Intelligence at the Edge: Unleashing the Power of AI in the Retail Industry

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The retail industry is undergoing a transformative shift, driven by the convergence of artificial intelligence (AI), edge computing, and data fusion (or multimodal AI), collectively referred to as edge intelligence (EI). Many major retailers are now adopting EI solutions for applications such as self-checkout systems, inventory optimization, and in-store customer engagement.

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- **EI offers organizations cost-saving opportunities and a competitive advantage through improved customer experience.** EI's benefits for the retail industry include real-time data processing, bandwidth savings, and context awareness. Because data are processed locally, EI also provides increased privacy and data security.
- **At the storefront level, EI has the potential to improve operational efficiency and prevent loss**. EI can enhance self-checkout systems by integrating multimodal technologies for advanced theft prevention and can improve inventory management through real-time, accurate predictions.

Glossary of Terms

Edge computing refers to a technology that processes information closer to where it's generated (like on a factory floor or in a retail store) rather than sending it all the way to a central data center, making things faster and more efficient.

Edge intelligence (EI) refers to the combination of AI and edge computing (i.e., the process of running AI algorithms locally on a hardware device rather than in a

centralized cloud-based server). The algorithms process data generated by the device itself, allowing for real-time processing and decision-making without the need for an internet connection. EI allows for low-latency, context-aware, privacy-sensitive solutions.

Data fusion is the process of combining information from multiple sources, such as sales data, customer feedback, and market trends, to create a more comprehensive understanding of a product's performance. For example, a retail company might use data fusion to blend online shopping behavior with in-store purchases and customer service interactions, providing a complete picture that helps in tailoring marketing strategies and improving customer experience.

> » *[EI] matters because it allows retailers to get more value from their data, faster. It saves on data streaming costs. And combined with 5G connectivity, it provides much lower latency and speedier data transfers. It can increase resilience against network outages, and it gives retailers more control over where their data is processed. Together, these capabilities unlock the real-time interactions and split-second automation that will be at the heart of future in-store shopping experiences. When retail infrastructure resides on the edge, the business can capture all the activity that's happening in the store in the moment—and respond immediately.*
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> - Gautham Reddy, Managing Director & Global Retail Technology Lead, Accenture

Edge Intelligence Adoption in Retail

EI is significantly improving business decision-making, increasing efficiency, and leading to sustainable long-term growth in the retail sector. It is capable of noticing inventory levels, detecting customer habits and behavior in the store, personalizing shopping experiences, enabling faster payment transactions, forecasting demand, managing inventory, detecting fraud, optimizing pricing, and implementing visual recognition and augmented reality. [1]

EI-powered personalization uses machine learning algorithms to analyze customer data and provide tailored recommendations and promotions.[2]

Among the benefits of EI in retail are:[3]

- **Lower latency and faster processing** By processing data locally on edge devices rather than sending them to the cloud, EI reduces network latency, allowing for real-time data analysis and faster response times. This capability is useful in retail for

inventory management, security monitoring, and personalized promotions.

- **Reduced costs** EI reduces bandwidth usage and reliance on the cloud, lowering costs associated with data transfer and cloud services. Retailers only pay for edge capacity.
- **Enhanced security and privacy** Sensitive customer data can be processed and stored locally on edge devices rather than transmitted to the cloud, enhancing data privacy and reducing risks.
- **Operational resilience** EI allows retail operations to continue even with intermittent cloud connectivity. Stores can still provide customized services using localized data.
- **New in-store experiences** With EI, retailers can provide immersive augmented and virtual reality experiences that combine localized data with cloud-based data, enabling advanced personalized promotions and services.
- **Improved customer experiences** By offering real-time localized insights, EI allows retailers to tailor recommendations, promotions, and services to each customer for a more personalized experience.

EI in Self-Checkout Systems

The retail industry has seen a rapid evolution of self-checkout systems over the past decade. Machine learning has become a critical component of loss prevention in self-checkout technology, allowing retailers to predict patterns, identify obstacles in checkout, and understand how theft occurs.

Adding multimodal technologies into the mix can bring theft prevention to the next level by:

- Linking video data to point-of-sale transactions;
- Using RFID to track products;
- Offering in-store heat maps to map emotions onto the body with colors or see the most heavily trafficked areas of the store to count customers, identify popular products, and track patterns, and;
- Reading license plates.

EI systems in self-checkout kiosks can detect anomalies in a customer checkout, flag suspicious transactions, and alert staff to suspected shoplifting in progress.[4]

EI in Retail Inventory Management

Smart shelves can monitor inventory levels in real time, automatically alerting staff when restocking is needed. This monitoring can significantly improve operational efficiency and customer satisfaction. [5]

EI takes predictive analytics, typically used for smart shelves management, to the next

level by enabling more complex and accurate predictions right at the edge. EI algorithms can analyze vast amounts of data from multiple sources in real time, identifying patterns and trends that humans might miss. These algorithms run on devices such as sensors and cameras deployed in the store, rather than relying on the cloud, resulting in extremely fast analysis and response times.

