GEORGE BROWN PRESS
JOURNALS, BOOKS & PROCEEDINGS

Journal of Computer, Signal, and System Research

Article

Research on the Application of Signal Integration Model in Real-Time Response to Social Events

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Abstract: With the increasing complexity of social events, how to quickly respond and make precise decisions in a dynamic and changing environment has become a key issue in the field of public management. The signal integration model, as an advanced information fusion technology, greatly improves the timeliness of event responses and the quality of decision-making by summarizing information from various data sources. This article deeply analyzes the application of signal integration models in handling social events, and explores the specific roles of the models in information collection, data synthesis, real-time response, and decision assistance. In the practical application stage, this article focuses on how to apply the signal integration model in social events, including how to integrate diverse signal sources, establish a rapid response system, and optimize decision-making processes. Through empirical analyses on multiple instances, the signal integration mode has been evaluated in terms of response speed, decision assistance effectiveness, and practical operational feedback. Research has suggested that the signal integration mode not only significantly improves the efficiency of responding to social events, but also enhances the accuracy of decision-making, providing solid technological support and theoretical basis for handling similar events in the future.

Keywords: signal integration model; social events; real-time response; decision support; application effect evaluation

1. Introduction

Due to the suddenness and complexity of social events, emergency response work has encountered numerous difficulties. Traditional emergency response mechanisms face delays in information and slow decision-making, making it extremely difficult to respond quickly to various emergency situations. When dealing with complex events, signal integration methods not only enhance real-time monitoring of situations, but also provide comprehensive decision-making assistance for decision-makers, helping to build more efficient response strategies [1]. Although signal integration has been applied in many industries, its specific application and effectiveness evaluation in the field of social emergency response are still insufficient. The purpose of this article is to explore the application of a signal integration model in social crisis events, analyze the role of signal integration model in accelerating response speed, improving decision-making assistance, and evaluate them through specific case studies. The aim is to provide theoretical support and operational references for efficient handling of similar emergency events in the future.

2. Theoretical Framework of Signal Integration Model

The signal integration model constructs a responsive social emergency response system through a hierarchical architecture that covers information collection, preliminary

Received: 4 March 2025
Revised: 16 March 2025
Accepted: 28 March 2025
Published: 02 April 2025

data processing, signal synthesis, real-time evaluation and feedback, and decision assistance. The core concept of this system is to aggregate and process information from multiple channels to reduce information uncertainty, optimize decision-making processes, and improve efficiency and accuracy in response to emergencies. The framework design of the signal integration model is shown in Figure 1, which focuses on the logical linkage as well as flow of information.

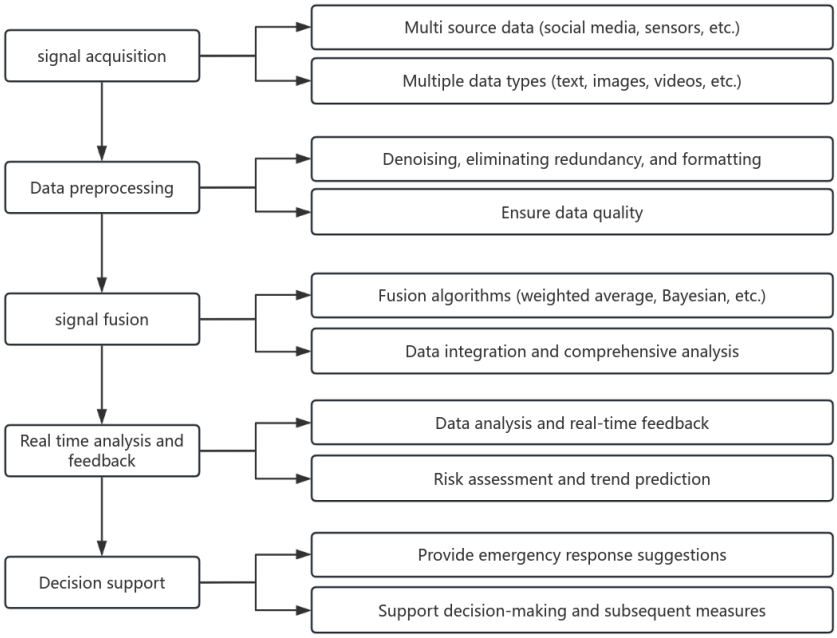

Figure 1. Design of Key Link Framework for Signal Integration Model.

