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Impact of Image Processing and Deep Learning in IoT based Industrial Automation System

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Abstract: The integration of Image Processing and Deep Learning techniques within the realm of IoT-based Industrial Automation Systems has ushered in a transformative era for the manufacturing and industrial sectors. This synergy empowers these systems to perceive, interpret, and respond to visual data with unprecedented precision and efficiency. By harnessing the capabilities of image processing, IoT devices can capture, analyze, and transmit real-time visual information, enabling a comprehensive understanding of the production environment. Deep learning algorithms, in turn, provide the intelligence to make informed decisions, detect anomalies, and optimize processes autonomously. Consequently, this convergence has a profound impact on enhancing productivity, quality control, predictive maintenance, and overall operational excellence in industrial settings. As we move forward, the continued advancement of this integration promises to revolutionize the way industries operate, fostering greater automation, agility, and competitiveness.

Keywords: *Image Processing, Deep Learning, IoT, Industrial Automation System*

1. Introduced

1.1 Image Processing

In order to improve their visual quality or extract usable information from digital photos, image processing is a basic area of study in computer vision and computer science [1-4]. It includes many different methods and algorithms for enhancing, analyzing, and comprehending visual content. Among the many aims of image processing is the improvement of pictures by techniques like noise suppression, contrast augmentation, and sharpening. The fields of medicine, photography, and video production all make regular use of this[6-10].

1.2 Deep Learning

Among the many areas that deep learning has had a profound impact on is computer vision, NLP, and voice recognition [11, 12,13,14,15]. Deep learning is fundamentally influenced by how the human brain works. In order to automatically learn and extract complicated patterns and representations from data, it is necessary to train artificial neural networks with numerous layers, often known as deep neural networks. Neural networks with numerous hidden layers, activation functions, and optimization algorithms are the cornerstones of deep learning. The success of AlphaGo demonstrates the ability of these networks to analyze massive amounts of data and learn hierarchical characteristics, making them suitable for a wide range of applications, from picture recognition and language translation to game playing [16, 17,18,19,20].From healthcare to finance to autonomous vehicles, deep learning has had a significant influence on several fields. Natural language processing, which includes chatbots, virtual assistants, and sentiment analysis, has also benefited greatly from it.

1.3 Image Processing and Deep Learning in IoT

Many useful applications that make use of the capabilities of IoT are made possible by advances in image processing and deep learning. Information is gleaned from these pictures using image processing methods including image identification, object detection, and segmentation [21, 22, 23,24]. By offering extremely

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precise and efficient approaches for tasks like face recognition, anomaly detection, and quality control in industrial settings, deep learning, and in particular convolutional neural networks (CNNs), have revolutionized image analysis inside IoT. This integration of image processing with deep learning in IoT ushers in a new era of intelligent and connected systems by enabling real-time decision making, automation, and improved security in fields as diverse as smart cities, healthcare, agriculture, and manufacturing [25].

1.4 Industrial Automation System

The goal of implementing industrial automation systems in manufacturing and industrial environments is to improve productivity, efficiency, and efficiency. To streamline operations like manufacturing, quality assurance, and inventory management, these systems integrate hardware and software [26, 27]. Programmable logic controllers (PLCs), sensors, actuators, HMIs, and communication networks are all vital components of industrial automation systems. PLC acts as the system's "brain," executing predetermined instructions to manage machines and procedures, while other components, such as sensors and actuators, provide input and output. HMIs provide a convenient way for operators to keep tabs on the system and make adjustments as needed. That's why they're so important to contemporary production, as they can boost quality, save costs, and streamline processes [28.29, 30].

1.5 Image Processing and Deep Learning play a crucial role in IoT-based industrial automation systems

Advanced monitoring, control, and optimization capabilities are made possible by image processing and deep learning in IoT-based industrial automation systems. These technologies may be incorporated into these kinds of systems in the following ways:

Data Acquisition and Preprocessing:

- **Sensor Data**: There is a large quantity of data collected by IoT devices in industrial automation systems from sensors.
- **Data Preprocessing:** Noise, outliers, and calibration errors may be eliminated from the raw sensor data by processing [31].

