Empower Customers and Streamline Operations with Computer Vision at Checkout

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Introduction

When considering customer experience (CX) and operational efficiency, brick-and-mortar retailers may perceive that stocking the right inventory or providing personalized product recommendations in-store may be where they should focus. While these are obviously important aspects of the shopping experience, the checkout process is potentially one of the most crucial factors for both CX and efficiency. This eGuide demonstrates how computer vision (CV) at the edge can improve CX by reducing friction points during checkout while boosting efficiency through loss prevention. You'll also learn how Intel is working with the ecosystem to enable foundational CV capabilities that make CV solutions easy to adopt and scale.

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Frictionless checkout using CV solutions

People hate to wait. In our always-on, communicate-instantly, get-it-today society, the checkout process at retail stores is often an aggravating experience for shoppers. Labor shortages in retail don't help matters, cutting down on available queues. Considering that the checkout experience is the last touchpoint between shopper and store, a poor checkout CX may impair the shopper/retailer relationship. Statistics underscore the need to improve the checkout experience:

- 15% of convenience store shoppers abandon their purchase and leave the store after one minute of waiting in line.[1]
- 70% of consumers are interested in being able to buy products without the need for someone at the checkout, and 61% are interested in the idea of unmanned shops.[2]
- 62% of shoppers prefer to make in-store purchases with digital or contactless payments.[3]

These statistics make it obvious that self-service and cashier-free checkout are key capabilities. But you might be thinking, "we've had self-checkout since the pandemic!" True. But many friction points remain from the CX perspective. For example, consumers may struggle to find the barcode on items, especially larger and bulkier purchases. Plus, not all items have barcodes, such as fruits and vegetables.

Adding computer vision to the checkout process can enable a seamless, easy CX. Cameras and edge sensors (such as a weight sensor) can capture images and other information, while an artificial intelligence (AI) model provides the know-how to categorize the item—without depending solely on barcodes (see Figure 1). In many cases, several items can be processed by the camera simultaneously instead of capturing images of the merchandise one item at a time. Faster checkout and improved accuracy enhance the CX and result in happier customers who are more likely to share their positive experience and return to shop again.
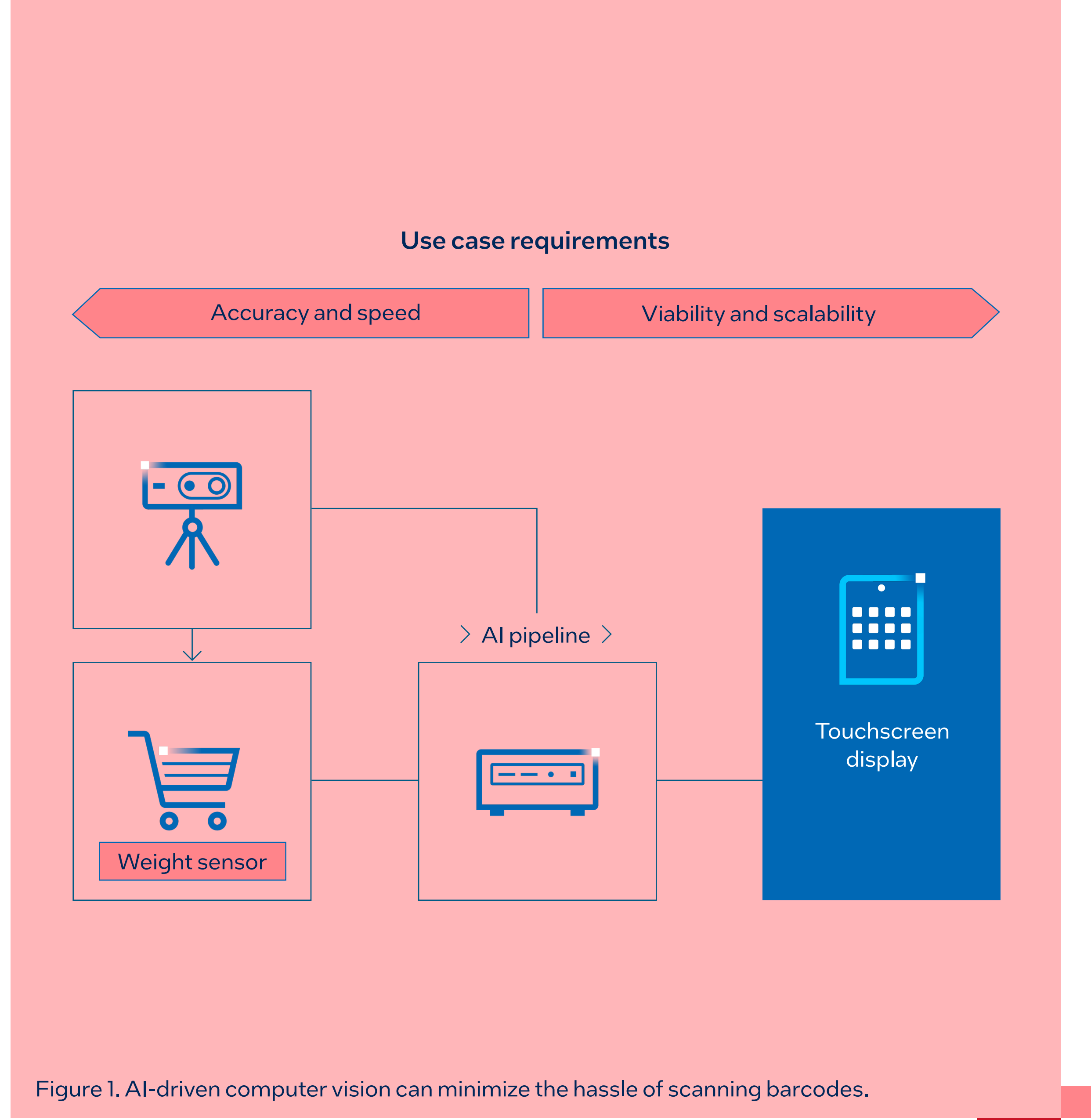
Use case requirements

