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Design and Implementation of a Web-Based Used Car Electronic Catalog with Decision Support System Using the Waterfall Model and SAW Method

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Abstract

Managing used car inventories poses significant operational challenges for showrooms, particularly regarding stock tracking inefficiencies and subjective multi-criteria evaluations during customer consultations. This study develops a web-based e-catalog and decision-support application engineered using the Laravel framework and MySQL database to streamline showroom operations. The system embeds the Simple Additive Weighting (SAW) method to provide objective, data-driven vehicle recommendations based on five critical operational variables: price, production year, inventory age, tax validity, and transmission type. To preserve operational integrity, the application enforces role-based access control distributed across three distinct user profiles: Marketing, Sales, and Owner. Systematic computational validation confirms the correct algorithmic execution of the backend scoring process, successfully generating automated, mathematical priority rankings that match the system's responsive user interfaces. The implementation proves that integrating a standardized decision-support algorithm into a scalable framework mitigates administrative bottlenecks, removes human subjectivity, and enhances executive data transparency in secondary automotive commerce.

Keywords: *Decision support system; E-catalog; Laravel framework; Simple Additive Weighting (SAW); Used car inventory.*

1. Introduction

The rapid development of information technology has forced various business sectors to undergo digital transformation to maintain efficiency and competitiveness. In the automotive industry, particularly the used car sector, accurate and real-time data management is critical for operational success [1]. CV. Samudera Jaya Group, a used car dealership network, heavily relies on precise vehicle inventory tracking to serve customers and manage sales strategies. Currently, the showroom still manages its vehicle stock data through conventional and manual approaches, which often leads to data duplication, slow information retrieval, and administrative errors. Consequently, sales representatives face difficulties in presenting up-to-date car listings to prospective buyers, and the management struggles to obtain an accurate overview of available stock.

To overcome these limitations, a digitalized system in the form of an electronic catalog (e-catalog) is highly required. Web-based e-catalogs provide centralized data accessibility, enabling real-time updates that minimize communication gaps between marketing, sales, and showroom owners [2][3].In software engineering, utilizing a robust framework is essential to build a secure and maintainable web application. The Laravel framework combined with PHP 8.2 offers an optimal solution due to its Model-View-Controller (MVC) architecture, robust built-in security features, and efficient database routing capabilities. By implementing Laravel, the e-catalog system can handle multi-user access levels including marketing, sales, and owners with strict data access control.

Furthermore, choosing a used car involves evaluating complex alternative choices based on varied customer preferences, such as price, vehicle year, mileage, and engine condition. To add a smart layer to the e-catalog, a Decision Support System (DSS) can be integrated. The Simple Additive Weighting (SAW) method is a widely recognized multi-attribute decision-making algorithm known for its simplicity and efficiency in finding weighted sums of performance ratings for each alternative [4][5].Integrating the SAW method into the Laravel e-catalog allows the system to evaluate car specifications against criteria weights, automatically generating a ranked recommendation list to assist sales personnel during customer consultations.

Several prior studies have addressed related challenges in used car management systems. A web-based inventory management system for a used car showroom has been developed, yet the system was limited to stock recording without any decision-support capability for vehicle recommendations [1]. Similarly, a web-based sales information system for a used car showroom has also been proposed, focusing on transaction recording without integrating multi-criteria evaluation features [3]. On the decision-support side, the SAW method has been independently applied to recommend used vehicles based on multiple criteria; however, both studies operated as standalone decision-support tools without integration into a full-featured web-based catalog system [4][5].

The present study addresses these gaps by combining a web-based e-catalog with an embedded SAW-based decision-support system within a single unified Laravel application, providing both real-time inventory management and automated vehicle recommendation in one platform. This study focuses on the design and implementation of a web-based used car e-catalog integrated with a SAW-based decision support system for CV. Samudera Jaya Group. The system development follows the structured Software Development Life Cycle (SDLC) Waterfall model, encompassing requirement analysis, system design, implementation, and rigorous black-box testing [6]. This paper contributes an empirical engineering approach to blending standard web application frameworks with multi-criteria decision-making algorithms to solve real-world inventory and sales optimization problems.

2. Literature Review

2.1. Electronic Catalog

An electronic catalog (e-catalog) is a digital platform designed to store, manage, and display product information electronically [1]. In commercial sectors, traditional inventory management often suffers from human errors, data asymmetry, and latency in stock updates. Implementing a web-based e-catalog resolves these inefficiencies by providing a centralized database that allows real-time data synchronization. This technological transition ensures that stakeholders can access identical, updated information simultaneously, thereby increasing operational transparency and accelerating consumer transaction cycles [2].

