Milesight

People Sensing: The Data Engine Powering the Next Era of Physical Retail

Make Sensing Matter

CONTENTS

INTRODUCTION

The global retail industry is at a pivotal transformation point. As consumer expectations evolve and digital competition intensifies, physical retail is shifting from a traditional transaction space into an intelligent, data-driven environment centered on experience and efficiency. This strategic evolution is powered by the integration of Artificial Intelligence (AI), the Internet of Things (IoT), and advanced sensing technologies—together giving rise to the era of Smart Retail.

This white paper explores how people sensing technology serves as the critical enabler of this shift. By transforming anonymous foot traffic into rich, actionable insights, retailers can now bridge the data gap with e-commerce, optimize operations in real time, and deliver personalized customer experiences that drive loyalty and growth.

Designed for retail leaders and technology strategists, this document examines:

- The growing role of AI and IoT in redefining physical retail.
- How people counting solutions provide the essential data layer for smart stores.
- Practical applications of customer analytics across site selection, operations, merchandising, and marketing.
- The tangible business value unlocked through enhanced customer satisfaction and operational intelligence.

For those invested in the future of retail, this report offers a focused overview of the technologies and strategies shaping the next generation of intelligent storefronts.

ABOUT MILESIGHT

Milesight is dedicated to pioneering intelligent sensing solutions that capture meaningful data and make it accessible across a wide range of applications. By innovatively applying emerging technologies such as AI and IoT, we enable new possibilities in data-driven decision-making and operational efficiency.

Our insight into retail reveals that the future lies in bridging the data-to-experience gap. While e-commerce leverages rich user data for personalization, physical stores have struggled to transform foot traffic into actionable insights.

Our mission is to equip brick-and-mortar retail with sensing intelligence—capturing real-time data on foot traffic、demographics, and behavior—to enable data-driven, continuously optimized customer experiences that increase satisfaction, loyalty, and conversion.

This report embodies our commitment to making sensing matter. We aim to empower retailers with the understanding and tools to turn physical spaces into quantifiable, optimizable assets—shifting from intuition-based to data-informed operations.

1.PHYSICAL RETAIL: AN ENDURING PILLAR OF THE GLOBAL ECONOMY

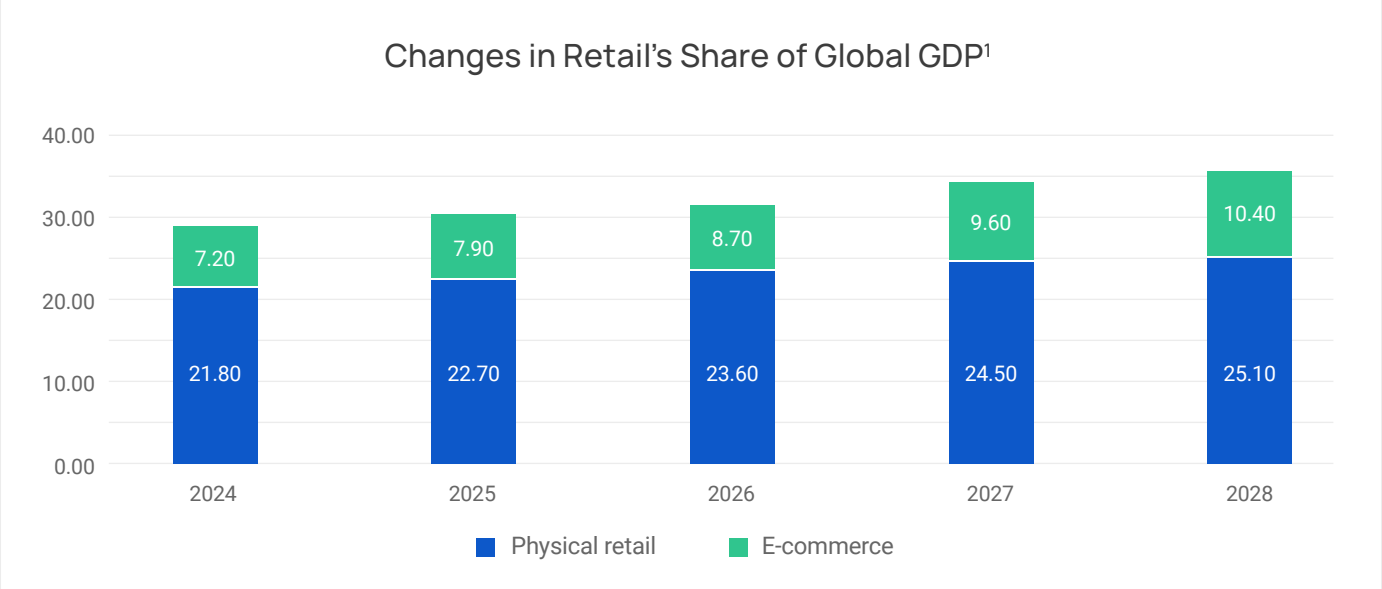
1.1 The Scale of the Retail Market

In 2024, the global retail market reached a scale of approximately $29 trillion USD. Retail holds a crucial position in the global economy, accounting for about 11% of total global GDP, and this proportion continues to rise year by year. From an employment perspective, using the United States as an example, the retail sector supported 55 million full-time and part-time jobs in 2022, representing 26% of total US employment. In 2024, retail accounted for 13.4% of total employment in Europe. According to the "Asia–Pacific Employment and Social Outlook 2022," retail jobs in Asia constituted roughly 12% of total employment.

Simultaneously, projections from the Tech and Media Outlook 2025 indicate that from 2024 to 2028, both physical retail and e-commerce sales globally are expected to show sustained growth. Overall retail sales are forecast to grow at a stable compound annual growth rate (CAGR) of 4.13%. Contrary to the "conspiracy theory" that e-commerce is eroding physical retail, physical stores are projected to maintain a stable 76% share of total retail sales. The reality is that e-commerce has largely activated incremental demand rather than merely cannibalizing the existing physical retail market. Global consumers' preference for online shopping is stabilizing, while the inclination to shop in physical stores is seeing renewed opportunities. Leading e-commerce companies are realizing that integrating online and offline channels is key to success in this new landscape. Amazon has been expanding its physical store footprint, with offline retail sales reaching $21.2 billion by 2024. Similarly, Alibaba has acquired numerous brick-and-mortar stores in China, aiming to leverage their distribution networks and in-store experiences.

Notably, according to a KPMG survey report, 58% of consumers still prefer shopping in physical stores, and 75% state that high-quality in-store service makes them more likely to make a purchase. The ability to see, touch, and feel products in person remains vital, as the shopping environment and sensory experience are integral parts of consumption. Pure online marketing is no longer an entirely effective tool for influencing purchasing decisions. The resurgence of offline, experiential services is now a primary factor shaping consumer psychology, fostering customer loyalty, and maintaining emotional connections with customers.

Globally, there are approximately 46,623,103 retail companies. Among these, the company with the most physical stores worldwide is Seven & i Holdings (e.g., 7-Eleven), operating around 40,000 locations. Within the top 20 retailers by store count, companies from Japan, Germany, and the United States constitute half of the list. The number of these physical stores remains stable, driving the development of physical retail and underscoring its enduring importance.



Estimated value of global retail sales 2024-2028, by sales channel[2]（Unit:in trillion U.S. dollars）

Company	Number
Seven & i	41,128
Oxxo (Femsa)	28,844
FamilyMart	24,464
Lawson	22,038
CP All	18,007
AS Watson	16,098
Carrefour	14,961
Schwarz Group	14,244
Aldi	13,877
Couche-Tard	13,167

Company	Number
Rewe	12,224
Walgreens Boots Alliance	12,134
Aeon	10,927
Walmart	10,692
Ahold Delhaize	8,111
Metro AG	7,181
Jeronimo Martins	6,714
Inditex	5,664
TJX	5,073
Tesco	4,833

Number of Stores of Major Global Retailers (2024)[3]

[1] Mordor Intelligence. "Retail Industry Size & Share Analysis - Growth Trends and Forecast (2025 - 2030)." Mordor Intelligence, 2025, https://www.mordorintelligence.com/industry-reports/retail-industry.

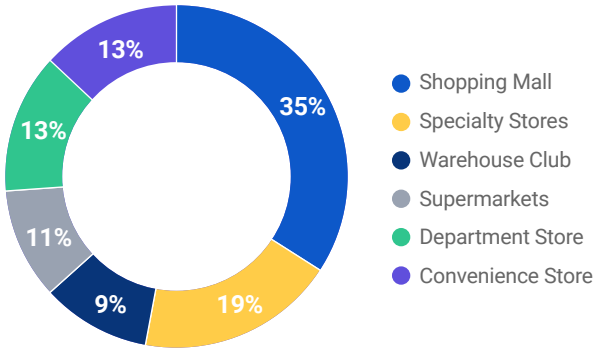
[2] Statista. "Estimated Value of the In-Store and E-Commerce Retail Sales Worldwide from 2024 to 2028 (in Trillion U.S. Dollars)." Statista, 22 Oct. 2024, https://www.statista.com/statistics/1095969/retail-sales-by-channel-worldwide/.

[3] Statista. "World: Number of Stores of the Leading Retailers 2024." Statista, 25 Nov. 2025, https://www.statista.com/statistics/1379330/leading-retailers-by-number-of-stores-worldwide/.

