

Artificial intelligence – Practical example: Industry 4.0 and the smart factory

The term Industry 4.0 refers to the Fourth Industrial Revolution and generally describes the digitalization of production with all its processes. People themselves no longer control the individual machines; rather, they monitor production from a central location. Artificial intelligence (AI) applications are used here as well. For this reason, these production plants are called smart factories.

How does a smart factory work and what does this have to do with artificial intelligence?

The essential elements of a smart factory are the following:

1. **Networking** of all machines and components used to make a product and, if possible, the procurement, sales, and logistics departments (internal networking). Networking can also include outside companies, such as suppliers (external networking).
2. **Automatic control** of the machines and generally also of all production flows (automation). Human monitoring takes place only from a central location.
3. **AI software**, which enables automatic control and optimization in the production process.

Networking critical to the smart factory

For networking and automatic control in the smart factory, first all its parts must be connected via the Internet. This enables information to be exchanged both among physical objects and among virtual objects and information-processing operations. Take, for example, a production robot linked with AI software. For this, a digital image must be available for all objects involved in the production process. Accordingly, each container, each driverless transport vehicle, each production robot has its own digital twin with important data for production and delivery. The entire factory can be virtually controlled via these digital twins. A production robot reads a chip on the transport container to determine what component is in the container and can process the component accordingly.

Examples of AI applications in a smart factory

Various AI applications ensure that the production flows and individual processes can increasingly and continuously control and improve themselves. Examples of such applications are the following:

- **Manufacturing execution system (MES):** Learning algorithms, or AI, process and interpret the data of the ongoing production process in order to control production. MES is thus a production control system that guides and monitors production in real time and optimally coordinates the flows. It processes information such as operating, machine, and personnel data and all other processes that have an immediate impact on the production process. In this way, the MES autonomously creates production flow charts for individual products.
- **Human-machine interface (HMI):** People monitor the production process from a central location. Humans and machines communicate via an HMI, even across great distances. The software contains user interfaces designed to be as intuitive as possible that simulate machine operation directly on site. To some extent the mode of operation adapts itself to the users. The inputs are usually entered manually, using a mouse, keyboard, touch screen, or smart speech recognition and voice command.
- **Predictive maintenance:** Predictive maintenance describes AI systems that capture and analyze sensor data (for example, power, rotational speed, temperature) and at times also other data, such as images of production machines. AI examines the data for error patterns

and can report in advance when maintenance is likely pending, thereby minimizing machine failures.

The exact number and type of AI applications involved in the production process, but also in ordering and delivery, depend greatly on the extent to which a company has already invested in automation and automatic control. This in turn depends on the particular product being manufactured and how advanced the suppliers and distributors are in this area. Presently, smart factories are implemented only in partial areas in most production units. According to studies in 2018, the automotive industry has invested most heavily in smart factory expansion. For example, in Germany, manufacturers such as Audi and Daimler currently produce cars using largely automatically controlled processes.

Advantages/disadvantages and opportunities/challenges on the path toward a smart factory

Advantages/opportunities

- Production processes can be improved with respect to timelines and the resources used.
- Production processes are more flexible, such that small batches and even single-unit production runs are economically feasible.
- The required workforce in production is reduced.
- New professions and jobs are created in monitoring and improving smart factories.

Disadvantages/challenges

- In order to leverage the advantages of a smart factory, vast knowledge is necessary that has barely played a role in most production methods until now. This knowledge includes codes of conduct that apply in certain cultures and language skills frequently necessary to operate the HMIs. On the whole, it requires new skills to operate and manage the complex software.
- End-to-end networking via the Internet necessitates new security systems to prevent industrial espionage and hacker attacks.
- Some jobs will be eliminated, primarily affecting the less qualified workforce. These workers will then have fewer employment opportunities.