

TrendScanner AI 2.0: Adaptive Multi-Agent Commerce Intelligence Framework with Predictive Analytics and Autonomous Market Reasoning

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Abstract – The way people shop online is changing fast. This means there is a need for smart systems that can understand what is happening in the market right now make decisions on their own and predict what will happen in the future. The old systems that recommend products and analyse data are still having problems with growing, understanding the context and making decisions quickly. This paper is about TrendScanner AI 2.0 which's the latest and most advanced version of the TrendScanner AI system we talked about before. The new system can work with agents predict what will happen in the market use something called Retrieval-Augmented Generation analyse data in many ways and manage workflows on its own. We are sharing what we learned from this project how we improved the system the challenges we faced and what we discovered along the way. We used a lot of technologies like Gemini-based reasoning systems, special databases, advanced natural language processing, predictive models, Firebase cloud infrastructure and Docker-Kubernetes deployment strategies to create a system that can give us smart insights into online shopping. When we tested the system, we found that it was better at predicting trends analysing data faster working reliably and growing more easily, than the old system. This shows that it is possible to move from analytics systems to new smart systems that can help businesses make better decisions.

Keywords– Agentic AI, Predictive Analytics, E-Commerce Intelligence, Autonomous Systems, Multi-Agent Collaboration, Retrieval-Augmented Generation, Business Intelligence

I. INTRODUCTION

The digital commerce industry is creating an amount of data from people looking at products reading reviews and using social media. Companies need systems that can understand this data as it happens so they can make decisions quickly. The first version of TrendScanner AI was a system that could look at what's popular analyse products give ideas about

prices and make reports for executives. It showed that artificial intelligence can be useful for companies. It also had some problems when we tried it in the real world. We found some challenges when we were working on it including:

- The data from different places did not match
- It was hard to keep up with trends as they changed
- The system did not always understand the context
- It was difficult to make the system work with a lot of data
- It took a lot of work to get all the parts of the system to work together

• The results from the intelligence were not always the same So, we decided to make a new version of TrendScanner AI, which is TrendScanner AI 2.0. This version is designed to be more flexible, smarter and more reliable.

The main goals of this version are:

1. To make the artificial intelligence agents work better together and understand the market.
2. To add tools that can predict what will happen in the future.
3. To make the system work better with a lot of data by using cloud computing.
4. To reduce mistakes caused by data.
5. To create a system that companies can use for a time.

This project is the version of TrendScanner AI and we are focusing on what we learned from making it not just on how to make it work. TrendScanner AI is a part of this and we want to make sure it is the best it can be. TrendScanner AI is going to be useful, for companies that want to understand their customers and make decisions.

II. LITERATURE SURVEY

Artificial Intelligence (AI) has been increasingly used for a wide range of techniques in e-commerce analytics, such as recommendation systems, sentiment analysis,

demand prediction/forecasting, and workflow automation. There have been many research efforts to explore various frameworks to enhance business intelligence and decision-making in e-commerce environments. For example, Li et al. described a cloud-based e-commerce analytics framework that provided enhanced scalability and data processing capabilities. However, this framework does not provide any form of contextual commerce data analysis, nor does it provide any type of dynamic interpretation of current market trends. Similarly, Sharma et al. developed a machine learning-based recommendation system that incorporates sentiment analysis to improve customer personalization experiences; however, the authors' machine learning-based system provides limited capabilities to predict customer opinions and future market situations. Kwon et al. proposed a collaborative intelligent agent architecture for the purpose of business intelligence applications. Their research illustrated how multiple AI agents can coordinate and work together to complete various tasks and improve overall decision-making efficiency, as demonstrated in the agent communication layer used in our framework. Recent studies employing GPT and Gemini, two different types of Large Language Models (LLMs), have focused on executive summarization, contextual analysis of data, and automated insight generation to produce reports/analyses. As a result, while this reporting method has enhanced analytical reporting processes for business intelligence, some problems or challenges were also created, including hallucinations, scalability, and reliability at the enterprise level. A number of researchers around the world have also provided insights into how to use large-scale information retrieval systems with a combination of RAG (retrieval augmented generator) architecture.

