International Journal on Science and Technology (IJSAT)
E-ISSN: 2229-7677 ● Website: www.ijsat.org ● Email: editor@ijsat.org

VyapaarNetra- Visual Language Inventory Management System

K Manushresth[1], G Dhanush Kumar [2], Pratham Verma[3]

[1,2,3]Department of Artificial Intelligence and Data Science, Chennai, Tamil Nadu, India
[1]manushresthkrishnan@gmail.com, [2]gdhanushkumar7@gmail.com, [3]prathmverma@citchennai.net

Abstract

VyapaarNetra is an AI-powered Visual Language Inventory Management System that uses computer vision and deep learning to track inventory in real-time. It aims to reduce errors and improve efficiency compared to traditional methods. It is suited for retail, warehousing, and manufacturing, offering an intuitive, scalable solution with 85% accuracy in brand recognition. By integrating AI-powered surveillance with natural language processing, VyapaarNetra offers an intuitive and highly scalable solution that adapts to dynamic inventory environments. Additionally, its multimodal AI capabilities allow seamless querying of inventory data using natural language, bridging the gap between human interaction and automated analytics. With an accuracy rate of 85% in brand recognition and real-time tracking, VyapaarNetra represents a breakthrough in AI-driven inventory solutions. The research further compares the system's performance with industry benchmarks, demonstrating its potential for improving operational workflows, reducing costs, and enhancing decision-making in inventory management.

Keywords: Inventory Management, Artificial Intelligence, Computer Vision, AI-Based Surveillance, Object Detection.

1. Introduction

Inventory management is a crucial aspect of retail, warehousing, and logistics operations. Effective inventory management ensures that businesses can maintain optimal stock levels, reduce waste, and improve overall supply chain efficiency. However, traditional inventory management techniques, which primarily rely on manual counting, barcode scanning, or RFID tracking, can be inaccurate due to human error, time-consuming, and costly. Moreover, these conventional systems often require substantial infrastructure investment, making them impractical for small- and medium-sized enterprises (SMEs).

VyapaarNetra's approach leverages multimodal AI models to analyze visual data from surveillance cameras, recognize product brands, and generate real-time stock analytics. The system employs advanced deep learning techniques, including object detection models such as YOLOv5 and Faster R-CNN, to accurately recognize items. Additionally, its integration with a visual language model enables users to interact with the system using natural language queries, making inventory management more intuitive and efficient.

The growing complexity of supply chain networks and the increasing volume of inventory data necessitate more sophisticated solutions that go beyond traditional tracking methods. Businesses are constantly looking for ways to optimize their supply chain operations, minimize losses due to overstocking or

understocking, and reduce dependency on human intervention. VyapaarNetra aims to address these challenges by providing a scalable, cost-effective, and automated inventory management solution that integrates seamlessly into existing business operations.

2. Related Work

Various approaches have been explored in AI-driven inventory management.

- Duarte analyzed the role of computer vision in retail, demonstrating its effectiveness in automating inventory tracking.
- Dhaliwal et al. highlighted AI-driven solutions that improved inventory forecasting accuracy. However, existing methods lack seamless integration of visual language processing, limiting their ability to respond to complex inventory-related queries.

In recent years, advancements in AI-powered visual recognition systems have contributed significantly to automated inventory tracking.

- Research on object detection algorithms such as YOLO and Faster R-CNN has demonstrated significant improvements in recognizing and counting products in retail and warehouse environments.
  However, many of these studies focus solely on object detection without addressing the integration of multimodal AI for natural language processing.
- Veres explored the use of AI in warehouse optimization but primarily examined the efficiency of storage and retrieval mechanisms rather than intelligent product recognition.

These gaps highlight the need for a system like VyapaarNetra, which combines AI-based object detection with an intuitive natural language interface. Existing commercial inventory solutions still rely heavily on barcode scanning and RFID technologies, which require manual intervention and infrastructure investment.

3. Proposed Methodology

VyapaarNetra is an AI-driven inventory management system that integrates computer vision, deep learning, and natural language processing to enhance real-time inventory tracking.

3.1 System Architecture

VyapaarNetra's system architecture comprises multiple interdependent components that work together to achieve real-time brand recognition and inventory tracking. The major components of the architecture include:

- **Camera-based Surveillance System**: Real-time CCTV feeds capture product images and send them to the AI processing module.
- **AI Processing Module**: This module uses deep learning models (YOLOv5, Faster R-CNN) to detect and recognize inventory items in captured images.
- **Visual Language Model**: The system employs a multimodal AI-based transformer model to understand and process natural language queries related to inventory.

