Guardians of Heritage Resources: A Preliminary Investigation into the Application of the Intelligent Sentry System in the Mount Tai Scenic Area

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Abstract This article examines the intelligent forest sentry system in the Mount Tai Scenic Area, analyzing its applications, accomplishments, and significance in forest fire prevention. It highlights the system's critical role in enhancing comprehensive forest fire prevention and control capabilities, accelerating emergency response times, and safeguarding the heritage resources of Mount Tai. Furthermore, the system is evolving into a "Smart Forest and Grassland Resources Supervision Platform" that integrates forest fire early warning, ecological environment monitoring, and pest and disease management to promote the sustainable development of forest resources.

Key words Mount Tai, Forest fire prevention, Intelligent sentry system, Ecological protection, Heritage resources

1 Introduction

To improve comprehensive forest fire prevention and control capabilities and enhance the monitoring and management of forest fire risks and potential hazards, the Mount Tai Scenic Area is actively pursuing an AI-driven approach to enhance "technology-based fire prevention"[1]. By developing the "intelligent forest fire prevention sentry system", the scenic area aims to establish a complementary, three-dimensional prevention and control system encompassing human defense, physical defense, and technological defense. This approach effectively safeguards the forest resources of Mount Tai and ensures the sustained stability and improvement of forest and grassland fire prevention and control efforts[2].

2 Context for using intelligent sentry

Mount Tai, designated as a World Natural and Cultural Heritage Site, possesses abundant forest resources and maintains a high rate of forest coverage. Its distinctive historical and cultural significance attracts numerous tourists annually[3]. Nevertheless, the substantial influx of visitors, combined with the complex surrounding environment, has imposed significant challenges on forest fire prevention efforts within the scenic area. Visitors who enter the forest via non-designated routes in violation of regulations represent a significant potential factor contributing to forest fires. Such unauthorized entry not only increases the risk of forest fires due to improper fire use but also harms the ecological environment of the scenic area, and may inflict severe damage on heritage resources. Traditional manual patrol methods exhibit considerable limitations, including extensive monitoring blind spots, numerous surveillance gaps, and delayed response times when addressing the challenges posed by vast mountainous and forested areas with complex terrain. In response to these issues, the Mount Tai Scenic Area has been actively seeking effective strategies to enhance personnel management in forest fire prevention efforts. The Mount Tai Scenic Area has established an intelligent sentry system organized by work team sub-areas, building upon the existing fire prevention infrastructure. This system enables comprehensive and verifiable monitoring of safety gates within the fire isolation network, the primary mountain entrances, adjacent minor roads, and personnel activity zones within the buffer area[4].

3 Challenges faced by forest fire prevention in the Mount Tai Scenic Area

3.1 Difficulty in personnel management The Mount Tai Scenic Area is characterized by a high forest coverage rate, extensive boundary lines, and a wide distribution of fire prevention points, which collectively complicate the implementation of all-round and all-time manual monitoring. Some tourists frequently enter the forest via unauthorized routes, either to evade admission fees or to pursue novel experiences, whereas traditional methods prove inadequate for effectively detecting and preventing such unauthorized access.

3.2 Limitations of traditional forest fire prevention measures Traditional forest fire prevention primarily depends on manual patrols, watchtower surveillance, and similar methods. However, manual patrols are limited by terrain and personnel availability, hindering comprehensive coverage and real-time monitoring of the entire area. Watchtower observation is subject to blind spots and is significantly influenced by environmental factors such as weather conditions and the time of day. Furthermore, conventional approaches to controlling unauthorized entry into mountainous and forested areas lack the capacity for timely detection and warning, allowing some violators to evade inspections and clandestinely introduce fire sources into forest regions, thereby increasing the risk of fire hazards[5].

3.3 Numerous fire hazards When tourists enter mountainous

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and forested areas via non-designated routes, they may engage in unauthorized fire-related activities, such as smoking, barbecuing, or attempting to keep warm. Even a minor error in these practices can easily result in forest fires. Furthermore, the scenic area contains a substantial accumulation of dead branches and fallen leaves from broad-leaved forests, as well as highly flammable coniferous species such as pine and cypress. Consequently, if a fire ignites, it will spread rapidly[6].

3.4 Delayed response times Reliance on forest rangers for fire detection often results in significant time delays. The interval between the initial discovery of a fire, its reporting, and the subsequent organization of firefighting efforts is prolonged, thereby hindering effective early-stage fire suppression.

