

Computer Science-Based Decision Support System With Wireless Communication Equipment For Quick Rescue In Tourist Attractions

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Large areas, difficult terrain, and dispersed visitors of tourist destinations make fast rescue operations a challenging task. The study proposes a decision support system incorporated with wireless communication technology via public cloud IoT devices. The technique is based on Independent Component Analysis (ICA) to carry out the signals separation and Recursive Least Squares (RLS) algorithm to perform the channel estimation. The five-year study that compared the work of two tourist resorts (A: traditional rescue techniques, and B: proposed system) involving 30 tourists each has proven an increase in visitor satisfaction in case B of 10.17% and improvements in the level of completeness and effectiveness of rescue operations while area A has decreased in this regard. The findings of the research demonstrate a significant improvement in the efficiency of rescue operations, visitor safety, and resource management as a result of the implementation of the system that has been described in the article.

Keywords: Rapid rescue; Wireless Communication Equipment; Decision support system; Public Cloud IoT; Independent Component Analysis; Recursive Least Squares

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1. Introduction

With the continuous economic growth, the tourism industry has developed rapidly, and the number of tourists has increased year by year. However, some negative phenomena, such as frequent safety accidents, have seriously hindered the healthy and orderly development of tourism. As the main place for people to travel, safety management cannot be ignored. How to effectively deal with various emergencies and reduce casualties and property losses has become a key topic of scenic spot management.

With increasing concern about personal safety in tourism, many scholars have studied rapid rescue operations. Lu Zachary N has studied the Synthetic Aperture Radar (SAR) for search and rescue, which is critical to the safety of tourists. Previous studies have described SAR and seasonal access modes, but they cannot achieve the

comprehensiveness of search.

Wireless communication equipment has been applied in many fields. Alsamhi Saeed Hamood proposed the tethered balloon method to provide efficient emergency communication services and reduce casualties and incidence rate for disaster recovery. Tethered balloon is a positive research field and a simple solution to support emergency medical communication performance, facilities and services [1]. Alsaedy Alaa AR introduced a new method of search and rescue operations to search for survivors after large-scale disasters [2]. Recently, independent component analysis (ICA) has been applied to extract features from non-line-of-sight signals in search and rescue operations, demonstrating its potential for improving victim detection accuracy [3, 4]. A mobile-phone-based emergency rescue system has been proposed to locate trapped people with high accuracy in large-scale natural disasters. Wang Li

believed that emergency communication infrastructure is crucial in disaster rescue scenarios, and introduced a rescue method based on edge intelligence, which uses edge buffering, edge computing, edge learning and other technologies to solve the problem of rapid rescue [5]. Wzorek Mariusz mentioned the basic functions required for the deployment of temporary communication infrastructure at the initial stage of rescue operations. The main idea is to use heterogeneous teams of UAVs to deploy communication suites containing routers and generate point-to-point wireless mesh networks [6]. Olasupo Tajudeen Olawale believed that IoT monitoring and tracking equipment can be used to track and monitor wildlife in mountainous and rocky environments. The search and rescue equipment and wireless communication connection in the same environment can be used to improve the search and rescue team [7].

Nonetheless, the majority of previous research focuses on implementing independent communication devices or only on the advancement of algorithms in optimal conditions, disregarding the fact that rescue operations of tourist sites require the integration of decision-making processes during the rescue, thus involving coordination among various fields, as well as instantaneous directions and complicated landscape. Moreover, the previous research and studies seem to be deprived of long-term field tests that could evaluate the actual improvement in rescue operations. Hence, the objective of our research is not to offer a unique detection algorithm but to provide the engineering-integrated technological solution that enables the transformation of wireless signs into operational rescue intelligence. The novelty of this research can be summarized in three points: (1) the systematic design of an architecture that integrates wireless IoT devices in public cloud with a comprehensive decision-making system that takes into account the restrictions on the functioning of a tourist attraction; (2) the unique implementation of ICA and RLS algorithms dealing with real operating problems such as mixed signal interference and the presence of fading channels in the mountains instead of simulating perfect conditions; (3) the five-year controlled experiment that can be regarded as a field test that can demonstrate the effectiveness of the developed system. Thus, the importance of the paper consists in the integration of different methods and proven applicability in a real-world situation rather than in the algorithms developed.