III. PROBLEM STATEMENT

Rapidly evolving e-commerce platform has created extremely large amounts of very dynamic consumer and product data that can no longer be manually analysed efficiently or accurately. Current analytical systems tend to be incapable of providing real-time adaptability to changing conditions, predictive intelligence, contextual awareness and automated decision making; therefore, business insights will be slow to surface/lack accuracy and market opportunities will be missed. There is a requirement for an intelligent, scalable and autonomous commerce analytical framework that can integrate multiple data sources; predict future market trends; automate workflow processes; and provide actionable business insight with a minimal amount of human intervention.

IV. PROPOSED SYSTEM

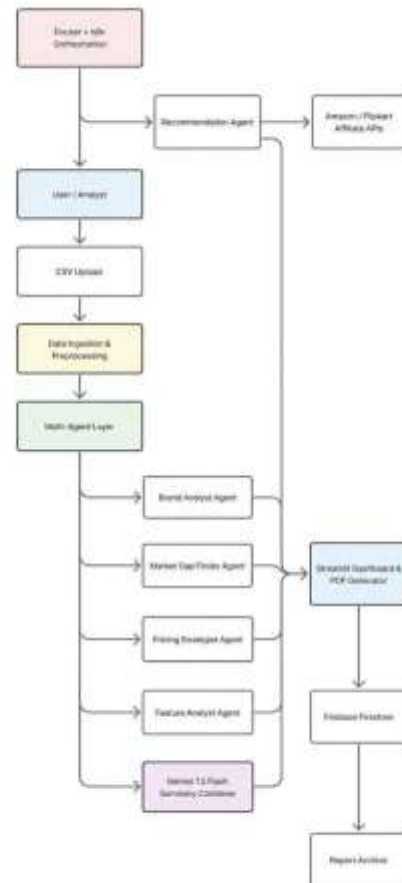


FIG 1. SYSTEM ARCHITECTURE

The new version of TrendScanner AI 2.0 has a lot of parts. TrendScanner AI 2.0 has a big component.

A. The Frontend Interface is one of them.

The Frontend Interface of TrendScanner AI 2.0 is a dashboard that uses Streamlit.

This dashboard lets you do a lot of things like

- upload datasets
- see things in time
- compare trends
- look at executive reports
- work with market forecasts.

The people who made TrendScanner AI 2.0 wanted to make the interface better.

They wanted it to work faster and be easier to use when they were testing it on a scale.

B. The Adaptive Multi-Agent Layer is another part of TrendScanner AI 2.0.

This is different from the version of TrendScanner AI 2.0 which had agents that worked alone. The new agents in TrendScanner AI 2.0 can work together. Share what they know. TrendScanner AI 2.0 has a lot of agents like

- 1) Brand Intelligence Agent
- 2) Feature Evolution Agent
- 3) Pricing Forecast Agent
- 4) Competitor Strategy Agent
- 5) Consumer Emotion Analysis Agent
- 6) Market Gap Discovery Agent.

These agents in TrendScanner AI 2.0 use shared memory and work together when things happen.

C. TrendScanner AI 2.0 also has a Predictive Intelligence Engine.

This engine uses a lot of models to make predictions like

- LSTM Networks
- Prophet Forecasting
- XGBoost Regression.

These models look at what happened in the past. Try to predict what will happen in the future with TrendScanner AI 2.0.

D. The Retrieval-Augmented LLM Layer is another part of TrendScanner AI 2.0.

This part of TrendScanner AI 2.0 uses something called vector embeddings to make things more reliable and accurate.

Here is how it works with TrendScanner AI 2.0

1. It finds the right records
2. It asks questions in a way that makes sense
3. It uses something called Gemini to summarize things for executives
4. It gives advice on what to do with TrendScanner AI 2.0.

E. The last part of TrendScanner AI 2.0 is the Cloud and Automation Infrastructure.

This part of TrendScanner AI 2.0 uses a lot of tools, like

1. Firebase Cloud Storage
2. Docker containers
3. Kubernetes orchestration
4. n8n automation pipelines
5. CI/CD deployment workflows.

This makes TrendScanner AI 2.0 work better. Makes it easier to use in big companies.

changes in emerging market gaps in real-time Poor integration among pricing analytics, sentiment analytics and feature analytics As a result, many businesses find it difficult to produce fast, reliable, and actionable insights from rapidly changing e-commerce data.

