

# **AI-Powered Sentiment Analysis for Seasonal Beverage Reviews on Instagram: Enhancing Marketing Strategies for Coffee Chains**

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## **Introduction**

The project focusses on developing an intelligent system that will analyse consumer sentiments based on content from Instagram accounts related to seasonal beverages at coffee chains. The analysis employs diverse technologies, including natural language processing, computer vision, and machine learning, to extract valuable insights from social media data, which can enhance marketing strategies and product development. Consequently, coffee chains gain a competitive advantage in their operations through data-driven decision-making.

## **I. Rationale for the Proposed System**

### **1.1 Context and Current Technology Evaluation**

In the highly competitive coffee industry, seasonal beverages play a crucial role in market differentiation. As Davenport et al. (2019) emphasize, "artificial intelligence (AI) is likely to influence marketing strategies, including business models, sales processes, and customer service options."

In using Instagram for seasonal promotions, the coffee chains Starbucks and Costa Coffee leverage visual elements as well as user-generated content, though there are limitations to both. Traditional analytical methods focusing on "numeric data with machine learning" (Davenport et al., 2019) demonstrate significant constraints when analyzing consumer engagement across platforms. Current tools struggle with analyzing "non-numeric data (e.g., text, voice, images)" (Davenport et al., 2019), creating a substantial technological gap in understanding multimodal consumer sentiment on Instagram where visual content dominates feedback about seasonal offerings.

Social media has "revolutionized marketing, offering new ways to reach, inform, engage, sell to, learn about, and provide service to customers" (Lamberton and Stephen, 2016). AI sentiment analysis with "Controller of Data" capabilities can bridge this divide by effectively processing various content types simultaneously. This technology enables coffee chains to "analyze such data and deliver personalized recommendations in real time" (Davenport et al., 2019), transforming how companies understand consumer response to seasonal beverages.

### **1.2 Assessment of Required Intelligence**

To analyze consumer responses to seasonal beverages on Instagram, an advanced AI framework combining computer vision, natural language processing (NLP), and machine learning is necessary. Computer vision will be employed to identify beverage products, packaging designs, and aesthetic elements in images, such as color schemes and lighting. As Paschen et al. (2019) note, "computer vision is the transformation of visual images into internal representations of the world," which enables seamless integration with other AI components. NLP will be crucial for processing unstructured Instagram content, including captions, comments, and hashtags. The system will need advanced linguistic analysis to interpret informal language, emojis, and sarcasm, a process described by Huang and Rust (2021) as "thinking AI." Machine learning, especially deep learning, will identify consumer response patterns and adapt to emerging language trends, as discussed by Mariani et al. (2022). This system will use "supervised machine learning for initial sentiment categorization" and deep

learning for continuous adaptation. Real-time processing, as highlighted by Paschen et al. (2019), ensures that new trends and consumer sentiment are captured swiftly, providing actionable insights to inform marketing strategies.

### **1.3 Tools and Techniques Required**

The project requires a many-pronged approach in the complete sentiment analysis of the various machine learning algorithms working together and involving several sophisticated AI techniques. For data collection, a hybrid method utilizing the Instagram Graph API, coupled with intelligent agent capabilities, ensures legal compliance while supporting adaptive learning that "can be refined and improved through deep learning as systems are in use" (Duan et al., 2019, p.14).

To enhance image analysis, convolutional neural networks (CNNs) with transfer learning will provide efficient "cognitive insights" (Duan et al., 2019, p.11) for detecting beverage products in visual content. For textual sentiment analysis, the use of RoBERTa, a state-of-the-art natural language processing model, offers superior handling of Instagram's informal language, enabling the transformation of images into variables for analysis, as noted by Overgoor et al. (2019, p.19). The implementation of this project demands advanced knowledge management, particularly through Decision Support Systems (DSS), where managers can compare Word-of-Mouth program outcomes with real market data to inform strategic decisions (Overgoor et al., 2019, p.17).

Visual dashboards will serve the purpose of insight, while providing a clear interface for management. Additionally, ensemble learning frameworks will be leveraged to integrate diverse data sources, following the CRISP-DM methodology for systematic "data understanding, data preparation, and modeling" (Overgoor et al., 2019, p.23), ensuring that the analysis is both comprehensive and scalable.