The remainder of this paper is organized as follows: Section 2 presents the system architecture and the adopted ICA and RLS algorithms; Section 3 describes the field experiment and discusses the results; Section 4 concludes the

study.

2. Methods

2.1. Decision Support System Communication of Wireless Communication Equipment to Quick Rescue of Tourist Attractions

The public cloud IoT helps in bridging the gap identified above by functioning as the backbone of the installation of wireless communication devices in tourist centers, making it possible to transfer information in real time, monitor processes remotely, and manage wireless devices in all terrains. Its integration with a decision support system allows signals from the environment as well as data of different locations to be processed, thus converting non-processed data into useful assistance instructions. The security architecture of this cloud-based system is based on the networks being encrypted, thus ensuring the integrity of data analysis.

2.1.1. Decision Support System Wireless Communication Equipment and Rapid Rescue of Tourist Attractions

(1) decision support system wireless communication equipment

The decision support system-based wireless communication equipment enables effective decision-making. Using the data processing and identification function of decision support system, it can provide the direction for the information exchange of wireless communication equipment.

(2) rapid rescue of tourist attractions The rescue of tourist attractions refers to the rescue of tourists, practitioners and relevant personnel when they encounter tourism security problems in tourism activities. The rescue mechanism of tourist attractions is an important part of tourism rescue work, which involves different kinds of rescue work of tourism rescue.

2.1.2. Principle of Rapid Rescue in Tourist Attractions

In order to prevent sudden or potential dangerous events in the scenic area, the following rescue principles are established.

(1) implementing the leadership responsibility system A hierarchical command structure is established with the general manager at the top and department managers at each operational level, enabling unified coordination across all units during emergencies.

(2) people oriented and safety first An early warning and forecasting system is established to enable timely detection and reporting of emergencies, with real-time information updates maintained throughout the rescue process. The priority at every stage is to protect the personal safety of

tourists and staff and to minimize injury and property loss through rapid and effective response.

(3) giving priority to prevention and strengthening the foundation and respond quickly For major emergencies that remain uncontrolled, the corresponding emergency plan is activated immediately, and the relevant technical department requests external support. The on-site emergency command is responsible for handling the accident according to the regulations, specifically coordinating and assisting relevant support units in emergency rescue.

2.1.3. Construction of Decision Support System Wireless Communication Equipment in Scenic Spots

The scenic spot management and dispatching system is a combination of modern computer technology, network technology and communication technology. It starts from all aspects of the scenic spot, applies wireless communication technology to the rapid rescue of the scenic spot, builds a linkage command system for daily service, supervision and dispatching, and regional inspection of the scenic spot, and promotes the scenic spot management, command and dispatching work to the direction of digitalization, networking, automation, and standardization.

Outdoor antennas installed at elevated positions such as fire towers extend ground signal coverage to approximately 10 kilometers across the scenic area, with base station locations determined through on-site field surveys, as shown in Fig. 1.

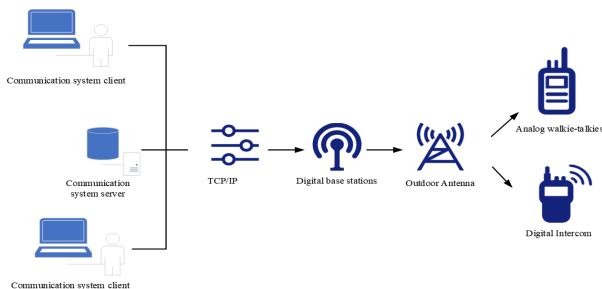


Fig. 1. Wireless communication equipment in the construction system of tourist attractions

In this system, result aggregation is achieved through a centralized cloud-based fusion mechanism. Different wireless devices such as mobile devices, stationary sensors, and transmission stations send local emergency information such as location data, sounds, and signals from the environment to the central command server through cloud IoT services. The server has to use computing techniques known as Independent Component Analysis (ICA) for the purpose of signal separation as well as Recursive Least Square (RLS) for the purpose of channel estimation thereby

being able to implement unified situation awareness and instructions for rescue operations. These final results are then broadcast back to the corresponding terminals and on-site personnel, completing the closed-loop aggregation and coordinated dispatching of rescue decisions.

