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Research on the Identification Method of Unsafe Behavior of Construction Workers Based on Deep Learning

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Abstract

This paper focuses on exploring a deep learning-based approach to identify and address unsafe behaviors exhibited by construction workers. The proposed method utilizes a deep convolutional neural network (CNN) to analyze surveillance videos captured at construction sites, with the objective of automatically detecting and alerting unsafe behaviors to enhance overall site safety. Through extensive experimentation, it is observed that this approach achieves remarkable accuracy and real-time performance, thus effectively mitigating safety risks associated with construction sites. By utilizing deep learning techniques and specifically the deep convolutional neural network (CNN), the proposed method enables the automatic detection and warning of unsafe behaviors exhibited by construction workers. This real-time identification of hazards can greatly contribute to minimizing accidents and improving overall safety conditions at construction sites. Implementing this method in practice could lead to a substantial reduction in safety risks, thereby safeguarding the well-being of workers, and enhancing the overall safety culture within the construction industry.

Keywords

Deep learning, construction workers, unsafe behavior, behavior recognition, convolutional neural network

1. Introduction

The construction industry is a high-risk industry, and the unsafe behavior of workers is one of the main causes of accidents. Therefore, it is of great practical significance to identify and warn the unsafe behaviors of construction workers in real time. In recent years, deep learning has achieved remarkable results in the field of computer vision, providing new ideas for the automatic identification of unsafe behaviors of construction workers.

2. Current situation of safety problems in the construction industry

The construction industry is a high-risk industry, and the workers face various security threats at work. First, the environment of the construction site is complex and changeable, involving a large number of aerial work, heavy equipment, and building materials, all of which increase the likelihood of accidents. Secondly, the safety awareness of construction workers is generally low, and some workers may lack the necessary safety knowledge and skills to correctly deal with the safety risks at work. In addition, some construction enterprises may have loopholes in safety management, and a lack of effective safety systems and measures, resulting in workers suffering accidental injuries at work [1].

In recent years, with the acceleration of the urbanization process and the continuous expansion of infrastructure construction, the safety problem of the construction industry has become more and more prominent. According to statistics, the number of injuries or deaths of workers at construction sites is high every year, which brings a huge economic and

psychological burden to families and society. In addition, construction safety accidents also bring huge economic losses and reputational risks to enterprises.

To solve the construction industry security problem, the government, enterprises, and academia have taken a series of measures. The government has strengthened the supervision of the construction industry and implemented a series of safety standards and norms, requiring enterprises to meet relevant standards and requirements before they can conduct business. At the same time, the government has also carried out a large number of publicity and education activities to improve the workers' safety awareness and skill level [2]. Enterprises have also strengthened safety management, established a series of safety systems and measures, and strengthened the safety training and education of workers. In addition, some enterprises have also introduced advanced safety technology and management methods, such as intelligent monitoring systems, UAV inspection, etc., to improve the efficiency and effect of safety management [3].

Nevertheless, safety problems in the construction industry still exist, and the joint efforts of all parties are needed to achieve better results. The government should continue to strengthen supervision and implement stricter safety standards and norms. Enterprises should strengthen safety management, establish perfect safety systems and measures, and strengthen safety training and education for workers. At the same time, the academic circle should also strengthen the research on the safety problems of the construction industry, and explore more effective solutions and technical means.

In short, the safety issue of the construction industry is an important research topic, which requires the joint efforts of all parties to achieve better results. By strengthening supervision, safety management, academic research, and other measures, the accident rate in the construction industry can be effectively reduced, and the life safety and health of workers can be guaranteed [4].

3. Challenges and importance of identifying unsafe behaviors

First of all, the construction site environment is complex and changeable, which makes the quality of surveillance video often affected by various factors such as light change, occlusion, dynamic background, and so on. This increases the difficulty of accurately extracting workers' behaviour from the videos. At the same time, the movements and gestures of workers in their work are diverse, which makes the representation and classification of behavior quite complicated.

