

Artificial Intelligence in Warehousing: 5 Key Insights on the Current Status

Guideline through Market
Offerings and Trends

Thought Paper

Introduction

Artificial Intelligence in Warehousing – From Hype to Reality?

The warehouse is a key part of the supply chain: As a direct link to internal and external stakeholders, it contributes to customer satisfaction and business success. Consequently, more sophisticated solutions need to be developed to meet the increasing requirements and demands of warehousing operations.

This is where Artificial Intelligence (AI) comes into play. Today, the term AI has become a well-known and widespread buzzword not only in the media but also in the business environment. Applying automating techniques can greatly boost your warehouse, but with AI you can push it even further. AI is not the only emerging technology suitable for warehousing: A combination of technologies, such as AI itself, Machine Learning, the Internet of Things and, robotics is used to create new solutions.

However, there are still some questions: Is Artificial Intelligence ready to be deployed at warehouses or not? What are the enablers and in which environment is it profitable? Companies struggle to find answers to these questions. That is why we provide this thought paper as an orientation guide.

To give you a deeper understanding of the current situation we provide you with term clarifications, an overview of applied technologies, and application areas. We also examine enablers and disablers, the current market situation, insights on fields of application as well as potential benefits.



ARTIFICIAL INTELLIGENCE (AI)

Term applied to any technique that enables computers to mimic human intelligence, using logic, if-then rules, ML/DL/RL



MACHINE LEARNING

Algorithms that learn from examples and experience rather than relying on hand-coded and predefined rules



THE INTERNET OF THINGS

Connection of entities (humans, physical objects & intelligent or embedded devices) with IT systems and other entities for the purpose of information exchange and (near) real time control



ROBOTICS

Intelligent machine with three components: Sensors (1) to perceive the environment and generate data from it, actuators (2) to interact with the environment and an intelligent center (3) for data input and actuator control

Machine Learning either requires the capacity of an employee for supervised learning or the effort to analyze the result of an unsupervised learning. Neural networks can also learn reinforced without supervision.

5 Key Insights on the Current Status of AI in Warehousing

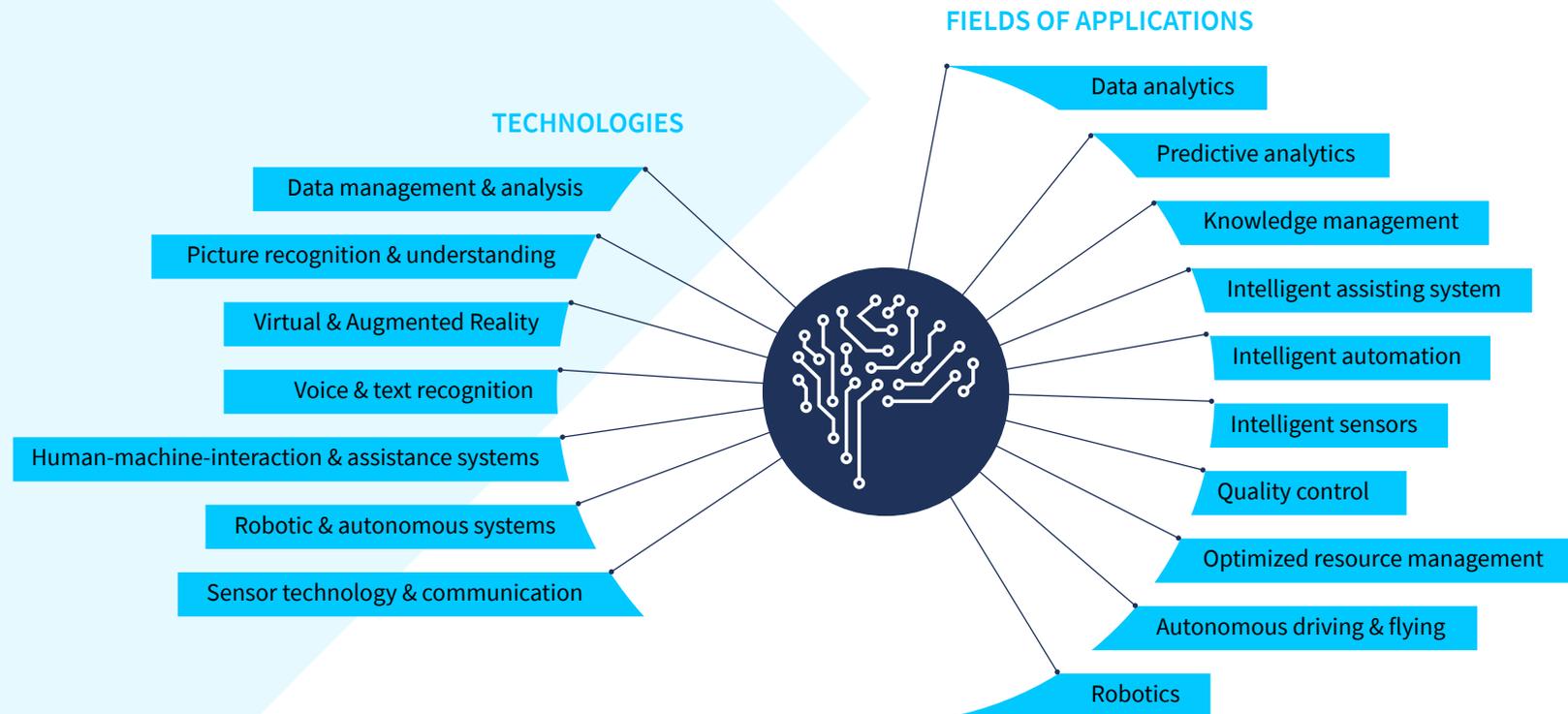
1 Technologies and fields of applications set the framework