1.2 The Evolution of Traditional Retail Formats and Digital Transformation: The Emergence of Smart Retail

Traditional retail stores can be broadly categorized into six main types: Shopping Malls, Department Stores, Supermarkets, Convenience Stores, Specialty Stores, and Warehouse Clubs. Among these, shopping centers account for the most significant share of revenue.

Digital transformation has introduced new formats to the retail industry. The advancement of digital technologies—such as cloud computing, big data, artificial intelligence, and the Internet of Things—has reshaped traditional retail, propelling it into the "Smart Retail" phase and enabling a second wave of growth.



The Core Business of Retail and the Forms of Smart Retail

Traditional Retail

- Shopping Mall: Retail entertainment hubs
- Department Store: Everything Under One Roof
- Supermarket & Grocery Store: High-frequency daily necessities
- Convenience Store: Ready-to-eat food, emergency products, and convenience services
- Specialty stores & Franchised Store: Single category but Professional
- Warehouse Club: Membership&Warehouse-style Display

Digitalization

New Retail Formats

- Online Retail: E-commerce
- Smart Retail: AI,IOT Embeded

2.THE RAPID GROWTH OF SMART RETAIL: AI AND IOT AS LEADING TECHNOLOGIES

The development of digital technology has spurred the emergence and growth of e-commerce, forming a "dual-engine" force alongside physical retail to drive the advancement of the retail industry. Meanwhile, the development and integration of digital technologies such as AI, the Internet of Things, and big data have broken the limitations of traditional brick-and-mortar retail — which was often experience-driven, inefficient, and monotonous." This has given rise to a new form of physical retail with core features such as "data-driven operations, intelligent optimization of experiences, and end-to-end collaboration"—known as smart physical retail. Today, the evolution of retail is inseparable from smart retail. According to publicly available market data, the global market size of smart retail reached approximately $42 billion in 2024, growing at a market growth rate of 25.2%. As reported by Deloitte in the 2025 Global Powers of Retailing report[4], global retail spending on information technology is expected to grow by 7.3%, exceeding $240 billion by 2026.

Institution	Market Size (Year2024BillionUSD)	Market Growth Rate (2025~2033)
Grand View Research[5]	43.13	30.3%
The Business Research Company[6]	54.5	24.5%
Zion Market Research[7]	38.26	21%
Verified Market Research[8]	43.32	28.20%
Market.us Scoop[9]	31.2	25.4%
Mordor Intelligence[10]	43.05	21.8%

[4] Deloitte. "Deloitte Releases Global Powers of Retailing 2025 Report." Deloitte, 13 June 2025, https://www.deloitte.com/cn/zh/Industries/retail/research/global-powers-of-retailing-2025.html.

[5] Grand View Research. "Smart Retail Market Size, Share & Trends Report, 2025–2033." Grand View Research, 2024, https://www.grandviewresearch.com/industry-analysis/smart-retail-market.

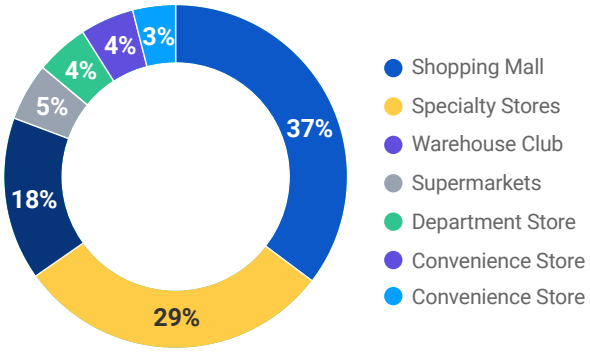
[6] The Business Research Company. "Smart Retail Market Report 2024." The Business Research Company, 10 Oct. 2024, https://www.thebusinessresearchcompany.com/press-releases/smart-retail-market-10102024.

[7] Zion Market Research. "Global Smart Retail Market Size to Surpass USD 212.72 Billion at a CAGR of 21% Growth By 2034." Zion Market Research, 5 May 2025, https://www.zionmarketresearch.com/news/global-smart-retail-market.

[8] Verified Market Research. "Global Smart Retail Market Size and Forecast." Verified Market Research, Nov. 2025, https://www.verifiedmarketresearch.com/product/global-smart-retail-market-size-and-forecast/.

[9] Pangarkar, Tajammul. "Smart Retail Market Worth USD 300.0 Billion by 2034." Market.us Scoop, Market.us, 15 Oct. 2025, https://scoop.market.us/smart-retail-market-news/.

[10] Mordor Intelligence. "Smart Retail Market Size & Share Analysis – Growth Trends And Forecast (2025 – 2030)." Mordor Intelligence, 2025 https://www.mordorintelligence.com/industry-reports/smart-retail-market.



Smart retail market size by regions[11]

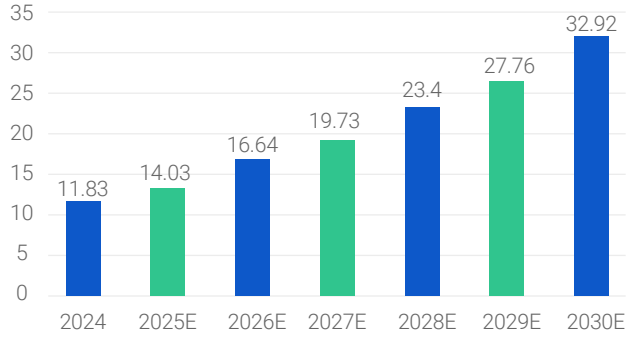
According to geographical segmentation, North America holds an absolute advantage as the world's largest regional market for smart retail. This is attributed to the mature digital infrastructure of North America's retail sector, including the advanced deployment by leading large-scale retailers such as Walmart and their strong technological R&D capabilities (e.g., the deep application of AI and IoT in retail scenarios). The Asia-Pacific region follows closely behind North America, accounting for nearly 30% of the market share.

2.1 Technical Choices for Smart Retail

AI: Reshaping Retail with Data and Intelligence

Among all the technologies enabling smart retail, AI and IoT are the most prominent. According to Gartner's 2024 survey of retail executives, budgets for AI in the retail sector are set to increase by 33%. In 2024, the global AI in retail market was valued at $11.83 billion and is growing at a compound annual growth rate (CAGR) of 18.14%, as reported by Precedence Research, with innovations like computer vision and other technologies becoming increasingly common in physical stores. The retail industry has entered an era of stock competition, characterized by a more complex market environment where traditional growth models struggle to keep pace. So in such a business context, AI is opening up a new pathway for growth. Another compelling statistic from Statista further highlights this trend.[12]

Retail stores using AI have achieved both sales and profit growth at twice the rate of those not using it. From an industry development perspective, the depth of AI/ML adoption will determine the competitive gap in retail.

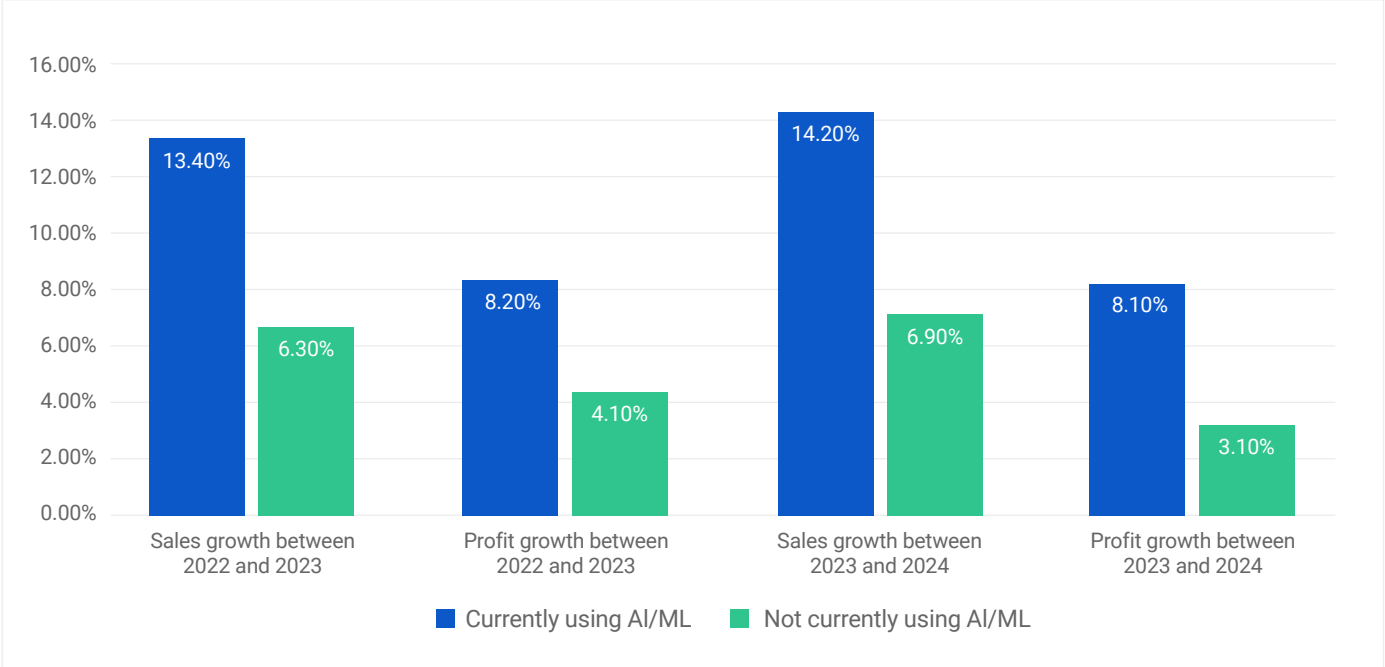


Artificial Intelligence in Retail Market Size 2024 to 2030[13]
(Unit: USD Billion)

[11] The Business Research Company. "Global Smart Retail Market: 2024 to Reach $143.36 Billion by 2028 at Rate of 26.8%." The Business Research Company, Oct. 2024, https://www.thebusinessresearchcompany.com/press-releases/smart-retail-market-10102024.

