

ENHANCING RETAIL OPERATIONS THROUGH COMPUTER VISION

Zhitnikova D.S., Zaitseva S.V.

Belarusian State University of Informatics and Radioelectronics, Minsk, Republic of Belarus

Goncharova I.V. – Lecturer at the Department of Foreign Languages

Annotation. This article discusses the application of computer vision in modern retail, focusing on automated shelf monitoring, queue management, customer traffic analysis, and checkout-less stores like Amazon Go. The study shows how these technologies detect empty shelves, ensure compliance with planograms and optimize the layout of stores. By processing visual data locally and sending only anonymous statistics, computer vision systems solve privacy issues. The findings suggest that retailers implementing these solutions gain a competitive advantage by reducing waste, increasing customer loyalty, and optimizing store layouts based on data.

Keywords: computer vision, retail, AI in retail, planogram compliance, IoT, queue management, heat maps, edge computing, retail automation

Introduction. Retail is a dynamic and growing industry that is facing some changes due to the development of artificial intelligence (AI). Retailers collect and process large data sets, such as sales records, data lists, and customer reviews. With advanced technology, retailers can gain valuable insights into buyer behavior, improve inventory management, and improve service levels. These technological changes contribute to the adoption of computer vision, which can take retail to the next level.

Main part. Computer vision (CV) is a general term that refers to sections of machine learning models whose purpose is to extract information from Visual Media. Currently, 44% of retailers use CV to improve customer service. By 2030, this industry is expected to grow by 45%. Computer vision's capabilities are transforming various types of retail operations, from logistics to advertising [1].

In retail, computer vision helps retailers see what is currently happening on the trading floor. The system receives data in real time, and the program analyzes it, for example, identifying where there are long queues at the checkouts, where there are empty shelves, or which goods are most in demand. In this process, none of the customers notices that they are being watched, that is, the introduction of this technology does not prevent anyone from walking and choosing goods, but at the same time the store receives a lot of useful information.

One of the main reasons for the loss of profits in retail is the lack of goods on the shelf at the moment when the customer is ready to buy them. The usual methods of inspection, in which an employee goes around the hall with the form and manually checks the presence of the goods, are time-consuming, which is inefficient. CV technology can automate this process by constantly monitoring the shelves and comparing them with digital planograms-display diagrams of goods. Using in-store cameras that are installed on the ceiling or shelves, CV models detect empty spaces on the shelves, incorrect distribution of goods, or missing tags, comparing the current layout with the original planogram.

If the cameras detect inconsistencies, the system automatically sends a notification to the staff about this error, indicating a specific government and the place where the product is located [2]. In addition, the system can analyze how competently the product is laid out on the shelves, taking into account the demand of customers. That is, popular and promotional goods should not be on the bottom shelf or in the far corner of the store, it is recommended to place them in a more passable place at eye level, and less popular ones can be placed higher or lower.

The integration of computer vision with Internet of Things (IoT) technologies opens up new possibilities for automating routine processes in retail.

Robots equipped with computer vision systems are able to perform a large list of tasks related to the maintenance of the store. In addition to automatic cleaning of premises, they can control the temperature regime in refrigerators to prevent spoilage of products, as well as check the compatibility of signs and advertisements based on marketing actions. These robots act as mobile sensors in the IoT system, constantly collecting data about the status of the point of sale. Information from a network

of sensors located throughout the store allows management personnel not only to respond to existing problems, but also to find and prevent potential failures in advance, before they even appear, which will significantly reduce maintenance costs and improve the quality of Service.

One of the biggest irritants for customers in the store is the long wait at the checkout. At the moment, there is already one solution to this problem-self-service cash registers. Thanks to this technology, queues have decreased significantly, but a short circuit allows you to automate the process of purchasing goods even more. Cameras analyze the length of the queue and can notify the administrator in advance about the need to open a new ticket office. It is also possible to predict the time of accumulation of queues. The System collects data and analyzes which days and hours typically have the most buyers. If the program notices that there will be a rush hour in the near future, it asks the administrator in advance to open additional cash registers. But there is also a more radical method.

In Amazon Go there are no cash registers, they have been replaced by CV. After entering the store, the customer scans the application, and then can take goods from the shelves, which are added to the virtual basket associated with the account. After leaving the store, the system automatically withdraws money from the card and sends a check to the email. This store has a system installed that uses computer vision, weight sensors on the shelves and deep learning algorithms. This means that the ceiling cameras and sensors on the shelves determine what you have taken or put away [3]. In shops there are no basic cash registers and sellers, there are only employees who help to check documents for alcohol and take care of order. Thus, going shopping turns into a quick and pleasant process, in which you just need to take the goods and put them in the basket.

Technology is able not only to capture specific problems, but also to analyze buyer behavior. This can be achieved through motion analysis and heat maps. Analysis of the flow of buyers, which is obtained using artificial intelligence, helps sellers understand how many customers visit the store and how they move in it. With sensors, cameras and advanced technologies such as short-circuit and machine learning, buyer flow analysis tracks customers' travel paths, the products they choose and the time they spend in different departments of the floor.

This technology provides detailed heat maps that indicate areas with high traffic, allowing retailers to calculate the location of hot and dead zones in the store layout. Where exactly the main paths that buyers follow are immediately visible: hot zones are highlighted in red, orange and yellow, and dead zones in blue. Knowing the location of these zones, sales managers will be able to competently arrange new stands with stock goods. Thanks to this, employees will be able to see where to move the goods, if necessary, so that they are most in demand.

Of course, privacy is an important issue, many customers are worried about this problem. People are afraid that cameras will monitor every step.

But modern CV systems use edge computing technology, that is, processing takes place directly in the camera, and then only the digital data goes to the cloud or server: how many people have passed, where they stopped, which shelves are empty. Personal data of customers shall remain confidential [4].

Conclusion. Computer vision is rapidly transforming the retail industry, enabling companies to reduce losses, increase customer loyalty and streamline the layout of showrooms based on Heat map data. However, with new technological advances, retailers need to master new areas of data privacy and technology investment. By understanding and solving these problems, merchants can harness the power of advanced technology, creating the basis for more efficient and customer-oriented work in the future.

References

1. *Computer vision in 2024: Main tasks and directions*. Mode of access: <https://habr.com/ru/companies/otus/articles/810207/>. Date of access: 27.02.2026.
2. Mirgorodskaya, O. N., Ivanchenko, O. V. *The use of artificial intelligence technologies in the marketing activities of foreign and Russian retail companies* // *Bulletin of the Russian State Economic University (RINH)*. – 2021. – № 3 (75). – Pp. 84-93.
3. *Artificial intelligence: how AI is changing retail* [Electronic resource]. Mode of access: <https://masterokk.ru/iskusstvennyjintellekt/kak-iskusstvennyj-intellekt-menyaet-roznichnyu-torgovlyu.html>. Date of access: 13.02.2026.
4. *AI Flying Off the Shelves: Restocking Robot Rolls Out to Hundreds of Japanese Convenience Stores*. Mode of access: <https://blogs.nvidia.com/blog/telexistence-convenience-store-robotics/>. Date of access: 26.01.2026.