2.2. Laravel Framework and MVC Architecture

Laravel is an open-source PHP web framework created by Taylor Otwell, designed for the development of web applications following the Model-View-Controller (MVC) architectural pattern. This study utilizes Laravel version 13.3 running on PHP 8.2 environment. The MVC architecture isolates the application logic into three interconnected components: the Model manages database interactions and business rules; the View handles the visual presentation layer; and the Controller acts as an intermediary that processes user requests and orchestrates data flow. Laravel provides built-in security features, including Protection against Cross-Site Request Forgery (CSRF), SQL Injection prevention, and encrypted session handling, making it a reliable framework for multi-user enterprise applications [7].

2.3. Simple Additive Weighting (SAW) Method

The Simple Additive Weighting (SAW) method, often known as the weighted linear combination or scoring method, is a foundational algorithm within Multiple Attribute Decision Making (MADM) [4]. The core principle of the SAW method is to find the weighted sum of performance ratings on each alternative across all criteria. The process requires a normalization matrix where each criterion rating is adjusted based on its type: benefit criteria (where higher values are preferred, such as vehicle condition or year) or cost criteria (where lower values are preferred, such as car price or mileage). The final preference value (Vi) for each alternative is computed using the following equation:

$$Vi = \Sigma\ (wj \times rij) \qquad (1)$$

Where wj represents the pre-determined weight of criterion j, and rij is the normalized rating of alternative i for criterion j. Alternatives with higher V values indicate top-ranked recommendations.

2.4. Waterfall Development Model

The Waterfall model is a classic, linear-sequential Software Development Life Cycle (SDLC) approach where development progresses steadily through distinct phases. Each phase must be fully completed before the next phase begins, ensuring rigorous documentation and structured engineering requirements. The standard phases include requirement analysis (gathering stakeholder needs), system design (modeling software architecture and databases), implementation (coding), integration and testing (verifying features), and maintenance. This model is highly suitable for projects with clear, stable requirements and well-defined technical scopes [8].

3. Research Methodology

The development of the web-based used car electronic catalog and decision support system follows the linear-sequential Waterfall software development life cycle. This structured framework ensures that each development phase is meticulously documented, verified, and completed before proceeding to the subsequent stage.

3.1. Requirements Analysis

The initial phase of the development model involves gathering and defining the system requirements, which includes identifying user needs and specifying the technical environment. To ensure optimal computing performance and prevent operational latency during the software engineering and testing phases, a standardized hardware and software infrastructure was established.

The hardware infrastructure utilized for executing the system architecture consists of an 11th Generation Intel Core i3-1115G4 processor operating at a base clock speed of 3.00 GHz. The computing system is equipped with 4.00 GB of Random Access Memory (RAM) and a 477 GB Solid State Drive (SSD) for high-speed data storage and retrieval. High-resolution integrated and external displays are utilized as output media to evaluate the responsiveness of the user interface layout.

On the software layer, the development environment runs on a 64-bit Microsoft Windows 11 Home Single Language operating system. Local server administration and backend integration are managed through the XAMPP stack ecosystem, which comprises the Apache web server engine version 2.4.58, a PHP interpreter version 8.2.12, and a MariaDB database server version 10.4.32 administered via the phpMyAdmin interface. Cross-browser compatibility and user interface functionality testing are conducted using Google Chrome, Mozilla Firefox, and Microsoft Edge. Code compilation and script writing are performed using Visual Studio Code, while the system architecture modeling and Unified Modeling Language (UML) diagrams are visualized using Draw.io and the Mermaid Live Editor.

3.2. System Design

System design translates the analyzed requirements into structured visual models to map the interactions between users and the software components. This study utilizes the Unified Modeling Language (UML) to specify and visualize the behavioral aspects of the web-based e-catalog [9].

3.2.1. Use Case Analysis

The functional boundaries and user access privileges of the proposed e-catalog system are modeled through a use case diagram involving three distinct actors: Marketing, Sales, and Owner, as illustrated in Figure 1. The Marketing actor operates as the super administrator, possessing full privileges to manage core backend modules, including user account administration (*Mengelola Data Pengguna*), car inventory configurations (*Mengelola Data Mobil*), and the calibration of decision-making criteria weights (*Mengelola Parameter Penilaian*).

