Symposium | Co-Innovation Program (CIP)：Frontiers of lab-automation technologies transforming research and development

Thu. Mar 27, 2025 9:00 AM - 11:20 AM JST | Thu. Mar 27, 2025 12:00 AM - 2:20 AM UTC
[E]F401(F401, Bldg. 4, Area 2 [4F])

[[E]F401-2am] Frontiers of lab-automation technologies transforming research and development

Chair, Symposium organizer: Shumpei Hitosugi, Ryo Koga, Genki Kanda, Ryojiro Hijikata, Hiroaki Iino

近年データ駆動科学が台頭してきています。データ駆動科学というとAI関連技術に目が向きがちですが、実際の研究開発の現場においては其となるデータの収集がボトルネックとなっているケースが少なくありません。そのようななか、従来法の限界を超える実験データ大量収集法として注目されているのがラボオートメーションです。また単純な高速化にとどまらず、コロナ禍を経た働き方・研究スタイルに変革をもたらす基盤技術としても期待されています。本セッションでは、将来のAI技術活用を念頭に置いた自動化技術やコンビナトリアル技術に焦点を当て、これらの最新研究成果と活用法について議論します。

本セッションは午前、午後に実施されます。
聴講後のアンケートへのご協力をお願いいたします。

9:00 AM - 9:10 AM JST | 12:00 AM - 12:10 AM UTC
Opening Remarks

Japanese Keynote Lecture
9:10 AM - 10:00 AM JST | 12:10 AM - 1:00 AM UTC
[[E]F401-2am-01]
Trends of AI for Science

○Sho Ozaki[1] (1. Japan Science and Technology Agency)

10:00 AM - 10:10 AM JST | 1:00 AM - 1:10 AM UTC
[2E_F40101-03-3add]
Incubation Time

Japanese Invited Lecture
10:10 AM - 10:40 AM JST | 1:10 AM - 1:40 AM UTC
[[E]F401-2am-02]
Humanoid Robots in Real-World Laboratories

○Genki N. Kanda[1,2] (1. RIKEN, 2. Institute of Science Tokyo)

Japanese Invited Lecture
10:40 AM - 11:10 AM JST | 1:40 AM - 2:10 AM UTC
[[E]F401-2am-03]
Laboratory Automation and Digital Transformation in Chemistry and Materials Science Research

○Ryota Shimizu[1] (1. The University of Tokyo)

11:10 AM - 11:20 AM JST | 2:10 AM - 2:20 AM UTC
[2E_F40101-03-6add]
Incubation Time

AI for Science の動向

（国立研究開発法人科学技術振興機構研究開発戦略センター）尾崎　翔
Trends of AI for Science (*Center for Research and Development Strategy, Japan Science and Technology Agency (JST)*) Sho Ozaki

With the advancement of AI technology, the spread of high-performance computing resources, and the openness of research data, efforts to utilize advanced AI technology in scientific research in various fields are progressing, referred to as AI for Science. As the use of AI in scientific research progresses, efforts are also progressing to automate part or all of experiments in scientific research by combining AI and robots. Efforts have also begun to automate not only experiments but the entire scientific research process using AI. Technology to automate the scientific research process can be said to be an extremely important trend that could become a new paradigm in scientific research. This technology could be a source of hope for Japan, which is facing a decline in research capabilities that cannot be considered separately from the serious problem of population decline, so in this article we will introduce the trends in AI for Science.
Keywords：AI for Science, Laboratory Automation

AI 技術の進展や高性能な計算資源の普及、研究データのオープン化を背景に、高度な AI 技術をさまざまな分野の科学研究で活用する取り組みが、AI for Science などと称されながら進んでいる。科学研究への AI 活用が進む中、AI とロボットを組み合わせることで、科学研究における実験の一部または全てを自動化する試みも進展している。また、実験だけでなく、科学研究のプロセス全体を AI によって自動化しようとする努力も始まっている。科学研究のプロセスを自動化する技術は、科学研究の新たなパラダイムとなり得る極めて重要な潮流と言える。深刻な人口減少問題と切り離して考えられない研究力の低下を抱える日本にとっても、この技術は希望となり得るため、今回は AI for Science の動向について紹介する。