[12] Statista Research Department. "Impact of AI and ML Use on Retail Performance 2022-2024." Statista, 19 Nov. 2025, https://www.statista.com/statistics/1453198/ai-and-ml-impact-on-retail-performance/.

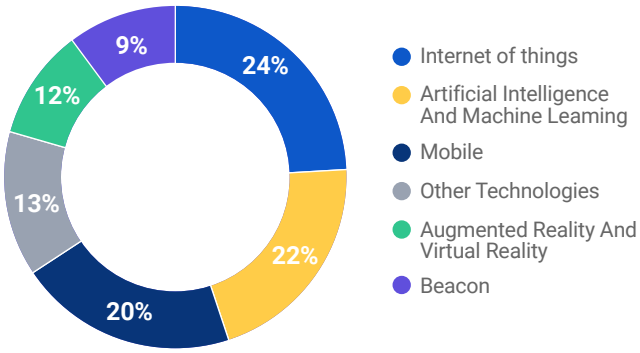
[13] Precedence Research. "Artificial Intelligence in Retail Market Advancements in Smart Retail Solutions." Precedence Research, 30 Jun. 2025, https://www.precedenceresearch.com/artificial-intelligence-in-retail-market



Impact of artificial intelligence (AI) and machine learning (ML) use on retail performance between 2022 and 2024

IoT: The Data Backbone of Smart Retail

Another area that has garnered significant attention from retailers is IoT devices. The operation of AI is inseparable from data collection, and IoT serves as a crucial carrier for gathering data. In the smart retail sector, the hardware domain leads the market and is projected to account for 64.5% of the smart retail market share by 2024[14]. When broken down by technology, IoT holds the leading position in terms of technical revenue share within the smart retail sector, accounting for one-quarter of the entire market. Similarly, we can see that AI represents the second-largest technology market.[15]



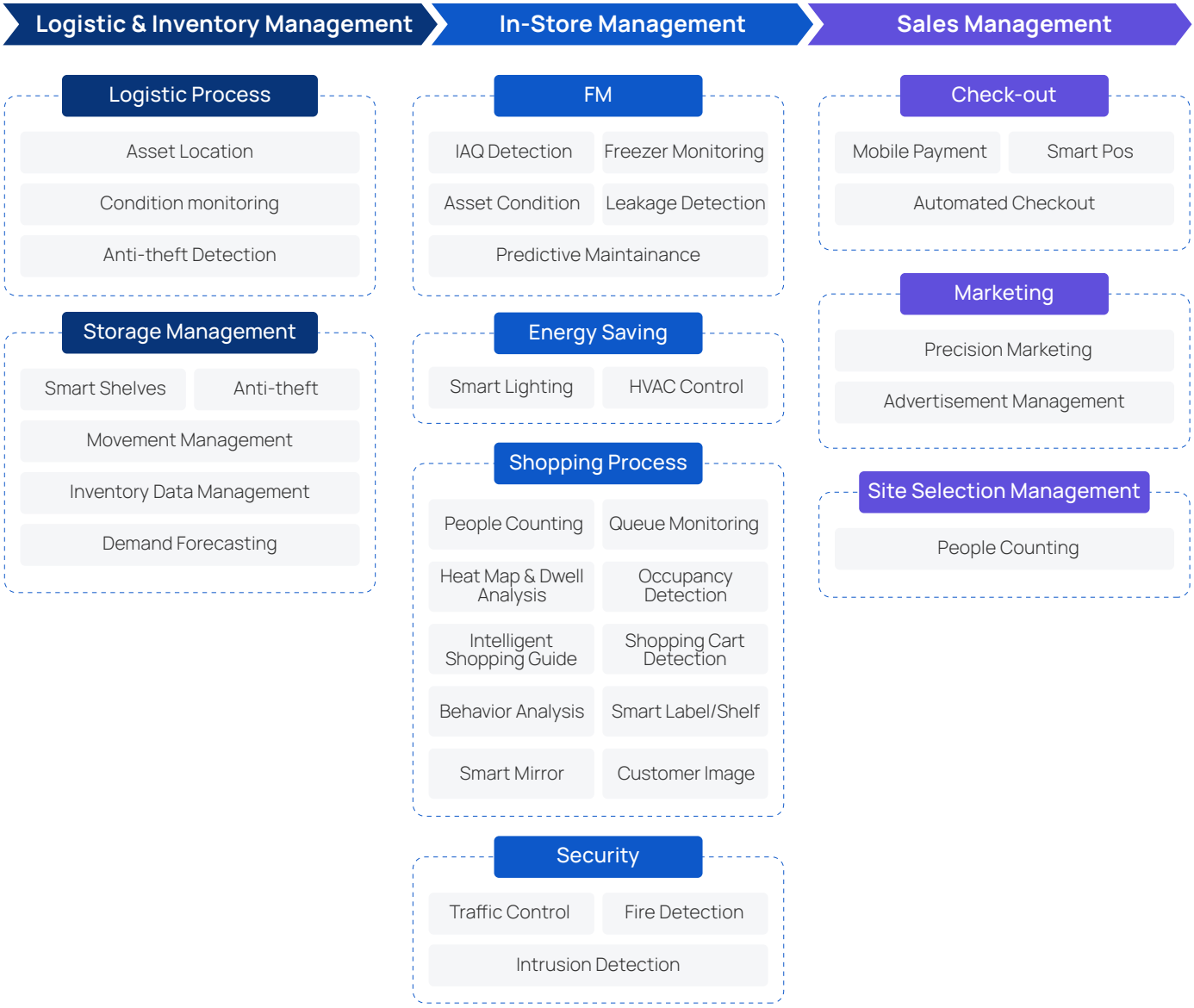
Proportion of the smart retail market segmented by technology

[14] Grand View Research. "Smart Retail Market (2025 - 2033): Size, Share & Trends Analysis Report By Solution (Hardware, Software), By Application (Visual Marketing, Smart Label, Smart Payment System), By Region, and Segment Forecasts." Grand View Research, 2025, https://www.grandviewresearch.com/industry-analysis/smart-retail-market

[15] The Business Research Company. Global Smart Retail Market Report 2024. Jan. 2025, The Business Research Company, https://www.thebusinessresearchcompany.com/press-releases/smart-retail-market-10102024

AI and IoT have many applications in the retail sector. Below are the main scenarios where IoT can be applied in retail.

IOT And AI in Retail by Value Chain



What should be the key focus of smart retail at present?

3.THE KEY TO RETAIL GROWTH: UNDERSTANDING CUSTOMERS WITH AI & IOT PEOPLE COUNTING

The traditional retail industry has entered an era of stock competition, with an increasingly complex market environment. Traditional growth strategies are no longer adequate to cope with the new competitive landscape. How can we find a second growth curve for traditional retail?

3.1 The Importance of Customer Satisfaction and Experience

Academic research tracking the relationship between customer satisfaction and corporate financial performance over 40 years indicates that customer satisfaction is positively correlated with both customer-level outcomes (retention, word-of-mouth, spending, and pricing) and company-level outcomes (product market, accounting, and financial market performance). Additionally, as early as 2021, a McKinsey study revealed that 71% of consumers expect retailers to provide personalized engagement and experiences. Furthermore, when this expectation is not met, 76% of consumers report feeling frustrated[16]. PWC conducted a survey which found that globally, 73% of customers consider experience to be an important factor in their purchase decisions, second only to price and product quality[17].

Meanwhile, data indicates that the difference in spending between average retailers and truly customer-centric retailers is worth USD 3.40 trillion to the industry[18]. Consider a straightforward scenario: a customer is unable to locate a desired product within a retail store. If a business lacks a comprehensive understanding of its user profiles, it cannot accurately identify customer needs to fulfill them and ensure satisfaction. Consequently, the ability to deliver personalized experiences and foster meaningful engagement is compromised, resulting in a significant gap between market demand and supply.

Currently, the satisfaction rate for in-store shopping is only around 9%[19]. Retail customers worldwide feel their expectations are not being met[20], which presents a significant revenue growth opportunity for retailers—on the condition that they gain a sufficient understanding of their customers.

[16] Awal, Raman. "How Data Analytics Can Drive Retail Customer Engagement." Retail Customer Experience, 9 May 2025, https://www.retailcustomerexperience.com/blogs/how-data-analytics-can-drive-retail-customer-engagement/.

