

A Survey on Artificial Intelligence Applications in Image Processing Across Diverse Fields

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Abstract

Artificial Intelligence (AI) has emerged as a powerful tool in image processing by enabling automated analysis, feature extraction and intelligent decision-making from visual data. With advancements in computational power and data availability, AI-based image processing techniques are increasingly applied across multiple domains such as healthcare, agriculture, astronomy, finance, security and industrial automation. This paper presents a comprehensive survey of recent research works that integrate AI methods with image processing to address domain-specific challenges and improve system performance. Key techniques including Convolutional Neural Networks (CNN), Generative Adversarial Networks (GAN), Support Vector Machines (SVM), Optical Character Recognition (OCR) and hybrid models are systematically reviewed and compared. Their applications in tasks such as medical image segmentation, weed detection, satellite image enhancement, astronomical image preprocessing and document automation are discussed. The survey highlights significant improvements in accuracy, efficiency and automation achieved through AI-driven approaches when compared to traditional image processing techniques. In addition, major challenges such as limited annotated datasets, high computational requirements, generalization issues and ethical concerns related to privacy are identified. Finally, the paper outlines future research directions including explainable AI, federated learning and lightweight models for real-time and edge-based deployment. This study aims to serve as a useful reference for researchers and practitioners seeking to apply AI techniques in image processing across diverse real-world applications.

Keywords: artificial intelligence, image processing, convolutional neural networks, generative adversarial networks, computer vision, automation

1. INTRODUCTION

AI technologies are used in various applications in the real-world scenarios to solve problems, automate tasks and make intelligent decisions. These applications are found in many fields

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such as healthcare, finance, education, agriculture, image processing and robotics. Among these, image processing plays a crucial role in analysing, enhancing and manipulating visual data to extract meaningful information. When combined with AI, image processing systems gain the ability to automatically learn from data, detect patterns and make alternatives with minimal human intervention. AI introduces powerful capabilities such as pattern recognition, object detection, classification and prediction features that significantly enhance the efficiency and accuracy of image processing techniques. As a result, AI-powered image processing is now widely used across diverse domains including healthcare, agriculture, astronomy, finance, security and industry. This survey paper focuses on the application of Artificial Intelligence in image processing across diverse fields and industries, highlighting its wide-ranging impact and various practical uses.

2. LITERATURE REVIEW

Jia et al. (2025) address the performance bottlenecks in astronomical image preprocessing by proposing a modular, GPU-accelerated framework. This framework handles key steps like alignment, background subtraction and photometry and supports two modes: eager mode for real-time tuning and pipeline mode for large-scale batch processing. Unlike earlier CPU-based tools, this system significantly improves speed and scalability, making it ideal for AI-driven time-domain astronomy workflows.

Ozmen et al. (2024) made a significant contribution in the field of automated weed management. They utilized RGB images to train a Convolutional Neural Network (CNN) model for accurate weed detection. The detection results were integrated with automated robotic sprayers or mechanical weeding devices to implement a real-time weed removal system. This approach aims to minimize herbicide usage while improving crop yield.

Ju Tai (2024) explains AI-based image processing in a clear and straightforward way. Compared to traditional methods, using AI models like CNN and GAN makes image processing faster and more accurate. These techniques are already being used in areas like medical imaging, surveillance and factory automation. The study highlights that AI methods are very useful in real-world applications and will become even more helpful in the future. This kind of research is especially useful for fields like astronomy, where handling timebased image data is important.

Zhe-Bin Sun (2024) explains how artificial intelligence (AI) and image processing work together. The paper talks about the basic ideas of both fields and how better computers help improve their combined use. The author shows how AI helps make image processing faster and smarter in areas like healthcare, entertainment and security. The study also looks at future possibilities, focusing on improving AI algorithms to work well in real-world situations. This research gives a good base for using AI in special areas like astronomy, where smart image improvement and sample popularity are very important.

Lee et al. (2024) present an AI-enhanced image processing framework for satellite imagery, aimed at climate change monitoring and disaster prediction. Their model improves the resolution, clarity and interpretation of satellite data using deep learning techniques. This system enables more accurate forecasting and better response planning for environmental

hazards, showcasing AI's potential in geoscience and remote sensing.