By processing data at the edge, EI can help retailers predict demand more accurately and respond more quickly, ensuring they have the optimal products in the right quantities at the right time. Moreover, as EI algorithms gain more data over time, they can continuously improve demand forecasting, inventory planning, and other operations through self-learning. Overall, EI gives retailers an intelligent, real-time edge in inventory optimization.

EI and In-Store Customer Engagement

EI is transforming in-store customer experience in retail. Customer Service Kiosk with NVIDIA Omniverse ACE for Project Tokkio (video) shows how EI performs. Customers interact with an EI-powered “talking kiosk” using vision and sound sensors to detect emotions, a state-of-the-art language model for understanding intent, and an AI engine to make meaningful recommendations. The 3D avatar is animated and visualized with NVIDIA Omniverse to deliver a visually stunning experience—all in real time.

By deploying edge devices like smart mirrors and interactive displays, retailers can enable personalized, real-time interactions right at the shelf. Interactive displays can showcase customized product information and promotions based on customer data and profile. This EI-powered approach delivers targeted, customized service through in-store tech, elevating engagement during the physical shopping journey. With EI, retailers can provide the personalized, instantaneous support that today’s consumers expect, driving satisfaction and sales. The EI retail revolution is creating next-gen, hyperpersonalized customer experiences that were impossible just a few years ago. [6]

Conclusion

The convergence of AI and edge computing is revolutionizing the retail industry, offering unprecedented opportunities for innovation, efficiency, and customer engagement. By harnessing these technologies, retailers can stay competitive, meet the changing needs and preferences of their customers, and drive sustainable growth.

Privacy Concerns and Legal Compliance

The integration of various technologies like machine learning, multimodal technologies, and edge intelligence systems in self-checkout kiosks in the retail industry brings about several privacy concerns and legal compliance issues:

1. **Personal data collection**: Linking video data to point-of-sale transactions, using

RFID to track products, and employing license plate readers involve collecting personal and identifiable information, raising concerns about how these data are stored, used, and shared. This information collection must comply with privacy laws like General Data Protection Regulation or California Consumer Privacy Act.

2. **Consent**: If customers are monitored through video or other tracking technologies, there may be legal requirements to inform them and obtain their consent. These requirements may include clear signage or notifications about the surveillance.
3. **Emotion mapping**: In-store heat maps that map emotions onto the body with colors might be seen as intrusive or overly invasive, potentially raising ethical concerns and requiring careful consideration of privacy rights.
4. **Security**: With the collection of sensitive data, there must be robust security measures in place to prevent unauthorized access or breaches, complying with data protection regulations.
5. **Bias and discrimination**: Machine learning models used for loss prevention must be carefully designed and tested to avoid biases that could lead to unfair targeting or discrimination against certain groups of customers.
6. **Transparency and accountability**: Retailers must be transparent about how these technologies are used and have clear policies and procedures for handling flagged or suspicious transactions. These procedures include training staff on how to appropriately respond and ensuring there are avenues for customers to dispute or question actions taken based on these systems.
7. **Compliance with local laws**: Different jurisdictions may have varying laws and regulations concerning surveillance, data collection, and consumer protection. Retailers must be aware of and comply with these local requirements.

In summary, while these technologies offer significant benefits in terms of efficiency and loss prevention, they also introduce complex privacy and legal challenges. Retailers implementing these systems must carefully consider and address these issues, working closely with legal and compliance experts to ensure they meet all applicable laws and regulations.

Endnotes

[1] Olli-Veikko Möttönen, *AI in Retail: Revolutionizing the Shopping Experience*, Xhockware, May 29 2023.

[2] Conversence, *The Benefits of AI-powered Personalization in Retail*, LinkedIn, March 26, 2023.

[3] Leo Fan, Jon McKim, and Amir Bahmanyari, *Edge Intelligence Trends in the Retail Industry*, Dell Technologies, February 7, 2023.

[4] Lily Lopate, *NRF 2023: How AI Is Helping Retailers with Loss Prevention*, BizTech, January 23, 2023; Loss Prevention Magazine, *How AI Helps Retailers Manage Self-Checkout Accuracy and Loss*, September 28, 2021.

[5] Marcin Frackiewicz, *The Power of Predictive Analytics: AI in Retail Inventory Management*, TS2 Space, July 19, 2023.

[6] Nextech, *AI in Retail Industry: Revolutionizing Customer Experiences*, June 13, 2023.

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