Computer Vision for Quality Control:

- **Defect Detection:** By analyzing photos or videos, deep learning models may be educated to identify flaws in manufactured goods [32].
- **Object Detection and Tracking:** Algorithms that use computer vision can monitor the whereabouts and functioning of machines and other items inside a factory.

Remote Monitoring and Surveillance:

- **Live Video Analysis:** To keep an eye on things may be applied to live video feeds from Internet of Things cameras.
- **Anomaly Detection:** Anomalies in surveillance video, such as the presence of unauthorized individuals or strange behavior may be detected using a deep learning model [33].

Energy Efficiency:

- **Energy Consumption Analysis:** Data collected by sensors tracking energy use may be analyzed by deep learning models [34].

Automation and Control:

- **Autonomous Robots:** Robots and autonomous vehicles in industrial environments might benefit from deep learning.
- **Process Control:** By using sensor data in real time, deep learning models may optimise processes to maximise output quality and efficiency.

Data Security:

- **Cybersecurity:** By analysing network data and looking for abnormalities, deep learning may aid in the identification and mitigation of security issues.

Edge Computing:

- **On-Device Processing:** Direct deployment of deep learning models on IoT devices or at the network's edge may minimize reliance on the cloud and increase real-time processing, allowing for quicker decision making [35].

2. Literature Review

N. K. Pandey, et al.(2023) introduced the cloud-based solutions for industrial automation provide unique security difficulties due to the nature of the internet of things [1]. P. Bedi et al. (2023) Inspecting Industrial 4.0 Procedures with CV and ML [2]. K. Sharifani et al. (2023) reviewed DL and ML. They take a look at the fundamentals of ML & DL, as well as their distinctions, potential applications, and effects across a variety of sectors [3]. A. Saberironaghi et al. (2023) Applied Deep Learning to the Task of Defect Detection in Industrial Products [4]. R. Rosati et al. (2023) focused on the maintenance in industry 4.0 requires a shift from a knowledge-based to a big data analytic methodology [5]. S. Kumar et al. (2023) reviewed the design, procedures, and production control using machine learning method in additive manufacturing [6]. M. Kor et al. (2023) analysised how to use DL and digital twins in the direction of Building 4.0 [7]. M. S. Abdalzaher et al. (2022) Protected Smart Systems Based on IoT using AI.IoT networks play a significant role within the new age of communication, and this study examines the trust strategies utilized for reduced various security concerns in these networks [8]. M. I. Uddin et al. (2023) reviewed the IoT service enablement and deep learning solutions [9]. M. S. Rahman et al. (2023) Industry 4.0 was using machine learning and the internet of things [10]. A. M. Al Shahrani et al. (2023) introduced the intelligent factory automation powered by ML using the interwebs [11]. S. K. Pandey et al. (2022) presented industry automation with IoT and ML-Based Data Analytics [12]. I. Kumar et al. (2021) The Potential of ML and AI in the Food Sector [13]. K. Vijayakumar et al. (2021) provided intelligence computation, machine learning methods, and the internet of things [14]. W. Xing et al. (2023) presented deep learning and image processing, automatic A-line identification in lung ultrasound images [15]. I. H. Sarker et al. (2021) explained the techniques, taxonomy, applications, and future research directions in deep learning [16]. P. Ambika et al. (2020) looked algorithms based on ML & DL for use in the IIoT's industrial context [17]. H. Naeem et al. (2020) presented methodology that combines image visualization and deep learning; they were able to identify malware in the IIoT for industrial applications [18]. T. J. Sheng et al. (2020) introduced the LoRa and the Tensorflow DL models were used in an IoT-based intelligent waste management system [19]. U. Subbiah et al. (2020) reviewed in-depth analysis and evaluation of DL object detection method [20]. R. A. Khalil et al. (2020) reviewed potentials, challenges, and emerging applications of DL in the industrial IoT [21]. N. Rahmatov et al. (2019) automated image processing using ML for quality control in the IIoT in industry [22]. A. Yazdinejad et al. (2023) introduced cyber threat hunted in the IIoT using an ensemble DL model [23]. N. Chander et al. (2023) provided RNN trained with DL for anomaly detection in the Industrial IoT using metaheuristic feature selection [24]. S. Kumar et al. (2019) focused on the concept of the IoT was a game-changed strategy for developed innovative technologies [25].