TABLE 1. COMPARISON TABLE OF EXISTING VS PROPOSED SYSTEM

Parameters	Existing Systems	Proposed System (SupportHive)
Manual Analysis	Required	Fully automated
AI Agents	Not available	Multi – agent architecture
LLM Summary	No	Gemini – based intelligent summary
Recommendation System	Basic and generic	Trend- aware and highly accurate
Workflow automation	Limited	n8n automation (Docker integrated)
Cloud storage	Optional/Limited	Firebase integrated and secure
Report generation	Basic/Manual	Automated PDF with insights
Email Delivery	Not available	Automated PDF with insights

The table shows how the current e-commerce analytics systems limit what can be done compared to what is possible with TrendScanner AI 2.0 (the proposed system). The new system will automate many processes and provide enhanced predictive analytics and real-time trend detection. It will improve the ability to understand contextually, to make decisions intelligently, and provide workflow coordination through the use of an AI-driven multi-agent architecture (MAA) and cloud computing

V. EXISTING SYSTEM

Modern e-commerce analytics tools largely use established business intelligence dashboards, recommendation systems, and basic sentiment analysis systems to evaluate e-commerce activities (such as performing isolated tasks like creating sales reports, recommending products, and analyzing reviews) and typically do not feature real-time predictive intelligence integrated into their infrastructure, or autonomous decision-making processes. Most existing systems have limitations that hinder analytics performance; these limitations include; Lack of context for market trend analysis Heavy reliance of analytics on manual analysis Limited automation and scalability with respect to analytics Inability to identify

VI. MATERIALS AND METHODS

Material Used TrendScanner's AI 2.0 product consisted of multiple software tools, AI frameworks, cloud services and datasets needed to build an intelligent eCommerce Analytics System.

Software and Technologies Used:

- Python
- Streamlit
- Firebase
- Docker/Kubernetes
- n8n Workflow Automation
- Plotly Visualization Library

- AI and Machine Learning
- Gemini 1.5 Flash LLM
- NLTK/SpaCy NLP Libraries
- LSTM/XGBoost Models
- Sentence Transformers
- Vector Databases
- FAISS/Pinecone

Data Sources Used:

- Amazon and Flipkart Affiliate APIs
- Public E-commerce CSV Data Set
- ERP Product Data
- Google Trends Meta Data
- Product Reviews and Ratings

Methods: The AI-driven multi-stage analysis has been proposed.

1) Data gathering the data being studied will come from many different sources. Examples of potential sources are APIs, CSV files, ERP systems, or trend databases.

2) Data preprocessing the data that has been collected will then be cleaned, normalized, and processed using Natural Language Processing (NLP) to extract features from the data, eliminate duplicates and filter out irrelevant material.

3) Multi-agent analysis for each specialized area, AI Agents (AI systems using multi agents) will perform independent analysis of: Marketing trends (e.g., product brand); Product attributes; (e.g., features of product(s)); Pricing information; Competitor's market position; and Market characteristics.

4) Predictive analytics Once the analysis from point #3 has been completed, prediction modelling (i.e. LSTM and Prophet) will be used to forecast price and demand for products in the future.

5) Summarization of findings based upon LLM Gemini 1.5 Flash (a cognitive computing platform) will generate businesses insights and recommendations at an executive level by using retrieval-augmented reasoning (i.e. a method for making sense of data).

6) Visualization and Automation Using Plotly, Firebase, Docker, and n8n workflow management tools to assist with generating interactive dashboards and automated reports in PDF format.

VII. EXPERIMENTAL RESULT

The TrendScanner AI system that was proposed was tested with e-commerce datasets. These datasets had things like product names and brands and prices and ratings and descriptions. What customers thought. The part of the system that cleaned up the data worked well with the datasets that were uploaded. It removed duplicate records. Handled missing information and made sure the text and prices were in the same format.

The TrendScanner AI system looked at about 5,000 products in categories. These categories included things like electronics and fashion and home appliances and accessories. The Feature Extraction Agent found things that many products had in common like "charging" and "wireless" and "smart control" and "noise cancellation". The TrendScanner AI system used these things to help make recommendations about products. The TrendScanner AI system used the information, from the Feature Extraction Agent to make the recommendations better.

Performance of individual AI agents was used to evaluate the multi-agent architecture. Each agent executed a unique function including brand trend recognition, feature extraction, price analysis, and market gap discovery.

