Sentiment Trend Analysis of SpaceX Tweets Using Time-Series Sentiment Classification with TextBlob Algorithm

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ABSTRACT

This study explores the dynamics of public sentiment toward SpaceX, focusing on how it fluctuates in response to key events, including successful missions and technical setbacks. Using sentiment analysis on a dataset of SpaceX-related tweets, this research captures the emotional reactions of the public, classifying them into positive, neutral, and negative categories. The analysis reveals distinct patterns: positive sentiment predominates during major achievements, such as rocket launches and new technological advancements, while negative sentiment spikes following failures or delays. The results demonstrate how public perception of SpaceX is intricately tied to the company's performance, reflecting both excitement for its successes and frustration for its setbacks. By examining these sentiment trends, this research offers insights into how companies in the space exploration sector can manage their public relations efforts and strategically engage with audiences on social media platforms. The study employs the TextBlob sentiment analysis tool, which classifies tweet polarity and subjectivity, to categorize public sentiment in a straightforward yet effective manner. Through time-series visualizations, the study tracks how sentiment evolves over time, highlighting key fluctuations tied to SpaceX's milestones. Additionally, the research integrates visualizations like word clouds and bar charts to identify frequent keywords associated with both positive and negative sentiments, providing a deeper understanding of public discourse surrounding the company. The study underscores the role of Twitter as a significant tool for shaping public perception, particularly in high-visibility industries like space exploration, where real-time feedback can influence both public opinion and corporate strategies. This research contributes to the broader field of sentiment analysis by focusing on the tech and space industries, where public sentiment plays a pivotal role in shaping business success and technological innovation. By examining SpaceX's public image through sentiment trends, this study highlights the importance of real-time sentiment monitoring in shaping company strategies. Future studies could extend this analysis to include other companies in the space sector or incorporate more sophisticated machine learning models for deeper sentiment classification.

Introduction

Social media platforms, particularly Twitter, have become integral to the way public discourse unfolds in the digital age. In this micro-blogging space, individuals from around the world converge to share thoughts, reactions, and opinions, often in real-time. The simplicity of a 280-character limit allows for the rapid dissemination of sentiments, enabling Twitter to serve as a significant platform for emotional expression during key events such as elections, crises, and cultural movements. Cury's analysis of tweet sentiments during the 2016 election of João Doria Jr. illustrates the oscillating nature of public sentiment, revealing sharp peaks in engagement that correspond with moments of political significance [1]. Such peaks underscore the power of Twitter as an immediate

and accessible pulse on public emotion, offering a snapshot of collective sentiment that can be measured and analyzed to understand shifts in public opinion.

The role of Twitter as a tool for shaping and reflecting public sentiment is not limited to political events but extends to how it influences traditional media narratives. McGregor's study highlights how journalists rely on Twitter not only as a source of breaking news but as a barometer for gauging public opinion [2]. This dual role—as both a reflection and an active participant in shaping discourse—complicates the relationship between social media and news outlets. By curating content that resonates with the sentiments expressed by Twitter users, journalists inevitably contribute to the creation of narratives that reflect, magnify, or even distort public perceptions. Moreover, studies such as those by Klingeren et al., which compared Twitter data with traditional surveys during the 2016 Ukraine referendum, demonstrate how Twitter can function as a proxy for gauging public sentiment [3]. This evolving dynamic between social media and journalism suggests that platforms like Twitter are not mere observers of public sentiment but active architects of the narratives that frame societal conversations.

Beyond politics, Twitter has also played a crucial role in the realm of public health. During the COVID-19 pandemic, platforms like Twitter became vital in disseminating public health information and gauging public response to health measures. Shofiya and Abidi's sentiment analysis of tweets related to social distancing revealed a complex array of reactions, with public sentiment oscillating between fear, frustration, and acceptance [4]. Similarly, research by Zhang and Ahmed highlighted Twitter's role in distributing health information, with users sharing news, advice, and personal experiences regarding the pandemic [5]. These studies underscore the ways in which Twitter becomes not just a conduit for information but a platform where public sentiment on health policies is formed, expressed, and debated. Such a dynamic underscores the growing role of social media as a vital component of public health communication, providing a direct window into the sentiments of the public regarding health protocols.

Further illustrating the utility of sentiment analysis, Twitter has become a key resource for understanding public perceptions of specific health initiatives, such as COVID-19 vaccinations. Khalid et al. demonstrated how sentiment analysis of tweets concerning vaccination campaigns reveals important trends in public reception, ranging from enthusiastic support to vehement opposition [6]. By quantifying these sentiments, policymakers can gain valuable insights into the effectiveness of their campaigns and adjust their strategies accordingly. This capacity for real-time feedback highlights how sentiment analysis, particularly on platforms like Twitter, can provide critical data for shaping public health strategies. Thus, the ability to analyze sentiment not only informs political campaigns and media narratives but also plays an essential role in public health efforts, emphasizing the growing intersection between social media analytics and policymaking.

The increasing volume of user-generated content on platforms like Twitter has revolutionized the ways in which public sentiment can be captured and analyzed. Twitter's real-time nature and expansive reach enable researchers and organizations to access and examine vast datasets that reflect the pulse of public opinion during critical moments. Unlike traditional forms of opinion gathering, which may take weeks or months to complete, Twitter allows for immediate insights into how people feel about events as they unfold. This ability

to monitor public sentiment in real-time has proven invaluable in the study of everything from political shifts to health emergencies, positioning Twitter as an essential tool for understanding public opinion. Research [7] demonstrated how Twitter's real-time data collection was leveraged to track public concern during the Ebola outbreak, illustrating the platform's capacity to capture not just attention but also emotional responses in moments of crisis. Similarly, Research [8] employed Twitter data to examine global public opinions about the COVID-19 pandemic, further highlighting the utility of social media in capturing sentiment during a rapidly evolving global health crisis.

As the volume of data increases, so too does the sophistication of the computational techniques employed to analyze it. The advent of natural language processing (NLP) and machine learning has significantly enhanced the ability to process complex social media data, including sentiment classification. Research [9] review various techniques used to categorize sentiments, emphasizing how these advancements allow for more nuanced and accurate sentiment analysis. Traditional methods of analyzing text were limited by the inability to understand context and emotional nuance. Still, the rise of NLP and machine learning has empowered researchers to go beyond basic keyword searches and classify sentiment based on deeper linguistic features. This technological evolution has dramatically improved the precision of sentiment categorization, distinguishing between positive, negative, and neutral tones with greater accuracy and providing a more reliable gauge of public sentiment.

The application of sentiment analysis, however, extends far beyond the realm of public health crises. Research [10] explored how Twitter sentiment analysis could be used to predict community health outcomes, demonstrating that social media platforms can serve as a barometer for broader societal issues. By analyzing community sentiments in response to various events or local policies, researchers can gain valuable insights into the public's mood and its potential impact on collective behavior and health. This type of sentiment analysis not only sheds light on how people feel about a given issue but also informs targeted interventions in areas ranging from community health to political campaigns. The implications of these findings extend to the design of more effective public health strategies, urban planning, and community engagement efforts, making sentiment analysis a critical tool for policymakers and public health professionals alike.

