

ARTIFICIAL INTELLIGENCE IN LOGISTICS

Terms, applications and perspectives

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SSI SCHAEFER
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AI

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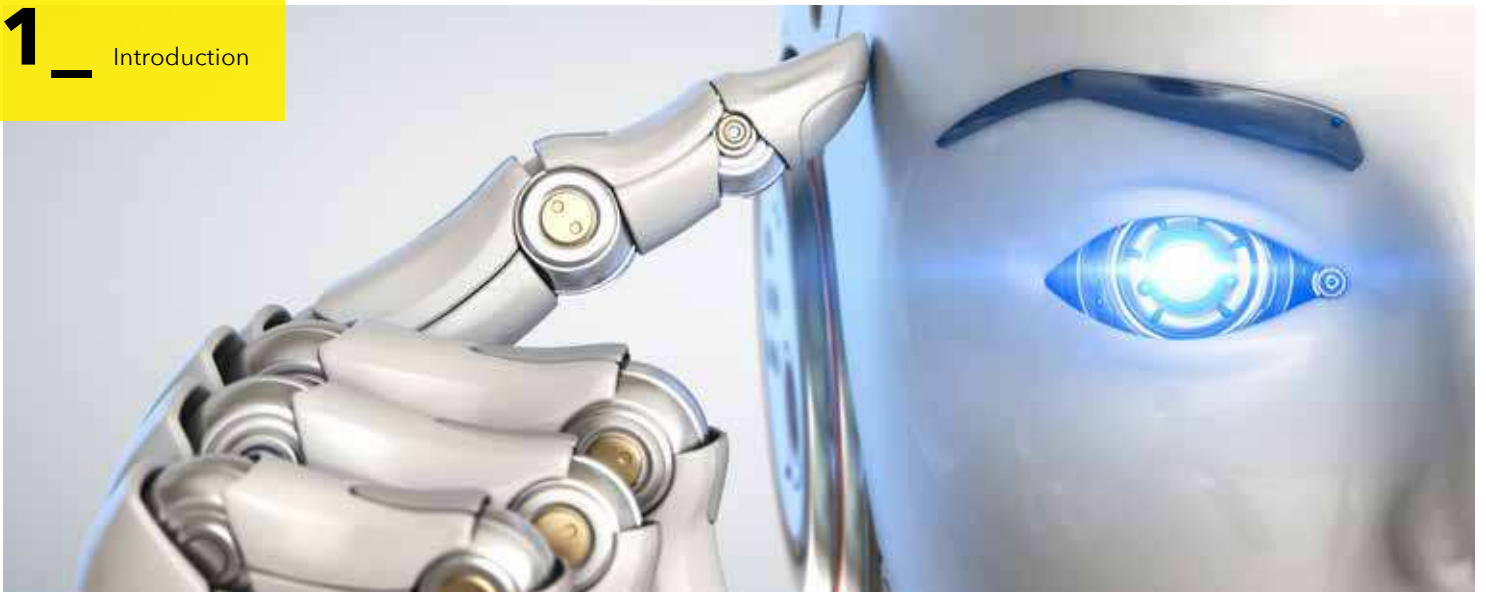


Artificial intelligence (AI) was the most-hyped concept of 2017: a supercomputer that beat the Go world champion, intelligent assistants such as Siri or Alexa that give (often) sensible answers to spoken questions, and numerous other applications - these are all proof of the now formidable potential of AI.

The topic of AI becomes the front-page story in many business and general-interest magazines. It often seems as though the technology is already mature enough not only to replace people in many specialist areas, but indeed to outdo them in terms of technical performance. Yet AI, as many experts concede, is still in the early stages of development when it comes to applications in operational logistics. While, some years ago, it was comparable to a (young) child who was able to make simple distinctions ("mum", "dad"), it has now grown into a teenager who can be entrusted with more complex tasks following appropriate instruction.

In addition, many specialist terms such as AI, machine learning, deep learning or neuronal networks are often used synonymously and without any clear differentiation, leading to a certain amount of confusion regarding the concepts among non-specialists.

In addition to providing an unambiguous definition of concepts and methods in the area of AI, this whitepaper aims to investigate which areas of application are already suited to AI and what prospects does the use of AI technologies open up for logistics.



ARE MACHINES CAPABLE OF THOUGHT?

A simple question that is difficult to answer. Even terms such as “thought” or “intelligence” are defined in different ways by different researchers. This is just one of the problems that is encountered when looking at artificial intelligence more closely.

While AI systems are able to process a far greater volume of data and therefore information than humans, to date they have suffered from the disadvantage of only being able to choose between known decision options. The unique characteristic of innovative and creative thought remains the preserve of humans.

One thing is clear: current progress in the development of algorithms, combined with greater processing power and an exponential growth in the amount of available data, mean that it is now possible to develop systems that can perform tasks that were previously viewed as the exclusive domain of humans. What is more, these tasks are often performed with a greater degree of accuracy, and with unchanging consistent reliability and no breaks, twenty-four hours a day.

Self-learning systems take on customer service tasks, manage logistics processes, analyze medical data or write messages and compose music. Deep learning, a variant of machine learning, uses multi-layer neuronal networks (hence the description “deep”) to extend the potential of AI to more complex tasks that can only be computed through multiple steps.

Today, machines are able to precisely identify objects and faces in a multi-faceted manner, to beat people in challenging games like chess and Go, to read lips and even to generate natural speech. Many companies, SSI SCHAEFER included, now view artificial intelligence as a central component of their strategy and a critical factor for their future core business

On the one hand, artificial intelligence could form the basis for huge productivity gains and improved quality of life. On the other hand, as with all new technologies, it could lead to a radical change in the world of work, comparable to the introduction of the conveyor belt. That is to say nothing of the ethical and societal issues that we must consider if machines acquire greater and greater intellectual capacity. ■

What was once science fiction is now reality. “Machine learning” uses the knowledge that is implicitly present in databases and data warehouses to be able to make explicit decision recommendations after a training phase.



BASIC CONCEPTS RELATING TO ARTIFICIAL INTELLIGENCE

2.1 ARTIFICIAL INTELLIGENCE

AI is a branch of information technology that deals with the automation of intelligent behavior. AI is the attempt to program a computer so that it is able to process problems independently, similar to the way a human with the appropriate training would. Problem solving means making decisions that constitute an appropriate response to the underlying problem within the specified time, based on data from various sources (databases, sensors, video cameras, etc.).