[17] "Experience Is Everything: Here's How to Get It Right." PwC, 16 May 2025, https://www.pwc.com/us/en/services/consulting/library/consumer-intelligence-series/future-of-customer-experience.html.

[18] Kantar. "CX+ Retail: Aligning Customer Experience and Brand Promise." Kantar, 2025, https://www.kantar.com/uki/Campaigns/CX-Plus/Retail.

[19] Toneguzzi, Mario. "IBM Study Reveals Massive Gap Between Consumer Expectations and Retail Experiences [Interview]." Retail Insider, 15 Jan. 2024, https://retail-insider.com/retail-insider/2024/01/ibm-study-reveals-massive-gap-between-consumer-expectations-and-retail-experiences-interview/.

[20] "Experience Is Everything: Here's How to Get It Right." PwC, 16 May 2025, https://www.pwc.com/us/en/services/consulting/library/consumer-intelligence-series/future-of-customer-experience.html.

3.2 Beyond Needs: How Staff and Environment Drive Consumption

A PwC report similarly indicates that 58% of customers are willing to pay more for better customer service. When delivered an outstanding experience, price sensitivity decreases significantly. When it comes to specific improvements such as convenience, this willingness increases to 70%. For physical retail, an exceptional user experience often goes beyond just "low prices"—it also encompasses efficiency, convenience, a clean and tidy environment, and the quality of staff.

Currently, over 75% of retail customers desire some level of interaction with staff. However, there is a significant mismatch between customer expectations and how employees deliver: only 38% of U.S. consumers report that the staff they interact with understand their needs, while 46% of consumers outside the U.S. share the same sentiment[21]. This highlights the need for employees to better understand customer demands. Furthermore, under crowded conditions, the rate of customers "abandoning their shopping" reaches 38%[22]. Similarly, cleanliness, tidiness, and appropriate temperature and humidity are also crucial.

To achieve coordinated optimization of staff services and the store environment, it is essential to have dynamic control over store operation data.

For example, by monitoring real-time foot traffic data, staff schedules can be properly arranged—preventing employee fatigue that could affect service quality, while also avoiding customer dissatisfaction due to long wait times. This ensures sufficient staffing during peak hours to maintain facility operations and provide professional shopping assistance.

At the same time, based on real-time conditions in different areas and time slots, environmental factors such as temperature and humidity can be adjusted accordingly, preventing customer discomfort due to heat or cold, and guiding dense crowds in a timely manner. When these details are precisely implemented, customers' sense of experience and engagement will naturally improve significantly, thereby driving higher conversion rates.

However, determining what type of environment and staff service are needed still requires physical retail stores to have a sufficient understanding of their customers. A poor shopping experience can drive customers away quickly, leaving no opportunity for the store to make improvements. So, how can we help physical retailers understand their end customers? We need certain information inputs—some form of "data."

[21] "Experience Is Everything: Here's How to Get It Right." PwC, 16 May 2025, https://www.pwc.com/us/en/services/consulting/library/consumer-intelligence-series/future-of-customer-experience.html

[22] Dotson, Michael J., and Dinesh S. Dave. "Enhancing Retail Services: An Empirical Investigation." International Journal of Services and Operations Management, vol. 5, no. 1, 2009, pp. 1-13. Inderscience Online, doi:10.1504/IJSOM.2009.021622.

3.3 Turning Physical Footprints into Data Assets: The Sensor Advantage for Stores

To effectively identify user needs, it's essential to gather specific user characteristics and behavioral data. E-commerce platforms have a distinct advantage in user insight due to the inherent ease of digital data collection. Simple user clicks can reveal basic demographic profiles. More significantly, e-commerce data captures the entire customer journey—from initial reach and browsing to interaction, conversion, and repurchase. This includes granular data points such as:

- Search terms entered by the user.
- Time spent on product pages.
- Cart addition and removal actions.
- Post-purchase reviews and reasons for returns or exchanges (which directly highlight product experience gaps).
- Engagement during live-streamed shopping sessions.

These multi-dimensional data points enable the construction of a comprehensive, dynamic "user demand profile." This approach stands in contrast to the often "flat" or static labels commonly used in traditional brick-and-mortar retail, such as basic demographic segments (e.g., "female, age 30-35"), broad purchase history ("frequent buyer"), or simplistic loyalty tiers ("gold member").

By integrating these static attributes with rich behavioral data, and leveraging AI or predefined analytical models, e-commerce platforms can rapidly gain deep user insights and accurately uncover latent needs.

For traditional retail, customer data collection is largely limited to POS transaction records and basic membership information, which can only reflect past purchasing data. The overall data dimensions are singular and fragmented. More importantly, this data is outdated—it cannot quickly reveal the current store situation or potential consumption trends, nor can it cover the entire customer shopping journey. It is even less capable of supporting precise user demand insights. It seems that traditional retail is inherently at a disadvantage compared to e-commerce, unable to capture and analyze data in real time.

However, brick-and-mortar retail is not content to stop there. It continues to explore ways to capture user data, and advancements in AI and IoT have provided the most effective means for this "data acquisition counteroffensive"—the people counting sensor. Utilizing technologies such as artificial intelligence, ToF, mature PIR, infrared beams, RGB cameras, and radar, these sensors provide real-time foundational data like foot traffic and occupancy for physical stores. More importantly, with advanced AI recognition, they can now capture the kind of static user data and detailed shopping journey breakdowns that were once exclusive to e-commerce—and even richer data dimensions.

Below is a comparison between the types of data that people counting sensors can collect and what e-commerce platforms can gather.

E-Commerce Data Acquisition VS People Counting Empowered Physical Retailing

User Static Characteristic Data

Gender, Age

Shopping Page Browsing

Age Views, Click-through Rate, Dwell Time

Shopping Interaction

Likes, Comments, Shares, Ad Performance

Purchase Conversion

Order Volume, Transaction Amount, Conversion Rate

Repeat Purchase

Repeat Purchase Frequency, Repeat Purchase Rate

User Static Characteristic Data

Gender, Age, Mood, Height, Shopper Group Attributes

Shelf/Store Browsing

People Counting, Dwell Time, Heatmap, Gaze Recognition

Shopping Interaction

Shopping Cart Detection, Facility Utilization Rate, Marketing Performance

Purchase Conversion

Comparison of Conversion Among Store Entry Count, Purchasing Customer Count, and Consumption Amount

Purchase Conversion

Re-ID (Re-identification): Automatically identifying repeat customers and potential VIPs, helping businesses recognize high-value individuals from "anonymous foot traffic."

Through sensor-based AI recognition for crowd counting, physical retail can now capture users' static characteristics—such as age, gender, height, and even mood—data that e-commerce traditionally accessed easily through user registration. Just as webpage browsing mirrors a customer walking through store aisles, physical retail can now effortlessly gather in-store metrics: visitor numbers, dwell time, heatmaps, and even shoppers' gaze direction.

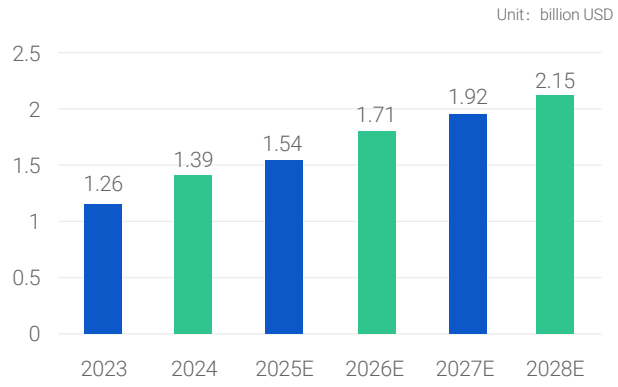
Customer interactions in physical stores are far richer than simple mouse clicks. Crowd-counting sensors can estimate shopping intent by tracking cart load levels, and more importantly, they can monitor facility usage to improve the customer experience—for instance, scheduling restroom cleaning during off-peak hours or opening additional checkout lanes when lines grow too long. Similarly, physical retail can now measure conversion rates—the ratio of store visitors to actual purchasers.

For years, “data scarcity” was a key challenge for traditional retail, but crowd-counting sensors offer a breakthrough, strengthening the foundation for user analytics. Moving forward, deep user insight and precise understanding of customer needs are no longer exclusive advantages of e-commerce. Physical retail, too, can understand its customers better and move toward data-driven, refined operations.

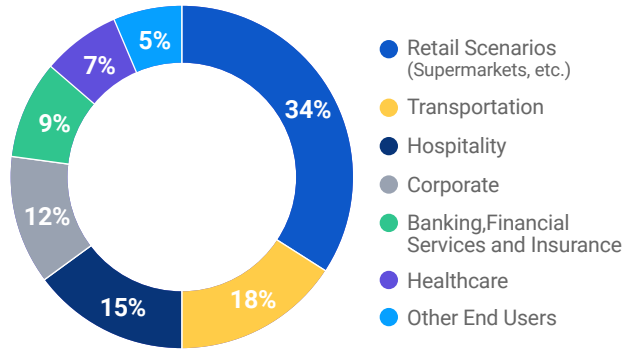
4.RETAIL: THE LARGEST MARKET FOR PEOPLE COUNTING — CAMERA-BASED SENSORS LEAD WITH RICH, PRIVACY-COMPLIANT DATA

4.1 Market Size of People Counting Sensors and Their Application Share in Retail

The current market size of people counting sensors is USD 1.4 billion, with the overall market application reaching maturity. The market is experiencing a growth rate of 11.38%, reflecting a sustained upward trend. Hardware currently dominates the market, accounting for 60% of the total market share. The retail sector stands as the largest and relatively most mature application scenario for people counting sensors, enabling traditional retailers to capture offline data.



