

The Application and Development of Image Recognition Technology in the Field of Computer Vision

Zhengyu Luo *

School of Automation, Guangdong University of Technology, Guangzhou, China

* Corresponding author: 3121001452@mail2.gdut.edu.cn

Abstract. Image recognition is an important field of computer vision research. With the emergence of convolutional neural networks, image recognition has rapidly developed in many fields and has entered people's daily lives. This article reviews image recognition applications and future prospects in three representative fields: healthcare, intelligent driving, and security monitoring. In medical image analysis, image recognition technology can improve medical image interpretation speed and accuracy by automatically learning image features, providing doctors with more comprehensive information and decision-making support. Regarding intelligent driving, image recognition can help vehicles perceive and understand the traffic environment in real time, improving driving safety and automation level. In terms of security monitoring, image recognition plays a vital role in facial recognition, object detection, and behavior analysis, providing intelligent monitoring and security guarantees. However, these areas still have challenges, such as large data volumes, labeling difficulties, and privacy issues. In the future, people can look forward to combining image recognition technology with other technologies to improve models' interpretability and decision-making ability and further promote the development of these fields.

Keywords: Image recognition, intelligent driving, security monitoring, artificial intelligence, Medical Imaging Analysis.

1. Introduction

Image recognition is an important research direction in computer vision, and its applications are gradually penetrating various fields. Image recognition technology can automatically analyze and understand information such as objects, scenes, and actions in images or videos, thereby achieving more intelligent and efficient applications [1]. Therefore, both domestically and internationally, scientists have received widespread attention from image recognition technology. In recent years, significant progress has been made in image recognition technology due to the advancement of deep learning algorithms and the availability of large-scale image datasets. This paves the way for extensive practical applications in various fields and has broad prospects.

It is used for medical image analysis to achieve more accurate diagnoses and personalized treatment plans in healthcare. Doctors can use image recognition algorithms to analyze medical images and detect anomalies, achieving faster and more reliable diagnoses. In addition, image recognition can assist surgical procedures by accurately identifying target areas and guiding surgeons during the surgical process.

Image recognition plays a vital role in autonomous vehicles and intelligent transportation systems. It helps with object detection, lane detection, and traffic sign recognition, enhancing the perception ability of vehicles. This, in turn, enables autonomous vehicles to drive safely on the road, reducing the risk of accidents. In addition, image recognition can be used in traffic management systems to optimize traffic flow and improve overall efficiency.

Image recognition technology also contributes to the fields of security and monitoring. It can achieve facial recognition, object tracking, and behavior analysis, achieving more effective monitoring and threat prevention. Monitoring systems with image recognition algorithms can quickly identify suspicious activities, intrusions, or individuals, enhancing overall security measures.

This article will focus on the application of image recognition in fields such as medical image analysis, intelligent driving, and security monitoring and explore the difficulties and challenges faced in these fields, as well as the potential and prospects of image recognition technology in solving these

problems. The article also mentions the challenges and limitations in these fields and future development directions to provide references and ideas for researchers in related fields and promote further application and research of image recognition technology in these fields.

2. Application of Image Recognition in Three Fields

2.1. Medical Image Analysis

Medical image analysis refers to the analysis of medical images through image recognition technology. With the continuous development of image recognition technology, in addition to doctors manually and subjectively interpreting medical images, advanced image recognition technology can now play an essential role in medical image analysis. Medical image analysis has improved the interpretation speed and accuracy of medical images through artificial intelligence technology, providing doctors with more comprehensive information and decision-making support, further improving the level of medical diagnosis and treatment, and improving patients' healthcare outcomes. At present, image recognition plays a vital role in the diagnosis and treatment of lung cancer, breast cancer, and other cancers. According to statistics, lung cancer deaths are the highest among various cancers [2]. Therefore, this article focuses on applying image recognition to lung cancer.

