ADLINK
LEADING EDGE COMPUTING

Automating Warehouse Logistics with AI



Edge AI is helping increase warehouse efficiency, accuracy, workforce productivity and safety, and floor space utilization.

Solution Brief

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Warehouses Under Stress

The pandemic and the ever-expanding global marketplace are pushing warehouse logistics to their limit. The pandemic is driving consumers to order more goods over the Internet, anticipating rapid delivery. Customers ordering an item in the evening may expect to get it in the afternoon the next day, which requires highly efficient logistics to move goods faster and faster. The need to accelerate processes adds a great deal of pressure to different types of warehouses, such as transfer, distribution, and fulfillment centers.

As package volume increases, accuracy at every step of the operation becomes critical. Accuracy is particularly important for picking, for which the average error rate in a typical warehouse or distribution facility is between 1% and 3%; studies show a single picking error can reduce the profitability of an order by as much as 13%.[1] Shipping mistakes also mean items need to be returned and the correct items sent back, and since many returned items cannot be resold, the loss from these errors is even higher.

With increasing order volume and activity in warehouses, it is a greater challenge to keep workers safe from common warehouse injuries caused by: forklift accidents; hazardous material exposure; being struck by goods; or getting caught between equipment and heavy objects.[2]

It is also a struggle to hire enough people to operate the warehouse, partly because of worker reluctance due to COVID-19. In fact, companies were already dealing with a labor shortage before COVID due to a huge uptick in e-commerce orders.[3]

Amid surging online orders and growing expectations for rapid delivery, the use of micro fulfillment centers (MFCs) and local fulfillment centers (LFCs) in urban areas is increasing. While MFCs/LFCs are closer to customers and help speed up delivery, this approach comes at a premium since floor space is typically a warehouse operator's highest fixed cost.

Logistics automation solutions providers are helping address these concerns using artificial intelligence (AI) at the edge of the network in a wide variety of applications.



Warehouse Processes

Figure 1 shows examples of common warehouse processes that could benefit from AI-based logistics automation solutions.

Receiving

Warehouses receiving high volumes of goods each day may be unable to manually inspect every incoming item because it would increase receiving time and cost; however, the tradeoff is a higher incidence of undetected damaged goods and missing items. "As much as 11% of unit loads arriving at a distribution center have some level of case damage, with the average figure around 2%," according to Packaging Digest.[4] AI-based receiving solutions can help by automatically identifying and counting received items, inspecting them for damage, and providing a real-time report.

One of the tedious and time-consuming receiving tasks is processing returns. With record-setting e-commerce sales, 1.9 million holiday package returns can enter the logistics system, and that is just one company in a single day.[5] But return processing is necessary to determine whether the customer shipped back an unopened box that can be restocked; or if opened, whether all the pieces are included. Working with a human, an AI-based vision system can increase the speed and accuracy of returns processing by identifying the pieces of the returned item and checking them against a packing list.

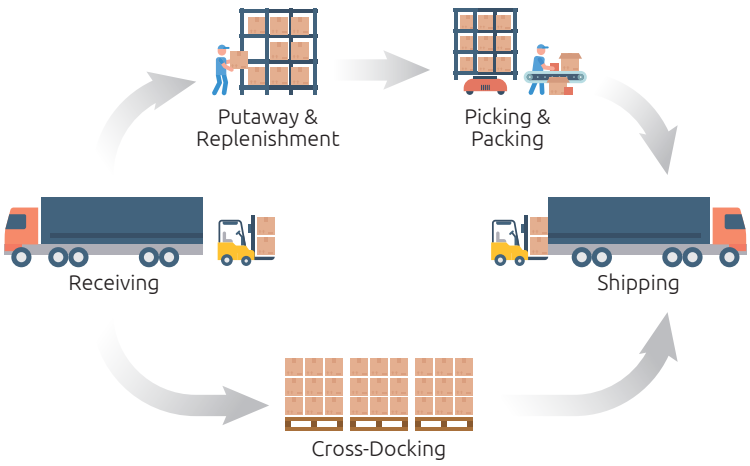


Figure 1. Examples of Warehouse Processes

Putaway and Replenishment

It is critical to move materials from the dock to the correct location (e.g., warehouse storage, replenishment, and pick area) to avoid increased picking and order fulfillment time. Material handling errors can also increase risk to the security and integrity of goods.

AI integrated into conveyer processes can help increase accuracy and productivity by sorting goods based on purchase order, product types or size, or part numbers. Examples include automated storage and retrieval systems.

Another way to automate material handling is with autonomous mobile robots (AMRs) that use vision systems and AI algorithms to plan routes and navigate based on their perception of the surroundings. In addition, AMRs can increase floor space utilization by allowing aisles to be narrower than if humans (socially-distanced) were working in them.

