

Deep Representation of Discursive Evolution via Semantic Embedding of Virtual Identities in Online Marginalized Communities

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Abstract: This paper proposes a deep semantic embedding frame to computationally model the discourse evolution of virtual identities in online marginal communities, aiming to explore how marginal groups gain discourse power and expression space online through virtual identities. This experiment takes the datasets of the LGBTQ+ community on Reddit and Douban as examples, constructing a multi-dimensional model of ‘user-speech-time’ to track the evolving expression paths of virtual identities, thereby validating the model’s ability to detect shifting discourse dominance and predict the dynamics of semantic adaptation within marginalized groups after the strategic adjustment. Findings reveal that marginalized users actively reshape mainstream discourse through linguistic strategies such as semantic ambiguity and emotional moderation, significantly improving their visibility and influence. This study challenges traditional views of the dynamic relationship between virtual identities and discourse power and expands the understanding of the online expression behaviors of marginalized groups. Practically, we provide new ideas for social media platforms to protect the voices of marginalized groups and call for greater attention to their voices.

Keywords: Virtual Identity, Discursive Power, Marginalized Community, Semantic Embedding, Representation Learning

1. Introduction

As online social media increasingly becomes part of people's lives, people's attention has spread from the real world to the virtual world. Even if the online platforms provide a freer and more open space for expression, the marginalized groups remain disadvantaged in the process of discourse power and space allocation under the algorithmic mechanism. In order to deal with this situation, they constantly adjust their expressive behavior and have formed an evolving path. However, the process by which the marginalized groups expand their influence through strategic adjustments has not yet been fully studied. This study examines and analyzes the interaction between semantic negotiation and the transformation of discourse power by establishing a deep semantic embedding framework to fill this research gap.

The research focuses on the contents within the LGBTQ+ communities on Reddit and Douban. We collected and processed the relevant data, such as the number of users and posts, providing datasets for subsequent studies. Based on these datasets, a hybrid model combining BERT embeddings and Graph Attention Networks is used to track the semantic trajectories of the users as they change over time and in different contexts. Finally, the paths were analyzed by computing the discourse clustering divergence and flow centrality. This study constructed a ‘semantic-structural-temporal’ multi-dimensional integration in the modeling part, while the path analysis part focused more on the shift of discourse power, and realized system modeling from ‘what to say’ to ‘who can say’.

By integrating deep semantic embedding and discourse trajectory modeling, we aim to illuminate the computational patterns of power redistribution in language and uncover new mechanisms linking algorithmic design, expressive agency, and social marginality.

2. Literature review

2.1. Constraints of real-life identity and liberation of virtual expression

In real life, real-life identity often prevents the marginalized from expressing themselves publicly because of social pressure and institutional constraints. The virtual world creates a less restrictive space in which users, unconnected from the real-life identity paradigm, can express authentic sentiment and latent identities [1]. For instance, in mainland China’s LGBTQ forums, numerous users anonymous in real life employ actual photographs and in-depth narratives to engage in discursive construction online [2]. The virtual face is not only an extension of one’s real-life identity but also a strategic linguistic tool through which marginalized individuals assert visibility, express sentiment, and coordinate identity in ways often constrained in real-life interactions [3]. While the virtual world imposes fewer identity-related constraints, this does not equate to absolute freedom of expression. Rather, the relatively greater expressive agency afforded by virtual identities helps marginalized users increase their online visibility and, in turn, bolsters their confidence in expressing themselves in real-life settings.

