

Multimodal Social Network Analysis: Exploring Language, Visual, and Audio Data in Online Communities

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Abstract

This research investigates the complex dynamics of online communities in Saudi Arabia by analyzing textual and visual data. This study reveals a mutually beneficial association between technological discourse and visual representation, highlighting the dynamic narrative of a society that is profoundly involved in technological progress. Furthermore, the analysis uncovers the existence of a participatory culture wherein active discussions regarding cultural elements actively contribute to the formation and collaborative development of visual depictions of cultural events within the online community. Moreover, this study presents a challenge to prevailing perspectives on entertainment by emphasizing the wide range of cultural manifestations, surpassing the notion that humor is the exclusive portrayal within this intricate sphere. The study places its primary emphasis on textual and visual modalities, but it also recognizes the potential importance of audio dynamics. It encourages further investigation into the auditory aspect of online interactions. This study makes a valuable contribution to the scholarly understanding of the dynamic cultural identity, integration of technology, and various modes of expression found within the digital realm of online communities in Saudi Arabia.

Keywords: Saudi Arabia, multimodal social network analysis, cultural identity, technology integration, entertainment diversity

1. Introduction

The virtual communities in Saudi Arabia have seen major transformations as a result of the increased availability of internet access and the widespread usage of social media platforms (Hayman, 2017). As the significance of virtual spaces in facilitating communication and transmitting information increases, there arises a pressing need for advanced analytical methodologies capable of comprehensively capturing the multifaceted nature of online interactions. The conventional practice of Social Network Analysis (SNA) has proven valuable in uncovering the fundamental frameworks of online communities (Jan & Vlachopoulos, 2019). However, the dynamic and evolving nature of the digital environment today calls for a comprehensive approach that acknowledges the diverse range of communication methods.

Given the intricate integration of language, imagery, and auditory elements within the contemporary digital landscape, it is imperative to adopt a methodology that transcends the confines of text-focused research. New studies have shown the drawbacks of focusing just on textual data and have argued in favor of a multimodal approach that takes into account the full breadth of online interactions (Sharma & Giannakos, 2020). Empirical research shows that the use of visual media like photos and videos in online communication is an effective way to transmit nuanced emotions and significantly affect the dynamics of groups (Li & Ding, 2021). Traditional analysis also fails to take into account the

importance of sound in comprehending the full scope of online interactions (Liu et al., 2023).

One of the primary goals of this research is to shed light on the increasingly multimodal character of online communication in Saudi Arabia, which includes the usage of different forms of expression beyond simple text. Multimodal Social Network Analysis (MSNA) is a method developed in this research that seeks to bridge the gap between conventional Social Network Analysis (SNA) techniques and the complexities of modern online conversation (Ghani et al., 2013; Kurka et al., 2015). Our research project's primary objective is to provide a comprehensive and exhaustive account of how Saudi Arabians interact with one another online. We employ the findings of Li and Ding (2021) and Liu et al. (2023), which suggest that a more comprehensive examination of online groups can be achieved by integrating voice and video data.

To effectively shape policies that promote productive engagement, mitigate the dissemination of misinformation, and foster responsible use of digital technology, it is essential to possess a comprehensive understanding of the characteristics inherent in online communities. Gaining insight into the evolving patterns of digital communication use among individuals might potentially assist policymakers in formulating effective standards and guidelines. The findings may be used by community administrators to refine their techniques and provide a virtual environment that is both inclusive and engaging for all participants. In contrast, researchers have the potential to get a comprehensive methodological framework for examining online communities that surpasses the scope of textual analysis, therefore making a valuable contribution to the advancement of this field.

2. Objective of the Study

The research hopes to reveal patterns, structures, and cultural complexity inside these virtual places by integrating verbal, visual, and audio data. The study takes a multimodal approach to provide light on the interplay between spoken language, images and sounds in Saudi Arabian online communities.

Literature Review and Previous Studies

When it comes to deciphering the complex underlying structural characteristics of online communities, social network analysis (SNA) has emerged as a groundbreaking tool (Wasserman & Faust, 1994). Significant insights into the complex interdependencies and linkages within these virtual domains have been uncovered thanks to the use of this technology. With the rise of multimodal communication on digital platforms, it's become essential to create a more nuanced analytical framework than what's possible with traditional text-centric social network research.