Accuracy and speed | Viability and scalability

> AI pipeline >

Weight sensor

Touchscreen display

Figure 1. AI-driven computer vision can minimize the hassle of scanning barcodes.

Lightning-speed checkout using computer vision

Intel is working with various ecosystem players to develop computer vision-based checkout solutions for retail. Here are two examples:

Autocanteen is a touchless self-checkout solution that increases checkout efficiency. The system can identify anything from fruits to meal plates with visual discovery. Often used by catering companies, the system features deep-learning algorithms matched with 3D image scanners that can quickly and accurately capture, detect and recognize objects. Autocanteen is an Intel® IoT Market Ready Solution.

The Mashgin Touchless Checkout System uses CV to accelerate the checkout process and eliminate long lines such as at sports venue concession stands and convenience stores. Customers walk up to a checkout station, place their items on a tray, and then the system—in the blink of an eye—identifies each item and displays them on the screen along with price. The customer can pay using a variety of methods including cash, card and contactless. According to Mashgin, the Touchless Checkout System, which runs on Intel processors, is 400% faster than traditional checkouts and can boost retailer revenue by 20%.[4]

Less shrinkage with CV-enabled checkout systems

Shrinkage is an unfortunate fact of life for retailers. Currently, overall retail shrink in the US is between 1-2%, with the retail average being approximately 1.6% in 2020[5], representing nearly $100B in shrink every year.[6] As with the CX issues, fewer available retail staff can add to the shrinkage problem—there are simply not enough eyes to go around. The US National Retail Federation's (NRF) latest Retail Security Survey reveals that the amount of organized shoplifting increased by 26.5% in the second half of 2022. In nine out of ten incidents, shoplifters targeted self-checkout registers.[7]