The Sales actor interacts with the operational front-end to execute vehicle queries (*Pencarian Unit*) integrated with the SAW filtering algorithm and dynamically updates car availability labels (*Memperbarui Status Mobil*) post-transaction. Meanwhile, the Owner actor is restricted to read-only access, allowing them to monitor stock summaries and graphical analytics via a secure dashboard to support showroom business decisions. To maintain data integrity, all actors must clear the authentication gateway (*Login*) before accessing their respective roles.

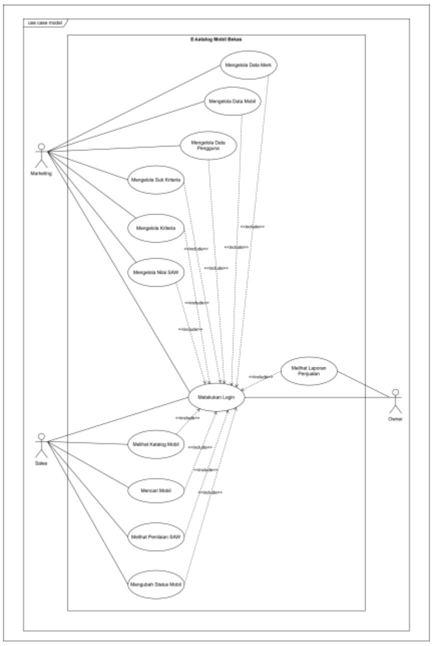

Fig. 1: Use Case Diagram

3.2.2. Activity Diagram Analysis

Activity diagrams model the dynamic behavioral workflows of the system, illustrating the sequential flow of activities from one action to another across different user operational spaces [9]. The operational workflows of the proposed e-catalog application are segregated based on the clear responsibilities of the three actors:

1. Marketing Workflow

Operating as the super administrator, the workflow initiates with session authentication via the login gateway. Upon successful validation, the system directs the actor to the administrative dashboard, which provides centralized access to three major back-end operational modules: user account administration (*Mengelola Data Pengguna*), used car inventory management (*Mengelola Data Mobil*), and the calibration of evaluation criteria and weight parameters for the decision-support system (*Mengelola Parameter Penilaian*). Each operational pathway allows the actor to execute full Create, Read, Update, and Delete (CRUD) transactions, and the entire sequential workflow concludes when the actor securely terminates the session via the logout command, as illustrated in Figure 2.

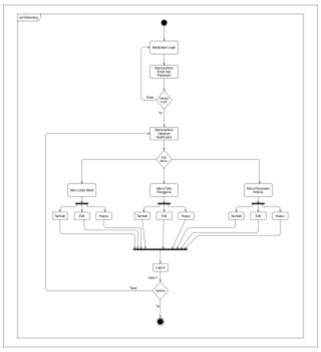

Fig. 2: Activity Diagram Marketing

2. Sales Workflow

The sales workflow is engineered to optimize customer consultation and real-time inventory tracking. After clearing the authentication gate, the Sales actor is directed to a dedicated dashboard featuring two primary operational streams: unit searching (*Pencarian Unit*) and vehicle status synchronization (*Memperbarui Status Mobil*). When executing a query, the system captures user-defined attribute filters, processes the Simple Additive Weighting (SAW) matrix matching in the backend, and renders a prioritized vehicle recommendation list. Alternatively, post-transaction or upon structural changes in the showroom, the actor can access specific car profiles to dynamically modify availability markers, which automatically updates the public-facing repository. The workflow terminates systematically when the user logs out, as illustrated in Figure 3.

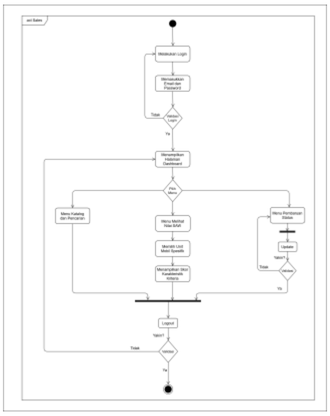

Fig. 3: Activity Diagram Sales

3. Owner Workflow

Designed for high-level monitoring, the Owner's sequential flow is restricted to analytical observation. Upon authentication, the system opens a dedicated reporting interface where the owner can track overall inventory metrics, available car counts, and transaction summaries without data modification privileges, as shown in Figure 4.

