PerfectPattern

KAYROS

Artificial Intelligence
optimizes the Smart Factory

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KAYROS is an innovative solution for dynamic production planning. KAYROS plans sophisticated production and logistics processes using Artificial Intelligence (AI) with mathematical precision. KAYROS independently plans any kind of order pools on highly complex networks of production systems – all aiming to ensure that deadlines are met, resource consumption is optimized and overall production costs are minimized. The underlying mathematical technology is a proprietary, by PerfectPattern substantially enhanced type of reinforcement learning technology.

Complex planning problems

A production planning of 500 work steps is a symbol for 101.000 possible sequences. Determining the best planning, taking into account the machine setup costs, is a mathematical problem that cannot be solved by conventional means. Today's common automatic planning systems assign orders and work steps to the available machines on the basis of simple heuristics. The heuristics essentially rely on step-by-step planning of the individual production order; overarching influences as well as planning decisions once made, are not questioned and are not changed. Even computers with the highest performance require many hours of computing time for extensive production planning and generate only moderately useful results. The available machine resources are not even close to being used optimally, and in many cases the material consumption is not optimized.

KAYROS performance

Thanks to the innovative core technology (constructive reinforcement learning), planning calculated with KAYROS represents a quantum leap forward.

With reinforcement learning, KAYROS is trained in cognitive behavior based on experience. This makes it possible to calculate extremely complex planning scenarios in a surprisingly short time.

This enables:
Dynamic planning: this means, for example, that the factory can handle unexpected rush orders without any problems. Rescheduling is done in minutes at the push of a button. Rescheduling after a machine failure is no longer a big problem.

High planning precision: KAYROS takes many more dependencies and parameters into account than other planning tools, for example:
• machine setup costs and consumption of raw materials
• deadline adherence and early detection of capacity bottlenecks
• consideration of transport routes
• flexible machine models that can map even very special mechanical engineering requirements
• management of limited resources needed at different times at different points in the production network (tools, operators)

As a result, a production facility can be controlled such, that it works significantly more efficient.
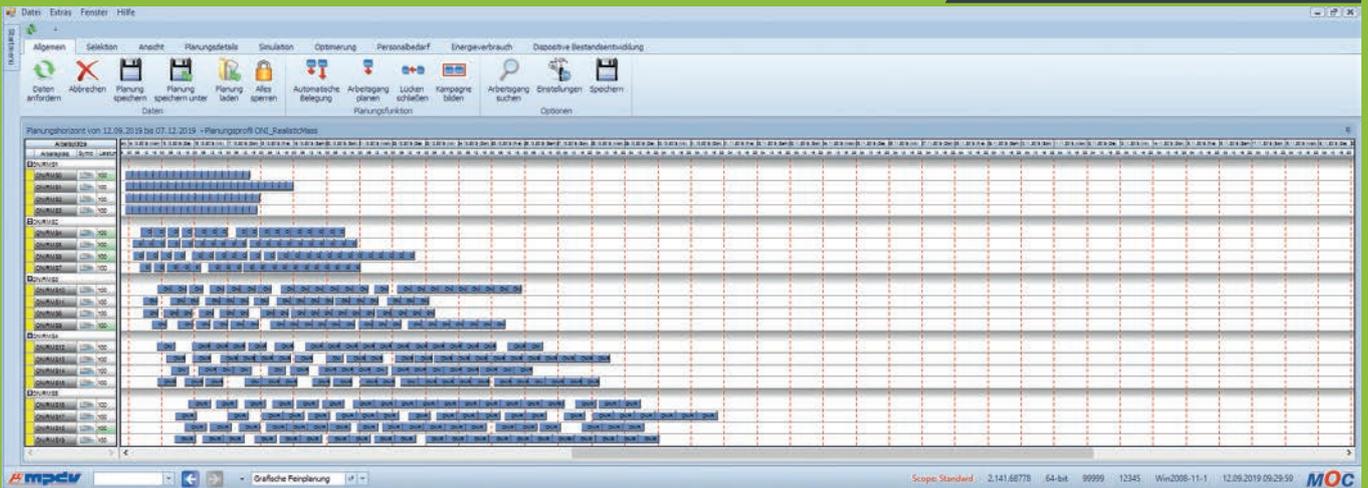
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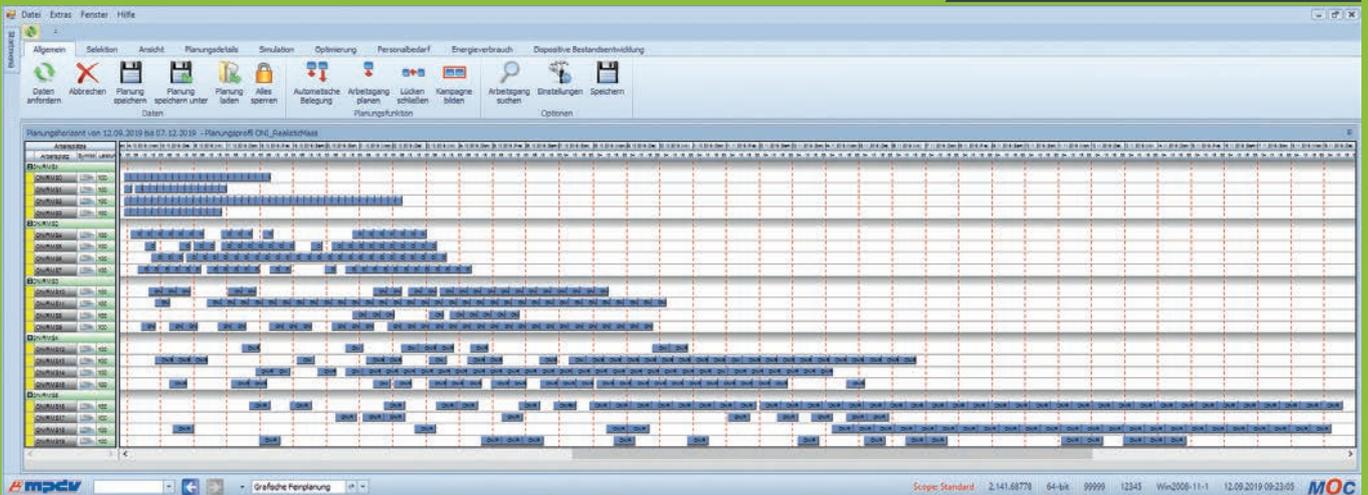
Comparison of today's planning tools (above) with AI-based cognitive planning (below)

