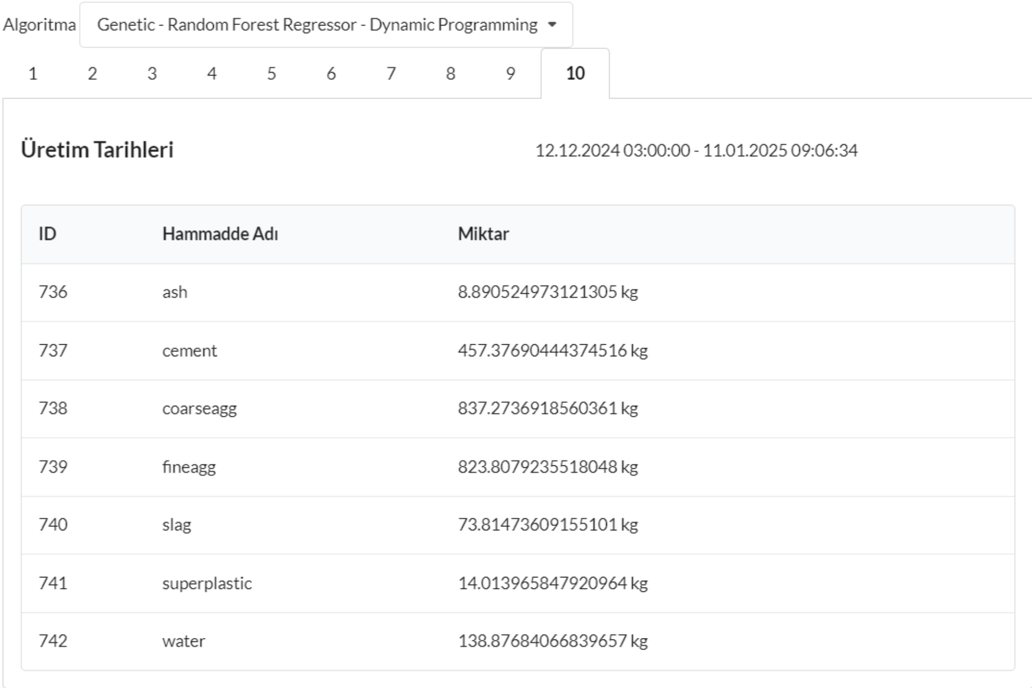
Algoritma Genetic - Random Forest Regressor - Linear Programming

1 2 3 4 5 6 7 8 9 10

Üretim Tarihleri 06.12.2025 22:37:40 - 14.02.2026 07:22:00

ID	Hammadde Adı	Miktar
729	ash	49.145891182088896 kg
730	cement	388.4570960723099 kg
731	coarseagg	948.8036801006888 kg
732	fineagg	719.8087388552058 kg
733	slag	210.97337235058004 kg
734	superplastic	26.69417873568707 kg
735	water	159.91400496851753 kg

Figure 7.71 System Output 71

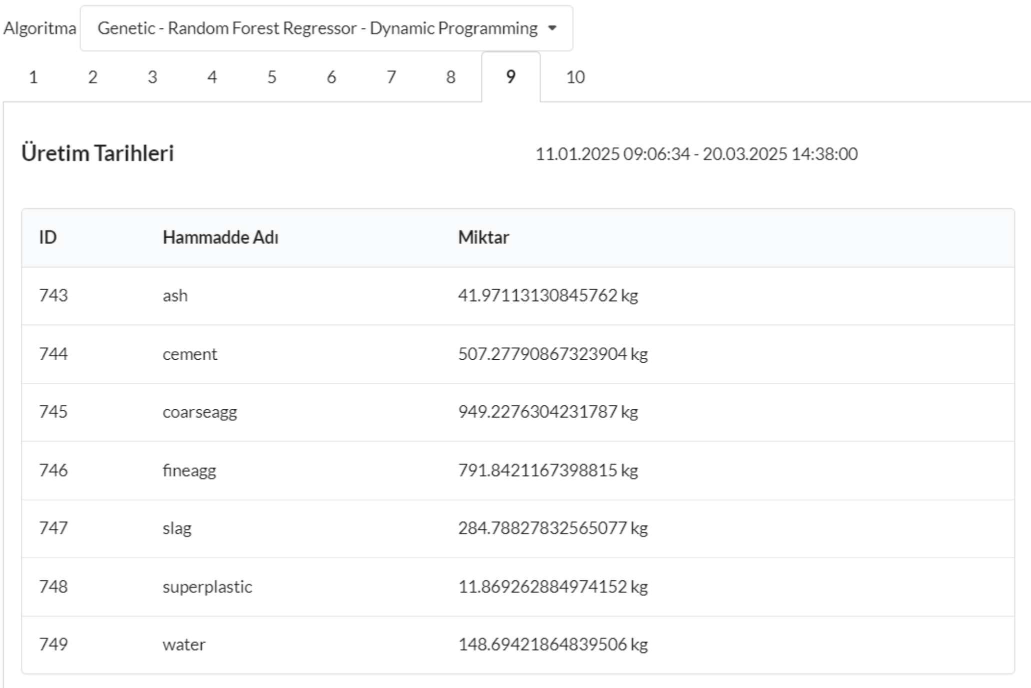

Algoritma Genetic - Random Forest Regressor - Dynamic Programming

1 2 3 4 5 6 7 8 9 **10**

Üretim Tarihleri 12.12.2024 03:00:00 - 11.01.2025 09:06:34

ID	Hammadde Adı	Miktar
736	ash	8.890524973121305 kg
737	cement	457.37690444374516 kg
738	coarseagg	837.2736918560361 kg
739	fineagg	823.8079235518048 kg
740	slag	73.81473609155101 kg
741	superplastic	14.013965847920964 kg
742	water	138.87684066839657 kg

