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A Review of Research Progress on the Application of Deep Learning and Image Processing Techniques in Multiple Fields

Haohan Zhang

School of Mechanical and Electrical Engineering, Yunnan Open University, Yunnan, Kunming, 650500, China

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Abstract: In recent years, the deep integration of deep learning and image processing technologies has driven breakthrough artificial intelligence applications across multiple fields. Through a comprehensive literature review, this paper examines the progress and innovations of these technologies in agriculture, industrial inspection, healthcare, cultural heritage preservation, and public safety. The study provides a systematic reference for interdisciplinary research on deep learning and image processing, while also discussing current challenges and potential future directions.

1. Introduction

The integration of deep learning and image processing technologies has significantly accelerated advancements in artificial intelligence. Powered by the robust feature extraction capabilities of models like Convolutional Neural Networks (CNN) and Generative Adversarial Networks (GAN), deep learning has demonstrated exceptional performance in tasks including image classification, object detection, and semantic segmentation. Based on a comprehensive review of relevant literature, this paper systematically examines the applications of these technologies across five key domains: agriculture, industrial inspection, healthcare, cultural heritage preservation, and public safety. Furthermore, it summarizes mainstream methodologies and their performance metrics, while addressing current challenges and potential future research directions.

2. Applications in the field of agriculture

2.1 Phenotypic measurement in aquaculture

Zhang Shiwēi et al.[1] developed a phenotyping system based on deep learning for the growth monitoring of Litopenaeus vannamei. Standardized shrimp images were obtained by designing a dedicated image acquisition box. The system combines the HRNet model for keypoint detection and the Mask R-CNN model for contour segmentation. Finally, a regression model is constructed to predict the weight. The system significantly improves the efficiency and accuracy of phenotypic measurement. The recognition rate exceeds 98%, providing new ideas for the intelligentization of aquaculture.

2.2 Crop pest and disease detection

Li Xinzhe et al.[2] combined drone technology with deep learning techniques and developed an inspection system for power transmission lines. Similar technologies can be transferred to the agricultural field. Wang Yonghong et al.[3] proposed a pellet ore particle size detection model based on YOLOv5 + U-Net. This method is also applicable to the analysis of crop particle size. Li Yushu et al.[4] focused on vulnerability detection in C/C++, The idea of "encoding function body slices as vectors" can inspire feature extraction in agricultural images. In addition, Wang Dandan et al.[5] used drones equipped with sensors to capture images of rice paddies. Combining Extended Kalman Filter (EKF), Unscented Kalman Filter (UKF), and Cubature Kalman Filter (CKF) algorithms optimizes positioning accuracy, providing a high-precision data foundation for pest and disease monitoring.

2.3 Fruit and vegetable quality analysis

Wu Zhili et al.[6] systematically summarized the applications of deep learning in the identification of color, shape, texture, and diseases in fruits and vegetables. It points out that data collection and model real-time performance remain the main challenges. In the research of harvesting robots, Xu Tao[7] compared the advantages and disadvantages of traditional image processing and deep learning methods, emphasizing the robustness of the latter in complex environments.

3. Industrial inspection and infrastructure maintenance

3.1 Bolt and rivet failure detection

Liu Chuanyang et al.[8] reviewed visual-based bolt detection methods over the past decade. They pointed out that two-stage algorithms, such as Faster R-CNN, have high accuracy but slow speed, while single-stage algorithms are more suitable for real-time detection. Wu Jie et al.[9] proposed an improved YOLOv7-tiny-CM algorithm for detecting the absence, looseness, and other states of bolts. They also combined the U-Net algorithm to calculate the angle of looseness, with an error less than 1.7°, which significantly improved the detection efficiency in industrial scenarios.

3.2 Lidar noise reduction and road surface detection

Wang Yonghong et al.[3]They designed an adaptive stacked modified sparse denoising autoencoder.,The method processes LiDAR image noise on a per-channel basis while simultaneously addressing the issue of blurring. Wei Mingdi[10]The recognition accuracy of asphalt pavement crack identification is as high as 90% through optimization using the VGG network. The feasibility of combining traditional image processing techniques (such as graying and histogram equalization) with deep learning has been verified.

