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Safety Situation Awareness Method for On-Site Safe Operation Based on Video and AI

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Abstract: Conventional field safety operation safety situation awareness methods mainly use UWB (Ultra Wide Band) tags for safety situation awareness, which is vulnerable to noise interference, resulting in high deviation of safety situation awareness prediction indicators. Therefore, a new field safety operation safety situation awareness method needs to be designed based on fusion video and AI. That is to say, using fusion video and AI to build a cloud center for on-site safe work safety situational awareness, and design an effective algorithm for operational safety situational awareness, so as to achieve on-site safe work safety situational awareness. The experimental results show that the safety situation awareness prediction indicators generated by the designed safety situation awareness method at different operation points are more consistent with the actual safety situation awareness indicators, which proves that the designed safety situation awareness method has good perception effect, reliability, and certain application value, and has made certain contributions to reducing the subsequent safety risks of on-site operations.

Keywords: Fusion video; AI; On-site; Safe operation; Safety; Situational awareness; Method

1. Introduction

Production safety has an important impact on social stability. Therefore, effective production safety management and control is the constant theme[1] in the social production process. There are different safety problems in different operation scenarios, and there are certain differences in the appropriate job safety management systems. However, no matter what kind of job safety management system, it is necessary to effectively carry out safety risk analysis and assessment[2] and develop risk emergency plans. At present, most enterprises have begun to pay attention to work production problems, and regularly popularize safe operation knowledge for employees. This will lead to intermittent training[3]. However, many enterprises have temporary operators, whose safety knowledge reserves are insufficient, and they are prone to safety accidents. Therefore, for the existing safety operation problem[4], it is necessary to study an effective safety situation awareness method for on-site safety operation.

Security situational awareness is a special perception method based on big data. It can effectively identify security threats to field operations from a global perspective

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and develop solutions[5]. In the context of information development, more and more job security situational awareness data are introduced by different information centers in China. In addition, the collection of on-site safety data is also influenced by factors such as production operation mechanisms and production measures. Therefore, it is difficult to conduct on-site security situational awareness[6]. Fusion video technology is a new type of virtual reality technology that can effectively capture scene images of on-site operations and fuse them with virtual scenes to create a new perception space. It is combined with artificial intelligence technology to intelligently generate on-site operation sites, judge the safety status of on-site operations, and effectively perceive the situation of on-site safety operations. Therefore, this article designs a method for on-site security situational awareness based on the fusion of video and artificial intelligence.

2. Design of Scene Safety Situation Awareness Method Integrating Video and Ai

2.1. Design the Cloud Center for Safety Situation Awareness of On-Site Safe Operation Based on Fusion Video And AI

In order to solve the problem of excessive deviation between perception and prediction indicators caused by noise interference during UWB's security situation awareness, this article designs a on-site security operation security situation awareness cloud center based on fusion video and artificial intelligence, with its infrastructure shown in Figure 1.

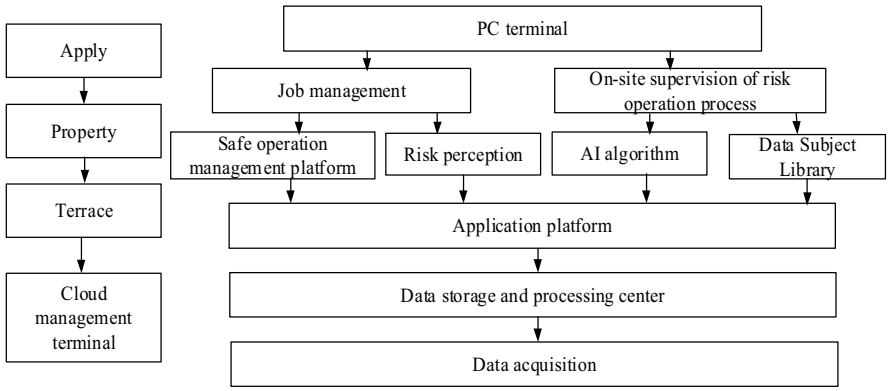

Figure 1. Cloud Center Architecture of Safety Situation Awareness for on-site Safe Operation