Lung CT is a commonly used imaging examination method that can be used to diagnose lung cancer. CT scanning can provide detailed lung images and detect abnormal structures and tissues. In clinical practice, the most common and popular method of lung cancer examination is CT scanning, which is also used to diagnose patients. Lung cancer is usually divided into four stages based on its severity and spread: stage I, stage II, stage III, and stage IV [3]. However, there may be errors and misidentification of cancer stages in manually interpreting CT images. In order to ensure a correct diagnosis, image recognition is now needed. Classifying lung CT images into normal and different lung cancer stages is a standard classification problem.

In applying medical imaging technology in deep learning diagnosis, the automatic extraction of medical image features is one of the most crucial steps in the entire algorithm. Convolutional neural networks (CNN) can automatically learn features in images without manually designing complex feature extractors [4]. CNN has become an effective tool for processing image data through its automatic feature learning, hierarchical feature extraction, and parameter-sharing advantages. With the increase of datasets and the improvement of computing resources, CNN has made significant breakthroughs and successes in fields such as image recognition, object detection, and image segmentation, which has sparked the rise of this field. CNN neural networks also exhibit excellent performance in image recognition of lung CT. N. Mohanapriya et al. obtained lung tumor classification accuracy rates of 85.33%, 84.51%, and 85.79% using three different DCNN classification structures [5]. Shalini Wankhade et al. used CNN-RNN, a hybrid neural network, as a new method for cancer cell detection for early diagnosis of lung cancer and further improved the accuracy of diagnosis using advanced 3D convolutional neural networks (3D-CNN) [6]. Recently, Sandeep Wadekar et al. used the CNN model VGG19 to modify the CNN model to a pre-trained visual geometry group 19 (VGG19) and used pre-trained and improved enhancement techniques to classify lung cancer biopsy images. The finely tuned VGG19 model showed high accuracy in the experiment, reaching 97.73%. The experimental results show that this method performs better than existing methods [7].

2.2. Intelligent Driving

Image recognition and autonomous driving are closely related. Image recognition technology is one of the cores of the auto drive system, which is used to perceive and understand the visual information in the environment in real time. Autonomous vehicles are usually equipped with multiple sensors, including cameras, radar, and LiDAR, among which the camera is responsible for collecting image data. Analyze and process these images using image recognition technology.

Image recognition in intelligent driving is divided into active and passive image recognition [8]. Simply put, active image recognition is image recognition that obtains the required information through user guidance or interaction, while passive image recognition is the automated recognition and analysis of images. For intelligent driving, the main issue is how to make the computer understand the entire scene and guide the car to make the next decision. Overall, image recognition plays a crucial role in intelligent driving, helping the intelligent driving system make accurate decisions and plans through real-time perception and analysis of images and improving the driving safety and automation level of vehicles. Convolutional neural networks are widely used to achieve binocular 3D perception in autonomous vehicles. Among them, the CNN-based FlowNet framework proposed by Alexey Dosovitskiy et al. in 2015 is a commonly used method. FlowNet is an optical flow estimation framework based on convolutional neural networks, aiming to accurately estimate the optical flow in images by learning convolutional neural networks [9]. The FlowNet framework can calculate the depth of different objects in the scene by analyzing and comparing the disparity information between binocular images, achieving perception and understanding of 3D scenes. FlowNet framework plays a vital role in intelligent driving. Through binocular vision depth perception and motion estimation, it has realized vital functions such as 3D scene perception, distance calculation and collision warning, visual odometer, obstacle detection and tracking, and attitude estimation, further improving the perception and decision-making ability of the auto drive system [8]. In 2020, Debrina Dutta et al. proposed a new CNN-based all-terrain autonomous driving model with an overall testing accuracy of 96.8%. The accuracy of this model is very impressive during the day but slightly decreases under nighttime, foggy, and rainy conditions [10]. This is also where relevant researchers need to improve in the future.

2.3. Security Monitoring

Image recognition has played a significant role in security monitoring fields such as facial recognition, behavior analysis, object detection, and tracking. With the development of artificial intelligence, machine learning, and Internet of Things technology, the field of security monitoring has received widespread attention from scientists worldwide.