2.2. Discursive power and semantic negotiation

Discourse power in the virtual world is not evenly allotted yet, redistributes through changing strategies, semantic borrowing, and structural inclusion [4]. Sociolinguistics puts forward the concept of ‘discourse adaptability,’ where people adapt their expressions according to the cognitive expectations of the target community in order to increase acceptance [5]. It usually involves the deployment of fuzzy semantics and borrowing from mainstream discourse. For instance, LGBTQ+ individuals would say, ‘Maybe I’m not “normal” in the mainstream, but I’m human,’ employing ‘maybe’ in mitigating confrontation and ‘normal’ in evoking common sense [6]. On Twitter, the minority groups use pre-formulas such as ‘MeToo’ in reducing complicated identities and enhancing identification [7]. Although the strategies enhance the visibility of discourse, they tend to obscure primary political objectives, making the expansion of discourse power dependent upon compromise and generating conflict between expanded expression and compromised positional specificity.

2.3. Semantic embedding and deep representations

The development of natural language processing has greatly improved the ability to model context-dependent and polysemous expressions. Word2Vec captures distributed semantic relations but lacks

responsiveness to temporal dynamics and community structure [8]. BERT introduces a bidirectional Transformer to generate context-aware embeddings, effectively identifying ambiguity and emotional nuances. Incorporating time variables into dynamic embeddings enables modelling of user strategy shifts over time [9]. Meanwhile, Graph Convolutional Network (GCN) integrates user interaction networks with semantic content, embedding language within the broader context of community behavior. By adding a time-window mechanism, the Graph Attention Network (GAT) model constructs a ‘user-speech-time’ dynamic sequence, well-suited for tracking the evolving expression paths of virtual identities in complex networks.

3. Methodology

3.1. Dataset construction and preprocessing

"Discourse" refers to multimodal expressive behavior within specific community contexts, including semantic construction, expression strategies, emotional modulation, and symbolic language use. Discourse trajectories manifest as temporal shifts in linguistic style, topic preference, and semantic distance from mainstream narratives. A cross-platform dataset of marginalized communities was constructed to capture discourse evolution across cultural and technical contexts. Data sources include Reddit communities such as r/LGBT, r/TwoXChromosomes, r/AsianIdentity, and Douban groups focused on gender and boundary issues. Data were collected using Python’s PRAW and Selenium from January 2023 to December 2024, covering 24 months, as shown in Table 1.

Table 1. Data content

Data Source	Number of Communities	Number of Users	Number of Posts	Number of Comments
Reddit	15 subreddits	28,547	156,832	892,456
Douban	12 groups	19,238	89,234	534,127
Total	27 communities	47,785	246,066	1,426,583

Multi-level preprocessing applied, starting with regular expressions to remove HTML tags, special characters, and noisy text. English and Chinese texts processed using spaCy and jieba for tokenization, part-of-speech tagging, named entity recognition, and semantic role labeling. A dynamic user interaction graph constructed, modeling replies, citations, and co-topic participation as weighted directed edges, forming a time-sequenced community structure.

3.2. Semantic representation modeling

This study proposes a deep representation learning framework that integrates contextual semantic understanding with community structure awareness, aiming to capture the multidimensional semantic features of virtual identity discourse. The model encodes user utterances using multilingual BERT (mBERT) and performs structured semantic representation learning via Graph Attention Networks (GAT) [10]. For each user’s utterance at time t , denoted as $D_{u,t}$, the BERT encoder generates context-sensitive token-level representations:

$$H_{u,t} = \text{BERT}(D_{u,t}) = [h_1, h_2, \dots, h_n] \quad (1)$$

Where $h_i \in \mathbb{R}^d$ denotes the semantic vector of the i -th token and d is the hidden dimension.

To incorporate the user's structural role in the community, a heterogeneous graph $G_t=(V_t,E_t)$ is constructed, where V_t represents the set of user nodes at time t and E_t denotes the set of multi-relational edges between users. Using the graph attention mechanism, the structural semantic representation of user u with respect to neighboring nodes is computed as:

$$z_{u,t}=\sigma\left(\sum_{v\in N(u)}\alpha_{u,v}^{(t)}W^{(l)}x_{v,t}\right) \quad (2)$$

Where $\alpha_{u,v}^{(t)}$ is the attention weight, $N(u)$ denotes the neighborhood of user u , and $W^{(l)}$ is the learnable parameter matrix in layer l . The model effectively captures the relative position of user semantic expressions in the community context and models their semantic adaptation process from the periphery toward the center.