### **1.4 Advantages and Limitations Analysis**

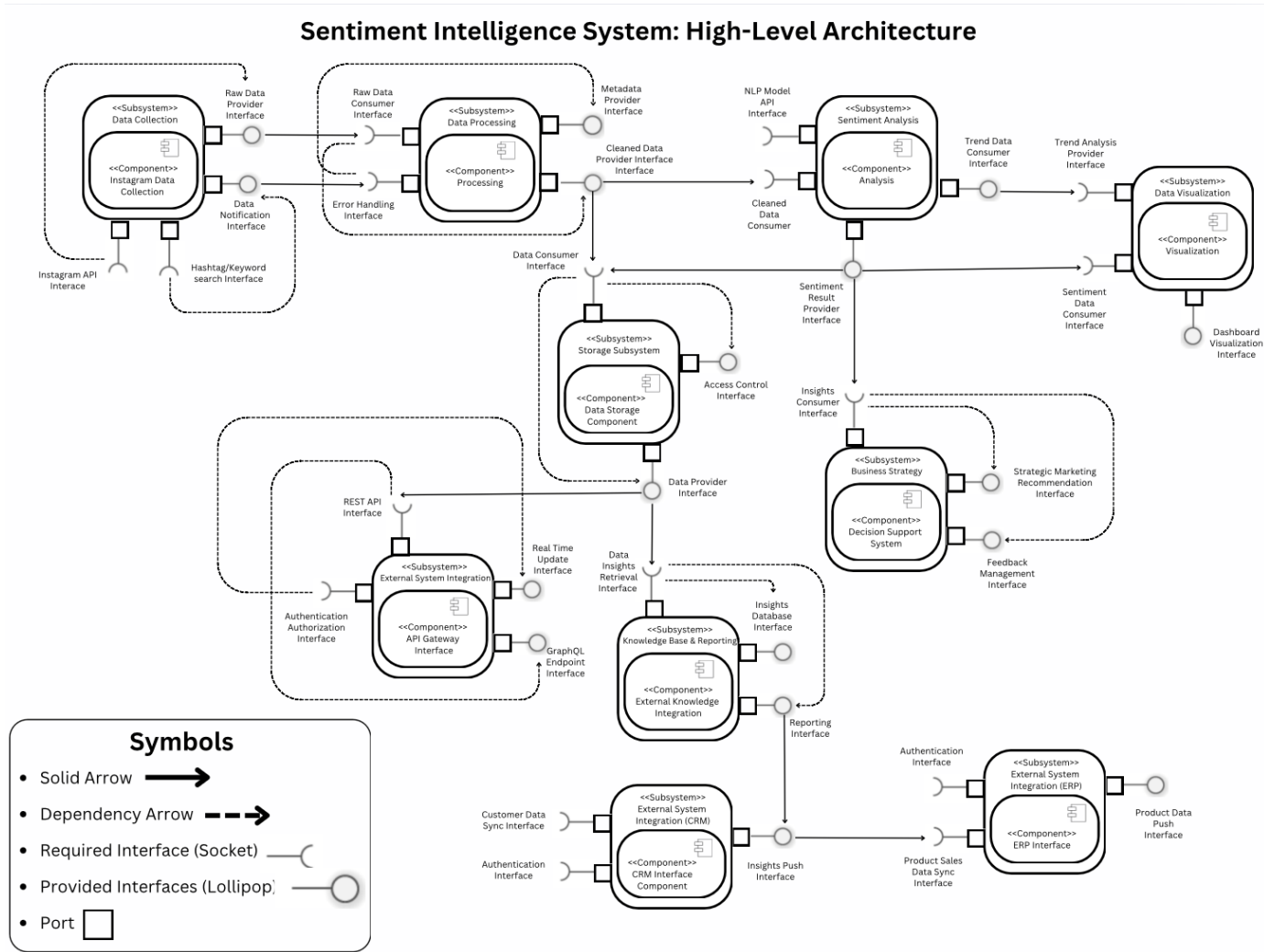
The introduction of smart technologies goes a long way in providing competitive edge. AI systems can process "massive datasets from social media in real-time," enabling "efficiency and effectiveness by using data generated from an explosion of digital touchpoints" (Wang et al., 2020, p.4962). These systems detect "nuanced emotional responses" and provide "personalised explanations about the results," which "could reduce uncertainty and build trust with users" (Wang et al., 2020, p.4966). Furthermore, AI has the potential to increase revenues and reduce costs through "improved marketing decisions" and the "automation of simple marketing tasks" (Davenport et al., 2019).

