CIM LOGISTICS SOFTWARE SPECIALISTS

White Paper

Data, analytics and artificial intelligence in warehouse management

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Contents

The significance of data in WMS systems

Data is an extremely powerful driver behind the decision to invest in a warehouse management system (WMS). Traditional list-based tools or WMS functionalities integrated in enterprise resource planning systems offer no or only limited optimisation potentials once intralogistics have reached a certain level of complexity. Specifically, the data entered is seldom used to enhance intralogistics processes. For this reason, manufacturers of WMS systems underscore the high optimisation potential offered by their software. Such potential can be found in accelerated goods issue, routing options or picking sequences, for instance. However, this potential can only be identified by correctly using the data for the relevant processes.

For software-driven warehouse management, it is essential to analyse, structure and utilise data. Software manufacturers apply methods such as data mining or data analytics to make the best possible use of the available data. Useful knowledge can be extracted by analysing large amounts of data, such as customer data or process data.[1] Data analytics applies statistical methods to explore, visualise, discover and make sense of patterns and trends in the data. The goal is to generate a competitive advantage for the company in question or its customers.[2]

[1] Sedkaoui, Soraya. Data Analytics and Big Data, John Wiley & Sons, Incorporated, 2018; page 44.

[2] Cleve, Jürgen and Lämmel, Uwe. Data Mining, Munich: De Gruyter Oldenbourg, 2014; page 2.

Two types of data collection in intralogistics

In practice, a great deal of effort is put into generating as much accurate data as possible about company articles, load units, storage types, and so on. There are two main types of data collection in intralogistics.

Generation of **static data records**

The first type is for static data that digitally maps an intralogistics company. Digitalisation in intralogistics is a practical development for activities previously performed in the warehouse using pen and paper. Today, articles and load units are digitally mapped in the warehouse using computers, scanners and mobile data entry devices. To optimise data quality and workflows, some manufacturers automate this process with purpose-built equipment such as drones and image recognition systems. The data generated is collated to represent intralogistics processes in digital form for the warehouse management software.

Aside from warehouse layout and storage structures, the bulk of the data is article master data containing information about the existing load units and articles. This may include the properties of articles in storage, specific rules for storage and shipping, information on the minimum shelf life, and so on.

Basically, the more detailed and up-to-date the master data, the higher the data quality and the greater the WMS's potential for optimisation.

Generation of live data

The second type of data collection focusses on live and history data, more specifically data generated while intralogistics process are running. All transactions in the warehouse are registered by the WMS since the system is responsible for steering these transactions.

For example, if an article is placed on a shelf, this is communicated to the software when the barcode is scanned. Activities of this kind generate live data during operation, which the system saves. The WMS records the amount of time taken for picking, how long it takes until the shelf is reached or which type of article is being transported. History data is created when the information is saved and can be used to make warehouse transactions visible retrospectively.

WMS manufacturers can use live and history data to optimise their intralogistics processes by searching specifically for connections and clusters in order to draw conclusions and on the basis of which decisions can be made.

While other industries have only just begun to generate data through advertising trackers, customer surveys and so on, logistics companies using professional warehouse management already have huge amounts of data at their disposal. The extent to which these are exploited depends significantly on the warehouse management system used. Most WMS system manufacturers spend vast amounts of time implementing logic to make fuller and better use of this data.

Optimum use of data as a key task

It's safe to say that data analysis is one of the core activities for manufacturers of intralogistics software. This is often forgotten due to the challenges many WMS manufacturers face when implementing their systems.

They tend to focus on the processes that users want to have integrated into or that need to be adapted to the software. System handling is also a major factor in practice. The interface between humans and software – the user interface – often requires intensive training measures, especially if the user interface has not been designed intuitively.

Another important process that happens actively on site is digitalisation and transfer of warehouse data. Understandably, users tend to lose sight of the fact that the data obtained in this process is of immense value in intralogistics.

It takes a high level of expertise to recognise the data's potential – the onus is on WMS manufacturers to realise this potential and implement it in their software. Ideally, users should not even notice this.

Data analytics in intralogistics

From the user perspective, the goal of a WMS system is to achieve optimum, smoothly operating intralogistics processes. From the developer perspective, however, the focus is firmly on generating as much data as possible and using the existing data effectively.

Keywords such as data mining, big data, data science and data analytics may not dominate marketing jargon in the industry, but they do describe an essential area of activity. Data analytics is the process of using computer-assisted methods to specifically identify relevant and influential patterns in data records and to use these for a specific purpose.