Figure 7.72 System Output 72


Algoritma Genetic - Random Forest Regressor - Dynamic Programming

1 2 3 4 5 6 7 8 **9** 10

Üretim Tarihleri 11.01.2025 09:06:34 - 20.03.2025 14:38:00

ID	Hammadde Adı	Miktar
743	ash	41.97113130845762 kg
744	cement	507.27790867323904 kg
745	coarseagg	949.2276304231787 kg
746	fineagg	791.8421167398815 kg
747	slag	284.78827832565077 kg
748	superplastic	11.869262884974152 kg
749	water	148.69421864839506 kg

Figure 7.73 System Output 73

Algoritma Genetic - Random Forest Regressor - Dynamic Programming

1 2 3 4 5 6 7 **8** 9 10

Üretim Tarihleri 20.03.2025 14:38:00 - 27.04.2025 10:13:03

ID	Hammadde Adı	Miktar
750	ash	137.52262276631794 kg
751	cement	213.9688946127808 kg
752	coarseagg	987.0712081951906 kg
753	fineagg	634.33866971128 kg
754	slag	154.62042853593547 kg
755	superplastic	10.156445988236609 kg
756	water	182.3156754248612 kg

Figure 7.74 System Output 74

Algoritma Genetic - Random Forest Regressor - Dynamic Programming

1 2 3 4 5 6 **7** 8 9 10

Üretim Tarihleri 27.04.2025 10:13:03 - 31.05.2025 07:26:24

ID	Hammadde Adı	Miktar
757	ash	120.63265912748086 kg
758	cement	440.09147964903326 kg
759	coarseagg	1138.7752814626429 kg
760	fineagg	732.3016112557348 kg
761	slag	189.10602709999978 kg
762	superplastic	12.583421756361748 kg
763	water	244.95304326245352 kg

Figure 7.75 System Output 75

Algoritma Genetic - Random Forest Regressor - Dynamic Programming

1 2 3 4 5 **6** 7 8 9 10

Üretim Tarihleri 31.05.2025 07:26:24 - 29.07.2025 02:04:26

ID	Hammadde Adı	Miktar
764	ash	38.62134339756662 kg
765	cement	533.7752495644214 kg
766	coarseagg	1007.2856831275612 kg
767	fineagg	890.1779789643808 kg
768	slag	338.82847698687993 kg
769	superplastic	11.073214064731324 kg
770	water	122.24032586381325 kg

Figure 7.76 System Output 76

Algoritma Genetic - Random Forest Regressor - Dynamic Programming

1 2 3 4 **5** 6 7 8 9 10

Üretim Tarihleri 29.07.2025 02:04:26 - 05.10.2025 06:19:00

ID	Hammadde Adı	Miktar
771	ash	11.711290449992685 kg
772	cement	303.2144899132222 kg
773	coarseagg	1035.7111609431636 kg
774	fineagg	991.7924273616668 kg
775	slag	168.47513667394733 kg
776	superplastic	4.664001693199314 kg
777	water	239.5347704303582 kg

Figure 7.77 System Output 77

Algoritma Genetic - Random Forest Regressor - Dynamic Programming

1 2 3 **4** 5 6 7 8 9 10

Üretim Tarihleri 05.10.2025 06:19:00 - 06.11.2025 13:11:38

ID	Hammadde Adı	Miktar
778	ash	107.30266053035432 kg
779	cement	425.928446566648 kg
780	coarseagg	923.7103254064963 kg
781	fineagg	872.4815789650656 kg
782	slag	211.92473793567274 kg
783	superplastic	31.759910910902175 kg
784	water	156.21715720330803 kg

Figure 7.78 System Output 78

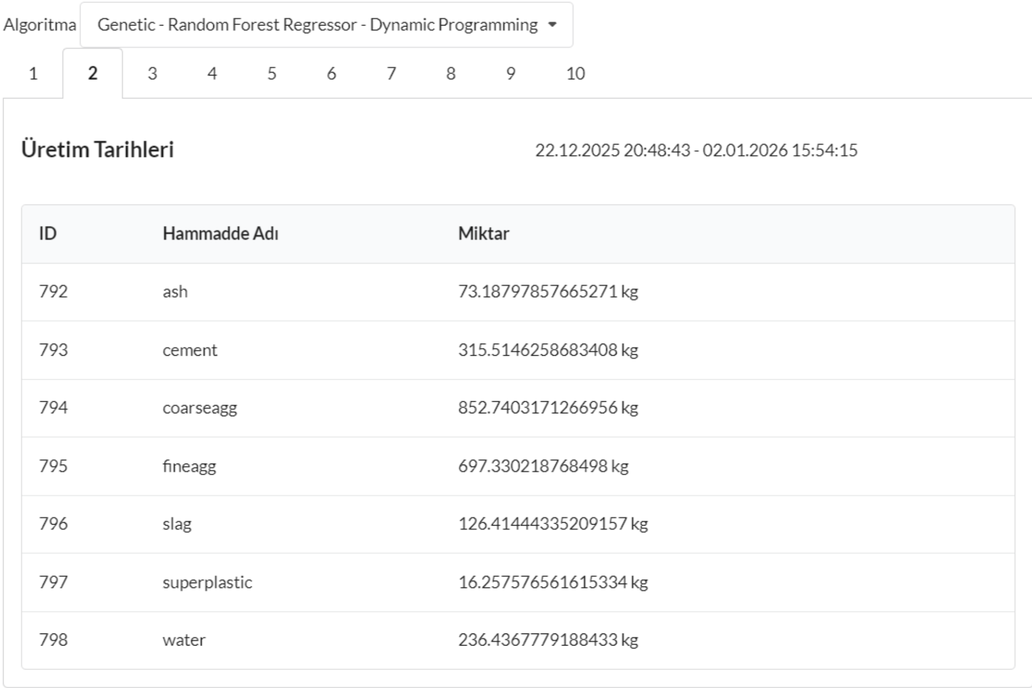
Algoritma Genetic - Random Forest Regressor - Dynamic Programming