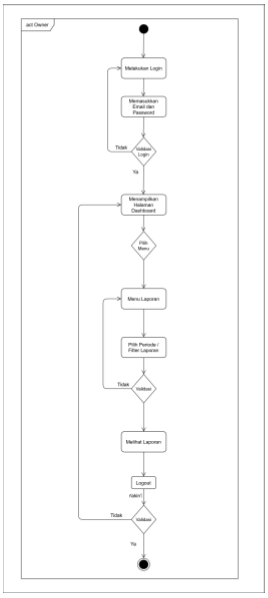

Fig. 4: Activity Diagram Owner

3.2.3. Database Design

Database design is executed to construct a structured repository that maps data entities and their underlying relational dependencies within the web application ecosystem. This study utilizes an Entity Relationship Diagram (ERD) to model the logical blueprint of the database [10]. The schema comprises several core entities, including the users entity for role-based credential preservation, and the cars entity which encapsulates physical and commercial attributes such as brand, year, mileage, pricing, and availability statuses. Additionally, the schema incorporates dedicated criteria and alternatives tables to support the dynamic parameter allocation required by the SAW scoring mechanism. Relational constraints are enforced across these entities to eliminate data redundancy and preserve referential integrity during concurrent transactions see Figure 5.

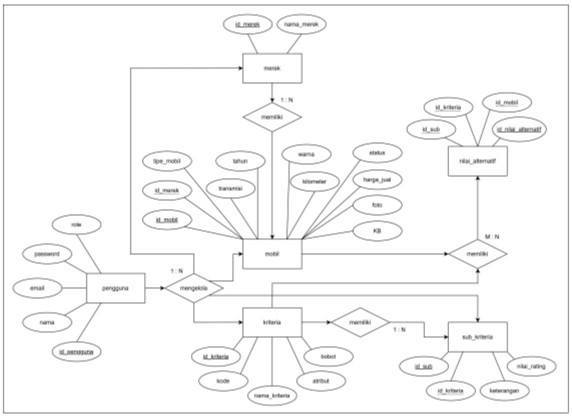

Fig. 5: Entity Relationship Diagram (ERD)

4. Results and Discussion

4.1. Implementation Results

The proposed web-based e-catalog application has been fully developed and deployed using the Laravel framework, combined with a MySQL database management system. The system translates the prior visual blueprints into an operational environment, utilizing secure, responsive user interfaces tailored for each distinct user role.

The primary gateway to the system is the unified authentication interface. This portal restricts access to the backend environment by requiring users to input validated corporate credentials, consisting of a registered email address and an encrypted password. Upon clicking the submission trigger, the Laravel middleware executes a database lookup to verify credential accuracy and detect the specific role profile. Based on this validation, the application handles session initialization and programmatically reroutes the actor to their designated dashboard workspace while successfully mitigating unauthorized directory traversal. The interface design for this secure authentication gateway is illustrated in Figure 6.

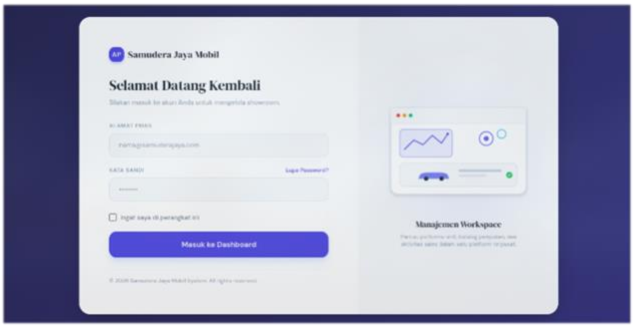

Fig. 6: Unified system authentication interface

Once authenticated as a Marketing actor, the system reroutes the user to the centralized administrative control panel. The left-sidebar navigation architecture reflects the full system privileges mapped in the use case model, granting access to comprehensive data mutation routes, including car management (*Manajemen Mobil*), brand classification (*Manajemen Merek*), alternative score assignments (*Manajemen Nilai SAW*), and criteria tuning (*Manajemen Kriteria*). The main workspace layout prioritizes data scannability by displaying four analytical KPI cards at the top: total available inventory count, sold units, unrated vehicles, and the cumulative commercial value of the current showroom stock. Directly below these metrics, the backend seamlessly updates two tracking widgets. The "Unit Unggulan Rekomendasi" component acts as a preliminary data display that queries and ranks the vehicle alternatives based on their definitive SAW preference scores, while the "Stok Terbaru Masuk" list monitors newly registered physical units chronologically to ensure operational data transparency. The comprehensive administrative dashboard for the Marketing role is displayed in Figure 7.