3. Problem Statement

The area of industrial automation has benefited greatly from many researches that have been undertaken on the topic. There is a need for IoT to enable industrial automation, although it has been noted that installing such a system is arduous.

4. Proposed Work

In the context of suspicious activity detection after capturing an image from an IoT sensor, both noise filters and deep learning play crucial roles in improving the accuracy and effectiveness of the detection system.

1. Noise Filtering:

Noise Reduction: IoT sensors may capture images in less-than-ideal conditions, leading to various types of noise such as Gaussian noise, salt-and-pepper noise, or motion blur.

Enhanced Feature Extraction: Clean images are essential for accurate feature extraction.

2. Deep Learning:

Feature Learning: Deep learning models, such as Convolutional Neural Networks (CNNs), are excellent at learning and extracting complex features from images. They can automatically identify patterns, shapes, and structures that may be indicative of suspicious activities.

Anomaly Detection: Deep learning models are well-suited for anomaly detection tasks. They can be trained on a dataset of normal activities to establish a baseline. Any deviation from this baseline can be flagged as a potential suspicious activity.

Real-time Analysis: Deep learning models can be optimized for real-time processing, making them suitable for continuous monitoring of IoT sensor data. This allows for immediate response to potential security threats.

Adaptability: Deep learning models can adapt and improve over time as they are exposed to more data. This adaptability is essential in handling evolving threats and changing environmental conditions.

Combining noise filtering and deep learning in the suspicious activity detection pipeline can significantly enhance the accuracy and reliability of the system.

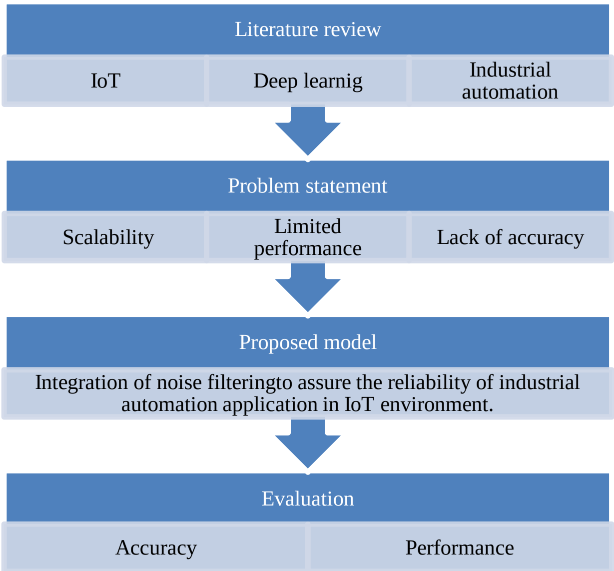


Fig 1 Research Methodologies

However, implementing an IoT strategy in industrial automation isn't without its challenges, not the least of which is the need to build in an noise filtering mechanism to safeguard a system's integrity while working in a connected world.

