DIGITAL INDUSTRIES

Using AI to enhance food and beverage innovation

Leveraging digitalization to develop visionary products and processes in a realistic environment

Executive summary

In Hollywood movies, we often encounter artificial intelligence (AI) in the context of out-of-control robots rebelling against humanity and trying to dominate the world. But reality is far different.

After all, AI has long since become part of everyday industrial life and is a driving force behind the digital revolution in the food and beverage industry. Its raw material is large amounts of data, which can be accessed with the help of AI solutions such as deep machine learning.

For example, predictive data analysis can be used to maintain machines and systems according to demand as well as reduce downtime. Alternatively, automated solutions are possible, which would not be solvable without using AI or would only be solvable at great expense.

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Introduction

Artificial intelligence is not a new development. But for today's boom a few prerequisites were necessary, which only became reality in the last few years: faster computers, better processes and almost endless storage space in the cloud.

The most important element for the current AI breakthrough, however, is the vast amounts of data that are available in production today and that cannot be transformed into useful insights with traditional programming, in which a clearly defined algorithm is processed.

As a cross-sectional technology, artificial intelligence contributes to all areas of the food and beverage industry for optimizing processes, increasing productivity and developing new business models.

Man and machine become digital companions
Siemens Digital Industries vision is AI will relieve people of a lot of busy work and support them in making better complex decisions. Man and machine will thus become digital companions.

The internet of things (IoT) and the integration of AI into the Siemens Totally Integrated Automation (TIA) portfolio – as well as the open cloud-based IoT platform Siemens' Insights Hub – offer many opportunities in the food and beverage industry for improving production processes and product quality.

Personalized nutrition: the future of food production

Individualization is one of the most important trends in the food and beverage industry. Manufacturers have to react ever faster to increasing social diversity, new lifestyles and needs, consumer habits, tastes and preferences.

This includes the individual consumer's characteristics. Startups such as Biomes, Atlas Biomed or Millionfriends have already launched cost-effective test kits to create personalized foods for consumers based on DNA, blood sugar or intestinal bacteria analyses. Artificial intelligence is also expected to help in this processes.

At the Mymuesli shop in Passau, Germany, which was founded in 2007, customers can already put together their breakfast according to their personal metabolism profile.

However, the tailor-made cereal mixtures are just the beginning. "We want nutrition to become even more personal and individual," Mymuesli said in a company statement.

Personalized food with help from AI

Big data and AI also help in developing food for specific target groups. For example, the Chilean startup NotCo (The Not Company) uses special AI software to decipher plant genes and uses this knowledge to assemble foods that do not differ in taste or consistency from the animal originals.

The young company has already achieved this with its "NotMilk," which consists of almonds, peas, rice, nuts, linseed, coconut and vanilla.

A "NotMayo" made from garbanzo beans and water was also successfully tested in supermarkets in Chile. "NotCheese" and "NotYogurt" are now also available in 220 Chilean supermarkets.

Algorithms create the perfect bread

The production of bakery products is based on complex physical and biochemical mechanisms. Naturally induced fluctuations in raw material quality, particularly flour, can quickly upset the balance of established processes.

Therefore, bakery associations and manufacturers have joined forces with universities and research institutes in the European Union (EU) research project FLOURPLUS. The idea of FLOURPLUS is to use artificial intelligence methods to determine parameters for the best baking results.

This not only considers the quality of flour, water and yeast, but also practical experience in the production process and theoretical knowledge.

In this project, all these aspects are combined and mapped in an algorithm. The results of test persons who judge bread rolls and bread based on subjective characteristics such as look, crispness, taste or smell are also incorporated.

In the future, the necessary processes and recipe adjustments will be computer-controlled and calculated in real time based on the measured data. The result could be tailor-made baked goods that consumers enjoy and purchase.

Use AI to produce drinks that suit your taste

The IntelligentX Brewing Co. of London is the first manufacturer to brew a craft beer that is created using AI. A chatbot automatically asks the consumer questions, the artificial intelligence collects the feedback and interprets the answers, which then flow into the brewing process.