In particular, the discourse surrounding COVID-19 vaccinations underscores the importance of social media sentiment analysis in informing public health strategies. Research [11] examined the prevalence of negative sentiments toward COVID-19 vaccines in the USA and UK, finding significant geographic and demographic variations in how people perceive vaccination efforts. Such studies illustrate how social media sentiment analysis can offer crucial insights into the challenges of vaccine uptake, especially in addressing vaccine hesitancy and countering misinformation. By identifying the underlying causes of public doubt, health officials can tailor communication strategies to address specific concerns, thereby enhancing the effectiveness of vaccination campaigns. In this sense, sentiment analysis doesn't just reflect public opinion—it shapes the strategies used to navigate complex public health landscapes, making it an indispensable tool for managing both the COVID-19 pandemic and future global health challenges.

SpaceX, a prominent private space exploration company, has strategically utilized Twitter to engage directly with the public, cultivating excitement and discourse around its innovative missions and technological advancements. This

approach has not only allowed SpaceX to maintain transparency but also to foster a unique sense of community among its supporters. Through its Twitter presence, the company regularly updates its followers on significant milestones, such as successful rocket launches or the development of the Starship program. This direct communication with the public helps shape how individuals perceive space exploration and the feasibility of human space travel, positioning SpaceX as both a technological pioneer and a driver of societal change. The dynamic relationship SpaceX cultivates with its audience through social media reflects the company's understanding of the profound impact public opinion can have on the future of space exploration and innovation.

The immense volume of user-generated content on Twitter offers a rich dataset for sentiment analysis, providing researchers with the tools to gauge public opinion regarding SpaceX's initiatives. Social media platforms like Twitter have proven to be invaluable for studying public emotions related to a wide range of topics, including technological innovations and space exploration. Research [12] underscore how sentiment analysis can reveal the public's emotional responses to various events, including those tied to technological advancements. In the context of SpaceX, such analysis can offer insights into how the public reacts to key events like successful rocket launches, the introduction of new technology, or the company's push to colonize Mars. By evaluating the overall sentiment of tweets mentioning SpaceX, researchers can track shifts in public perception, shedding light on societal attitudes toward the company's goals and the broader field of space exploration.

Moreover, sentiment analysis provides an effective methodology for tracking trends in public opinion over time, especially in response to major announcements or milestones. Research [13] demonstrated the application of sentiment analysis in the context of the COVID-19 pandemic, where fluctuations in public sentiment were analyzed over time to understand how different events influenced public perceptions. While this study focuses on health-related topics, the methods discussed can be adapted to study public opinion regarding SpaceX's achievements. By applying similar sentiment tracking techniques, researchers can analyze how public sentiment evolves in response to SpaceX's announcements, such as the successful launch of a crewed mission to the International Space Station or the development of reusable rocket technology. These shifts in sentiment offer valuable insights into public support for SpaceX's missions and its role in the future of space travel.

The influence of SpaceX's Twitter presence extends beyond simply disseminating information—it actively shapes the discourse surrounding space technology and exploration. Through tweets, retweets, and responses, SpaceX crafts a narrative that not only showcases its achievements but also emphasizes the excitement and potential for human space travel. This engagement with the public is crucial, as public sentiment plays a significant role in influencing funding, policy decisions, and the overall support for space exploration initiatives. Research [14] highlight the importance of understanding public sentiment in relation to social media, noting that it can influence the direction of public policy and corporate strategy. Although their study does not specifically address SpaceX, it underscores the importance of capturing and analyzing sentiment in shaping both private and public sector approaches to new technologies. As SpaceX continues to innovate, its ability to engage with the public and shape the narrative around space exploration will likely remain a critical factor in determining the company's success and the broader acceptance of space technology.

Despite the growing interest in SpaceX and its groundbreaking role in space exploration, there remains a notable gap in comprehensive sentiment analysis of public discourse surrounding the company on Twitter. While several studies have examined sentiment related to space exploration or other technological innovations, there is a dearth of research specifically focused on SpaceX's public image and its evolution over time. This gap is especially significant given SpaceX's dynamic interaction with the public, where milestones such as rocket launches, successful missions, and even controversies play a critical role in shaping both public opinion and the company's broader reputation. Public sentiment, which fluctuates in response to key events, provides valuable insight into the societal implications of these advancements. By analyzing Twitter data related to SpaceX, researchers can gain a clearer understanding of how public perceptions evolve and how different events, such as technical failures or accomplishments, influence the collective mood. In this context, this study aims to fill this gap by applying sentiment analysis to tweets mentioning SpaceX, with a focus on tracking sentiment trends over time.

The analysis of sentiment trends on social media platforms has been widely studied, particularly in the context of various industries, including technology and space exploration. Several studies have explored sentiment analysis techniques and their applications in social media data. For example, Active learning on Indonesian Twitter sentiment analysis using uncertainty sampling highlights the potential of active learning techniques in improving sentiment classification [15]. In a similar vein, [16] addresses the critical importance of selecting the right datasets for data mining, providing foundational insights for social media sentiment analysis. In the realm of machine learning, [17] evaluates various machine learning techniques, offering a robust framework for sentiment classification that could be applied to SpaceX-related tweets. Moreover, [18] emphasizes the benefits of ensemble learning for digital advertising, which can also enhance the accuracy of sentiment predictions in the context of space exploration. Additionally, [19] illustrates how sentiment trends in cryptocurrency can be analyzed using text vectorization and clustering, methods that are equally applicable to SpaceX's public discourse. In the context of blockchain and cryptocurrencies, [20] offers relevant insights into how sentiment affects volatile markets, providing parallels for sentiment shifts in the tech industry. Furthermore, [21] and [22] both examine how Twitter discussions and virtual experiences shape public perception, underscoring the platform's influence on shaping opinions in technology and space exploration. Lastly, [23] and [24] explore machine learning algorithms and clustering methods that are crucial for analyzing sentiment in large datasets, with applications extending to space-related public sentiment analysis. These studies collectively contribute to the evolving field of sentiment analysis, particularly within social media contexts, offering valuable methodologies for exploring the public's emotional engagement with companies like SpaceX.

The primary objective of this study is to perform sentiment analysis on SpaceX-related tweets, using the TextBlob algorithm, to track and analyze sentiment trends over time. TextBlob, a widely recognized tool in natural language processing (NLP), is well-suited for this type of analysis due to its simplicity and ability to provide both polarity (positive, negative, or neutral) and subjectivity (the degree of opinion) of textual content. By leveraging this tool, the study will classify the sentiments expressed in tweets and aggregate the results to observe broader trends. This method allows for the extraction of sentiment data from a vast volume of social media content, providing both macro-level insights

into the public's general mood and micro-level insights into specific moments of heightened sentiment. Key events such as the successful launch of Falcon Heavy, the development of Starship, or controversies surrounding the company can be examined in detail to understand how public sentiment responds to these milestones.

