WHITE PAPER

AI-powered Additive Manufacturing

IntelliJeni – faster, cheaper, cleaner production by integrating AM and machine learning

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Executive Summary

3D printing has already revolutionized how we create complex components. The JENI™ technology from Photocentric takes the next step, changing how we think about additive manufacturing. Combining advanced 3D printing technology with artificial intelligence, JENI™ creates a fully automated system that can learn and improve with every part it produces. The IntelliJeni project, a collaboration of Photocentric, Intellegens, and AMFG, has created a new, innovative approach that can make production faster, cheaper, and better for the planet. IntelliJeni couples the automated 3D printing of JENI™ to the powerful Alchemite™ machine learning algorithm from Intellegens, which has been optimized to extract maximum value from experimental and process data. This enables JENI™ to adjust its settings in real time to deliver the best results. In this white paper, we report the results – reduced waste, less energy usage, and lower costs.

Introducing IntelliJeni

JENI™ 3D printing

Additive manufacturing (AM) is changing the face of manufacturing. 3D printing with polymers is now a well-established technology, enabling the creation of complex components from custom medical devices to intricate prototypes. Photocentric has developed a world-leading position in a specific type of 3D printing, **photopolymerization**, which uses light to harden liquid materials into solid shapes. The Photocentric **JENI™** technology is highly versatile, allowing for difficult designs to be produced rapidly with excellent quality control.

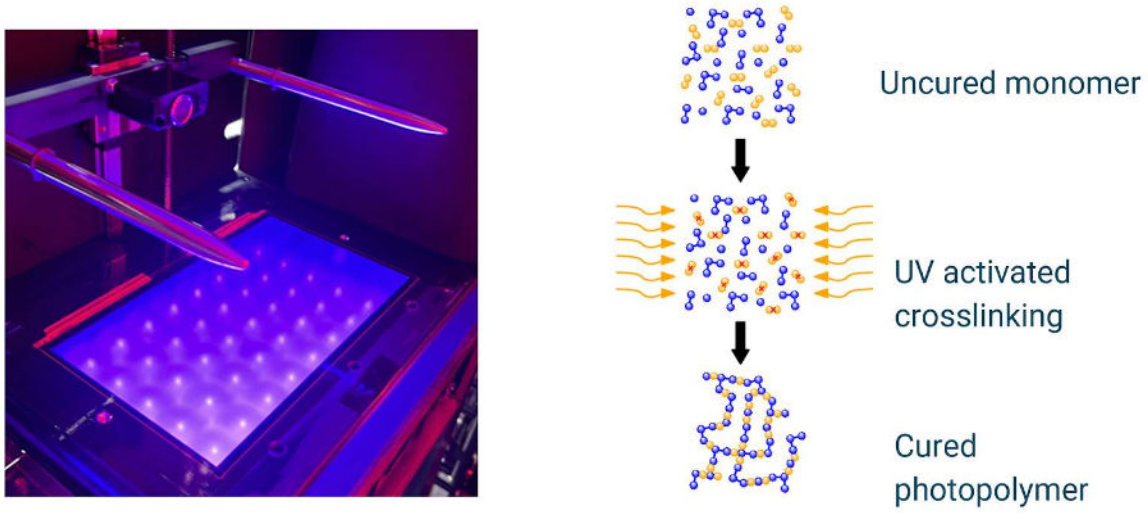


Figure 1. Photopolymerization with JENI™

Challenges in photopolymerization-based 3D printing

Photopolymerization-based 3D printing still faces significant challenges:

- **Objects can deform** under strong UV light, but on the other hand, **printing can be slow** if the light isn't intense enough
- Processing **high-viscosity** resins is complex
- Appropriate printing settings or swapping to a new resin takes a lot of **trial and error** and thus costs resources and time.

Solving these issues requires optimization of over fifty process parameters through a multi-phase process of printing, curing, rinsing, and washing – as shown in Figure 2. A typical application might be printing dental aligners, where tens of thousands of parts could be manufactured, yet each part needs to be customized. This need for customization further complicates the optimization process. But the high volumes mean that even small gains in efficiency could represent significant payback in time and cost.