3.3. Discursive power detection and path analysis

This study designs a multi-metric discursive power detection mechanism to identify the trajectory of power shifts by quantifying the changing patterns in users' semantic trajectories [11]. The semantic centrality shift metric $\Delta C_{u,t}$ is used to measure the degree of semantic migration from peripheral to mainstream discourse:

$$C_{u,t}=\cos(s_{u,t},c_t)-\cos(s_{u,t-1},c_{t-1}) \quad (3)$$

Where $s_{u,t}$ denotes the semantic representation vector of user u at time t , and c_t denotes the community's semantic centroid at time t , calculated by the weighted average of all active user vectors. This metric effectively captures the dynamic distance between user discourse and the mainstream semantic space. To further quantify the practical change in discursive influence, the response gain rate $R_{u,t}$ is introduced as an external validation metric:

$$R_{u,t}=\frac{\sum_{d\in D_{u,t}}(r_d+l_d+c_d)}{|\{d\in D_{u,t}\}|} / \frac{\sum_{d\in D_{u,t-k+1}}(r_d+l_d+c_d)}{|\{d\in D_{u,t-k+1}\}|} \quad (4)$$

Where r_d , l_d , and c_d represent the number of replies, likes, and citations for post d , and k is the size of the time window. By comparing the average response level in the current and historical windows, this metric reflects the actual variation in discursive influence.

Based on the quantitative indicators, the semantic strategies of marginalized users are further examined. In LGBTQ+ communities, some users reduce direct identity terms (e.g., from "queer activism" to "social equality") and adopt emotionally softened expressions (e.g., "I think", "maybe") to enhance mainstream acceptability. Users employing such semantic ambiguity strategies saw a 127 percent increase in average response gain rate and a 0.23 rise in semantic centrality shift over six months, indicating that adaptive expression facilitates discursive power acquisition.

4. Results

4.1. Model performance against baselines

To evaluate the effectiveness of the BERT-GAT model in modeling discourse evolution of virtual identities, three core tasks were designed: semantic consistency modeling, identity classification, and discursive influence trend prediction, compared against baselines including Word2Vec-KMeans,

TF-IDF+SVM, and LDA. For semantic consistency, the model achieved Silhouette Scores of 0.73 and 0.69 on Reddit and Douban respectively, outperforming baselines by over 10%, indicating stronger ability in capturing temporal coherence and stylistic variation. In the identity classification task, the model achieved an F1-score of 0.87, significantly higher than TF-IDF's 0.71 and LDA's 0.65, and maintained over 82% accuracy even with users exhibiting semantic ambiguity. For influence trend prediction, LSTM-based modeling of semantic trajectories yielded an accuracy of 83.2%, validating the model's ability to anticipate changes in users' discursive impact. As shown in table 2.

Table 2. Evaluation tasks and model performance comparison

Evaluation Task	Metric	BERT-GAT	Word2Vec-KMeans	TF-IDF-SVM	LDA
Semantic Consistency	Silhouette Score (Reddit)	0.730	0.650	0.610	0.580
Semantic Consistency	Silhouette Score (Douban)	0.690	0.620	0.590	0.560
Identity Classification	F1-Score	0.870	0.740	0.710	0.650
Identity Classification	Precision	0.850	0.720	0.690	0.630
Identity Classification	Recall	0.890	0.760	0.730	0.670
Trend Prediction	Accuracy	0.832	0.756	0.748	0.731

4.2. Statistical analysis of discursive power

Statistical analysis shows that marginalized users experienced significant discourse power growth over 24 months. On Reddit, average comments per post for LGBTQ+ users doubled from 1.7 to 3.4, while mainstream users saw only a 9.5% increase. On Douban, marginalized users increased by 67%, compared to 12% for mainstream users, indicating that semantic strategy adjustments effectively enhance influence, with platform differences shaped by cultural and algorithmic factors.