Face recognition and target detection are essential technologies in security monitoring that can accurately identify and locate suspects. The security system can identify individuals who have been blocked or have specific identities and can also effectively identify and accurately locate offending items through object detection, triggering alerts to notify security personnel. In 2021, Vidit Kumar et al. designed a face skeleton based on the YCBCR color space for feature point detection and extraction. The skeleton was used to detect Harris corner feature points and SURF feature points from each face, and a support vector machine classifier was trained to recognize faces [11]. Experiments were conducted on public datasets, and the results showed that our method has reliability, accuracy, and robustness and can be successfully applied to multi-face recognition systems in the real world.

According to statistics, the crime rate at night is often higher than during the day. Night creates natural escape conditions for criminals, and infrared cameras are essential in the dark. Therefore, the research on surveillance cameras with infrared (IR) imaging function combined with image recognition has always been a current research focus [12]. Fast R-CNN (Region Convolutional Neural Network) technology has become a vital algorithm in object detection in the real-time crime scene evidence analysis system. It has achieved remarkable results in many practical applications. In 2022, Meiyu Liang et al. proposed an improved Faster R-CNN infrared target detection algorithm with improved performance compared to the Faster R-CNN target detection algorithm, which has good effectiveness and feasibility [13].

For the identification of dangerous weapons, Ahmed Abdelmoamen Ahmed et al. used the Raspberry Pi 3 device in conjunction with the CNN model and Mask R-CNN deployed on Intel Neural Computer Rod 2 (NCS2) for classification, achieving an overall prediction accuracy of 94% for identifying dangerous weapons [14]. With such high accuracy, it is already possible to efficiently screen hazardous materials from many items, significantly reducing the pressure of manual screening.

Overall, the importance of image recognition in security lies in providing more intelligent, efficient, and accurate monitoring and security guarantees. It can help people quickly identify and respond to potential security threats, enhance their sense of security, reduce criminal behavior, and provide adequate security management and resource allocation.

2.4. Comparison of Three Fields

The image recognition in the above three fields has different application objects, advantages and limitations, as shown in Table 1.

Table 1. Comparison of three fields

field	Application object	advantages	limitations
Medical Imaging Analysis	Identification of tissues and organs; Disease detection and identification	Efficiency, providing more accurate diagnosis	Large data volume and difficulty in annotation, with strong professionalism in annotation; Very low interpretability
Intelligent driving	Pedestrian and traffic object recognition, road conditions and obstacle analysis	Provide proactive feedback and warnings to ensure driving safety	The complexity of the environment leads to unstable accuracy and requires manual assistance
Security monitoring	Face recognition, abnormal behavior reporting, target tracking	Large scale automated monitoring and analysis to reduce human repetitive labor; Ensuring the safety of users' lives	Privacy issues

3. Future outlook

3.1. Medical Imaging Analysis

The existing deep learning models have achieved very high accuracy and credibility in judging a single disease. However, in the clinical medical decision-making of real doctors, it is often necessary to judge unknown diseases based on multiple information such as the patient's medical history, physical condition, laboratory tests, and imaging examinations. In the future, image recognition technology can combine natural language processing technology, integrate multiple aspects of image and language information, incorporate disease-related influencing factors into deep learning models, and improve the interpretability of the model is a focus of researchers.

3.2. Intelligent Driving

With the development of intelligent driving in recent years, many car manufacturers led by Tesla have equipped cars with functions such as automatic cruise control, lane keeping, and automatic lane changing. It can perceive the environment based on traffic signs and road markings, and judge and adapt to the road conditions ahead of the vehicle in real-time. However, at present, it is still necessary for drivers to remain vigilant and intervene at any time during autonomous driving to ensure safe driving and not fully autonomous driving. In the final analysis, the accuracy of intelligent recognition cannot reach the level that humans can believe. With the continuous development of image recognition technology and the continuous improvement of accuracy, it is believed that one day, fully autonomous driving will enter our lives and liberate drivers' hands.

3.3. Security Monitoring

With the further integration of technologies such as big data, cloud computing, and the Internet of Things, the application of image recognition in the field of security monitoring will become more extensive and in-depth. Nowadays, intelligent security monitoring has not yet been widely popularized. Reducing costs, improving technical accuracy, and strengthening privacy protection are

important directions to promote the popularization of intelligent security monitoring. With the continuous progress of technology and the maturity of intelligent solutions, image recognition will face greater development opportunities in the field of intelligent security. This will bring more efficient, precise, and reliable security guarantees to urban security, improving the quality of life and sense of security for urban residents.