Below, we'll take a look at three types of data use that are common in intralogistics, namely descriptive, predictive and prescriptive analytics, which will be explained using best-practice examples.

In addition, it is important to look at the statistical methods used and the question of what the whole thing actually has to do with artificial intelligence.

Descriptive analytics – processing history data

Optimisation opportunities in intralogistics often have to be made visible before they can be implemented. Business intelligence tools are used for this reason to provide support. They help with decision making, which is why consulting firms sell them at a high price.

Professional WMS providers, on the other hand, integrate business intelligence tools into their software with graphic functionalities so that they can be consulted in day-to-day warehouse and production operations. The analyses and collations produced by these tools are based on the data available in intralogistics. The above-mentioned history data plays a pivotal role in this context[3] and is used to improve system usage or make business decisions.

In very concrete terms, for example, the key performance indicators for the material flow data in a warehouse can be analysed, including throughput times, inventory changes or picking times. Business intelligence tools access the collected data, analyse it, display it graphically if needed, and underline flaws or optimisation potential in the warehouse.

This type of data analysis is called descriptive or diagnostic analytics. It uses historical data to make diagnoses and describe conditions. It is important to note that the diagnosis is usually not made by the tool itself, but by humans. Descriptive analytics simplifies decision-making by making metrics easy to grasp.[4]

[3] Cf. Abbot, Dean: Applied Predictive Analytics: Principles and Techniques for the Professional Data Analyst (Wiley, 2014). page 3. [Predictive Analytics]

[4] Möller, Frederik; Hompel, Michael ten (publisher) e.a.: Bedeutung von Daten im Zeitalter der Digitalisierung (Whitepaper). In: Future Challenges in Logistics and Supply Management, Fraunhofer IML publication series (4/2017). page 14. [Whitepaper Daten]

Best-practice application:

Business Intelligence based on PROLAG World

The **PROLAG World WMS** suite uses history data for its integrated business intelligence tool, and the dashboard processes and displays live data coming directly from warehouse operations.

Personalisation of the dashboard for each individual employee has proven to be particularly valuable in practice, meaning that relevant key performance indicators, quality indicators and structural data can be displayed quickly and easily for use in trend analysis.

PROLAG World dashboard displaying historical and live data on warehouse operations.

Predictive analytics with live and history data in resource management

Predictive analytics is no longer just about collecting and processing existing data. The goal is rather to make the most accurate forecast possible about the mediumterm and immediate future. An application based on predictive analytics accumulates the frequencies with which certain data points have been considered and automatically derives a probability analysis for the future.[5]

Given the quantity of data that is constantly generated and available during live operation, it is simply no longer possible for humans to perform this task. Predictive analytics can be used to calculate the probabilities of high capacity utilisation in intralogistics on certain days, for instance. Both historical data and live data can be used for this purpose.

Depending on the WMS manufacturer and software architecture, different predictive analytics methods are used. These methods are usually based on an algorithm capable of make a prediction about the immediate future based on previous data. Sophisticated WMS systems have already been using this kind of logic for a long time, for instance in resource management, where probabilities play a role.

Based on past data, the required capacities in goods receipt for the coming days and weeks can be planned accordingly to prevent bottlenecks. Seasonal data providing information about increased volumes of specific articles can also be used for forecasting based on predictive analytics.

[5] Cf. Predictive Analytics, page 3ff.

Best-practice application:

Forecasting in intralogistics using PROLAG World

The **PROLAG World** warehouse management system constantly tracks the picking times required by employees in their daily work. The software uses the data generated in this way to make different forecasts based on stored logic. This means that predictions can be made about the picking time for specific article groups as early as the order entry stage.

This data is extremely important for planning manpower and making business intelligence decisions. In particular, the end-of-working-day forecast calculated from the data has a high practical relevance for shift planning in the warehouse.

Continuous tracking of picking times in **PROLAG World** is extremely useful for accurate warehouse forecasting.

Prescriptive analytics – data usage in putaway

Data can also be used for prescriptive analytics. As the name suggests, this type of data usage is no longer intended to merely describe a condition (descriptive analytics) or to predict (predictive analytics), but to result in a concrete proposal for action.[6]

A complex system of logic capable of distinguishing at least two possible decision paths based on data input is required to achieve this goal. The complexity of the underlying algorithm depends very much on the required scope of services. Existing definitions of prescriptive analytics speak of models that themselves make a prediction, on the basis of which a decision is recommended or even carried out. These models often require deep learning methods using artificial neural networks, which we will discuss later.