4 Composition and advantages of the intelligent sentry system

Under the new circumstances, enhancing technological support to improve the modernization of forest and grassland fire prevention and control represents a critical strategy[7]. The development of the intelligent sentry system in the Mount Tai Scenic Area constitutes a comprehensive solution that integrates advanced hardware and software technologies, with the objective of improving the monitoring and management efficiency of heritage resources.

The system's hardware architecture primarily comprises an efficient 4G video transmission platform, which facilitates the real-time transmission of high-definition video data to ensure the timeliness and accuracy of monitoring information. Additionally, the system incorporates an infrared trigger module that automatically activates the camera during nighttime or low-light conditions, thereby effectively capturing abnormal activities and enhancing all-weather monitoring capabilities. The surveillance camera, serving as the system's visual perception unit, features a high-resolution design that enables clear recording of every detail within the scenic area, thereby providing robust support for the protection of heritage resources. The voice speaker, a critical tool for information dissemination, can deliver early warning messages to tourists or staff during emergencies, thus improving the timeliness of emergency responses. To guarantee the uninterrupted operation of the system, it incorporates solar panels and backup batteries. By integrating renewable energy sources with energy storage technologies, the system attains energy self-sufficiency and diminishes dependence on the conventional power grid. The erection rods serve as the supporting framework, ensuring the stable installation and optimal arrangement of all hardware equipment.

At the software composition level, the intelligent sentry system in the Mount Tai Scenic Area utilizes Hikvision's remote monitoring platform [Yingshi (EZVIZ)]. This platform, equipped with robust data processing and analytical capabilities, enables centralized management, remote access, and intelligent analysis of the monitoring images within the scenic area. Users can conduct real-time monitoring and video playback via the computer interface, and monitor the safety status of the scenic area at any time and from any location through the Yingshi (EZVIZ) monitoring application on mobile devices. This capability significantly enhances the convenience and flexibility of management. The highly integrated and intelligent design of both the software and hardware components constitutes a robust foundation for the intelligent sentry system, thereby providing substantial technical support for the security of heritage resources.

The intelligent sentry system is characterized by ultra-high-definition image quality, incorporating high-resolution lenses and advanced image processing technology to deliver clear and smooth visuals across diverse lighting conditions. It integrates an AI-based human shape detection algorithm, enabling intelligent motion tracking and anomaly detection capabilities. Upon detecting an anomaly, the system promptly sends an alert notification to the user's mobile device. Additionally, it features a two-way voice intercom function, facilitating real-time audio communication between administrators and the camera via mobile phones. The system offers a wide-angle field of view with horizontal and vertical rotation capabilities, allowing comprehensive surveillance coverage of nearly all areas. This system is equipped with a highly effective night vision function, incorporating infrared capabilities that ensure clear monitoring images in low-light or nighttime conditions. Additionally, the system features a compact design, includes an integrated WiFi module, and is straightforward to install and configure. Installation requires only the setup of appropriate support poles in forested areas, making it adaptable to the operational requirements of diverse environments.

5 Deployment of the intelligent sentry system

5.1 Precise allocation based on risk levels Utilizing data obtained from the second-class forest resource survey, this study conducted a comprehensive analysis of five potential factors influencing forest fires: tree species, elevation, slope gradient, slope aspect, and buffer distance from human activity zones[8]. High-risk forest fire hazard areas were identified, and the deployment of monitoring equipment was optimized in locations including zones with concentrated flammable tree species, forest edge transition areas, tourist trails, and burial grounds.

5.2 Coordinated allocation of critical time periods and regions Statistical data indicate a positive correlation between the frequency of forest fires and rising temperatures. The designated fire prevention period typically extends from December of the preceding year to May of the subsequent year. The majority of forest fires occur under adverse weather conditions and are primarily attributed to human activities involving fire use[9]. During dry, hot, and windy seasons, it is imperative to enhance fire risk monitoring, inspection, and early warning systems[10]. Considering the combined effects of meteorological factors and forest phenological factors, it is recommended to increase the number of "intelligent sentries" and to expand both the monitoring scope and threshold.

5.3 Dual allocation of "biology + technology" The forested regions within the Mount Tai Scenic Area predominantly consist of small patches of coniferous and broad-leaved forests, including fire-resistant broad-leaved species such as *Robinia pseudoacacia* and *Quercus* L. Firebreaks have been established to enhance the ecosystem's inherent fire resistance. Complementing this biological defense, the "Mount Tai intelligent sentry system" network belt has been designed in accordance with site-specific conditions to address the limitations of manual patrols and enable real-time monitoring of the entire area.