Humanoid Robots in Real-World Laboratories

([1]*RIKEN*, [2]*Institute of Science Tokyo*) ○Genki Kanda[1, 2]
Keywords: Laboratory Automation; Dual-arm Robot; Regenerative Medicine

The integration of biotechnology and IT has catalyzed significant advancements in life sciences, yet major challenges remain unresolved. For instance, experimental data often lacks reproducibility. Modern technologies have facilitated large-scale and high-throughput experiments, yet they have concurrently escalated the demand for labor-intensive, repetitive tasks, consuming valuable human resources. High biosafety-level experiments necessitate costly preventative measures to protect researchers from hazardous reagents. Furthermore, laboratory resources are rarely fully utilized, leading to daily surpluses of resources, including expensive instruments and laboratory spaces. To address and mitigate these issues, we have developed the humanoid robot Maholo LabDroid [1]. It stands as a prime solution for transitioning towards laboratory automation. Maholo is programmed to perform a variety of life science experiments using standard laboratory instruments, eliminating the need for specialized equipment. The current paradigm of laboratory automation largely involves 'Robotizing,' or simply replacing human tasks with robots. However, our approach, 'Robotalizing,' leverages robots and AI to create new value in life sciences. We have successfully developed several applications in the field of regenerative medicine: an autonomous culture system combining Maholo with AI [2], an autonomous experimentation system integrating Maholo with optimization AI [3], and a robotic cell processing facility for clinical use [4]. These developments have successfully led to the Robotalization of the entire spectrum from basic to clinical research in cell culture. In this presentation, we aim to introduce these initiatives and discuss the future of life sciences driven by robots and AI.

[1] Yachie et al, Robotic crowd biology with Maholo LabDroids. *Nature Biotechnology* (2017)
[2] Ochiai and Motozawa et al, A variable scheduling maintenance culture platform for mammalian cells. *SLAS Technology* (2020)
[3] Kanda and Tsuzuki et al, Robotic search for optimal cell culture in regenerative medicine. *eLife* (2022)
[4] Terada et al, Robotic cell processing facility for clinical research of retinal cell therapy. *SLAS Technology* (2023)

日本化学会 第105春季年会 (2025)

化学・材料科学の研究現場におけるラボオートメーションと DX 化：勘所と留意点

（東大院理）清水 亮太
Laboratory Automation and Digital Transformation in Chemistry and Materials Science Research
(*Department of Chemistry, The University of Tokyo*) ○Ryota Shimizu[1]

The landscape of materials exploration is rapidly expanding to meet the social demand for functional materials. Autonomous materials research, using AI-based decision-making with automated synthesis and measurements carried out by robots, presents a promising avenue. Recently, significant progress has been made in the development of solid-state systems, alongside conventional liquid systems where materials are more easily handled. Here, we present our recent research on the autonomous synthesis of functional inorganic oxide thin films. Through iterative operations of automated thin film deposition (utilizing robots), measurement of electronic/ionic conductivity (also performed by robots), and the application of Bayesian optimization (AI) for decision-making, we autonomously study chemistry and materials science, achieving a tenfold increase in throughput. Additionally, I will discuss future perspectives regarding the introduction of combinatorial technology and a materials exploration system integrated with various measurement instruments.
Keywords : Autonomous experiments; Inorganic materials; Combinatorial synthesis

機能性材料に対する社会的な需要に応えるため、材料の探索空間が急速に拡大している。そのアプローチとして、AI を基盤とした意思決定とロボットによる自動合成・測定を活用した自律的な材料研究が注目されている。最近では、材料の取り扱いが比較的容易な従来の液体系に加え、固体材料の開発への適用にも大きな進展が見られている。そこで本発表では、機能性無機酸化物薄膜の自律的合成に関する最近の研究を紹介する。我々の装置では、ロボットを利用して薄膜成膜（ロボットを使用）や電子/イオン伝導率の測定を自動で行い、ベイズ最適化（AI）による意思決定が可能である。この装置による自律探索により、スループットを 10 倍に増加させることに成功している。さらに、複数の測定機器と統合された材料探索システムや、コンビナトリアル合成技術の組み合わせに関する今後の展望についても紹介する予定である。

1) R. Shimizu *et al*., APL Mater. **8**, 111110 (2020).
2) S. Kobayashi, R. Shimizu *et al*., ACS Mater. Lett. **5**, 2711 (2023).