The startup combines a high standard with its automatic brewing intelligence: "We want to become the most customer-centric company in the world and bring about a change in the beverage industry," reported IntelligentX Brewing in a company statement. The algorithms support identifying variables that can be changed during brewing. They then collect more detailed information on these variables to adapt the recipe accordingly.

Bringing new beer varieties to market faster with beer fingerprinting

In its "Beer Fingerprinting" project, the Danish Carlsberg Group is also using AI to bring new types of beer to the market faster with the help of sensors and self-learning algorithms. The brewery, which has been in existence since 1847 and offers 140 beverage brands in 150 countries, works closely with universities in Scandinavia to develop the sensors and explore how they can be used at different stages of the brewing process.

The aim of the project is to significantly reduce the time required to test combinations and processes to create more new types of beer and bring them to market faster than the competition.

Swedish manufacturer wants to find the perfect whiskey recipe

In addition to the mere composition of the ingredients, in the recipe for a good whiskey, innumerable factors such as the choice of cask or the length of ripening are incorporated into the characteristic properties of the drink. In the almost 1,000-year-old history of whiskey production, countless master blenders have tried creating the perfect recipe. The Swedish manufacturer Mackmyra now wants to achieve this with the help of AI.

It has used an algorithm with various recipes and data on maturation, fermentation, distillation, taste, sales figures and popularity with customers. Based on these key data from over 70 million promising variations, it suggested an optimal recipe that is already being implemented. Whether the result meets the high expectations will only become apparent after the AI whiskey has matured in the barrel for three years.

Food and beverage production: numerous application fields for AI

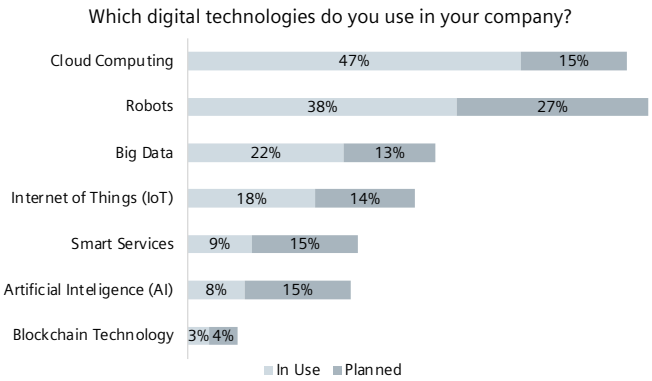
In addition to using data analysis to develop new foods and beverages faster, artificial intelligence also helps to optimize ongoing operations and ensure high quality, such as sorting raw materials or providing predictive maintenance.

The study "Food & Beverages 4.0, 2018" by market researchers from Frost & Sullivan found that in the future "technologies such as internet of things, big data analytics or artificial intelligence will play a major role in accelerating and standardizing manufacturing processes through advanced automation and analysis" in the food and beverage industry.

Individually produced food in a batch size of one

A representative survey of more than 300 companies in the food industry commissioned by the German Information Technology IT association Bitkom and The Federation of German Food and Drink Industries (BVE) also revealed "the food industry will change radically in the next 10 years."

Two-thirds of the surveyed decision-makers see individually produced food in a batch size of one as a common scenario in the year 2030. Digital technologies such as cloud computing, robots, big data analytics or artificial intelligence should become part of everyday life in companies by then.



The German industry is on the right track. According to a recent study by IDG Research Services in cooperation with Siemens and five other partners, more than half of all companies surveyed in Germany already use artificial intelligence and machine learning (ML).

For example, in the food and beverage industry the automation of production and processes, managing manufacturing lines and reducing supply chain waste is a constant challenge that AI can help overcome.

New possibilities for better quality control

Due to the rapid and highly variable nature of products and goods, quality inspection – of fish or meat, for example – is sometimes difficult to solve in an automated manner using conventional technology.

Today, this is only done with a great deal of programming effort using camera systems, and even then a subsequent manual inspection is often required.

For this reason, some companies in the industry have been experimenting with using machine-learning algorithms in automation for some time and others are already using them.

Training instead of time-consuming reprogramming

By using trained neural networks to recognize the quality of products, an automated quality check can be performed with significantly less effort. This applies not only to production, but also to individual processes – such as the manufacture of chocolate.