With the help of a multi-link information transmission and analysis process, the signal integration model relies on cutting-edge data fusion technology and real-time computing capabilities, greatly enhancing the response speed and decision-making accuracy in dealing with social emergencies, and providing strong support for emergency management.

3. The Application of Signal Integration Model in Social Events

3.1. Signal Collection

In the emergency response phase to sudden social situations, the collection and comprehensive processing of information constitute the core steps of the signal integration model. The information collection work collects various types of information related to emergencies through various channels. These sources of information are diverse, covering data from monitoring devices, dynamics on social platforms, official announcements, real-time media coverage, and location data from map information systems. The data from monitoring devices provides accurate values about environmental changes, such as temperature, humidity, and other aspects [2]. Information on social media platforms also provides aspects of public's attitudes and emotional fluctuations towards emergencies. Official announcements and media reports reveal the official perspective of the event's progress, while map information systems show decision-makers the specific geographical location of the event. Through these diverse sources of information, the information collection process provides a comprehensive and dynamic information foundation for the subsequent handling and decision-making of emergency events.

3.2. Data Preprocessing and Signal Fusion

After completing the signal acquisition steps, comprehensive data processing is a critical stage. The key task of this stage is to merge the data provided by various data sources into a comprehensive composite signal, aiming to eliminate redundancy and noise while ensuring the accuracy and uniformity of the data. In data synthesis processing, commonly used techniques include weighted average strategy and Bayesian inference method. In the weighted average strategy, corresponding weights are assigned based on the credibility of different signal sources, and then the weighted composite signal is calculated. For example, the data provided by sensors is given high weight due to its high credibility, while data from social media, although able to map the emotional attitudes of the public, is usually given lower weight due to its strong subjectivity and high noise content [3]. In this case, the fusion formula (1) can be expressed as:

$$S_{fused} = \sum_{i=1}^{n} \cdot S_i \quad (1)$$

Among them, S_{fused} represents the fused signal, W_i is the weight of the $i-th$ type signal, and S_i is the value of the $i-th$ type signal. Through this weighted fusion, the advantages of different signals can be effectively combined to reduce uncertainty in the data.

Bayesian inference methods have also been widely applied, especially in the analysis of social events with uncertainty and variability. Bayesian inference can combine pre-acquired knowledge with real-time observation data, continuously revise the reliability of signals, and make predictions about potential development trends of events. The Bayesian formula (2) is:

$$P(H|D) = \frac{P(D|H) \cdot P(H)}{P(D)} \quad (1)$$

Among them, $P(D)$ is the total likelihood of observing the signals, or simply $P(S_{fused})$; $P(H|D)$ is the posterior probability of event H occurring given observation data D; $P(D|H)$ is the likelihood probability of observing data D under the assumption that event H occurs; $P(H)$ is the prior probability of event H.

With the help of Bayesian inference, the integration of different signals becomes more flexible and can more accurately map the changes in social events. This technology enables signal integration models to keep up with changes in social dynamics, providing more accurate data support for decision-making.

In the process of signal acquisition and data fusion, it is necessary to allocate and process signals from different sources reasonably to ensure the reliability and timeliness of synthesized information [4]. This process provides the necessary information foundation for rapid response to social events, helping decision-makers extract core points from various dimensions of information and providing solid information support for subsequent emergency response and decision-making.

3.3. Real Time Response and Decision Support Mechanism

After the signals are merged, the decision support system will need to search for the optimal strategy with the synthesized signal and risk preferences. This step involves the dynamic evaluation of trade offs, predicting the potential benefit of response development, and selecting the best response plan available. The purpose of a decision-making step is to maximize the response effect and obtain the most suitable decision result through some pre-determined optimization procedures.