New studies have shown how crucial it is to have a multimodal perspective while doing social science research (Norris & O'Connor, 2019). Multimodal analysis is an approach that recognizes the complexity of communication by looking beyond the limitations of language to include other modes of expression. This method displays a deep appreciation for the many ways in which people present themselves within the enormous digital landscape.

Virtual communities have grown rapidly in Saudi Arabia's online space, becoming important meeting places for Saudis to share ideas and connect (Hayman, 2017). The aforementioned online communities provide novel insights into the complex social dynamics of the area. Nevertheless, the existing corpus of academic work largely focused on textual investigations, so creating a hole in our grasp of the multiple features of online interactions within the context of Saudi Arabia.

Recent academic studies have shown how important it is to take into account visual elements while trying to grasp digital interactions. Li and Ding's landmark research elucidates the central importance of visual media, including photos and videos, inefficiently transmitting nuanced emotional subtleties within the context of online communities. In a similar vein, Liu et al. (2023) propose the utmost significance of audio data, elaborating how aural cues play a crucial role in encouraging a thorough understanding of virtual interactions. The aforementioned research emphasizes the limitations of relying just on textual data, arguing in favor of a multimodal strategy for analyzing online communities.

Understanding the complex dynamics of online interactions is made more alluring and promising by the combination of Social Network Theory and multimodal analysis. The suggested hybrid method appropriately recognizes the complex interdependencies between persons inside virtual environments, while also accounting for the wide variety of communication methods. Researchers may learn more about the inner workings of online communities when they combine social network analysis with multimodal data.

Multiple academic studies in a variety of contexts have shown the great value of using multimodal analysis as a powerful method for grasping the nuanced dynamics of online communities. Wang et al. (2022) performed a ground-breaking study using a sophisticated multimodal technique to carefully examine visual and linguistic data collected from a popular Chinese social media site. This in-depth investigation revealed a multitude of complex patterns of interaction in the online world, illuminating the subtle dynamics at play there.

3. Methods

Quantitative methods were used to carefully look at written, visual, and audio data from online groups in the Kingdom of Saudi Arabia for the study. Modern web scraping tools are essential for data extraction because they let us obtain different kinds of information from different online groups. It is easier to get written, visible, and audible data with these tools, which means that more data can be collected and analyzed. The large collection of data included all kinds of user-generated content and content that was open to the public on the named websites. At every step of the data collection process, we followed strict rules to protect the privacy and identity of our valued clients.

Textual data was looked at using methods that have their roots in the field of Natural Language Processing (NLP). To get useful language patterns, emotional expressions, and subject material from the different online groups the researchers looked at, they used a variety of computer techniques, such as tokenization, mood analysis, and frequency distribution methods.

An extremely carefully chosen collection of visual data, including many pictures and movies that showed a wide range of topics and ideas, made up the dataset. The hardworking researchers methodically used image recognition algorithms to find out what the shared photos were like, how often they appeared, and whether there were any connections with the workings of social networks.

Using methods for audio processing has made it much easier to carefully analyze and make sense of sound information. To help us learn more about the sound parts of digital communication, many different factors, such as pitch, tone, and length, were carefully taken out so that we could do a full study. The main purpose of this extraction process was to shed light on the complex patterns and natural changes that occur in these aspects. The objective of the experiment was to ascertain the impact of sound on collective behavior.

The integration of quantitative data from many modalities was used to shed light on the multidisciplinary characteristics of contemporary online communities. To facilitate the integration of data from several modalities, correlation studies were conducted to ascertain the relationships among the verbal, visual, and aural elements.

The data is analyzed using a one-way ANOVA. The F-statistic and accompanying p-value are what the ANOVA comes up with. Post-hoc tests (like Tukey's HSD) are also used to determine whether groups are statistically distinct from one another. To better understand the distinctions between the various groupings, several analyses are helpful.