Another advantage of using AI is when products or recipes are changed, it is much easier and quicker to optimize the neural network with post-training than with manual post-programming. This results in considerable time savings and cost advantages.

Minimizing risks with predictive maintenance

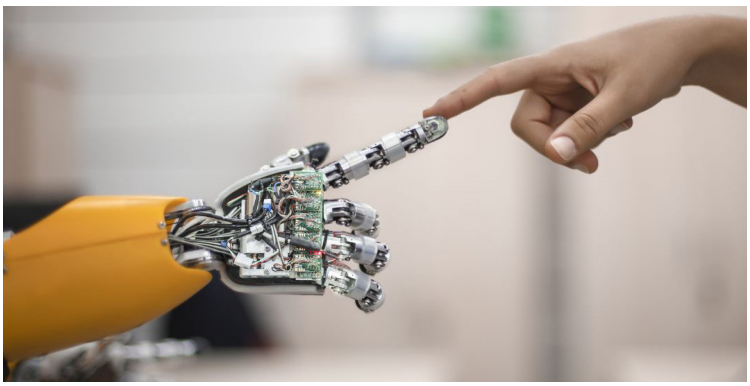
The failure of individual components, machines and possibly entire plants is one of the biggest fears of food and beverage manufacturers. After all, downtime is costly.

For this reason, preventive maintenance measures have traditionally been used but it has now been accepted that many regular maintenance measures were unnecessary since the specific wear that occurs when a system is used cannot be taken into account at fixed maintenance intervals.

Predictive rather than reactive maintenance offers a solution to this problem. By intelligently combining permanent component monitoring (condition monitoring) and analysis algorithms, reliable predictions can be made regarding impending failures.

Based on these forecasts, affected components in the system can be replaced in a timely and targeted manner – long before they even start causing damage.

For reliable predictions about the condition of machines and plants, enormous amounts of data are required. As machines are progressively networked along the entire process chain, however, the amount of data being generated is steadily increasing.



The current challenge lies in merging, structuring, evaluating, contextualizing and visualizing this data. In this case, the interaction of intelligent tools is required.

The first step is a detailed overview

Before users in the food and beverage industry can become involved with data-based predictive maintenance, they must first ensure clarity about the nature, scope and interaction of all plant components.

However, in many brownfield plants, this self-evident working basis is either not present or at least not universally usable.

Although information about assets is available in a multitude of software systems, it is not homogeneous and is often contradictory. The information is not correct or comprehensive and it certainly does not provide a current picture of the plant with its components.

This is remedied with a digital twin, a holistic digital image of the physical plant that goes with it throughout its lifecycle and is additionally enriched with operating data during the operation and maintenance phase.

This not only allows the planning, organization and execution of maintenance operations to be organized more efficiently, but it enables all changes carried out in the plant to be simultaneously documented so the digital twin is automatically kept up to date.

Necessary changes in production, such as seasonal fluctuations in demand or new product variants, can be simulated and efficiently implemented with the highly precise and time saving digital twin.

AI predicts upcoming events

Machines are now equipped with more sensors and communicate with the cloud via the industrial internet of things (IIoT).

Artificial intelligence can use time series data, analysis algorithms, statistics and machine learning techniques to create predictive models.

With Insights Hub, Siemens offers a cloud platform that as an open IoT operating system offers corresponding interfaces and services. For example, Insights Hub Analytical Services already provides a special service for predictive maintenance.

It transmits data either directly from IoT-enabled components or via edge computing from conventional sensors and machines using secure interfaces.

In the cloud, algorithms are then used to perform analyses in real time. The results can in turn be visualized directly on site at the plants and machines via dashboards, trends or key performance indicators (KPIs).

The service personnel can thus react promptly and proactively to prevent cost-intensive machine or system failures. Unplanned plant downtimes are drastically reduced, while any planned shutdowns can be used more effectively.

Press a button to switch from strawberry juice to elderberry syrup

With the analysis possibilities in Insights Hub, the efficiency of production processes can also be compared and evaluated across plants and countries to achieve sustainable performance improvements.

