

Research on the Application of Lightweight AI Technology in Safety Instruction for Operational Training of Primary-Level Firefighting Forces

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Abstract: Operational training safety is an important guarantee for the combat effectiveness and standardized duty and training of primary-level firefighting forces. With the increasing number of complex and high-risk emergencies, safety instruction for operational training of primary-level firefighting forces is facing greater challenges. According to data from the National Fire and Rescue Administration, the annual average incidence of high-rise building fires, hazardous chemical leaks, high-altitude rescues, water and ice rescues, and other emergencies has increased by approximately 5% over the past two years. At present, safety instruction for operational training of primary-level firefighting forces is generally confronted with prominent problems, such as limited practical training scenarios, rigid teaching modes, difficulty in memorizing safety regulations, and inefficient review of typical cases. Traditional teaching methods can hardly meet the practical operational needs of “all-hazard types and major emergencies.” To address the pain points and difficulties in primary-level safety instruction, this study takes lightweight artificial intelligence technology as the research medium and, based on the Operational Training Safety Guidelines for National Comprehensive Fire and Rescue Forces (Trial) (hereinafter referred to as the Safety Guidelines), investigates the adaptation advantages and implementation pathways of three lightweight tools, namely Jimeng AI, Doubao AI, and Jianying AI, in safety instruction for operational training.

Keywords: lightweight AI technology; firefighting forces; operational training safety; visualized teaching

1. Introduction

With the continuous changes in social industries and business forms, complex and high-risk emergencies, such as building fires, hazardous chemical leaks, high-altitude rescues, water and ice rescues, and deep-well operations, are becoming increasingly frequent. The operational training environments of primary-level firefighting forces are becoming increasingly complex, and safety risks are also increasing, placing increasingly higher demands on the standardized operation, risk assessment, and safe response capabilities of fire officers and soldiers. Operational training safety is the bottom line of fire and rescue operations and is also a guarantee of the life safety and combat effectiveness of fire and rescue forces. At present, primary-level safety instruction still faces obvious practical contradictions: First, due to limitations in sites and safety conditions, high-risk training subjects cannot be routinely conducted as full-process practical training. Second, the Operational Training Safety Guidelines contain numerous provisions, making them difficult for fire officers and soldiers to understand. Third, teaching methods are monotonous and rigid, relying primarily on methods such as document dissemination, oral explanation, and demonstrations by experienced personnel, making it difficult to present abstract content intuitively. With the rapid development of lightweight AI technology, its characteristics of low cost, quick adoption, and strong practicality mean that it does not require professional equipment or a technical foundation. This is consistent with the actual conditions of primary-level firefighting forces, which have limited funding and weak technical capabilities. It can transform abstract safety regulations, high-risk scenarios, and standardized operational procedures into intuitive dynamic images, and visually present content that is difficult to explain through text or unsafe to practice on site. This effectively addresses the pain points of primary-level safety instruction and provides a practical and feasible new approach to safety instruction for operational training at the primary level.

2. Prominent Problems in Operational Training Safety of Primary-Level Firefighting Forces

2.1 Limitations on Practical Training in High-Risk Subjects

Due to limitations in site conditions, safety risks, equipment and apparatus, and organizational capabilities, primary-level fire stations cannot routinely conduct full-process practical training in high-risk subjects such as interior fire attack,

rope rescue, water and ice rescue, and hazardous chemical incident response. Most high-risk training programs can often only avoid risks by simplifying procedures, reducing steps, or even suspending training. Due to the lack of opportunities for realistic emergency training, fire officers and soldiers have difficulty improving their capabilities in risk identification, pre-event assessment, and emergency response.

2.2 Difficulties in Learning the Safety Guidelines

The Safety Guidelines are complex in content and contain numerous professional terms, covering the entire process of duty, training, and rescue. Meanwhile, primary-level duty and training tasks are complicated, and most learning is fragmented. Fire officers and soldiers generally have problems such as insufficient understanding, weak memory, and incomplete mastery. As a result, the Safety Guidelines are not fully implemented in actual operations, and implementation standards are inconsistent.