3.3 Inspection of power facilities and building structures

Xia Kai et al.[11] used parallel images and CNN to identify defects in substation frameworks. The recognition accuracy rate reaches 96.5%,Their multi-scale feature extraction method can be generalized to other structural inspections. Li Xinzhé et al.[2] demonstrated the potential of deep learning in target localization in complex environments using their drone-based power transmission line inspection system.

4. Innovations in the fields of healthcare and public safety

4.1 Assisted diagnosis of dental caries

Xiang Jinfan et al.[12] developed a dental caries detection system for small oral radiographs based on U-Net and YOLOv5,The optimal mAP@0.5 value reaches 95.3%,By integrating a PyQt5 interface to enhance the operational efficiency of doctors, it provides a model for the implementation of medical AI.

4.2 Fingerprint and signature recognition

Han Ke[13] reviewed the progress of deep learning in fingerprint segmentation, enhancement, and 3D feature recognition. They pointed out that contactless recognition is the future trend. Gao Xianting et al.[14] proposed a signature recognition technique that integrates Fast Fourier Transform (FFT) with an improved LeNet-5, effectively reducing the interference from writing conditions and enhancing the reliability of identity authentication.

4.3 Image tampering detection

Zhang Rubo et al.[15] systematically summarized deep learning-based tampering detection methods, emphasizing the importance of multi-scale feature fusion and adversarial training. This provides technical support for image authenticity verification in the fields of journalism and the judiciary.

5. Applications in cultural heritage and special scenarios

5.1 The collation of ancient Yi script

Xiong Tienu et al.[16] utilized object detection models to extract ancient Yi script from images of ancient texts. By employing feature matching, they achieved automated collation of the script. This method effectively addressed the challenges of numerous variant characters and scarce annotation resources, thereby paving a new path for the study of ancient scripts.

5.2 Elevator button recognition

Li Yitong et al.[17] achieved a recognition accuracy of 97.17% for elevator buttons by employing morphological operations to reduce data noise and training the model with images from multiple angles. This validated the effectiveness of data augmentation in scenarios with limited sample sizes.

6. Techniques and Challenges

6.1 Mainstream Models and Optimization Strategies

In the field of object detection, the YOLO series is widely used due to its fast speed and high accuracy. Wu Jie et al. [9] have made improvements in bolt detection. In the field of semantic segmentation, Xiang Jinfan et al.'s U-Net [12] and Zhang Shiwēi et al.'s Mask R-CNN[1] have shown outstanding performance in medical and industrial scenarios. In the field of image denoising and enhancement, the stacked autoencoder by Wang Yonghong et al.[3] and the Generative Adversarial Network (GAN) by Luo Yizhong [18] have become important tools for image restoration.

6.2 Facing challenges

In terms of data bottlenecks, there is a lack of high-quality annotated datasets in fields such as ancient Yi script and C/C++ smart contracts. In terms of model generalization, the complex environments in agricultural and industrial scenarios, with factors such as lighting and occlusion, can easily lead to performance degradation. In terms of real-time requirements, applications such as drone inspection and harvesting robots demand stringent computational efficiency. There are deficiencies in terms of interpretability. In medical diagnosis, models need to provide interpretable results to comply with clinical standards.

6.3 Future Directions

Firstly, cross-domain transfer learning can utilize pre-trained models to address the issue of small sample sizes. Secondly, the development of lightweight models, which are friendly to edge devices, is essential. Thirdly, multimodal fusion, which involves combining data from multiple sources such as infrared and LiDAR, can enhance the robustness of detection. Fourthly, ethics and security issues need to be addressed by strengthening research on image tampering detection and privacy protection technologies.

7. Conclusion

The integration of deep learning and image processing technologies has demonstrated significant potential in the fields of agriculture, industry, healthcare, and more. However, issues such as data scarcity and insufficient model generalization capabilities still need further breakthroughs. Future research should focus on interdisciplinary collaborative innovation, promoting the transition of technology from the laboratory to practical applications, while also paying attention to ethics and security, in order to achieve the sustainable development of artificial intelligence technologies.