The Spitz Group, headquartered in Attnang-Puchheim, Austria, has developed, produced, refined and marketed food and beverages for over 160 years. It produces sweets such as cakes, waffles and coconut domes, but also mayonnaise, honey, iced tea, syrup, juices and alcoholic beverages on 30 process lines at 35 filling and packaging plants.

To do this as efficiently and economically as possible, the company relies on automation and digitalization technology from Siemens such as the manufacturing execution system (MES) Simatic IT® suite.

Recipe is automatically adapted to the properties of raw materials

At the touch of a button, it is now possible to switch from one product to another on a production line; for example, from strawberry juice to elderberry syrup. In the past the machines had to be rebuilt and reprogrammed, while today all you have to do is select which product to produce next on a single computer. And that is it: The machines even fetch the necessary raw materials and packaging materials.

The system also knows exactly what quantity of a raw material is still available in the warehouse and automatically replenishes it when stocks run low. In the future, the individual recipes will also adapt intelligently to the different properties of the raw materials.

For example, the sugar content of a certain raw material is measured when it is added to the processing and the recipe is automatically recalculated depending on the result. This ensures the final product always has the same taste, texture and appearance even if the raw material quality fluctuates.

Condition monitoring will also play an important role at Spitz in the future. Sensors monitor each individual engine for temperature, acoustics and vibrations. Determining the engine condition this way facilitates the planning of maintenance cycles and ensures optimal availability. With the help of Insights Hub and artificial intelligence, this analysis could also be performed in real time in the cloud and used for predictive maintenance, further reducing the risk of system failure.

AI is embedded in Siemens' digitalization strategy. Today all Siemens products are already intelligent to some extent and will be more so in the future, generating and preprocessing data and communicating with other devices.

With the help of AI, man and machine become digital companions. On the one hand, it automates error-prone and simple activities, but on the other hand it also supports people engaged in complex, creative tasks.

Today, artificial intelligence has reached a point where it can trigger the next wave of technological disruption. Deep learning methods based on neural networks reach their limits in terms of context at a higher level (above the controller and field level).

Industrial knowledge graphs take AI to a new level

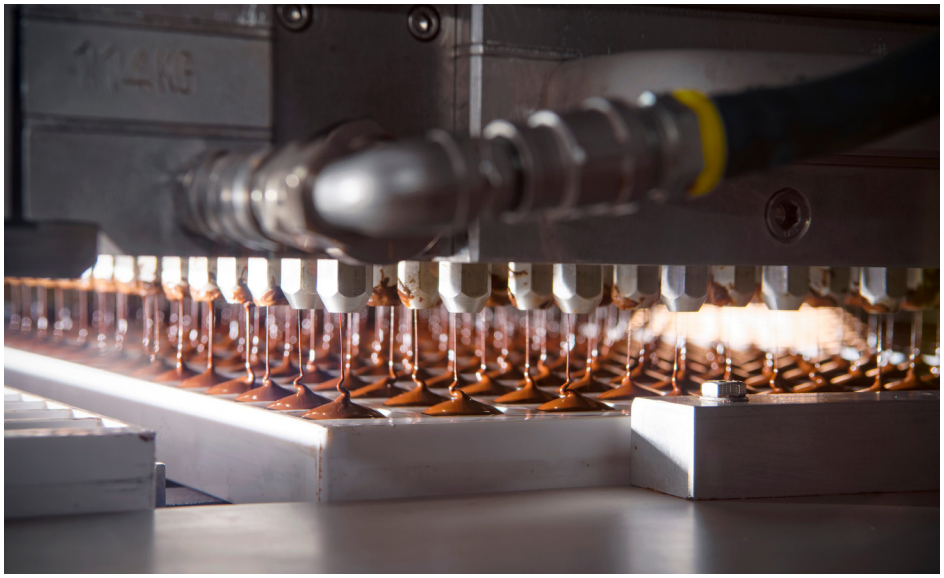
Industrial knowledge graphs overcome these and take artificial intelligence in the industrial environment to a new level. This approach summarizes widely ramified knowledge and connections in a structured way and thus enables the development of an almost unlimited "memory for AI systems."

