Research Topic

(1) Body of the AI-robot Scientists

Progress until the fiscal year 2022

1. Summary

Robotic platforms and micro-robotic tools are being developed to enable accurate, precise, and dexterous manipulation beyond the physical capabilities of human scientists to perform scientific experiments that could not be done by human scientists alone.

2. Progress

Experiments in the field of life sciences require accurate, precise, and complex tasks under a microscope. However, even skilled scientists often encounter failures due to the limitations of human physical abilities. Furthermore, existing robotic technologies excel at routine tasks for handling rigid objects but struggle with non-routine tasks involving small and flexible samples, such as samples taken from plants and animals.

In this project, we are proceeding with development in two steps. First, we aim to surpass the accuracy, precision, and dexterity of skilled scientists in handling samples in life science experiments through remote control of robots or automation. Then, we aim to integrate AI with the robotic system to autonomously perform experiments. Currently, we are working on prototyping platforms and micro-robotic tools in preparation for integration with AI.

(1) Robotic platform (Harada-PI)

As a platform for autonomous scientific exploration, we have developed the AI Robot Platform shown in Fig. 1. This platform consists of four robotic arms with different functionalities placed around the experimental subject under a microscope. The robotic arms can be equipped with various experimental tools, and depending on the requirements of the experiment, AI robotic arms with the required tools can gather and perform the tasks. We have implemented controls to automatically avoid collisions between the robotic arms and collisions between the robotic arms and the surrounding environment to enable tasks within a very small field of view of the microscope. We have successfully demonstrated the platform's tele-manipulation ability to perform highly precise and complex experimental manipulations on a real sample. This remote manipulation will be used to collect learning data for the AI for Skills.

Fig.1 Prototype of the robotic platform
Developed as an open-source platform.
https://aiscienceplatform.github.io/

(2) Micro-robotic tools (Arai-PI)

Micro-robotic tools have been engineered to exceed human physical capabilities, enabling the precise manipulation of small and delicate experimental samples, such as cells. A robotic glass pipette with a force sensor (Resolution: 0.62 μN) has been developed as a micro-robotic tool of AI-robot scientists as shown in Fig.2. The force sensor can detect very small forces that cannot be sensed by the human hand.

Development is also underway for other micro-robotic tools, including a tool that can retrieve individual cells of approximately 10 μm from a plant root (with a diameter of about 100 μm), while simultaneously tracking its position and another tool that collects samples from animal tissues. Such micro-robotic tools facilitate the execution of precision tasks that are challenging for even skilled scientists, due to inherent human physical limitations.

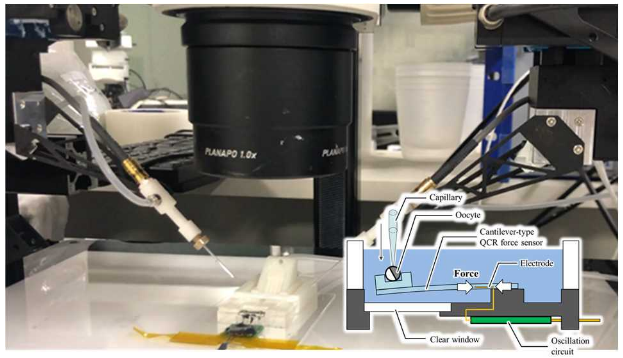

Fig. 2 Micro-robotic tool with a force sensor

3. Future work

After integration of the micro-robotic tools into the robotic platform, AI technologies being developed by the research topic **(2) Brain of the AI-robot Scientists** will be integrated to step up from the tele-robotic manipulation or robotic automation to autonomous exploration of science. Potential contribution by the AI-robot scientists will be demonstrated by the collaboration with scientists in **(3) Scientific applications** by demonstrating discoveries that could not be done by human scientists alone.

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