2.2. Design Safety Situation Awareness Algorithm for On-Site Safe Operation

Aiming at the intelligent identification problem in the process of video surveillance management, this paper designs an effective AI on-site safety situation awareness algorithm based on AI technology. In combination with the real-time monitoring requirements of the operation site, in order to view the real-time situation of the risk

operation site through the PC and mobile phone port, it is necessary to calculate the comprehensive perception parameters f, as shown in Eq. (1) below.

$$f = \sigma(Wx_t + b_f) \tag{1}$$

In Eq. (1), σ represents the situation awareness memory state coefficient, W represents input unit, represents b_f stands for Forgotten Gate, x_t represent reset gate. The above sensing parameters are not linearly transformed. This paper combines the linear transformation principle to generate the comprehensive sensing linear transformation parameters r_t as shown in Eq. (2) below.

$$r_t = \sigma(Wx_t + b_r) \tag{2}$$

In Eq. (2), b_r represents the linear transformation parameter, and the security situation awareness speed at this time o as shown in Eq. (3) below.

$$o = \sigma(W_o x_t + b_r) \tag{3}$$

In Eq. (3), W_o represents the output unit. In order to reduce the perception dependency and avoid being affected by complex factors in the situation awareness process, this paper designs a security awareness function x_f, as shown in Eq. (4) below.

$$x_f = wx_t \tag{4}$$

In Eq. (4), w represent the perceived dependency value, which can generate a security awareness algorithm in combination with the above safety situation awareness coefficient of on-site safety operation C, as shown in Eq. (5) below.

$$C = F_t \cdot c_t + rx \tag{5}$$

In Eq. (5), F_t represents the perceptual gradient, c_t represents the control moment, rx represent the input sequence. The use of the above on-site safety operation safety situation awareness algorithm can effectively eliminate the impact of awareness dependent information on safety situation awareness, and improve the reliability of awareness.

Combined with the above safety operation situation awareness algorithm, visual monitoring can be carried out, and the data in the operation process can be statistically analyzed and presented, including the qualification rate of the operation, operation

supervision alarm, operation closed-loop, etc. At the same time, it is bound with the operation process data and video monitoring data, from which information such as sub processes, one case, one file, and video monitoring can be obtained. Through remote video guidance and spot check, the operation consistency between the manager and the construction personnel is achieved, which helps the manager to grasp the front-line situation in real time and make decisions in a timely manner.

3. Experiment

In order to verify the actual perception effect of the designed on-site safe operation safety situational awareness method based on fusion video and AI, this paper selects a qualified on-site operation scene, compares it with the conventional on-site operation safety situational awareness method, and conducts experiments as follows.

3.1. Experiment Preparation

In combination with the demand for safety situational awareness of on-site safe operation, this paper selects a project for safety situational awareness analysis. It is known that the project is located in the central section of a city, bordering on HS07-04-03 plot. This project is a basic residential project that is jointly executed by several design units. In order to meet the construction requirements, the project uses a large number of high basket scaffolds for construction operations, which has certain safety risks. Therefore, this experiment takes the operation of building #3 of the project as an example, and carries out a safety situation awareness experiment. The operation information of building #3 is shown in Table 1 below.

Table 1. Operation Information of Building #3

Item	Content
Monomer structure	Cast-in-place reinforced concrete shear wall structure, with a wall thickness of 240mm, and a side beam width of 200mm and 240mm. The overhanging length of the roof overhang exceeds 1.5m, and the plan size of Building #3 is 41.48m × 13.48m, with a storey height of 3m and a building height of 57m.
Connection of profile steel main beam to slab free wall and beam	The outer side of the elevator shaft of Building #3 is a cast-in-place shear wall, and within the elevation range of the coupling beam, the profile steel beam and tie rod can be installed as normal. The outer side of the #3 staircase is a cast-in-place shear wall and frame beam, and within the elevation range of the frame beam, profile steel beams and tie rods can be installed as normal. The daylighting shaft of Building #3 is located inside the corridor, and the corresponding part is set up with a construction scaffold by horizontally placing the main beam at 11F
PC components	The PC components of Building #3 are distributed on the exterior wall, laminated panels, bay windows, and stairs. The beam is a cast-in-place structure with a concrete strength of C30.