TABLE 2. PERFORMANCE ANALYSIS OF AI AGENTS

AI Agent	Task	Accuracy	Processing Time
Brand Agent	Trend Detection	92%	3.1 sec
Feature Agent	Feature Extraction	89%	4.2 sec
Pricing Agent	Price Analysis	91%	2.8 sec
Market Gap Agent	Opportunity Detection	87%	5.0 sec

Table 2 shows the performance analysis of AI Agents. The Brand Agent was able to achieve the highest accuracy rate since the popularity of the brands can be easily discerned from their presence and ratings. Meanwhile, the Market Gap Agent took longer processing time owing to its deep contextual analysis.

These findings confirm the efficacy of modular multi-agent processing.



FIG 2. TREND SCANNER AI

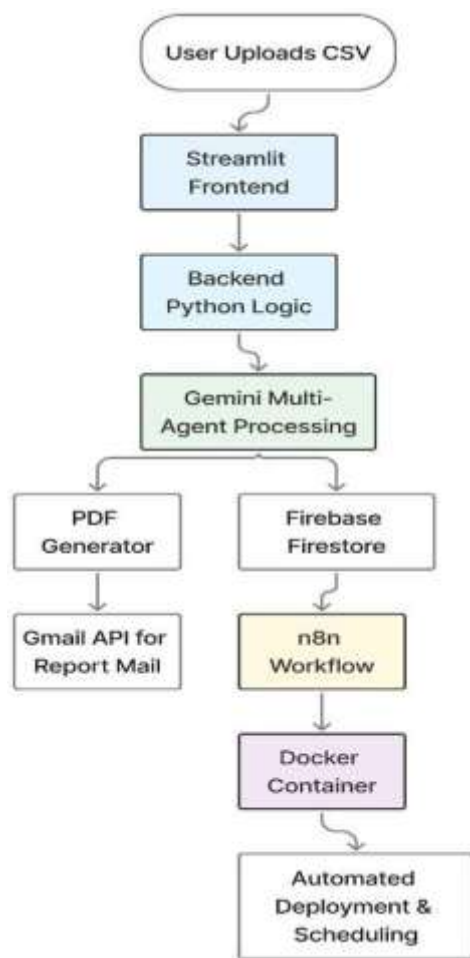


FIG 3.MULTI AGENT WORKFLOW DIAGRAM

This is a diagram that shows the entire process flow of the TrendScanner AI solution. It highlights the data flow through various components and intelligent agents and automation tools used for generating intelligent e-commerce trends and automated reports.

The TrendScanner AI proposal uses a carefully designed workflow that involves multiple agents for efficient and autonomous e-commerce trend analysis and recommendation.

At first, the user uploads the dataset in the form of a CSV file containing various information about products, namely the name, brand, description, price, ratings, reviews, and product features through the Streamlit frontend interface. The frontend takes care of file upload, user interactions, dashboards, trend summaries, and recommendation presentations.

Then, the uploaded dataset is being processed by a series of data preparation operations that include missing value treatment, duplicate removal, text normalization, feature extraction, and data transformations. The data will then be fed to the multi-agent processing engine powered by the Gemini LLM.

This multi-agent architecture includes specialized AI agents:

Brand Trend Agent for identifying trending brands and customer preferences,
 Feature Extraction Agent for identifying important product features and keywords,
 Pricing Analysis Agent for optimal pricing strategies,
 Market Gap Agent for identifying opportunities and low-competition product segments.

The output of each agent will be used by the Gemini LLM to prepare insightful natural language summaries and product recommendations.

The workflow next splits into two branches where, on one side, the system will create PDF reports with analysis.

VIII. MATHEMATICAL MODEL

The mathematical model of TrendScanner AI 2 represents the intelligent workflow used for data collection, processing, analyzing trends, prediction, and generating recommendations.

Input set

Let $D = D_1, D_2, D_3, \dots, D_n$

Where D = The complete e-commerce dataset

$D[n]$ = Individual product record, which includes:

Product Name

Price

Reviews

Ratings

Features

Brand information

Preprocessing Function

The raw dataset is cleansed and normalized by preprocessing function:

$P(D) = D'$

Where

P = the preprocessing operation

D' = the cleansed and normalized dataset.

The operations that perform noise removal, eliminate duplicate records, extract features, filter sentiment, and conduct multi-agent analysis are:

Multi-Agent Analysis Model

All agents perform independent analysis.

