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Application of deep learning in visual detection in intelligent manufacturing environment

Xuefei Xiong

Guangdong Lyric Robot Automation Co., Ltd. 516057

ABSTRACT

This paper discusses the challenges of real-time and robustness and safety protection faced by the application of visual detection in intelligent manufacturing, and puts forward the corresponding optimization countermeasures. The importance of model optimization and acceleration, environmental adaptability enhancement, and the hardware adaptation strategy are emphasized in real-time and robustness. By adopting model compression and hardware acceleration, the real-time detection capability of deep learning model can be improved; the adaptive algorithm can improve the robustness of the model to environmental change; and the deployment scheme for different hardware platforms can ensure the performance and compatibility of the model. In terms of security protection, the paper proposes the mechanisms of data encryption and anonymous processing, model security reinforcement and compliance management. By implementing these mechanisms, we can effectively protect the security of visual detection data, enhance the resistance of deep learning models to attacks, and ensure the legitimacy and compliance of the technology.

KEYWORDS

intelligent manufacturing; visual detection; deep learning; safety protection

With the continuous development of intelligent manufacturing technology, visual detection, as a key link, is playing an increasingly important role in product quality control, production efficiency improvement and other aspects. However, in practical application, visual detection technology is still facing many challenges. On the one hand, the real-time detection requirements on the fast production line put forward extremely high requirements on the response speed and accuracy of the deep learning model; on the other hand, environmental factors such as light change, occlusion, reflection and differences between different hardware platforms also bring challenges to the deployment and performance of the model.

1 Characteristics of deep learning application in visual detection in the intelligent manufacturing environment

1.1 The technical advantages of deep learning in intelligent manufacturing visual detection

Deep learning in intelligent manufacturing visual detection show significant technical advantages, its efficient feature extraction ability makes deep learning model can automatically

learn high level characteristics of the data, thus significantly improve detection efficiency and accuracy, compared with the traditional visual detection method, deep learning without artificial design features, greatly reduce the human cost, and improve the level of detection automation [1]. Deep learning model generalization ability is strong, can well adapt to the change of different production scenarios, including the identification ability of new defect type, and under the stability of different conditions of light, Angle, the adaptability makes deep learning in intelligent manufacturing can cope with complex detection tasks, improve the flexibility and reliability of the production line.

1.2 The new demand for visual detection in the intelligent manufacturing environment

With the rapid development of intelligent manufacturing, the visual detection system is faced with the new requirements of high precision and high speed. In intelligent manufacturing, the positioning accuracy and detection speed of products are extremely high. Deep learning technology can meet these requirements through its powerful data processing ability. With the continuous changes of the product line, the visual detection system needs to have the ability to quickly adjust and expand. The deep learning model shows significant advantages in this aspect, which can quickly adapt to the detection needs of the new product line and reduce the adjustment time and cost. As a key information source, visual detection data can support production optimization and quality control decision-making. Through deep data mining and analysis, deep learning provides powerful data support for intelligent manufacturing and promotes the intelligent upgrade of the production process.

1.3 Selection and training strategy of the deep learning model

In intelligent manufacturing visual inspection task, the choice of deep learning model and training strategy is crucial, different deep learning model (such as CNN, RNN, YOLO, etc.) in the visual inspection task showed different performance characteristics, when choosing the model, according to the specific application scenarios and requirements, choose the most suitable model architecture[2]. In intelligent manufacturing, a large amount of production data provides rich resources for the training of deep learning models.

However, in the case of small samples, how to improve the performance of the model has become a challenge. At this time, methods such as transfer learning can be used to transfer existing knowledge to new tasks to improve the generalization ability and accuracy of the model. Model iteration and optimization is also the key to improve the performance of the visual detection system. Through continuous data feedback and model tuning, the accuracy and efficiency of the visual detection system can be continuously improved to meet the continuous development needs of intelligent manufacturing.

1.4 The combination of deep learning and edge computing

The combination of deep learning and edge computing brings new opportunities for real-time improvement and efficient resource utilization for intelligent manufacturing visual detection. Edge computing reduces data transmission delays by sinking computing tasks to the edge of the network, enabling the deep learning model to achieve rapid response in the intelligent manufacturing site.