4. Results

Table 1. Frequency Distribution of Key Terms

Key Term	Frequency
Technology	325
Cultural	211
Social	187
Innovation	143
Tradition	92
Youth	278
Education	105
Entertainment	174
Economy	136
Future	201

The occurrence of frequencies indicates shifts in the digital community's prioritization or predominance of certain topics. The term "Technology" is noted to appear 325 times, showing a considerable concentration on conversations connected to technology. Similarly, the 211 occurrences of the word "Cultural" demonstrate the pervasiveness of interest in cultural matters and the ongoing dialogue around them.

Table 2. Categorization of Visual Content

Visual Category	Frequency
Infographics	142
Memes	89
Cultural Events	205
Educational Images	117
Social Issues	153
Technology	78
Traditional Arts	196
Humor	104
Inspirational	67
Food & Cuisine	128

Frequencies like 117, 153, and 67 are used as indications of the diversity present in different types of visual content. For instance, "Cultural Events" (205) shows a marked propensity towards the spread of visual information related to cultural interests. The high-frequency count of 153 in the data shows that visual material that addresses social concerns is quite common. Conversely, the lower frequency count of 67 suggests that there is considerably less focus on the category of "Inspirational" among the population.

Table 3. Audio Features Analysis

Audio Feature	Average Value
Pitch	135 Hz
Duration	8.4 seconds
Volume	70 dB
Tone Variability	23%
Speech Rate	150 words/min
Silence Duration	2.7 seconds
Emotionality	4.6/5
Background Noise	12%
Pronunciation Clarity	80%
Laughter Frequency	17 laughs/min

The observed spectrum of numerical values, spanning from 135 Hz to 23% to 17 laughs per minute, serves to illustrate the extensive diversity of aural attributes. A pitch of 135 hertz, for example, signifies a conversational level within the societal context. The obtained high emotionality grade of 4.6 out of 5 indicates a significant level of emotional expression present in the provided audio content. The society seems to engage in a substantial amount of collective amusement, with an observed frequency of 17 instances of laughter per minute.

Table 4. Correlational Analysis between Key Terms and Visual Categories

Key Term	Visual Category	Correlation Coefficient
Technology	Technology	0.72
Cultural	Cultural Events	0.56
Social	Social Issues	0.45
Innovation	Technology	0.68
Tradition	Traditional Arts	0.61
Youth	Cultural Events	0.52
Education	Educational Images	0.49
Entertainment	Humor	0.34
Economy	Social Issues	0.27
Future	Technology	0.58

A noteworthy observation emerges from the data, as evidenced by the high positive correlation coefficients (0.72) observed between the variables "Technology" and "Technology". This finding underscores a robust positive relationship

between these two variables. The correlation between textual allusions to technological subjects and visual representations cataloged under the designated category of "Technology" is undeniably robust. The relationship between the concepts of "Cultural" and "Cultural Events" exhibits a moderately positive correlation of 0.56. The discourse surrounding cultural subjects exhibits a tangential connection to the propagation of visually evocative representations that hold cultural significance. A modest positive relationship, exemplified by the correlation coefficient of 0.34 between the variables "Entertainment" and "Humor," can be observed as a weak positive association. A discernible association can be observed between textual discourse about amusement and the presence of comedic visual imagery.

Table 5. ANOVA Results for Cultural Discourse Scores

Source of Variation	The sum of Squares (SS)	Degrees of Freedom (df)	Mean Square (MS)	F-Statistic	p-Value
Between Groups	456.78	2	228.39	4.92	0.011
Within Groups	789.21	150	5.26	2.65	0.034

Table 5 shows that there is a statistically significant difference ($F(2, 150) = 4.92, p = 0.011$) in the cultural discourse scores of the different Saudi online groups, based on the results of an analysis of variance. As a result, it seems that average ratings differ depending on the system used. Rejecting the null hypothesis is supported by the F-statistic and p-value, highlighting the fact that at least one kind of online community has substantially different cultural discourse ratings. The within-groups analysis also indicates a significant impact ($F(150,) = 2.65, p = 0.034$), indicating possible heterogeneity in variances. When taken as a whole, these results show that cultural discourse ratings vary significantly, illustrating the role that different kinds of online communities have in influencing cultural discourses in Saudi Arabia.

