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# Emergency Information Recommendation Based on Multimodal Heterogeneous Information Network

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## Abstract

During public crises, guidance-oriented emergency information is often dispersed across sources and modalities, limiting its organization, discovery, and targeted access. This study constructs a multimodal heterogeneous information network (MHIN) as a graph-based knowledge organization structure and uses its learned representations for emergency information recommendation. The MHIN organizes publishing sources, emergency information items, their textual, visual, and video components, and engagement attributes. SAGA-Net is then proposed to learn computable representations from heterogeneous relations and multimodal semantics. Experiments on the rainstorm event show that the MHIN supports meaningful item representations and the MHIN-based recommender outperforms competitive baselines, facilitating targeted access to emergency guidance.

Keywords: Emergency information recommendation; Knowledge organization; Multimodal heterogeneous information network; Representation learning; Social media

## 1.0 Introduction

During public crises, social media platforms and authoritative portals continuously publish guidance-oriented multimodal emergency information, such as precautions, response steps, and official advisories (Wang et al. 2026). As emergency knowledge resources, their value depends on whether they can be effectively described, linked, organized and

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accessed. However, in real settings, these resources are often dispersed across platforms and modalities, with limited explicit relations and no unified organizational structure. This makes it difficult to transform fragmented emergency information objects into reusable emergency knowledge structures for discovery and targeted access (Ma et al. 2021).

To address this problem, this study constructs a multimodal heterogeneous information network (MHIN) as a graph-based knowledge organization system. The network connects source entities, emergency information items, multimodal content components and item-level engagement attributes through explicit entity and relation structures. On this basis, SAGA-Net is then applied to learn computable knowledge representations from the semantic and structural relations encoded in the MHIN. These representations are finally used in a demand–item ranking framework to recommend emergency information, thereby supporting targeted access to organized emergency knowledge.

## 2.0 Literature review

Existing knowledge organization studies have developed approaches for describing, standardizing, organizing, and providing access to knowledge resources, including classification schemes, thesauri, and controlled vocabularies (Hjørland 2008). With the increasing complexity of digital knowledge resources, ontologies, semantic web technologies, linked data, and knowledge graphs have further extended knowledge organization systems by representing concepts, entities, and semantic relations (Santana et al. 2024). In emergency management, knowledge resources are more sensitive to time and space and evolve more dynamically. Existing studies have therefore organized crisis events, locations, actors, response actions, and response resources through ontology reconstruction and temporal-spatial semantic modeling (Ma et al. 2021; Hjørland 2025). Overall, these studies have promoted the transformation of emergency knowledge from scattered information into structured, semantically organized, and reusable knowledge resources through concept system construction and semantic relation representation.

With the development of social media and multimodal information environments, emergency information resources have increasingly appeared as composite knowledge objects involving sources, textual content, images, videos, timestamps, and engagement signals (Wu et al. 2022). Related studies have used multimodal fusion, heterogeneous information networks, knowledge graphs, and graph neural networks to support emergency information retrieval, recommendation, and crisis response (Xu et al. 2024). However, these elements are often treated as feature inputs or task-specific modeling objects. Less attention has been paid to how multimodal emergency information items, publishing sources, modality nodes, and engagement attributes jointly form an organizational structure for emergency knowledge resources, and how this structure supports knowledge discovery, reuse, and access.

## 3.0 Method

### 3.1 Dataset construction

Given the growing impacts of rainstorm-induced disasters and the resulting public demand for response guidance, this study uses rainstorm events as the target scenario for emergency information organization and recommendation. Data were collected from Sina Weibo and three authoritative online portals, namely China Meteorological Administration (n.d.), China Meteorological Science Popularization Network (n.d.), and Guangming Daily (n.d.), between January 1, 2020, and July 31, 2025. The source scope was limited to Weibo accounts verified by blue-badge institutional status and authoritative portals selected for institutional credibility, public accessibility, and relevance to extreme-weather guidance. The same retrieval keywords, "暴雨应对提示" (rainstorm response essentials), "暴雨科普指南" (rainstorm science popularization guide), and "极端天气指南" (extreme weather guidance), were then applied across all sources through platform APIs and website search functions. Records were retained when they contained guidance-oriented emergency information and removed when they were unrelated, duplicated, advertising-oriented, or associated with invalid URLs or inaccessible media. After cleaning, 54,912 Weibo posts and 2,576 website records were retained, including text, images, videos, engagement signals, timestamps and source metadata. All data were anonymized before analysis.