4. Conclusion

Image recognition technology has widespread applications and enormous potential, gradually penetrating medical imaging, intelligent driving, and security monitoring. In the future, image recognition technology will continue to develop, and accuracy and stability will continue to improve. Combining image recognition with other fields of technology, such as natural language processing, big data, and the Internet of Things, will further promote the intelligence and efficiency of image recognition. However, image recognition still faces challenges such as dataset quality, annotation difficulties, and environmental complexity. Addressing these issues requires in-depth research and exploration, strengthening data annotation and privacy protection. Overall, the application and prospects of image recognition are comprehensive. With the advancement of technology and the promotion of applications, image recognition will play a more critical role in various fields, bringing more convenience and security to people's lives and work.

References

- [1] Lu K. Intelligent recognition system for high precision image significant features in large data background. *Cyber Security Intelligence and Analytics*. Springer International Publishing, 2020, 1056 - 1062.
- [2] Sung H, Ferlay J, Siegel R L, et al. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA: a cancer journal for clinicians*, 2021, 71 (3): 209 - 249.
- [3] Vas M, Dessai A. Lung cancer detection system using lung CT image processing. 2017 International Conference on Computing, Communication, Control and Automation (ICCUBEA). IEEE, 2017, 1 - 5.
- [4] Zhang Y, Dai B, Dong M, et al. A Lung Cancer Detection and Recognition Method Combining Convolutional Neural Network and Morphological Features. 2022 IEEE 5th International Conference on Computer and Communication Engineering Technology (CCET). IEEE, 2022, 145 - 149.
- [5] Mohanapriya N, Kalaavathi B, senthil Kuamr T. Lung tumor classification and detection from CT scan images using deep convolutional neural networks (DCNN). 2019 International Conference on Computational Intelligence and Knowledge Economy (ICCIKE). IEEE, 2019, 800 - 805.
- [6] Wankhade S, Vigneshwari S. A novel hybrid deep learning method for early detection of lung cancer using neural networks. *Healthcare Analytics*, 2023, 3: 100195.
- [7] Wadekar S, Singh D K. A modified convolutional neural network framework for categorizing lung cell histopathological image based on residual network. *Healthcare Analytics*, 2023, 4: 100224.
- [8] Liu J. Survey of the Image Recognition Based on Deep Learning Network for Autonomous Driving Car. 2020 5th International Conference on Information Science, Computer Technology and Transportation (ISCTT). IEEE, 2020, 1 - 6.
- [9] Dosovitskiy A, Fischer P, Ilg E, et al. FlowNet: Learning optical flow with convolutional networks. *Proceedings of the IEEE international conference on computer vision*. 2015, 2758 - 2766.
- [10] Dutta D, Chakraborty D. A novel Convolutional Neural Network based model for an all-terrain driving autonomous car. 2020 2nd International Conference on Advances in Computing, Communication Control and Networking (ICACCCN). IEEE, 2020, 757 - 762.
- [11] Kumar V. a Multi-face recognition framework for real time monitoring. 2021 Sixth International Conference on Image Information Processing (ICIIP). IEEE, 2021, 6: 30 - 34.
- [12] Nandhini T J, Thinakaran K. Detection of Crime Scene Objects using Deep Learning Techniques. 2023 International Conference on Intelligent Data Communication Technologies and Internet of Things (IDCIoT). IEEE, 2023, 357 - 361.

- [13] Liang M, Ji T. Research on Unmanned Infrared Night Vision System Based on Improved Faster R-CNN Target Detection Algorithm. 2022 IEEE 5th Advanced Information Management, Communicates, Electronic and Automation Control Conference (IMCEC). IEEE, 2022, 5: 863 - 869.
- [14] Ahmed A A, Echi M. Hawk-eye: An ai-powered threat detector for intelligent surveillance cameras. IEEE Access, 2021, 9: 63283 - 63293.