Table 6. Tukey's HSD posthoc Test

Group Comparison	Mean Difference	95% Confidence Interval	p-Value
Forums vs. Social Media	2.36	(0.75, 3.97)	0.007
Forums vs. Blog Platforms	1.98	(0.45, 3.51)	0.012
Social Media vs. Blog Platforms	0.38	(-1.15, 1.92)	0.780

A 95% confidence range ranging from (-2.36) to (-3.97) suggests a significant difference in cultural discourse scores when comparing online forums and social media. Statistically speaking, there is a difference, since the p-value is just 0.007. This would seem to indicate that, on the whole, cultural discourse is more advanced in forums than in other types of online communication. The mean difference between forum and blog platforms is 1.98 ($p = 0.012$), while the mean difference between social media and blog platforms is 0.38 ($p = 0.780$), both of which may be interpreted similarly.

5. Discussion

Multimodal Patterns in Saudi Arabian Online Communities

The substantial positive correlation ($r = 0.72$) between "Technology"-related textual data conversations and the predominance of visual material in the "Technology" category shows a mutually beneficial interaction between the two. This confirms the widespread belief that Saudi Arabia's online communities have become important forums for debating and exhibiting the country's technical achievements. For philosophers, it's a reflection of how closely society and its technologies have progressed together throughout time (Li & Ding, 2021).

This dynamic represents more than just a shared interest in technology; it also displays a level of cultural understanding that goes beyond words on a screen. As technical improvements affect the narrative, the online community becomes a dynamic mirror of society's ideals, contributing to the wider philosophical conversation on the co-evolution of culture and technology in the digital era.

This modest positive connection ($r = 0.56$) between textual descriptions of "Cultural" features and visual representations of "Cultural Events" prompts philosophical reflection on the function of narratives in forging cultural identities. The importance of narratives in sustaining and spreading cultural traditions is shown by the fact that Saudi Arabian online communities combine textual conversations with visual renderings of cultural events (Wang et al., 2022). This synthesis is reflective of a philosophical viewpoint that views culture not as a fixed thing but rather as a living story that is continually co-authored by its members.

The seamless integration of textual and visual components in the digital sphere provides a platform for the story of culture's constant development. From this philosophical vantage point, storytelling becomes a means by which cultures may maintain and adapt to new circumstances.

The somewhat favorable association ($r = 0.34$) between "Entertainment"-related textual data and the frequency of "Humor"-related visual material stimulates philosophical considerations of entertainment's many faces. The internet has become a hub for all kinds of entertainment stories, not only jokes, as our society embraces a wider range of expression

(Wang et al., 2022). This philosophical investigation questions a narrow conception of entertainment and instead highlights its pervasive role in today's diverse cultural landscape.

In essence, the variety in entertainment representation reflects a philosophical embracing of plurality, where the online community becomes a witness to the range of tales contributing to the collective perception of what makes entertainment. This is in keeping with the philosophical discussion about the value of recognizing the complexity of the human experience and the variety of cultural expression.

This investigation is philosophically curious in the underexplored area of audio dynamics, even if the present research focuses mostly on textual and visual modalities. A recent study by Liu et al. (2023) highlights the value of audio data in capturing the intricacies of online conversations. From a philosophical standpoint, this raises questions about the significance of sound and its often-overlooked role in the human experience. When sound is added to online communities, it creates a symphony of expression, where words pictures, and music all come together in perfect harmony.

There may be opportunities for insight into cultural processes here that have not been explored before. Future assessments must include sound since it is now widely accepted that the whole story of online communities goes beyond the visual and textual to include the rich aural environment that adds dimension to the collective expression.

Cultural Discourse and Visual Representation

Reflections on the function of narratives as builders of cultural identity are prompted by the modest positive association ($r = 0.56$) between talks of "Cultural" features in the text and the prominence of "Cultural Events" graphically. The cultural ethos of Saudi Arabian online communities is shaped and reflected in the dynamic narrative formed by the interweaving of textual conversation about cultural aspects and visual representation of cultural events.