1 2 **3** 4 5 6 7 8 9 10

Üretim Tarihleri 06.11.2025 13:11:38 - 22.12.2025 20:48:43

ID	Hammadde Adı	Miktar
785	ash	1.7633104701009206 kg
786	cement	525.5356909908139 kg
787	coarseagg	1112.9714905691217 kg
788	fineagg	795.4827224842629 kg
789	slag	341.2806295665256 kg
790	superplastic	19.816453067697303 kg
791	water	175.8364100483616 kg

Figure 7.79 System Output 79



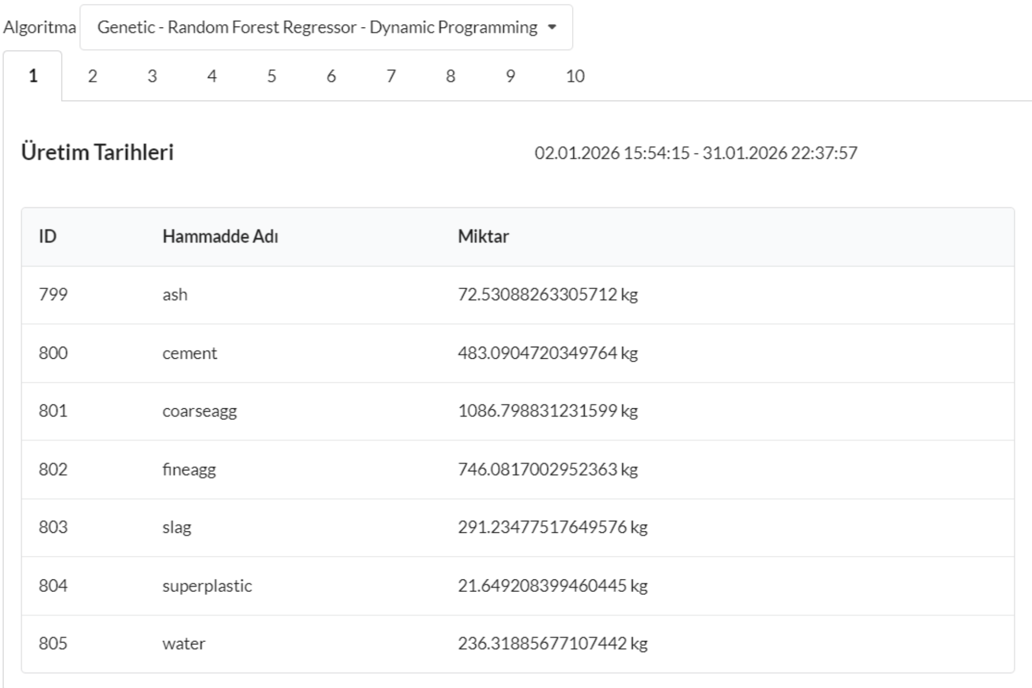
Algoritma Genetic - Random Forest Regressor - Dynamic Programming

1 **2** 3 4 5 6 7 8 9 10

Üretim Tarihleri 22.12.2025 20:48:43 - 02.01.2026 15:54:15

ID	Hammadde Adı	Miktar
792	ash	73.18797857665271 kg
793	cement	315.5146258683408 kg
794	coarseagg	852.7403171266956 kg
795	fineagg	697.330218768498 kg
796	slag	126.41444335209157 kg
797	superplastic	16.257576561615334 kg
798	water	236.4367779188433 kg

Figure 7.80 System Output 80



Algoritma Genetic - Random Forest Regressor - Dynamic Programming

1 2 3 4 5 6 7 8 9 10

Üretim Tarihleri 02.01.2026 15:54:15 - 31.01.2026 22:37:57

ID	Hammadde Adı	Miktar
799	ash	72.53088263305712 kg
800	cement	483.0904720349764 kg
801	coarseagg	1086.798831231599 kg
802	fineagg	746.0817002952363 kg
803	slag	291.23477517649576 kg
804	superplastic	21.649208399460445 kg
805	water	236.31885677107442 kg

Figure 7.81 System Output 81

8
Performance Analysis

8.1 Model Evaluate

Table 8.1 shows the regression models and their results for the strength calculation functions used to check product compliance.