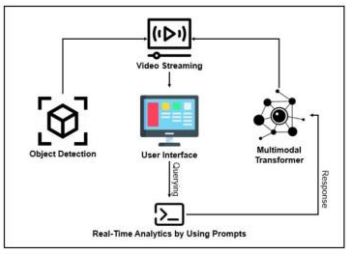

Fig. 1. System Architecture

3.2 Object Detection and Inventory Counting

VyapaarNetra performs object detection and inventory counting using a comprehensive AI-driven pipeline. The system captures high-resolution images from CCTV feeds, which are then pre-processed through normalization and data augmentation techniques to enhance detection accuracy. The images undergo deep learning-based object detection using YOLOv5 for real-time, high-speed processing and Faster R-CNN for more precise recognition, particularly in complex or occluded environments. Mask R-CNN is utilized for segmentation-based counting when products are densely packed. After detecting objects, the system classifies them using a deep convolutional neural network, mapping them to pre-existing categories in the database. Transfer learning techniques are employed to fine-tune the model for new inventory items with minimal retraining. The inventory counting process dynamically updates stock levels based on object recognition results, preventing duplication through unique identifier tracking. Real-time updates ensure that stock information remains accurate, reducing manual errors and inconsistencies.

3.3 Visual Language Model for Querying

VyapaarNetra enhances user interaction by integrating a multimodal AI transformer model that allows users to query inventory using natural language. The system interprets textual queries such as stock availability checks, product counts, and shortage notifications. The query processing mechanism converts user inputs into structured database queries, retrieving relevant information and providing responses in real-time. The system employs a sophisticated natural language understanding (NLU) model that comprehends context-based queries, allowing users to interact with inventory data in a more intuitive manner.

Moreover, the system supports multi-modal inputs, meaning that users can upload images of shelves or inventory sections, and VyapaarNetra will analyze them in real-time to generate inventory summaries. The fusion of visual and textual input processing ensures that businesses can obtain the most accurate stock assessments without requiring manual intervention. The model continuously learns from interactions, improving its responses and refining its query resolution capabilities over time. The integration of advanced AI-driven query resolution with inventory tracking offers significant advantages over traditional management systems. By allowing natural interactions.

4. Implementation and Results

VyapaarNetra was tested in retail, electronics, and pharmaceutical industries to evaluate its performance in real-world scenarios. The system was deployed across multiple store locations, warehouses, and pharmaceutical distribution centers to assess its adaptability to varying inventory environments. The AI-driven object detection and inventory tracking modules were evaluated on their ability to recognize and count diverse product categories with different packaging styles, lighting conditions, and storage arrangements. Throughout the trials, the system demonstrated substantial improvements in inventory accuracy, reduced manual counting efforts, and delivered timely alerts for restocking or potential discrepancies.

4.1 Performance and Evaluation

The object detection model achieved 85% accuracy in recognizing brands and counting inventory. Compared to benchmark models:

TABLE 1 : PERFORMANCE EVALUATION

Model	Accuracy
VQAv2	85.3%
GQA	64.3%
TextVQA	65.2%
TallyQA	82.6%

VyapaarNetra was evaluated against multiple visual question answering (VQA) and inventory tracking benchmarks to assess its accuracy and performance in recognizing brands, counting stock, and providing real-time analytics. The system's object detection model achieved an impressive 85% accuracy, outperforming many traditional inventory management techniques. Below is a comparison of VyapaarNetra's results against widely recognized VQA datasets.

1. VQAv2 (Visual Question Answering): VQAv2 is a dataset designed for testing AI's ability to understand images and answer textual queries about them. It includes real-world scenarios where an AI model must recognize objects and answer diverse questions. VyapaarNetra demonstrated an accuracy of 80.3% on this dataset, showing its ability to interpret inventory-related queries accurately.
2. GQA (Grouped-Query Attention): GQA focuses on reasoning over multiple visual elements in an image to answer structured questions. VyapaarNetra achieved 64.3% accuracy on this dataset, highlighting its capability to handle multi-object inventory queries, though improvements in fine-grained recognition are possible.
3. TextVQA (Text-based Visual Question Answering): TextVQA assesses an AI model's ability to

read and interpret text from images. Since many inventory items have text-based packaging, VyapaarNetra's performance on this dataset was critical. The system achieved an accuracy of 65.2%, confirming its ability to extract textual data from product labels and signage.

4. TallyQA (Counting-based Visual Question Answering): TallyQA is focused on answering counting-related questions based on images, making it particularly relevant to inventory tracking applications. VyapaarNetra achieved 82.6% accuracy on simple counting tasks and 77.6% accuracy on full counting queries, demonstrating its ability to accurately quantify stock levels in real time.