ABC models are examples of less complex but nevertheless sophisticated solutions usually not capable of making predictions about the future. Given defined data points, however, they are capable of making a required decision and having it implemented. This is not artificial intelligence in the strict sense, rather the logical description of previously defined parameters with real-time data.

It is important to note the difference in method: Prescriptive analytics does not necessarily need to rely on artificial neural networks. Often, human data analysts define the parameters for an algorithm so that the logic essentially does what has already been defined. This is possible both with machine learning (supervised learning) and without machine learning. In both cases, the analysis of data records is used for decision-making.

[6] Cf. Cote, Catherine: What is Prescriptive Analytics? 6 Examples. In: Harvard Business School online. ***https://online.hbs.edu/blog/post/prescriptive-analytics*** (Last accessed on: 11/04/2023).

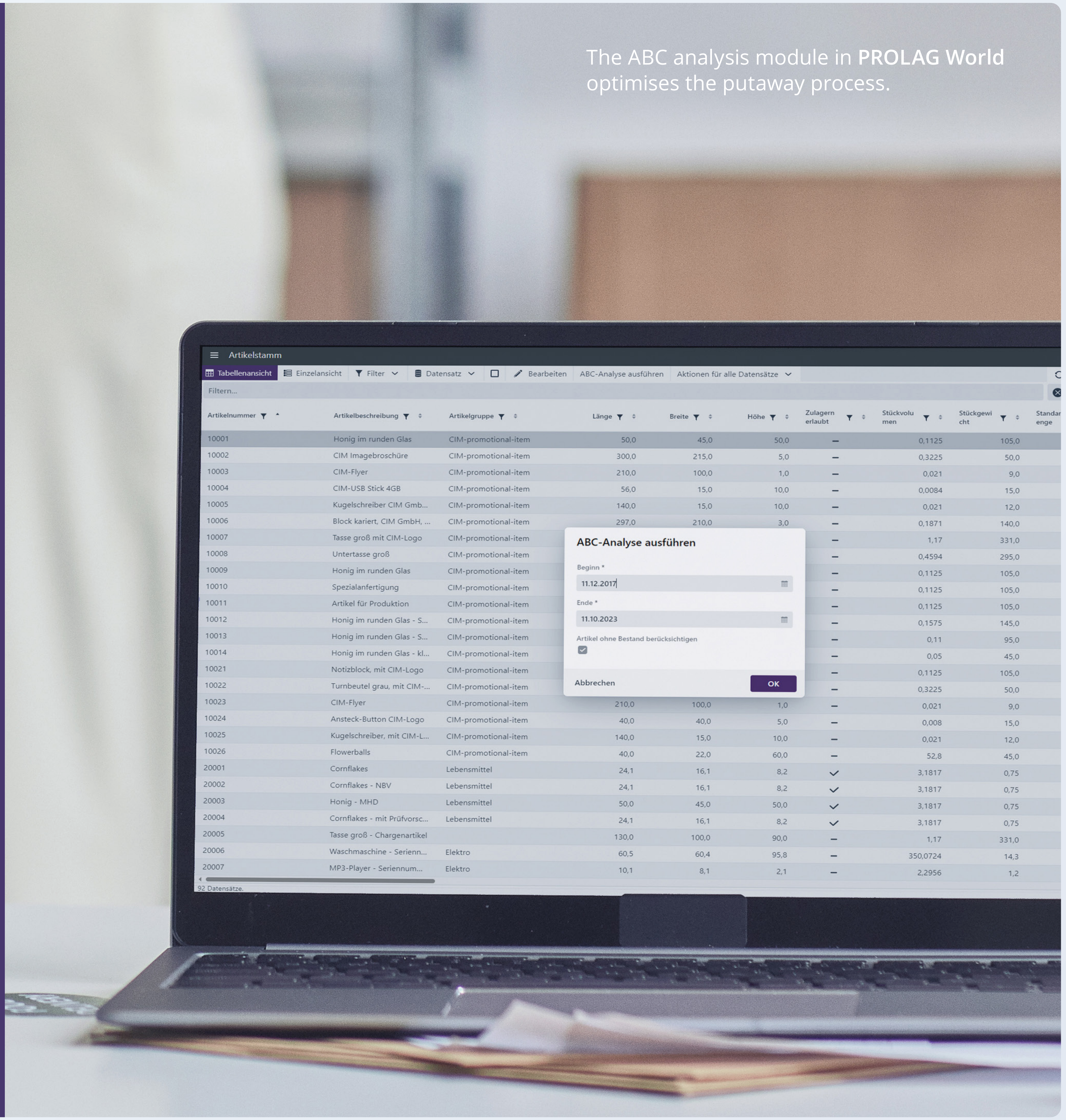
Best-practice application:

Prescriptive analytics in putaway with PROLAG World

CIM’s intralogistics suite **PROLAG World** includes a module called ABC analysis for enhancing putaway efficiency.

ABC analysis generates the best possible storage locations based on predefined parameters in the article master. In simple terms, articles are positioned further back in the warehouse at ‘C’ locations or closer to the picking area, at ‘A’ locations, depending on their turnover frequency, i.e. whether they are slow or fast-moving articles.

Thanks to optimised placement of articles in the warehouse, travel times can be significantly shortened, for instance. Data analysis means that the ABC analysis can always be optimised using statistical methods to automatically transfer the article turnover times on a regular basis.



The ABC analysis module in **PROLAG World** optimises the putaway process.

Data analytics using artificial intelligence – a logical development?

Today, discussions about data mining or data analytics often imply the use of artificial intelligence.[7] This has much to do with the fact that machine learning methods are known to produce promising results with high data volumes (big data) and clearly defined parameters in data analytics.

Along with the launch of large-scale language models (LLM) by American IT corporations, media coverage has reinforced the impression that artificial intelligence is now ready for use in all areas.

Because regardless of the application, artificial intelligence always has the same starting point – its sole purpose is to independently analyse vast amounts of data, draw conclusions, make predictions and take decisions.
In short, AI does everything already mentioned in the previous section of this white paper and still frequently implemented by data analysts.

In the intralogistics sector, the expectation is that AI will sift through intralogistics data more quickly and find a greater number of improbable correlations than a human would do.[8]

[7] Cf. Whitepaper Daten, page 13 [8] Cf. Whitepaper IML KI in der Logistik

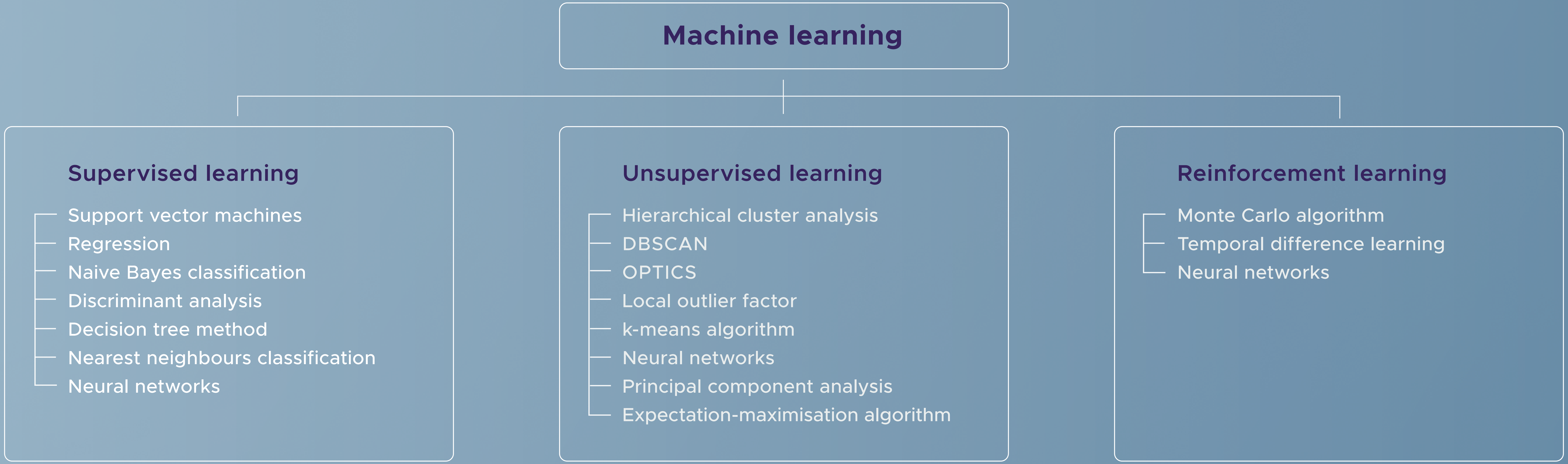


Figure 1: An overview of machine learning methods.
Source: KI in der Logistik, Fraunhofer IML; page 8.