6 Workflow of the intelligent sentry system

6.1 Real-time monitoring and early warning Upon entry into the electronic fence area, the monitoring system is activated. The intelligent sentry promptly sends an alarm signal to the mobile terminal while simultaneously transmitting real-time image data. If the mobile terminal fails to respond in a timely manner, the system initiates a phone call to notify the user, enabling grid workers to promptly assess the situation. This approach effectively addresses blind spots encountered during patrols and prevents unauthorized individuals from accessing mountainous and forested areas via alternative routes.

6.2 Human-machine interaction and handling When an individual enters the monitored area and triggers an alarm, grid workers typically employ one of the following three response strategies upon receiving the alert. First, they utilize the two-way voice intercom via the mobile application to communicate with the individual in real time, promptly advising and persuading them to leave the area. Second, they immediately contact nearby patrol personnel to arrive at the scene and encourage the individual to depart. Third, if the individual does not comply with persuasion, the workers promptly request reinforcement from higher authorities to manage the situation and provide educational information regarding forest fire prevention. This human-machine interaction has significantly enhanced the inspection efficiency of forest rangers, enabling them to promptly and accurately deter rule violations and thereby mitigate potential human-induced fire hazards.

7 Application effectiveness of the intelligent sentry system

7.1 Reducing the number of individuals entering the mountains in violation of regulations Since the implementation of the intelligent sentry system, statistical analysis of data collected from multiple monitoring points has revealed a significant decrease in the number of unauthorized attempts to enter the mountainous areas. Compared to the period prior to the system's installation, these attempts have been reduced by approximately 80%.

7.2 Reducing the risk of fire The system has effectively prevented the illegal use of fire by individuals who violated regulations upon entering the mountains, thereby reducing the likelihood of forest fires at their origin.

7.3 Improving the management efficiency of the scenic area The implementation of the intelligent sentry system allows the scenic area management department to allocate patrol forces with greater precision, invest additional human and material resources in the prevention and control efforts during key areas and critical periods, and enhance the overall management efficiency and safety of the scenic area[11].

8 Significance of the intelligent sentry system

The implementation and utilization of the intelligent sentry system have effectively mitigated the dependence on extensive human labor in forest fire prevention and control. This system has addressed blind spots and vulnerabilities in forest patrols, thereby establishing a complementary three-dimensional prevention and control model that integrates human defense, physical defense, and technological defense. It represents an optimal integration of technological defense via wireless monitoring and alarm systems and human defense through personnel management. The system facilitates human-machine interaction, effectively mobilizes all fire prevention resources within the area, and accurately manages emergencies, representing a valuable advancement in grid-based management[12]. The implementation of active management at the monitoring terminal serves as a beneficial complement to the intelligent Mount Tai system within the scenic area. The intelligent sentry system not only enhances the forest fire prevention capabilities of the scenic area but also significantly contributes to the preservation of its heritage resources, while simultaneously providing robust support for the scientific management of the area.

9 System limitations and future prospects

Although the intelligent sentry system implemented in the Mount Tai Scenic Area has yielded certain positive outcomes, it continues to encounter limitations related to technology, data management, and collaborative processes in practical applications. These shortcomings stem from both inherent technical constraints of the system and challenges arising from management practices and external environmental factors. For example, there are "blank spaces" and "ambiguities" during the monitoring process. The complex terrain of Mount Tai inevitably results in fixed cameras being obstructed. Even the current system exhibits blind spots within its field of view, allowing initial fires to develop undetected. The system's detection capability significantly diminishes at night and under adverse weather conditions such as fog, rain, or snow. Although the existing system incorporates features such as infrared technology, further advancements are necessary to accurately identify fires under all weather conditions, thereby addressing the variable climate of Mount Tai. The system operates in an outdoor environment and encounters challenges including high temperatures, lightning strikes, and humidity, which place considerable stress on equipment stability as well as on operation and maintenance processes.

Furthermore, longstanding issues such as inadequate road infrastructure and limited water sources in certain forested areas hinder the early detection and prevention of fires once they have started.

In the future, the management area can further optimize the intelligent sentry system by attempting to integrate it into the scenic area's big data center and exploring its compatibility with UAVs and other security systems. This approach aims to enhance the system's intelligence in forest fire prevention as well as its comprehensive prevention and control capabilities. Additionally, efforts will be made to overcome the limitations associated with monitoring a single type of disaster. Building upon the existing hardware infrastructure, system architecture, and early warning procedures, the system will be advanced toward a "Smart Forest and Grassland Resources Supervision Platform". This platform will integrate forest fire early warning, ecological environment monitoring, and pest and disease control, thereby establishing a robust safety defense mechanism to support the sustainable development of the Mount Tai Scenic Area.