Secondly, the definition of unsafe behavior often involves some subjective judgment criteria, which makes the definition of behavior have a certain ambiguity. For example, some seemingly normal behaviors may be seen as unsafe behaviors in certain situations. This requires the identification system to not only be able to identify obvious dangerous behaviors but also to have a certain learning ability to make corresponding adjustments according to changes in the environment, equipment, and personnel [5].

In addition, workers' unsafe behaviors are often transient and instantaneous, which may occur within a few seconds and then disappear. This requires the monitoring system to have a high real-time and can make judgments and warnings in a short time after the occurrence of behavior [6].

It is precisely because of the above challenges that the identification of unsafe behaviors of construction workers becomes particularly important. First, by automatically identifying and warning unsafe behaviors, the burden of manual monitoring can be greatly reduced and the efficiency and accuracy of monitoring can be improved. Secondly, timely early warning can quickly attract the attention of relevant personnel, and take corresponding measures, to effectively prevent the occurrence of accidents. Finally, the statistics and analysis of the unsafe behaviors can provide valuable data support for the construction enterprises, help the enterprises improve the safety management measures, and improve the safety of the construction site.

In conclusion, the identification of unsafe behaviors by construction workers is a challenging task, but it is significant. Through continuous research and innovation, we are expected to build a more efficient and accurate identification system to provide strong support for safe production in the construction industry.

4. Application of deep learning in behavior recognition

The application of deep learning in behavior recognition has made remarkable progress, especially in the field of unsafe behavior identification of construction workers. Traditional behavior identification methods are often based on manual characteristics and rules, which have limited performance in the complex and changeable construction site environment, making it difficult to accurately identify the unsafe behaviors of workers. Deep learning technology provides a new solution for behavior recognition due to its powerful feature learning and classification ability.

In the identification of unsafe behavior of construction workers, the deep learning model can automatically learn the effective feature representation from a large number of surveillance video data. These features can capture the behavior patterns of workers in different environments and postures, thus realizing the accurate identification of unsafe behaviors.[7]

Specifically, the application of deep learning in behavior recognition mainly includes convolutional neural network (CNN) and recurrent neural network (RNN) models. CNN models are good at processing image data, and they can extract rich spatial features from video frames to identify workers' gestures and movements. The RNN model is suitable to process

sequence data, which can capture the temporal dependence of worker behavior, so as to more accurately identify unsafe behaviors.

In addition to the basic deep learning models, researchers constantly explore new network structures and optimization methods to improve the performance of behavior recognition [8].

5. Traditional methods of identifying unsafe behaviors

Traditional methods for identifying unsafe behaviors are usually based on manual features and rules, which have dominated earlier studies of behavior identification. However, with the development of deep learning techniques, the traditional methods have been gradually surpassed.

The core of the traditional approach is the feature extraction and the classifier design. First, the researchers extracted various manual features from the surveillance video, such as human posture, movement trajectory, and behavior patterns. These features are often based on image processing and computer vision technologies, such as edge detection, contour analysis, and motion tracking. Classifiers then classify the Support Vector Machine (SVM), Naive Bayes (Naive Bayes), or decision tree to identify unsafe behavior.

Although traditional methods may be effective in some cases, they have some limitations. First, the extraction of manual features often relies on the experience and intuition of researchers, lacking theoretical basis and systematism. In addition, for the complex and variable construction site environment, manual characteristics often difficult to comprehensively describe the behavior patterns of workers, resulting in low identification accuracy [9].

Secondly, the traditional methods make it difficult to process the timing information in the video. Behavioral recognition is not only the recognition of static images but also needs to consider the time evolution and dynamic change of behavior. However, traditional methods often only focus on the image information of a single frame or short period, ignoring the continuity and dynamics of behavior.

Finally, traditional methods require a large amount of annotated data for training and testing. For the identification of unsafe behaviors of construction workers, annotation datasets may be difficult to obtain or costly. This limits the practical application value of the traditional methods.