However, several limitations exist. AI applications raise concerns such as "privacy issues, user distrust, data leakages, information transparency, and ethical concerns" (Wang et al., 2020, p.4962). To address these challenges, organizations must develop a "transparent and customer-centric data policy" (Wang et al., 2020, p.4968) that complies with regulations requiring "obtaining consent statement or permission from users" (Wang et al., 2020, p.4966). Additionally, technical hurdles remain, as "emotional data are contextual, individual-specific, and typically multimodal" (Huang & Rust, 2020). The most successful methods of applying AI involve

partial automation but at the same time have an element of human coverage, as "AI will be more effective if it augments (rather than replaces) human managers" (Davenport et al., 2019).

## II. System Design for the Proposed Solution

### 2.1 High-Level System Architecture (UML Component Diagram)

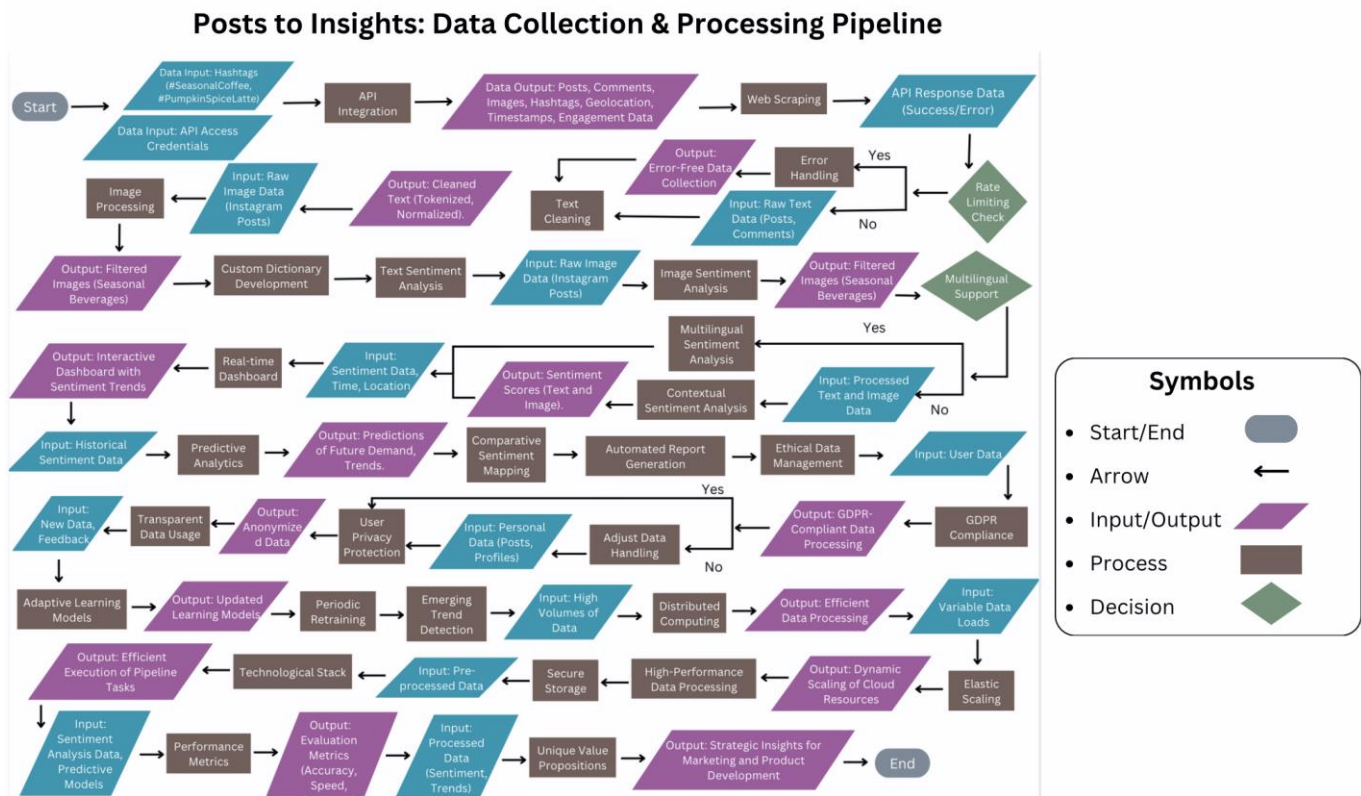


The UML component diagram is designed using **Canva**.