Conventional software programs are coded by developers with specific instructions about the tasks that the programs must carry out. While this works well in many situations that can be defined very precisely, limitations are encountered beyond a certain level of complexity. It is not possible for the human programmer to take all possible future use cases into account when writing the code. If the environment changes, the programs will no longer be able to attain the desired objectives or the required performance, given the significantly changed background conditions.

The development of machine learning began as a way around this problem: **it is based on adaptive algorithms that are able to learn from data without being reliant on rule-based programming.** The system is able to detect patterns, make associations and gain insights from the data. So, it is about creating what are generally meaningful connections between input and output using AI.

The prerequisites for this type of learning process are high processing power and having a sufficiently large amount of data. Both have only been available for the past few years, thanks to big data, and it is therefore unsurprising that machine learning has also made tremendous progress in recent years. ▶

Up until around ten years ago, the aim of AI research was to reproduce human intelligence in machines. This brought to light a series of problems, not least what we actually understand by the term “intelligence”. The five following capacities were included as a minimum under this term:

- **Perceiving**
- **Drawing consequences**
- **Learning**
- **Solving problems**
- **Linguistic intelligence**

Of course, human intelligence is much more differentiated, but the focus on five key cognitive capacities resulted in a great leap forward in AI research. Instead of attempting to program “general intelligence”, as found in humans, the focus shifted to precisely-defined tasks.

AI is now no longer at the basic research stage, but has become part of our everyday lives. Whether it is speech recognition algorithms as used by Apple’s Siri and Amazon’s Alexa, or the interpretation of findings in the medical sector, facial recognition in CCTV footage or in pharmacological research, working without AI technologies has now become unthinkable in many sectors. ■

2.2 MACHINE LEARNING

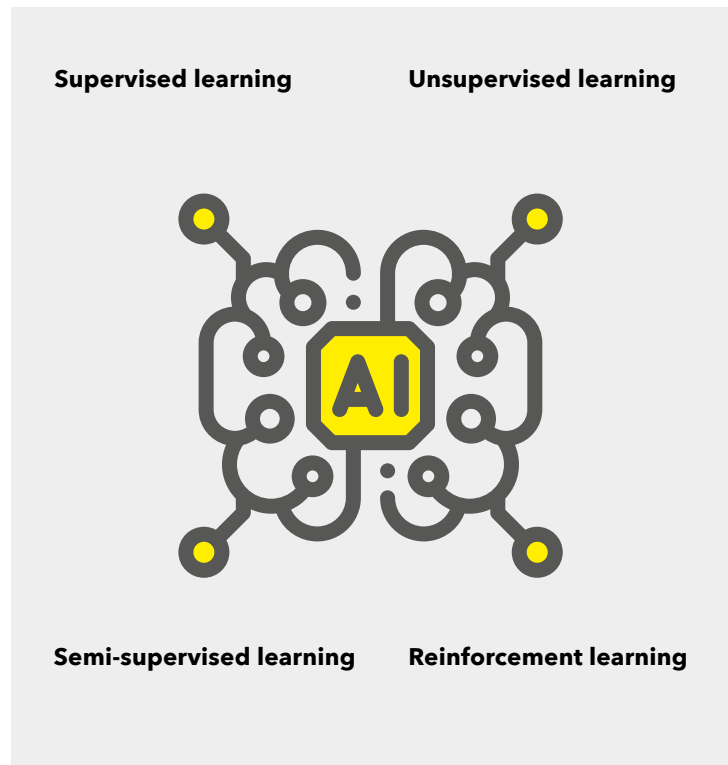
Machine learning is a collective term for various processes used to determine an unknown functional inter-relationship between input and output data. In addition to still-important traditional applications such as cluster formation, regression, factor and time series analyses, it also integrates more complex methods such as neuronal networks, evolutionary approaches and support vector machines.

In its basic form, a machine learning algorithm is fed with information which it must analyze and recognize in order to obtain a specific result. One example is the classification of spam, as used by the majority of big e-mail providers: The program is presented with thousands of e-mails that are classified as either “spam” or “not spam”. In this way, the algorithm “learns” to identify spam by identifying certain elements whose presence distinguishes spam from legitimate e-mails.

So, the algorithms attempt to detect patterns in existing databases, to classify data or to make predictions. Some examples are music or buying recommendations in the case of online platforms, and the optimization of marketing campaigns or customer service.

Tracing the right patterns is of key importance here, as patterns can almost always be found in databases and links made to other events. However, whether these will be meaningful when it comes to solving a specific problem is another question. ■

A distinction is generally made between four main learning strategies used by algorithms:



2.2.1 SUPERVISED LEARNING

In what is by far the most common type of machine learning, supervised learning, the algorithm is presented with an input (for example images), together with the desired output (label).

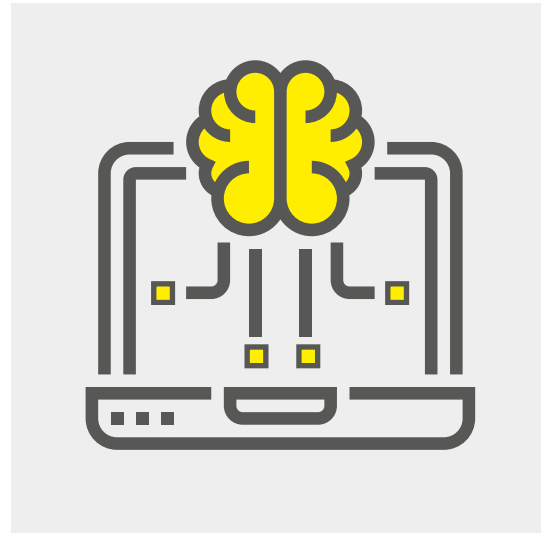
Example: If a computer is to distinguish between images of cats and dogs, it is presented with hundreds of images of cats and dogs from a very wide range of angles, each with the appropriate label "CAT" or "DOG". By this means, the algorithm should be able to develop a rule that it can use to make a clear distinction between dogs and cats in the future. The learning algorithm also needs to be able to abstract or generalize from the training data. "Overfitting" may occur if the existing digital knowledge becomes obscured by the input of too much data. This strategy has already been in use for many years in applications where a camera, rather than a conventional laser scanner, is used to detect and evaluate barcodes or data matrix codes. ■

2.2.2 UNSUPERVISED LEARNING

Unsupervised learning tries to detect appropriate patterns simply by looking at the input data, and thereby to reduce the huge quantity of data in the real world in terms of dimensions and complexity, without noticeable losses. It is clear that this is a more complex task without an objective. ■

2.2.3 SEMI-SUPERVISED LEARNING

Semi-supervised learning is a mixture of the two processes described above. This means that, in addition to the task of recognizing labeled data, the task of reducing the dimensions for quicker, more efficient, and potentially more robust recognition is simultaneously carried out. ■



2.2.4 REINFORCEMENT LEARNING

With reinforcement learning, an algorithm independently learns the best strategy to attain an objective in the future. The algorithm is not presented with the result, but is given an indication (reinforcement) as to what extent the algorithm is nearing its objective or moving away from it. Reinforcement learning algorithms based on deep neural networks ("deep reinforcement learning") have proven to be particularly successful here.