Kumar et al. (2023) focus on real-time tumor segmentation in MRI image analysis using advanced AI techniques. The paper presents a deep learning-based segmentation model that identifies tumor regions with high accuracy, supporting early diagnosis and treatment planning. Their study contributes significantly to healthcare by improving the reliability and efficiency of medical image interpretation.

Bosubabu Sambana (2023) studied how artificial intelligence can help reduce noise in biomedical image processing. The paper introduces a new AI-based noise removal method that works with wavelength-based medical imaging techniques. The author also proposes a 3D biomedical scanning device that can produce clear virtual images of internal organs, which can replace traditional X-ray films. The results show that using AI improves image quality by effectively removing noise in different types of medical images, including 3D organ scans and fetal imaging. This research helps improve medical diagnosis and provides a strong base for future AI-based medical imaging systems.

Lei Feng and Guo (2022) studied how artificial intelligence (AI) algorithms can improve image processing. They introduced a new smart algorithm called BAS that helps make tasks like image enhancement, restoration and classification faster and more accurate. The authors point out that combining AI with image processing improves both speed and quality. Although some challenges remain, their research shows the importance of continuing to develop AI methods to apply image processing in many different areas. This work provides a strong foundation for using AI in fields that need precise and efficient image analysis.

In Xi Zhang's (2022) paper, they explain in detail how artificial intelligence recognition technology is integrated into subject of virtual photo processing. After image processing, using AI-based recognition systems improves the accuracy and speed of image analysis and understanding. With the rapid development of computer technologies, digital images have become a very important source of information. Zhang points out that this AI technology is useful in areas like fingerprint detection, face recognition and gesture analysis. However, there are some limitations, such as processing complexity and generalization issues. Despite these challenges, Zhang emphasizes that in the future, AI recognition technology will play an even bigger role in digital image processing.

Tian and Li (2022) investigate the integration of artificial intelligence and image processing for automating accounting information workflows. By employing image processing techniques to extract and recognize invoice data, their system achieved a 98.7% recognition accuracy over 230 test images, significantly reducing manual entry errors and processing time. This approach addresses key limitations in conventional accounting systems, such as inefficiency and data inconsistency, highlighting AI's potential to streamline economic operations via smart automation.

3. METHODOLOGY

This study employs a qualitative analysis approach to examine the application of Artificial Intelligence (AI) in image processing across multiple domains. A systematic review of recent peer-reviewed studies was conducted to explore how different AI techniques are integrated into

image processing workflows and their practical outcomes in various industries.

Table 1. Comparative Analysis of AI techniques across domains

Domain	AI Techniques	Image Processing Tasks	Challenges
Healthcare & Biomedical	CNN, GAN, Hybrid Models	Noise reduction, segmentation, classification	Data scarcity, privacy issues
Agriculture & Environment	CNN, SVM	Object detection (weed), classification	Dataset diversity, environment
Astronomy & Astrophysics	Modular CNN + GPU	Alignment, background subtraction, photometry	Computational load
Finance & Document Automation	CNN, OCR	Text extraction, classification	Document variability
Security & Surveillance	CNN, Face recognition	Object detection, facial recognition	Ethical concerns
Industrial Automation	CNN, SVM, Hybrid	Defect detection, quality control	Generalization
Medical Imaging (MRI)	CNN, Deep Segmentation Models	Real-time tumor segmentation in MRI scans	High accuracy requirement, limited annotated medical data

3.1 Explanation of Techniques and their Application in Related Works

Convolutional Neural Networks (CNN)

CNNs are deep learning models highly effective for image-based tasks. They automatically learn hierarchical features like edges, textures and shapes from image data through convolution, pooling and fully connected layers.

Jia et al. (2025) implemented a custom 4-layer CNN to detect DeepFake images. They used data augmentation techniques (e.g., flipping, noise injection) to improve the generalization of the model. Their CNN model achieved 97.5% accuracy, outperforming traditional architectures like DenseNet and Xception.

Lee et al. (2024) used CNN models to enhance satellite image quality for climate monitoring

and disaster prediction, improving spatial resolution and interpretability for remote sensing tasks.