Disturbingly, retailers also recorded a major increase in mis-scanned items in 2022. For example, unpackaged goods such as avocados (relatively expensive) magically turn into onions (relatively inexpensive), possibly because the shopper mistakenly chose the wrong SKU number from a list. Mis-scanning also includes intentional incidents, where not all items in the shopping cart are scanned, or product barcodes are switched. According to a recent US shopper survey, 20% admitted to intentionally cheating at the self-checkout registers.[8]

Intelligence at the edge, enabled by self-checkout stations with CV, can help mitigate these trends and protect retailers from shopper scanning errors (whether intentional or unintentional). For example, the combination of images and analytics can identify items that are being incorrectly rung up as a different product and can also alert store personnel to incidents where a customer may not ring up all items in the cart.

Three best practices for a CV-based checkout platform

When evaluating the potential for integrating CV into your checkout processes, these best practices will help you quickly get a system up and running and realize business value from the start.

Choose hardware that supports open, industry standards for interoperability and extensibility

The last thing that any retailer wants is out-of-control CapEx and IT management issues. So, when evaluating CV checkout solutions, consider how the system can be scaled to additional CV use cases.

For example, a proprietary checkout system running on purpose-built hardware may provide excellent checkout performance but may not accommodate loss prevention use cases. Additionally, integrating and managing disparate systems can be an IT nightmare. Instead, choose hardware that any software can run on for optimal flexibility. Avoid vendor lock-in by choosing frameworks and systems that adhere to open, industry standards. In this way, there are fewer limitations if you decide to switch to alternative hardware or software solutions in the future.

Another consideration is remote manageability. You'll want to investigate systems that feature a hardware-based remote connection to the CV checkout computing devices from a support center (even if all software fails including the OS). This will help reduce manageability costs by eliminating physical repair trips and can also accelerate time to repair.

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Right-size the solution and plan for the future

Terms like AI and machine learning may be intimidating at first. But to get started with CV and AI, you don't necessarily need to allocate a large portion of your budget to expensive servers powered by dedicated (sometimes called discrete) graphics processing units (GPUs), and you definitely don't need to become an AI expert. It is quite possible to get started with pre-trained algorithms and an edge device equipped with an off-the-shelf processor (CPU) and/or integrated GPUs (which may be less expensive than discrete GPUs).

Response time is key for optimal CX, so processing the CV data at the edge is critical. It is conceivable to run CV workloads in the cloud, but response times would escalate as would data transfer costs—plus, you have less control over what hardware and software is being used.

So, how much performance do you really need? Right-sizing your CV checkout deployment helps keep costs down but still provides the necessary level of performance (customers don't want to wait for the machine to respond). Table 1 provides some general recommendations for sizing.

To accommodate business growth, it is wise to procure compute systems that have open PCIe slots so that you can add discrete GPU cards in the future. Another consideration when making sizing decisions is the potential to consolidate several CV checkout stations, or a number of different workloads, onto a single edge device—thereby reducing total cost of ownership and management effort.