Global People Counting Market Size[23]



Market Share of Key Application Scenarios for People Counting[24]

4.2 Development of People Counting Sensor Technologies and Comparison of Typical Technologies

The Initial Attempts with Manpower and Machinery

From the emergence of modern retail settings even up to the present day, you can find staff manually recording foot traffic using pen and paper or mechanical counters. This method was costly and highly error-prone, as the human eye could not accurately judge large crowds.

In the early 20th century, theaters and factories adopted gear-driven mechanical counters, but they could only tally total numbers and could not distinguish entry from exit. This technology was later applied to revolving door mechanisms.

[23] Technavio. *People Counting System Market Analysis, Size, and Forecast 2025-2029: North America (US and Canada), Europe (France, Germany, and UK), APAC (China, India, and Japan), South America (Brazil), and Rest of World (ROW)*. Report No. IRTNTR74188, Technavio, Jul. 2025.

[24] The Business Research Company Sources: National Statistics Offices, UN Comtrade, TBRC Analysis, TBRC Estimates, TBRc Secondary

Early Attempts with Electronic Devices

Infrared Beam Counters: From the 1980s onward, these became mainstream. They use an infrared emitter and receiver on opposite sides of a doorway to form a beam; interruptions trigger a count. Typical detection range is 2.5–6 meters, with accuracy around 60–80%. However, they were prone to errors from multiple people walking side by side or obstructions like shopping carts.

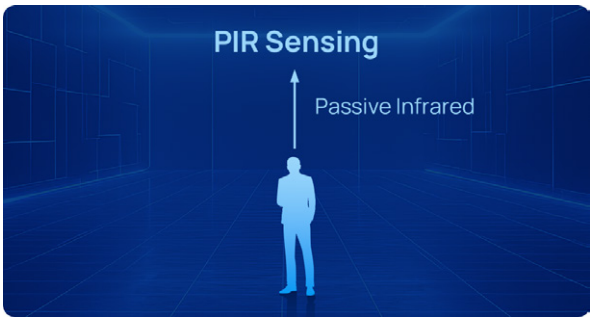
Subsequently, Thermal Sensor Counters: After 2000, these gradually came into use. They employ array sensors to detect body heat and can be mounted overhead (no need for dual-side installation). They perform more reliably than infrared in low-light conditions but still cannot distinguish between humans and high-temperature objects. Overall accuracy remained relatively low, and the data dimension was limited—only the total number of passersby could be known.

These technologies later evolved into PIR sensors, Active Infrared sensors, and Thermopile sensors.

PIR (Passive Infrared)

Principle

Detects changes in infrared heat emitted by human to count people as they pass by.



Pros

- Low cost
- Low power consumption
- 100% anonymous detection
- Effective for basic counting

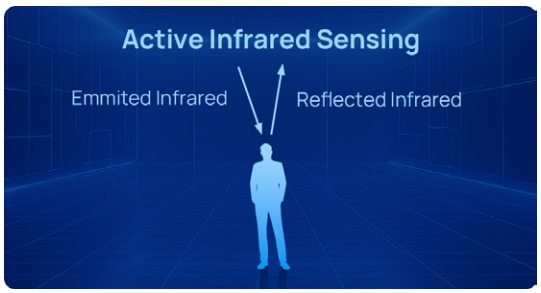
Cons

- Can be interfered with by obstacles or stationary objects
- Can't detect exact numbers in overlapping movements
- Changes in temperature or airflow (like from air conditioning) can cause false readings or reduce accuracy

Active Infrared

Principle

Emits infrared beams from a transmitter to a receiver, and when someone passes through, the beam is interrupted or reflected, registering a count.



Pros

- Higher accuracy than PIR
- Low power consumption
- 100% anonymous detection

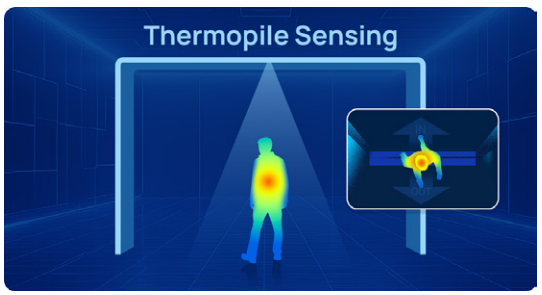
Cons

- Can't detect exact numbers in overlapping movements
- Objects like shopping carts or luggage can trigger false counts
- Can be affected by external factors like ambient light, temperature, and atmospheric conditions

Thermopile

Principle

Detects heat distribution to recognize and count people.



Pros

- Effective in low light or complete darkness
- Can detect stationary people
- Anonymous protection: thermopile imaging doesn't identify individuals

Cons

- Sensitive to temperature changes
- Limited accuracy in large or crowded spaces

Wi-Fi Probe Counting

With the widespread adoption of Wi-Fi, this technology began to be utilized for people counting purposes. Wi-Fi Probe Counting (Wireless Wi-Fi Counters) emerged around 2012, estimating foot traffic by detecting the Wi-Fi signals of mobile devices. This method is suitable for large venues such as exhibition halls and transportation hubs. However, its accuracy is affected by users turning off their Wi-Fi and by signal interference, with precision typically ranging between 75% and 85%. In addition to basic headcounts, this approach can provide data on area density, but it still lacks the granularity to track individuals with precision.

IP Camera (IPC) Based Counting

With the advancement of camera technology, IP cameras (IPCs) are no longer limited to security surveillance. By integrating advanced backend software algorithms such as machine learning, and distinguishing individuals through head and shoulder recognition, the accuracy of people counting has improved to 85%. This approach also enables richer recognition logic and more diverse data dimensions, such as customer gender, height, and user characteristics, as well as foot traffic direction.

However, IPCs face a significant issue: privacy concerns. IPCs capture and store clear images of individuals, often focusing on their faces for security purposes, requiring additional steps to blur or anonymize the data. This method of people counting struggles to comply with regulations like the GDPR[25]. And there is another issue: IPCs were not originally designed for people counting. From a security perspective, they are typically installed at an angle, which can cause partial obstruction during recognition and reduce accuracy. To cover wider entrances, multiple cameras need to be installed at different angles, further increasing the cost of the CCTV solution. It is undeniable that certain customer behaviors can be captured by IPCs. However, during their design, compatibility with other retail systems—such as POS machines and CRM systems—was not considered. Based on these limitations, dedicated People Counting sensors have been developed.

Privacy-compliant People Counting Sensors

Dedicated people counting sensors, enhanced with AI, can be categorized into three main types: 2D Vision (single-camera with image retention), Binocular Vision (dual-camera), and the innovative Time-of-Flight (ToF) technology (camera-free solution). All three technologies offer higher accuracy in people counting compared to traditional CCTV systems, while providing richer customer data details under privacy protection standards such as GDPR.

First, from a privacy perspective, monocular and binocular people counting sensors process the captured image data locally without transmitting any images. Through AI analysis, they can still identify important data while maintaining a high level of privacy. Additionally, the footage captured by these sensors is blurred, and only processed images are displayed in the backend.

Dedicated ToF Counting Sensors

In contrast, ToF (Time-of-Flight) technology does not use cameras. It determines the distance to an object by measuring the time it takes for light to travel[26], which inherently ensures privacy protection. ToF image sensors can also capture information in the Z direction,

[25] Wolford, Ben. "What is GDPR, the EU's New Data Protection Law?" GDPR.EU, Proton AG, https://gdpr.eu/what-is-gdpr/.

[26] "Time of Flight." Analog Devices, Analog Devices, Inc., 2025, https://www.analog.com/en/resources/glossary/time-of-flight.html.

enabling 3D sensing. 3D sensing makes it possible to identify objects that are difficult to distinguish with traditional 2D images.

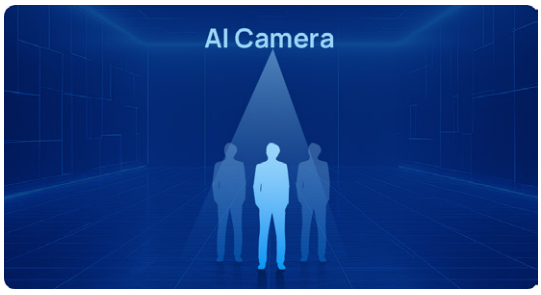
From an accuracy perspective, dedicated people counting sensors are installed vertically, providing a top-down view. This significantly reduces obstacles and ensures a clear, unobstructed view of the counting area. Additionally, these specialized sensors only need to identify people and related elements, simplifying the overall recognition task and improving accuracy. Under normal environmental conditions, binocular cameras achieve the highest algorithmic precision. However, in environments with strong lighting, camera-free solutions such as ToF (Time-of-Flight) offer greater accuracy in people counting, though the richness of customer attributes provided by monocular cameras and ToF is significantly less than what binocular sensors can deliver.