Firstly, we can calculate the required result using the following formula (3):

$$R(d_i) = \alpha E(d_i) - \beta C(d_i) \quad (2)$$

Among them, d_i is the decision, and α and β are the weight coefficients related to efficiency (E) and cost (C), respectively. This formula helps decision-makers quantify the trade-off between efficiency and cost of different strategies, in order to select the strategy that best fits their risk preferences.

Optimization for decision support typically use objective functions to quantify the outcome of various response strategies, which can be expressed as formula (4):

$$g(d_i) = P\left(H \middle| S_{fused}\right) \cdot R(d_i) \tag{3}$$

Among them, S_{fused} is the fusion signal, R is the outcome preference indicator, and g is the decision optimization function, which evaluates the effectiveness of different decision strategies based on the synthesized signal and preference parameters. By finding d^* that maximizes g, the model can find the most suitable strategy to deal with current social events, this is essentially a linear programming problem, and its formula (5) takes the following form:

$$d^* = \arg\max_{d_i \in D}[g(d_i)] \text{s.t.} \qquad C(d_i) \le C_{\max} \qquad E(d_i) \ge E_{\min} \tag{4}$$

And in the case that R is a non-linear function, other methods such as convex optimization may be used. The system can thus evaluate the effectiveness of various responses and dynamically adjust decision plans based on the evaluation results. This continuously optimized cycle mechanism ensures that decision-making can keep up with the progress of the situation and respond quickly to emergency situations, thereby enhancing the accuracy and speed of responding to social events.

4. Evaluation of the Signal Integration Model in Social Event Response

Taking the security incident that occurred during a large-scale public event in a certain city as an example, the sudden and rapid expansion of the incident posed a great threat to social order and citizen safety. In this context, signal integration models can be put into use for real-time monitoring, emergency response, and decision assistance, assisting governments and security agencies in quickly taking measures. With the support of the model, the government and security agencies can immediately activate emergency plans after the outbreak of the incident. At the same time, the signal integration model continuously updates the progress of events, enabling decision-makers to quickly respond to the development and changes of events and adjust response strategies [5].

As can be inferred from the above, the measurement of model response speed should mainly revolve around the following core steps: time for event recognition, speed of information processing and fusion, timeliness of emergency response initiation, and efficiency of resource allocation. Therefore, the model should be evaluated based on the following key indicators:

1) Response time, which is the core indicator for evaluating the efficiency of system operation. This measurement involves the duration from event occurrence to decision implementation, including the entire process of event identification, information integration, and emergency response initiation. Reducing response time can accelerate emergency response speed and alleviate the negative impact of events on society.
2) Resource allocation efficiency, which reflects the ability of decision support systems to utilize resources. An efficient model can allocate resources such as manpower and equipment reasonably in a short period of time, ensuring that the most urgent tasks are given priority processing. The efficiency of resource allocation is directly related to the effectiveness of emergency response, and is crucial for ensuring the rapid assembly and efficient utilization of rescue forces.
3) Decision accuracy, which is a key metric that measures whether the system can accurately predict the development trend of events based on collected signals and provide reasonable response suggestions. An efficient decision support system should be able to accurately assess the development dynamics of events and develop optimal emergency strategies to effectively handle unexpected events.
4) The cost-benefit evaluation. Decision-making system needs to maintain a balance between resource investment and returns. Efficient emergency response should not only pursue speed and effectiveness, but also focus on maximizing

efficiency and reducing unnecessary consumption of resources under the premise of limited resources.

5) System robustness, which is the evaluation of a system's ability to cope with uncertainty and external disturbances. A robust system can make reasonable decisions even in environments with incomplete information, data interference, or sudden changes, ensuring the persistence and accuracy of emergency response.

5. Conclusion

This study proposes a signal integration model in the immediate response to social emergencies, including its design, and effectiveness assessment of the model in collecting intelligence, identifying risks, and formulating response strategies. The model brings promises in creating a positive effect on improving emergency response speed and decision-making accuracy, optimizing resource allocation, and enhancing public safety governance capabilities. However, in the specific application of this model, attention should also be paid to the scope of application, data accuracy, and collaboration issues among multiple departments. In the future, by enriching data sources, strengthening technological integration, and enhancing the technical capabilities of emergency management personnel, the potential application of signal integration models in social event response is expected to be more fully realized.

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