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Use AI to Build Adaptive Greenhouse for Climate Changes

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Introduction

Although most existing greenhouse control solutions can optimize the crop environment in greenhouses, most of the actuators have fixed deployment and performance ceilings. Once the climate changes over the ceiling limit of greenhouses, their performance will crush. Therefore, we need a greenhouse that can adapt to climate change.

Objective

We aim to improve the adaptation ability of greenhouses to climate change. Instead of controlling the existing actuators of greenhouses, we research how the structure of greenhouses can be controlled to adapt to climate change. As the first step, we aim to control the position and temperature of greenhouse heaters. The temperature of a greenhouse is normally uneven and dynamically changes. We use Deep Reinforcement Learning (DRL) to learn the dynamic environmental temperature and dynamically control the position and temperature of greenhouse heaters.

Results

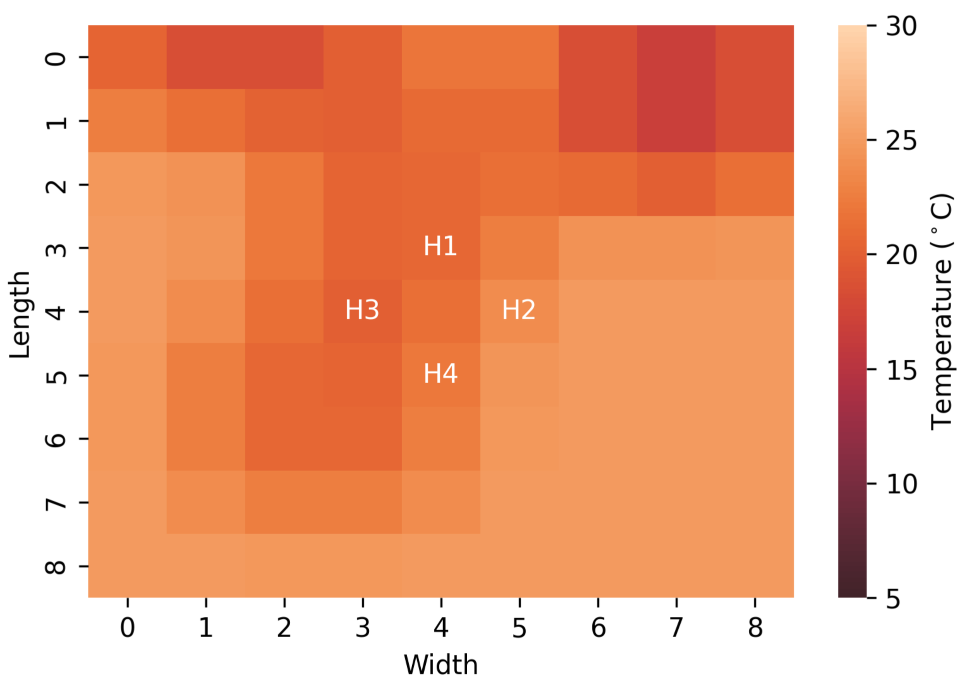

Figure 1. An initial state of the dynamic environmental temperature with default positions of the four dynamic heaters.

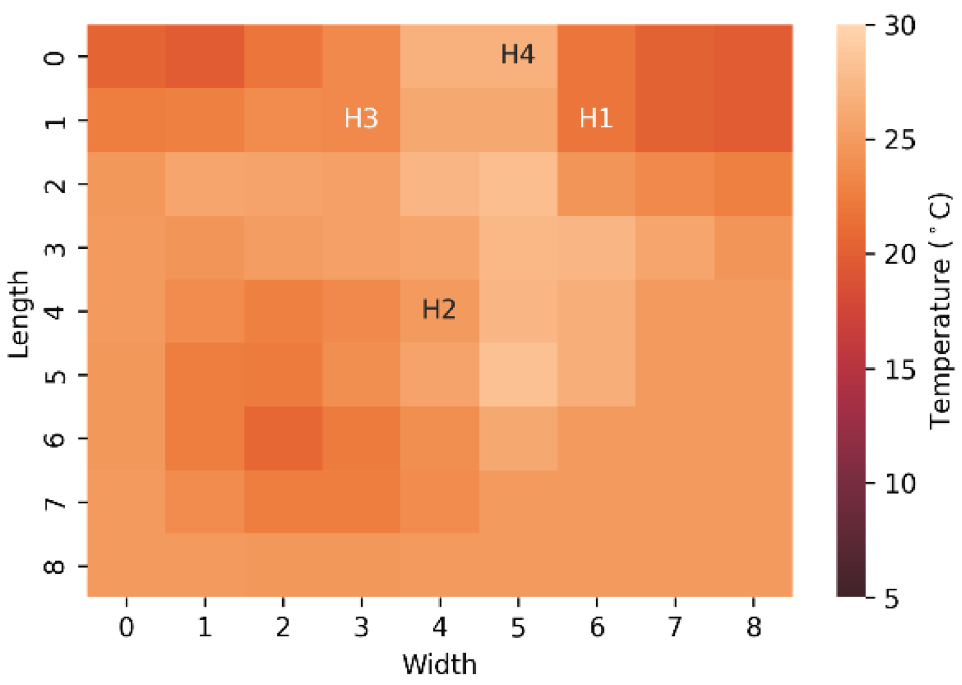

Figure 2. A final state of the dynamic environmental temperature after being heated by the four dynamic heaters.

