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Research on the Intelligent Control Platform for Construction Workers' Unsafe Behavior Driven by Green and Low-Carbon Concepts

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Abstract

With the dual demand for safe production and sustainable development in the construction industry, this study proposes a smart control platform for workers' unsafe behaviors that integrates the concept of green and low-carbon. With the core objective of reducing the safety accident rate, the platform monitors workers' unsafe behaviors in real time (e.g., failure to wear helmets, intrusion into dangerous areas) through computer vision intelligent detection algorithms, AI danger prediction systems and other technologies and optimizes the construction process and resource management by combining with the smart construction site technology. In the module of safety knowledge management and skill improvement, immersive teaching means are used to reduce the resource consumption of traditional training; and physiological and psychological data sensing technology is used to prevent the risk of work stoppage caused by workers' health problems. The platform not only effectively reduces the waste of resources and carbon emissions caused by accidents, but also responds to the national "green project" policy, promotes the construction industry's transformation to digitalization and low-carbonization, and provides a systematic solution for smart construction sites and sustainable development.

Keywords

Green Low Carbon, Intelligent Control, Computer Algorithm, Risk Identification.

1. Introduction

1.1. Overview of Worker Unsafe Behavior Intelligent Control Platform

To reduce the rate of safety accidents in the construction industry and to minimize casualties and economic and property losses, many scholars at home and abroad have carried out long-term and in-depth research on the safety of the construction industry in a targeted manner. Research shows that workers' unsafe behavior is the main cause of construction safety accidents, and construction safety accidents caused by improper operation of workers account for about 88% of the total number of accidents. Therefore, effective control of workers' unsafe behavior can obviously reduce the rate of construction safety accidents very effectively and promote the sustainable and healthy development of the construction industry.

1.2. Overview of the Green Low Carbon Concept Based on the Platform of Workers' Unsafe Behavior

While continuously innovating the construction industry's scientific construction, intelligent construction, and building a platform for workers' unsafe behavior, the construction industry should also implement the strategy of following the national policy, advocating the concept of green and low-carbon, and solidly maintaining sustainable development. For this reason, many new technologies have been integrated into the construction process of the worker unsafe

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behavior platform, such as computer vision intelligent detection algorithms, intelligent construction site technology, green project management module, etc.[1]

2. Smart Management Platform for Workers' Unsafe Behavior

2.1. Structure of Intelligent Management Platform for Workers' Unsafe Behaviors

In order to realize effective control of workers' unsafe behaviors in an all-round way, the platform is constructed from two levels, namely, the behavioral formation and behavioral control of engineering construction workers. On the one hand, it realizes workers' behavioral development through safety knowledge management and safety skills improvement; on the other hand, it designs intelligent identification and detection algorithms of workers' unsafe behaviors from the perspectives of workers' implicit behaviors and explicit behaviors, combined with physiological and computer vision sensing technologies, to control workers' unsafe behaviors.

The main functional architecture of the platform is shown in Fig. 1:

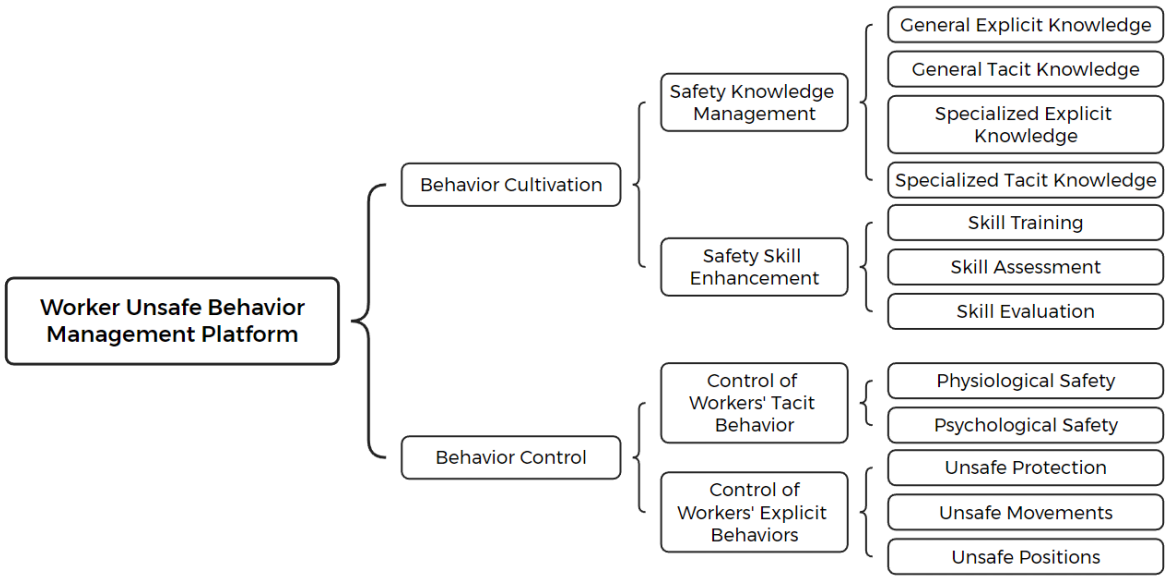

Fig. 1 Main Functional Architecture of the Platform

2.2. Worker Unsafe Behavior Intelligent Control Platform Content Module

2.2.1. Safety knowledge management module

The security knowledge management module of the platform belongs to the part of behavioral development, which is divided into four parts: general explicit knowledge, general tacit knowledge, specialized explicit knowledge and specialized tacit knowledge; the management goal of security knowledge is accuracy and professionalism, and the solution includes the integration of existing security knowledge and the creation of new security knowledge. The specific division of safety knowledge management is shown in Fig. 2:

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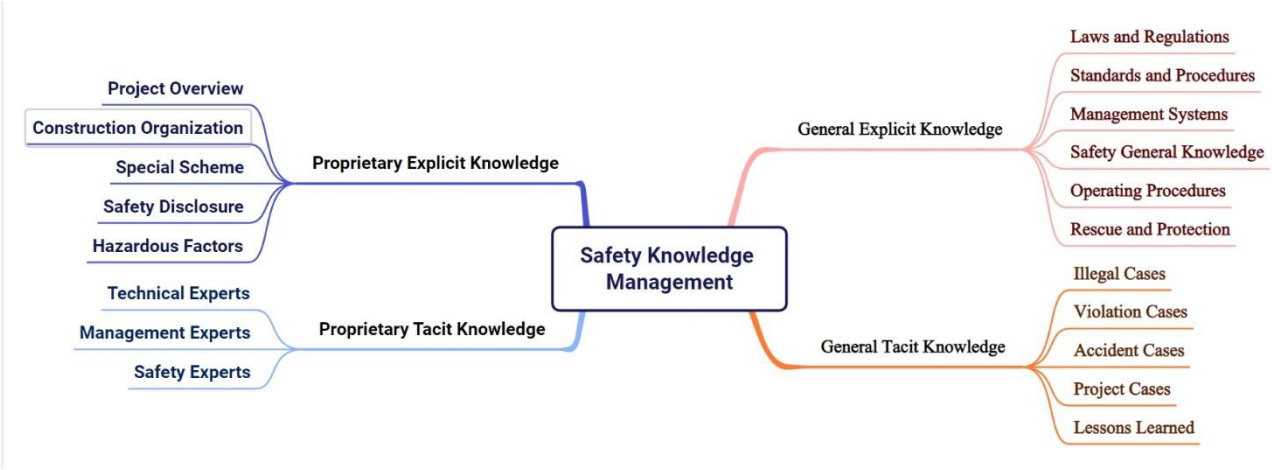

Fig. 2 Specific Classification of Safety Knowledge Management

2.2.2. Enhancement of Safety Competence

Safety skills are the internal traits of an organization or an individual under the influence of their knowledge, experience, skills, values, safety motivation and safety attitudes, etc. According to the results of existing safety accident investigations, the lack of safety skills of construction workers is one of the key triggers of unsafe behaviors.[2] The core of safety skills lies in effectively controlling operational risks to a minimum or within a tolerable range, which covers the dimensions of hazard identification, standardized operation of protective devices and emergency response capability. Therefore, systematically upgrading workers' safety skills is the core measure to prevent unsafe behaviors and ensure construction safety. The specific decomposition of the safety skill enhancement module is shown in Fig. 3:

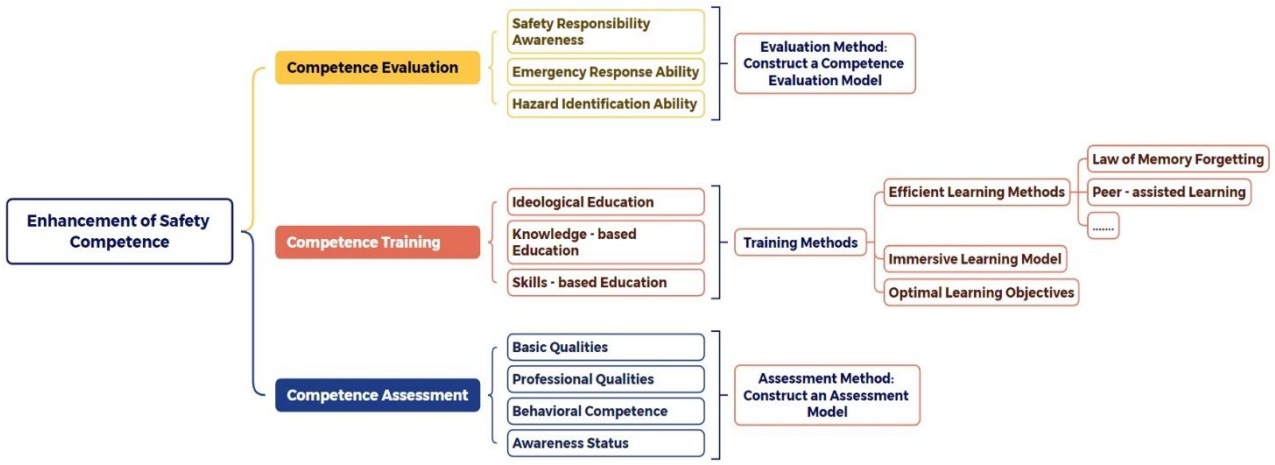

Fig. 3 Decomposition of Safety Skill Enhancement Modules

2.2.3. Control of Workers' Behaviors

The implicit behavioral control of workers starts from two aspects: physiological safety control and psychological safety control. The specific division is shown in Fig. 4

2.2.4. Worker Explicit Behavior Control Module

The control of workers' explicit behavior is mainly carried out in three aspects:unsafe guarding, unsafe actions, and unsafe positions, and the specific division of these three aspects is shown inFig. 5:

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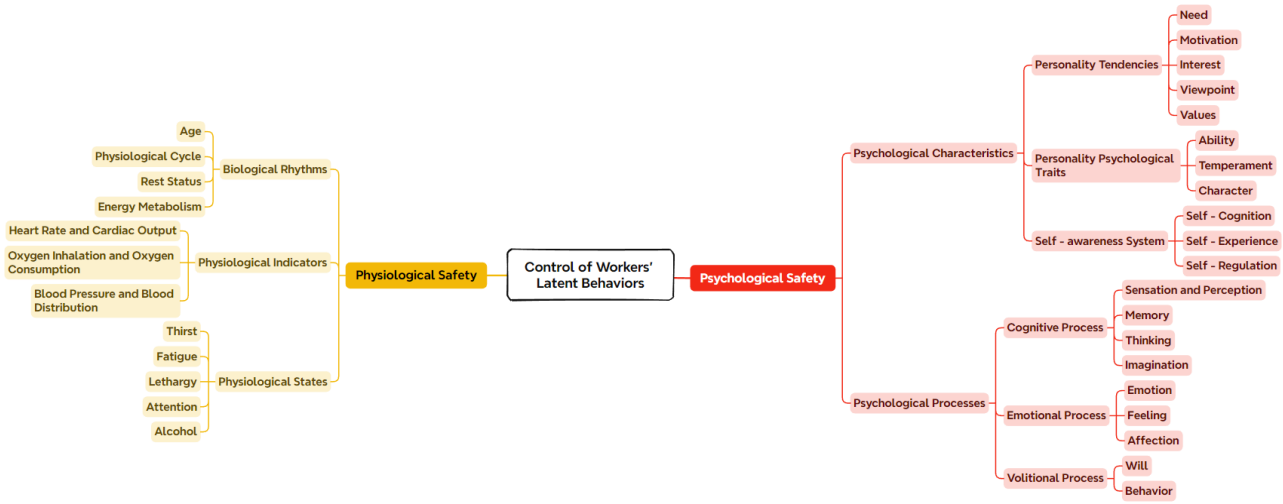