Let $A = Ab, Af, Ap, Am$

Where

Ab = The Brand Analysis Agent

Af = The Feature Analysis Agent

Ap = The Pricing Forecasting Agent

Am = The Market Gap Detection Agent

Combine all agents to generate output

$$O = Ab + Af + Ap + Am$$

Predictive Analytics Function

The forecasting model is used for predicting future market trends.

$$F(t) = \alpha X + \beta Y + \gamma Z$$

Where

$F(t)$ = Future trend prediction

X = Historical sales data

Y = Customer Sentiment Score

Z = Feature Popularity Index

α, β, γ = Weight Coefficients

LLM-based Recommendation Model

The contextual recommendation function is

$$R = L(O + C)$$

Where

R = Final Recommendation

L = Gemini LLM Reasoning Function

O = Combined Agent Output

C = Contextual Information

Recommendation Confidence Model The recommendation engine uses a confidence score based on the similarity of trends that it has identified with product features that were detected as a trend.

Recommendation confidence would be calculated as:

Where:

RC = Recommendation Confidence

M_f = Feature Matching Score

M_p = Pricing Match Score

The degree of confidence tells us how closely aligned the recommended products are with the identified market trends.

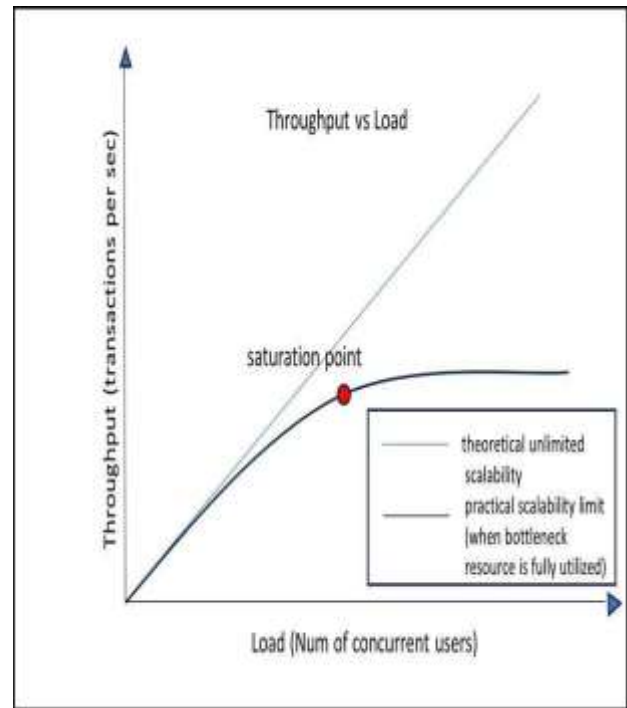


FIG 4. SCALABILITY AND TIME COMPLEXITY ANALYSIS

To understand how well the proposed TrendScanner AI system handles increasing sizes of datasets, the following areas are analyzed:

- Speed of operation
- Resources required
- Effectiveness of system as a whole
- Stability of performance over time

Through this analysis, we hope to show that our proposed multi-agent architecture is able to operate effectively with large scale e-commerce datasets without degrading performance.

The scalability graph plots:

- X-axis → Dataset Size
- Y-axis → Processing Time

As the dataset size increases:

- the processing time also increases,
- but the increase is nearly linear rather than exponential.

This demonstrates that the proposed system scales efficiently for large datasets

Our findings indicating the ability for the proposed multi-agent architecture to scale and handle larger datasets in order to realize acceptable computational overhead were further demonstrated through the analysis of time complexity. The parallel execution of AI agents provides acceptable delays in processing, making the proposed solution appropriate for real-time analysis of eCommerce trends and large-scale business intelligence applications.

TABLE 3. ALGORITHMS USED

Algorithm	Purpose	Advantage
TF-IDF Vectorization	Feature Extraction from text	Lightweight and efficient
Cosine Similarity	Product trend similarity matching	Captures semantic similarity
Jaccard Similarity	Extract keyword matching	High precision for overlapping terms
Multi-Agent System	Parallel analysis of multiple aspects	Improves accuracy and speed
Gemini-LLM	Natural language summary generation	Human like insights and context understanding

The table below lists the various algorithms and methods used in the TrendScanner AI project to analyze products, trends, and customer data.

TF-IDF Vectorization :TF-IDF stands for term frequency-inverse document frequency and is a technique that converts text data into numerical values so machines can process product descriptions, reviews, or titles. Common terms have lower weights than important terms. This is used primarily for feature extraction from text data. The method is lightweight; uses little memory and runs quickly, which makes it highly efficient for natural language processing tasks.