Picking and Packing

Industry reports suggest distribution centers can increase profitability by reducing picker travel time, picking error rate, and product damage. Up to 70% of pickers' time can be consumed by travel, which really hits the bottom line considering labor is one of the highest costs.[6] Picking errors leading to returns are also costly, and leading causes for returns of online purchases are wrong items (23%) and product damage (20%).[7]

Collaborative robots with AI-based vision can streamline picking by bringing goods to a picker, picking items from conveyors, or placing them in shipping boxes. Similarly, conveyors with AI-enabled vision capabilities can check for product damage, verify the correct products are being picked, and capture proof-of-packing to resolve disputes. AI-based palleting solutions can automate stacking and validate the accuracy of loading packages. Overall, these solutions can help reduce picker travel time, increase picking accuracy and throughput, and automate picking and other manual processes.

Docking and Shipping

Distribution centers, under pressure to ship growing order volumes more quickly, are increasing their reliance on forklifts. In prior years, more than 11% of all forklifts were involved in some type of accident,[8] and with warehouse activity surging, faster and safer material handling solutions are needed.

Another concern is congestion in the receiving area caused by incoming goods that require short-term storage or need to be directly loaded onto outgoing trucks. Failure to timely and accurately move goods from inbound to outbound docks leads to bottlenecks in the receiving area that have a cascading effect on shipping delays.

AI-based logistics solutions can increase throughput and enhance worker safety in highly dynamic environments. Capable of handling full, palletized truckloads, AMRs and autonomous forklifts can coordinate with robotic peers to keep goods flow and operations error-free. They can detect objects, avoid collisions, and safely move around human associates in distribution centers. The warehouse dock can also use AI-based solutions to accept or reject consignments based on schedules, and validate product quantity and integrity to enhance just-in-time (JIT) delivery.

AI-based vision systems with real-time object detection can spot and notify warehouse workers who are not using the proper personal protective equipment, like hard hats, goggles, and gloves.[9] In warehouses with restricted areas, vision systems can identify workers who are not authorized to enter such areas by the color of their vests (i.e., yellow vest required to enter).

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Design AI-Based Logistics Automation

There are a comprehensive set of building blocks and tools that greatly speed up AI development and deployment in warehouses. AI-focused hardware and software building blocks deliver the performance, reliability, and development environment needed to perform the typical warehouse tasks. This section describes some of the key design practices and capabilities these edge AI building block bring to customers, OEMs, ODMs, and systems integrators.

Employ Edge AI

AI algorithms used in warehouses for pick-and-place, goods movement, AMR navigation, and other functions need to be fast, yielding decisions in 0.2 seconds or less. These time-critical processes require AI processing at the edge to ensure actions can be acted on in near real time. Edge AI advantages compared to cloud AI include:

Reduced latency
Enable corrective actions to be taken in real time.

Enhanced security and privacy
Avoid data tampering by sending less data across networks and maintain privacy by keeping camera footage on the premises.

Improved resilience and reliability
Reduce mobile system reliance on wireless connectivity.

Lower communications cost
Use less network bandwidth.

Optimize Computing Performance

Solution developers deploying AI should consider using a computing platform that could consist of different types of computing cores suited for unique AI workloads, as shown in Figure 2. AI algorithms, working on different types of data, may run best on a mix of processor cores, like CPUs, graphics processing units (GPUs), vision processing units (VPUs) and field-programmable gate arrays (FPGAs). This design approach is called heterogeneous computing, which enables systems to be optimized in terms of size, weight, and power (SWaP) based on the type of workloads.

When selecting a computing platform, developers should determine which computing cores and performance level are best suited to run the required AI workloads and how much computing power and I/O bandwidth are needed. For example, the warehouse processes previously discussed run different types of AI workloads, such as:

Vision
Vision systems validate the integrity and quantity of incoming goods and allow sorting robots to detect, identify, and select items on conveyors.

Navigation
Autonomous forklifts and AMRs employ simultaneous location and mapping (SLAM) and collision avoidance when picking and docking.

It is also important that application-specific functionality can be readily added to systems requiring precise-control, low-latency AI-based machine vision, or coordination among robots, conveyors, and other warehouse subsystems.

Maximize Reliability

Solutions for deploying AI on mobile devices or at the edge of the network require special consideration of cost and SWaP constraints. For example, compact, low-power computing platforms are needed for battery-powered AMRs and warehouse environments where space and ventilation are limited. For systems that will work with or in other subsystems, electromagnetic compatibility (EMC) is an important consideration to ensure reliable operation.

Leverage Extensive Development Environment

Building robotics and AI applications from scratch to solve warehouse challenges is expensive and time-consuming. Leveraging pre-trained AI models, ready-to-use software development kits, and open source resources allows developers to fast track their projects from proof-of-concept to prototype. When building scalable commercial solutions, it is also important that software stacks are optimized to run on the computing system.

