Fraunhofer IWU

Press Release

Orcha-3 Independently Solves Complex Manufacturing Challenges

Agentic AI: "The Next Big Thing" After Image Recognition and Generative AI, Including in Industry

A few years ago, artificial intelligence began making its way into manufacturing through image-based data comparison. Not exclusively, but especially for quality control applications, neural networks have since been trained to detect deviations from target specifications by comparing a component's actual state with reference images. Today, generative AI based on large language models helps users solve typically well-defined problems step by step. In an iterative process, humans provide prompts and instructions until a satisfactory solution is reached. Agentic AI operates very differently. For complex problems, it autonomously selects the AI tools (agents) required and develops solutions with minimal human intervention.

Everyday chatbots such as ChatGPT already illustrate the transition toward agentic AI. Users see how their request is broken down into multiple steps, such as searching, analyzing, and summarizing. However, they do not see the logic by which the system selects and sequences the appropriate tools. Agentic AI is already demonstrating its strengths in software development, customer service, IT operations, knowledge management, and administrative business processes. It excels wherever complex tasks consist of multiple steps and require coordination across various systems.

- Customer Service: In customer service, agentic AI can autonomously process a large portion of customer requests. It can do more than answer questions; it can execute complete service workflows and make independent decisions within predefined rules.
- Software Development: Modern coding agents analyze requirements, write code, run tests, and iteratively identify and fix defects.
- Retail: In retail environments, well-orchestrated AI agents can support inventory management, demand forecasting, logistics, and product administration. These agents independently combine information from different systems, prepare operational decisions, and in some cases execute them.

The Orcha-3 platform, developed at Fraunhofer IWU, transfers this approach to manufacturing engineering. Orcha-3 is designed to address questions that cannot easily be solved using a single AI model. These include open-ended issues along an entire process chain whose answers do not arise from a single measurement but from a sequence of interconnected analytical steps. In such scenarios, the most appropriate next step only becomes clear after evaluating the previous one.

Consider the following example: Dimensional deviations occur at the end of a process chain consisting of forming and joining operations, but the root cause remains unknown. Orcha-3 autonomously decomposes the problem into individual work steps: Retrieving process data from machines and production equipment - Consolidating time-series data from multiple stations - Calculating correlations - Simulating parameter variations - Evaluating intermediate results. After each step, Orcha-3 reassesses the situation and determines how to proceed. Each step is executed by a specialized agent with a clearly defined responsibility.

A key requirement for manufacturing applications is the strict separation between language-model planning and operational execution. The language model performs planning, but it never accesses production systems directly. Orcha-3 executes database queries, calculations, and simulations exclusively within local agents. Raw data never leaves the company's network. The language model receives only a curated and fully documented representation of the planning context. This representation is generated deterministically and stored for every planning step. As a result, every piece of information provided to the model can be traced and verified. Manufacturing expertise embedded in production parameters often represents a company's true competitive advantage. Orcha-3 is therefore designed to enable the use of powerful language models without requiring disclosure of this proprietary knowledge.

For the same reason, the entire execution process is orchestrated deterministically. All activities follow defined rules, and every decision can be reconstructed afterward. The platform maintains a complete audit trail of every execution step, every intermediate result and every decision. All information remains stored and traceable even months later. For recommendations that influence serial production, this traceability is not merely a convenience feature; it is an essential requirement. In addition, Orcha-3 can autonomously execute missing analysis steps by generating and running small software programs whenever the existing toolset proves insufficient for a particular problem.

At present, the platform serves as a research and experimentation environment. The medium-term objective is to expand its scope from individual process chains to entire production systems. This includes questions concerning machine allocation, workforce deployment, facility space requirements, and logistics concepts. Questions that normally require extensive manual analysis.

Synthetic Data for Modeling a Wide Range of Tasks and Use Cases

Planning or optimizing a complex manufacturing operation requires a solid data foundation. The classic chicken-and-egg dilemma at the outset can be addressed elegantly through specially generated synthetic data derived from virtual process chains. These virtual process chains can replicate real manufacturing processes, including individual forming operations. AI can then operate on these virtual process chains to identify optimization opportunities and propose improvements. As a result, problems and use cases can be generated and varied almost endlessly, enabling broad experimentation and validation.