2.3 Traditional and Monotonous Teaching Methods

Primary-level safety instruction mainly relies on traditional methods such as document dissemination, oral recitation, and demonstrations by experienced personnel, while lacking intuitive and visualized teaching methods. For content involving hidden risks, dynamic hazards, standardized movements, and prohibited behaviors, it is difficult to achieve precise and thorough transmission and understanding through explanation, memorization, and demonstrations alone. The effectiveness of teaching is constrained by factors such as individual experience and communication skills, making it difficult to establish a unified and standardized safety instruction system.

2.4 Low Efficiency of Case Review

Due to limitations in time and energy, primary-level case reviews mainly rely on on-site rescue video materials and oral accounts by fire officers and soldiers to organize and reconstruct the review process. It is difficult to quickly restore the overall rescue scene or dynamically reproduce the development of accident risks, and understanding of the safety lessons from cases often remains superficial. Meanwhile, due to limitations in equipment and personnel capacity at the primary level, it is relatively difficult to rapidly produce review-based teaching content, making it impossible to quickly develop review materials for operational assessment and explanation. As a result, the lessons from many cases cannot be promptly transformed into practical safety warnings.

3. Adaptation Advantages of Lightweight AI Technology in Primary-Level Safety Instruction

3.1 Low-Cost Implementation, Consistent with Primary-Level Conditions

Primary-level fire stations frequently face situations such as insufficient funding and inadequate hardware. Traditional review software is costly, complicated to operate, and difficult to popularize. Lightweight AI technology can be operated using only an ordinary office computer and does not require professional equipment or personnel. It has low costs and no maintenance burden, and its free usage quota can meet the needs of routine instruction. It is an effective teaching tool for primary-level units that can be rapidly implemented and used routinely.

3.2 Visualized Scenarios, Addressing the Challenges of High-Risk Practical Training

Lightweight AI technology can transform high-risk subjects such as interior fire attack, rope rescue, water rescue, and hazardous chemical incident response into dynamic and visualized scenes, reproducing scenarios such as fire spread, collapse hazards, water-related risks, and the consequences of violations without risk or equipment loss. Simulation training scenarios created using AI technology enable fire officers and soldiers to intuitively experience the changing processes of various risks in a virtual environment without actual operation, understand the hazards of violations, and address the problems of being “afraid to train, unable to train, and unable to complete all training,” thereby compensating for deficiencies in practical training for high-risk subjects.

3.3 Concretizing Standards, Reducing the Difficulty of Learning and Memorization

The content of the operational training safety guidelines is abstract and complex. Lightweight AI technology can transform abstract provisions into dynamic procedures with step-by-step instructions, annotations, and explanations, convert textual requirements into intuitive actions, and break down complex standards into clear steps, enabling fire officers and soldiers to quickly understand and strengthen their memory, greatly reducing learning difficulty and improving learning efficiency.

3.4 Dynamic Case Review, Strengthening Safety Warning Education

Lightweight AI technology can rapidly reproduce the entire process of emergency response and present the generation of safety hazards, escalation of risk levels, occurrence of violations, and other processes in a visualized form, thereby effectively exposing safety deficiencies and shortcomings. The review content is clear and the warning effect is profound, enabling trainees to learn lessons promptly, avoid the recurrence of similar accidents, and transform operational case experience into safety capabilities.

4. Lightweight AI Tools and Practical Applications

Lightweight AI technology is based on the principles of low cost, zero threshold, ease of use, practical relevance, and routine application. In accordance with the requirements of the Safety Guidelines, operational verification is conducted using a combination of three AI tools, namely Jimeng, Doubao, and Jianying, to complete the entire process of prompt writing, safety animation generation, standardized editing and voice-over, and final video output. This meets the actual needs of safety instruction at primary-level fire stations and units and provides a practical and useful AI application solution for primary-level fire stations and units.