This real-time improvement is of great significance for improving the automation level and production efficiency of the production line. In the edge computing environment, the deployment strategy of deep learning models also faces challenges.

2 Problems exist in the application of deep learning in visual detection in the intelligent manufacturing environment

2.1 Data quality and annotation problems

In the field of intelligent manufacturing visual detection, data quality and annotation problem constitute a big obstacle to the deep learning model application, the actual production environment, high quality, diversified training data is often difficult to obtain, due to the complexity and diversity of the production line, different batches, different specifications of the product in the appearance, texture, size, the lack of enough diversity collected data, difficult to fully cover all the detection scenario, the problem of insufficient data diversity, directly affects the deep learning model generalization ability, make it in the face of new types of defects or complex background. Visual detection data annotation work also faces great challenges, annotation process not only need a lot of artificial participation, and annotation accuracy and consistency is difficult to guarantee, due to the professional level of annotation personnel, work experience and annotation standard difference, annotation results inconsistency and error, further affect the model training effect and accuracy. With the expansion of production scale and the increase of detection demand, the labeling workload also increases dramatically, making data annotation a time-consuming task, with high labeling cost and low efficiency.

2.2 Model complexity and interpretability

Deep learning model in the application of intelligent manufacturing visual detection has achieved remarkable results, but its complexity and explanatory problems, deep learning model usually has a high degree of nonlinear and complexity, makes its internal working mechanism is difficult to intuitively understand and explain, this "black box" features not only affects the credibility and transparency of production decisions, but also lead to the model in certain cases appear unpredictable behavior, increase the uncertainty and risk in the production process. Model overfitting is one of the common problems in deep learning application, because the deep learning model has strong fitting ability, when training data is insufficient or noise, the model will overfit the noise and details in the training data, resulting in poor performance on the test data, overfitting will not only reduce the generalization ability of the model, but also make the false or missing for specific type of defects or abnormal data, thus affecting the normal operation of the production line and product quality.

2.3 Real-time performance and robustness challenges

In the rapid development of intelligent manufacturing, deep learning model of real-time and robustness is facing severe challenges, fast production line of real-time detection requirements for deep learning model put forward high requirements, in high-speed production line, every second is crucial, any delay leads to the decline of production efficiency even production line stagnation, the complexity of deep learning model and calculation often limits the response speed, makes the bottleneck in real-time[3]. The influence of environmental interference on the visual detection effect cannot be ignored. In the intelligent manufacturing environment, environmental factors such as light change, occlusion and reflection all interfere with visual detection, leading to the decrease of the accuracy and stability of detection results. For example, insufficient light or excessive light make the image blurred or shaded, thus affecting the recognition ability of the model. Occlusion and reflection lead to the loss or misleading information of some information of the target object, which

further increases the difficulty of detection. The changes of these environmental factors are uncertain and unpredictable, which poses a severe challenge to the robustness of deep learning models. Hardware compatibility is also one of the key factors affecting the deployment and performance of deep learning models. In intelligent manufacturing systems, hardware differences between different devices lead to differences in the deployment and performance of deep learning models.

2.4 Safety and protection

With the widespread promotion of visual detection application in intelligent manufacturing, data leakage risk has become a problem to be solved, visual detection data usually contains a lot of sensitive information, such as the appearance of the product, size, defects, etc., once the information, to enterprise business secrets and customer's privacy caused serious damage. Deep learning model is also faced with new security threats such as confrontational attack, confrontational attack is a kind of carefully constructed input data to cheat the model, can make the model in particular cases produce wrong output, this attack mode is concealment and pertinence, the stability and reliability of deep learning model poses a serious threat, once the model, cause detection results distortion or false positive, and affect the normal operation of the production line and product quality. Compliance challenge is also one of the important problems facing the application of visual detection in intelligent manufacturing. In different countries and regions, data protection regulations are different, and these regulations have different restrictions and requirements on the application of visual detection in intelligent manufacturing.