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References

[1] Zhang, S., Dai, P., Gao, G., et al. (2025). Development and application of a phenotyping system for Litopenaeus vannamei growth based on deep learning algorithms. Acta Hydrobiologica Sinica, 49(05), 198-210.

[2] Li, X., Zhao, Q., Yue, T., et al. (2025). UAV transmission line component detection system based on deep learning technology. China High-tech Science and Technology, (01), 115-117.

[3] Wang, Y., Wang, X., Liu, R. (2025). Sparse denoising method for LiDAR images based on deep learning. Laser Journal, 46(03), 154-160.

[4] Li, Y., Xing, Y., Lu, S., Pan, H., Chai, S., Si, X. (2025). C/C++ smart contract vulnerability detection tool based on deep learning at the function body slice level. Computer Applications, 1-11. [Retrieved from http://kns.cnki.net/kcms/detail/51.1307.tp.20250417.1425.004.html]

[5] Wang, D., Zhang, L., Yu, L., Song, H. (2025). Detection and analysis of rice pests and diseases based on deep learning. Journal of Heilongjiang Institute of Technology (Comprehensive Edition), 25(01), 89-93.

[6] Wu, Z., Du, Z., He, Y., et al. (2025). A review of deep learning applications in fruit and vegetable quality detection. Agricultural Engineering, 15(01), 120-128.

[7] Xu, T. (2025). Research on target detection methods for harvesting robots based on deep learning. Jiangsu Agricultural Mechanization, (02), 26-29.

[8] Liu, C., Wu, Y., Liu, J. (2025). Research progress on visual detection methods for bolt/rivet failures. Chinese Journal of Scientific Instrument, 1-19. [Retrieved from https://doi.org/10.19650/j.cnki.cjsi.J2413553]

[9] Wu, J., Huang, C., Han, B., Zou, C., Huang, S. (2025). Research on bolt damage detection based on deep learning and image processing. Journal of Harbin Engineering University, (09), 1-11. [Retrieved from http://kns.cnki.net/kcms/detail/23.1390.U.20250313.1329.008.html]
[10] Wei, M. (2025). Detection and analysis of asphalt pavement based on image processing and deep learning. Heilongjiang Science and Technology of Communications, 48(03), 31-35. DOI:10.16402/j. cnki.issn1008-3383.2025. 03.010.
[11] Xia, K., Chen, T. (2025). Defect identification method for fully prefabricated substation frame structure based on parallel images and deep learning. Microcomputer Applications, 41(02), 203-205+218.
[12] Xiang, J., Miao, J., Yang, Y., et al. (2025). Dental caries auxiliary diagnosis system based on deep learning. Intelligent Computer and Applications, 15(03), 64-71. DOI:10.20169/j.issn.2095-2163.250309.
[13] Han, K. (2025). Research progress of deep learning technology in fingerprint information. Criminal Technology, 1-7. [Retrieved from https://doi.org/10.16467/j.1008-3650.2025.0007]
[14] Gao, X., Liu, J., Wang, Z., et al. (2025). A handwriting signature recognition technology based on deep learning. Science and Technology Innovation and Productivity, 46(02), 76-79.
[15] Zhang, R., Lin, Q., Zhang, T. (2025). A review of image tampering detection methods based on deep learning. Journal of Intelligent Systems, 20(02), 283-304.
[16] Xiong, T., Qiu, J., Hu, J. (2025). A method for collecting and organizing ancient Yi script images based on deep learning technology. Journal of Intelligent Systems, 1-8. [Retrieved from http://kns. cnki.net/kcms/detail/23.1538. TP.20250221.0930.008.html]
[17] Li, Y., Cao, X., Pu, C. (2025). Recognition method for elevator buttons based on deep learning. Mechanical Design and Manufacturing Engineering, 54(01), 100-104.
[18] Luo, Y. (2025). Design of OpenCV image processing software based on deep learning. Software, 46(01), 50-52.