Application scenario: chocolate naps arranged individually

A graph is defined as a "graphic representation of relationships, for example, in the form of marked vertices (also called nodes or points) and connecting lines (also called edges)." And this is exactly how industrial knowledge graphs work.

They extract data from their data silos such as 3D models, blueprints and histories (of machine lifecycles, etc.) and identify interrelationships within the data of several machines or plant components.

As a result, they can provide answers that artificial intelligence with learning neural networks has not been capable of until now.



This represents a quantum leap for applications of all kinds – be it flexible production, predictive maintenance, supply chain management or advanced diagnostics.

AI should support but not determine everything

Such graphs make it possible to tailor service offerings to the needs of customers more precisely than ever before. This requires comprehensive domain knowledge that Siemens has built up over many years in the food and beverage industry.

This knowledge is now being gradually raised and integrated as expert know-how into the knowledge graphs for digital automation. The intelligence stored there clearly surpasses our human capabilities.

The knowledge graphs can combine and evaluate distributed know-how in fractions of a second, which no human brain can do. But does this mean that in future we will leave decisions to the machine alone?

Researchers at Siemens have a different vision. Their goal is the digital companion. Such AI systems, which people like to work with, are designed to relieve them of annoying and dangerous tasks in the future. And through their interaction – also in natural language – make helpful suggestions for solving tricky problems.

In addition, they adapt individually to their users. To help people efficiently with tips and concrete suggestions for solutions, they must first understand the tasks to be solved.

Even when a digital companion is used, people retain decision-making autonomy. However, with its support, people should be able to make faster and better decisions in the future.

You know them from exhibition stands or from practices – the small chocolate bars called naps. Unfortunately, in most cases the bowl is no longer filled with your own favorite variety. The same problem applies to the chocolate mix you buy: The favorites quickly disappear and the same varieties always remain untouched in the package.

Industry 4.0 enables production in a batch size of one

A new picking system now solves this dilemma. For demonstration purposes, the Swiss manufacturer Chocolat Frey, together with Siemens and several partners, has developed a solution that allows its customers to have an individual pack composed of their favorite chocolate naps.

For example, three black chocolate naps and some others with nuts. The rest of the pack is filled with milk chocolate, while the white chocolate is left out completely. The customers send their orders to the company via X (formerly Twitter), the order flows automatically and without human intervention into the production program and a standard industrial robot assembles the mixture and puts it into a plastic can for dispatch.

Since production at Chocolat Frey today is geared to mass production and individual orders must be packed by hand, such an individual offer to customers would be expensive. With smart manufacturing and fully automated production in a batch size of one, however, this could change.

The choco-robot, which now also responds to voice commands, is operated via an Insights Hub app from Siemens partner Autexis. MindConnect(R) Nano hardware, which is also part of Siemens Xcelerator, collects data from sensors and actuators on site and transmits it to the cloud where it is processed. A Simatic S7-1500 controller then directs the 6-axis Kuka robot using the TIA Portal Library. This makes the engineering of the robot much easier, as the engineer needs to only be familiar with the TIA Portal. The robot path points are taught in via a SIMATIC Mobile Panel (KTP900F) and enable machine and robot operations in a common look and feel.

Next stage of digitalization with Insights Hub and neural networks

The demand for products with more individuality and shorter lifecycles requires food and beverage manufacturers to produce more and more variants, recipes and brands in ever smaller batch sizes.

The challenge is to achieve greater flexibility and speed while simultaneously increasing productivity, optimizing costs and achieving high product quality.

With the aid of censors, this is accomplished by consistently monitoring the raw materials and the entire production process. This is precisely where Insights Hub comes into play. Insights Hub is the cloud-based, open IoT operating system from Siemens that connects products, systems and machines.

Better product quality through data analysis
With its help, the data from food and beverage production is not only collected and securely transferred to the cloud, but can also be analyzed in real time using artificial intelligence and processed sensibly in quality assurance and maintenance systems.

Necessary changes in production, such as seasonal fluctuations in demand or new product variants, can be implemented in a time-saving and efficient manner.

The capability of Insights Hub to use the collected data to optimize product quality, production efficiency and costs provides an important tool to help the industry move to the next stage of digitalization.