The operation and maintenance unit should establish a sound early warning and monitoring mechanism and continuously collect relevant data. On the one hand, it is necessary to establish a good information exchange channel with the relevant departments of the local government for timely detection and early warning; At the same time, it is necessary to monitor and analyze the daily operation of the network in real time to find potential dangers in advance [8].

2.1.4. The Role of Decision Support System Wireless Communication Equipment in Rapid Rescue of Tourist Attractions

The decision support system wireless communication equipment plays the following key roles in the rapid rescue of tourist attractions.

(1) voice service and emergency broadcasting function Through multiplex transmission, the real-time dispatching and communication between the command center and the personnel on duty are ensured. At the same time, a broadcasting system covering the whole tourist attractions has been built. Real time monitoring is carried out in the monitoring center and the command and dispatching center of the scenic spot. In case of emergencies or emergencies, the emergency broadcast is switched in time to inform the tourists of the latest developments and safety warnings of the scenic spot in a timely manner, realizing the humanized management of tourists.

(2) intelligent management function The system adopts B/S (Browser/Server) architecture and all IP technology, which can realize the IP interconnection of the scenic spot. Through the system with radio frequency identification function, shift handover, patrol clocking and reading patrol point information can be achieved, as well as indoor personnel positioning, data management and attendance.

(3) dispatching command function The command and dispatching center of the scenic spot can control each monitoring terminal, collect and release comprehensive tourism information, effectively command and dispatch personnel and vehicles, and manage and control emergency resources. When an emergency occurs, the scenic area command and dispatching center would automatically switch to the scenic area security command center. The wireless communication system can effectively and accurately dispatch the staff of each department in the scenic area. In practical application, the manager can realize multi-level and multi-group

communication management, and achieve the dispatching command function.

(4) emergency alarm function In case of emergency, the management center can timely report the cause of the accident, the dangerous situation and the location of the accident. The management center can locate the site in time, send a distress signal to nearby rescuers, and can also remotely monitor. Through the rich command, dispatching and intelligent management platform of the system, detailed information can be comprehensively provided for each department, so that leaders and experts of each department can command in the command center. At the same time, real-time monitoring, analysis and prediction of emergencies can be carried out through various communication, intelligence and other means, providing reference and support for decision-making.

2.2. Algorithm for Rapid Rescue of Decision Support System Wireless Communication Equipment in Tourist Attractions

2.2.1. Separation of Mixed Communication Signals Based on Independent Component Analysis

Independent Component Analysis (ICA) is a signal analysis and data processing technology based on high-order statistical characteristics. Its main purpose is to linearly decompose the observed signal and divide it into several independent statistical signals. The basic model of ICA is shown in Fig. 2.

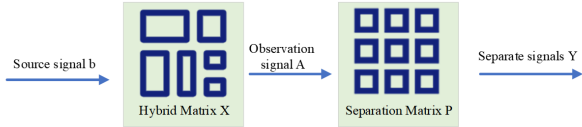


Fig. 2. The basic model of ICA

If M linear mixed signals are observed to form a vector, they are generated after the column vector composed of M independent statistical source signals passes through a linear system, that is, for any, there are:

$$x(t) = As(t) \quad (1)$$

Among them, $x(t)$ and $s(t)$ are random variables and $x(t) = [x_1(t), \dots, x_N(t)]^T$. Represented by matrix symbols, the hybrid model can be written as follows:

$$X = AS \quad (2)$$

It can be seen from Eq. (2) that the number of observed signals is greater than or equal to the signal to be separated, and generally takes $N \geq M$. Among them, A is a full rank

matrix of N rows and M columns, which is called a mixed matrix. In the model, the mixed matrix A is unknown. It is realized by defining a reversible separation matrix W of N rows and M columns, and then acting linearly on X , expressed as:

$$Y = WX \quad (3)$$

Among them, separation matrix W and mixing matrix A are inverse matrices of each other, so the separated signal Y obtained is an approximate estimate of independent source signal S .