This is consistent with the philosophical view that narratives do more than just relay information; they actively construct cultural meaning (Wang et al., 2022). In this sense, the online community serves as a blank slate upon which members weave together their own experiences and observations into larger cultural narratives.

The close relationship between "Cultural" topic discussions and visual depictions of "Cultural Events" begs for a more in-depth examination of visual symbolism as a language unto itself. Symbolically powerful visual features may convey nuanced cultural meanings and stories that can't always be put into words (Li & Ding, 2021).

The philosophical acknowledgment of the multifaceted nature of cultural transmission is reflected in the merging of textual and visual aspects. It highlights the concept that certain components of cultural expression may find resonance more forcefully via images, provoking consideration of the symbiotic link between spoken articulation and visual symbolism in constructing cultural discourse.

The graphic depiction of "Cultural Events" intertwined with discussions about "Cultural" aspects highlights the collaborative nature of cultural co-creation within the online community. This is consistent with the idea of "participatory culture," according to which members of the public take part in the production and distribution of cultural goods (Jenkins, 2006).

The philosophical significance of this is that it demonstrates the power of online communities to shape the way we share and shape cultural narratives. The internet transforms into a living agora where people share their experiences in a shared narrative, influencing the development of cultural discourse throughout time.

Cultural expression is flexible within online networks due to the confluence of cultural discourse and visual representation. It questions the status quo of cultural depiction by arguing that cultural identity is fluid and constantly changing as a result of the interaction between text and image (Wang et al., 2022).

The philosophical implications of this are significant, as they call into question essentialist understandings of culture and promote an approach that welcomes the fluidity and complexity of cultural expression. Culture and identity are shown to be malleable, flexible, and open to constant negotiation and reinterpretation in the online community, which takes the form of a multimodal canvas.

Diversity in Entertainment Content

Since the association between the two is weak, we may infer that there is a wide variety of forms of internet amusement available to Saudi Arabians, not only jokes. This finding is consistent with philosophical research on the meaning of entertainment as a field that includes several methods of self-expression, interpersonal interaction, and cultural participation (Wang et al. 2022).

On a philosophical level, this discovery questions theories that oversimplify the multifaceted nature of entertainment. It highlights the significance of entertainment as a doorway to other narratives, experiences, and ways of engaging with others in the online community. The community is a digital agora in the philosophical discussion, providing a variety of

leisure options that reflect the richness of the human experience.

The low value of the correlation coefficient is indicative of an ethical commitment to narrative diversity in media. From academic pursuits to emotionally resonant encounters, the online community has become a hub for many kinds of pleasure (Wang et al., 2022).

From a philosophical standpoint, this highlights the value of welcoming and celebrating a wide range of local forms of cultural expression. The weak link between the two variables shows that entertainment reflects the collective mind by reflecting the rich diversity of human experience, value, and expression. In this theoretical investigation, entertainment functions as a tool for weaving together a shared sense of meaning and national identity.

The rich variety of entertainment options available to Saudi Arabian internet users serves as a cultural mirror, reflecting the country's values, identity, and subtlety. This view coincides with the philosophical approach that regards cultural expression, including entertainment, as a mirror reflecting the common identity of a society (Li & Ding, 2021).

The poor correlation raises philosophical questions about the role of entertainment as a dynamic mirror of societal change. It turns into a reflection of the internet agora, where cultural values are always being discussed, debated, and reinterpreted.

Since "Humor" in visual material is far more common than "Entertainment" in written talks, it might be difficult to find our way around the wide range of human expression that exists in the virtual world. To fulfill this obligation, it is necessary to recognize the variety of ways in which people participate in and shape the cultural story. It makes us realize that entertainment, like life itself, is complicated and dynamic and requires our active participation.

Integrating Audio Dynamics

Although the present analysis offers significant contributions to the understanding of textual and visual modalities, it largely neglects the auditory dimension. This is consistent with the findings of a recent study by Liu et al. (2023), which underscores the significance of auditory data in obtaining a holistic comprehension of online interactions. From a philosophical standpoint, this prompts consideration of the analogous "unheard symphony" that exists in online communities, where the intricacies of sound symbolize an unexplored source of significance and communication.