MSE and R-squared (R2) are two extensively used measures in the evaluation of regression models. MSE measures the model's accuracy by calculating the average squared difference between actual and predicted values. A lower MSE suggests higher model performance since it represents fewer mistakes. R-squared, on the other hand, measures the amount of the variation in the dependent variable explained by the independent variables. A higher R-squared value, ranging from 0 to 1, indicates a larger degree of variance explained by the model. We used MSE and R-squared in our model evaluation to assess their performance.

Table 8.1 Regression Models Evaluate

Model	Mean Squared Error	R-Squared
Linear Regression	118.54536558702142	0.5950675298086894
Random Forest Regressor	28.392843668532386	0.9030144766476365

8.2 System Performance Analysis

Google Developer Tools, which provides a complete set of functions for assessing and enhancing website performance, was used extensively in the system performance evaluation. These browser-based tools provide visibility into many elements of a web application's operation, such as network traffic, rendering, and JavaScript execution.

Google Developer Tools includes features like the Network panel, which allows you to monitor network requests, loading times, and resource sizes. The Timeline panel depicts the application's runtime, emphasizing actions such as scripting, rendering, and painting. Furthermore, the Performance panel allows for in-depth study of JavaScript performance and aids in the identification of possible bottlenecks.

Using Google Developer Tools to monitor system performance entails measuring and analyzing characteristics such as page load times, resource use, and general responsiveness. Developers may find areas for improvement, optimize code, and improve the overall user experience by studying these metrics.

To summarize, Google Developer Tools is an important tool for evaluating and optimizing system performance, providing developers with vital information to refine and increase the efficiency of online applications. So that our system's performance analysis was also carried out utilizing Google Developer Tools and reviewed under this part and summarized in Table 8.2.