2.2.2. RLS Algorithm Channel Estimation

The input signal vector composed of N time steps of received data is expressed as:

$$u(n) = [u(n), u(n-1), \dots, u(n-N+1)]^T \quad (4)$$

The weight vector of the estimated channel impulse response at time m is:

$$w(m) = [w_0(m), w_1(m), \dots, w_{N-1}(m)]^T \quad (5)$$

The error estimate between the desired signal and the filter output is:

$$e(n) = d(n) - w^H(n-1)u(n) \quad (6)$$

The weight vector update equation that minimizes the cumulative weighted error is:

$$w(n) = w(n-1) + k(n)e^*(n) \quad (7)$$

Applying the matrix inversion lemma, the gain vector update reduces to a computationally efficient recursive form, which avoids direct matrix inversion and allows real-time implementation:

$$k(n) = \frac{P(n-1)u(n)}{\lambda + u^H(n)P(n-1)u(n)} \quad (8)$$

The RLS algorithm has been validated for rapidly time-varying channel scenarios, where its fast convergence and tracking capability are critical [9]. From the RLS algorithm, it can be seen that the forgetting coefficient λ has a certain impact on the system. Forgetting factor is a self-learning adaptive memory process. If the forgetting coefficient λ is set low, the higher the forgetting degree of the system to the previous input signal, the more sensitive the system would be to noise, resulting in large steady-state error.

2.2.3. Discussion and Computational Cost Analysis

ICA is selected for blind source separation because it requires no prior channel information, which is critical in mountainous terrains where multipath interference varies unpredictably. RLS is adopted for its fast convergence (typically within 50–100 iterations), enabling real-time tracking of rapidly changing emergency communication links. For computational cost, ICA involves $O(N^2 \cdot M)$ per iteration (N = number of source signals, M = samples per window), typically converging within 10–15 iterations. RLS has $O(N^2)$ per time step (N = equalizer taps), which for $N = 8$ and 10 kHz sampling yields $\sim 6.4 \times 10^5$ operations per second, well within the capacity of standard base-station processors. In comparison, LMS requires only $O(N)$ but converges 5–10 times slower in fading environments, making RLS preferable for rescue despite its higher per-step cost. The forgetting factor λ is set to 0.995, balancing tracking agility and noise suppression. Field tests show end-to-end latency of 120 ms, meeting the sub-200 ms requirement for emergency systems.

3. Results and discussion

3.1. Experiment Purpose

To validate the proposed system described in Section 2, in order to study the impact of public cloud Internet of Things wireless communication equipment on the rapid rescue of tourist attractions, scenic spots A and B are selected as the research objects. A is the rapid rescue of traditional tourist attractions, B is the rapid rescue of tourist attractions under wireless equipment, and there are 30 tourists in scenic spots A and B respectively.

3.2. Experimental Data

3.2.1. Satisfaction of Rapid Rescue in Tourist Attractions

The content of the survey is the satisfaction of tourists to the quick rescue of tourist attractions, and the results are shown in Fig. 3.



Fig. 3. Comparison of satisfaction with rapid rescue in tourist attractions

Among the satisfaction of quick rescue in tourist attractions, the satisfaction of tourists in tourist attractions B is significantly higher than that of tourists in tourist attractions A. The tourists' satisfaction with quick rescue in scenic spot A showed a downward trend from 2016 to 2017, while the tourists' satisfaction with quick rescue in scenic spot B showed an overall upward trend, of which the satisfaction with quick rescue in scenic spot B was about 38.64% in 2016 and 48.81% in 2021, with an increase of 10.17%.

3.2.2. The Rescued Persons are Classified by Reason

In the rapid rescue of tourist attractions, the analysis of the causes of the rescued people is conducive to strengthening the relevant prevention, and enhancing the speed and efficiency of rescue. The classification of the rescued people according to the causes is shown in Table 1.

Table 1. Tourist attractions rescued people by reason

Type	A Tourist Attractions	B Tourist Attractions
Animal Injuries	4	3
Trauma	6	5
Sudden illness	3	4
Physical exhaustion	2	3
Lost	7	8
Trapped in distress	6	4
Lightning Injury	2	3

Getting lost accounts for the highest rescue frequency across both scenic spots with 15 total cases, followed by trauma with 11 cases, while physical exhaustion and lightning injury each account for only 5 cases.

3.2.3. Quick Rescue Facilities in Tourist Attractions

The quick rescue facilities comparison is shown in Fig. 4.