When choosing your infrastructure, consider that it should take less than a second for the CV checkout system to ID items—but the ID process must be accurate (see Figure 2). Overprovisioning to reduce response times to milliseconds (ms) doesn't add business value because the human brain won't notice the difference.[9] Also, consider that AI model performance is only one consideration for end-to-end performance—other components such as the network can also affect response time.
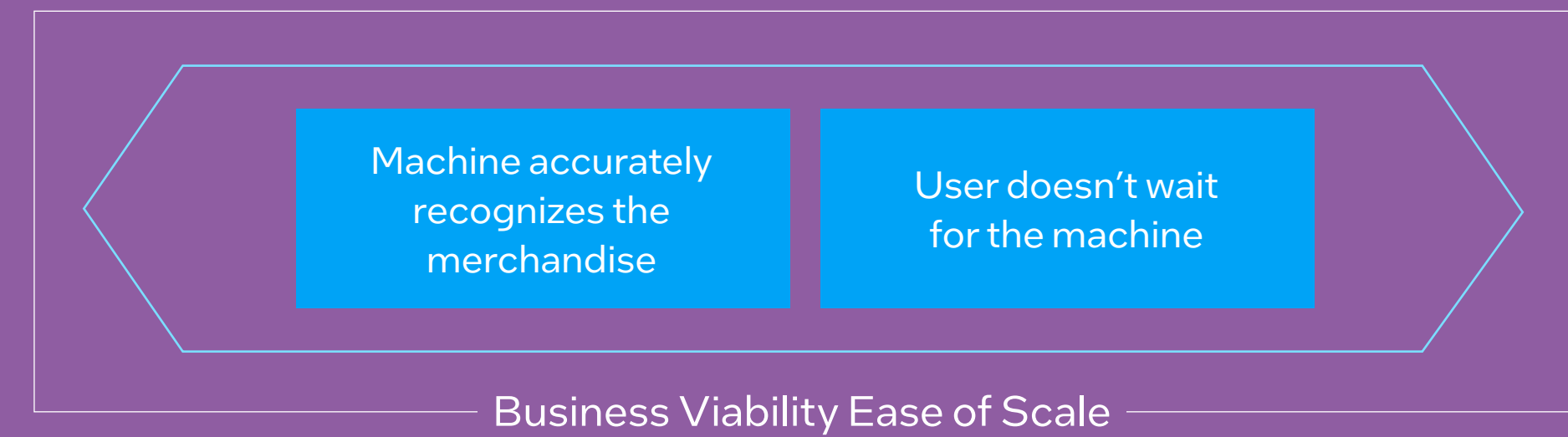

| Machine accurately recognizes the merchandise | User doesn't wait for the machine |

Business Viability Ease of Scale

Figure 2. CV-based self-checkout infrastructure must support accuracy and responsiveness.

Use Case	Number of Items	Processor Recommendation	Processor Recomended Number of Cameras	AI Model and Pipeline Characteristics
Single item small basket used for something like produce	<300 unique merchandise SKUs	Recent-generation Intel® Core™ i5 processor (can run multiple lanes)	1	Small model
Multi item small basket used in convenience stores or similar	~1,500 unique merchandise SKUs	Recent-generation Intel Core i5 processor with integrated or discrete GPU	3-6 for multiple angles	Medium model with additional detection and classification pipelines
Single item large basket for large stores	10,000+ unique merchandise SKUs	Recent-generation Intel Core i7 processor or Intel® Xeon® processor with integrated or discrete GPU	5-8 for higher-speed detection	Large model with complex pipeline for tracking and loss prevention

Table 1. Example sizing of infrastructure based on basket size

Built-in AI accelerators let Intel® CPUs handle demanding AI workloads

The majority of small- to mid-sized retailers can take advantage of Intel's innovations at the silicon level. In many cases, Intel Core processor-based solutions can handle CV checkout workloads. If more power is needed, retailers can upgrade to edge servers powered by 4th Generation Intel® Xeon® Scalable processors, which have the broadest and widest set of built-in accelerator engines for today's most demanding workloads.[10] The following are just some of the AI accelerators built into Intel Xeon Scalable processors:

- Intel® Advanced Matrix Extensions (Intel® AMX)
- Intel® In-Memory Analytics Accelerator
- Intel® Data Streaming Accelerator (Intel® DSA)
- Intel® Advanced Vector Extensions 512 (Intel® AVX-512)
- Intel® Deep Learning Boost (Intel® DL Boost) with Vector Neural Network Instructions (VNNI)

When a GPU is necessary, Intel has you covered

If your CV checkout solution needs additional acceleration, you may want to add one or more discrete accelerators. Some of the choices available from Intel include the following:

- Intel® Data Center GPU Flex Series supports an open, flexible, standards-based software stack together with Intel® oneAPI so developers can build high-performance, cross-architecture applications and solutions. This helps retailers to reduce the complexity, cost and time requirements to bring CV solutions to market.
- Intel® Arc™ Graphics offer a range of GPUs to meet your computing needs. For example, Intel® Arc™ Pro A-Series Graphics are a professional range of GPUs. With built-in machine learning capabilities, Intel Arc Pro graphics unites fluid viewports and the latest in visual technologies.
- X^e HPG Microarchitecture is engineered from the ground-up to deliver high performance, efficiency, and scalability. X^e-cores feature built-in AI capabilities and advanced 3D acceleration hardware.