References

[1] ZHAO CB, ZHANG YJ. Analysis of the current situation and development trend of Journal of Wildland Fire Science Technology[J]. Journal of Wildland Fire Science, 2023, 41(3): 43 – 46. (in Chinese).

[2] CHEN Y, YU LZ, LIU CX, *et al.* Discussion on promoting forest ecological protection through systems engineering thinking[J]. Journal of Wildland Fire Science, 2024, 42(4): 57 – 59. (in Chinese).

[3] ZHOU WZ. Development and protection of eco-tourism resources in forest parks: Taking the 22nd urban forest flower exhibition as an example[J]. Forest Products Industry, 2024, 61(11): 97 – 98. (in Chinese).

[4] SONG SB, YU HY. Research on the application of intelligent monitoring system in forest fire safety management[J]. Electronic Engineering & Product World, 2022, 29(6): 28 – 30. (in Chinese).

[5] XUE ZZ, XIAO RT, LEI F. Assessing wildfire risk and mitigation strategies in Qipanshan, China[J]. International Journal of Disaster Risk Reduction, 2022, 80: 103237.

[6] ZHOU Q, ZHANG H, WU ZW. Effects of Journal of Wildland Fire Science policies on probability and drivers of forest fires in the boreal forests of China during different periods[J]. Remote Sensing, 2022, 14(22): 5724.

[7] XU CY. Thinking about comprehensively promoting the integration of forest and grassland fire prevention and suppression in the new era[J]. Journal of Wildland Fire Science, 2024, 42(3): 1 – 4. (in Chinese).

[8] WU LX. Research on ArcGIS forest fire risk zoning based on forest resources data[J]. Anhui Agricultural Science Bulletin, 2018, 24(18): 93 – 96, 121. (in Chinese).

[9] XIAO J. Influence of meteorological factors on forest fires and fire prevention countermeasures[J]. Forestry of China, 2010(7): 41. (in Chinese).

[10] TIAN XJ. Analysis on the current situation and countermeasures of forest fire prevention in Changping district of Beijing[J]. Journal of Wildland Fire Science, 2023, 41(4): 30 – 32. (in Chinese).

[11] XU ZH. Development planning study of forestry eco-tourism industry chain: Taking the academic seminar of forest park and forest tourism of Chinese Society of Forestry as an example[J]. Forest Products Industry, 2024, 61(7): 105 – 106. (in Chinese).

[12] ZHANG J, WANG SZ. Grid management: The infrastructure of China's grassroots governance[J]. Governance Studies, 2024, 40(5): 42 – 52. (in Chinese).

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[9] YAO YJ, CHEN B, LI TJ. Sequencing and analysis of the mitochondrial genome of Scoliidae[J]. Acta Entomologica Sinica, 2023, 66(1): 99 – 107. (in Chinese).

[10] HUANG Z, GUO QX. Mitochondrial whole genome assay and phylogeny of *Bactrocera* (*Zeugodacus*) *atrifacies* (Dipitera, Tephritidae)[J]. Journal of Fujian Forestry Science and Technology, 2024, 51(4): 8 – 16, 42. (in Chinese).

[11] YUAN ML, ZHANG QL, GUO ZL, *et al.* Comparative mitogenomic analysis of the superfamily Pentatomoidea (Insecta: Hemiptera: Heteroptera) and phylogenetic implications[J]. BMC Genomics, 2015, 16: 460.

[12] HUANG Z, YU H, BAI YH, *et al.* Morphology, mitochondrial genome and phylogenetic analysis of six important *Bactrocera* (*Zeugodacus*) species[J]. Fujian Journal of Agricultural Sciences, 2026, 41(1): 1 – 13. (in Chinese).

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[3] YU SH, LUO XP, JIANG RX, *et al.* Baoshan small-grain coffee: The origin of New China's coffee[J]. Yongchang Literature Coffee Special Issue, 2022, 188(5): 16 – 43. (in Chinese).

[4] MO LZ, YAN L, DONG YP, *et al.* Illustrated cultivation techniques for high-yield and high-quality small-grain coffee[M]. Kunming: Yunnan People's Publishing House, 2012. (in Chinese).

[5] Baoshan Daily. New quality productive forces help build premium Baoshan coffee (Baoshan small-grain coffee)[EB/OL]. (2025 – 01 – 13)[2025 – 05 – 30]. https://credit.baoshan.gov.cn/detail.do?channelId=1585dc297ed84cb3bac94532f7faa33e&contentId=ac23b1eedb3e40bd91044084a4dab51f. (in Chinese).