Fig. 4 Detailed Categorization of Workers' Implicit Behavior Control

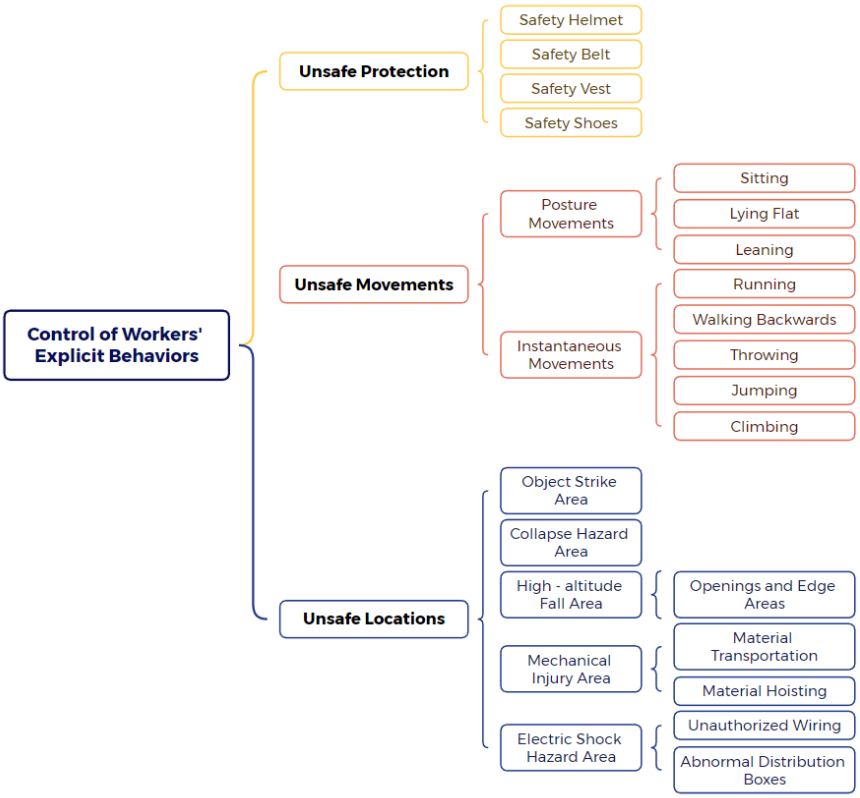

Fig. 5 Classification of Workers' Explicit Behavior Management

3. Key technologies and green low-carbon concepts

3.1. Green Smart Site Technology

Relying on the information-based management and control platform, it integrates construction safety, progress, resource deployment and other data to realize digital and intelligent management of the construction process.[6] This reduces duplicate procurement or waste of materials (e.g. reinforcement bars, concrete, etc.) due to confusing management, and reduces carbon emissions from the production and transportation of building materials. Optimize the scheduling and use efficiency of machinery and equipment, avoid idling or inefficient operation, and reduce fuel and power consumption.[4]

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3.2. Computer Vision Intelligent Detection Algorithm

The use of computer algorithms related to the detection system, the risky behavior of workers, facial expressions and the location of the unsafe position to lock, combined with digital monitoring means and the specific conditions of the construction site, systematic management of the construction site. Thus preventing operational errors caused by workers' excessive fatigue or emotional loss of control, and reducing the waste of resources caused by human error. Early intervention through the health early warning system reduces the risk of work stoppage due to sudden illnesses, safeguards construction continuity, and avoids carbon emissions from schedule delays.[3]

3.3. AI Hazard Prediction System

Build a safety platform to delineate hazardous areas, reduce equipment damage or material destruction (e.g., falling objects damaging building materials) due to accidental entry into hazardous areas, and avoid carbon emissions from repetitive production and transportation[7] At the same time, through precise control of dangerous work processes, we can reduce the need for redundant configuration of safety protection facilities and save resource investment.

4. Summary

This paper focuses on the control of workers' unsafe behaviors in construction, and builds a set of intelligent platform integrating green and low-carbon concepts. Through the combination of technological innovation and green concepts, the platform systematically reduces resource waste and carbon emissions while improving construction safety, providing a reusable technology path for the high-quality development and low-carbon transformation of the construction industry. Green intelligent construction site technology manages construction progress and resource deployment through digitalization, reduces waste of building materials and energy consumption of equipment, and directly reduces carbon emissions. Computer vision algorithms and AI hazard prediction systems monitor worker behavior and hazardous areas in real time, preventing accidents that lead to work stoppages and rework, and reducing indirect carbon emissions. The safety knowledge management module integrates environmental construction specifications (e.g., material recycling guidelines) to promote green construction standardization. [8]

The physiological data monitoring system protects construction continuity and avoids additional energy consumption due to delays by warning workers of health risks. The platform responds to the national policy of "intelligent construction site" and "green project", and realizes the in-depth integration of safety control and low-carbon goals through technical means. In the future, the platform can be extended to bridges, tunnels, comprehensive pipeline corridors and other infrastructure areas, helping the construction industry to realize the "dual-carbon" goal.

Acknowledgements

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