At the machine level, this knowledge can in turn be used directly via industrial edge and the machine-oriented application of machine learning algorithms. For example, visual quality checks in production plants or image-guided robot systems can be efficiently realized.

Siemens has developed the SIMATIC S7-1500 NPU hardware product, a module for the S7-1500 controller that has a chip with artificial intelligence capabilities. It can be integrated directly into automation systems and delivers efficient data processing with the use of neural networks.

Neural networks simulate the brain
A natural brain consists of many individual neurons that are connected with each other via many synapses. In an artificial neural network, these components are simulated by mathematical means. The advantage of the artificial brain is high performance with very low power requirements.

In addition, the solution is easy to integrate and can be scaled as required, as many modules can be plugged in one behind the other. The production and quality data collected in the cloud or edge can be used directly in the production system for training a deep neural network.

The advantage of using deep learning methods at the field level lies in the necessary deterministics and reaction speed, for example, flexible gripping processes of robots or the visual quality control of products.

Human expert knowledge for automation
Both data from directly connected sensors (such as cameras or sound sensors) and the central processing unit (CPU) can be used as input for the evaluation. This makes it possible, for example, to provide recorded camera images directly with context data from the program.

It is possible to quickly and easily adapt automation to changing circumstances since there is no programming necessary for the complex algorithms of each product. The evaluation of existing production data can be expected to significantly reduce the costs for quality inspections by relieving the bottleneck at the quality assurance (QA) station.

Shaping the future from the Siemens Living Lab: testing visionary ideas under realistic conditions

Siemens is thus able to incorporate human expert knowledge and its ability for complex pattern recognition into the automation process.

The aim is not only to make AI solutions accessible to experts, but also to provide a workbench for automation specialists so they will be able to use artificial intelligence in the future to implement efficient solutions.

Siemens is working at its Living Lab Process Industries in Vienna-Floridsdorf, Austria, on digitalizing bioprocesses in the food and beverage industry and in the production of pharmaceuticals, among others. This is the site of a smart manufacturing pilot plant – unique in Europe – in which visionary ideas can be realistically tested and further developed. The aim is to learn how bioprocesses can be better controlled.

For example, fermentation with yeast. Instead of leaving it alone like baking bread and looking under the cloth only at the end – to perhaps discover that the dough has not risen – the fermentation process is digitally reproduced. Sensors monitor the pH value, oxygen concentration, temperature and much more around the clock. With the hep of artificial intelligence, the data is analyzed in Insights Hub. Errors can be corrected immediately, not days later. In bioprocesses with yeast or bacteria, everything revolves around the right growth and the optimal growth time.

Conclusion

Digitalized process analysis technologies, such as those tested by Siemens in the Vienna laboratory, can be used to better monitor and control product quality. This online monitoring minimizes the risk of errors and the process can run without interruptions. Cost reduction and ample time can be bought since quality control no longer takes place at the end of the process with an uncertain outcome, but in real time during production.

Numerous Siemens products are used in the Living Lab Process Industries. The focus is on the SIMATIC PCS 7 process control system for automation. This controls the pumps, regulates temperature and pH and collects measurement data. The SIMATIC SIPAT solution combines the collected data and is responsible for process analysis and feedback to the process control system.

The SIMIT software plays the main role in simulation, while for MES applications the SIMATIC IT eBR solution is available. These technologies monitor quality specifications and critical parameters in real time. If a deviation occurs, the process can be readjusted without operational interruption.

Essential activities in the Living Lab are the practical implementation of research topics in the form of projects or case studies in which Siemens customers as well as employees can participate, for instance, in the form of training courses.

Siemens Digital Industries (DI) is an innovation leader in automation and digitalization. Closely collaborating with partners and customers, DI drives the digital transformation in the process and discrete industries. With its Digital Enterprise portfolio, DI provides companies of all sizes with an end-to-end set of products, solutions and services to integrate and digitalize the entire value chain. Optimized for the specific needs of each industry, DI's unique portfolio supports customers to achieve greater productivity and flexibility. DI is constantly adding innovations to its portfolio to integrate cutting-edge future technologies. Siemens Digital Industries has its global headquarters in Nuremberg, Germany, and has around 72,000 employees internationally.

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