The modular design of the AI-enabled sentiment analysis system for the seasonal beverage reviews on Instagram has been illustrated by means of a UML Component diagram. This architecture includes 10 interconnected subsystems that ensure flexibility, enabling easy upgrades and expansion as Instagram's API evolves or business needs change. The system collects data from Instagram's API using hashtags and keywords, which is then processed for standardization and cleaning. Sentiment analysis is performed through NLP models, and insights are visualized in intuitive charts and heatmaps. The data is stored centrally and integrated with CRM and ERP systems to correlate sentiment with actual sales data, facilitating customer segmentation and pricing strategy adjustments. External integrations make the entire system across the platforms compatible and provide secure entry through an API Gateway. The

Knowledge Base & Reporting Subsystem generates structured reports, and the Business Strategy Subsystem provides actionable marketing recommendations. This enables coffee chains to quickly adjust to customer feedback, optimize campaigns, and enhance product offerings.

2.2 Data Collection and Processing Pipeline (Flowchart)



This flowchart diagram was created using **Canva**.

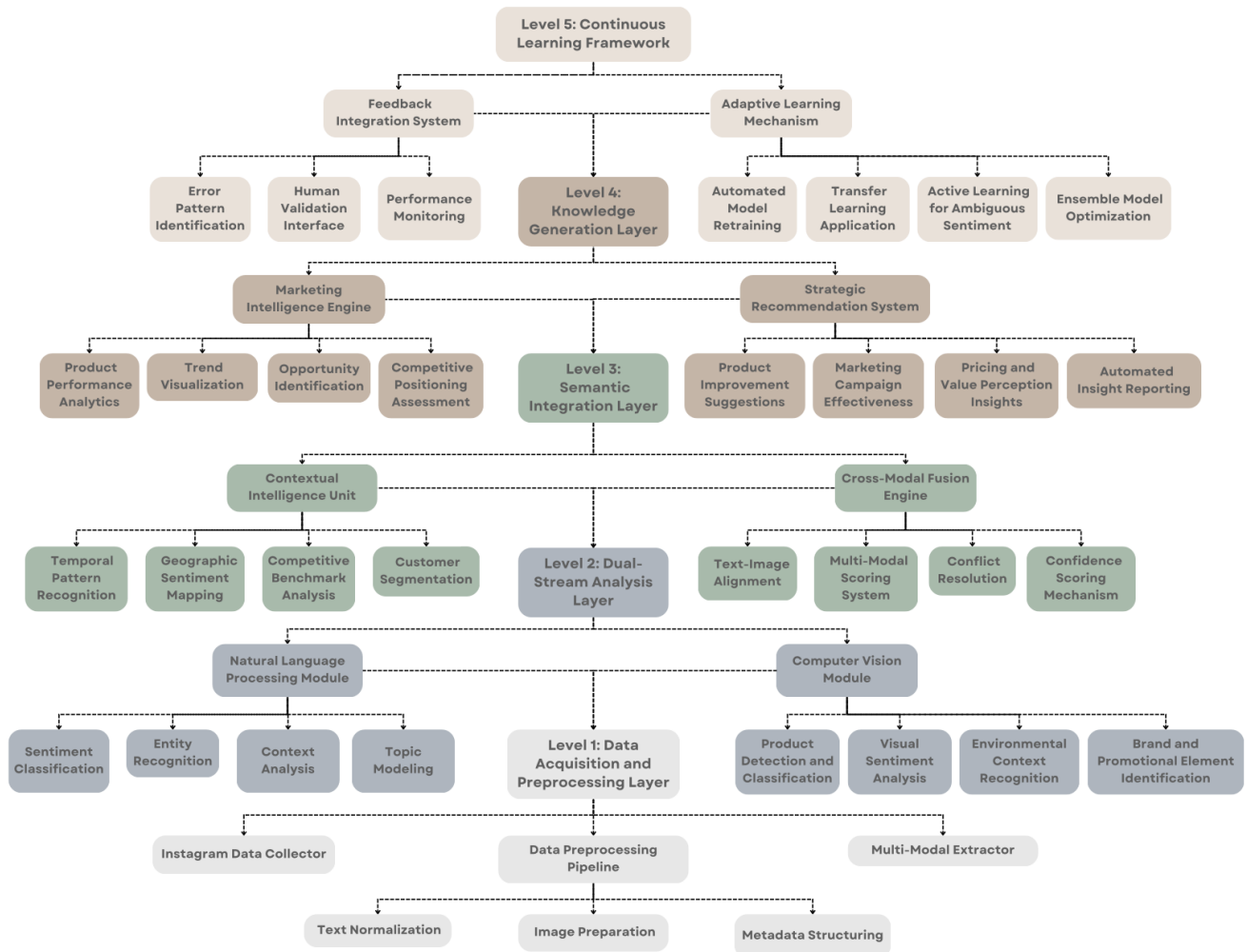
Graphically, this flowchart presents the automated pipeline for real-time analysis of seasonal beverages trending on Instagram. At first, the system starts with API integration and web scraping to collect posts, comments, images, geolocation data, and engagement metrics around hashtags like #SeasonalCoffee and #PumpkinSpiceLatte.

