Connecting real-time production processes with self-learning software

AI-based Scheduling and Sequencing with Qualicision

Deep Qualicision combines the Qualicision optimization engine with goal conflict-based machine learning as well as further AI methods. The software efficiently learns to adjust parameters so that it can predictively optimize and achieve key performance indicators (KPIs) in the best possible way. Analytics functionalities are provided to combine manual and AI-based optimization. For this, Advanced Scheduling and Monitoring and the Qualicision AI framework provide the technological foundation.

Qualicision AI-based scheduling and sequencing algorithms can be used to obtain efficient multi-criteria KPI decisions from individual decisions. This is done by data-based KPI evaluation from automatically calculated conflicting goals in the production processes to be optimized. In addition, priorities of the KPI-based criteria can be machine-learned in such a way that consistent priority settings of the criteria are automatically recommended (see Figure 1).

Thus, Deep Qualicision AI can be used to calculate the deeper interaction between individual decisions and goal criteria, as well as to learn in a data-driven way. When applying this AI principle to scheduling or sequencing production orders and operations, the production process can be optimized either in real-time or in terms of planning or simulation scenarios.

Figures 2 and 3 show a typical Qualicision scheduling and sequencing interface as they are available as soft-

Fig. 1: QFDD (Qualicision Functional Decision Design) web interface.

Fig. 2: PSIasm/Qualicision Gantt chart.

Fig. 3: PSIasm/Qualicision line graph.

Fig. 4: Deep Qualicision AI framework.

ware products. The data derived from the tools can then go directly into the Deep Qualicision AI software, where it is machine-learned (Figure 4).

Balancing inequalities Qualicision-based

In practice, a very common scenario shows that there are sometimes significant deviations between the assumptions about the performance parameters of the production resources that are present in the process and the reality in the day-to-day process.

Numerous industrial applications confirm that both Qualicision-based planning and real-time optimization can successfully balance these deviations. With the learning software, additional deviations between planned and actual sequences can be systematically identified and preventively treated without costs.

Studies show that such deviations consist on the one hand of a mix of spontaneously occurring anomalies of the process. These arise from unplannable resource downtimes, quality-related stops or supplier failures, as well as from order mix that is spontaneously changing.

Learning from historicized data

In addition to spontaneous anomalies, structural deviations between planned and actual processes can also occur. Regularly, these only become apparent in the processes retrospectively and lead to avoidable cost effects such as machine downtime or conveyor belt stoppages. Therefore, it is better to automatically learn the structural anomalies in advance from historicized data. Such scenarios can be implemented and optimized by using Deep Qualicision AI.

With predictive optimization, past production plans are compared with actual processes and the differences are evaluated in such a way that subsequently defined KPI goals are weighted predictively and thus better followed. Here, goal conflict analysis and automated anomaly detection cooperate hand in hand. This detection is implemented using Machine Learning (ML) and relies on Qualicision-based Qualitative Labeling of process data in addition to the classically known ML methods.

In this process, property classes of orders, operations and resources from past production sequences are systematically detected in their patterns associated with structural anomalies. From this, the anomalies can be translated into optimization goals for optimization algorithms where optimization balances systematic anomalies. Using learned interactions in the context of available resources and actual margins, these anomalies are removed.

Fig. 5: Cluster surface showing the positive and negative Deep Qualicision clusters.

Figure 5 shows the application of learned anomaly classification to a demonstration example from vehicle sequence optimization for ranking in scope of sequencing processes. Based on a set of already planned and then produced sequences, it is detected that orders that include, for example, a combination of a certain drive variant and the features “right-hand drive”, “rearview camera”, and “panoramic roof” systematically experience a certain delay between planned and actual positions in their respective sequences.

If such a combination is learned by Deep Qualicision AI, a specification for optimization algorithm can be automatically generated, so that future sequences can be additionally optimized against the learned anomaly.

KPI-oriented manual evaluation and selection of pre-optimized production plans

In addition to the option to perform an AI-based anomaly analysis, the software is also equipped with a manually controllable pre-stage of the learning logic. For this purpose, the KPIs to be used as a basis for evaluating the deviations can be defined manually and evaluated using Qualicision labeling functions (see Figure 2). Subsequently, the optimized production plans (sequences or schedules) are ranked. Thus, further analysis can also be done manually. The adjustment of KPI priorities (Figure 2) and evaluation of goal achievement levels of the KPIs can also be performed during this manual analysis and additionally compared with machine-achieved results. This also allows hand-in-hand work between the manual process analysis and a Qualicision AI-supported machine analysis. The results obtained in this way can then in turn be incorporated into the machine learning logic or the manual learning process in the same way. The result is an interactive and explainable AI application.

Based on the PSI platform with a number of advantages

All tools described so far are built on the PSI platform where the direct scheduling and sequencing software packages additionally use the ASMQ component. The products are under one technological umbrella and can be regarded as basic platform components in terms of their PSI App Store as well as web capability.

This offers a number of advantages: On the one hand, linking with all PSI software products is directly possible and can be integrated. On the other hand, the Qualicision and Deep Qualicision AI functionalities are available in these tools with regard to both intelligent optimization and the AI functional scope which can be used as a door opener to AI. This allows open and intelligent systems to be realized easily, efficiently and in a very short time-to-market, especially via the AI framework, by linking original functionalities with AI technology.

At the same time, the applications can be further developed by PSI’s partners as well as customers via the programming interfaces provided. In the case of Deep Qualicision AI, this is achieved via a Python AI interface (Figure 6). For the scheduling and sequencing tools, it is possible via a Python interface, and for the interactive Qualicision decision analyses, via the interface (GUI) of the Qualicision component QFDD (Qualicision Functional Decision Design Engine) directly itself. The latter can also be operated by non-programmers. Therefore, not only the functionality is available, but also the existing partner capability is still secured.

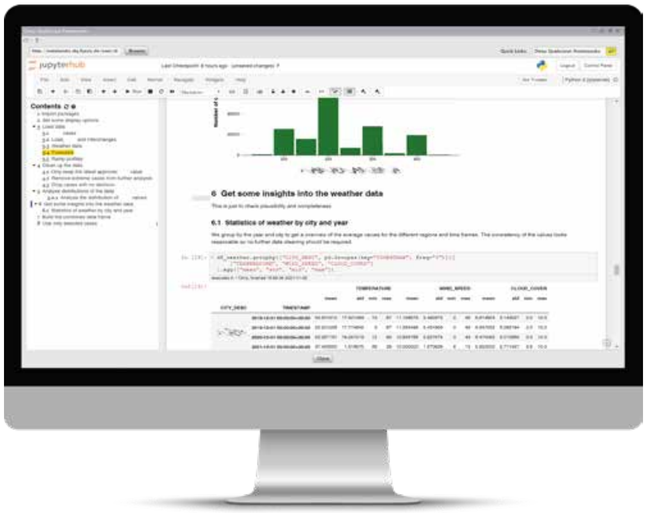

Fig. 6: Deep Qualicision AI with the Python Jupyter notebook frame.

Numerous connections to PSI software products

The integration concept has already been implemented in a number of PSI software products. The application examples range from infrastructure optimization and mobility to the energy sector, monitoring and optimization of maintenance processes and asset management processes, production planning and control in the metal industry, automotive OEM and discrete manufacturing. Further examples such as raw material extraction and BPM (Business Process Modeling) with Qualicision decision support are in preparation.

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