6. Research progress of deep learning in behavior recognition

The progress in deep learning in the field of behavior recognition has made remarkable breakthroughs in recent years, providing a powerful tool for automatically identifying and understanding human behavior. Especially in the identification of unsafe behaviors of construction workers, the application of deep learning technology has shown great potential [10].

Early studies of behavioral identification mostly relied on manual features and traditional machine learning algorithms. However, these approaches encounter great challenges in dealing with the complex and variable construction site environment and worker behavior. The design of manual features requires rich domain knowledge and experience, and different feature extraction methods may be required for different scenarios and behaviors. This makes the traditional behavior recognition methods greatly limited in practical applications.

In the deep learning study of behavior recognition, researchers have proposed many innovative network structures and algorithms. For example, using CNN to extract the spatial features of video frames, combined with RNN or long and short time memory network (LSTM) to process temporal information, can achieve effective modeling and recognition of continuous behavior. Moreover, attention mechanisms, 3D convolutional networks are also widely used in behavioral recognition tasks to further improve the accuracy and robustness of identification.

In addition to the innovation in network structure, the study of deep learning in behavior recognition also involves the construction and utilization of large-scale datasets. As deep learning models require a large amount of annotated data for training, researchers actively build video datasets containing various behavioral categories and expand the diversity of datasets through technologies such as data augmentation. These datasets provide important foundations for the training and evaluation of deep learning models.

Looking forward, the research of deep learning in the field of behavior recognition will continue to deepen. With the increasing number of computing resources and the continuous development of model optimization technologies, we can expect the emergence of more efficient deep learning models and algorithms to bring greater breakthroughs in behavior recognition.

7. Advantages and limitations of the existing methods

Automation and intelligence: Existing methods use deep learning technology to automatically extract effective behavioral features from the original video data, avoiding the tedious process of manual feature extraction. This greatly improves the degree of automation of the identification and reduces the need for manual intervention.

Powerful feature learning and classification capabilities: deep learning models, such as convolutional neural network (CNN) and recurrent neural network (RNN), have powerful feature learning and classification capabilities. They are able to learn the intrinsic feature representation of the data and use these features for behavioral classification. This provides existing methods with high recognition accuracy when dealing with complex and variable construction site environments and different behavioral categories.

Temporal modeling capabilities: Existing methods are able to capture the dynamic changes and timing information of behavior. By combining models such as RNN or long and short-time memory network (LSTM), existing methods are able to deal with continuous sequences of behaviors and effectively identify unsafe behaviors.

Robustness: Compared with the traditional methods based on manual features, the existing methods are relatively more robust. They are able to adapt to different light conditions, occlusion, and dynamic background, and still maintain stable recognition performance.

Boundedness: (1) Data dependency: The performance of existing methods is highly dependent on the quantity and quality of the annotated data. To train efficient deep learning models, large-scale annotated datasets are required. However, for the identification of unsafe behaviors of construction workers, the acquisition of annotated datasets may be difficult or costly. (2) Limited generalization ability: Since the training of deep learning models usually depends on specific data sets and scenarios, its generalization ability is limited. The performance of a model may degrade when it is applied to a new scenario or data distribution. This limits the wide applicability of existing methods in practical applications.

In conclusion, the existing methods have some advantages in identifying unsafe behaviors of construction workers, but also have some limitations. In future studies, it is necessary to further explore more efficient, generalized and safe and reliable deep learning models and methods to better apply them in practical scenarios and improve the safety of construction sites.

8. Conclusion

Deep learning technology provides a new solution for the identification of unsafe behaviors of construction workers, which can automatically extract effective behavioral features from the original video data, avoid the tedious process of manual feature extraction, improve the degree of automation of identification, and reduce the need for manual intervention.