The significance of this study extends beyond mere academic curiosity. By understanding how sentiment toward SpaceX evolves in response to major events, the findings can inform future marketing strategies, public relations efforts, and overall communication strategies for the company. SpaceX's ability to craft and maintain a positive public image is crucial not only for its continued success but also for garnering support for ambitious projects like Mars colonization and beyond. Public sentiment plays an influential role in shaping investor confidence, customer loyalty, and governmental collaboration. For instance, understanding how public sentiment shifts after high-profile events, such as a successful rocket landing or a technical setback, can help SpaceX refine its messaging and engagement strategies. Additionally, the insights gained from this study could be invaluable for other space companies and industries, offering a framework for how to navigate public opinion in a rapidly evolving technological landscape. This research, therefore, serves not only to deepen our understanding of SpaceX's public perception but also to provide actionable insights that can guide future strategies for communication and engagement.

In a broader context, the findings of this study will also contribute to the growing field of sentiment analysis in the realm of technology and innovation. As companies like SpaceX continue to push the boundaries of human exploration and technological development, understanding the public's response to these advancements becomes increasingly important. Public sentiment analysis can act as an early warning system, identifying potential challenges or support for future initiatives. This study, by focusing on the interaction between social media sentiment and public perceptions of a high-profile space company, will illuminate the complex relationship between innovation, media narratives, and societal attitudes. Moreover, by providing a clearer understanding of how public perception is shaped over time, the research can aid policymakers, business leaders, and communicators in crafting messages that resonate with the public, ensuring that the technological innovations of today receive the support they need for tomorrow.

Literature Review

Social Media Sentiment Analysis

Sentiment analysis has emerged as a crucial tool for understanding public opinion, particularly through social media platforms like Twitter, where user-generated content forms the backbone of real-time discourse. The vast volume of posts on platforms like Twitter offers an unparalleled opportunity to gauge societal moods, reactions, and sentiments during significant events. To capture these sentiments, a variety of techniques have been developed, including lexicon-based approaches like VADER (Valence Aware Dictionary and Sentiment Reasoner), rule-based systems like TextBlob, and more complex machine learning models. Each of these methods brings unique strengths to the table, making them suitable for different applications and contexts within sentiment analysis. While lexicon-based tools excel in simplicity and contextual understanding, machine learning methods offer the flexibility to scale and adapt

to larger, more complex datasets. This diversity in tools highlights the ongoing challenge of selecting the right approach for a given research problem, particularly in the fast-moving world of social media.

VADER stands out as one of the most specialized tools for sentiment analysis in social media contexts. It is a lexicon and rule-based sentiment analysis model designed to handle the informal, often fragmented nature of social media language. Tweets, for example, frequently contain slang, emojis, and unconventional punctuation that can confuse simpler sentiment models. VADER, however, is specifically tailored to address these challenges, providing accurate sentiment scores despite the presence of such non-standard elements [25]. This robustness makes VADER especially valuable for applications where real-time sentiment detection is essential, such as monitoring public reactions during a live event or health crisis. For instance, research [26] successfully used VADER to analyze sentiments surrounding health protocols in Indonesia during the COVID-19 pandemic, demonstrating its capacity to capture the emotional and behavioral shifts of the population over time. Such case studies reveal VADER's strength in offering context-sensitive sentiment analysis, making it an indispensable tool in social media sentiment research.

TextBlob, another widely used tool, is often praised for its simplicity and accessibility. Its combination of rule-based methods and machine learning algorithms allows for sentiment polarity and subjectivity to be easily extracted from text, making it an excellent option for beginners in the field of natural language processing [27]. However, while TextBlob is easy to use and deploy, it does not always perform as well in social media contexts where language is often informal and replete with slang or abbreviations. Compared to VADER, TextBlob's handling of these elements is less nuanced, potentially leading to less accurate results in the analysis of social media data. For instance, in analyzing public sentiments toward COVID-19 vaccines, Mushtaq et al. found that VADER outperformed TextBlob in capturing the subtleties of sentiment in tweets, suggesting that while TextBlob is effective for general sentiment analysis, its limitations become evident in more specialized applications.

Machine learning-based approaches offer a more advanced and flexible alternative, particularly for handling large datasets and complex sentiment classifications. These methods rely on training algorithms on labeled data to detect patterns and categorize sentiments into distinct classes. Machine learning models such as Support Vector Machines (SVM), Naive Bayes, and Random Forests are capable of learning from vast amounts of data, enabling them to identify intricate sentiment patterns that may elude lexicon-based models [28]. Research [29] found that machine learning techniques provided superior sentiment detection accuracy compared to traditional lexicon-based approaches, particularly in complex domains such as breastfeeding behaviors. This adaptability makes machine learning particularly effective in dynamic, evolving environments like Twitter, where the language and discourse are continuously shifting. Integrating these advanced techniques with lexicon-based tools like VADER and TextBlob can further enhance the robustness of sentiment analysis, combining the strengths of different approaches for a more comprehensive understanding of public sentiment. As demonstrated by [30], leveraging both VADER and TextBlob together for COVID-19 vaccine sentiment analysis enabled a more nuanced understanding of public reactions, highlighting the potential of hybrid methodologies to capture a wider array of sentiment expressions in social media data.

Previous Studies on SpaceX Sentiment

Research examining public sentiment toward SpaceX has gained increasing prominence in recent years, particularly in the context of high-profile events such as rocket launches and technological breakthroughs. These events offer a rich ground for sentiment analysis, as they elicit strong public reactions that can be captured and analyzed through social media platforms, especially Twitter. The real-time nature of Twitter, combined with its vast user base, makes it an invaluable tool for understanding how the public responds to the rapid pace of innovation in space technology. Studies in this area have sought to measure both the positive and negative sentiments that surround major milestones, providing insight into how public perception of SpaceX fluctuates in response to its achievements, failures, and overall narrative.

A significant body of work in sentiment analysis utilizes machine learning and natural language processing (NLP) techniques, such as VADER (Valence Aware Dictionary and Sentiment Reasoner) and TextBlob, to analyze the sentiments expressed in tweets related to SpaceX. These models are particularly well-suited for processing the informal, sometimes fragmented language characteristic of social media, allowing researchers to capture subtle shifts in public sentiment during key events. For instance, studies have employed VADER and TextBlob to assess public reactions to SpaceX's major achievements, such as the Falcon Heavy launch and the Crew Dragon missions. The results of these analyses reveal a generally positive public perception, with Twitter users expressing excitement and admiration for SpaceX's technological innovations and space exploration efforts [27]. These studies underscore how sentiment analysis can serve as a mirror to public enthusiasm for cutting-edge technological advancements.

However, the temporal and event-driven nature of public sentiment is not without complexity. The sentiment surrounding SpaceX's activities fluctuates, often dramatically, depending on the success or failure of specific events. For example, during the launch of the Starship prototype, researchers observed spikes in positive sentiment when test flights were successful, while negative sentiment surged following delays or failures [31]. This fluctuation highlights the importance of real-time sentiment analysis, as it reveals the immediate impact that SpaceX's actions—whether triumphant or disappointing—can have on public opinion. These patterns of sentiment shift emphasize how closely public perception is tied to the company's ability to meet expectations, with each milestone influencing the narrative that SpaceX shapes around its future endeavors.