Work with trusted partners

You know retail—customer behavior and preferences, inventory management, and so on. But you may not be an expert on AI, CV, and integrating hardware and software with your existing systems like billing and customer relationship management (CRM) platforms. Working with a trusted partner, like a system integrator (SI), as well as with the suppliers of the solutions you choose, can be helpful. These partners can help you evaluate your needs, choose the right hardware and software, and deploy quickly and hassle-free. You can work with your Intel representative to find the right SIs, based on your requirements. Examples of SIs you might explore include Autocanteen, Mashgin, UST and Radius AI.

Intel works with the ecosystem to build CV checkout solutions

Any AI workload, including CV checkout solutions, requires compute resources. But the relationship between hardware and software is very close. For example, most people perceive Intel as a silicon manufacturer, which of course is true. Intel does indeed focus on the compute elements required to handle compute-intensive AI workloads.

However, Intel is also dedicated to working with the ecosystem so that the AI software runs optimally on Intel architecture, and also provides many tools to the ecosystem to make it easier to develop and deploy AI solutions. Digital transformation is a team effort. Therefore, Intel has developed an immense ecosystem of relationships with information technology companies around the world. Working with these fellow travelers, Intel provides technologies, solutions and years of expertise and knowledge to help you embrace retail digital transformation. With over 24,000 real-world edge deployments[11], Intel and our world-class ecosystem deliver trusted Edge AI solutions cost-effectively, accurately and efficiently.

Bring us into your next conversation, talk with us about the challenges you're facing, and let us help you put AI everywhere.

Remote management for CV checkout systems

It is expensive and time consuming to travel to a store to repair a downed business computer, such as those used to power CV checkout. This is especially true if the non-functional PC is far from the central IT support center. Intel vPro® Platforms feature integrated Intel® Active Management Technology (Intel® AMT), which can remotely discover, repair and help protect networked computing assets. Intel AMT provides persistent out-of-band connectivity that operates independently of the OS, allowing fixes to a wide range of systems issues, even when the OS is down. Repair corrupted drivers, application software, or the OS on non-responsive systems that will not run or boot or use Keyboard, Video, Mouse (KVM) to monitor OS upgrades or boot to the system BIOS.[12]

Optimized AI frameworks and libraries

Because CX is so important in CV checkout solutions, getting the best performance from the software is paramount. Intel has worked with all major AI frameworks for deep learning and classical machine learning—such as TensorFlow and PyTorch—to optimize them using Intel oneAPI libraries that provide optimal performance across Intel CPUs and GPUs. These Intel software optimizations help deliver orders of magnitude performance gains over out-of-the-box implementations of the same frameworks.[13]

Development and deployment tools

Intel understands that time to market is important to business success. Retailers and CV solution vendors have access to a wide range of tools from Intel that help speed development and deployment. Here are some examples:

- Intel® Distribution of OpenVINO™ toolkit is an open source toolkit that makes it **easier to write AI code once and deploy it anywhere**—on any hardware.
- The AI Analytics Toolkit helps pull all of Intel's AI tools and libraries together. The components are built using oneAPI libraries for low-level compute optimizations. This **toolkit maximizes performance from preprocessing through machine learning** and provides interoperability for efficient model development.
- Intel® Geti platform is a commercial software platform that enables enterprise teams to **develop vision AI models faster**. With the platform, companies can build models with minimal data, and with OpenVINO integration, facilitate deploying solutions at scale.
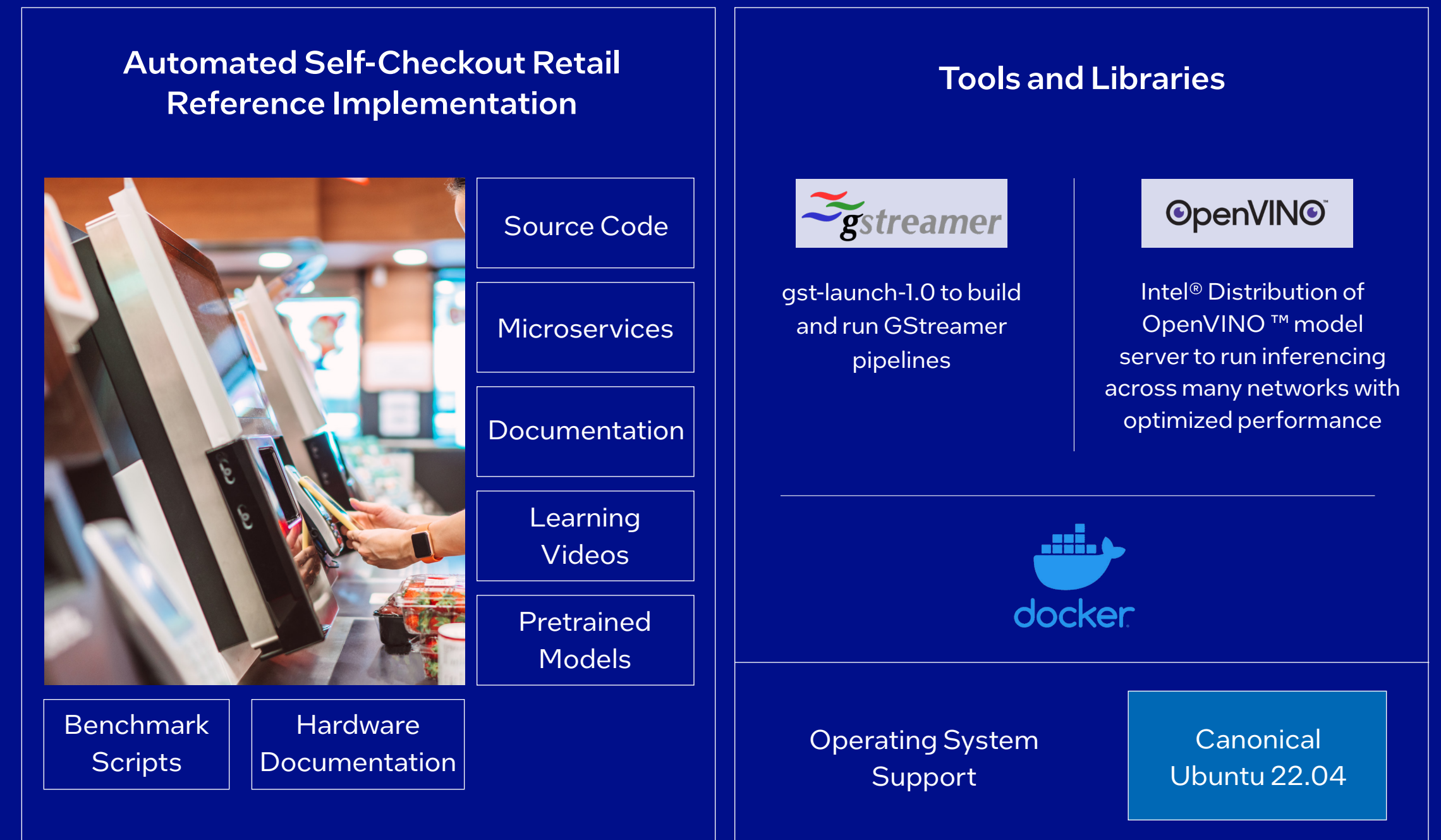
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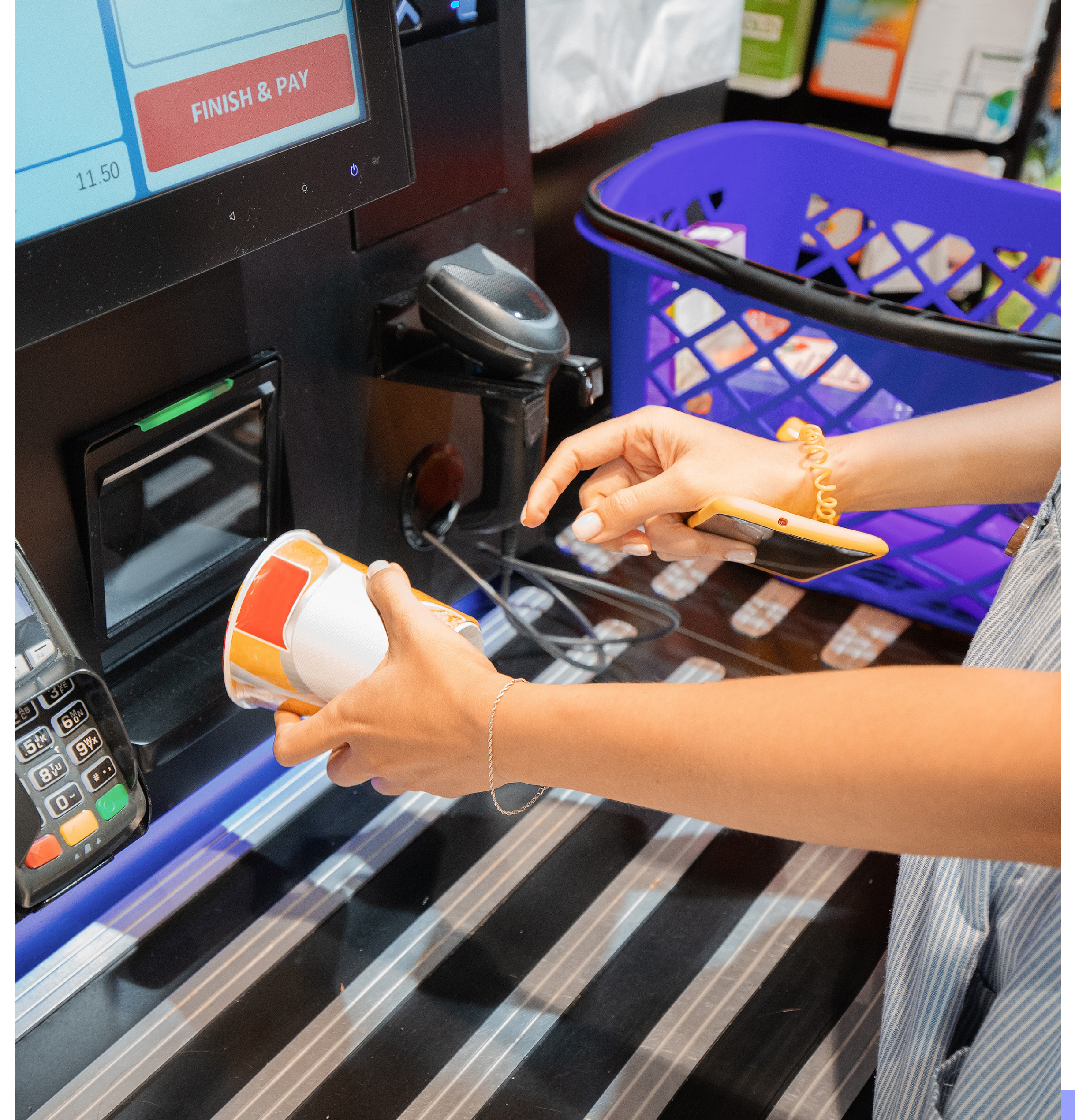
What's next: automated self-checkout