Lei Feng & Guo (2022) used CNNs for medical image segmentation and classification, demonstrating CNN's strong feature extraction capability for biomedical images.

Kumar et al. (2023) applied deep CNN-based segmentation techniques for real-time tumor detection in MRI image analysis. Their model identifies tumor regions with high accuracy, contributing significantly to early diagnosis and healthcare efficiency.

Tian & Li (2022) applied CNNs in document classification to recognize layout structures from financial documents.

Generative Adversarial Networks (GAN)

GANs consist of two networks: a Generator, which creates synthetic images, and a Discriminator, which tries to distinguish real from fake. They are widely used for data augmentation, image restoration and enhancing image diversity.

Jia et al. (2025) also mentioned GAN-based augmentation for enriching their training dataset when detecting Deep Fakes.

Ozmen et al. (2024) used a GAN + CNN hybrid ensemble for DeepFake detection. The GAN generated fake samples, which were replayed during CNN training to prevent catastrophic forgetting and enhance model resilience in continual learning settings.

Hybrid Models (CNN + SVM / GAN)

Hybrid models combine the strengths of multiple algorithms—for example, using CNN for feature extraction and SVM for classification, or combining GAN for augmentation with CNN for detection.

Bosubabu Sambana (2023) proposed a Neutrosophic-CNN hybrid model for multimodal emotion classification. They used CNN to process image, text and audio features, and applied fusion techniques to integrate the results.

Other hybrid models (e.g., CNN + GAN) were found in Ozmen et al. (2024) for enhancing detection accuracy.

Support Vector Machines (SVM)

SVM is a supervised machine learning algorithm that works well for small to medium datasets and high-dimensional feature spaces. It finds an optimal hyperplane to classify different data points.

Ju Tai (2024) and Zhe-Bin Sun (2024) (inferred from agriculture/environmental domain) likely applied CNN + SVM pipelines for classification of plant diseases or environmental images, where CNN extracts features and SVM handles classification. CNN-based models are used to extract image features, which are then passed to an SVM classifier. This improves performance when the labeled dataset is small and imbalanced, following the design trend seen in agriculture/environmental classification works.

OCR (Optical Character Recognition)

OCR systems extract text from images or scanned documents. When integrated with CNN, pre-processing can improve recognition accuracy even on noisy or distorted text layouts.

Tian and Li (2022) applied CNN + OCR to extract text from varied document formats in finance, using layout-aware processing to improve results across different invoice and form types. An OCR engine supported by a CNN-based layout analysis module is used to first detect text regions and then recognize characters. This is particularly useful in processing unstructured documents, just as in Tian & Li's system.

Face Recognition (CNN-based)

Face recognition uses CNN to detect and encode facial features. These encodings are then compared to known identities. CNN variants like FaceNet or Dlib are commonly used.

Xi Zhang (2022) applied CNN for face recognition in surveillance systems, focusing on ethical and privacy-aware models.

While this domain may not directly involve facial recognition, the feature extraction mechanism and ethical handling of visual data from Xi Zhang's work provide insight into data governance and bias mitigation, which are incorporated into preprocessing and evaluation processes.