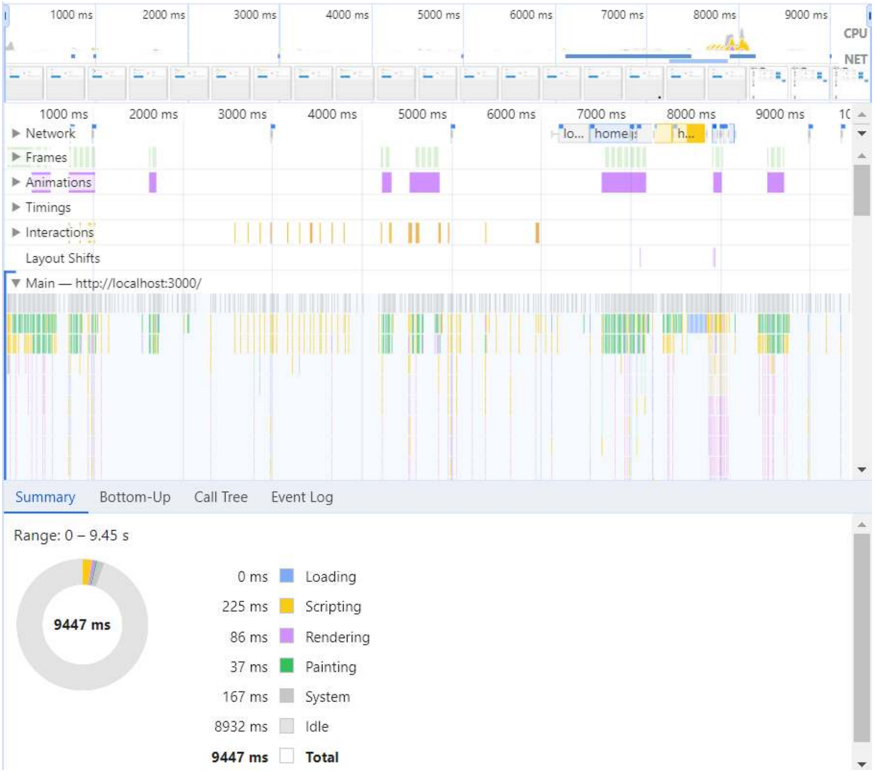


Figure 8.1 Log In & Load Production Plans

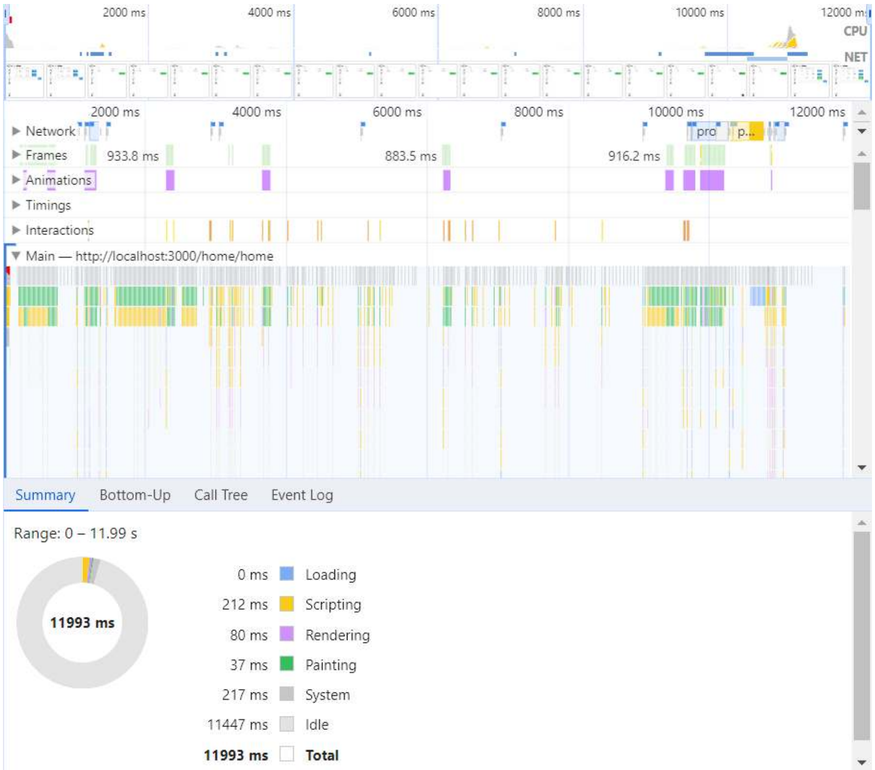


Figure 8.2 Add Production Plan

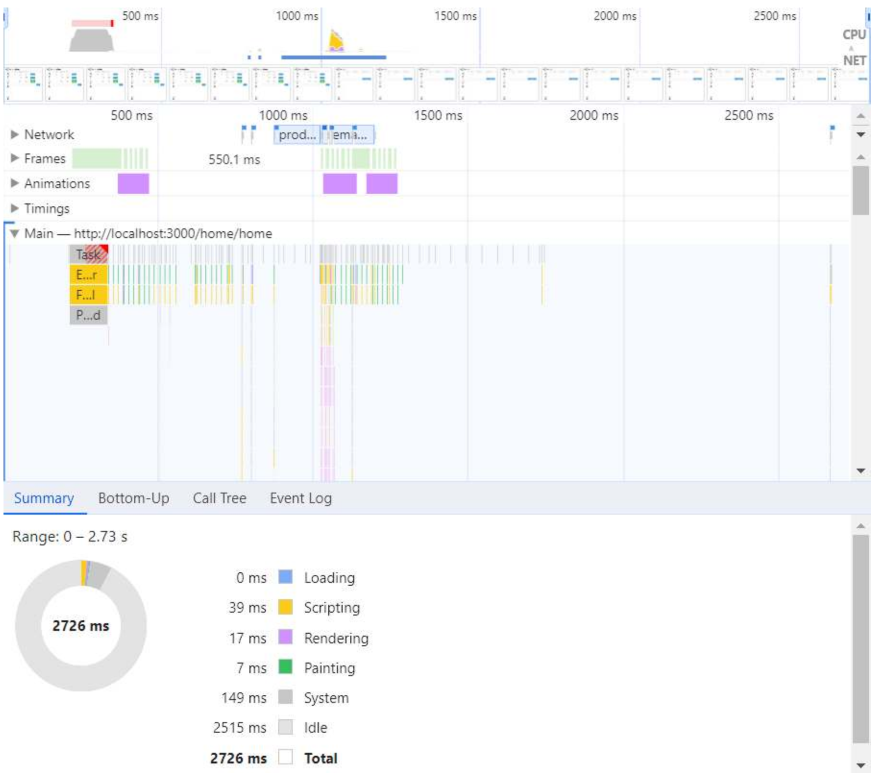


Figure 8.3 Load Products

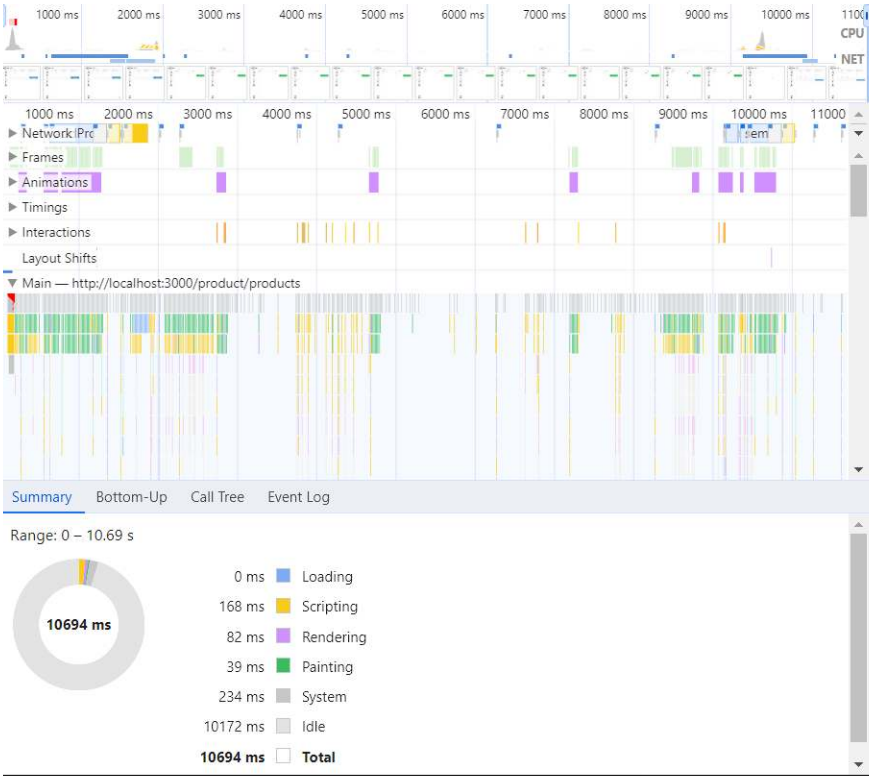


Figure 8.4 Add Product

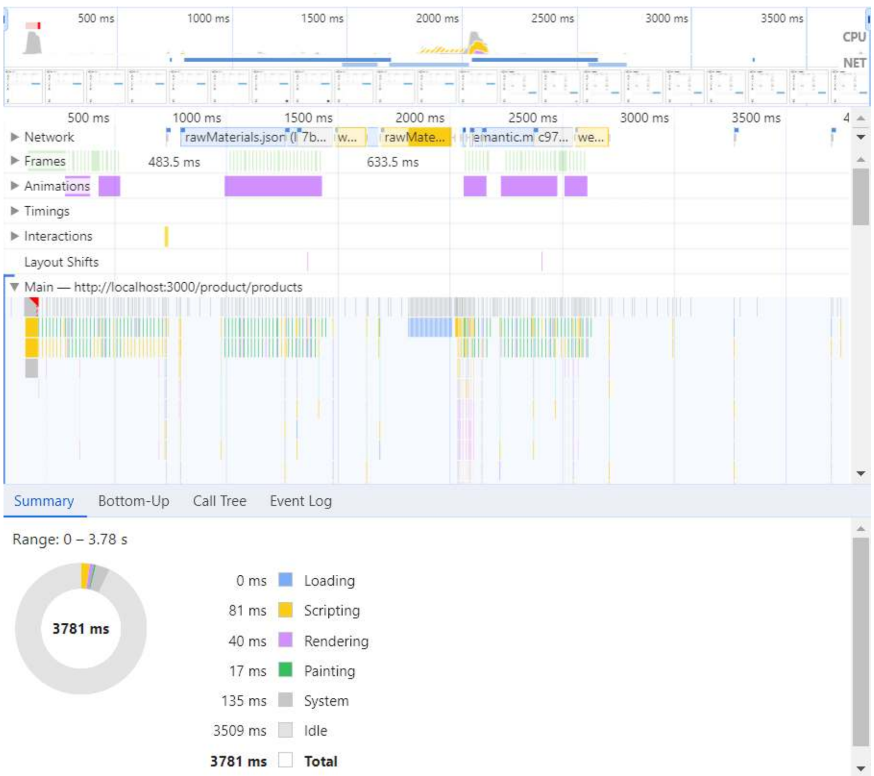


Figure 8.5 Load Raw Materials

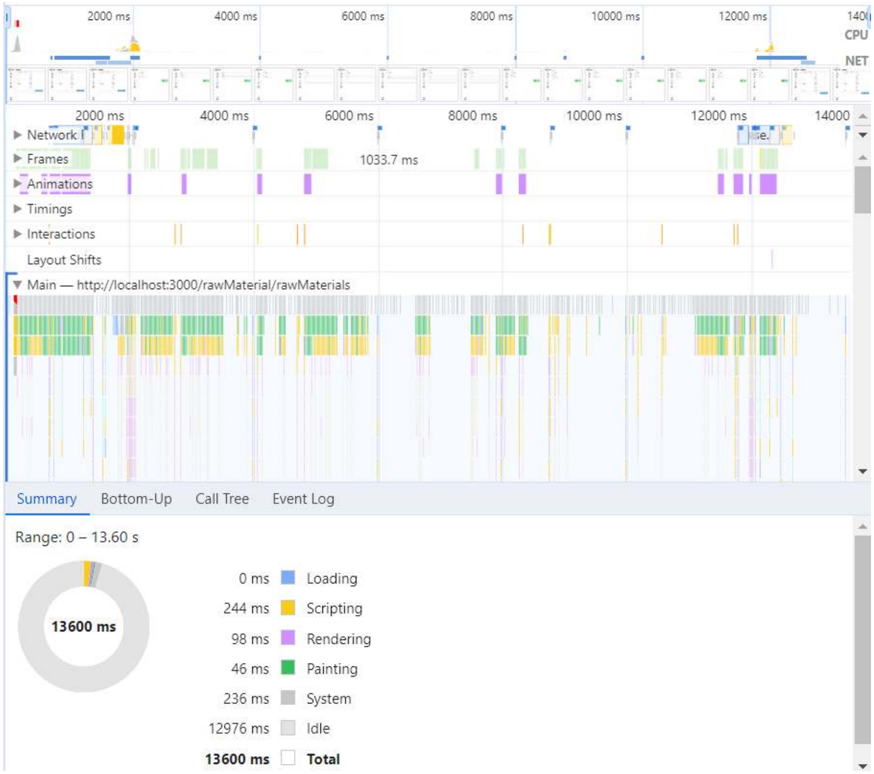


Figure 8.6 Add Raw Material

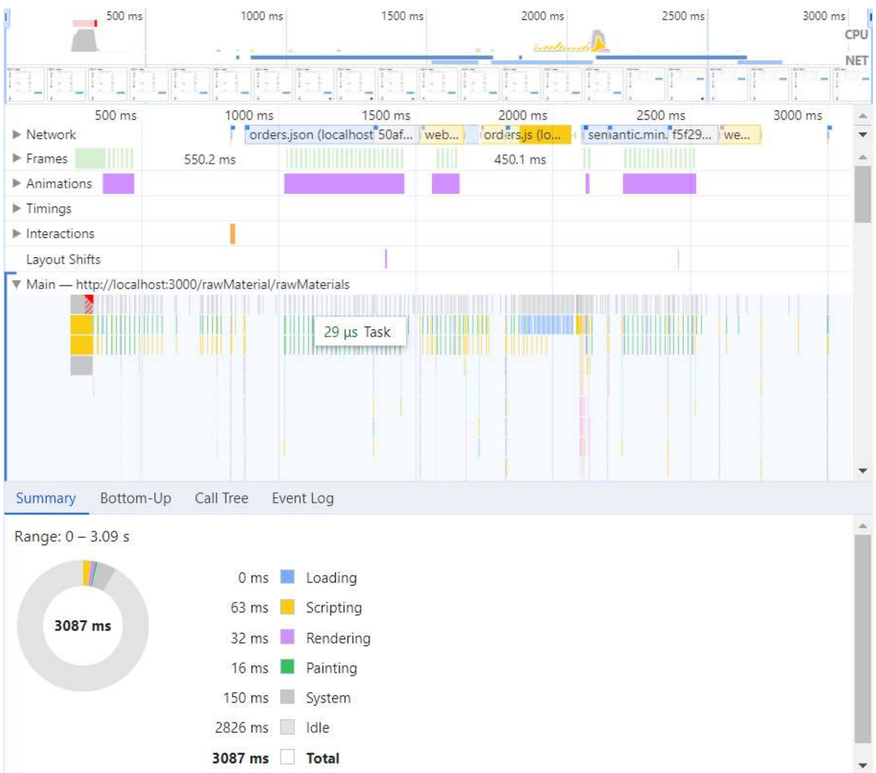


Figure 8.7 Load Orders

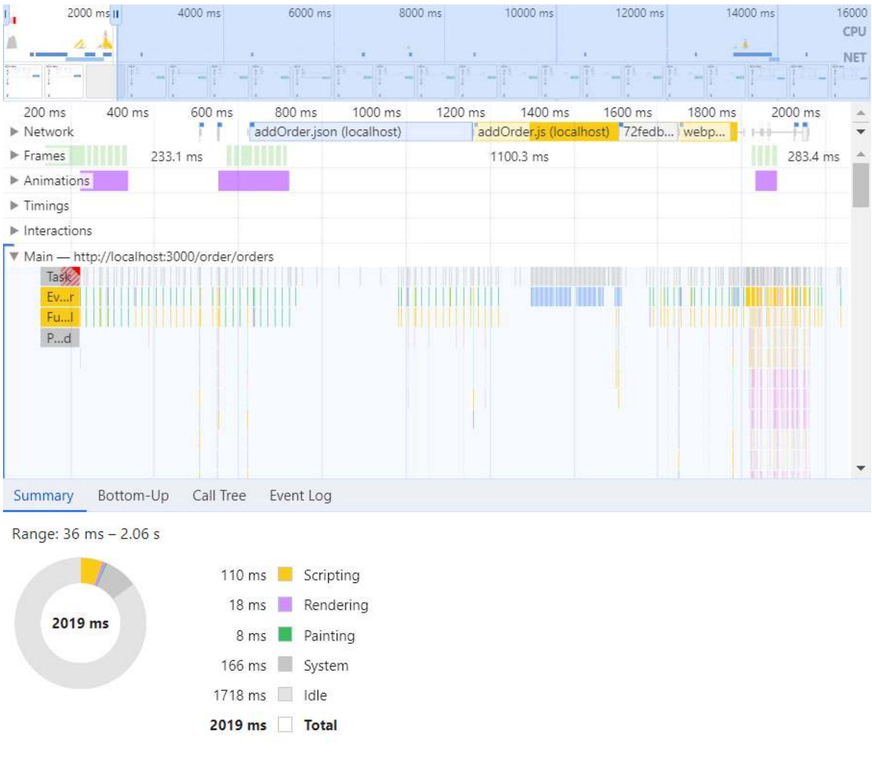


Figure 8.8 Add Order

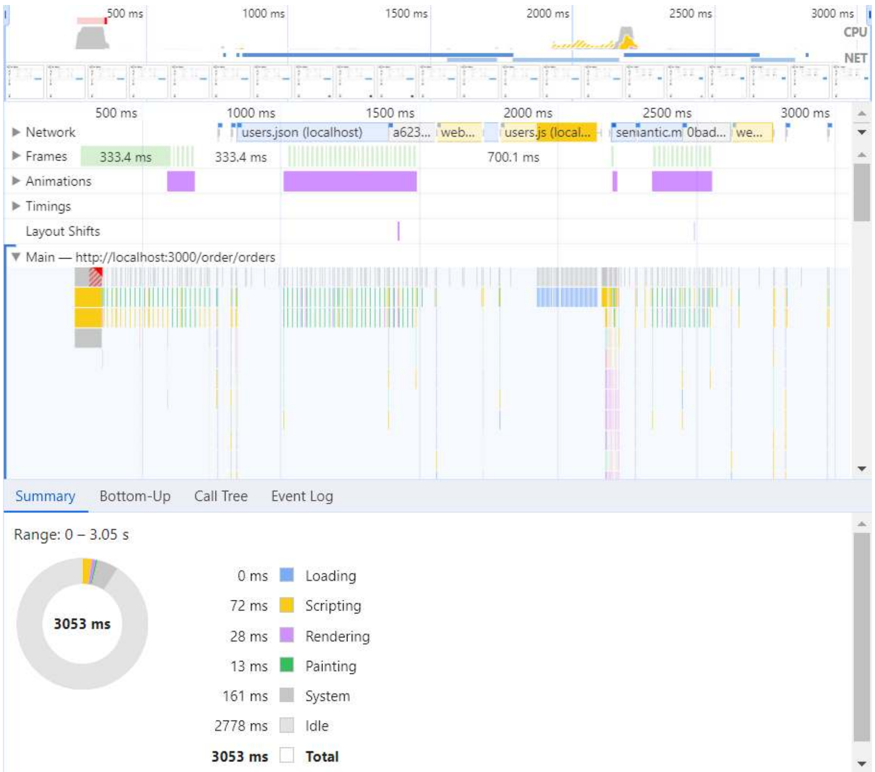


Figure 8.9 Load Workers

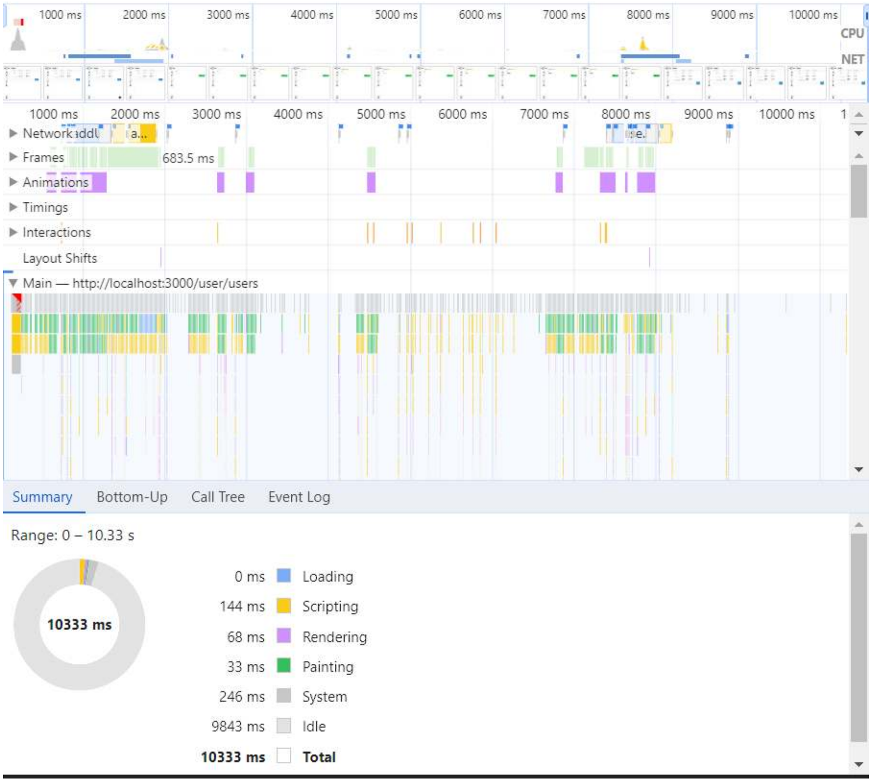


Figure 8.10 Add Worker

Table 8.2 System Performance Analysis