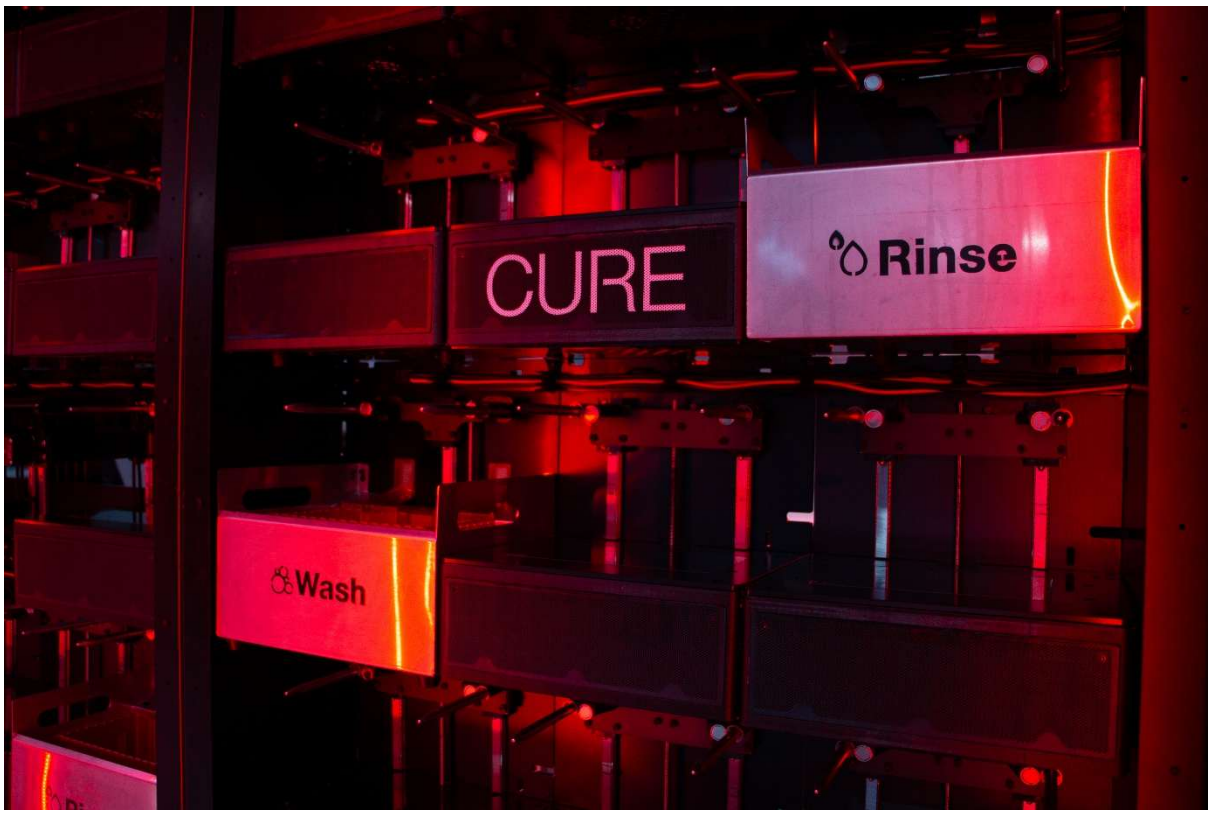


Figure 2. JENI™ 3D printing machines showing print, cure, rinse, wash cycle.

JENI™ provides a flexible, automated manufacturing platfrom, capable of high-speed photopolymerization-based 3D printing in which process parameters can be easily tuned. The The **IntelliJeni project** aimed to marry this technology with machine learning to both select optimal process parameters and learn from each new manufacturing cycle, enabling continuous improvement.

The transformational role of AI

Adaptive experimental design

By using machine learning, IntelliJeni's system can study the printing process, learn from it, and improve over time. This means fewer errors, faster production, and materials and parameters that are perfectly suited to their purpose. The IntelliJeni project employs automated **adaptive experimental design** for manufacturing – an approach that promises:

- Up to **80% reduction** in required experiments per component
- Accelerated material and process development cycles **by more than 20%**
- Tailored optimization of parameters for **each unique part**

The concept of adaptive experimental design is illustrated in Figure 3. Experimental data is used to train a machine learning model, which can capture how settings like curing time or light intensity impact final properties. The model can then be used predictively to propose what print runs to do next and data gathered from those runs can be used to re-train the model, improving its accuracy. This continuous improvement means that the printer gets better with each use, making production more efficient and reliable.