Semantic centrality shift was used to quantify users' semantic proximity to mainstream discourse. Results show 32% of marginalized users moved closer to the community center, reducing average distance by 0.19. This shift was especially evident in topics like gender equality and identity, where more neutral expressions improved acceptability. Regression results indicate a strong positive correlation between semantic ambiguity and response gain ($\beta=0.34$, $p<0.001$), while moderate emotional restraint also contributes to discourse power increase ($\beta=-0.21$, $p<0.01$). These findings suggest that marginalized users adopt controlled and ambiguous expressions to better align with algorithmic environments and improve visibility. As shown in figure 1.

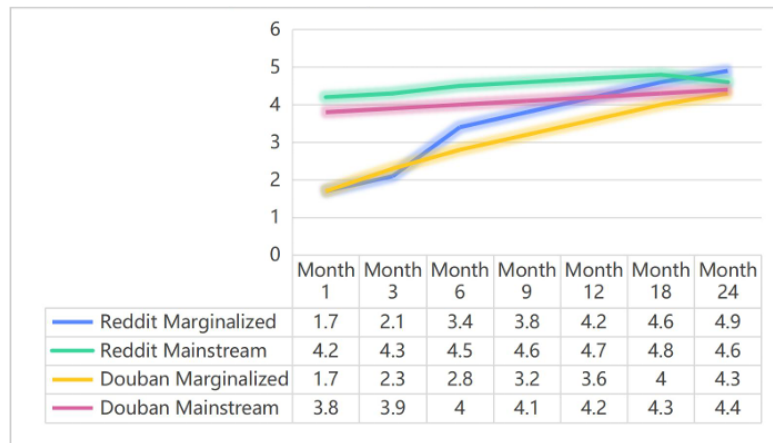


Figure 1. Response rate evolution: marginalized vs mainstream users

5. Discussion

This study reveals that virtual identities are not passive recipients of discursive marginalisation in fringe communities, but actively reshape the structure of mainstream discourse through strategic semantic adaptation. Findings suggest that discursive ambiguity significantly enhances the ability of fringe users to access mediated discursive spaces, this finding that challenges the traditional view that fringe voices can only be absorbed or diluted by mainstream discourse. Marginal users strategically shifted semantically by adopting more neutralised and mainstreamed frames of expression, such as shifting from “queer activism” to “social equality”, and by adding emotionally buffered expressions such as “I think” and “maybe”. This kind of adaptation is not a simple compromise, but a complex discursive game, in which users maintain their core positions while gaining more space for expression and social acceptance through the adjustment of language strategies.

6. Conclusion

In this study, we propose an integrated framework fusing deep semantic modelling, graph structural analysis and time series prediction for systematically investigating the mechanism of virtual identity discourse evolution in fringe communities. By integrating BERT semantic embedding, graph attention networks and dynamic trajectory tracking, we successfully constructed a deep representation learning model capable of capturing semantic-structural-temporal multi-dimensional features, and achieved accurate quantification and prediction of the change of virtual identity discourse. The experimental results demonstrate that edge users are indeed able to gradually increase discourse influence through strategic semantic adaptation, and that such changes are structured, predictable, and obviously strategic in nature, reflecting the complex interactions among algorithms, social structures, and linguistic practices in online expression. The theoretical contribution of the study lies in expanding the understanding of the dynamic relationship between virtual identity and discourse power, and revealing the mechanism of dynamic expression of fringe communities in an algorithm-dominated environment. On the practical level, this study provides technical foundations and policy recommendations for enhancing the fairness of expression in marginalised communities, which helps platforms to design more inclusive algorithmic mechanisms and promote the effective dissemination of diverse voices.

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