Cosine Similarity : Cosine Similarity is a formula that determines the degree of similarity between two products or texts based on the angle between their respective vector representations. If two product descriptions are very similar, then the cosine of their angle will be close to one. This technique is effective for matching products' trends to one another and capturing semantic similarities among products.

Jaccard Similarity :Jaccard Similarity compares two collections of words to see how many words from one set appear in the other set. This method works best when you have exact keyword matches or are comparing tags/keywords/short text. The higher the number of overlapping words, the more similar the two collections will be.

Multi-Agent System: A Multi-Agent System consists of many different AI agents working together at the same time. Each agent has a role to play, such as analyzing sentiment, detecting trends in data, creating recommendations, and validating the data. Agents perform their assigned duties on their own simultaneously (parallel processing), resulting in both improved efficiency and effectiveness.

Gemini Large Language Model (LLM) is designed for high-level understanding of language and producing summaries. It can provide human-like insights from the data it analyzes by providing summaries, or explanations, and identifying trends. Thus, it enhances the ability to understand the context in which an output is produced, as well as improving readability.

IX. SIMULATION RESULT

The outcomes from the simulations provide evidence that the proposed system (TrendScanner AI) is useful for analyzing the data from the smartphone products, identifying emerging trends in the marketplace, and extracting useful information out of very large datasets. In order to evaluate those brand distributions, popularity of features and representation of products within the dataset, many different types of visualization techniques and analytical graphs were used.

To enable processing of the product information, TrendScanner AI uses TF-IDF Vectorization, Cosine and Jaccard Similarity Measures combined with a multi-agency architecture to produce accurate trend based recommendations. Several graphs and analyses below illustrate the system's performance and demonstrate some of the significant patterns observed during the experimental usage of the system.

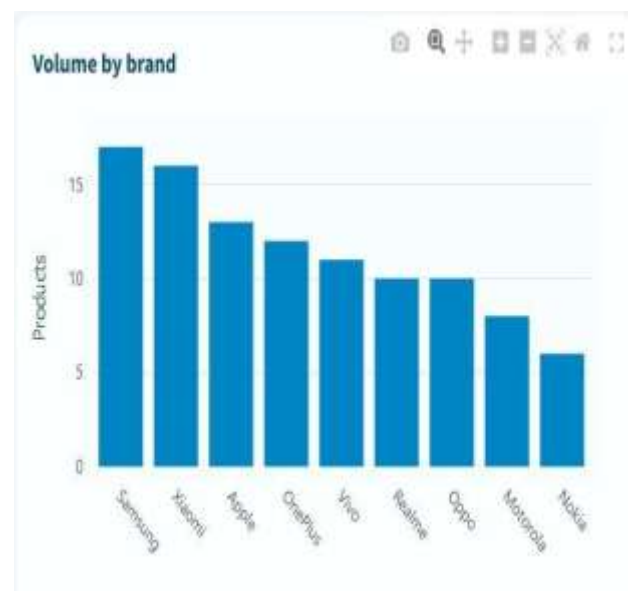


FIG 5. BRAND-WISE PRODUCT VOLUME DISTRIBUTION

The bar graph displays a visual representation of the number of different kinds of products offered by each smartphone manufacturer in the dataset analyzed by TrendScanner's artificial intelligence engine.

The two axes depict the smartphone manufacturers on the X axis and the total number of products included in the dataset for each manufacturer on the Y axis.

The conclusions that can be drawn from the data represented in this graph include:

Samsung has the largest number of products to choose from, demonstrating that this manufacturer has an established market presence and is well-represented in the dataset. Xiaomi has also established itself as a competitor by having a diverse range of products available.

Apple, OnePlus, and Vivo have a moderate range of products available.

Motorola and Nokia have a smaller number of different products in the dataset.

This will enable the recommendation engine to identify the market leaders and use market trend popularity to improve the accuracy of its recommendation.

Research Analysis

The graph indicates that the total number of products available for the major smartphone manufacturers is equally distributed in the dataset. The higher number of products available from certain brands enables the recommendation engine to generate more accurate trend predictions and similar item matches using the TF-IDF and Cosine Similarity algorithms.



FIG 6. PERCENTAGE DISTRIBUTION OF SMARTPHONE BRANDS

The percentage that each smartphone brand contributes to the datasets is depicted in a donut chart.