In terms of functionality, all three types of people counting sensors can accurately count people, as well as distinguish between adults and children based on height, perform zonal footfall counting, employee recognition, generate heatmaps, measure dwell time, detect shopping cart fullness, and capture other static and dynamic customer journey data. Binocular people counting sensors, which employ active stereoscopic vision technology to mimic human sight, work in tandem with AI akin to the human brain to process combined images and create depth maps. This gives them a natural advantage in capturing richer customer attributes. Beyond the functions mentioned above, they can also provide personalized "information" such as gender, facial expression, gaze tracking, age estimation, and VIP recognition.

2D Vision (AI Cameras)

Principle

Uses one camera to captures video footage and uses AI algorithms to analyze the number of people



Pros

- Uses machine learning algorithms to accurately identify and count individuals
- Differentiates between humans and other objects
- Adaptive learning: learn from data and improve their accuracy over time

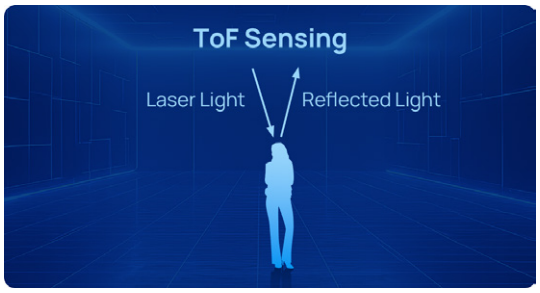
Cons

- Struggles in extreme lighting conditions (e.g., glare, low light)
- Privacy concerns: captures images and videos, raising GDPR compliance issues.
- Excessive power consumption makes battery operation impractical.

ToF (Time of Flight)

Principle

Measures the time it takes for light to travel from the sensor to human body and back to calculate distance and detect presence.



Pros

- High accuracy in low lighting conditions even in darkness
- Anonymous protection: ToF sensing doesn't identify individuals
- Can accurately distinguish individuals in groups

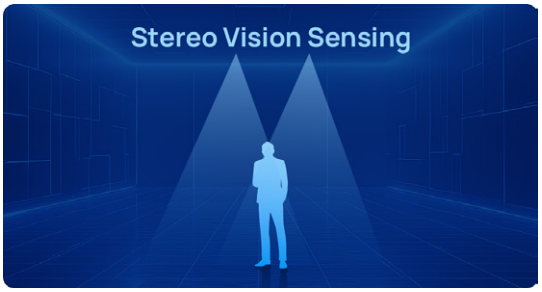
Cons

- Can be affected by reflective surfaces
- Can be influenced by outdoor hard light
- Limited in installation height
- Excessive power consumption makes battery operation impractical

Thermopile

Principle

Uses two or more cameras to capture video footage and depth information and uses AI algorithms to analyze the number of people

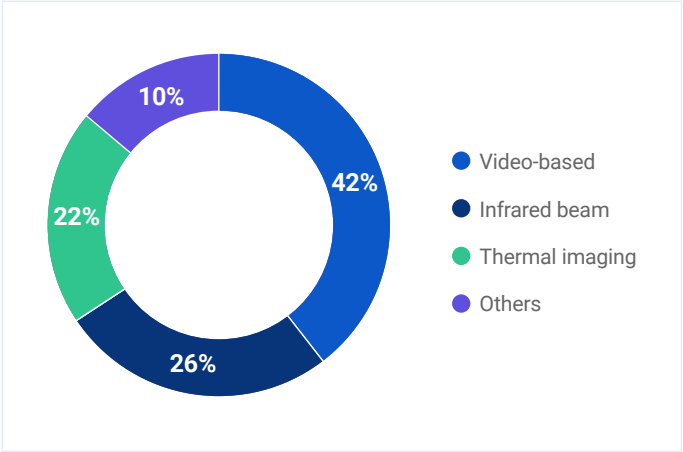


Pros

- High Accuracy
- Improved precision in distinguishing humans from objects compared to 2D systems
- Improved precision in crowded areas compared to 2D systems
- Provide more attributes, like gender recognition and facial expression recognition

Cons

- Higher cost
- Performance can decrease in poor lighting or extreme brightness
- Excessive power consumption makes battery operation impractical
- Privacy concerns: captures images and videos, raising GDPR compliance issues



Delving into the population statistics sensor market, an analysis of current market applications reveals that video-based technology is currently the most widely accepted and applied solution[27]. Meanwhile, Time-of-Flight (TOF) represents the fastest-growing segment in the current market, with an overall compound annual growth rate reaching 14.4%[28]. Different technologies can be selected based on specific scenarios, each capable of providing data across different dimensions.

5.HOW TO LEVERAGE CUSTOMER DATA TO BOOST SATISFACTION AND REVENUE IN BRICK-AND-MORTAR RETAIL

As mentioned earlier, people counting sensors can empower every aspect of the retail process. Equipped with these sensors, the entire retail space functions like a large-scale simulation sandbox, providing static user data and enabling the collection of comprehensive shopping journey data. This addresses the key challenges of retail digitalization.

Pre-operational footfall data enables retailers to determine optimal store locations, identify peak traffic periods, and increase overall store visibility.

In the store location selection phase — a primary strategic decision in retail operations where the stakes are inherently high — many retail practitioners are often plagued by profound doubts before finalizing a site: "Is this location truly optimal?" and "Is there sufficient pedestrian traffic?" After all, even with the best merchandise and superior service, a store situated in a low-footfall area will struggle to maximize its commercial potential. Here, infrared sensing technology emerges as a powerful "tool" to resolve these uncertainties.

[27]"People Counting System Market Analysis, Size, and Forecast 2025-2029." Technavio, Infiniti Research Limited, July 2025, https://www.technavio.com/report/people-counting-system-market-industry-analysis.

[28]"People Counting System Market Size & Share Analysis - Growth Trends & Forecasts (2025 - 2030)." Mordor Intelligence, Mordor Intelligence, 9 July 2025, https://www.mordorintelligence.com/industry-reports/people-counting-system-market.

By deploying infrared sensors around a target area, retailers can achieve precise and continuous monitoring of passing foot traffic. The technology not only clearly reveals how many people pass by a potential site — providing a data-driven basis to assess whether the area has an adequate customer flow and is the best choice for a new store — but, more critically, it meticulously records peak traffic times across different periods. This allows practitioners to pinpoint exactly when footfall is highest. For instance, if infrared sensing at a candidate location on a commercial street identifies weekday evenings and all-day weekends as peak traffic periods, this insight offers invaluable guidance for subsequent operational planning. It informs decisions on business hours, staff scheduling, and promotional activities, enabling the store to align its operations with customer flow patterns from the very start.

Understanding Customer Profiles, Adjusting Strategies, and Enhancing Satisfaction During Retail Operations

Through the collection of customer group information via people counting sensors—including daily visitor counts, customer attributes, gender, age group, location distribution, and heatmaps—the following improvements can be achieved:

Sales Management

1. Instead of relying solely on POS transaction data, data on daily store visitors is collected and compared with actual purchases to calculate the effective conversion rate, providing more precise insights.

2.By analyzing varying levels of shopping cart occupancy, retailers can understand customers' shopping journeys, assess whether the product assortment meets customer needs, and identify the primary customer segments.

3. Real-time mood analysis can be conducted to gauge overall customer satisfaction with the store.

4. More importantly, the system can integrate directly with existing POS databases and CRM platforms.

By automatically identifying returning customers and potential VIPs, it helps retailers distinguish high-value individuals from anonymous foot traffic, enabling targeted services and boosting repurchase potential.

Optimized facility management enhances operational efficiency and retail safety, thereby increasing customer satisfaction.

1.By tracking daily foot traffic, stores can optimize management. Identifying peak and off-peak hours enables better staff scheduling—increasing manpower during busy periods and reducing it when quieter. This leads to more efficient operations and a fairer distribution of work for employees.

2.By detecting occupant presence, building facilities such as HVAC and lighting systems can be automatically switched on or off to achieve energy savings. The system can even perform more refined adjustments—precisely regulating different building zones based on real-time headcounts and setting differentiated air quality standards and thermal comfort parameters according to the number of people present in each area.

3.Through effective queue management, additional checkout counters can be promptly opened when longer lines form. This enhances customer shopping efficiency and improves the overall shopping experience.

4. By identifying crowded areas, customer flow can be intelligently redirected, staff can be deployed to guide dense crowds, and entry can be temporarily paused if necessary. These measures enhance overall safety and comfort.

5. Using AI-enabled behavior recognition, the system can identify unusual individuals within normal customer flows, enabling early detection of potential threats such as theft or robbery, which allows security personnel to intervene proactively. Additionally, when the retail venue is closed, the system can detect unauthorized personnel other than employees on the premises, helping to reduce incidents of theft.