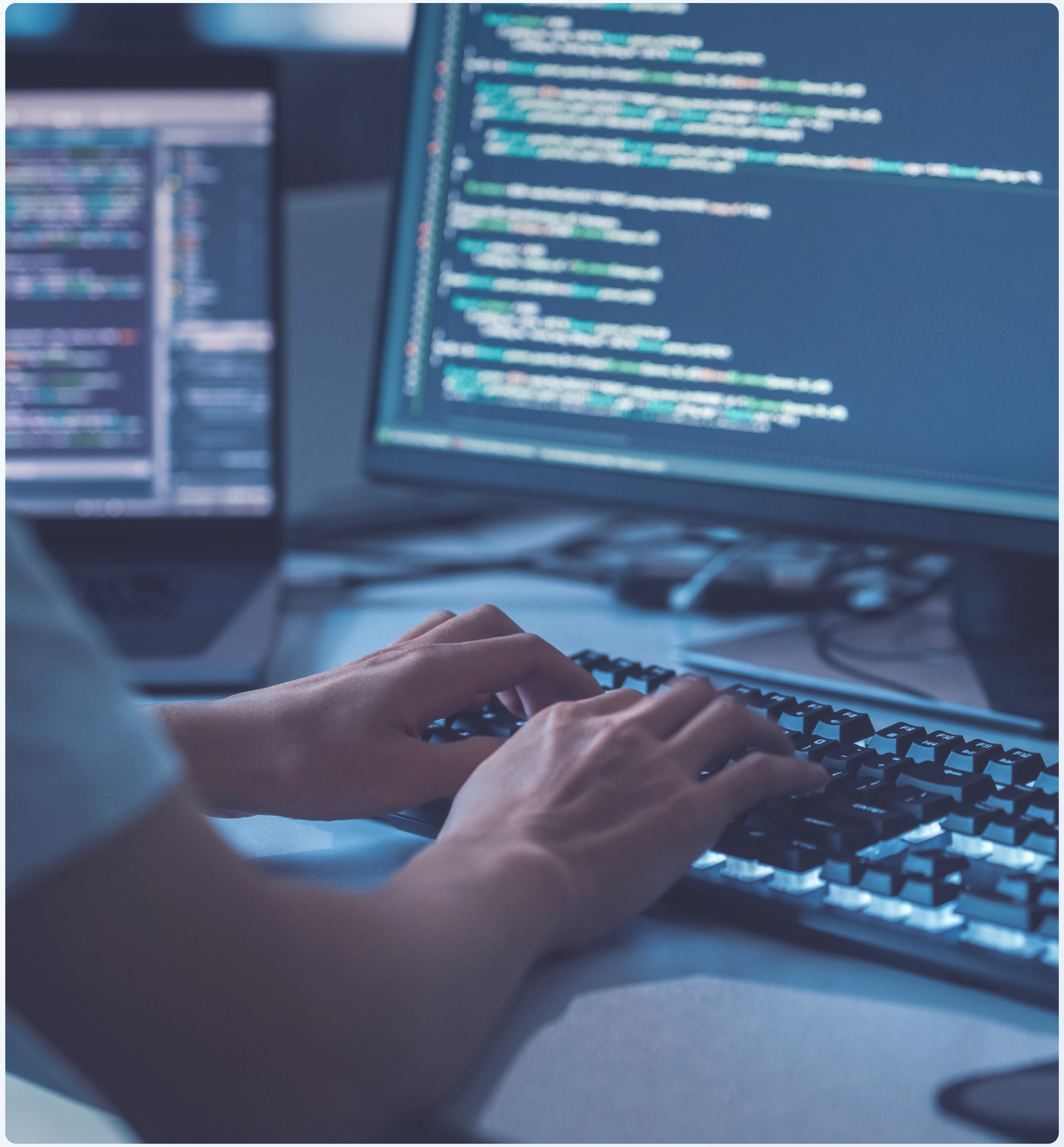
*[**Explanation:** Machine learning methods are often reduced to but are not limited to artificial neural networks. Algorithms based on linear regression also count as machine learning, for instance. Unlike neural networks, however, they are only used for the machine learning method known as supervised learning. Neural networks, on the other hand, are also used for unsupervised and reinforcement learning, which is why they are probably the best-known type of machine learning.[9]]*