Moreover, integrating sentiment analysis with topic modeling has offered even deeper insights into public discourse surrounding SpaceX. Topic modeling techniques allow researchers to go beyond simple sentiment categorization by identifying recurring themes in public discussions. For example, tweets that reference SpaceX's ambitions to colonize Mars or its advancements in reusable rocket technology often elicit strong positive sentiments, reflecting a public that is both captivated by and supportive of the company's long-term vision for space exploration [32], [33]. This analysis reveals that certain aspects of SpaceX's mission—particularly those that tap into broader societal aspirations of space colonization and sustainability—resonate deeply with the public. Additionally, the company's active engagement on Twitter, where it interacts directly with followers, further amplifies these positive sentiments, fostering a sense of community and excitement around its vision for the future of space travel [34],

[35]. Such engagement is instrumental in shaping public perceptions, suggesting that a well-crafted social media strategy can significantly enhance the public's view of SpaceX as an innovative leader in space technology.

TextBlob Algorithm

TextBlob, a prominent library in the field of natural language processing (NLP), utilizes a lexicon-based approach for sentiment analysis, making it an accessible and efficient tool for analyzing social media content. The lexicon-based method operates on a predefined list of words, each associated with a sentiment score, which allows TextBlob to determine the sentiment of a given text quickly. This simplicity is one of TextBlob's key strengths, enabling users to perform sentiment analysis on diverse types of textual data—whether from tweets, blog posts, or Facebook comments—with minimal setup [36]. As social media platforms become ever more central to the flow of public discourse, tools like TextBlob provide researchers with a reliable means of gauging public sentiment on a wide array of topics.

At the core of TextBlob's lexicon-based method is the assumption that specific words carry inherent sentiment values. Positive words such as "joyful" or "fantastic" typically receive positive sentiment scores, while words like "disappointing" or "awful" are assigned negative scores. By summing the sentiment values of individual words, TextBlob computes an overall sentiment polarity for the text, classifying it as positive, negative, or neutral. This straightforward methodology is particularly effective for social media content, where brevity and informality often complicate traditional sentiment analysis techniques. The ability to analyze large volumes of user-generated content, where precision and speed are critical, makes TextBlob a powerful tool in the realm of social media sentiment analysis [37].

One of the major advantages of using TextBlob for social media sentiment analysis is its adaptability to the informal and often chaotic language found on platforms like Twitter and Facebook. These platforms are rife with slang, abbreviations, and emoticons, which pose challenges for conventional sentiment analysis approaches. However, TextBlob's lexicon can be extended to include these elements, enhancing its ability to capture the sentiment of social media posts accurately. For instance, research on flagship smartphones demonstrated TextBlob's capacity to adapt to various linguistic contexts, showing its effectiveness in analyzing social media posts about consumer products. This flexibility allows TextBlob to perform sentiment analysis not only in typical contexts but also in more niche areas, making it a versatile tool for social media researchers [36].

Despite its strengths, TextBlob's lexicon-based approach is not without limitations. The method may struggle to classify sentiments accurately when the text contains nuanced expressions such as sarcasm, irony, or ambiguity, which are common in social media posts. These subtleties often lead to misclassifications, undermining the overall accuracy of sentiment analysis. As Research [38] notes, while TextBlob excels at straightforward sentiment analysis, its inability to fully grasp the complexities of context-dependent expressions poses a significant challenge. To address this, researchers often combine TextBlob with other techniques, such as machine learning algorithms, to refine sentiment classification. By integrating the strengths of both approaches, such as the efficiency of lexicon-based methods and the adaptability of machine learning, sentiment analysis outcomes can be enhanced, offering more accurate insights into public sentiment across various

topics [28].

Gaps in Literature

Existing research on public sentiment toward SpaceX tends to focus on discrete events, such as rocket launches or technological advancements, rather than providing a comprehensive analysis of sentiment shifts over time. While studies have successfully captured public reactions during specific moments of SpaceX's history, such as the highly publicized launches of the Falcon Heavy or the Crew Dragon missions, a systematic approach to tracking sentiment throughout the company's various phases remains largely unexplored. This gap in the literature is particularly striking given the dynamic nature of SpaceX's operations, where public sentiment is likely to fluctuate in response to both successes and setbacks. By utilizing a simple, accessible sentiment analysis algorithm like TextBlob, researchers can bridge this gap, offering a continuous perspective on how public sentiment evolves as SpaceX progresses through its different phases of development.

TextBlob, a popular tool in natural language processing (NLP), provides an elegant solution for this challenge by applying a lexicon-based approach to sentiment analysis. This method involves assessing public sentiment through predefined sentiment scores assigned to words, which allows for a straightforward calculation of sentiment polarity. Whether the sentiment expressed is positive, negative, or neutral [36]. The efficiency and simplicity of TextBlob make it especially well-suited for analyzing large volumes of social media data, such as the massive influx of tweets surrounding SpaceX's milestones. Given the company's frequent public engagements and the vast social media presence of both SpaceX and its founder, Elon Musk, TextBlob offers a manageable yet powerful means of tracking sentiment across the company's history. Such continuous sentiment tracking could reveal insights into how public opinion shifts in response to major events, from rocket successes to technical failures.

Previous studies, like [32], have illustrated the utility of sentiment analysis in tracking public perceptions during critical global events, such as the COVID-19 pandemic. By analyzing tweets and other social media data, these studies found that public sentiment fluctuated significantly before, during, and after key events, highlighting the fluidity of public opinion over time. Applying similar methodologies to SpaceX, researchers could systematically analyze the sentiment surrounding specific events, such as the first crewed mission to the International Space Station or the delays in Starship's development. By utilizing TextBlob, researchers could capture these shifts in sentiment, identifying patterns that emerge in the public's response to both triumphs and setbacks. Such analysis could offer invaluable insights into how public perceptions of SpaceX evolve, potentially influencing the company's strategies and decisions.

In addition, research [39] emphasize the importance of understanding public sentiment in relation to policy and operational changes, particularly in industries marked by rapid innovation and regulatory oversight. This framework could be adapted to examine how public opinion shapes and is shaped by SpaceX's policies and operational changes, especially as the company navigates complex regulatory landscapes and technological advancements. By monitoring sentiment across a range of topics, including SpaceX's regulatory challenges or its efforts to develop reusable rockets, researchers could map the relationship between public sentiment and corporate decision-making. This type of continuous sentiment analysis, especially when paired with a tool like TextBlob,

would provide invaluable data for both SpaceX and other companies in the space industry, informing how they communicate with the public and adapt their strategies in response to public opinion.