The neuronal network detects patterns in the data and, from these, develops a model of the part of the world that is described by the data. The training data are not presented to the algorithm, and instead it obtains these data through interaction with and feedback from the environment. This method is especially well suited to problems of classification, prediction and production. ▶

Reinforcement learning is used in cases where the route to the objective also plays a role and no precise information on the outcome is available, with the outcome instead being assessed in relation to the previous knowledge base.

Machine learning can help solve classification, prediction and generation problems

Classification	Classify/label visual objects	Identify objects, faces in images and video
	Classify/label writing and text	Identify letters, symbols, words in writing sample
	Classify/label audio	Classify and label songs from audio samples
	Cluster, group other data	Segment objects (e.g., customers, products features) into categories, clusters
	Discover associations	Identify that people who watch certain TV shows also read certain books
Prediction	Predict probability of outcomes	Predict the probability that a customer will choose another provider
	Forecast	Trained on historical data, forecast demand for a product
	Value function estimation	Trained on thousands of games played, predict/estimate rewards from actions from future states for dynamic games
Generation	Generate visual objects	Trained on a set of artist's paintings, generate a new painting in the same style
	Generate writing and text	Trained on historical text, fill in missing parts of a single page
	Generate audio	Generate a new potential recording in the same style/genre
	Generate other data	Trained on certain countries' weather data, fill in missing data points for countries with low data quality

For example, classification problems require the identification of objects (photos, videos, texts, sounds) and connecting them to one another or to other data sources. One example of an application is the clustering of customers in various categories. The creation of inter-relationships between objects/data is also a prerequisite for forecasts and for the production of texts and images, such as the generation of a missing frame in a video. ■

2.3 DEEP LEARNING IN NEURONAL NETWORKS

For a long time, tasks that even a child would have no problem with, such as detecting image content or voice recognition, were a stumbling block for machines.

This has changed over recent years thanks to deep learning, an approach based on neuronal networks technology. In this context, the term "deep" refers to the number of hidden layers in the network - neuronal networks that are based on deep residual learning, currently the most complex method used for object recognition, may contain a thousand or more such layers. ■

2.3.1 NEURONAL NETWORKS AND DEEP LEARNING: FUNDAMENTAL PRINCIPLES

Neuronal networks are based on the model of the human brain and aim to solve problems in a similar way to humans. They are networks of closely-connected processing elements, the neurons, which are known as "nodes". These receive information from the environment or from other neurons, process it, and pass it on to other nodes or to the environment.

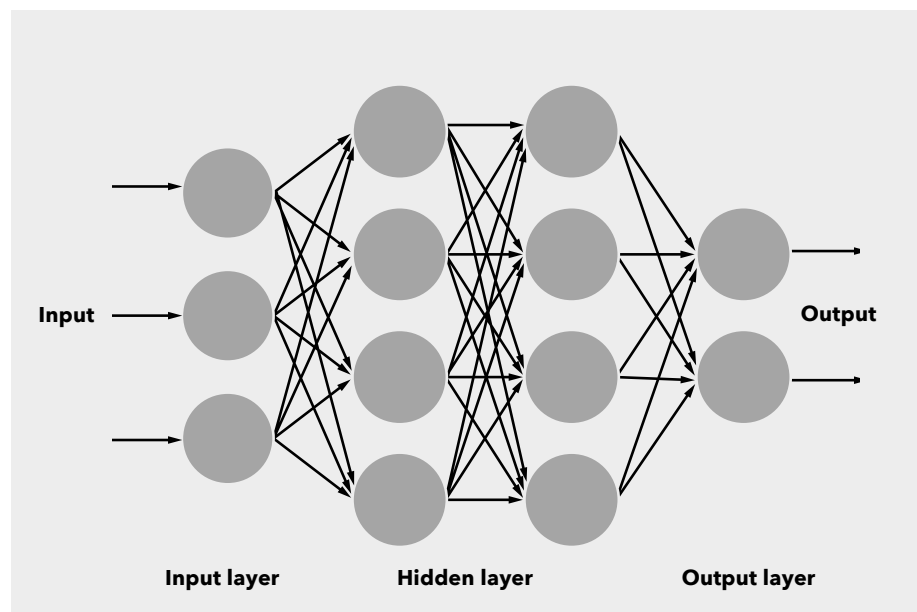
Only the outer layers, i.e. the input layer and the output layer, are accessible to the observer. What happens within the network is invisible and it is often difficult to do plausibility checks for the purposes of validation and verification.

The artificial neurons are modeled and arranged in multiple layers behind or above one another. Each level of the network contributes to attaining the (hopefully) correct output. This extraction of characteristics takes place independently within the individual levels. In its turn, the output from the individual layers then serves as the input for the next level. Through large volumes of high-quality training data, the network learns to complete specific tasks.

Neuronal networks consist of three fundamental layers:

- The input layer
- (Potentially) one or more hidden layers and
- The output layer

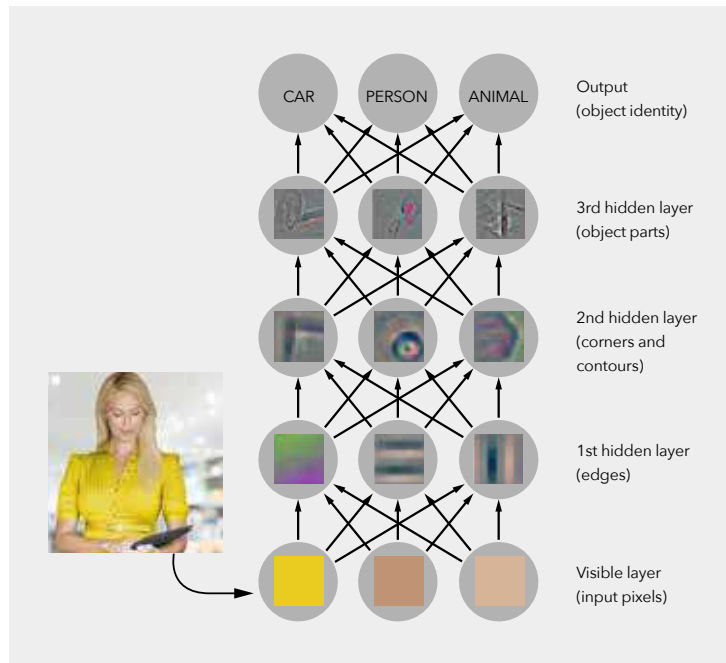
Example: It is relatively difficult for a computer to register the significance of a photo at first glance in the same way that humans do. Discerning a meaningful shape from a group of pixels is a highly-complex task, which it is almost impossible to do directly.