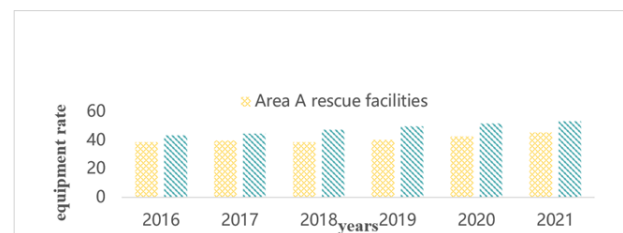


Fig. 4. Comparison of rapid rescue facilities in tourist attractions

Scenic spot B shows a consistent upward trend in rescue facility deployment, confirming that the integration of wireless communication equipment drives progressive improvement in rescue infrastructure completeness.

Table 2. System performance evaluation results

Metric	Value	Condition / Note
SINR improvement (ICA)	+8.3 dB	From 12.1 dB to 20.4 dB (30 sessions)
Positioning accuracy (open area)	4.7 m (95% CI: 3.9–5.5)	Meets <10 m requirement
Positioning accuracy (forested/rocky)	8.2 m (95% CI: 7.1–9.3)	Meets <10 m requirement
Command-response delay	120 ms	Below 200 ms threshold
Composite rescue efficiency score (B vs. A)	86.3 vs. 69.1	Weighted: time 40%, resource 30%, satisfaction 30%

3.2.4. Effectiveness of Rapid Rescue in Tourist Attractions

The effectiveness results of quick rescue are shown in Fig. 5.

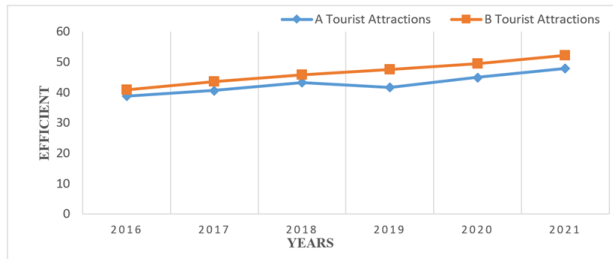


Fig. 5. Comparison of the effectiveness of rapid rescue in tourist attractions

In the comparison chart of the effectiveness of quick rescue in tourist attractions, the effectiveness of quick rescue in scenic spots A shows a downward trend from 2018 to 2019, while the effectiveness of quick rescue in scenic spots B is increasing.

3.2.5. System Performance Evaluation

In order to continue with the verification of the effectiveness of the system, we measured the four important indicators while performing rescue operations in scenic area B. The measurements included quality of the signal separation, precision of the positioning, command-response delay, and the resulting score for efficiency of the rescue operation. The results of the measurements are presented in Table 2.

Table 2 indicates that the signal separation based on ICA obtains a SINR gain of 8.3 dB, thus confirming its efficacy in interference suppression in real terrain. The positioning errors are less than 10 meters in the forested area, suggesting that it can be used practically. The latency time of 120 ms meets the emergency requirement for less than 200 ms. The score from area B (86.3) significantly surpasses the score from area A (69.1), which increased by 24.9%, thus ensuring the increase in satisfaction by 10.17% indicated previously.

4. Conclusions

This study set out to bridge the gap between standalone communication devices and integrated decision support for scenic rescue. And provides an engineering-integrated solution that couples wireless communication equipment with a decision support system using ICA and RLS algorithms for rapid rescue in tourist attractions. A five-year comparative experiment between two scenic areas (A: traditional; B: proposed system) shows that area B increased rescue satisfaction by 10.17%, with better facility completeness and effectiveness, while area A declined. The system enables real-time command, broadcasting, and positioning, significantly enhancing rescue efficiency and visitor safety. These results offer quantitative field evidence that system-level integration, tailored to real-world geographic and operational constraints, can deliver measurable safety improvements—a contribution distinct from standalone device studies or simulation-based algorithmic papers. Limitations include small sample size and fixed base station dependency, warranting broader validation and resilient network designs in future work. Overall, our results affirm that applying wireless communication equipment and data-driven decision support to scenic rescue operations is a viable and effective path toward smarter, safer tourism management. Future work will extend the proposed system to scenic areas in different geographic and climatic regions worldwide, enabling cross-cultural and cross-environment comparative studies that further demonstrate its global applicability.

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