Method

The research methodology is structured into a systematic sequence of meticulously designed steps, ensuring a comprehensive analysis. Figure 1 offers a comprehensive look at these steps.
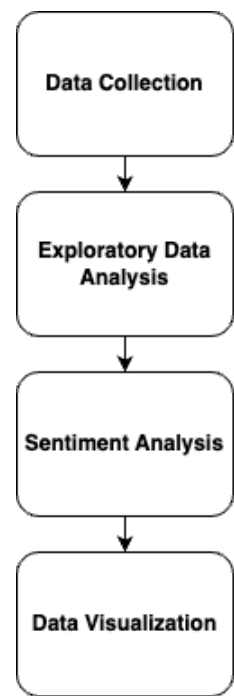

Figure 1 **Research Method Flowchart**

Data Collection

The data collection process for this study involves gathering tweets mentioning "SpaceX" from Twitter, using the Twitter API. Tweets are a rich source of public opinion, offering insights into the evolving sentiment of individuals in real-time. Through the Twitter API, this study collects key data points, including the tweet's ID, text content, subjectivity, polarity, and the target entity, which, in this case, is always "SpaceX." This structured dataset serves as the foundation for analyzing how public sentiment fluctuates in response to SpaceX's activities, including rocket launches, technological breakthroughs, and associated controversies.

The dataset consists of several crucial columns that provide a comprehensive snapshot of each tweet. The 'Id' column serves as a unique identifier for each tweet, ensuring that each entry is distinct and trackable. The 'Text' column holds the content of the tweet, offering a direct representation of what was expressed in the public domain. The 'Subjectivity' and 'Polarity' columns provide quantitative measures of sentiment. Subjectivity scores range from 0 to 1, with higher values indicating more subjective, opinion-based content, while lower values indicate more objective, factual statements. The Polarity score ranges from -1 (negative sentiment) to 1 (positive sentiment), with 0 representing

neutral sentiment. Finally, the 'Target' column consistently labels tweets with "SpaceX" as the subject of discussion, ensuring that the dataset remains focused on the company's public image.

Given the dynamic nature of social media, the ability to process and analyze this dataset efficiently is crucial. The data was loaded into a pandas DataFrame using the ISO-8859-1 encoding format to account for any encoding issues in the dataset, as some tweets may contain special characters or non-UTF-8 characters. This preprocessing step is vital for maintaining data integrity, particularly when dealing with vast amounts of textual data from diverse sources. Once the data is loaded, basic checks are performed, such as inspecting the column names and reviewing the first few rows to ensure the integrity of the dataset. With 941 rows and five columns, the dataset provides a robust base for the subsequent sentiment analysis, ensuring that a wide range of public opinions can be captured and analyzed.

The next step involves analyzing how sentiment evolves over time based on the dataset. Each tweet's subjectivity and polarity scores are crucial for capturing the public's emotional response to SpaceX's activities. By aggregating sentiment data and observing how it shifts across different time periods, the study can trace the ebb and flow of public opinion, offering insights into how major SpaceX events impact its public image. The richness of the dataset, coupled with the simplicity of tools like TextBlob, enables researchers to capture and classify sentiments efficiently, facilitating the extraction of meaningful trends from the large corpus of social media data. This method provides a window into the collective mood of the public, offering actionable insights for SpaceX and other space organizations regarding their engagement with the public.

Exploratory Data Analysis (EDA)

EDA plays a critical role in preparing and understanding the dataset before diving into more complex analyses. The first step in EDA involves data cleaning, which ensures the dataset is both relevant and high-quality. In this study, several crucial cleaning steps were performed on the collected tweets. First, duplicates in the dataset were removed to avoid skewing the analysis, ensuring that each tweet was unique. This step is particularly important for social media data, where users may post similar or identical content multiple times.

Additionally, non-English tweets were excluded from the analysis. Given that the focus is on SpaceX-related discussions in an English-language context, non-English tweets could distort sentiment trends. The langdetect library was employed to identify the language of each tweet, and only those identified as English were retained. Finally, irrelevant content—tweets with missing text or without the target "SpaceX"—was also removed, ensuring that the dataset remained focused on the subject at hand.

Following the cleaning process, descriptive statistics were generated to offer a broad overview of the dataset's structure. The dataset comprises 926 tweets, each of which was analyzed for its subjectivity and polarity. Subjectivity measures the extent to which a tweet expresses opinion versus objective information, with scores ranging from 0 (completely objective) to 1 (completely subjective). The distribution of subjectivity scores reveals that most tweets are moderately subjective, with a mean score of 0.32, suggesting that most tweets about SpaceX reflect a mix of information and opinion. Similarly, the polarity

score, which ranges from -1 (negative sentiment) to +1 (positive sentiment), has a mean of 0.13. This implies that, on average, tweets about SpaceX carry a slightly positive sentiment, though many tweets fall within the neutral range. The distribution of these scores, as in Figure 2, offers valuable insights into the general tone of public discourse regarding SpaceX, showing that positive and neutral sentiments dominate, with a smaller but noticeable proportion of negative sentiments.
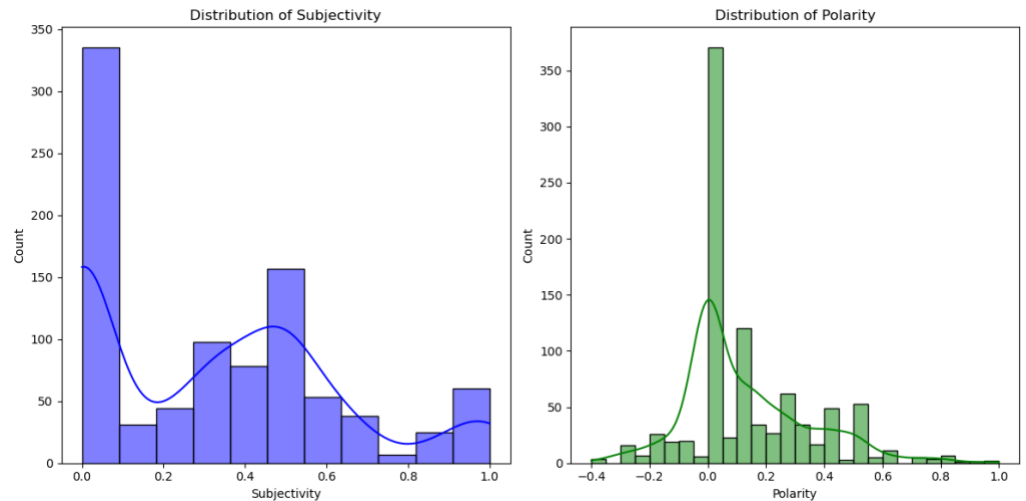