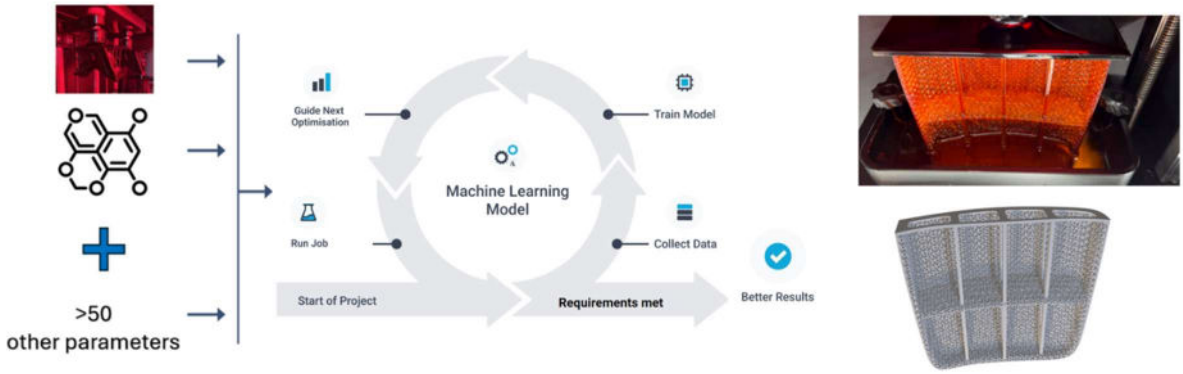


Figure 3. Adaptive experimental design. For each new component the system optimises the parameters until the requirements are met

How it works: Integrating Alchemite™ and JENI™

The integration of Intellegens' **Alchemite™** machine learning software with Photocentric's JENI™ Automated 3D Printing System operates in two key stages: learning and production.

Learning Stage

The system employs adaptive experimental design to gather and analyze data. Alchemite™ processes information from the 3D printing setup — such as material properties, environmental conditions, and process settings — to identify patterns and relationships. By refining these insights, the AI builds a predictive model that understands how different

parameters influence the final product's quality. This stage drastically reduces the need for trial-and-error testing, saving both time and resources.

Production Stage:

Once the learning stage is complete, the system transitions to continuous optimization during production. Here, the AI dynamically adjusts process parameters in real time — such as light intensity and layer curing times — to balance speed, cost, and quality. The system also evolves with every print job, as data from each production run is fed back into the model, enhancing future predictions and ensuring consistent improvements over time.

This two-stage approach, powered by Alchemite™, transforms JENI™ into a self-learning, self-optimizing manufacturing solution.

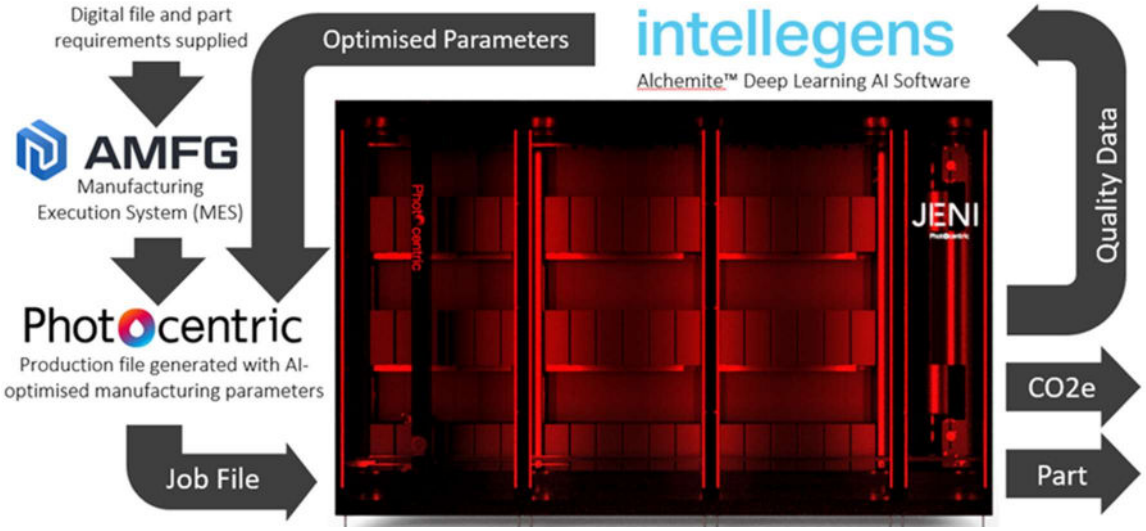
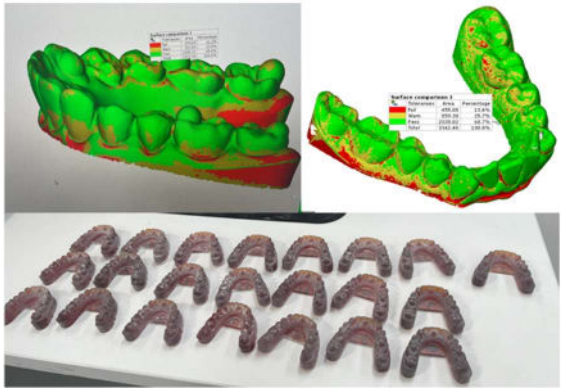