### 3.2 Construction of the multimodal heterogeneous emergency information network

The multimodal heterogeneous emergency information network is constructed as a graph-based knowledge organization structure for fragmented emergency information resources. It is defined as $G=\{N, E, A\}$, where N, E, A denote heterogeneous entities, organizational relations, and item-level engagement attributes, respectively. The entity set $N=\{S, P, T, I, V\}$ includes source entities $S$, emergency information items $P$, and modality components consisting of text $T$, image $I$, and video $V$ nodes. The relation set $E=\{E_{pub}, E_c\}$ includes publishing and composition relations: $E_{pub}$ links source entities $S$ to the emergency information items $P$ they publish, while $E_c$ links each information item $P$ to its text, image, and video nodes. Each information item $P$ is further assigned item-level engagement attributes, including reposts, comments, and likes, which indicate the public visibility and interaction intensity. For portal records without engagement data, these attributes were zero-filled and masked. Figure 1 illustrates the schema of the MHIN, which explicitly organizes source entities, multimodal composition, and engagement evidence for computational representation and targeted emergency information recommendation.

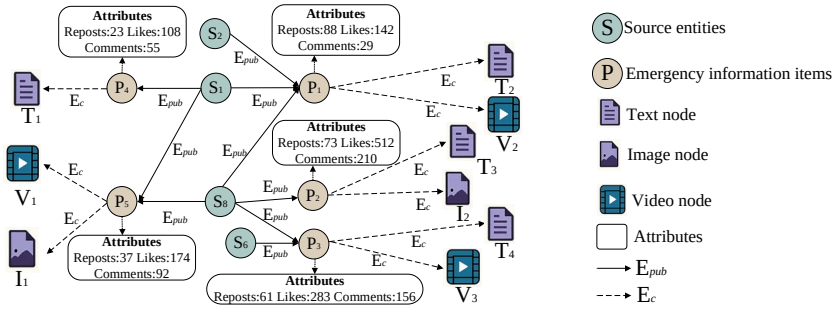

Figure 1. Schema of the MHIN

### 3.3 Representation learning on the MHIN and emergency information recommendation

Feature representations were initialized for entities and attributes in the MHIN. Source entities $S$ were initialized with learnable embeddings. Text nodes $T$ and image nodes $I$ were encoded using Chinese RoBERTa-wwm-ext and CLIP, while video nodes $V$ combined CLIP visual features with Wav2Vec2 audio embeddings. For each emergency information item $P$, its associated modality representations were aggregated to initialize the item embedding. Missing or invalid modalities were zero-filled and masked before fusion. Engagement attributes $A$ were constructed from normalized repost, comment, and like counts and attached to the corresponding $P$ nodes. Based on these inputs, SAGA-Net is proposed to learn node representations through feature refinement and structural aggregation, which emphasize informative neighbors and aggregate local relational signals. The resulting embeddings capture multimodal semantics and heterogeneous relations for ranking.

Emergency information recommendation was formulated as a demand–item ranking task to evaluate targeted access to organized emergency knowledge. Each sample consists of a public information demand query $q$, a candidate emergency information item $p$, and a binary relevance label $y_{qp} \in \{0,1\}$. The training set contained 29,220 approximately balanced pairs generated through rule-guided weak supervision, while an independent test set contained 6,000 manually annotated pairs. For pairwise optimization, positive and negative candidate items were sampled under the same demand query to construct training triples $(q, p^{+¿, p^{-¿)¿}}$. Candidate items were ranked by the matching score between the demand representation and the final MHIN-based item embedding. The recommender therefore consists of a demand encoder, SAGA-Net as the MHIN item encoder, and a matching function trained with the pairwise ranking objective. Recommendation performance was evaluated by Recall@K, MRR@K, and NDCG@K, with $K=\{5,10\}$.

## 4.0 Results and analysis

The constructed MHIN contains 93,283 nodes and 102,601 edges, with an average degree of 2.2057. Its high modularity score of 0.9482 indicates that the network forms distinguishable structural communities, which provides a suitable basis for representation learning. Table 1 reports the embedding performance of different graph representation models. NMI, ARI, and Silhouette were used to evaluate whether the learned $P$ node embeddings preserve meaningful cluster structures. Table 1 shows that SAGA-Net achieves the best NMI and ARI, and competitive Silhouette performance. This suggests that SAGA-Net better preserves heterogeneous relations and multimodal semantics in the MHIN.