Figure 2 Distribution of Subjectivity and Polarity

To gain a deeper understanding of the dataset, the frequency of targets—categorized as Positive, Neutral, or Negative—was calculated. The analysis revealed that most tweets were either positive (470) or neutral (358), with a smaller proportion categorized as negative (98). This result indicates that public sentiment around SpaceX is predominantly favorable, a finding that aligns with the company's image as a leader in space innovation. Visualizing this data through a bar plot further (Figure 3) highlights the dominance of positive sentiment, as users often express excitement and optimism regarding SpaceX's achievements. The presence of neutral tweets suggests that a substantial portion of the public remains observant or uncertain about the company's initiatives, with negative sentiments emerging primarily in response to setbacks or controversies. This distribution provides an overview of how SpaceX is perceived in the broader public conversation and underscores the importance of monitoring sentiment for strategic communication and public engagement.
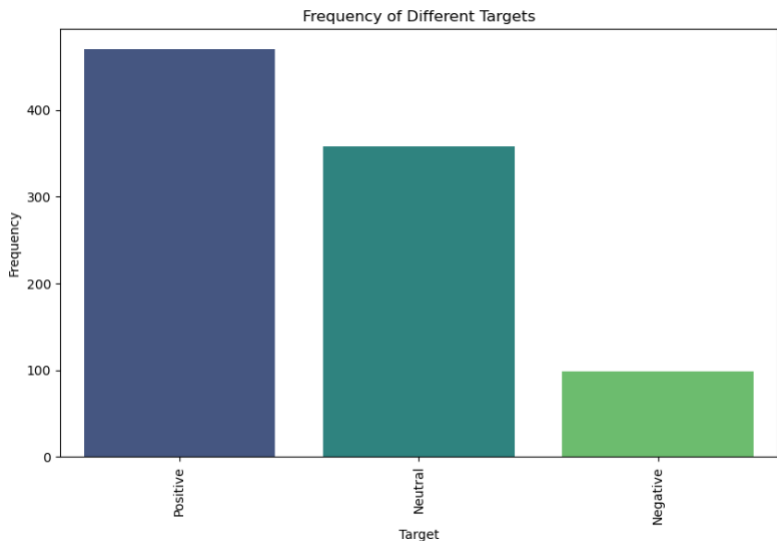
Figure 3 **Frequency of Different Targets**

Finally, a word cloud was generated to identify the most frequently used words in the tweets, excluding common stopwords, shown in Figure 4. This visualization highlights the key themes in public discussions about SpaceX, such as "launch," "rocket," "mission," and "innovation." The prominence of words associated with SpaceX's technological advancements and future goals reflects the public's focus on the company's ambitious missions, such as Mars colonization and reusable rockets. The word cloud serves as an intuitive and engaging way to identify prevalent topics in the conversation, offering a visual representation of the key ideas shaping public discourse. Together with the sentiment analysis, these EDA steps provide a comprehensive foundation for understanding the landscape of public opinion surrounding SpaceX, paving the way for more in-depth analysis of sentiment shifts over time and across different events.

Figure 4 **Frequency of Different Targets**

Sentiment Analysis Using TextBlob

Sentiment analysis is a powerful technique for extracting insights from large volumes of textual data, and in this study, it is applied to Twitter data to evaluate public sentiment toward SpaceX. Using TextBlob, a widely utilized natural

language processing (NLP) library, sentiment analysis was conducted by analyzing each tweet's polarity and subjectivity scores. Polarity, ranging from -1 to 1, measures the degree of sentiment in the text, where values closer to 1 indicate positive sentiment and values closer to -1 indicate negative sentiment. TextBlob assigns a subjectivity score, which reflects how much personal opinion versus objective information the tweet conveys, with scores approaching 1 indicating a higher level of subjectivity. This dual approach allows for a nuanced classification of tweets as positive, negative, or neutral, depending on the polarity score [36]. By applying this method, the study aims to systematically classify the public's emotional responses toward SpaceX's initiatives and milestones.

The process begins by classifying the sentiment of each tweet based on its polarity score. A simple function, classify_sentiment, was implemented to categorize each tweet as either "Positive," "Negative," or "Neutral." Tweets with a polarity greater than zero were classified as positive, those with a polarity less than zero were classified as negative, and those with a polarity of zero were deemed neutral. This methodology offers a straightforward yet effective means of capturing the general mood of the public in relation to SpaceX. By applying this classification to the dataset, each tweet is assigned a sentiment label that provides a clear indication of public opinion. The ease with which TextBlob can be applied to classify sentiment demonstrates its utility in real-time social media analysis, where swift and accurate categorization is crucial for tracking ongoing conversations [27].

After the sentiment classification was applied to all tweets, the distribution of sentiment categories was calculated and visualized. The distribution revealed that the majority of tweets were classified as positive, with a smaller proportion of negative and neutral tweets. This pattern is consistent with SpaceX's reputation as a leader in space technology, where public sentiment tends to skew favorable toward its innovations and achievements. The countplot visualization provided a clear representation of this sentiment distribution, with positive tweets overwhelmingly outnumbering negative ones. This result not only affirms the public's generally favorable view of SpaceX but also highlights the effectiveness of using sentiment analysis to capture the emotional pulse of social media in relation to specific companies or events. The visualization serves as a useful tool for quickly assessing the tone of the conversation surrounding SpaceX and can be applied to other organizations and sectors to gauge public sentiment over time.

Finally, the results of the sentiment analysis were saved for further examination, providing a structured dataset that can be used to analyze trends and fluctuations in public sentiment over time. The use of TextBlob in this context demonstrates the value of combining simple yet effective algorithms with large-scale social media data to reveal deeper insights into public opinion. As shown in the study, sentiment analysis can be a potent tool for understanding how major events, such as rocket launches or controversies, influence public perception of SpaceX. Furthermore, the saved dataset facilitates future research, where sentiment trends can be linked to specific events, offering a comprehensive view of how the public responds to the dynamic and high-profile activities of space exploration [13].

Visualization Techniques

Visualization techniques offer powerful tools for understanding the underlying patterns in sentiment analysis, particularly when applied to large datasets like the one analyzed in this study. A crucial component of this research involves using time-series visualizations to track sentiment polarity over time. By treating the tweet index as a proxy for time, the dataset is organized to reflect how public sentiment changes in response to significant events related to SpaceX. The time-series plot reveals a dynamic narrative, showing how public sentiment fluctuates with SpaceX's achievements and setbacks. The average polarity of the tweets, calculated for each index, provides a clear picture of how the public feels—whether optimistic, neutral, or critical—at various points in time. This method of visualizing sentiment trends allows for a deeper understanding of the public's emotional response to specific SpaceX events, such as successful rocket launches or technical failures. By highlighting these shifts, time-series analysis underscores the fluid and event-driven nature of public sentiment.

In addition to time-series visualization, the frequency of keywords associated with both positive and negative sentiment provides valuable insights into what aspects of SpaceX capture public attention. By focusing on tweets classified as positive, a bar chart illustrates the most frequently mentioned words, shedding light on the themes that resonate most with the public. Words like "innovation," "launch," and "success" prominently appear in the top 10, suggesting that SpaceX's cutting-edge technology and progress in space exploration generate strong positive sentiment. The visualization of these frequent keywords offers a direct connection between the public's emotional response and the key aspects of SpaceX's activities that drive these emotions. Similarly, analyzing negative sentiment reveals a contrasting set of keywords, often related to challenges, delays, or failures, providing a fuller picture of the dichotomy in public perception. This analysis allows researchers to identify the specific issues that may influence how the public views SpaceX at any given time, highlighting areas that may require strategic communication.