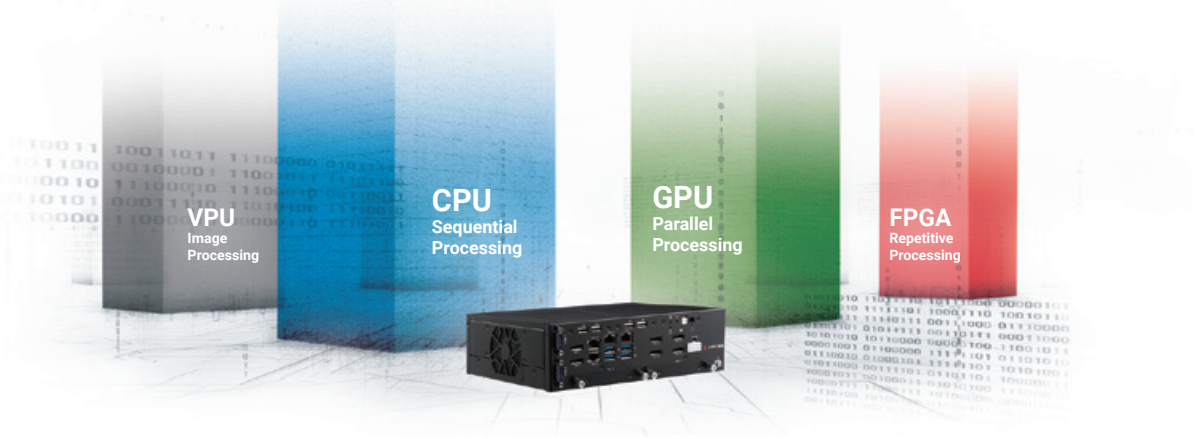


Figure 2. Different Cores Available to Heterogeneous Computing Platforms

Build AI-Based Logistic Automation with Success

Choose Performance from Various Building Blocks

To optimize the performance of different AI workloads, hardware building blocks should support a combination of specialized computing cores used to accelerate a wide range of functions. For instance, AMRs must decide a safe course of action by processing data from multiple sources, such as stereo cameras, lidar, and infrared sensors, in real time. ADLINK's portfolio of GPU-based and VPU-based solutions offer different performance levels, power efficiency, and form factors for AI applications as shown in Figure 3.

The embedded graphics products provide hundreds or thousands of parallel cores for AI inferencing that require sophisticated image processing, and mathematical and statistical computations. Mobile PCI Express Module (MXM) modules are well-suited for SWaP-constrained applications.

To help developers select the right computing platform, ADLINK offers consultancy services via an ADLINK-developed profiling tool that models computing performance based on the elements, such as the types of neural networks, framework, and batch size. The profiling tool runs these and other inputs against a large database of deep learning accelerators and recommends optimal configurations in terms of inferences per second, performance per watt, and performance per dollar.

Developers can easily expand ADLINK systems using PCIe expansion boards and custom function modules because system configuration flexibility is built-in to support motion control, I/O control, real-time image and data acquisition, and other automation tasks.

Edge-Optimized Reliability

ADLINK hardware is ruggedized, SWaP-optimized, and compliant with industrial-grade EMC standards, meeting the stringent requirements of edge AI devices. For space-constrained environments, ADLINK offers palm-sized, low-power, deep learning acceleration platforms and the world's most compact (as small as 3.2 litter in volume) industrial-grade GPU-enabled platform. ADLINK solutions also support an extended temperature range, so they can be embedded in automation or robotic systems where space is limited and poorly-ventilated.

There are also fanless systems to further increase reliability and low power systems capable of running on batteries, as is necessary for AMRs.

ADLINK hardware platforms can be safely used in industrial environments, such as warehouses and distribution centers, because they are designed for EMC compliance, so they can withstand emissions and not interfere with other systems. In addition, systems are tested to EN55032/35, EN61000-6-4/-2, CE and FCC Class A standards.