Clarifying Consumer Profiles & Enhancing Customer Experience via Precision Marketing

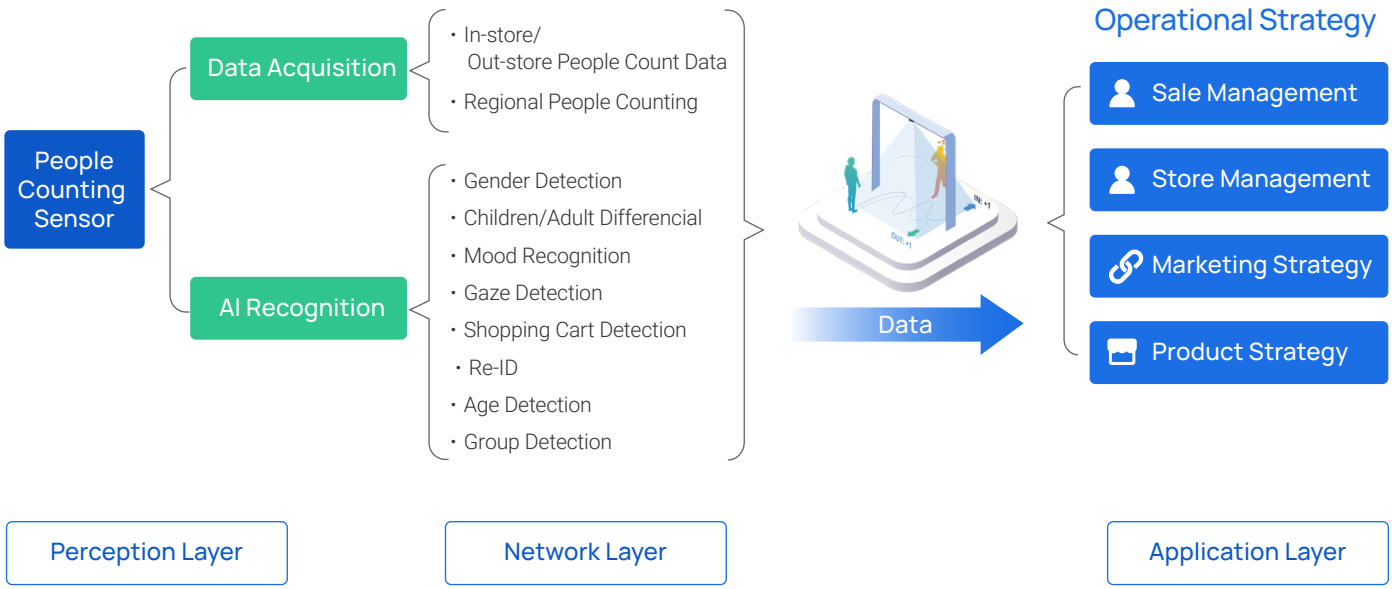
1.The portrait characteristics and preferences of individuals vary by gender and age. With data collected from people-counting sensors, this information can be provided to professional marketing teams to design targeted promotional campaigns. More importantly, the effectiveness of these campaigns can be monitored through data feedback, allowing for dynamic updates.

2.By analyzing the duration of individuals' stays in different areas, we can not only directly gauge their level of interest in specific zones and map each customer's shopping journey, but also assess the effectiveness of the space layout. This data further supports optimizing user engagement—for instance, adjusting service point locations to increase interaction rates. Additionally, by combining data on customers' gaze directions, advertisements can be strategically and unobtrusively placed in the most "heated" spots along their journey.

Optimizing Product Placement with Pedestrian Traffic Data

1.Introduce more suitable products tailored to the user profiles, achieving precise alignment between the merchandise structure and customer needs, and even optimizing the supply chain.

2.The system provides the distribution of pedestrian traffic within specified areas and identifies prime locations. Based on this data, merchants can reallocate high-value products to these spots to maximize profits.



People Counting Application Topology Diagram

6. WHAT MILESIGHT OFFERS

6.1 The Role of People Sensing in Smart Retail Transformation

Milesight's Retail People Insights solution leverages People Sensing technology to convert retail traffic into actionable intelligence. This approach addresses key retail challenges by providing data-driven insights into customer behavior, optimizing operations, and enhancing conversion rates across diverse retail environments.

6.2 Smart Retail Solution Framework

It is apparent that leveraging advanced, compliant sensor technology has become central to retail's digital transformation. Building on this foundation, Milesight—through its core People Sensing strategy—delivers a complete smart retail solution that directly responds to industry needs. Designed to transform unquantified foot traffic into actionable business intelligence, Milesight's offering enables retailers to move beyond simple headcounts toward deeper understanding of customer journeys, operational efficiency, and conversion optimization—turning data into decisions and insights into growth.

6.2.1 End-to-End Retail Journey Analytics

Milesight's solution covers the complete customer journey from outside the store through checkout:

A. Outside the Store

Devices: VS361 (Coming Soon), VS125-Outdoor
Key Metrics: Footfall traffic trends, heat maps of public areas
Business Insights:

- Storefront valuation and rental decision support
- Advertising space performance assessment
- True conversion rate calculation (outdoor vs. indoor traffic)
- Marketing campaign effectiveness analysis

B. Entrance Analysis

Devices: VS13x Series, VS125 Series
Key Metrics: In/out customer counts, demographic data (group, gender, adult/child), staff detection
Business Insights:

- Storefront valuation and rental decision support
- Advertising space performance assessment
- True conversion rate calculation (outdoor vs. indoor traffic)
- Marketing campaign effectiveness analysis

C. In-Store Insights

Devices: VS121, VS13x Series, VS125 Series
Key Metrics: Regional people counting, dwell time, heat maps, view detection, shopping cart detection
Business Insights:

- Store layout and product placement optimization
- Identification of high-engagement zones
- Staff scheduling aligned with customer flow patterns
- Conversion optimization in high-dwell areas

D. Checkout Monitoring

Devices: VS13x Series, VS125 SeriesACheckout efficiency improvement

Business Insights:

- Dynamic staff allocation during peak periods
- Customer experience enhancement through reduced wait times
- Queue management impact on sales conversion

6.2.2 Product Portfolio & Technical Capabilities

Milesight offers a comprehensive range of retail traffic counters with distinct technical advantages:

Product Model	Primary Application	Key Features	Accuracy	Technology
VS125 Series	Indoor entrance/zone counting	Bi-directional counting, gender recognition, adult/child differentiation, group detection, staff exclusion	Up to 99.8%	AI + RGB + Stereo Vision
VS13x Series	In-store behavior analytics	Dwell time detection, heat mapping, shopping cart detection, zonal counting	Up to 99.8%	AI + 2nd Generation ToF
VS121	Occupancy monitoring	Occupancy detection, people counting, area utilization	Up to 95%	AI + RGB
Specialized Models				
VS125-LW	Low-mount wide coverage	Mounting: 1.9–3.5m, coverage: 45m²	Up to 99.8%	Stereo Vision
VS126	High-ceiling installations	Mounting: 6–15m, coverage: 75m²	Up to 99.8%	Ultra-wide Stereo Vision
VS125-Outdoor	Outdoor footfall tracking	IP67 rated, -30°C to 65°C operation	Up to 99.8%	Outdoor-optimized Stereo Vision
VS361	Storefront analysis	Outdoor traffic trend capture for conversion analysis	High Accuracy	Dedicated storefront sensing

6.2.3 Technical & Deployment Advantages

Advanced Detection Capabilities:

- Multi-device stitching for seamless large-area coverage
- Adult/child differentiation and gender recognition
- Group counting with staff detection and exclusion
- Dwell time analytics and heat map generation
- Shopping cart detection and customer gaze analysis

Flexible Deployment Options:

- Multi-Transmission Support: LoRaWAN®, Ethernet, Cellular, Wi-Fi HaLow
- Wireless Design: No wiring required, minimizing installation cost and disruption
- Easy Integration: Open API with MQTT/HTTP(s) support for third-party platform compatibility
- Scalable Architecture: Suitable for single stores to multi-site retail chains

Compliance & Performance:

- GDPR Compliant: Fully anonymized data processing with privacy-by-design architecture
- High Accuracy: Up to 99.8% counting precision for reliable decision-making
- On-device AI Processing: Reduces data transmission requirements while enhancing security and privacy

Powerful Retail Traffic Counter Portfolio Behind Smart Retail insights

B VS125-LW
AI Low-Mount & Wide-Area People Counter

- Special low-mount version support mounting from 1.9~3.5m with wider coverage of up to 45 m²

A VS125
AI Stereo Vision People Counter

- Accuracy: Up to 99.8%
- Technology: AI, RGB, Binocular Technology
- Functionality: Bi-Directional/Regional People Counting, Dwell Time Detection

C VS125-Outdoor
AI Stereo Vision People Counter

- IP67 rated and light-resistant outdoor people counter supports mounting from 1.9~6m with operation temperature from -30 to 65 °C

E VS13x
AI ToF People Counter

- Accuracy: Up to 99.8%
- Technology: AI, 2nd Generation ToF
- Functionality: Bi-Directional/Regional People Counting, Dwell Time Detection

D VS126
AI Ultra High-Mount People Counter

- Super high mounting version supports mounting from 6~15 meters with wider coverage of up to 75 m²

F VS121
AI Workplace Occupancy Sensor

- Accuracy: Up to 95%
- Technology: AI, RGB
- Functionality: Bi-Directional/Regional People Counting, Occupancy Detection

G VS361 (Coming Soon)
Storefront Footfall Sensor

- Capture outdoor foot traffic trends to evaluate storefront value and calculate conversion rates. Ideal for retailers to optimize location decisions, ad placement, and marketing strategies based on real-world movement data

Maximizing Retail Potential: Features of Milesight People Counter

Group People Counting
Intelligently count grouped data to present valid consumption data.