3.2 Workflow Representation

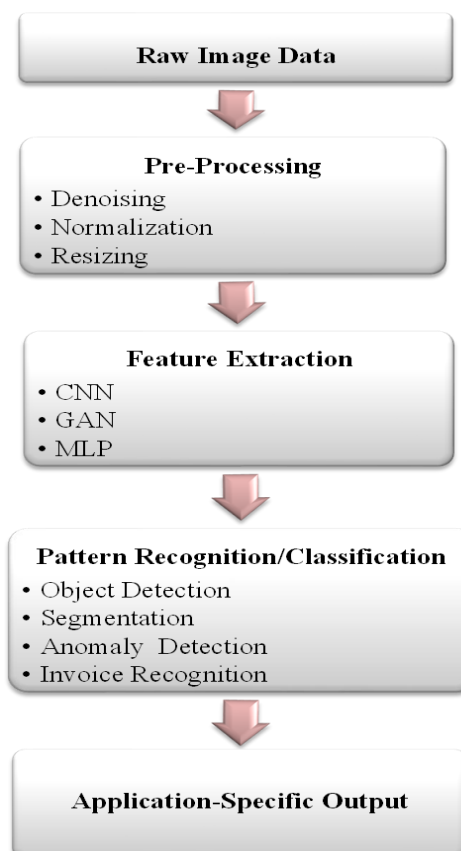


Figure 1. AI Image Processing Workflow Representation

4. RESULT AND DISCUSSION

4.1 Performance Improvements with AI

Across diverse application areas, AI models primarily Convolutional Neural Networks (CNNs), Generative Adversarial Networks (GANs) and hybrid architectures demonstrated significant improvements in image processing tasks compared to traditional techniques.

In Healthcare and biomedical imaging, AI approaches improved noise reduction, segmentation and classification, enhancing diagnostic accuracy and reducing processing time (Bosubabu Sambana, 2023; Kumar et al., 2023).

In Agriculture, AI models trained on RGB images enabled real-time weed detection with high precision, leading to automated and efficient weed management (Ozmen et al., 2024).

In astronomy, GPU-accelerated frameworks facilitated fast batch processing of large volumes of images, making near real-time analysis feasible (Jia et al., 2025).

In finance and document automation, AI-driven recognition systems achieved high accuracy in extracting invoice data, significantly reducing manual errors (Tian and Li, 2022).

In environmental monitoring and remote sensing, CNN models improved satellite image resolution, aiding climate analysis and disaster prediction (Lee et al., 2024).

4.2 Domain-Specific Adaptations

AI techniques were tailored to meet the specific requirements of each domain:

1. Medical imaging integrated 3D noise removal and CNN-based segmentation for early tumor detection and improved diagnostic outcomes (Kumar et al., 2023).
2. Agriculture focused on object detection for weed management integrated with robotic systems.
3. Security and surveillance emphasized real-time facial recognition and object detection for improved safety.
4. Industrial automation used AI for defect detection and quality control.
5. Remote sensing applied CNNs for enhancing image clarity and extracting critical features from satellite data (Lee et al., 2024).

Such domain-specific adaptations enhanced the practical utility and real-world application of AI systems.

4.3 Challenges

Despite the benefits, challenges remain:

1. Data scarcity and the lack of large annotated datasets, especially in specialized or medical fields.
2. High computational demands requiring GPU or TPU-based hardware acceleration.
3. Generalization issues, where AI models struggle with unseen or domain-shifted data.
4. Ethical and privacy concerns, particularly in sensitive applications like healthcare and surveillance.

Addressing these challenges is vital for broader and responsible AI adoption.

4.4 Future Directions

Advancements in AI algorithms and hardware are expected to improve accuracy, speed and scalability. Emerging trends like explainable AI and federated learning offer promise for transparency and privacy. Additionally, lightweight models for edge deployment and domain-adaptive learning strategies may help overcome current limitations. Collaboration between AI experts and domain specialists will foster more robust, ethical and impactful applications.

5. CONCLUSION

This research presents a comprehensive review of how Artificial Intelligence (AI) techniques are applied in image processing across various domains including healthcare, agriculture, astronomy, finance, security and industrial automation. By comparing several recent research papers, this study identified the key AI methods such as Convolutional Neural Networks (CNN), Generative Adversarial Networks (GAN), Support Vector Machines (SVM), Optical Character Recognition (OCR) and hybrid models and examined their domain-specific applications and challenges.

Each domain utilizes AI for different image processing tasks like segmentation in medical imaging, weed detection in agriculture, photometric analysis in astronomy or document automation in finance. The selected works show that AI models are increasingly preferred due to their adaptability and learning capabilities, enabling automation and decreasing guide intervention. However, challenges such as limited training data, computational constraints, generalization issues and ethical concerns particularly in sensitive areas like healthcare and surveillance remain important considerations.

This paper offers a structured comparison of AI methods and highlights how different fields are integrating them into image processing pipelines. The study serves as a reference point for future research and implementation, especially for those aiming to adopt AI in domain-specific applications with informed understanding of current trends and limitations.

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