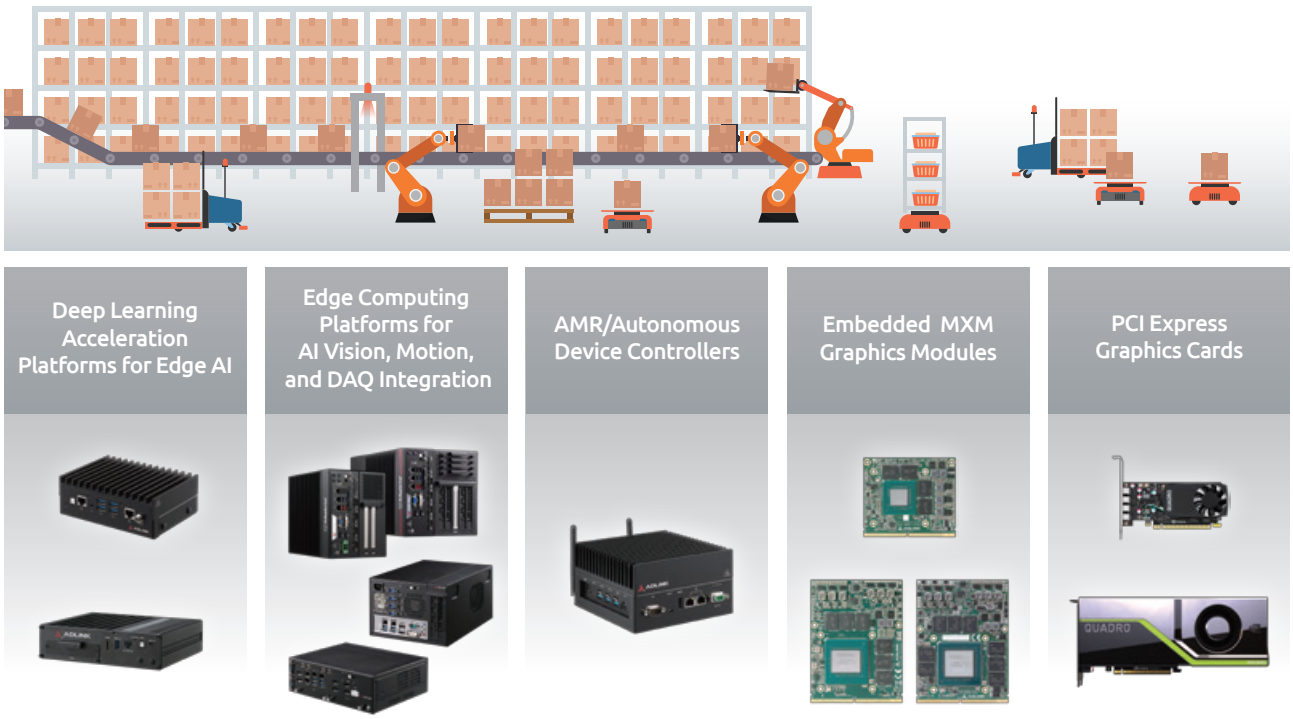


Figure 3. Various Building Blocks for AI-Based Logistics Automation Solutions

Streamlined Development

ADLINK supports a wide range of software development kits (SDKs) to streamline the development and prototyping of AI applications.

Machine Vision SDK

Developers can jumpstart their vision system development with ADLINK's Machine Vision SDK, one of the quickest, easiest, and most cost-effective ways to add AI to logistics automation. It is an all-in-one solution that allows machine vision experts and developers to build, test, and deploy machine learning models faster.

Smart Pallet Solution

ADLINK Edge™ Smart Pallet adds intelligence and automation to manual warehouse fulfillment operations such as receiving, bin picking, packing, shipping, and worker safety. Smart Pallet provides an end-to-end integrated system to connect new and existing equipment, capture multiple image data streams, and apply the high-performance processing power of VPUs to enable machine learning and inferencing at the edge. Deploying these capabilities on packing lines – to compare a package's contents to the items listed on the packing slip – has shown to improve accuracy, staff allocation, and more importantly, customer service.

NVIDIA SDKs

ADLINK solutions with NVIDIA GPUs support NVIDIA's Metropolis and Isaac SDKs, allowing developers to use pre-trained AI models and the Transfer Learning Toolkit (TLT) to build AI-enabled video analytics applications without starting from scratch. For example, developers of AI-enabled picking and packing applications can quickly prototype and fine-tune functions, like object counting, image classification and recognition, and segmentation.

ADLINK NeuronSDK™

For developers of robotics and AMR applications, ADLINK NeuronSDK™ is a powerful software development package for intelligent robotics development based on the Open Robotics Robotic Operating System 2 (ROS 2) project. The SDK features an optimized environment that provides full access to hundreds of open-source robotic algorithms, thereby enabling rapid development and faster time-to-market. For advanced use cases, NeuronSDK includes a data distribution service (DDS) and shared memory mechanism to further increase communications reliability.

Conclusion

System developers, OEMs, and systems integrators can more easily deploy AI with help from ADLINK's large portfolio of computing products that deliver performance, reliability, and an extensive development environment for a wide range of form factors. These solutions enable developers to deploy AI to improve warehouse operations without disrupting existing standard operating procedures.

Combining its strong expertise serving embedded developers and its close partner relationships with NVIDIA and Intel, ADLINK is delivering high-performance, long-life embedded graphics solutions for logistics automation.

To learn more about ADLINK solutions for logistics automation, please visit the ADLINK website at https://www.adlinktech.com.

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