Vendors' solutions are either already established technologies enhanced by new technologies, or a combination of new technologies. The application of technologies, which can be seen in the following figure, makes the solutions intelligent.

AI can be used to perform the following functions

- ▶ Make processes more efficient and flexible
- ▶ Avoid errors, or contribute to their avoidance
- ▶ Be a component in flexible automation, even in the orchestration of networked devices
- ▶ Make predictions to improve processes or proactively create basic conditions and transparency for error-free processes

Artificial Intelligence generally enables forms of 'perceiving', 'recognizing', 'learning' or 'predicting' beyond the limits of predefined, manually programmed rules. The hyped sub-field of reinforcement learning currently is not used in any warehouse solution found on the market.



2 The market is in an early stage, but should not be overlooked

The market offerings that use Artificial Intelligence are still only a fraction of the overall market. Nevertheless, we see an ever-increasing number of solutions provided, especially in the area of autonomously acting robots or vehicles. There is a variety of offerings and use cases that can be found from goods receipt to outbound. However, no products are specifically offered for consolidation & dispatch, instead this is always part of a broader solution.

In addition, vendors are eager to develop new solutions, even if they are not yet available on the market. In theory, the potential for applying AI to the field of warehousing is (almost) limitless. The following overview shows what types of solutions leveraging Artificial Intelligence are currently offered. A lot of business potential exists in the field of robotics and autonomous systems, (automatic) process analysis as well as forecasting. On top of that, robotics is becoming more and more collaborative since camera feedback eliminates the need for fences to separate them from workers.

CORE AI TECHNOLOGIES	Goods receipt	Identification & checking	Storing	Storage / Retrieval	Picking	Packing	Consolidation & dispatch	
Image recognition & understanding / Augmented Reality (AR)	Collect relevant data from shipping documents  Capture packaging labels 	Quality check of damaged goods using trained vision systems (TVS) 	TVS controlling hardware to depalletize (even mixed pallets)  Visual storage instructions by AR in field of view 	TVS supporting sorting processes on conveyors  WMS roof & drones cameras identify & update inventory 	Optical instructions for the picking process via AR 	Supportive packing workstation adopting to employee accordance 		Business potential  moderate  high Business suitability  High volume environments  Known products with good data quality  Environments with high volume fluctuations
Robotics & autonomous systems			Fully automatic pallet storage by AGVs  Guided storage using collaborative AGV (manual & self-driving) 	AGVs with sorting conveyor on the loading surface 	Collab. order picker AMRs & AMMRs conveying or picking units  Immobile pick-robot for gripping 			Core technologies build the foundation for the concept or are key enablers. The concepts can also use other AI technologies
	WAREHOUSE MANAGEMENT							
	PROCESS ANALYSIS	FORECASTING	SECURITY		MASTER DATA MANAGEMENT			
Descriptive, predictive & prescriptive analysis	Automation of process analysis using various sensors and evaluation techniques aiding process optimization 	Order arrangement with specification of optimized routes using forms of Machine Learning  Real-time forecasting of order volume and return probability for real-time process & resource control 	TVS detects whether protective clothing is worn, and access can be granted  Driving assistance systems for forklifts or other transport units 	TVS can classify & identify known objects and automatically update master data entries 				The solutions offered are concepts, i.e. there may be several vendors offer variants of e.g. collaborative order pickers AMRs

3 Circumstances are the key to success

While most solutions offered at the market are generally applicable, certain setups or environments are more favorable for a successful implementation and a high return on investment. Unfavorable settings can result in costs overshadowing the resulting benefits or over-engineering the solution.