Digital representation of the production

In a modelling language of KAYROS, at first a digital representation (digital twin) of the factory is created.

Besides modelling the characteristics of the machines, this includes:
- every process that the machine can perform
- assigned costs and times
- setup states of the machine
- conversion times and costs from one setup state to another
- availability times of the machine
- further preconditions

Other factors are also described, including:
- goods transport times and costs
- necessary rest periods (e.g. cooling times, drying, etc.)
- interim storage
- available operators (required for certain tasks)
- storage of raw materials and other materials
- order backlog

and many more.

Furthermore, the products that are produced in the factory are modelled:
- which raw materials or other materials are required
- which production steps have to take place in which order to manufacture the product

For the reliable operation of KAYROS, these models must be carefully implemented and adjusted when the parameters are changed. The data for modelling the digital twin of manufacturing is usually available in the company's MIS or MES system (e.g. Hydra from MPDV). This often makes it possible to completely automate model maintenance.

KAYROS planning

Based on the digital twin and a current order pool, a planning calculation is triggered.

An automated machine learning process (AutoML) now runs within KAYROS. At its core, this is the PerfectPattern proprietary "Constructive Reinforcement Learning" algorithm. An autonomous software agent explores its environment, perceives information about its condition and takes action. In return, the environment offers a reward signal, which can be positive or negative. The agent's goal is to maximize the positive reward during the interaction.

In this way, the learning process can also be optimized in applications whose decision spaces are usually very large and inconsistent, such as industrial production plants. Based on the decisions of the AutoML process, KAYROS always models the currently best flow of orders through the production network.

In general, the system always selects the production variant that comes closest to the goals of meeting deadlines (highest priority), as well as minimizing resource requirements and production costs. Due to its dynamic nature, it adapts spontaneously to unforeseeable occurrences, such as machine failures, and compensates for these by rescheduling.

By setting the input parameters (especially the cost parameters), the user can have far-reaching influence on the behavior of KAYROS in planning. For example, in case of overall planning requirements being unrealizable, it can be controlled whether many small production orders or one large sales production order shall violate the required deadline.

The generated plan contains precise instructions for controlling production and is transferred from KAYROS to the management system (e.g. HYDRA from MPDV).

Using the most advanced mathematical technology (AI), KAYROS creates efficient, cost-optimized production planning for complex industrial manufacturing.

Reduced operating costs
(electricity, personnel, etc.)

Savings result from...

Lower material costs, less waste
(strongly dependent on the type of production)

Capacity expansion through better machine utilization
(resulting in CAPEX savings)