In deep learning, the neuronal network breaks up the image into many partial images, each of which is processed by one layer, for example edges, corners, contours, etc. So, for example, the first hidden layer might detect edges by comparing the brightness of adjacent pixels and pass this information on to the second hidden layer, which then searches for corners or contours (after all, these are nothing more than a group of edges). Based on this information, the third hidden layer then looks for groups of corners and edges that are typical of a specific object, etc., until a certain object is finally identified. ▶

Each connection between the nodes is assigned a weighting, and this is modified in the course of the learning process. A positive weighting means that a neuron is exercising an excitatory influence on another neuron, while a negative weighting means that the influence is inhibitory in nature. Where the weighting is zero, a neuron is not exercising any influence on another neuron. Just as in everyday life, where we might not notice a mosquito sting or a tick bite, the neuronal networks also require an "activation function" that eliminates the smallest values and concentrates on the inter-relationships that are actually significant.

In the example above, the "pixel value" to the right of the image (input value) corresponds to the category value "person" (output value). If the output value generated by the neuronal network does not correspond to the category value, a signal with an error message is sent back into the network. In consequence, the weighting values are changed and a new attempt is made. Over time, these small changes in the weightings accumulate so that the network learns to translate a pixel value presented to it into the correct category value. ■



2.4 COGNITIVE COMPUTING

Some authors cite a further variant of AI: cognitive computing.

This is understood as systems that take over specific tasks or make specific decisions as assistants or in place of humans, for example in claims management for an insurance company or in diagnostics at a hospital.

These systems can handle ambiguity and vagueness, and have a high degree of autonomy within their area of knowledge. ■



ARTIFICIAL INTELLIGENCE IN LOGISTICS

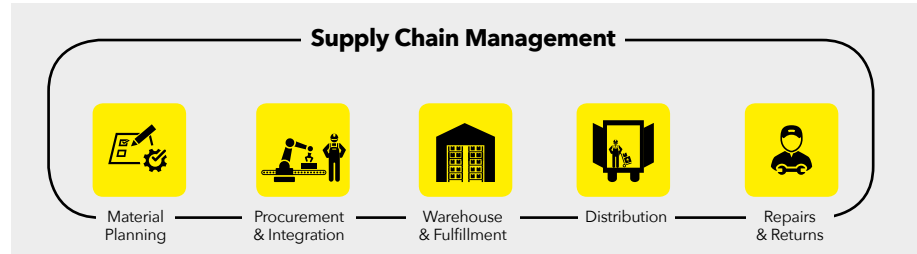
In a 2016 study carried out by Crisp Research AG among IT decision-makers, the logistics sector was found to be one of the sectors with the greatest number of companies already making active use of machine learning processes.

Current status of industries in the implementation of machine learning (n=168)

Sector	In evaluation/ planning	Initial experiences & prototypes	Being used in selected sectors	In productive operation in broad sections of the company
Automobile and automotive supplier	60 %	20 %	0 %	20 %
Machine and system engineering	52,9 %	17,7 %	29,4 %	0 %
Chemical industry	30 %	40 %	30 %	0 %
Metalworking industry	38,5 %	46,2 %	15,4 %	0 %
Consumer goods and trade	18,8 %	43,8 %	25 %	12,5 %
Logistics and transportation	16,7 %	41,7 %	41,7 %	0 %
Bank and insurance	28,6 %	33,3 %	28,6 %	9,5 %
Professional services	38,5 %	23,1 %	30,8 %	7,7 %
Pharmaceuticals and healthcare	22,2 %	55,6 %	22,2 %	0 %
IT, telecommunications, and media	11,8 %	47,1 %	26,5 %	14,7 %
Public sector and education	27,8 %	44,4 %	27,8 %	0 %



This is perhaps partly due to the fact that the change in background conditions became noticeable at an earlier stage in the highly-competitive logistics sector than in other industries due to the changed requirements (e.g. e-commerce) and associated rapid digitalization, along with the new business models based on this. The logistics sector has to contend with the ever-more critical competitiveness factor and has had to grapple with numerous new challenges over the years. These challenges are made all the greater by the ever-more expansive promises made by the online providers and the resulting increased expectations of end consumers, such as same-day delivery and constant goods availability, even in over-the-counter trade. Added to this, there is an increasing trend for ordering small quantities at higher frequency.



These developments call for the reorganization of logistics companies' existing business models and strategies. One answer to this is the large-scale automation of all logistics processes and their integration into and management by a standardized IT system. Such a system, however, is still based on inputs from human operators, even if individual process steps already run largely autonomously due to the integration of sensors, etc

This is where the phenomenon known as the "curse of dimensionality" comes into play: as the size and complexity of logistics operations increase, or with the necessity for time-critical decisions, even previously established mathematical optimization algorithms fail. The time frame in which to reach a decision becomes shorter and shorter, while the size of the problem simultaneously increases.

Through the use of AI technologies, logistics providers are not only able to differentiate themselves from the competition, but also to increase their returns. Intelligent analysis of the data volumes that arise at all stages of the supply chain makes it possible to detect previously unseen inter-relationships, develop realistic scenarios for the near future and design the overall flow of goods to be much more agile and less susceptible to disruption.

Even today, AI technologies are being used in a range of applications. These are often as yet isolated solutions, but the trend is clearly towards integration.

Manish Chandra and Anand Darvbhe of Accenture Strategy even believe that "the use of AI in the supply chain will ultimately result in an eco-system where different value chains are linked to one another and enable the seamless flow of products and information from one end to the other".

In the following section, we present some of the fields within the logistics sector where artificial intelligence is currently being used. The examples do not claim to be exhaustive, but are intended primarily to highlight the potential offered by AI technologies. ■

3.1 SIMULATION

When it comes to planning logistics systems and processes, simulations have played a central role for many years.