4.1 Jimeng AI

Jimeng AI is a lightweight video generation tool designed for primary-level firefighting forces. It is suitable for operation on ordinary office computers and does not require professional skills in three-dimensional modeling. The operation process is simple. Operators can create a new animation project on the platform, enter standardized firefighting prompts, set parameters such as image resolution, duration, character appearance, and disaster scenario, and generate a short teaching video with one click. It supports segmented generation by storyboard, partial image redrawing, and batch export of short-video materials, enabling a single person to complete the production of a set of safety demonstration animations. Based on the Safety Guidelines, the platform functions are divided into four modules to produce visualized teaching resources, ensuring both standardized reproduction and operational convenience.

4.1.1 Basic Safety Standards

From the perspective of practical operation, the entire process from receiving an alarm to responding to an emergency is taken as the core for writing prompts. A unified outdoor real-scene animation style is adopted, with the duration of a single shot controlled at 5–8 seconds. After generating segments such as boarding the vehicle, driving, parking, establishing a safety perimeter, and reconnaissance through storyboards, the segments are combined online. The animation does not explain complete provisions but focuses on high-frequency and error-prone operations such as vehicle hazard avoidance, reconnaissance team formation, and safety perimeter distance. It visually demonstrates mandatory safety red lines and addresses the problem of fire officers and soldiers having unclear memories of basic response standards.

4.1.2 Firefighting Operation Safety

During practical operation, an indoor fire-scene simulation template is used, with prompts mainly specifying elements such as prohibited high-risk positions, three-person interior attack teams, self-contained breathing apparatus monitoring, and emergency evacuation. Risk close-up shots such as heavy smoke, flashover, and building collapse can be generated separately. Partial images at key stages such as forced entry, ventilation and smoke exhaust, and fire-scene cleanup can be redrawn to improve visual details. Batch processing can be used to separately export various warning segments for use during operational assessments, thereby compensating for the insufficient expressive power of traditional static images.

4.1.3 Emergency Rescue Safety

Templates for multiple scenarios, including roads, hazardous chemicals, confined spaces, and water areas, are switched as needed, with important parameters such as protection levels, safety perimeter distances, rope anchor points, and underwater operations specified in the prompts. The platform can add warning markers and dynamic risk arrows and can also generate layered animations to distinguish routine response from emergency situations. These functions can be used for specialized safety instruction in safety training. High-difficulty scenarios such as ice rescue and high-altitude rescue can be individually adjusted in terms of the degree of visualized danger for specialized safety instruction.

4.1.4 Daily Training Safety

Based on real-scene training-ground materials used in practical training, standardized movements for climbing, rope, and water-area training are restricted through prompts, while fixed-shot templates for two-person protection, double-rope fixation, and warm-up protection are created. Standardized demonstration segments produced in batches can be separately developed into comparison animations of non-compliant operations, placing correct and incorrect operations side by side to

provide a more intuitive display of risks during training. After lightweight short videos are exported, they can be promptly distributed to fire stations and units, enabling warning education before training through fragmented learning time.

4.2 Doubao AI

Doubao is a general-purpose text assistance tool with advantages such as free access and simple operation. It mainly focuses on coordinating and organizing the written content covering all provisions of the Safety Guidelines, thereby compensating for the deficiencies of primary-level fire officers and soldiers in professional copywriting. First, it optimizes prompts for animation generation by converting colloquial expressions into professional expressions that comply with the requirements of the guidelines, thereby preventing inconsistencies between visual actions and standardized requirements. Second, it prepares supporting teaching narration by extracting explanatory scripts from each provision one by one and strictly following regulations concerning protection standards, safety perimeter distances, team formation requirements, and other aspects. Third, it proofreads terminology in the copy and standardizes terms such as “three-person team formation,” “guide rope,” “parking in the upwind direction,” and “double-anchor fixation,” correcting deviations in safety-related expressions. Fourth, it refines safety warning copy and organizes risk-warning narration based on the consequences of violations and prohibited provisions, ensuring that all teaching content has clear rules and supporting evidence.