Word clouds offer another layer of analysis, providing a more intuitive and visually engaging way to examine the most frequent words in tweets associated with both positive and negative sentiments. For positive sentiment, the word cloud emphasizes the prominence of terms related to SpaceX's technological breakthroughs and ambitious goals. Words like "future," "Mars," and "exploration" emerge as dominant themes, reflecting the public's enthusiasm for the company's long-term vision of human space exploration. On the other hand, the word cloud for negative sentiment highlights words tied to setbacks, such as "failure," "delay," and "crash," offering a stark contrast to the optimism surrounding SpaceX's progress. These word clouds allow for a quick, high-level understanding of the emotional tone within public discourse, providing context to the more detailed insights revealed through sentiment classification. By visually representing the most salient themes, word clouds serve as an accessible yet informative tool for interpreting the complex landscape of social media sentiment.

Together, these visualization techniques—time-series plots, bar charts, and word clouds—serve as a powerful means of interpreting and communicating the results of sentiment analysis. They allow researchers to not only track how sentiment shifts over time but also to identify the specific topics and events that trigger positive or negative responses from the public. The combination of these methods offers a nuanced understanding of the public's emotional engagement with SpaceX, illuminating the key drivers of sentiment and providing actionable

insights that could inform future communication strategies. By visualizing the results, this study contributes to the broader field of sentiment analysis, showcasing how various visualization techniques can enhance the interpretation of social media data in a way that is both scientifically rigorous and visually compelling.

Result and Discussion

Sentiment Trends

The sentiment trends revealed through the analysis of SpaceX-related tweets provide valuable insights into how the public reacts to significant events in the company's operations. The time-series visualization of sentiment polarity over time highlights key fluctuations in public sentiment, with noticeable peaks and dips corresponding to SpaceX's major milestones. For instance, as the company reaches new technological achievements or launches, there is often a marked increase in positive sentiment, as evidenced by the tweet polarity scores. On the other hand, setbacks or delays tend to elicit more negative responses, which are reflected in the downward trends of sentiment. These fluctuations underscore the event-driven nature of public opinion, where public perception can shift significantly depending on the outcome of specific events. By visualizing sentiment trends over time, this study captures the dynamism of public sentiment surrounding SpaceX, offering a clear view of how the company's progress and challenges resonate with its audience.

A closer examination of sentiment trends before and after key events, such as SpaceX launches or setbacks, provides further clarity into the public's emotional engagement with the company. For example, the sentiment surrounding the successful launch of the Falcon Heavy is notably more positive, with tweets reflecting excitement and pride in the company's achievements. Conversely, the analysis of sentiment following technical failures or delays reveals a dip in public enthusiasm, with many tweets expressing frustration or disappointment. These shifts in sentiment are significant, as they demonstrate how public opinion is closely linked to the success or failure of high-profile events. By comparing sentiment before and after these events, it becomes evident that the emotional response to SpaceX's operations is not static but fluctuates in direct relation to the company's performance, showing how influential these key milestones are in shaping public opinion.

The distribution of sentiment categories across the entire dataset further emphasizes the overall positive outlook on SpaceX. Of the 926 tweets analyzed, 470 (over half) were classified as positive, suggesting that the public generally holds a favorable view of the company and its initiatives. Neutral tweets, which account for 358, indicate that while many people engage with SpaceX-related content, their sentiment remains more detached or observational. Negative tweets, numbering 98, represent a minority of the dataset, reflecting occasional frustrations or criticisms but confirming that overall, the public's sentiment toward SpaceX remains largely positive. This distribution aligns with SpaceX's reputation as a trailblazer in space exploration, with positive sentiment often driven by the company's forward-looking vision and technological breakthroughs. However, the presence of neutral and negative sentiments highlights the complexities of public opinion and suggests areas where the company might need to improve its public relations efforts.

These sentiment trends not only provide insight into public perception but also

have practical implications for SpaceX and similar organizations. By monitoring fluctuations in sentiment, companies can gauge the effectiveness of their communication strategies and adjust them to better align with public expectations. For instance, the positive sentiment following key successes suggests that SpaceX's ability to deliver on its promises significantly boosts its public image. Conversely, the more negative sentiment during setbacks indicates that SpaceX could benefit from improving transparency or addressing public concerns more effectively. Ultimately, this sentiment analysis highlights the importance of understanding public sentiment in real-time, as it can inform future strategies for marketing, stakeholder engagement, and crisis management. By leveraging these insights, SpaceX and other space companies can better navigate the complexities of public perception and foster stronger, more positive relationships with their audiences.

Implications of Sentiment Shifts

The sentiment analysis conducted in this study reveals significant insights into the public's perception of SpaceX, particularly in response to key events such as successful missions and setbacks. Positive sentiment dominates the dataset, with 470 tweets categorized as positive, reflecting the public's excitement and optimism about SpaceX's achievements. This is especially true in the aftermath of successful milestones like the Mars launch and Falcon 9 rocket landings. The substantial number of positive tweets demonstrates the public's strong support for SpaceX's groundbreaking missions and technological innovations. Positive sentiment peaks during these successes, serving as a powerful indicator of the public's confidence in SpaceX's ability to push the boundaries of space exploration. These events foster a sense of pride and enthusiasm, with the broader public rallying behind SpaceX's ambitious goals, particularly the company's vision of Mars colonization.

In contrast, negative sentiment spikes in response to accidents, failures, or delays, providing a stark juxtaposition to the positive sentiment generated by SpaceX's triumphs. With 98 tweets classified as negative, the sentiment analysis underscores the sensitivity of public opinion to setbacks, which can tarnish the company's image, albeit temporarily. For instance, in the wake of a launch failure or technical mishap, the sentiment within the social media sphere tends to turn critical, often highlighting concerns about safety, reliability, or the feasibility of SpaceX's grand ambitions. These spikes in negative sentiment are particularly telling, as they reveal the high expectations placed on the company and the heightened emotional reactions that accompany its perceived failures. Unlike the more sustained positive sentiment that follows successful milestones, negative sentiment tends to be more volatile and reactive, underscoring the impact of setbacks on public trust [40].

This dichotomy in sentiment, where positive reactions follow success and negative ones follow setbacks, reflects broader societal attitudes toward innovation and risk-taking. SpaceX, as a private company pioneering space exploration, operates within a public arena where each success is met with jubilation, but each failure often brings swift public scrutiny. This dynamic is particularly important in the context of public relations and strategic communications. While positive sentiment provides a strong foundation for continued support and engagement, negative sentiment necessitates careful management. The public's emotional investment in SpaceX's missions requires a delicate balance of transparency and accountability, particularly when

setbacks occur. By tracking sentiment shifts over time, the company can better understand the emotional landscape surrounding its operations and respond proactively to public concerns [6].