Simulation models determine results by assessing the dynamic behavior of a system for set parameters. Due to the inter-relationship between the output quantities and parameters of a logistic system that is often not completely apparent, manual optimization is difficult or may only be possible for the use case in question, without any claim to general validity.

The area of simulation has recently received a boost with the concept of the “digital twin”. The almost identical offline representation of a particular system, along with suitably comprehensive data input, enables AI-based algorithms to learn, continue learning and re-learn in the event of changes in the logistics environment.

The option of training AI using virtual models, given suitable model quality, now links an existing, mature and recognized technology, in the role of enabler, to the enhanced potential of computational science. Depending on the task, various problem-solving approaches are available here (i.e. FEM/CFD, event-oriented, system dynamics, agent-based). ■

In the case of manufacturers of intralogistics systems, AI can also access the data from many past tasks, whose parameters are similar to those of the current problem.

Once again, it is the case here that a suitably large, representative data volume that does not run the risk of overfitting is the basis for learning success.

3.2 OPTIMIZATION

Another area in which AI is already being used is in optimizing logistics processes so that they are able to adapt independently and dynamically to changing market requirements.

For example, this might include adapting order processing in line with seasonal fluctuations, but also patterns in ordering behavior that would not be apparent to a human analyst at first glance. “Conventional” optimization always starts from a set, unchanging objective (target function). However, this constraint must be eased in modern logistics, as what is the optimum changes depending on the customer’s business. ■

3.2.1 “H” AT HITACHI: AI ISSUES INSTRUCTIONS FOR WAREHOUSE EMPLOYEES

Japanese electronics group Hitachi developed an AI technology called “H” that was adapted for various application ends. “H” is an AI version of Kaizen, the continuous improvement of working processes.

The AI system analyzes how the employees deal with problems. Although they frequently operate within the narrow framework of clear instructions, the employees are constantly looking for possible ways to improve their workflow, even if these improvements are only minimal. “H” collects information on this and evaluates the efficiency of the individual approaches. If a particular approach helps to increase efficiency, it is analyzed in greater depth and then passed on to other employees as a work instruction.

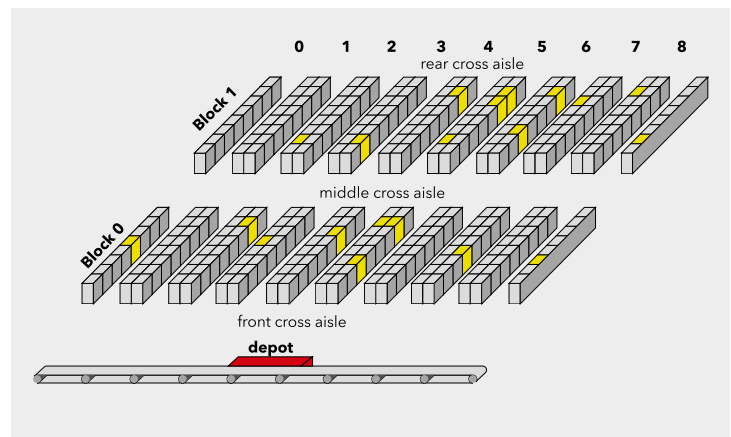


At the same time, “H” is able to react to short-term changes and to issue instructions for events arising from specific situations. The AI can also incorporate weather data and fluctuations in demand into its analyses. By way of example, a period of poor weather can lead to delays in the arrival and departure of HGVs; at the same time, the demand for waterproof clothing may rise.

“H” operates without any prior feedback from a human supervisor. The AI system issues its instructions directly to the employees or to connected systems. This enables a rapid response and measures to increase efficiency can be implemented without delay. By using “H”, Hitachi claims to have increased productivity by 8% compared to similar warehouses without AI. ■

3.2.2 ZALANDO: ROUTE OPTIMIZATION WITH DEEP LEARNING

A central problem with picking in warehouses is calculating the optimal routes for the pickers. At Zalando, a neuronal network was trained to ascertain the shortest picking routes. The AI algorithm produces a solution that makes it possible to allot the picking work between the employees more effectively and to accelerate the picking process.

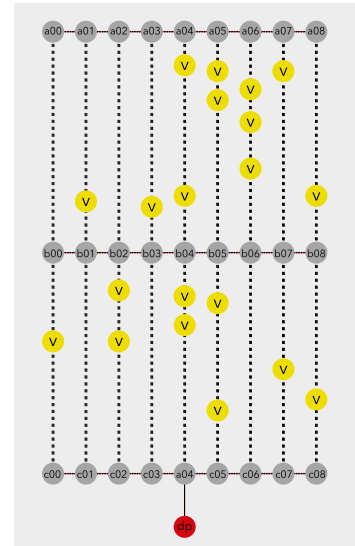


The initial assumption was a simplified warehouse where the items to be picked lie on racks configured parallel to one another. There are longitudinal and transverse aisles between the racks. The picker receives a picking list and moves along the racks with a carousel carrier to remove the required items from the racks. In principle, the combination of a picking list and a route is a more complex variant of the traveling salesman problem.

The OCaPi algorithm (optimal cart pick) developed by Zalando’s IT experts not only considers the employees’ routes, but also the paths of the carousel carriers, which are sometimes parked in transverse aisles while the employees collect items from the racks. In doing so, it comes up with the shortest route. ▶

Unfortunately, the OCaPi algorithm takes several seconds to calculate the optimal picking list. Since Zalando receives thousands of orders every hour, this is too long to be practicable. In order to bring this time down to a few milliseconds, a million random picking lists were generated and labeled with their calculated picking time using OCaPi. These data were then fed into a neuronal network. In this way, a network architecture was developed that is able to calculate travel times with an error rate in the region of just over 32 seconds per hour, a negligible value.

To test the AI system, a simple optimization algorithm was written that starts with 40 orders of 2 items each, randomly divided between two picking lists. For 40 orders, there are approximately 69 billion possible ways of dividing the items into two picking lists. The routes calculated by the AI resulted in an 11 percent reduction in travel time per picked item. ■



3.2.3 AI AND AUTONOMOUS ROBOTS

Today there are warehouses whose operating principles can no longer be understood by human observers - because they are managed by an artificial intelligence. Their shared characteristic is generally robots, and particularly automated guided vehicles (AGVs). In these warehouses, products are no longer grouped by category and simply positioned next to one another, as we are familiar with from supermarkets, for example. Instead, they are stowed in various racks and aisles in what appears to be a chaotic fashion. What would mean unnecessary travel and search times for a human picker is no problem for the autonomous robots: **when an order is received, the first available robot picks up the item that is stored closest to its position and conveys it to the human packers at the end of the warehouse.**

The robots themselves are not particularly “intelligent”, but the underlying AI system certainly is. It treats the warehouse as a constantly moving quantity with constantly changing parameters, from the demand for specific products to the current position of each robot. If robots from Kiva Systems are used, the geography of the warehouse also changes constantly, as these robots do not take individual products to the packer, but instead the entire rack.