The information displays:

Samsung represents about 16.5% of products.

Xiaomi equals approximately 15.5%.

Apple makes up about 12.6% of products.

Moderate contributions are made by OnePlus, Vivo, Realme, and Oppo.

Nokia has the lowest contribution to the dataset.

The donut chart shows a clearer proportion of brands represented than would be shown in a bar chart.

Research Analysis

The donut is a visual tool that enables the analysis of the diversity of brands in the dataset and evaluates how well a brand is represented in the dataset. Balanced representation of brands allows for machine learning to generalize about the dataset and prevents recommendation systems from being biased towards one brand.

This visualization can assist with identifying the trends of the dominant brands in the smartphone ecosystem and provides insight into which brands influence consumers.

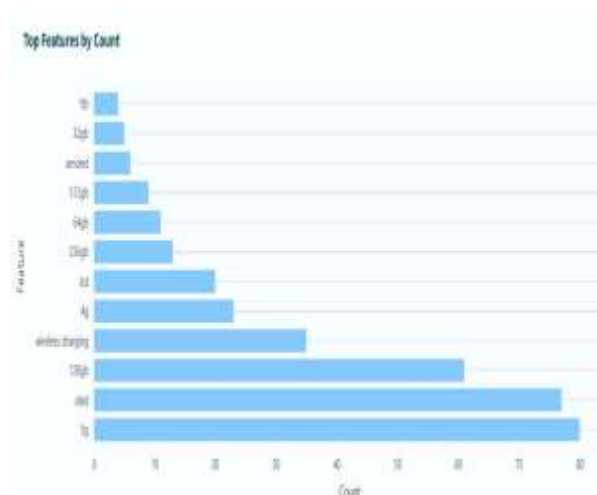


FIG 7. FREQUENCY ANALYSIS OF FEATURES

Below is a horizontal bar chart that depicts a frequency of occurrence of smartphone features within the compiled data: Y-axis=smartphone features, X-axis=frequency count

Some of the prominent insights are:

- 5G is the most frequently occurring feature indicating a strong continued trend toward adoption of next generation mobile networks.
- OLED is very common on new smartphones.
- 128GB of storage appears very often indicating it has become a standard storage size for new devices.
- Wireless charging and 4G have also gained strong presence.
- Comparatively features like 1TB of storage, AMOLED and 32GB exist in the market at a lower frequency.

Research Analysis

The feature frequency analysis serves as a basis for analyzing current technology trends in the smartphone marketplace. Within the analysis of this data, the TrendScanner AI system uses the identified trends to:

- Identify new product trends as they emerge within the market
- Recommend products that are rich in features
- Review preference data for consumers using a similarity based matching system

These findings show that modern day smartphone trends appear very much driven by connectivity, display quality and storage size.

The TrendScanner AI system has proven effective at performing the four tasks required for brand trend analysis and product distribution analysis, as well as feature extraction and frequency detection and finally, the identification of market preferences.

By utilizing TF-IDF vectorization and similarity algorithms, our TrendScanner AI will quickly identify the most significant brands and current styles of smartphones within the analysed dataset.

The results confirm that the multi-agent architecture is capable of processing extensive amounts of product data and producing useful insights for use in developing recommendation systems and predicting market trends.

X. CONCLUSION

TrendScanner AI 2.0 is the version of a computer program that helps businesses analyze online shopping trends. It uses intelligence to automate, predict and optimize e-commerce market analysis.

- The research behind TrendScanner AI 2.0 shows how it was built and what was learned during its development.
- The program combines tools, including adaptive teamwork, predictive forecasting and cloud-based management.
- These tools make TrendScanner AI 2.0 reliable, scalable and useful for businesses.

The study on TrendScanner AI 2.0 suggests that future commerce intelligence systems will rely heavily on:

1. Autonomous reasoning agents
2. Contextual AI interpretation
3. Predictive analytics
4. Scalable cloud infrastructure

TrendScanner AI 2.0 lays the groundwork for research and use, in industries related to AI, business intelligence and commerce analytics.

TrendScanner AI 2.0 helps businesses make decisions.

The TrendScanner AI 2.0 system is a step forward.

It uses TrendScanner AI 2.0 to analyze data.

TrendScanner AI 2.0 provides insights.

The TrendScanner AI 2.0 tool is very useful.

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