4.3 Jianying AI

Jianying is a general-purpose free lightweight editing software designed for primary-level users. It has built-in functions such as AI voice-over, intelligent subtitles, and visual annotation, enabling integrated production of finished videos from animation materials generated by Jimeng AI. No professional editing skills are required, and it can be operated using only a mobile phone or an ordinary terminal. The practical process consists of four steps: First, organize and import the materials by batch-uploading animation clips and actual rescue footage, using the multi-track layering function to arrange them according to the response sequence and automatically align them with the logic of operational training. Second, generate AI voice-over by copying and pasting the narration script proofread by Doubao AI into the text-to-speech module, matching a professional firefighting voice and generating a narration track at a unified speech rate, while adjusting the synchronization between audio and visuals. Third, process key visual markings by using intelligent highlighting and text pop-up functions to add prominent dynamic subtitles for operational red lines and mandatory standards without manually creating them frame by frame. Fourth, complete mixed-editing and review optimization by using functions such as split-screen display and interspersed transitions to combine actual case footage with AI demonstration animations and add comparative narration in segments. The finished video supports rapid export in lightweight 720P and 1080P formats, with relatively small file sizes that facilitate internal transmission and archiving by fire stations and units. The generated videos can be directly used for routine instruction and post-operation reviews, enabling intuitive identification of potential violations in response procedures with reference to the Safety Guidelines.

4.4 Safety Animation Production Process

4.4.1 Requirements Analysis

Based on training deficiencies at fire stations and units, common emergency risks, and key points of safety instruction, the themes and main content of three types of materials—instructional, warning, and review materials—are determined in accordance with the Safety Guidelines.

4.4.2 Copywriting Preparation

Doubao AI is used to write and proofread animation prompts, teaching narration, and risk-warning copy to ensure that the content complies with relevant regulations and that the terminology and expressions used are appropriate and standardized.

4.4.3 Animation Generation

Standardized prompts are entered into Jimeng AI to generate dynamic demonstration clips that comply with safety standards for firefighting operations and training.

4.4.4 Editing and Optimization

Jianying AI is used to splice and process the materials, perform intelligent voice-over, add key annotations, adjust image color, and conduct other processing to produce the final complete teaching video.

4.4.5 Archiving and Reuse

The materials are classified and archived into three major categories: firefighting and rescue, emergency response, and daily training. A dedicated lightweight safety teaching resource library is established for each fire station and unit to enable

materials to be retrieved at any time and reused repeatedly.

5. Implementation Pathways for Lightweight AI Instruction

Based on the actual conditions of primary-level firefighting forces, including operational readiness requirements, high personnel mobility, and heavy workloads, implementation measures are formulated from three aspects—personnel, systems, and resources—in strict accordance with the relevant provisions of the Safety Guidelines to ensure the long-term and routine implementation of AI-based visualized instruction.

5.1 Cultivating Key Personnel and Conducting Mentorship-Based Learning

A team with squad leaders, safety officers, and communications officers as the core personnel is established. Practical training on the three tools is conducted through short-cycle intensive training, and localized teaching videos are produced based on common emergencies within the jurisdiction. A mentorship mechanism is established, with popularization-oriented training conducted during fragmented periods such as squad meetings and evening roll calls, gradually improving the operational and application capabilities of all fire officers and soldiers.

5.2 Standardizing the Use Mechanism and Integrating AI into Duty and Training

AI instruction is integrated into the safety instruction system of primary-level fire stations and units. Instructional activities are conducted as required within the prescribed learning hours, and standardized teaching is carried out based on existing resource libraries. Animation materials are flexibly used in scenarios such as case reviews and high-risk practical training to identify problems and issue warnings with reference to the Safety Guidelines, thereby compensating for deficiencies in practical training.

5.3 Optimizing Resource Management and Maintenance and Improving the Resource Library

Teaching videos are classified and archived into three categories: fire suppression, emergency rescue, and operational training. Teaching resources such as safety teaching animations that correspond to the characteristics of disasters within the jurisdiction are organized. Safety officers at fire stations and units are designated to centrally manage and regularly update teaching resources, ensuring that materials can be retrieved at any time and reused repeatedly.