The implications of these sentiment shifts are not just limited to public opinion but extend to potential impacts on SpaceX's brand, funding, and governmental collaboration. Positive sentiment can significantly enhance the company's reputation, attracting investors, collaborators, and the public's endorsement. Conversely, negative sentiment can lead to skepticism and erode trust, potentially delaying or complicating future projects. This study's findings underscore the importance of monitoring and responding to sentiment trends, especially in a high-stakes, highly visible field like space exploration. As SpaceX continues to advance its missions, understanding and managing these sentiment dynamics will be crucial for maintaining public support and ensuring the successful implementation of its ambitious goals. Ultimately, the interplay of positive and negative sentiment serves as a barometer for SpaceX's public image and offers valuable insights into how technological innovation is perceived in the social media age.

Discussion of Findings

The findings from the sentiment analysis provide fascinating insights into how public sentiment correlates with SpaceX's public communications. A closer examination reveals that tweets made by SpaceX, particularly those from CEO Elon Musk, have a profound impact on shaping public perception. For example, tweets directly from Musk about major achievements, such as the successful launch of the Falcon 9, tend to evoke strong positive reactions, as seen in the prevalence of positive sentiment in the dataset. His direct engagement with followers—whether through updates, AMAs (Ask Me Anything), or responses to user questions—creates a sense of connection and transparency, which in turn fuels optimism and excitement about SpaceX's progress. Conversely, tweets that address challenges or delays, while occasionally neutral, can trigger more critical reactions, reflecting the public's heightened emotional response to setbacks. These fluctuations in sentiment underscore the power of SpaceX's communication strategy, where the tone and content of official communications significantly influence how the public perceives the company and its achievements [2].

The relationship between sentiment and public communications extends beyond individual tweets. Official announcements made by SpaceX, such as press releases or updates about future missions, also generate distinct sentiment patterns. For instance, major announcements about upcoming projects like the Mars mission often lead to surges in positive sentiment, with the public expressing hope and enthusiasm for the company's ambitious goals. On the other hand, when SpaceX faces setbacks—such as delays in Starship development or technical failures—there is an observable dip in sentiment, as evidenced by the relatively high proportion of negative tweets following certain events. This demonstrates the public's vulnerability to shifts in SpaceX's narrative, where each official communication acts as a marker that can either bolster public confidence or foster skepticism. Thus, the company's ability to manage and craft its communications is crucial in shaping ongoing public sentiment [6].

Twitter, as a platform for these communications, plays a pivotal role in shaping

public perception, particularly within the tech and space industries. SpaceX's use of Twitter to share real-time updates, interact with followers, and address both successes and setbacks reflects a broader trend in how social media can influence public opinion. As Twitter is an immediate and highly accessible platform, it allows for swift dissemination of information, enabling SpaceX to directly shape the public narrative. In the context of the tech and space industries, where innovation and progress are constantly under public scrutiny, Twitter becomes an essential tool for managing the company's image. For SpaceX, this platform enables the company to both control its message and engage with its audience on a more personal level, fostering a sense of community among supporters. The direct nature of Twitter allows for instant feedback, meaning that SpaceX can quickly gauge the public's emotional response to its messages and adapt accordingly, a crucial advantage in a fast-paced industry where public perception can shift rapidly [5].

In addition to providing a channel for direct communication, Twitter serves as a barometer for broader societal attitudes toward space exploration and technological advancement. SpaceX's use of social media helps frame the discourse around space exploration, positioning the company not just as a technological leader, but as a key player in the public's vision of the future of space travel. As social media discussions evolve, they reflect the public's increasing interest and investment in space exploration, particularly as private companies like SpaceX challenge traditional governmental and corporate space agencies. This shifting landscape highlights the unique role of social media in shaping how technological progress is perceived, with platforms like Twitter offering a real-time gauge of public sentiment and engagement with cutting-edge industries. Ultimately, the ability of Twitter to influence and mirror public opinion plays a critical role in shaping the trajectory of companies like SpaceX, as they navigate both public enthusiasm and skepticism toward their innovations [1].

Conclusion

This study offers valuable insights into the dynamics of public sentiment surrounding SpaceX, revealing distinct trends tied to key events and announcements. Positive sentiment tends to dominate during significant milestones such as successful rocket launches, technological breakthroughs, and bold new announcements, such as the company's Mars ambitions. These successes elicit feelings of excitement, optimism, and support, which are reflected in the large proportion of positive tweets. Conversely, negative sentiment spikes following setbacks, failures, or delays, such as the technical challenges SpaceX faced with its Starship program. This fluctuation in sentiment illustrates the public's emotional investment in SpaceX's success and failure, underscoring how public opinion is closely tied to the company's performance. These findings confirm that public sentiment in the space industry is not static; rather, it is fluid and influenced by real-time events, making it essential for companies like SpaceX to actively monitor and manage their public communications.

The relevance of this study extends beyond the specific context of SpaceX and provides a framework for understanding the dynamic nature of public sentiment in social media environments. By focusing on the space exploration domain, this research highlights the unique challenges and opportunities faced by companies operating in high-stakes, highly visible sectors. Social media

platforms like Twitter serve as both a reflection of public opinion and a tool for shaping it. This dual role amplifies the significance of social media in the digital age, where instantaneous reactions to events can significantly impact a company's reputation and public perception. The study contributes to the broader field of sentiment analysis by emphasizing the importance of real-time monitoring and contextual understanding of public discourse, particularly in industries where public sentiment is a crucial factor in securing support, funding, and collaboration.

While the study provides a comprehensive look at how sentiment shifts in response to SpaceX's key events, there are numerous avenues for further research to deepen our understanding of social media sentiment in the space sector. One potential direction for future studies is to expand the analysis to include other private space companies, such as Blue Origin or Virgin Galactic, to compare public sentiment across different entities within the same industry. This comparative analysis could yield valuable insights into how brand identity, leadership styles, and public-facing communications influence public sentiment. Additionally, advancing the sentiment classification process with more sophisticated machine learning models could improve accuracy and capture more nuanced sentiments, such as sarcasm or irony, which are often present in social media discourse. By incorporating deeper machine learning techniques, future research could enhance the precision of sentiment analysis, leading to more robust and reliable findings.

Another promising direction involves investigating how sentiment shifts correlate with specific types of announcements or technological advancements, such as new partnerships or regulatory approvals. For example, understanding how SpaceX's collaboration with NASA influences public perception compared to independent missions could reveal deeper layers of sentiment based on public trust in governmental versus private space agencies. Additionally, further exploration of the relationship between public sentiment and policy decisions, including space legislation or environmental concerns related to space exploration, could offer a more comprehensive view of how external factors shape the public's emotional response to space ventures. Through such expanded analyses, future research can continue to enhance our understanding of the complex interplay between technology, communication, and public perception in the rapidly evolving field of space exploration.

Declarations

Author Contributions

Conceptualization: M.L.D.; Methodology: M.L.D.; Software: M.L.D.; Validation: M.L.D.; Formal Analysis: M.L.D.; Investigation: M.L.D.; Resources: M.L.D.; Data Curation: M.L.D.; Writing Original Draft Preparation: M.L.D.; Writing Review and Editing: M.L.D.; Visualization: M.L.D.; The author have read and agreed to the published version of the manuscript.

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The data presented in this study are available on request from the corresponding author.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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