[9] Cf. Whitepaper KI – Künstliche Intelligenz in der Logistik page 5-8; see also: IWML Report 06/2023: Daten. Das Gold des 21. Jahrhunderts; page 23. [Whitepaper KI]

In intralogistics, artificial intelligence methods such as deep learning based on artificial neural networks are still largely unknown.[10] This is presumably not only due to technological hurdles and the knowhow required for the development of neural networks or similar methods. Another barrier could be that the warehouse data needed for training is not available on the internet in vast quantities. Nevertheless, deep learning and machine learning are considered to be the most important focal points in development for the coming years.[11]

[10] Cf. Fraunhofer Institute for Material Flow and Logistics: WMS Marktreport Kompakt 2022. Trends und Entwicklungen auf dem Markt für Warehouse-Management-Systeme, page 22, 33. [WMS Marktreport Fraunhofer Institute for Material Flow and Logistics]

[11] WMS-Marktreport, page 33.



Conventional software and machine learning – what's the difference?

Regardless of which goal is associated with machine learning and which method is used to achieve it, one key distinction must be made between conventional algorithms and artificial intelligence methods.

Conventional software generates its output through logic within the algorithm, with the logic making decisions based on the input data. Depending on the algorithm used, statistical methods and frequencies can also be the basis for calculation.

But the fact is that an algorithm is first developed by a human. As described above, this requires data analysis, on the basis of which an analyst draws conclusions for warehouse strategies or route optimisation, for example. From the insights gained, an algorithm is formulated that uses the observed patterns and achieves the defined goal.[12] >

[12] Cf. Whitepaper KI, page 4ff.

› Methods of artificial intelligence, specifically artificial neural networks, are capable of performing this process themselves. The process is reversed as follows: Data analysts send processed data to the neural network or another machine learning method and the AI analyses the data to generate an output.

Using a system of rewards with an underlying cost function, the AI learns whether the output has produced a desirable or less desirable outcome. It adjusts the basis of the decision accordingly (meaning the logic on which the decision was made). The algorithm is the result of this learning process.

Thanks to the huge amount of data an AI uses for training, it may find other correlations between the individual data items with which it can achieve better results. The logic on the basis of which the AI develops its algorithm is correspondingly unpredictable.

