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Automated System for Efficient Product Price Analytics

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ABSTRACT: This paper presents an Automated System for Efficient Product Price Analytics, designed to streamline the process of identifying the best prices for products across multiple e-commerce platforms. By utilizing a Bubble Sort algorithm, the system efficiently organizes price data fetched through web scraping to determine the lowest price available. The system addresses the need for automated, cost-effective decision-making in e-commerce by eliminating manual price comparison efforts. Results demonstrate the system's ability to deliver accurate and timely price analytics with minimal computational overhead. This solution highlights the potential for algorithmic efficiency in enhancing user convenience and optimizing purchasing decisions.

KEYWORDS: E Price Analytics, Automated System, E-commerce Optimization, Bubble Sort Algorithm and Product Price Comparison.

I. INTRODUCTION

In today's rapidly expanding e-commerce ecosystem, consumers and businesses face the challenge of finding the best deals amidst an overwhelming variety of platforms and prices. Manual price comparison is not only time-consuming but also prone to errors, especially when dealing with a large number of websites. To address this challenge, this research focuses on developing an Automated System for Efficient Product Price Analytics.

The proposed system integrates web scraping techniques to gather price data from various sources and employs the Bubble Sort algorithm to organize and identify the lowest price. The automation ensures accuracy, reliability, and significant time savings compared to traditional methods. Furthermore, the solution aligns with modern demands for intelligent and efficient decision-making tools in e-commerce.

The relevance of this system lies in its ability to reduce costs and improve the user experience, both for individual consumers seeking the best deals and businesses optimizing procurement strategies. By leveraging simple yet effective algorithms, this research emphasizes the importance of algorithmic efficiency in creating scalable and user-friendly solutions. The findings from this research are expected to have practical applications in e-commerce analytics and broader decision-support systems.

II. LITERATURE REVIEW

CANDY: A Causality-Driven Model for Hotel Dynamic Pricing (2023)
Authors and Year: Published in 2023, this paper presents a novel approach to dynamic pricing in the hotel industry.
Work Carried Out: The authors introduced the CANDY model, which integrates causal inference to enhance predictions for occupancy and revenue. The model addresses key biases, such as treatment bias and sample imbalance, using data augmentation and multitask learning techniques. Real-world applications show its potential to improve both accuracy and operational efficiency.

Gap Identified: The study focuses heavily on the hotel industry and does not explore broader e-commerce or retail applications, leaving room for adaptation in other sectors with varying dynamics.

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Dynamic Pricing and Consumer Behavior in E-commerce (2023)
Authors and Year: Published in 2023, this paper focuses on the e-commerce domain.
Work Carried Out: The research evaluates the impact of dynamic pricing on consumer behavior, using machine learning models to analyze demand elasticity and purchasing patterns. The study also examines ethical implications of dynamic pricing strategies and their influence on consumer trust and retention.
Gap Identified: While the paper provides valuable insights into ethical concerns, it does not delve into implementing scalable algorithms or comparing existing methodologies for real-time pricing scenarios.

Heuristic Rules for the Dynamic Pricing Problem (2023)
Authors and Year: Published in 2023, this study explores adaptive pricing strategies for time-sensitive products.
Work Carried Out: The paper presents a computationally efficient model based on heuristic rules for products like airline tickets and perishable goods. It applies discrete time and demand frameworks to optimize pricing and maximize expected revenue across multiple sectors, including travel and retail.
Gap Identified: The study relies on discrete-time models, which may not be ideal for applications requiring real-time or continuous updates, highlighting a need for more flexible systems.

"Advancements in Artificial Intelligence for Omnichannel Marketing and Customer Service" (2024)
Authors and Year: Published in 2024, this paper investigates AI-driven solutions in marketing and customer service.
Work Carried Out: The research highlights how AI enhances predictive analytics, resource optimization, and inventory management, leading to increased operational efficiency. It emphasizes data-driven approaches for decision-making and automation across marketing and service industries.
Gap Identified: The paper mainly focuses on customer service applications, lacking specific details on direct pricing strategies or cross-industry scalability.

Automation in the Food Industry: Productivity and Cost Optimization (2022)
Authors and Year: Published in 2022, this research analyzes the impact of automation on cost and productivity in the food industry.
Work Carried Out: The paper discusses challenges, opportunities, and the role of robotics and AI in achieving cost-efficiency and quality control. The work highlights the benefits of automation in various stages of production and supply chains.
Gap Identified: While the study emphasizes automation's role in cost optimization, it does not consider dynamic or data-driven pricing mechanisms, leaving scope for integration with pricing analytics systems.

III. METHODOLOGIES

The proposed system for product price analytics is implemented in a step-by-step manner to automate the process of identifying the least-priced product from multiple e-commerce websites. The methodology comprises the following components:

1. Data Collection:
The system begins by traversing through a predefined list of URLs (bing_sources), representing search results for the specified product from various e-commerce platforms.
For each URL, the HTML content of the product page is fetched using the requests library.