Another approach is to use intelligent self-driving vehicles. Swarms of AGVs, which are able to perceive their environment independently of one another using laser scanners, sensors and RFID chips, navigate autonomously to their respective destinations. Without a central control system, such AGVs control the distribution of incoming transport orders themselves, establish rules in order to find the correct route and share their position with each other. As each AGV processes the information in a decentralized manner, in practical terms control is shared among multiple vehicles. If obstacles occur or in the event of a disruption, the swarm reacts independently and solves the problem. ■



AI-controlled KIVA robots in action

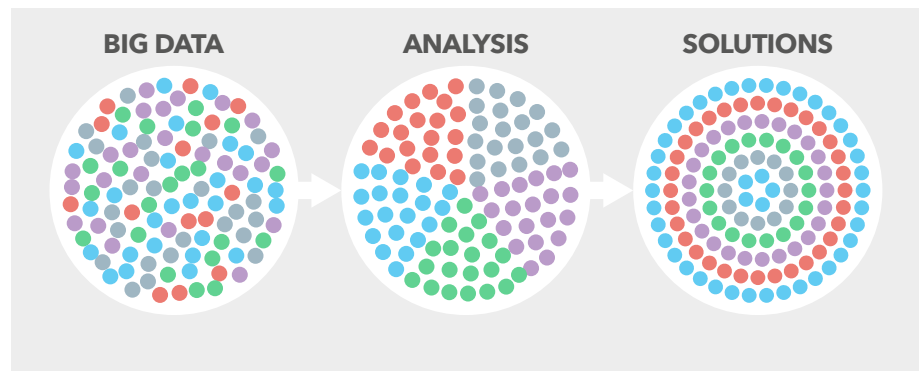
3.3 PREDICTIVE ANALYTICS

Today, big data technologies are elements within an agile supply chain. Only by using these technologies has it become possible to process the huge quantities of data generated - for example by sensors - to depict the real world there and then and to make sound decisions. Big data technologies enable forecasts and sophisticated scenario analyses and, in this way, permit precise capacity planning and the optimization of supply chains and inventories.

Predictive analytics is based primarily on data mining, a traditional area of use for artificial intelligence. It is a matter of detecting patterns in data volumes. This involves using statistical calculations, potentially elements of game theory, semantic processes and operations research methods.

The preliminary stage of predictive analytics is known as descriptive analytics; the subsequent stage goes by the name of prescriptive analytics, where the AI makes recommendations for action based on the inter-relationships detected.

A high level of data integrity is the prerequisite for a meaningful result. A prediction is only ever as good as the data made available to the system. This integrity is not necessarily guaranteed. In too many cases, data entry is still carried out manually and therefore contains errors, even if these are unintentional. However, particularly in logistics, the continuously generated data constitute an excellent basis for adapting the system repeatedly to the modified environmental conditions.



Although AI systems are able to compensate well for individual errors in large data volumes, if many minor discrepancies accumulate, there is the risk of obtaining incorrect results. It is therefore not merely a matter of collecting data, but also of “understanding” it from the outset.

One commonplace example is the use of different measurement units. If some data records work with the measurement unit “meters”, while others use the unit of “feet”, care must be taken to ensure that standardization to a pre-determined standard unit of measurement takes place in advance. For this, suitably qualified and experienced data scientists are required. This is a relatively new job description for specialists who are able to handle huge quantities of data and derive the greatest possible benefit from these thanks to their up-to-date IT skills, sound knowledge of the mathematical and statistical processes and accurate information about the contractee’s technical environment.

The 1986 Challenger catastrophe is a prime example of what happens when a problem is not analyzed and recognized in its entirety. Looking only at the failure measurements for the questionable O-ring, which triggered the explosion, did not provide enough information to correctly assess the risk of launching the shuttle at temperatures below 37 °F. If the data from the failures had been compared in context to the values from the successful tests, the corresponding grouping of the poor values in the lower temperature range and the grouping of the values in the upper temperature range would immediately have led the scientists to recognize the fact that temperature was a critical factor for this component. ■

3.3.1 OTTO: RETURNS CUT BY TWO MILLION DUE TO AI

Otto is a multi-channel business and one of the biggest online fashion and lifestyle retailers in Germany. The Group generates 75 percent of its total sales through online shops. It offers 1.8 million items and 3,600 brands.

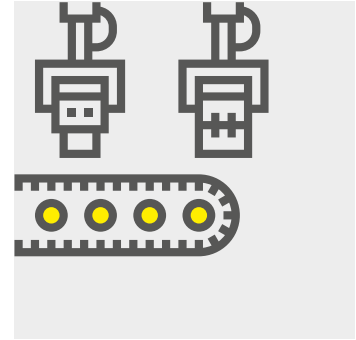
As with other e-commerce enterprises, returns result in high costs – several million euros each year for Otto. An analysis of the available data revealed that customers who received their goods within two days of ordering them return less items on average. In addition, customers prefer to receive their order in a single delivery and not split up into multiple consignments.

As Otto sells items from other manufacturers and does not hold a large proportion of these in stock, this created a difficult position: either you wait until all items for an order have arrived before sending them out in a single delivery, which generally takes longer than two days. Or you ship the items immediately after goods-in, which then results in multiple deliveries.

Otto deployed a deep learning algorithm originally developed for applications in particle physics. The AI analyzed approximately three billion data records and 200 variables, including transactions, search queries on the Otto website and weather forecasts, in order to derive a forecast for the coming week's purchases.

The AI system proved to be markedly successful. It is able to predict, with 90% accuracy, what will be sold within the next 30 days. Consequently, Otto is now able to order around 200,000 items in advance each month, and to send items more quickly in a single consignment when a customer places an order. The outcome: since the introduction of the AI system, the number of returns per year has fallen by around two million items. Fewer packages being sent out means their carbon emissions have also been significantly cut.