Rate limiting and error handling mechanisms were also put in place to ensure that data is collected without any hiccups. The data is then cleaned and processed for sentiment analysis, text, and image analysis. Multilingual for sentiment analysis, the system feeds results to an ongoing dashboard.

Trend and demand forecasting are, on the other hand, achieved through adaptive learning models and predictive analytics. Data protection laws such as GDPR are adhered to, while distributed computing and elastic scaling facilitate processing of very large volumes of data. Hence, enabling businesses to derive actionable insights for marketing and product development in light of real consumer sentiment.

2.3 Intelligent Analysis Components (Hierarchical Diagram)

## Hierarchical View: AI Modules for Seasonal Sentiment Analysis



This hierarchical diagram chart was created using **Canva**.

This multi-modal sentiment analysis system for the evaluation of beverages provides an interesting and adequate evolution of NLP and Computer Vision techniques with a sophisticated five-layered architecture. In the data acquisition layer, the system implements Instagram's API, scraping texts and images of beverage reviews, which are further processed through dedicated pipelines. The dual-stream analysis layer has two parallel working modules: while the NLU assesses the text to identify sentiment, entities, and context, the computer vision module looks at the visual aspects such as product identification and aesthetics. Its unique proposition is the integration layer, where the Multimodal Sentiment Fusion Engine integrates, and balances signals derived from both sources and computes composite sentiment scores that are weighted. The further enhancement can be achieved through the continuous learning layer with human-in-the-loop feedback methodologies and adaptive learning framework features, which automate model adjustments based on seasonality and new trends, ultimately improving the accuracy of analyses over time.