Figure 4. Production stage combines technology from Photocentric, Intellegens, and AMFG.

Results



The Intellijeni approach was validated in the mass manufacturing of dental aligners (shown in Figure 5, right). For every 100,000 dental aligners, the adaptive experimental design approach:

- **Reduced build time from 12 to 9 days**
- Achieved **21.2% time savings per part**
- **Increased part accuracy by 18.75%.**

Comparisons are with a process using the default settings achieved by trial and error.

Looking ahead

The IntelliJeni project shows how technology can transform industries by integrating AI and advanced manufacturing technology into practical solutions. This project is setting a new standard for efficiency, quality, and sustainability in 3D printing.

Such integration is facilitated by Alchemite™ Architect, which provides advanced API-based access to the Alchemite™ computational engine. You can put the powerful Alchemite™ machine learning algorithm to work within your R&D workflows or business processes.

For any manufacturing businesses looking to stay ahead, IntelliJeni provides a powerful case study demonstrating how AI is being harnessed for faster, cheaper, cleaner production.

Useful links

£3.7m awarded to advanced UK smart factory projects - https://www.ukri.org/news/3-7-million-awarded-to-advance-uk-smart-factory-projects/

Intellegens provides AI support for robotic, high-speed digital manufacturing project - https://www.businessweekly.co.uk/posts/intellegens-provides-ai-support-for-robotic-high-speed-digital-manufacturing-project

Photocentric's JENI System: Is 3D Printing Outpacing Injection Molding? - https://www.fabbaloo.com/news/photocentrics-jeni-system-is-3d-printing-outpacing-injection-molding

Implications of Photocentric's JENI 3D Printing System - https://www.fabbaloo.com/news/implications-of-photocentrics-jeni-3d-printing-system

7 Things We Saw at Formnext 2024 - https://www.youtube.com/watch?v=HDUQLIQme8U&feature=youtu.be

The Most Exciting Things We Saw at Formnext 2024 - 3Dnatives - https://www.youtube.com/watch?v=V0yhBLu7Yeo&t=34s

Photocentric's New Large Automated JENI 3D Printer Array - https://3dprint.com/311463/3d-printing-news-briefs-7-20-2024/

Beyond R&D – embedding machine learning into products and processes – https://intellegens.com/beyond-rd-embedding-machine-learning-into-products-and-processes/

Project partners

About Photocentric

Photocentric has manufactured photopolymer resins since 2002 and is a patent holder in visible-light curing technologies. Photocentric applies its expertise in photopolymerization within the visible-light spectrum and its patented daylight-curing process to invent the use of LCD screens as the selective light source for 3D printing, a technology that is today disrupting Additive Manufacturing.

About AMFG

AMFG is a leading provider of MES software for manufacturing. **Its** software solutions empower manufacturers, allowing them to manage their workflows and achieve streamlined, automated processes. With over 500 successful implementations in 35 countries and across a range of industries, AMFG specialize**s** in enabling companies to successfully integrate software for AM and CNC production into their wider manufacturing processes and scale their AM operations.

About Intellegens

The **Intellegens** vision is that machine learning will drive innovation and deliver value wherever data is used in R&D. Intellegens aims for best-in-class, easy-to-use machine learning software for data analysis in chemicals, materials, life science, and manufacturing. The Alchemite™ technology originated at the University of Cambridge and has been further developed and applied across these industry sectors by Intellegens since 2017.

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Support from the UKRI Made Smarter Innovation challenge

This project was supported by the Innovate UK smart factory initiative.

https://www.ukri.org/news/3-7-million-awarded-to-advance-uk-smart-factory-projects/