Investigation of an AI to Suggest Scanning Paths for Uniform Temperature Distribution in the Selective Laser Thermoregulation Method

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We developed the Selective Laser Thermoregulation (SLT) method [1] to heat samples into various shapes by rapidly scanning a laser with a fiber laser and a Galvano scanner. In the previous study, we developed AI, which studied the relationship between temperature distribution and laser irradiation conditions [2-3]. However, it didn't consider laser movement, which is crucial for SLT. In this study, we focused on AI learning laser movement through reinforcement learning to suggest paths with minimal movements.

Reinforcement learning teaches agents optimal actions in an environment. In this study, a laser is an agent moving on the sample surface. Rewards are based on temperature distribution, which is the environment of this study. We compared the Monte Carlo (MC) and Temporal Difference (TD) methods [4].

We defined learning of 1000 episodes as one learning session. We compared the number of the agent's movements and the time spent on a learning session. Because learning involves a factor of randomness, we compared the average of 10 learning sessions. Figure 1 shows the number of times the agent moved in the first and the last episode and the time it spent on one learning session. TD learned about ten times faster than MC, with fewer timeouts and non-converging policies.

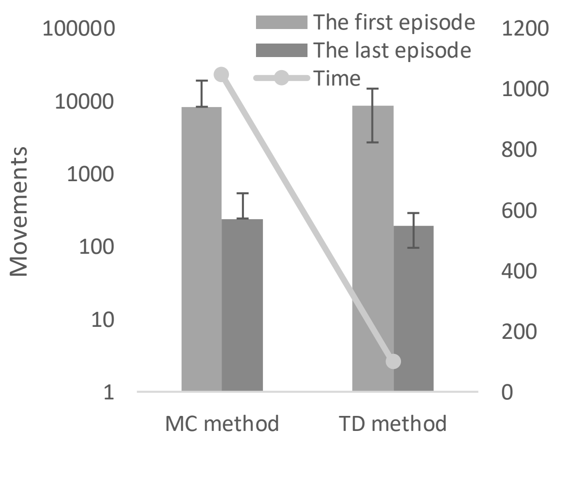

Figure 1: Result learning.

References: [1] Hayato Koshiji, Tomomasa Ohkubo, Yuki Ueno, Ken Goto, and Yutaka Kagawa. J. Laser Micro Nanoeng. 15, (2020) 174; [2] Miki Nakaone, Tomomasa Ohkubo, Yuki Ueno, Ken Goto, and Yutaka Kagawa. J. Laser Micro Nanoeng. 16, (2021) 84; [3] Miki Nakaone, Tomomasa Ohkubo, Yuki Ueno, Ken Goto, and Yutaka Kagawa. J. Laser Micro Nanoeng. 17, (2022) 194; [4] Richard S. Sutton, and Andrew G. Barto. Reinforcement learning. An introduction. MIT press (2018) 91-119;