Table 1 Representation Learning Performance on the MHIN

| Model | NMI | ARI | Silhouette Score |
|---|---|---|---|
| GraphSAGE | 0.8292 | 0.7856 | **0.4059** |
| RGCN | 0.5210 | 0.3990 | 0.1204 |
| HAN | 0.8402 | 0.8499 | 0.2308 |
| **SAGA-Net (this study)** | **0.9242** | **0.9405** | 0.3659 |

The proposed MHIN-based recommender was compared with BPR, GCN, GAT, and MMGCN, which replaced SAGA-Net as the item encoder under the same demand encoding, sampling, matching, and training settings. As shown in Table 2, the proposed model achieves the best performance across all metrics, indicating that MHIN-based representations improve emergency information ranking and targeted access to organized emergency knowledge.

Table 2 Overall Recommendation Performance Comparison

| Model | Recall@5 | Recall@10 | MRR@5 | MRR@10 | NDCG@5 | NDCG@10 |
|---|---|---|---|---|---|---|
| BPR | 0.1667 | 0.3333 | 0.0556 | 0.0833 | 0.0645 | 0.1427 |
| GCN | 0.2384 | 0.3436 | 0.2083 | 0.2500 | 0.2343 | 0.2667 |
| GAT | 0.3667 | 0.5000 | 0.2176 | 0.3833 | 0.3052 | 0.3290 |
| MMGCN | 0.4718 | 0.5052 | 0.3645 | 0.4587 | 0.4417 | 0.4556 |
| **MHIN-based recommendation** | **0.6033** | **0.6439** | **0.5177** | **0.5874** | **0.5334** | **0.5417** |

## 5.0 Discussion and conclusion

This study proposes an MHIN-based knowledge organization method for multi-source and multimodal emergency information, addressing the difficulty of organizing fragmented guidance resources for targeted access. The results show that the constructed MHIN supports effective representation learning and improves demand–item ranking in emergency information recommendation. Its main contribution to applied knowledge organization lies in representing sources, emergency information items, multimodal content, and engagement attributes within a computable graph structure. In practice, this structure can support the organization, discovery, and access of authoritative emergency

guidance. This study is limited to rainstorm-related data from China, and future work will examine its portability across different crisis types, data platforms, and cultural contexts.

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AI Usage Statement: The authors declare that no generative artificial intelligence (AI) tools were used in the research.

References

China Meteorological Administration. n.d. “Search Results for ‘暴雨’.” Accessed July 31, 2025. [manter o URL já presente na referência atual]

China Meteorological Science Popularization Network. n.d. “Search Results for ‘暴雨’.” Accessed July 31, 2025. [manter o URL já presente na referência atual]

Guangming Daily. n.d. “Search Results for ‘暴雨’.” Accessed July 31, 2025. [manter o URL já presente na referência atual]

Hjørland, Birger. 2008. “What Is Knowledge Organization (KO)?” Knowledge Organization 35: 86-101. doi:10.5771/0943-7444-2008-2-3-86.

Hjørland, Birger. 2025. “Knowledge Organization for Resilience in Times of Crisis: Challenges and Opportunities.” Em Questão 31: 1-29. doi:10.1590/1808-5245.31.148670.

Ma, Xiaoyue, Pengzhen Xue, Nada Matta, and Qiang Chen. 2021. “Fine-Grained Ontology Reconstruction for Crisis Knowledge Based on Integrated Analysis of Temporal-Spatial Factors.” Knowledge Organization 48: 24-41. doi:10.5771/0943-7444-2021-1-24.

Santana, Lílian Dominguez, Raissa Michalsky Martins, Leonardo Borges Rodrigues Chagas, Frederico Cesar Mafra Pereira, Gercina Ângela de Lima, and Maria Aparecida Moura. 2024. “Sistemas de Organização do Conhecimento: análise comparativa e modelagem de instrumentos de representação do conhecimento.” Encontros Bibli: Revista Eletrônica de Biblioteconomia e Ciência da Informação 29: e97708. doi:10.5007/1518-2924.2024.e97708.

Wang, Xiwei, Siguleng Wuji, Mali Li, Yutong Liu, and Ran Luo. 2026. “Social Impact of Recommendation Algorithm in Crisis: Forming Algorithmic Experience through Group Information Interaction and Algorithm Task Fit.” Information Processing & Management 63, no. 1: 104323. doi:10.1016/j.ipm.2025.104323.

Wu, Xuehua, Jin Mao, Hao Xie, and Gang Li. 2022. “Identifying Humanitarian Information for Emergency Response by Modeling the Correlation and Independence between Text and

Images." Information Processing & Management 59, no. 4: 102977. doi:10.1016/j.ipm.2022.102977.

Xu, Shuo, Xinyi Ma, Hong Wang, Xin An, and Ling Li. 2024. "A Recommendation Approach of Scientific Non-Patent Literature on the Basis of Heterogeneous Information Network." Journal of Informetrics 18, no. 4: 101557. doi:10.1016/j.joi.2024.101557.