In the current market offerings, it was clear from both the vendors and our own review that a sufficiently high throughput is a key enabler in most cases. Other drivers are, for example, the handling of small parts, a wide SKU-variety, high labor costs or, particularly, data quality. For example: The use of Artificial Intelligence in demand forecasting can greatly increase the quality since explanatory factors can be considered. Yet, this requires a clear data base. There is no forecasting solution where you can simply put in non-correlating data and expect to get a meaningful result.

In many cases, solutions are suited for e-commerce or distribution centers that supply stores. However, solutions are expected to evolve over time as diffusion and maturity increase. Pricing models, such as robot-as-a-service, could make the use of sophisticated systems more affordable.

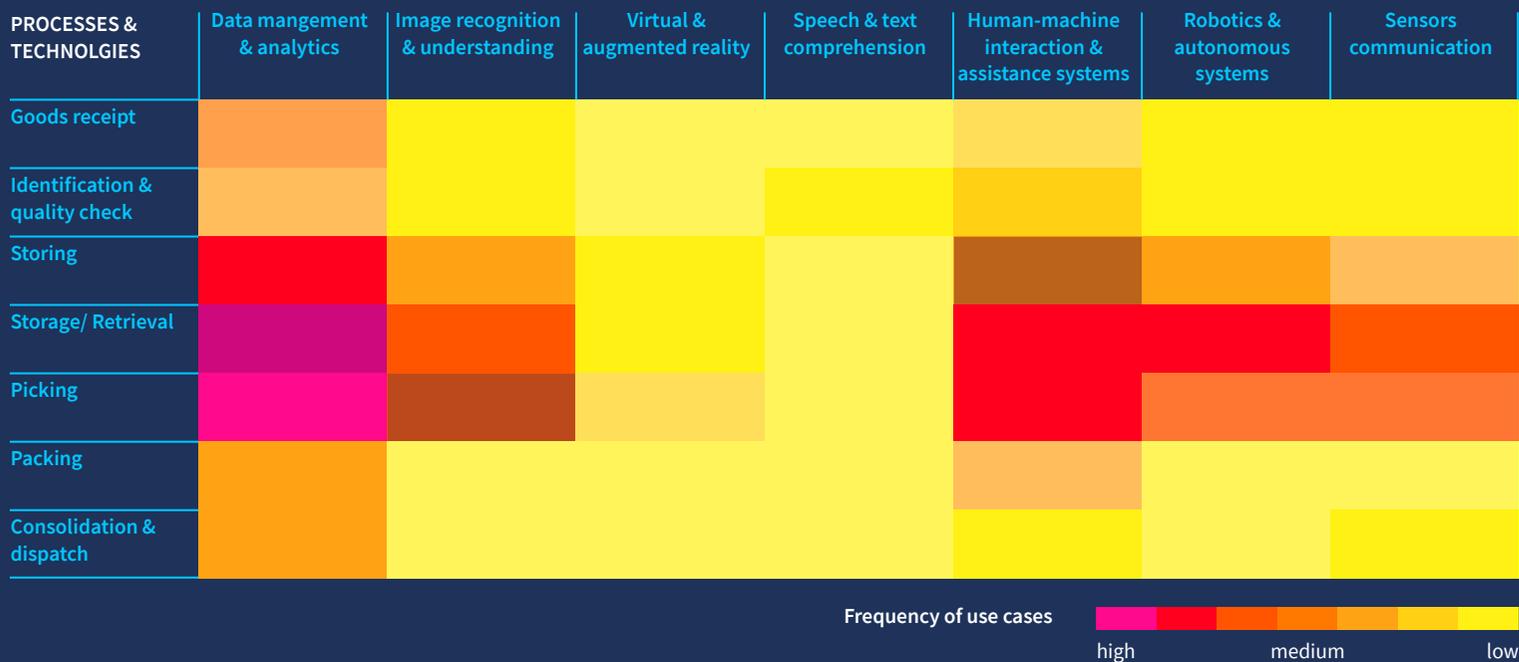


4 The focus is on picking

An analysis of the solutions offered has shown that hardware-driven solutions put emphasis on picking, storing, and retrieval. This is because picking is one of the most expensive activities in warehousing, which can amount to up to 50% of overall operating costs.¹ The increasing variety of articles and the fluctuating ratio between small and large orders due to the changing customer market are key cost-drivers in this process. Robotics can help reduce these costs significantly. Augmented Reality (AR) via data glasses is suited for training and maintenance, rather than for an entire shift.