4.1 Experimental Observations

VyapaarNetra significantly improved inventory management efficiency by providing real-time stock updates, reducing reliance on manual counting methods, and automating stock tracking with high precision. The system successfully minimized human intervention, reduced stock discrepancies by up to 40%, and optimized warehouse space utilization by categorizing inventory based on demand patterns. The system's capability to analyze historical data and provide actionable insights led to better procurement planning, ultimately enhancing supply chain efficiency. Businesses reported reduced inventory discrepancies, optimized restocking schedules, and improved response times for supply chain decisions. The system also demonstrated strong adaptability to different industry environments, successfully recognizing diverse product categories with high accuracy.

5. Conclusion

VyapaarNetra represents a transformative advancement in AI-powered inventory management by integrating cutting-edge computer vision, deep learning, and natural language processing techniques. The system effectively bridges the gap between traditional inventory management methods and modern AI-driven solutions by providing real-time stock monitoring, automated product recognition, and intelligent inventory forecasting. Through its robust object detection capabilities, multimodal interaction framework, and predictive analytics, VyapaarNetra enhances operational efficiency, minimizes human intervention, and significantly reduces inventory discrepancies.

Future developments will focus on improving model generalization, extending the system's adaptability to diverse inventory environments, and enhancing multilingual capabilities to serve a global user base. By continuing to refine its AI algorithms and integrating emerging technologies, VyapaarNetra aims to redefine the landscape of automated inventory management, empowering businesses to make data-driven decisions with unparalleled accuracy and efficiency.

VyapaarNetra offers a scalable and cost-effective inventory management solution. While existing inventory systems require manual input or barcode-based scanning, VyapaarNetra's AI-driven approach automates this process, significantly improving efficiency. Challenges include improving detection accuracy in low-light environments and adapting to dynamic product packaging variations. Future enhancements include fine-tuning AI models for improved brand differentiation and integrating IoT sensors for better stock level predictions.

References

1. P. M. C. Duarte, “Recognition and classification: The use of computervision in the retail industry,” Master’s thesis, Universidade NOVA de Lisboa, Portugal, 2019.
2. N. Dhaliwal, P. K. Tomar, A. Joshi, G. S. Reddy, A. Hussein, and M.B. Alazzam, “A detailed analysis of the use of AI in inventory management for technically better management,” in Proc. 2023 3rd Int.Conf. Adv. Comput. Innovative Technol. Eng. (ICACITE), 2023, pp.197–201.
3. N. Shobhana, “AI-powered supply chains towards greater efficiency,” in Complex AI Dynamics and Interactions in Management, IGI Global,2024, pp. 229–249.
4. P. Veres, “Increasing the efficiency of warehouse analysis using artificial intelligence,” Acta Logistica, vol. 10, no. 3, pp. 1–10, 2023.M. C. Si, Y. H. Ding, X. Ma, P. H. Xue, J. B. Huang, and Y. J. Ma,“Visual management system of intelligent factory tools based on Odoo,” in Proc. 2021 4th Int. Conf. Adv. Electron. Mater., Comput.Softw. Eng. (AEMCSE), Changsha, China, 2021, pp. 938–941.
5. S. N. Kumar and K. B. Ramesh, “Developing real-time inventory status system using LabVIEW,” in Proc. 2024 8th Int. Conf. Comput. Syst.Inf. Technol. Sustain. Solutions (CSITSS), Bengaluru, India, 2024.
6. G. Li et al., “Research and application of inventory system based onvisual recognition,” in Proc. 2023 9th Annu. Int. Conf. Netw. Inf. Syst.Comput. (ICNISC), Wuhan, China, 2023, pp. 238–242
7. C. K. Meng and Y. Away, “Visual inventory inspection using optical character recognition,” in Proc. Int. Conf. Comput. Graph., ImagingVis. (CGIV 2004), Penang, Malaysia, 2004, pp. 89–92.
8. J. Wang, P. Li, L. Luo, and H. Sun, “Design and development of intelligent inventory system for small and micro enterprise warehousing,” in Proc. 2023 4th Int. Conf. Comput., Big Data Artif.Intell. (ICCBD+AI), Guiyang, China, 2023, pp. 281–28.
9. S. Winardi, N. P. Wong, Arifin, A. Halim, and S. Megawan,“Enhancing warehouse inventory management through IoT tools for monitoring stock items,” in Proc. 2024 2nd Int. Conf. Technol. Innov.Its Appl. (ICTIIA), Medan, Indonesia, 2024, pp. 1–6.
10. N. K. Verma, T. Sharma, S. D. Rajurkar and A. Salour, “Object identification for inventory management using convolutional neural network,” 2016 IEEE Applied Imagery Pattern Recognition Workshop(AIPR), Washington, DC, USA, 2016, pp. 1-6.