Smart Automation of Trial and Error to Beat Cancer Sooner

Authors: Jonas Bermeitinger

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Affiliation: LABMaiTE GmbH, Freiburg im Breisgau, Germany

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In this essay, I reflect on my engineering work on integrating lab automation with artificial intelligence (AI) to revolutionize cancer research. This novel technology aims to use high-throughput automation to generate reproducible data and analyze it using AI, particularly reinforcement learning. This approach automates the feedback loop between experiments and analysis, finding solutions through trial and error. The aim is to manage the complexity of cancer's genetic mutations and optimize the development of personalized therapies. This essay was submitted to the BioInnovation Institute (BII) & Science Prize for Innovation in 2023.

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Jonas Bermeitinger
jonas@labmaite.com
LABMaiTE GmbH, Freiburg im Breisgau, Germany

Abstract

In this essay, I reflect on my engineering work on integrating lab automation with artificial intelligence (AI) to revolutionize cancer research. This novel technology aims to use high-throughput automation to generate reproducible data and analyze it using AI, particularly reinforcement learning. This approach automates the feedback loop between experiments and analysis, finding solutions through trial and error. The aim is to manage the complexity of cancer's genetic mutations and optimize the development of personalized therapies. This essay was submitted to the BioInnovation Institute (BII) & Science Prize for Innovation in 2023.

When I co-founded the startup LABMaiTE, my vision was to combine high-throughput lab automation, to generate large amounts of empirical reproducible data, with artificial intelligence (AI), to analyze this data in a closed-loop manner.

As an engineer, I have always been fascinated by automated systems that help fellow scientists in simplifying the complex riddles they try to solve. When I came across the idea of having conventional lab automation enhanced by AI I was instantly convinced that this approach has the potential to revolutionize empirical research as we know it. Since cancer is one of the leading scientific and social challenges in health, I was eager to test our hypothesis in this field.

The central patented idea (1-3) of LABMaiTE is to build a system that brings lab automation to the next level. By leveraging AI we can close the loop between empirical findings and follow-up experiments. Once the goal of the experiment is set, the system can autonomously find a viable solution by exploring a pre-determined solution space in the classical empirical way of trial and error. The main type of AI algorithm we use is called “reinforcement learning”. This type of algorithm does not need to be programmed on peculiarities of the system but autonomously learns which actions lead to the most accumulated rewards (similar to solving the problem posed by the researcher) (4, 5). The result of experiments analyzed and planned by the AI and performed on an automated system is an in-vitro validated recipe for solving the task defined by the researcher.

We as LABMaiTE aim to enhance in-vitro research, thus enabling laboratories to optimize individual candidate therapies for each cancer patient. As for the social benefits, the LABMaiTE system will help to advance both cancer treatments as well as access to them.

The LABMaiTE device was also inspired as a potential solution to a more general scientific problem known as the reproducibility crisis in biology and medicine, that is, the high rate of failure to reproduce published scientific experiments by other scientists or one's own (6). Some studies have identified human and social factors including pressure to publish and selective reporting, as the main causes of this problem (6). At LABMaiTE we believe that the main cause of the reproducibility crisis in biomedical cancer research is the complexity of biology itself combined with standard research methods that are insufficiently precise or prone to human variability, even if they are handled by trained scientists under ideal circumstances

(7). Additionally, as my co-inventors Mertelsmann and Boëdecker explain, cancer is an elusive and highly complex killer that has more potential combinations of carcinogenic mutations than there are atoms in the observable universe (btw 10^{72} to 10^{82}) (4, 8). They argue that each genetic variation exerts unique effects on individuals and the introduction of novel drugs, different combinations, and varying dosages exponentially increase the number of potential solutions. Hence, searching for new cancer therapies is finding the proverbial needle in a haystack (4). However, as an engineer, I believe that biological complexity can be overcome (or at least tamed) by a technical solution. Hence, at LABMaiTE we aim to tackle complexity with an automated lab assistant capable of planning, analyzing and performing in-vitro experiments. This "agent" can deal efficiently with enormous solution spaces, like the AI agents that mastered the game of Go which has 10^{170} possible board configurations (4, 9).

However, we need to acknowledge that the idea may sound simpler than its implementation. Devil in the details being that automated systems available on the market usually do not allow the user to directly interact with the hardware without using proprietary software. Setting up alliances for getting in-depth access is time-consuming and often fails since companies are reluctant to open their systems to new players. The typical focus of companies is to protect their markets and intellectual property making them hesitant to such cooperations. Hence, we have developed our hardware and software, and we are currently working with strategic research groups to implement our technology closer to the bench and the scientists.

Regarding LABMaiTE's scientific development strategy, the general idea of having an AI algorithm controlling a real-life experiment (as opposed to pure in-silico setups) has already been shown to work using a color mixing setup and an RGB camera. We did not publish this application to avoid potential interference with our patent application process. Moving up on the complexity ladder to a proof-of-concept with cell cultures, we have implemented a simplified system for optimizing bacterial cultures. This serves as a model to prove that the agent is able to optimize biological applications. This setup has been validated to reproduce findings that have already been published before using state-of-the-art equipment and statistical methods (10). Currently, we are working on the algorithm to reproduce these findings without encoded human knowledge about the organism. This approach is under evaluation for an additional patent and therefore not yet published. The next step is then to apply the algorithm to mammalian cell culture using a more sophisticated hardware setup. This setup is currently under

development and will be established by mid-2024. Two grant applications have led to this project, the LOCAI and the iCARus grants, both funded by the Federal Ministry of Education and Research (BMBF) of Germany. The next step is to prove the ability of our device to optimize the activation and proliferation of Chimeric Antigen Receptor T-cells (CAR T-cells, iCARus grant). The generation of substantial quantities of T-cells for therapy is one of the challenges scientists are facing in this field: 9% of CAR T-cell therapy candidates cannot be given the treatment since their T-cells cannot be grown in sufficient quantities (11). We expect LABMaiTE will spark a new era in cancer treatment since it has the potential to make personalized therapies not only more effective but also making them more economical and accessible to more patients. We hope that with smart automation of trial and error we can help scientists and patients to beat cancer sooner.

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About the Author

Jonas Bermeitinger holds a diploma in Aeronautical engineering as well as a MBA in general management and is committed to advancing cancer research through innovative technology. As the co-founder and CEO of LABMaiTE GmbH, he focuses on automating scientific experiments using artificial intelligence to accelerate breakthroughs in cancer treatment. Previously, Jonas worked as a Key Account Manager at Knoll Feinmechanik GmbH, specialising in lab applications and custom solutions for medical and automotive sectors.