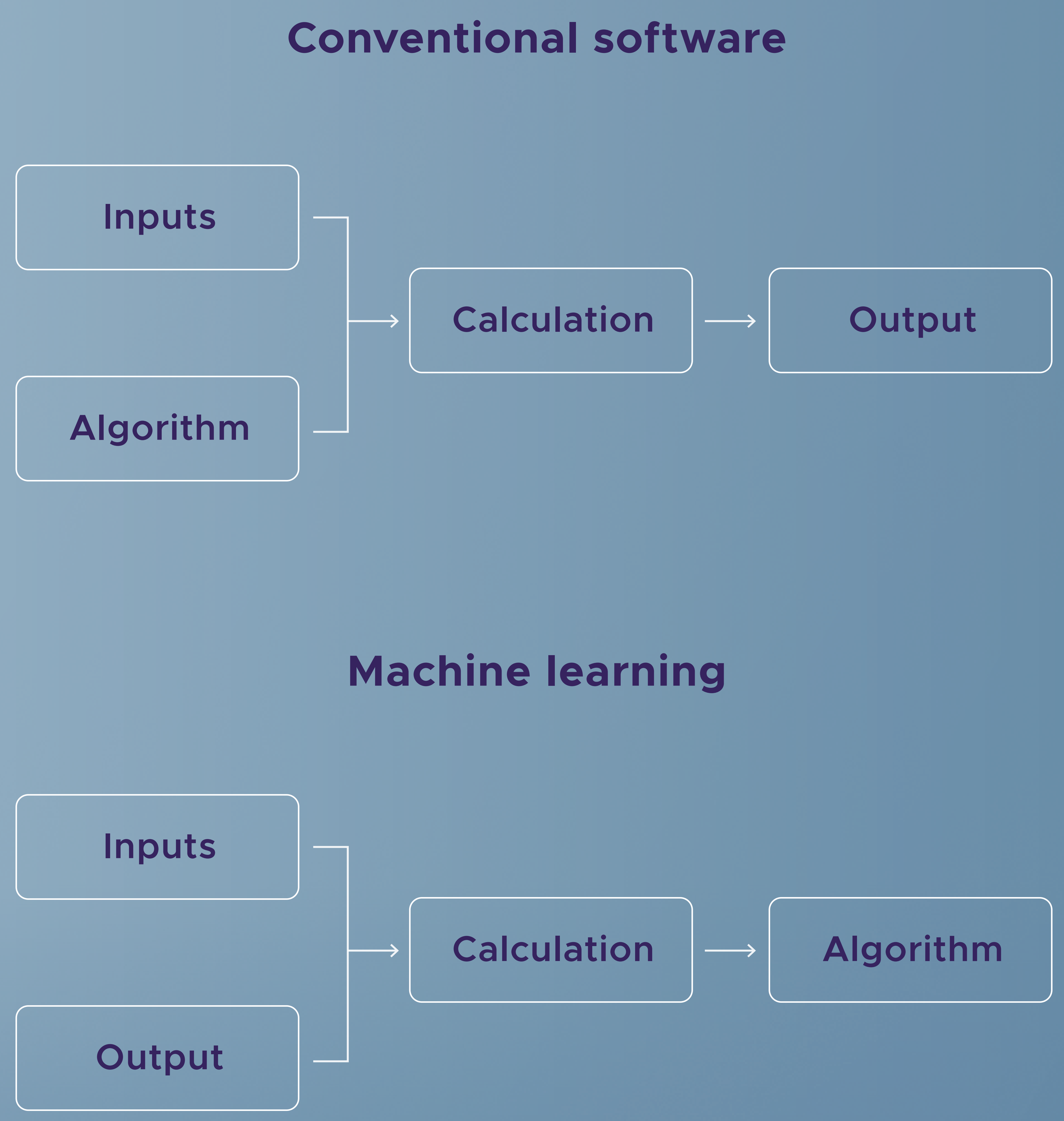


Figure 2: The difference between conventional software and machine learning.
Source: KI in der Logistik, Fraunhofer IML, page 5

Best-practice AI:

Intelligent putaway strategies through artificial intelligence

Following two years of cooperation on a dedicated research project, CIM is now introducing the "location suggestion by AI" module in its **PROLAG World** software as a market innovation. The feature offers complex intralogistics companies a high degree of optimisation by automatically assigning the ideal location to an article without having to use master data. By training with the live and history data of the relevant warehouse, the AI module is able to ideally position even single locations based on turnover frequency so that travel times are measurably reduced in goods issue. This means that logistics companies can achieve the best possible times when retrieving stock, consequently accelerating goods issue, reducing travel times, saving energy and potentially lowering personnel costs through better utilisation.

Tips for AI in intralogistics:

- AI module training becomes increasingly cost-effective as intralogistics productivity grows.
- Better results can be achieved using AI to select putaway strategies for complex article structures. Thanks to training, the AI module discovers correlations that human data analysts miss.
- The more data, the better the AI: Large intralogistics companies can more easily achieve better results using an AI module.
- Is artificial intelligence always the best choice? Contact CIM’s experts with your questions and for further information.

Conclusion – data analytics in warehouse management

The central insight from considerations on data analytics in intralogistics is that data is essential. Data may be of immense importance for some sectors, but, for WMS systems, it is the reason for existence.

Quality in WMS systems is characterised by the quality of data usage. The more effectively the available intralogistics data is used, the greater the potential for optimisation. Optimised routes, sophisticated putaway strategies and improved goods issue can be implemented using the three major analytics methods. Descriptive, predictive and prescriptive data analytics are the subsectors of data analysis relevant to intralogistics. They are of paramount importance for business intelligence tools, decision-making systems and specific automations that the WMS can perform on its own.

The best-practice applications with **PROLAG World** highlight the ways in which data analytics can be used in intralogistics. At the same time, it's clear that that professional data analysis can uncover numerous potentials for optimising intralogistics.

Thanks to **PROLAG World**'s AI module, which independently develops intelligent putaway strategies, companies with complex article structures can take the optimisation potential of their intralogistics to a new level. The points raised in this white paper also highlight the fact that artificial intelligence in intralogistics is not disruptive. Instead, its use is the result of an ongoing technological trend which has been reinforced by the use of AI: Data analysis for high level optimisation in intralogistics.

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