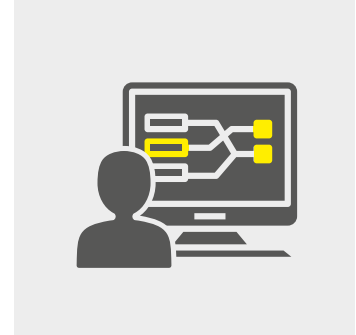
Zalando is also trialing another approach. In order to reduce the number of returns, experiments are being conducted into the issue of sizes, as it was established that a product being the wrong size is responsible for 30 to 40 percent of returns. The aim is to reduce this figure. To this end, Zalando is relying on machine learning. A start has been made with shoes. A number of men and women are trying on shoes in their size and reporting on whether or not they fit. The AI is evaluating these data and attempting to derive a pattern from them. In future, if a customer orders a shoe and generally always takes a size 39, the system should be able to say to him or her that size 40 may perhaps be better for this particular brand. ■



3.3.2 ZALANDO: A PERSONAL SHOP FOR EVERY CUSTOMER

Zalando started out as a footwear and fashion retailer, but now sees itself as a technology group that is aiming to become a service provider for the fashion industry as a whole. Consequently, the group now employs several thousand programmers.

According to a report in the Handelsblatt newspaper, the group plans to invest tens of millions of euros into intelligent algorithms over the next eighteen months. These algorithms will go beyond existing recommender approaches and create individual online shops for each customer, offering an optimized, reduced selection from the 300,000 items that Zalando brings to the market each season. ■



3.3.3 AI IN THE AIR

In large warehouses, counting and data-entry errors in the inventory of stored goods are a frequent annoyance. In the US alone, such errors are responsible for financial losses in the billions of dollars. Artificial intelligence can help to solve this problem too.

US-based company Intelligent Flying Machines (IFM) has developed a drone that does not require GPS for spatial orientation, but instead is able to move about with pinpoint accuracy in an enclosed space using AI algorithms. The camera records the items and their position, then the data are compared with the warehouse management system (WMS). Intelligent algorithms form the basis for this solution. ■

3.4 FROM PREDICTIVE MAINTENANCE TO PRESCRIPTIVE MAINTENANCE

In order to move closer to the requirement for (almost) completely reliable hardware for a high-performing warehouse operation and to prevent production downtime, AI technologies are also used to predict the (remaining) service lives of machines and systems. Predictive maintenance is used to detect the forthcoming failure of an item of operating equipment and to initiate preventive measures to forestall this. There are four pillars of predictive maintenance:

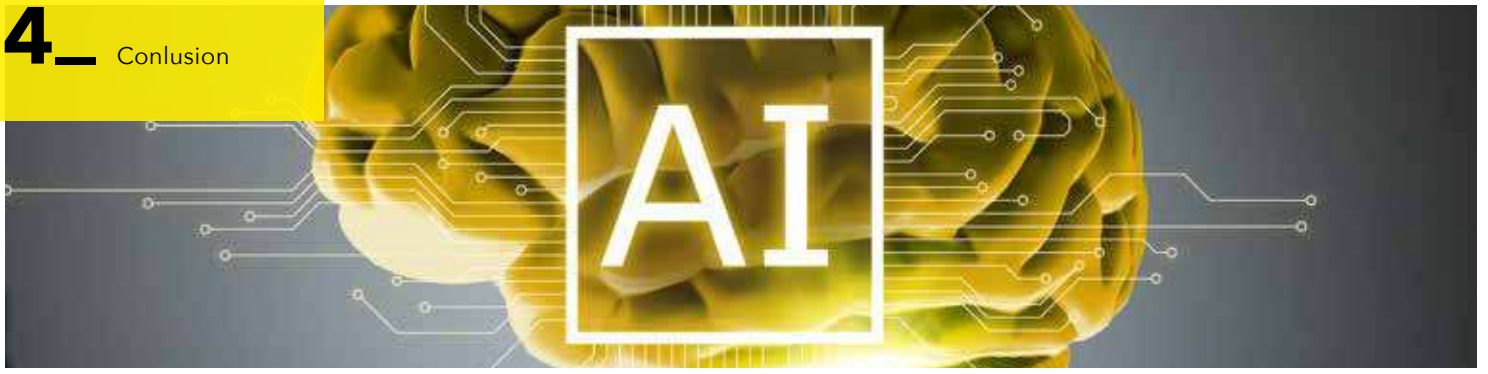
- **Data acquisition**
- **Data transfer**
- **Data evaluation**
- **Measures to maintain functionality**

For reasons of cost, in most industrial installations, data acquisition still takes place through tests and servicing work. However, due to the falling costs of sensors and data transfer equipment, digital monitoring in real time will become established. The data acquired are collected centrally and can be evaluated looking at various aspects. Where there is a likelihood of problems arising, it is then possible to initiate the necessary measures in good time, in order to prevent a malfunction or a long period of system downtime.

Suitably-trained AI systems are already able to provide assistance here, particularly when it comes to analyzing the flood of data. In order for predictive maintenance to function correctly, all relevant movements of the components under consideration must be recorded and saved, including the associated parameters. The factors influencing operational reliability vary depending on the device under consideration. With a dock, for example, these factors are each opening and closing event, together with the actions of all components involved, from the control system to the pressure cylinder and roller wear.

Building on this, the next step is then prescriptive maintenance. Based on a prediction of the next malfunction, the service date and time, the relevant personnel and, ideally, also the spare parts to be supplied, are proactively scheduled for an off-peak period. This plan may go so far as to influence the parameters for the equipment in question so that movements could worsen the damage are no longer executed with full power, but rather as carefully as possible with optimal use of the infrastructure, in order not to trigger a malfunction prior to the scheduled maintenance date.

Moreover, it would be incorrect to assume that it is a case of solely relying on the sensors. Modern sensors and the linking of sensors makes it possible to detect incorrect sensor values and for the AI to interpolate these in combination with other measurement values. However, the problem is not always the machine - the sensor itself may have a fault that does not necessarily have to lead to scheduled downtime. ■



CONCLUSION: HOW AI CHANGES THE VALUE CHAIN

It can already be said with certainty that the use of AI will have a tremendous impact on logistics processes at all levels in the coming years. The examples cited demonstrate the extent to which AI is already in use in the logistics sector at present.