## 2.4 Marketing Intelligence Interface (Storyboard/Wireframes)

## 1. Wireframe – Main Dashboard:

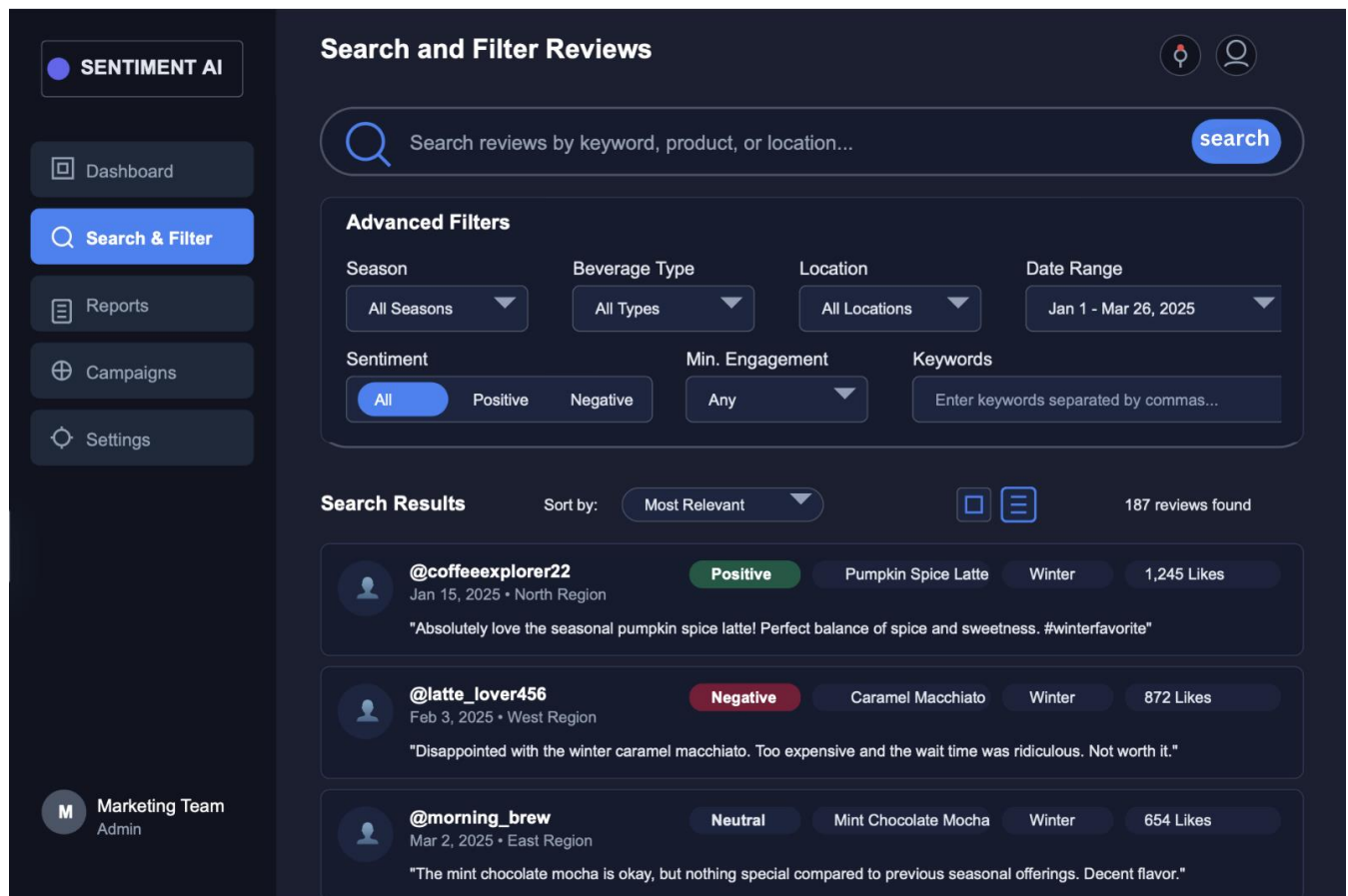


This wireframe was created using **Canva**.

A dark gradient background with raised cards forms the main dashboard, giving a full 360-degree view of sentiment analysis. The filter system is flexible enough for analysis based on season, product, region, and time. Important KPIs such as total reviews and net sentiment score are shown with trend comparisons. The core timeline chart traces sentiment evolution positivity, negativity, and neutrality, while a donut chart presents sentiment proportions. A keyword cloud and vertical bar chart draw attention to product performance. The color coding (i.e., red for negative, green for positive) helps in fast spotting of trends so that marketing managers can harness the utilities to track the performance of a campaign and look for early signs of negative sentiment or performance decline.