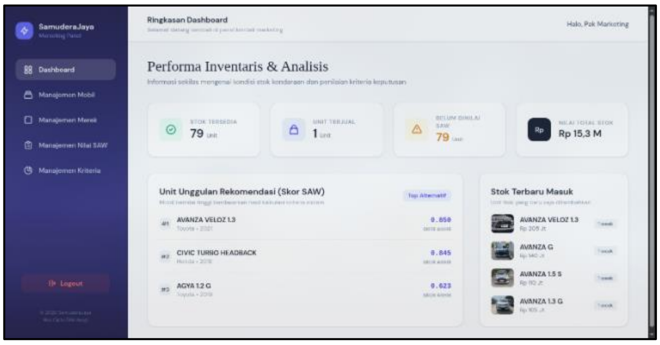

Fig. 7: Centralized Marketing administrative control panel

When a user authenticates with a Sales role profile, the Laravel routing middleware directs them to a dedicated frontend portal, optimized for high-speed stock checking during customer consultations. Shifting from the administrative sidebar layout, the Sales interface implements a streamlined horizontal top-navigation bar featuring quick-access routes to the *Dashboard*, *Katalog*, and *Hasil Rekomendasi SAW*. The main view of the catalog module displays available vehicles organized in a highly responsive multi-column grid architecture. Each product card serves as an atomic data component that dynamically pulls specific attributes from the MySQL cars entity, encapsulating the manufacturer brand, model type, license plate registration number, manufacturing year, transmission mechanism, and color profile alongside a clear commercial price indicator. A prominent green badge displaying "TERSEDIA" is programmatically rendered at the top-left corner of the vehicle image container, pulling live boolean markers from the database to prevent sales collision. Furthermore, the application integrates an asynchronous pagination component at the bottom to maintain optimal page load times and prevent browser layout shifting during massive multi-unit query renders. This sales-centric inventory repository view is shown in Figure 8.

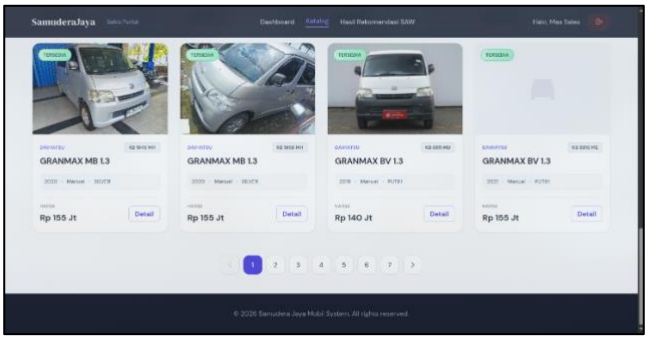

Fig. 8: Sales inventory catalog and dynamic grid portal

For the final user profile, the system structures a data-read-only administrative environment for the Owner role. The interface prioritizes business intelligence metrics by rendering a comprehensive "Riwayat Transaksi" datatable that aggregates real-time sales tallies. This view traces operational summaries including exact transactional timestamps, specific vehicle attribute breakdowns, license plate numbers, sales statuses, and precise final closing prices. To ensure optimal decision-making and offline accounting synchronization, the module integrates direct export pipelines controlled via two prominent action triggers at the top right: "Export Excel" and "Cetak PDF". When activated, the Laravel backend handles asynchronous file compiling, allowing the owner to generate physical reports or download structured digital spreadsheet documents securely. This layered dashboard design confirms that data access separation between the administrative, operational, and executive nodes is strictly maintained. The final executive reporting viewport is illustrated in Figure 9.