Many experts believe that AI technologies will have impacts on the following areas in particular:

- **Productivity:** AI significantly increases productivity in the warehouse, particularly for online retailers, due to the automatic computation of better solutions.
- **Communication:** Warehouse employees and supervisors have to communicate with one another promptly in order to respond to changes or disruptions. Networked robots controlled by AI ensure almost simultaneous and error-free communication and so help to increase productivity.
- **Warehouse management:** In just a few years' time, large areas of warehouses will be completely automated. AI technologies are increasingly becoming integral components, particularly in relation to short and medium-term forecasts.
- **Personnel costs:** More effective use of personnel thanks to AI-controlled resource planning leads to lower personnel costs or higher reliability thanks to the formation of reserves, to be used in the case of staff sickness, for example.
- **Robotics:** Robots controlled by AI significantly reduce picking times.
- **Warehouse stock:** AI technologies lead to a reduction in warehouse inventories and faster cycle times.

What is more, in DHL's Logistics Trend Radar study, two overarching trends can be seen that are only made possible by the use of AI:

- **Anticipatory logistics:** The forecasting of demand trends has effects on the entire supply chain, from manufacturers, who are able to ramp up production, to transport businesses that can have the appropriate number of vehicles in readiness, through to the retailers, who can order and store appropriate stocks in advance and adjust their personnel planning in response to the predictions. What is more, anticipatory logistics make it possible to detect risks in the supply chain at an early stage, from the likelihood of a vehicle or a machine malfunctioning through to seasonal waves of illness with impacts on staffing levels.
- **Self-learning systems:** Machine learning is used to read handwritten documents (e.g. labels on letters or packages) and to detect recurring events in the warehouse or during picking, which can then be incorporated in specific picking rules. Prompt automatic reordering of items in the appropriate quantities can also be optimized using self-learning algorithms.



However, in many cases the examples cited here are still isolated solutions that also require a high level of outlay in terms of processing power and programming, with the need for major investment in personnel and technology. For this reason, it will not be cost-effective for medium-sized enterprises, in particular, to establish their own AI departments. However, there are experienced external service providers that can provide appropriate services.

We should never lose sight of the fact that, in an integrated supply chain, the storage system must be able to respond to the information output by the AI, as otherwise all that is being created is another stand-alone solution. **Gradual integration of AI technologies into a comprehensive and scalable logistics software system therefore appears to be the best strategy at present.** By proceeding in this manner, disruption will largely be avoided and additional elements can be incorporated in the system step-by-step.

This approach will also ensure that control of the system is not lost. Furthermore, there should always be fallback strategies for unforeseeable changes. Only in this way can the ongoing operation of the warehouse be guaranteed. ■



WAMAS® Lighthouse from SSI SCHAEFER is a central information platform that analyzes and visualizes the entire supply chain. Using a number of dashboards, it is possible not only to view current performance data for the logistics systems and processes at any one time, but also to draw up and run scenarios based on integrated AI algorithms.

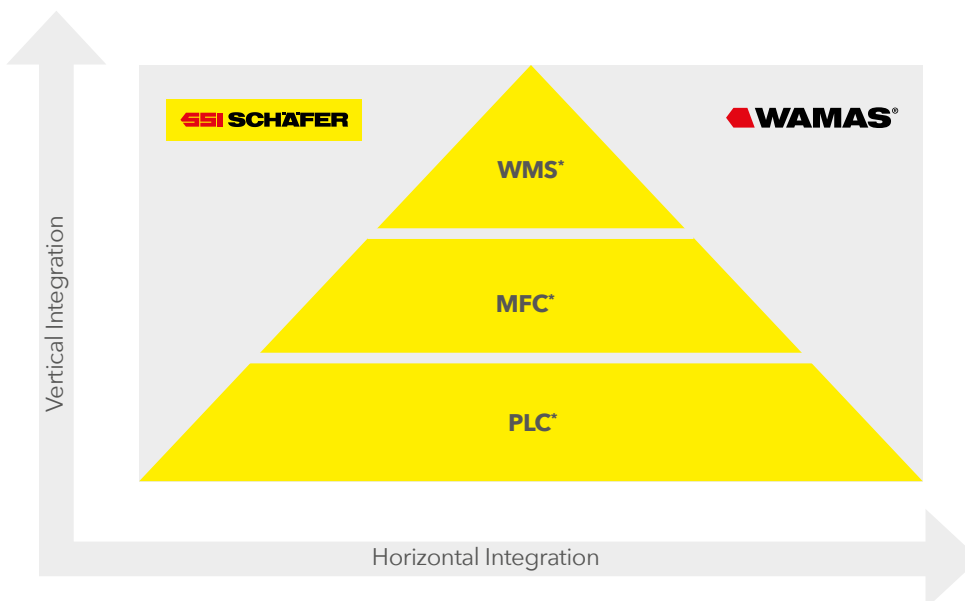


THE APPROACH TAKEN BY SSI SCHAEFER

An integrated approach is necessary, particularly for warehouse technology. Although developments such as Industry 4.0 use decentralized control as a fundamental approach, optimization procedures that are controlled in a decentralized manner, i.e. local machine or installation-specific procedures, must also form part of the integrated process and be harmoniously aligned with each other.

But, how can this work if components or sub-systems originate from different manufacturers, suppliers or partners? What restrictions arise automatically if it is not possible to provide the necessary feedback due to interface or functionality problems, particularly in the case of procedures based on supervised or reinforced learning? And last but not least: how efficiently can AI be used if the respective approaches of the individual manufacturers/suppliers are not sufficiently known to be aligned with one other?

SSI SCHAEFER is the only intralogistics provider offering the option of horizontal and vertical integrability of all components and system parts as the basis for implementation of new technologies: ▶



*WMS (warehouse management system), MFC (material flow computer), PLC (programmable logic controller)

This integrated world of hardware components and corresponding software tools is a basic prerequisite, not only to allow individual machines within the flow of goods to learn from each other, but also to be able to simultaneously evaluate the joint overall success of the intelligent (local) control systems through feedback from the higher-level systems.

This also opens up the possibility of using this enhanced technology for targeted positioning of the relevant algorithms and approaches. The motto "local as much as possible - central as little as necessary - all WITHOUT any loss of quality or performance" is the guiding principle for the targeted positioning of appropriate forecasting, prediction, decision-making and other decision-support tools where they make the most sense and bring the greatest benefit.

What is more, this integrated approach has an advantage in the event that an AI is faced with a completely new situation that it has not yet learned. In such a case, it is then possible to fall back on existing conventional, validated and established strategies from the world of WAMAS® for decision-making.

However, notwithstanding all the technology, the benefit for the customer in terms of an optimal, more flexible and more dynamic warehouse operation will be what decides the success of any new development. ■

Legal Notice

Whitepaper

Artificial Intelligence in Logistics

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