6. Application Outcomes and Existing Limitations

In accordance with the implementation requirements of the Safety Guidelines, the practical effects and existing problems of the lightweight AI technology-based teaching model are systematically summarized and analyzed, providing a practical basis for further improving the lightweight AI technology-based teaching model.

6.1 Practical Application Outcomes

Compared with traditional teaching, the lightweight AI technology-based teaching approach, represented by Jimeng, Doubao, and Jianying, has practical value in operational training safety for primary-level firefighting forces.

6.1.1 Addressing the Teaching Bottleneck of High-Risk Subjects

AI animations can reproduce operational procedures and indicate safety risks under zero-risk conditions, deepening the understanding of the Safety Guidelines among primary-level fire officers and soldiers.

6.1.2 Improving Learning and Review Efficiency

AI technology transforms abstract provisions into visualized animations, reducing the difficulty of understanding. AI technology can rapidly generate dynamic materials and intuitively demonstrate deficiencies in the rescue process, making safety warning education more impactful.

6.1.3 Adapting to the Actual Work Conditions at the Primary Level

The tools mainly rely on free functions and do not require professional software or hardware. They have low costs, simple operation, and fast production, and do not occupy excessive duty and training time of fire officers and soldiers.

6.1.4 Enriching Teaching Formats and Stimulating Learning Initiative

Dynamic videos, digital human narration, and other approaches are used to stimulate the learning interest of fire officers and soldiers, transforming safety learning from “passive listening” into “active learning and research.”

6.2 Existing Application Limitations

Due to the current capabilities of AI algorithms for content generation and various factors in practical application, this teaching model still has many shortcomings and cannot completely replace on-site practical training or the role of mentor-

ship by experienced personnel. The primary problem is that the model has limitations in reproducing complex scenarios and precise movements. At present, AI faces similar problems in the simulation of complex scenarios across multiple industries. For example, AI technology has difficulty simulating high-precision content such as certain operational details in rope training, coordination in equipment operations, changes in building structures, and the reaction processes of hazardous chemicals, and can only present general procedures. Second, the quality of generated content depends to a considerable extent on the user's level. The effectiveness of animation generation is closely related to the quality of prompts and narration scripts. If the wording is not rigorous, the generated visuals can easily be inconsistent with the provisions of the Safety Guidelines. Each piece of material requires manual verification and correction, thereby increasing the workload. In addition, for extreme disaster scenarios and complex rescue emergencies, the limitations of the platform's generation capabilities result in poor animation reproduction effects, thereby indirectly restricting the scope of application of this model.

7. Conclusion

For a long time, safety instruction for operational training of primary-level firefighting forces has faced practical problems such as limited practical training conditions, monotonous teaching formats, and low effectiveness of case reviews. In accordance with the relevant provisions of the Safety Guidelines, this study combines the three lightweight AI tools, Jimeng, Doubao, and Jianying, to establish a visualized teaching system. This solution is low-cost, simple to operate, and easy to implement, making it suitable for primary-level work environments characterized by heavy duty tasks, high personnel mobility, and limited funding. Practical results show that lightweight AI animations can transform abstract safety provisions into intuitive dynamic visuals, effectively addressing problems such as difficulties in practical training for high-risk subjects and difficulties in understanding and memorizing safety standards, while also improving the effectiveness of case reviews and safety warning education. However, due to the current limitations of AI software development, this model still has certain deficiencies in reproducing precise movements and complex scenarios and cannot completely replace on-site practical training. With the continuous updating and development of artificial intelligence technology, the application capabilities and coverage of this model will become increasingly extensive. Overall, the lightweight AI visualized teaching model meets the practical operational needs of primary-level firefighting forces, can effectively improve the safety awareness of fire officers and soldiers and standardize their operational training behaviors, and has good practical application and promotion value.

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