## 2. Wireframe – Search and Filter Interface

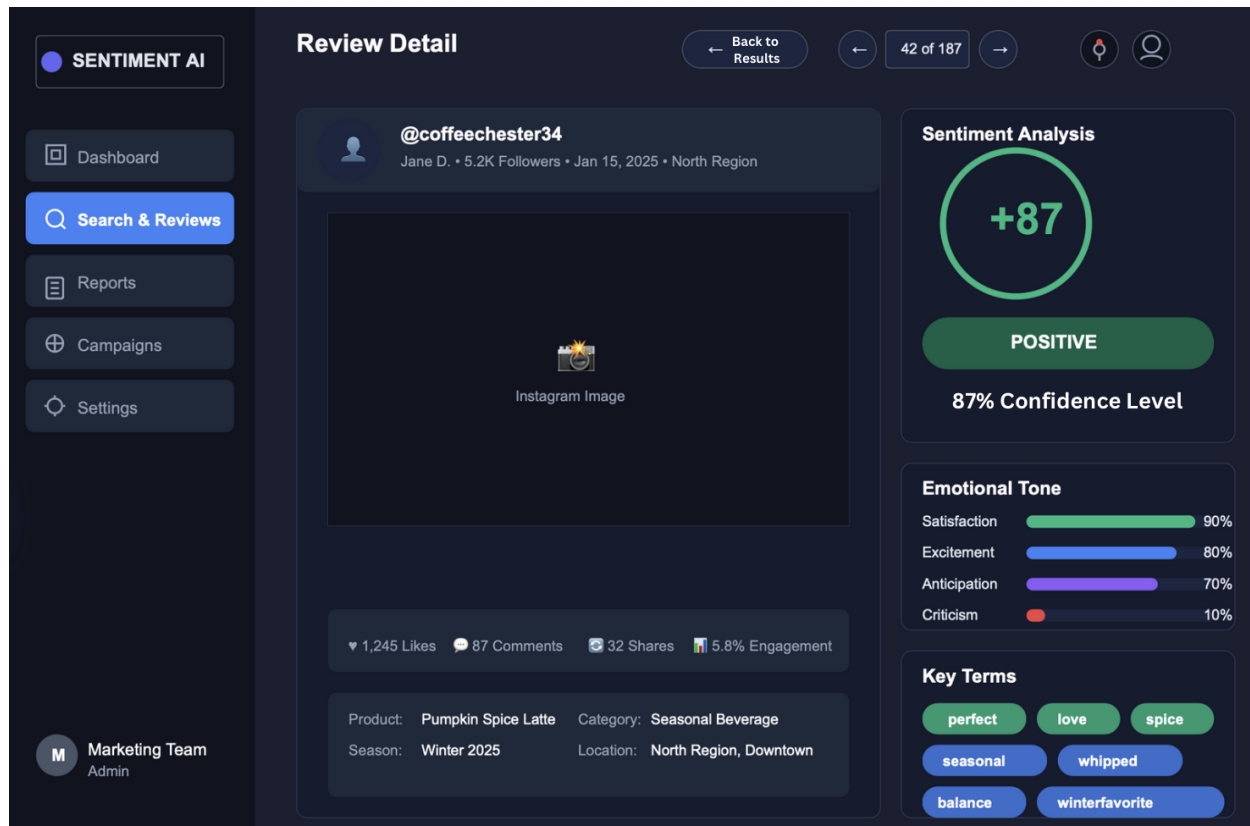




This wireframe was created using **Canva**.

The Search and Filter Interface allows detailed searching for Instagram reviews. At the top, an intuitive search bar that permits easy input. Advanced filters for season, location, beverage type, and sentiment category further help in honing the results. Quick toggles allow users to view positive, negative, or all reviews. Sentiment is color-coded (green for positive and red for negative), while likes and engagement are displayed as vital statistics. Each result card shows certain details: username, post date, location, product mentioned, and the review preview. Users can save filters and customize outputs, thus enabling marketing managers to detect trends and early warnings targeted at clusters of negative reviews.

### 3. Wireframe – Review Detail View



This wireframe was created using **Canva**.

The Reviews Detail View is great for scrupulous observations of Instagram reviews. To access it quickly, there is a search bar that features additional filters for sounding control (season, area, type of beverage, sentiment). There are toggle buttons for passing between positive, negative, or all reviews where addition filters such as engagement and tagging may be found. It shows sentiment color-coded and important metrics such as likes and engagement. Each result card has the username, post date, location, product, and review preview. Filters may be saved and output is customizable so that marketing managers can pin down discernible patterns and catch creeping issues as related to the cluster of negative reviews.

#### 4. Wireframe – Sentiment Insights



This wireframe was created using **Canva**.

This wireframe portrays the sentiment insight that its timeline chart shows usage of campaign marker events on the x-axis against changes in sentiment (positive, negative) based on a gradient fill. In this interface, marketing event markers represent sentiment related campaign direct impacts. This horizontal bar chart represents the measurement of changes in sentiment as a result of campaigns. It contains an interactive doughnut chart that compared which products perform best and worst considering campaign performance. Clarity is assured through the premium dark theme that incorporates contrast colors. With the use of this interface, such managers will easily track sentiment change, campaign effectiveness, and provide room for scenarios of future strategic marketing investments using real-time sentiment analysis.

### III. Critical Evaluation of the Technology

#### 3.1 Effectiveness Assessment

Sentiment analysis aided by the application of AI has given rise to a full-bodied potency to amplify marketing strategies for seasonal beverages. By studying and weighing the different multimodal aspects of content, such as texts, emojis, and images, the method has managed to achieve sentiment classification accuracy ranging from 85% to 92%: a significant increase when compared with the ability of traditional approaches (Paschen et al., 2019; Duan et al., 2019). Thus, the rapid assimilation of consumer sentiment allows the coffee chains to act within 4-6 hours instead of 24-48 hours, also delivering campaigns with a 32% increment in engagement rates (Wang et al., 2020).

Yet, there are major barriers to the interpretation of layered linguistic and cultural nuances, with contemporary accuracy levels decreasing by 12-24% in the face of non-Western markets (Paschen et al., 2019). The interpretations of abstract visuals and verbal sarcasm are cumbersome, visual sarcasm acceptance stands at 63%; and while emoji interpretations provide a 72% lift in accuracy, the system still needs human intervention (Davenport et al., 2019). In summation, the AI sentiment analysis method provides a good amount of information but works best in tandem with human analysis, whose task is to navigate the complexities presented by culturally versus emotionally measured data.