Regarding software that uses data management and analytics, solutions tend to be broader with a slight focus on picking and storage (software for robotics etc. also uses data analysis). With increased expectations in on-time delivery, labor shortages, and large numbers of SKUs, this end-to-end perspective will become increasingly important to ensure smooth processes for all warehousing activities. The use of these software solutions will automate decision making and move employees' focus from resource allocation to supervision.

BASED ON OUR AI & ML DATABASE WE SHOW A HEATMAP OF THE FIELDS OF APPLICATIONS



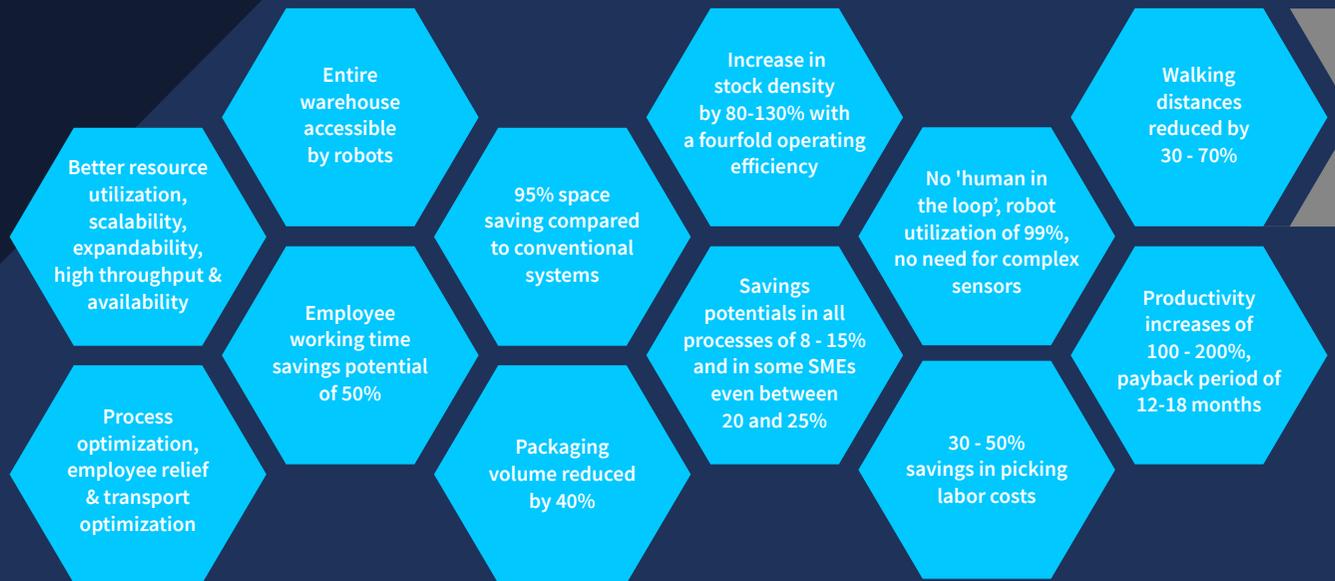
¹ Vgl. Hompel/Sadowsky/Mühlenbrock (2019); VDI Wissensforum GmbH (2019), S. 161.

5 If requirements are met, results can be outstanding

As noted, specific enablers such as high throughput and data consistency are key drivers for the solutions offered to make the investment worthwhile.

However, when these requirements are met, the result can be a rapid increase in productivity, efficiency, or cost reduction. Robots can, for example, assist your employees in their daily tasks or take over time-consuming activities. Warehouse management systems can anticipate fluctuations within the warehouse or due to an external cause and readjust and react accordingly. A storage system can increase your capacity utilization and adapt itself automatically to the environment. In the long term, distributed Artificial Intelligence could negotiate, schedule, optimize inventories, simulate flows of goods, and analyze goods via camera.

If your warehouse meets the requirements for AI solutions, remarkable results can be achieved within a short period of time.



While these benefits are impressive, they are achieved in specific cases and figures are provided by vendors

CAMELOT Management Consultants

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Why CAMELOT

- CAMELOT combines **logistics expertise** with supply chain solution knowledge and long experience in the focus industries chemicals, life sciences, CPG, and industrial manufacturing
- CAMELOT provides a systematic assessment approach to discover **use cases** and the **benefits** involved
- CAMELOT regularly scans the **Artificial Intelligence solution market** and has experience in integrating a variety of solutions via the affiliate Camelot ITLab

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