Flowchart of proposed work

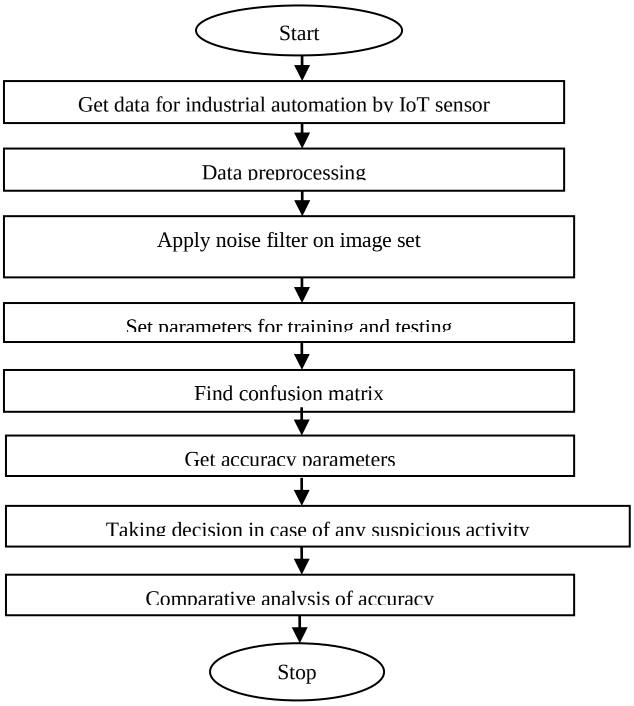


Fig 2 Flow chart of proposed work

Additionally, there is a need for conventional research methods to be more scalable. To address the accuracy and performance difficulties plaguing the industrial automation system, a new strategy is urgently required.

5. Result and Discussion

This part considers noise removal techniques such as bilateral, blur, median, and Gaussian filters. After preprocessing, MSE, PSNR, and SSIM are calculated to evaluate the quality of an image. Then deep learning models such as ResNet, DenseNet, and RESDEN have been applied to perform binary and categorical classification.

5.1 Noise removal techniques

To improve the quality of the image, noise removal operation has been performed with the Bilateral, Blur, Median, and Gaussian filters. The research observed that the Gaussian filter provides refined results than the median, blur, and bilateral filters in many perspectives. Filtered images are presented in the Fig. 3.

Normal images		
Bilateral filtered images		
Median filtered images		
Gaussian filtered images		

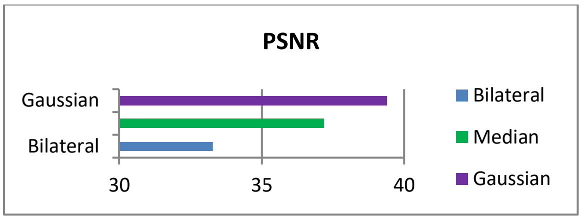
Fig. 3. Filtered images of LFW dataset

5.2Simulation for filtered images

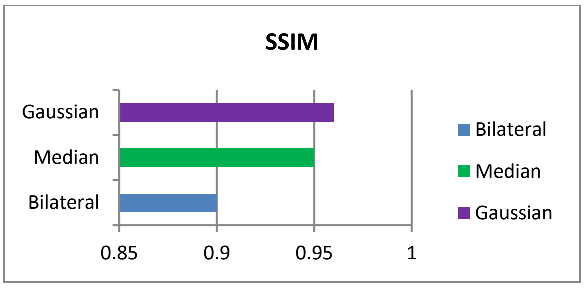
Firstly the simulation is performed for the Bilateral, Blur, Median, and Gaussian filters, and MSE, PSNR, and SSIM values are evaluated for the above filters. The overall result observed that the Gaussian filter provides better than other filters illustrated in Table II, and Fig. 4 respectively.

Table 1 Simulation of Filtered Images

Filter	**Image**	**PSNR**	**SSIM**
Bilateral	1	33.28	0.90
	2	34.01	0.90
Median	1	37.20	0.95
	2	38.70	0.96
Gaussian	1	39.38	0.96
	2	36.98	0.96



(a)



(b)

Fig 4. (a) PSNR, (b) SSIM for different filters

6. Conclusion and Future Scope

The field of industrial automation is now home to a number of active research initiatives that make use of machine learning. A recent investigation of the history of

AI and ML studies revealed that researchers have historically targeted practical problems. There are a number of issues with applying deep learning to industrial automation, the most prominent of which include a lack of precision and poor performance. In order to increase output, conventional research must adopt a more flexible and scalable methodology. It has been calculated that the proposed strategy needs less time and takes up less space than the current status quo. The proposed approach also provides a more precise model since its error rate is reduced overall.

Industrial automation, agriculture, healthcare, education, infrastructure, transportation, cyber security, banking, manufacturing, and the hospitality industry are just some of the sectors where AI is making inroads in India, despite the country's relatively young AI industry. The development of AI is similarly nascent in America. ML algorithms and other cognitive technologies are only two of the many AI-based tools that have found use in the rapidly expanding sectors of industrial automation and healthcare. Simply expressed, AI refers to the capacity of computers and other technology to learn, think, and behave in ways that are strikingly similar to those of human beings.

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