Regional People Counting
Capture the foot traffic in multiple customized areas to determine customer behaviors.

Multi-Device Stitching
Smooth fusion of multiple sensors through simple configuration extends the coverage of the target area.

Line Crossing People Counting
Count the number of people entering and exiting, and use the U-turn filtering to exclude redundant data from loitering individuals.

Dwell Time Detection
Tracking how long customers spend in specific areas to gauge customer satisfaction and engagement.

Shopping Cart Detection
Detect the number and fill level of shopping carts for retail analytics.

Staff Detection
Identify different categories of personnel using special markings, such as reflective strips or employee work lanyards.

Adults and Children Differentiation
Differentiate between adults and children by height and other indicators to improve data accuracy and granularity.

Gender Recognition
It effectively recognizes tailgating and is suitable for use in environments where access control, such as card swiping or monitored entrance and exit, is required.

Heat Map
Visually representing the flow of people, the length of stay, and their movement patterns. It provides valuable data on the distribution and intensity of passenger traffic.

7.SUCCESS STORY SPOTLIGHT

Europe

Smart Retail Evolves with IoT and AI-Powered Differentiation

The Milesight Retail Store People Counter VS133 is deployed in over 700 retail stores across Europe, with more than 3,000 units installed. This solution is utilized in various industries, including clothing, retail, jewelry, cosmetics, and more. Leading retail brands like JOTT, Herno, and Hawkers use this technology to optimize operations and enhance performance.

Location:
Europe

Partner:
TC Group Solution

Devices Deployed:
VS133*3000+pcs

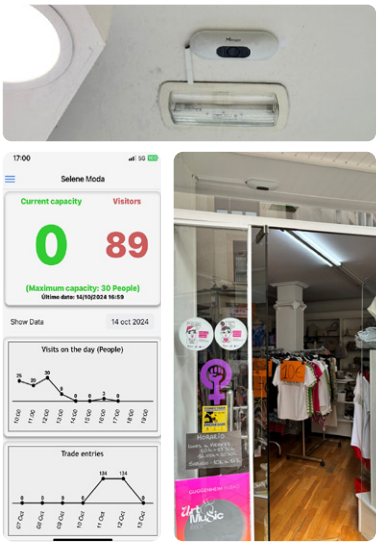
Explore Details →

Spain

Spanish Retailers Boost Efficiency and Marketing with Milesight

This project helped retail managers gain valuable, anonymous customer insights to improve operations and marketing effectiveness.

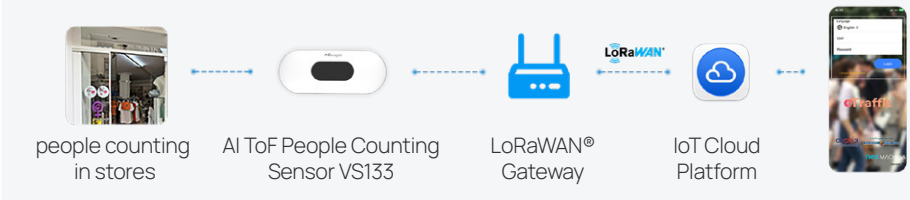
- Better Customer Experience: Optimized store layouts and displays based on customer flow
- High Operational Efficiency: Improved staff and stock planning to reduce costs and increase profits
- Smarter Marketing: Tracked foot traffic to evaluate online and offline campaign performance



Location:
Bizkaia, Spain

Partner:
Monolitic, Nexmachina

Devices Deployed:
VS133*35pcs



Explore Details →

Singapore

Bringing Improved Sanitation and Hygiene to 15 Heartland Mall Sites in Singapore

Milesight's smart restroom solution helped JLL, a global leader in real estate services, transform restroom operations through IoT-enabled monitoring, ensuring cleaner environments, higher efficiency, and better user experiences.

Location:
Heartland Mall, Singapore

Partner:
UnaBiz

Devices Deployed:
VS350, GS301, UG65

Explore Details →

Australia

Milesight Optimizes Mall Restroom Operations in Australia

Milesight People Counting Solution helped malls optimize restroom operations and satisfaction with real-time insights, demand-driven services, and automated dispatch.

- Optimized Cleaning Schedules: Adjusted based on real usage to improve efficiency
- Smarter Resource Allocation: Identified low-usage toilets for better maintenance decisions
- Maximized Occupant Experience: Aligned services with needs to enhance hygiene and satisfaction

Location:
Australia

Partner:
DKTOB Pty Ltd

Devices Deployed:
VS350*150pcs, WS201*100pcs, UG65*10pcs, GS301*5pcs, VS330*5pcs，EM400-UDL*1pcs, WS301*5pcs

*Contact us for more case details.

Singapore

Over 1,000 Milesight Devices Transform Traffic Insights Across Canadian Malls

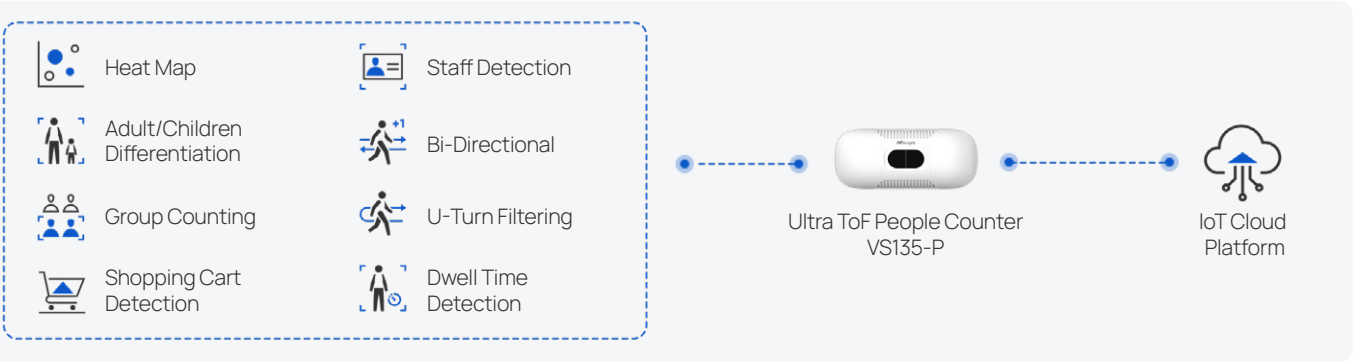
Milesight Ultra ToF People Counter VS135 was chosen to power smart traffic insights across Canadian shopping malls, with over 1,000 units deployed. Starting with a pilot in 2024, the project expanded to multiple sites in 2025 and is set to cover 15 malls in total.

Location:
Canada

Partner:
A1 Innovation

Devices Deployed:
VS135*1000+pcs

*Image for reference only



*Contact us for more case details.

The Future of Smart Retail, Powered by Milesight

The global retail landscape stands at a critical juncture. Despite the continued rise of e-commerce, physical stores remain the dominant channel, accounting for an estimated 76% of sales and serving as vital hubs for employment and customer experience. However, the transition to a data-driven era presents a significant challenge: the "data gap." Traditional physical retail has historically operated with limited insight into customer behavior, while e-commerce platforms thrive on rich, real-time user data. Bridging this gap is the core mission of smart retail.

Smart retail, fueled by the synergistic power of AI and IoT, is emerging as the definitive solution, projected to grow at a remarkable rate of over 25%. At the heart of this transformation is people sensing technology. **By deploying intelligent sensors, physical stores can now capture a wealth of data previously exclusive to online platforms—from basic footfall and dwell time to sophisticated customer demographics, heatmaps, and even shopping journey analysis.** This empowers retailers to move beyond guesswork and make informed, strategic decisions.

However, not all sensing solutions are created equal. While various technologies exist, from basic infrared beams to Wi-Fi probes, camera-based dedicated people counting sensors, particularly those leveraging advanced AI like binocular vision, offer the optimal balance. They provide the highest accuracy and the richest depth of customer attribute data—such as age, gender, and emotion—all while ensuring compliance with stringent privacy regulations like GDPR through on-device processing and data anonymization.

In this context, comprehensive Retail People Insights solutions are defining the next stage of retail transformation. These solutions map the entire customer journey—from analyzing outdoor storefront traffic and entrance demographics to monitoring in-zone behavior and checkout efficiency—through a suite of specialized sensors. The technology portfolio supporting this transformation is diverse, encompassing AI Stereo Vision for high-precision counting and demographic recognition, second-generation ToF sensors for in-store behavioral analytics, and dedicated devices for outdoor or high-ceiling environments. Key enabling features include multi-device stitching for seamless coverage, flexible wireless deployment options, and open API integration, all designed with privacy-by-design principles to ensure compliance.

The efficacy of this approach is evidenced by global adoption, with solutions deployed across various retail environments to help optimize operations, evaluate marketing performance, and enhance the customer experience. By converting anonymous foot traffic into granular, actionable intelligence, these solutions provide the critical data layer that connects the physical and digital retail worlds. This enables a fundamental shift: from intuition-based management to a model where strategic decisions on store layout, staffing, marketing, and inventory are driven by a deep, real-time understanding of customer behavior, paving the way for a more efficient, responsive, and sustainable future for physical retail.