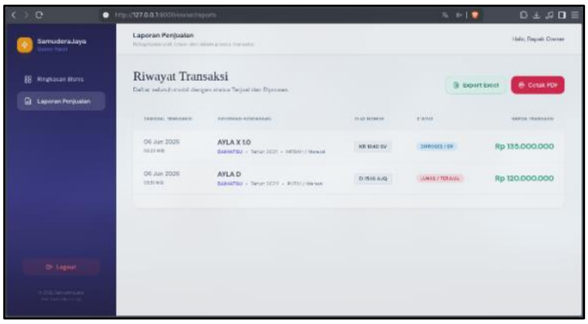

Fig. 9: Owner transaction summary and data reporting interface

4.2. SAW Calculation and Discussion

This subsection details the algorithmic execution of the Simple Additive Weighting (SAW) method within the application's decision-support system. The evaluation process is demonstrated using a dataset containing five evaluation criteria (*Cj*) and three vehicle models configured as alternatives (*Ai*). The system weights (*W*) mapped from the core configuration parameters are defined as $W = [0.30, 0.25, 0.20, 0.15, 0.10]$. The foundational properties and initial evaluation matrix (*X*) translating physical vehicle attributes into structural fit ratings (ordinal scale 1 to 4) for alternative A_1 (Daihatsu Ayla D), A_2 (Daihatsu Ayla X 1.0), and A_3 (Toyota Avanza Veloz 1.3) are summarized in Table 1.

Table 1: Evaluation Criteria and Initial Matrix Configuration (*X*)

Alternative	Harga (C_1, Cost)	Tahun (C_2, Benefit)	Usia Stok (C_3, Cost)	Pajak (C_4, Benefit)	Transmisi (C_5, Benefit)
A_1 (Ayla D)	1	1	1	1	3
A_2 (Ayla X 1.0)	2	3	2	4	3
A_3 (Avanza Veloz 1.3)	3	4	1	4	4

Based on the decision matrix properties, the application initiates the normalization sequence. Criteria designated as benefit attributes are computed using $Rij = Xij / \max_i Xij$, whereas cost attributes utilize $Rij = \min_i Xij / Xij$. The mathematical operations for each column yield the normalized matrix entries: Price (R_{11}=1/1, R_{21}=1/2, R_{31}=1/3); Production Year (R_{12}=1/4, R_{22}=3/4, R_{32}=4/4); Inventory Age (R_{13}=1/1, R_{23}=1/2, R_{33}=1/1); Tax Validity (R_{14}=1/4, R_{24}=4/4, R_{34}=4/4); and Transmission System (R_{15}=3/4, R_{25}=3/4, R_{35}=4/4). These calculations synthesize the standardized matrix *R*, as outlined in Table 2.

Table 2: Normalized Matrix (*R*) and Final Ranking Summary

Alternative ID	C_1	C_2	C_3	C_4	C_5	Final Score (*Vi*)	Rank
A_3 (Avanza Veloz 1.3)	0.333	1.00	1.00	1.00	1.00	**0.8000**	1
A_1 (Ayla D)	1.00	0.25	1.00	0.25	0.75	**0.6750**	2
A_2 (Ayla X 1.0)	0.50	0.75	0.50	1.00	0.75	**0.6625**	3

The final stage determines the definitive preference value (*Vi*) by multiplying the matrix entries against the structured priority vectors using $Vi = \Sigma\ (Wj \times Rij)$. The matrix evaluations are calculated as: $V_1 = 0.3000 + 0.0625 + 0.2000 + 0.0375 + 0.0750 = 0.6750$; $V_2 = 0.1500 + 0.1875 + 0.1000 + 0.1500 + 0.0750 = 0.6625$; and $V_3 = 0.1000 + 0.2500 + 0.2000 + 0.1500 + 0.1000 = 0.8000$. Based on these computations, alternative A_3 secures the highest preference score, positioning it as the top recommendation. This distribution matches the automated ranking visualization loaded onto the administrative dashboard interface, confirming the computational correctness of the application backend system.

5. Conclusion

This study successfully demonstrates the development and deployment of a web-based e-catalog and decision-support application built on the Laravel framework and MySQL database, tailored specifically for used car showroom operations. By integrating the Simple Additive Weighting (SAW) method, the system effectively resolves inventory bottlenecks and removes subjectivity during customer consultations. Operational data separation is securely maintained across three distinct user roles: Marketing actors manage data mutations and weights, Sales agents utilize the multi-column product grid for real-time stock verification, and Owners monitor business intelligence metrics through structured transaction reports. The computational validation verifies that the SAW algorithmic backend executes correctly, delivering a consistent hierarchy of vehicle preferences based on multi-criteria variables (price, production year, inventory age, tax validity, and transmission type). In the tested simulation, the system mathematically prioritized the optimal vehicle with a definitive preference score of 0.8000, aligning perfectly with the automated user interface rendering. For future development, this system can be expanded by integrating real-time API pricing engines to dynamically adjust cost sub-criteria and incorporating advanced data-driven predictive algorithms to forecast used vehicle depreciation curves more accurately.

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