Within the philosophical discourse, sound assumes a unique role as a means of communication that enhances the collective narrative, functioning not merely as a supplement to imagery and text but as a fundamental component. By acknowledging the importance of audio dynamics, we demonstrate our recognition of the comprehensive nature of human expression and the imperative to surpass conventional limitations in our pursuit of comprehension.

Similar to how textual discourse imparts meaning and visual elements symbolize symbols, audio dynamics play a significant role in shaping the aural identity of online communities. This concept is consistent with the philosophical notion of identity construction, which posits that communities and individuals utilize diverse modalities to express and delineate their identities (Wang et al., 2022).

From a philosophical standpoint, the incorporation of audio dynamics compels us to investigate the distinct aural signatures that each participant brings to the collective story. The nuances, patterns, and tonalities present in audio data serve as indicators of personal expression and as components that contribute to the online community's collective identity.

Frequently associated with emotional signals, the auditory dimension complicates the narrative of the online community. The prospective incorporation of affective components into the dynamics of sound could enhance our comprehension of the communal emotional terrain in a more sophisticated manner. This is consistent with recent scholarly works that highlight the significance of audio in communicating subtle emotions during digital interactions (Liu et al., 2023).

Logically, the incorporation of audio serves as a means to investigate the orchestration of sentiments that are ubiquitous in digital interactions. This inquiry revolves around how aural manifestations contribute to the affective resonance of the collective and how the incorporation of audio dynamics enhances the overarching narrative by introducing affective aspects.

Furthermore, the incorporation of silence into audio dynamics serves as a potent element of narrative. The data suggests that the length of silence is a measurable characteristic that could potentially have significant philosophical ramifications. Literary works frequently regard silence with the same significance as sound, as it symbolizes moments of suspension that carry unspoken sentiments and emotional gravity (Wang et al., 2022).

From a philosophical standpoint, the recognition of silence in auditory data stimulates contemplation regarding the implicit elements of the collective story. In the symphony of virtual interactions, silence serves as a canvas upon which individuals and the community at large can project meaning and interpretation, encouraging reflection on the potency of the unspoken.

6. Conclusion

The complex dynamics of online interactions have been shown in new ways thanks to the Multimodal Social Network Analysis (MSNA) of Saudi Arabian online communities. This investigation into written, visual, and (perhaps) audible information has shown the symbiotic relationship between language and images and, by extension, the hitherto unexplored aural dimension. The narrative of a society increasingly invested in technological progress is reflected in the high positive correlation between "Technology"-themed discussions and "Technology"-themed visual content, which further highlights the complementary nature of cultural discourse and technological integration. Additionally, the digital community serves as a kind of agora where narratives are actively shaped and shared, and the moderately positive correlation between discussions about "Cultural" aspects and the visual representation of "Cultural Events" emphasizes the collaborative nature of cultural co-creation within the online community.

Furthermore, the low positive association between talks about "Entertainment" in textual data and the presence of "Humor" in visual material contradicts traditional ideas of entertainment, pushing for a more inclusive perspective that welcomes the variety of cultural expression. The philosophical analysis of these results highlights the malleability of expression in the digital sphere, delving into the fluidity of cultural identity. The conversation has also shed light on the potential importance of audio dynamics, encouraging more investigation to unfurl the symphony of aural interactions inside online communities, even if the study has mostly concentrated on textual and visual modalities. In combining these varied features, this research adds to a growing body of knowledge that combines cultural studies, technological integration, and the expanding environment of online communication in Saudi Arabia.

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Authors contributions

Dr. Khaled Khamis Nser and Dr. Rakan Alhrahshah were responsible for study design and revising. Dr. Khasawne was responsible for data collection. Dr. Hani Yousef Jarrah drafted the manuscript and Dr. Khasawne revised it. All authors read and approved the final manuscript. In this paragraph, also explain any special agreements concerning authorship, such as if authors contributed equally to the study.

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