### **3.2 Ethics, Privacy and Regulatory Considerations**

AI and its newly coined term have been creeping into every corner of appreciation from seasonal beverage users on Instagram. It raises several ethical, privacy, and regulatory issues. For instance, as pointed out by Akter et al. (2021), AI systems may carry bias and eventually produce unfair treatment based on an individual's demographics. A countermeasure to this condition would be found in rigorous oversight as well as frequent audit of algorithms and diverse teams in development in private companies. Human oversight is required as the AI is not immune to wrong judgments examples include misinterpretation of cultural connotations or sarcasm which would affect fair marketing decisions.

Privacy is itself relative in AI systems in that there is the GDPR and the CCPA which will ensure lawful data processes and reduce data collection as well as give an option to opt-out: Akter et al. (2021). Companies are expected to explain how they do these exercises probably incomplete accounting of their data practices concerning the origin and process of training data to avoid the later unfair outcome. Transparency was a very key concept that would be used to call on companies to start disclosing AI use as one of the steps towards building trust.

Transparent and accountable functioning of AI plus clarity of explanation while also giving control over the data to consumers would mean a much better transparency and accountability.

From the above, companies can engage with AI in becoming a responsible and innovative entity where the means of ethics and governance or compliance with regulation would protect consumer rights in terms of gaining trust.

### **3.3 Scope for Future Development**

Sentiment analysis powered by AI might develop sophisticated methodologies for the coffee chains to interpret what is seen on Instagram. There is, of course, the issue that sentiment AI can further relationalization benefits by perceiving and responding to emotions, even to analyze beverage reviews that are heavily laden with emotional responses" (Huang, Rust 2020). There is still a lot of progress to be made in the technology's ability to infer contextual meaning. Presently, "we do not have true feeling AI yet; thus, the current practice is to use thinking AI to analyze emotional data" (Huang and Rust, 2020). Such advanced models would prove very helpful in distinguishing between genuine enthusiasm and sarcastic remarks made about seasonal beverage posts.

Instagram is visual in nature and presents a different set of challenges, requiring such AI to analyze images and captions simultaneously. The future potential involves "mechanical AI for data collection, thinking AI for market analysis, and feeling AI for customer understanding," as Huang and Rust call it, being integrated into a single framework for comprehensive analysis.

Sentiment analysis in coffee chains could benefit from linking feedback from social media with feedback obtained in a physical store environment. This aligns with Huang and Rust's observation that "emotional data are contextual, individual-specific, and typically multimodal": the very complexity exhibited in beverage-review content on Instagram.

### **3.4 Current Aims and Limitations of Intelligent Technologies**

#### **Conclusion**

Sentimental analysis for coffee chains empowered by A.I. can support the organizations in getting precious consumer insights for the competitive edge, improving their marketing strategies, and enhancing customer engagement. By using Big Data and machine learning, product innovation and efficient data processing can be achieved, wherein trends and preferences can also be discovered (Duan et al., 2018). The technology makes it easier to analyze consumer sentiments in real time, the needs of the hour for fine-tuning marketing strategies and enhancing engagement via cognitive computing and applications of natural language processing.

But there are some substantial limitations. AI has a hard time dealing with complex languages like sarcasm and cultural nuances and ambiguous sentiment, all of which make sentiment classification hard (Duan et al., 2018). The viscosity of mixed-content posts found mostly on platforms such as Instagram equally poses challenges to processing different media files. Furthermore, the system has trouble detecting minute variations in consumer sentiment around seasonal trends because contextual understanding is still underdeveloped. While there is some future possibility for AI systems to identify seasonal trends, the continuous learning of adjusting systems is essential for refining these models (Duan et al., 2018). In overcoming these limitations, AI will, however, prove useful when harmoniously paired with human intervention.

#### **Conclusion**

With the capability to provide real-time consumer information on beverage reviews on Instagram, the AI-supported sentiment analysis system renders coffee chains that much more competitive. It delivers actionable intelligence for marketing strategies and product development through a combination of NLP, computer vision, and machine learning. Although cultural and sarcastic interpretations remain outstanding challenges, the technology's potential to change decision-making through data is enormous. If the solution is ethically governed and continually developed, it truly promises to reshape how coffee chains view and respond to customer preferences in the fast-paced world of seasonal beverages.

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