Complexity That Only Agentic AI Can Master

In multi-stage manufacturing environments, many questions should be answered but often remain unresolved because doing so would require days of manual data analysis:

"Components at the end of the process chain fall outside tolerance limits, yet every individual station reports that everything is within specification."

"Where is the deviation originating?"

"The material supplier has changed. The datasheet looks identical, but the process no longer performs as it did before. Which parameters need adjustment?"

"Scrap rates vary significantly between shifts. There is a theory about why, but nobody can spend two weeks analyzing process data to verify it."

Questions like these cannot be answered with a single analysis. They require many analyses: Combining data from multiple stations, investigating correlations and dependencies, testing and rejecting hypotheses, formulating and evaluating new hypotheses. This is exactly the workflow Orcha-3 performs autonomously while ensuring that every step remains fully transparent and traceable.

The platform is fully operational and has been validated using virtual process chains. The next step is applying it to real-world manufacturing challenges. To that end, we are seeking discussions with companies currently facing such questions. Together, we can evaluate whether the problem is suitable for this approach, determine what the available data can support, and explore what an initial implementation could look like.

Agentic AI

Agentic AI refers to AI systems that act as autonomous agents capable of independently executing complex, multi-step tasks. Unlike conventional chatbots, which primarily respond to direct instructions, these systems can work through sophisticated challenges and autonomously utilize tools, additional agents, or other resources as needed. Agentic AI systems break larger tasks into logical sub-tasks, require significantly fewer human interventions during execution, adapt flexibly to unexpected developments and changing conditions. They select and coordinate appropriate tools independently and pursue goals across multiple stages of execution.

Orcha-3

Orcha-3 processes complex challenges as so-called "jobs" and manages them through a structured, iterative workflow. At its core, the platform is built on a clearly separated architecture consisting of API (Application Programming Interface), orchestrator, supervisor, and specialized agents. The platform is consistently state based. All information is stored persistently within the file system, ensuring complete transparency, traceability, and recoverability. The execution of a job follows a recurring cycle of planning and execution:

- A Planner Agent analyzes the current state and determines the next actions.
- These actions are converted into tasks executed by specialized agents.
- Results are stored and incorporated into the subsequent planning cycle.
- The process repeats until a solution is found or a predefined termination condition is reached.

Fig. 1 Agentic AI can take on sophisticated, complex tasks, and propose highly tailored solutions. © Fraunhofer IWU

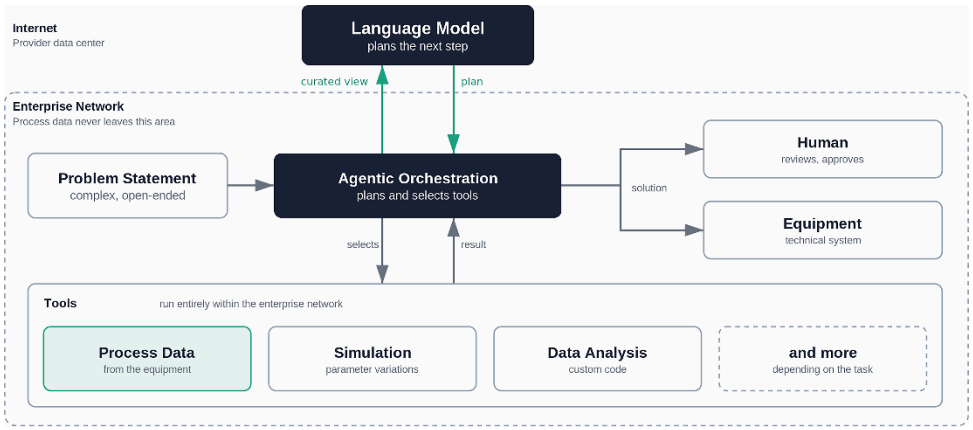

Fig. 2 Orcha-3: how it works. © Fraunhofer IWU

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