It can be seen from Table 1 that #3 staircase is a cast-in-place reinforced concrete building with additional scaffolding for main and auxiliary operations. In order to focus on the characteristics of #3 building, relevant construction units have designed the construction scaffolding before the start of construction, and the design parameters are shown in Table 2 below.

Table 2. Design Parameters of Construction Scaffold

Item	Parameter	Item	Parameter
Number of scaffold rows	Double row scaffold	Scaffold steel pipe type	48.3×3.2
Height of scaffold body (m)	20.25	Step distance (m)	1.8
Vertical distance and span of upright pole (m)	1.5	Horizontal distance of vertical pole (m)	0.9
Distance from inner upright pole to building (m)	0.3	Calculation method for double vertical poles	No double vertical poles
Layout of wall connecting parts	One floor with two spans	Connection method with wall connecting parts and fasteners	Double fastener
Scaffold laying method	Two steps and one setting	Laying method of toe board	Two steps and one setting

It can be seen from Table 2 that the safety situation awareness model of on-site safe operation can be designed by combining the above scaffold design parameters, as shown in Figure 2 below.

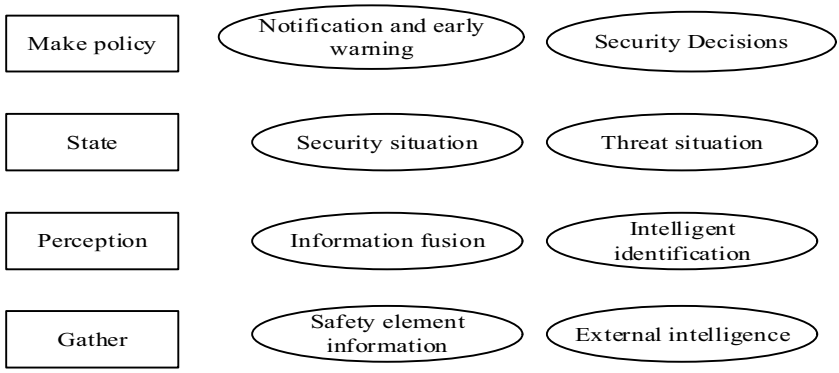

Figure 2. Safety situation awareness model of on-site safe operation

It can be seen from Figure 2 that the safety situation awareness prediction index can be selected based on the safety situation awareness model of on-site safety operation constructed above Q, the calculation formula is as follows Eq. (6).

$$Q = \frac{R + R_A + R_C}{F} \tag{6}$$

In Eq. (6), R represents the security situation index, R_A represents the threat situation index, R_C represents the risk situation index, F represents the prediction and assessment parameters, and sets the standard security situational awareness prediction index to 1.00. If the calculated security situational awareness prediction index is close to the standard index, it proves that the security situational awareness

effect is good, otherwise it proves to be relatively poor. At this time, it is necessary to preset construction items and operation requirements, as shown in Table 3 below.

Table 3. Construction Items and Operation Safety Requirements

Number	Item	Safety requirements	Inspection tools
*1	Welded steel pipe size	±0.5 mm	Vernier caliper
*2	Deviation of cutting inclination at both ends of steel pipe	±10%mm	Vernier caliper
*3	Rust depth of outer surface of steel pipe	1.70 mm	Vernier caliper
*4	End bending of rod steel pipe	≤0.18 mm	Steel ruler
*5	Bending of upright steel pipe	≤5 mm	Vernier caliper
*6	Bending of steel pipes for horizontal and diagonal bars	≤30 mm	Vernier caliper
*7	Deformation of adjustable support plate	≤20 mm	Steel ruler
*8	Pressed scaffold board surface twisted	≤12 mm	Feeler gauge
*9	Scaffold erection main beam	1350 mm	Steel ruler
*10	Scaffold three-dimensional frame	56.1m	Steel ruler
*11	Vertical span of vertical pole	1.5m	Steel ruler
*12	Distance from inner upright pole to building	0.3m	Steel ruler

It can be seen from Table 3 that Microsoft Visual Studio can be selected as the experimental platform in combination with the above construction work items and work requirements. This platform has a high-performance database. In addition, it supports the NET standard, has good scalability, and can effectively carry out on-site safety work situation awareness. The composition structure of this platform is shown in Figure 3 below.