CV checkout solves many CX pain points as well as helps retailers become more efficient and lower the risk of shrinkage at checkout. The natural evolution of CV checkout is automated self-checkout, where the whole shopping experience is seamless and fast from start to finish (see the sidebar, "The path to the autonomous store starts today"). However, automated checkout solutions can be complex. Considerations include hardware and software, the costs involved in setting up and scaling the system and the configuration that best suits a retailer's needs—but figuring all this out takes time and can delay system deployment. To ease these challenges, Intel provides the Automated Self-Checkout Retail Reference Implementation (see Figure 3).

While not intended as a one-size-fits-all, out-of-the-box solution, the reference implementation does include critical components required to build, deploy and scale automated self-checkout using Intel® hardware, software, and other open source software ingredients.

Retailers, ISVs and SIs can use the high-quality testable building blocks, performance benchmarks, and hardware/ software recommendations to decide on the required hardware, minimize the cost per vision stream and accelerate the development of software.

Automated Self-Checkout Retail Reference Implementation

Source Code

Microservices

Documentation

Learning Videos

Pretrained Models

Benchmark Scripts

Hardware Documentation

Tools and Libraries

gst-launch-1.0 to build and run GStreamer pipelines

Intel® Distribution of OpenVINO ™ model server to run inferencing across many networks with optimized performance

Operating System Support

Canonical Ubuntu 22.04

Support for Platforms Based on Intel® Architecture

Figure 3. Automated self-checkout retail reference implementation.

The path to the autonomous store starts today

Integrating computer vision (CV) into the checkout process is just a first step toward full automation in the store. Using the foundational elements discussed in this eGuide, you'll be able to continue to evolve the customer experience (CX) and make operations more efficient. This is not just a dream— Nourish + Bloom has made it reality. This grocery store is entirely autonomous. Not only does the market provide good, affordable food, and is one of the most technologically advanced grocery store in the U.S.

At Nourish + Bloom, a customer can download the Nourish + Bloom app, scan in when they enter the store, pick up products off the shelf, walk out, and automatically get billed for the products. How does it work? The solution was developed by Intel, UST and Microsoft. Thirty cameras throughout the store along with shelves with scales accurately identify products using CV algorithms, and then interface with customer data to accomplish billing.

Conclusion

As retailers seek to elevate CX and increase operational efficiency, they are employing AI and CV technologies to create a super-fast checkout experience that removes barcode scanning, shortens lines and delights customers. Intel can be your trusted advisor on your CV journey, providing open architectures that facilitate flexibility and scalability. You can also rely on Intel to connect you with the right solutions that meet your business needs and help you get them into production quickly.

Start a conversation with your Intel representative today about how Intel can help accelerate your digital transformation.

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Learn more:

- Retail technology solutions from Intel

- Intel's artificial intelligence and deep learning home page

- Intel® vision products for computer vision solutions

- Intel® RealSense technology

- 4th Gen Intel® Xeon® Scalable processors

- Intel® Core™ processors

- Intel® Data Center GPUs

- Artificial intelligence in retail

- Vision Checkout at the Intel Museum Store video

- Design a Vision Self-Checkout white paper

- Automated Self-Checkout Retail Reference Implementation

- Reimagining the Traditional In-Store Customer Experience eGuide

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6. Loss Prevention Magazine, December 2022, "Shoppers Target Self-Checkout Registers Amid Soaring Inflation."

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8. Ibid.

9. PubNub, November 2022, "How Fast is Real-Time? Human Perception and Technology."

10. https://www.intel.com/content/www/us/en/products/docs/accelerator-engines/overview.html

11. https://www.intel.com/content/www/us/en/newsroom/news/report-edge-computing-drives-business-innovation.html#gs.4jaslv

12. KVM Remote Control (Keyboard Video Mouse) is only available with dual-core Intel® Core™ i5 vPro® processor and Intel® Core™ i7 vPro® processors with active integrated graphics. Discrete graphics are not supported. All versions of the Intel vPro® platform require an eligible Intel processor, a supported operating system, Intel LAN and/or WLAN silicon, firmware enhancements, and other hardware and software necessary to deliver the manageability use cases, security features, system performance and stability that define the platform. See intel.com/performance-vpro for details.

13. https://www.intel.com/content/www/us/en/developer/tools/frameworks/overview.html#gs.3a4hvd