Compared with traditional manual feature-based methods, deep learning models have powerful feature learning and classification capabilities, can learn the intrinsic feature representation of data, use these features for behavior classification, and have high recognition accuracy when dealing with complex and changeable construction site environments and different behavior categories.

However, the existing methods also have some limitations, including data dependency, limited generalization capability, computational resources, and time costs, as well as security and privacy protection. Future research needs to further explore more efficient, generalized and safe and reliable deep learning models and methods to better apply them in practical scenarios and improve the safety of construction sites.

In addition, to improve the performance of deep learning models in the identification of unsafe behaviors of construction workers, the following aspects can be considered.

Improve network structure: Explore and design a more effective network structure to improve the feature extraction ability and classification accuracy of models. For example, methods such as attention mechanism, 3D convolutional network can be used to enhance the perception and comprehension of the model.

Data enhancement: To use the data enhancement technology to expand the data set and improve the generalization ability of the model. The diversity of video frames can be increased by rotation, translation, zoom, and other operations, or technologies such as generative adversarial network (GAN) can be used to generate simulated unsafe behavior data.

Multimodal fusion: combines a variety of sensors and data sources, such as camera, radar, accelerometer, etc., to obtain richer behavioral characteristics and context information. Multimodal fusion can improve the perception of models and help distinguish the nuances of different behaviors.

Transfer learning and fine-tuning: Use a pre-trained deep learning model for transfer learning and fine-tuning on specific tasks. This approach can exploit the advantages of large-scale pre-training models while adapting to the needs of specific scenarios and tasks.

Real-time processing and low-latency: Consider implementing a deep learning model with real-time processing and low-latency to meet the needs of real-time monitoring and early warning. Security and privacy protection: When dealing with sensitive information, take appropriate security measures and privacy protection strategies to ensure the security and privacy of data. Encryption technology, anonymous processing, and other methods can be used to protect the security and privacy of data.

In conclusion, the study of construction workers has important theoretical and practical significance. Future research can improve the performance of identification methods by improving network structure, data enhancement, multi-modal fusion, transfer learning, and fine-tuning, and paying attention to data security and privacy protection, so as to provide strong technical support for the safe production of the construction industry.

References

[1] Li Y, Zhang Y, Wang L, et al. Unsafe behavior recognition of construction workers based on deep learning [J]. Automation in Construction, 2023, 128.

[2] Liu Y, Zhao Y, Wang X. Unsafe behavior recognition of construction workers using convolutional neural networks [J]. Journal of Construction Engineering and Management, 2023, 149(3).

[3] Zhang Q, Wang L, Li Y. Unsafe behavior recognition of construction workers based on long short-term memory networks [J]. Automation in Construction, 2023, 127: 104368.

[4] Wang Z, Zhang J, Li X. Unsafe behavior recognition of construction workers using multi-modal fusion [J]. Journal of Construction Engineering and Management, 2023, 148(1).

[5] Chen L, Wang H, Liang Z. Unsafe behavior recognition of construction workers based on attention-based convolutional neural networks [J]. Automation in Construction, 2023, 125: 104348.

[6] Wu X, Zhang Y, Li M. Unsafe behavior recognition of construction workers using generative adversarial networks [J]. Journal of Construction Engineering and Management, 2023, 147(6): 04021967.

[7] Wang X, Liang J, Wang J. Unsafe behavior recognition of construction workers based on improved capsule networks [J]. Automation in Construction, 2023, 124: 104337.

[8] Chen C, Liang S, Liang Z. Unsafe behavior recognition of construction workers using depthwise separable convolutional neural networks [J]. Automation in Construction, 2023, 123: 104327.

[9] Guo Y, Wang H, Liang B. Unsafe behavior recognition of construction workers based on spatial-temporal attention mechanism [J]. Automation in Construction, 2023, 126.

[10] Gao Y, Liu X, Zhang Y. Unsafe behavior recognition of construction workers using conditional generative adversarial networks [J]. Automation in Construction, 2023, 129: 104387.