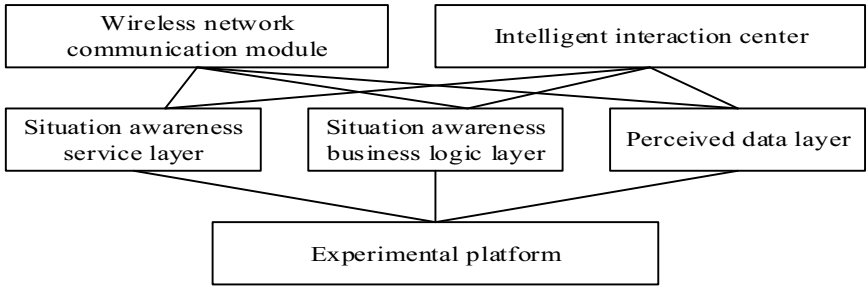

Figure 3. Composition of the experimental platform

It can be seen from Figure 3 that the above built experimental platform meets the requirements of situational awareness experiment for on-site safe operation, and subsequent awareness experiments can be conducted on the above platform.

3.2. Experimental Results and Discussion

In combination with the above experimental overview and preparations, on-site safety situation awareness experiment can be carried out, that is, the construction operation model of the selected construction operation project can be constructed in the above selected experimental platform. Use the on-site safe operation safety situation awareness method based on fusion video and AI designed in this paper and the

conventional on-site safe operation safety situation awareness method to predict situation awareness. Use formula (1) to calculate the safety situation awareness prediction indicators of the two methods at different operation points and compare them with the standard safety situation awareness indicators. The experimental results are shown in Table 4 below.

Table 4. Experimental Results

Construction site	The safety situation awareness prediction index obtained from the on-site safety operation safety situation awareness method based on fusion video and AI designed in this article	Safety situation awareness prediction indicators obtained from conventional on-site safety operation safety situation awareness methods	Standard security situational awareness indicators
#1	0.985	0.623	1.00
#2	0.974	0.661	1.00
#3	0.988	0.565	1.00
#4	0.936	0.656	1.00
#5	0.978	0.765	1.00
#6	0.946	0.556	1.00
#7	0.935	0.698	1.00
#8	0.945	0.742	1.00
#9	0.996	0.599	1.00
#10	0.915	0.665	1.00

It can be seen from Table 4 that the safety situation awareness prediction index calculated by the on-site safety operation safety situation awareness method designed in this paper based on fusion video and AI under different operation points is relatively close to the standard safety situation awareness index, with a small difference. The safety situation awareness prediction index calculated by the conventional on-site safety operation safety situation awareness method at different operation points is quite different from the standard safety situation awareness index, which proves that the safety situation awareness method designed in this paper for on-site safety operation has good perception effect, reliability and certain application value.

4. Conclusion

At present, most job sites have insufficient human resources to obtain the actual situation in real time and accurately, and many job sites lack remote communication and information transmission, which often lead to job safety problems. In order to form a full coverage management system such as operation process monitoring, operation completion, and operation data analysis, improve the compliance rate of business processes, and reduce the probability of safety accidents, this paper conducts a digital transformation of safety operation scenarios based on online processes, and designs an effective safety situation awareness method for safety operations by integrating new ICT technologies such as video and AI artificial intelligence. The experiment results show that the design of on-site safe operation safety situation awareness method based on fusion of video and AI has good perception effect, reliability, and certain application value, and has made certain contributions to reducing operation risks in all stages.

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