3 Optimization countermeasures of deep learning in visual detection in intelligent manufacturing environment

3.1 Data enhancement and semi-supervised learning

Data enhancement technology, data enhancement technology through a series of transformation of the original data, such as rotation, zoom, translation, flip, generate more training samples, so as to increase the diversity of data, this method can not only improve the model generalization ability, make it better adapt to different scenarios of detection task, also can to a certain extent, alleviate the cost of data annotation[4]. To reduce the annotation cost, the semi-supervised learning strategy is introduced into the visual detection task. The semi-supervised learning allows the model to use the unannotated data to assist the training process, and extract useful information from the unannotated data through self-supervised learning and pseudo-labels, so as to further improve the performance of the model. In view of the noise and abnormality in the data, design abnormal detection algorithm is essential, abnormal detection algorithm can automatically identify and process data noise and outvalues, to ensure the accuracy and reliability of training data, by combining the data enhancement technology and semi-supervised learning strategy, and abnormal detection algorithm, can effectively solve the problem of data quality and annotation, for the application of deep learning model in intelligent manufacturing to provide more reliable data support.

3.2 Model simplification and interpretability improvement

Using model pruning and quantification technology, model pruning reduces the redundancy of the model by removing neurons or connections that contribute little to model performance; while

quantification technology transforms the weight and activation values in the model from high-precision representation to low-precision representation, further reducing the computation and storage requirements of the model. Study and apply interpretability tools and technologies that can reveal the logic and characteristic importance of decisions within the model, allowing decision makers to better understand the outputs of the model and make more informed decisions accordingly. Integrated learning method is also an effective means to improve the model performance while maintaining some interpretability. By combining the outputs of multiple base models, we get more accurate and stable prediction results. We can retain the explanatory model by selecting some explanatory base models, such as decision tree, random forest, etc.

3.3 Real-time detection and robustness optimization

Perfect model optimization and acceleration technology, model compression technology, such as weight pruning, quantitative and low rank decomposition, by reducing the model parameters and calculation complexity, significantly improve the operation efficiency of the model, hardware acceleration technology, such as the use of GPU, FPGA high performance computing equipment, further accelerate the model reasoning process, make deep learning model in millisecond time to complete the complex detection task. Improve the model's ability to adapt to the environmental change, the development of adaptive algorithm has become the current research hotspot, these algorithms can dynamically adjust the parameters or structure of the model according to the change of the environment, so as to maintain the stability and accuracy of the model in different environments, for example, by introducing the attention mechanism or context information, the model can better identify the blocked or reflection target object, improve the robustness of detection. For different hardware platform of deep learning model deployment scheme is important for real-time detection and robustness optimization, due to the big difference between the hardware of intelligent manufacturing equipment, formulate unified model deployment scheme is often difficult to achieve, according to the characteristics of the specific hardware platform and requirements, the model of customized optimization and deployment. This includes adjusting the input and output format of the model, optimizing the computational process of the model, and using the hardware acceleration library to ensure that the model performs the best on different hardware platforms.

3.4 Security and protection mechanism

The implementation of data encryption and anonymous processing strategy, through the data encryption, can ensure the security of data in the transmission and storage process, prevent the data from unauthorized access or leakage, through the anonymous processing of data, can remove the personal identity information in the data, protect the user's privacy rights and interests of privacy. Enhance model of the resistance to attack, research confrontation training technology is particularly important, antagonistic training through the introduction of the training process antagonistic samples, make the model to learn more robust characteristics, to improve the model to attack defense, can also be combined with other security reinforcement technology, such as model distillation, defensive distillation, etc., further enhance the security of the model[5]. Establish compliance management mechanism is also to ensure that the visual inspection application security of intelligent manufacturing, due to the differences in data protection regulations in different countries and regions, so need to consider in the development and application of local laws and regulations and compliance requirements, by establishing the compliance management mechanism, can ensure the legitimacy of technology and compliance, reduce the risk and loss

caused by violation of laws and regulations.4 Sum up

Article through the intelligent manufacturing visual detection application of real-time and robustness challenges, security protection problems are analyzed, put forward including model optimization and acceleration, environmental adaptability, hardware adaptation strategy and data encryption and anonymous processing, model security reinforcement, compliance management, such as optimization countermeasures. The implementation of these countermeasures can effectively improve the real-time detection capability and robustness of the deep learning model, protect the security of visual detection data, enhance the resistance of the model to attacks, and ensure the legitimacy and compliance of the technology. In the future, with the continuous development of technology, it is believed that the application of visual detection technology in intelligent manufacturing will be more extensive and in-depth, providing strong support for the transformation and upgrading of the manufacturing industry and high-quality development. reference documentation

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