	Loading	Scripting	Rendering	Painting	System
Log In & Production Plans	0 ms	225 ms	86 ms	37 ms	167 ms
Add Production Plan	0 ms	212 ms	80 ms	37 ms	217 ms
Load Products	0 ms	39 ms	17 ms	7 ms	149 ms
Add Product	0 ms	168 ms	82 ms	39 ms	234 ms
Load Raw Materials	0 ms	81 ms	40 ms	17 ms	135 ms
Add Raw Material	0 ms	244 ms	98 ms	46 ms	236 ms
Load Orders	0 ms	63 ms	32 ms	16 ms	150 ms
Add Order	0 ms	110 ms	18 ms	8 ms	166 ms
Load Workers	0 ms	72 ms	28 ms	13 ms	161 ms
Add Worker	0 ms	144 ms	68 ms	33 ms	246 ms
Average	**0 ms**	**135.8 ms**	**54.9 ms**	**25.3 ms**	**186.1 ms**

9 Conclusion

This study offers a comprehensive approach, focusing on a production optimization system and employing a wide range of analytical and optimization techniques such as linear regression, random forest regressor, genetic algorithm, gradient descent, linear programming, and dynamic programming. The obtained results suggest that these strategies are effective in optimizing the system. Given the significance of production optimization in enhancing corporate efficiency and cost-effectiveness, the findings of this study will have a significant impact on industry practical applications.

The overall review of the research emphasizes the creation of a solid foundation for better production process planning and management via the many optimization methodologies provided.

It is important to highlight that this study provides a foundation for future development and innovation, providing significant insights to other industry researchers. Finally, it is hoped that this study in the field of production optimization would serve as a model for future research, stimulating the development of more effective optimization procedures with evolving technology. As a result, further research efforts in this subject, as well as the development of fresh approaches, will increase the potential for making industrial processes smarter and more efficient.

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Curriculum Vitae

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Project System Informations

System and Software: Windows Operating System, Python, Java, PostgreSQL, Node.js
Required RAM: 16GB
Required Disk: 4096MB