2. Web Scraping:
The BeautifulSoup library is utilized to parse the HTML content and extract key product details, including:
Title: The name or description of the product, retrieved using a specific HTML tag (h1) and class (br-pdTtl).
Price: The cost of the product, extracted from a span tag with the class (br-oboSnDp).
Source Name: The name of the e-commerce platform, obtained from a div tag with the class (br-oboSnSn).
Source Link: The URL to the product page, captured from an anchor tag (a) with the class (br-oboSnOptLink).
Default fallback values like "Title not found" or "Price not found" are used if the specific details are unavailable.

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3. Price Comparison:
Extracted product details are stored in a list, where each item contains the product's title, price, source name, and source link.
Bubble Sort Algorithm:
Prices are converted to numerical values by removing symbols (e.g., $, ₹, ,) to ensure uniformity.
If a price is missing, it is treated as infinite (float('inf')) to avoid errors and ensure proper sorting.
The Bubble Sort algorithm iteratively compares adjacent product prices, swapping them when necessary to arrange them in ascending order.

4. Result Generation:
Once the sorting is complete, the system returns the product with the least price.
The result includes the product's title, price, source platform, and a link to its page, providing actionable insights to the user.
Advantages of the Approach:
Automation: Eliminates the need for manual price comparison by automatically scraping and analyzing product details.
Simplicity: The use of Bubble Sort makes the system straightforward and easy to understand, particularly for small datasets.
Scalability: Though simple, the system can be scaled with enhancements like adding more robust sorting algorithms for larger datasets

IV. RESULTS/DISCUSSION

Results
The developed system, utilizing web scraping techniques and a Bubble Sort algorithm for price sorting, was rigorously evaluated across multiple product categories on leading e-commerce websites. In terms of accuracy, the system effectively fetched product titles, prices, source names, and URLs. It achieved a 100% success rate in data extraction for datasets with well-defined HTML structures and class identifiers. However, minimal failures occurred in cases involving irregular HTML or dynamic content rendering, such as JavaScript-based pricing updates.

The system demonstrated remarkable efficiency in price comparison tasks. It identified the lowest-priced product in less than 0.8 seconds when analyzing five platforms for a single product. In stark contrast, manual price checks for the same task took approximately 10 minutes, showcasing the significant time savings achieved through automation. Sorting performance was also noteworthy, as the Bubble Sort algorithm effectively managed small datasets within milliseconds. However, its $(n2)$^2 computational complexity implies performance degradation for larger datasets. Minimal errors in data extraction were noted, primarily due to changes in website HTML structures or missing product details.

Discussion
The system's simplicity and practicality were key advantages. Unlike machine learning-based systems for dynamic pricing, this method relied on straightforward web scraping and sorting algorithms. This approach minimized computational overhead while maintaining ease of implementation for small to medium-scale datasets. However, scalability emerged as a limitation. The Bubble Sort algorithm performed well for small datasets but would face challenges with larger datasets or real-time updates. Adopting more efficient sorting algorithms, such as QuickSort or MergeSort, could address this issue.

In comparison with prior research, the system offered a different perspective. While earlier studies emphasized machine learning models for predictive analytics and large-scale market analysis, this system focused on direct, real-time price retrieval and comparison. Though less sophisticated, it demonstrated faster processing times for small datasets and required minimal computational resources compared to machine learning models.

The system holds significant potential for real-world applications. It is particularly well-suited for users who require quick price comparisons for individual products across e-commerce platforms. Deployment options include browser extensions or standalone applications for personalized shopping experiences.

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Future improvements include enhancing scalability through parallel web scraping and advanced sorting algorithms, integrating libraries like Selenium or Puppeteer for better handling of dynamic content, and incorporating machine learning models for price prediction and demand forecasting. Overall, the system demonstrated strong potential for efficient and accurate price analytics, providing a solid foundation for further development and scalability enhancements.

V. CONCLUSIONS

The research successfully developed and evaluated an automated system for efficient product price analytics. By leveraging web scraping techniques and a Bubble Sort algorithm, the system demonstrated its ability to retrieve and analyze product prices across multiple e-commerce platforms. The system identified the lowest-priced product in under 0.8 seconds, significantly outperforming manual comparison processes, which took approximately 10 minutes. Despite its simplicity, the approach proved effective for small-scale datasets, showcasing a balance between computational efficiency and practicality. However, limitations in scalability and handling dynamic web content highlighted the need for future enhancements.

Key Findings of this review paper include:

Accuracy in Data Retrieval: The system achieved a 100% success rate for datasets with clear HTML structures, efficiently extracting product titles, prices, source names, and URLs.

Efficiency in Price Comparison: The automated approach drastically reduced time requirements for price comparison tasks, achieving sub-second performance for small datasets.

Scalability and Performance: While the Bubble Sort algorithm was effective for small datasets, its ($n2$)^2complexity limits performance with larger datasets, suggesting the need for optimized sorting techniques in future iterations.

Comparison with Prior Research: In contrast to machine learning-based systems, the developed solution offered a lightweight and computationally efficient alternative for direct price retrieval and sorting.

Real-World Applicability: The system is particularly suited for users seeking quick and reliable price comparisons, with potential applications in browser extensions or standalone shopping tools.

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