Figure 1 and 2 illustrate that the final state of the environmental temperature is more uniform than its initial state. This is because the four heaters can move adaptively to optimal positions.

- Figure 3 shows that the average temperature increases as heaters move.
- Figure 4 shows a high temperature deviation, which means the temperature of the greenhouse is uneven.
- Figure 5 shows a low temperature deviation, which means the temperature of the greenhouse becomes more even by moving heaters to optimal positions.

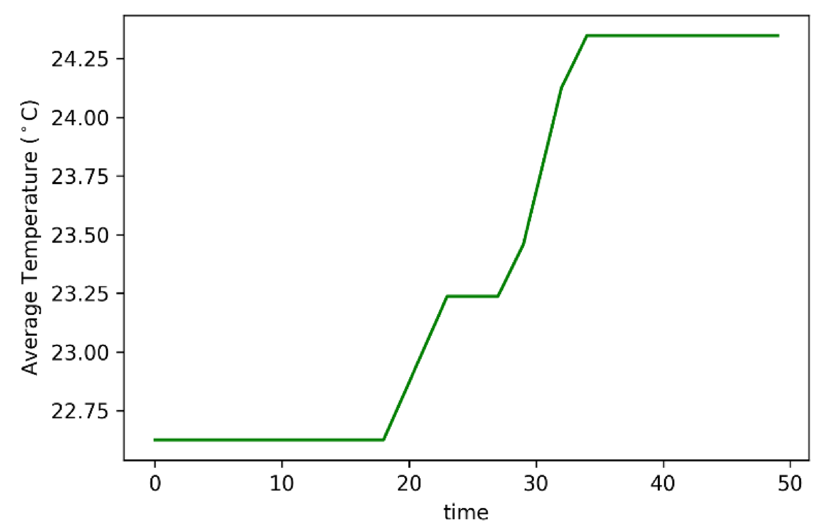

Figure 3. The change of average temperature while heaters move in the greenhouse.

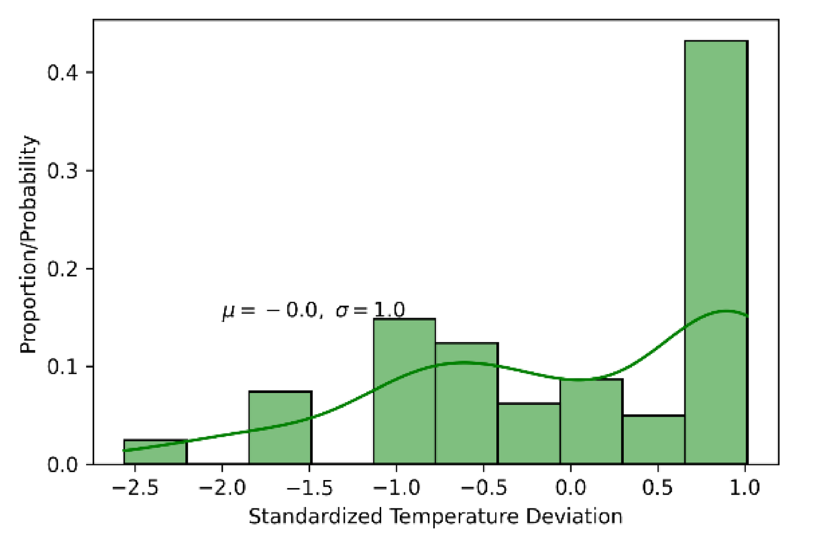

Figure 4. The distribution of initial temperature deviation values.

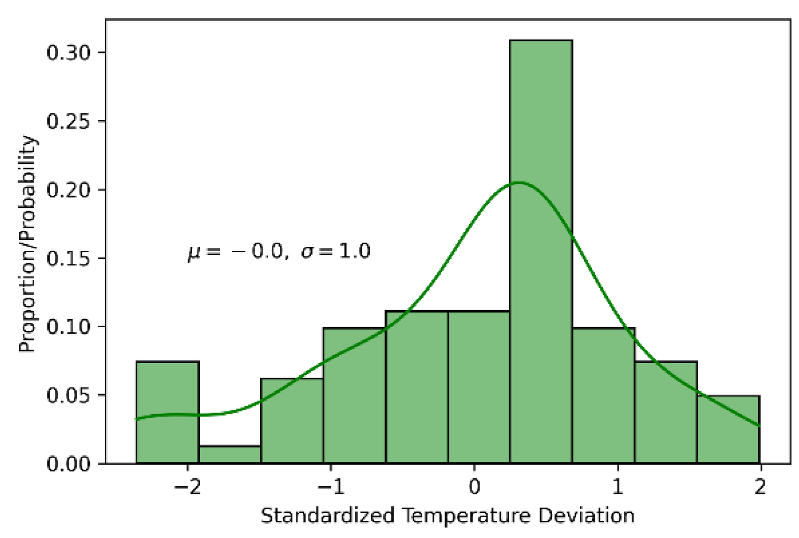

Figure 5. The distribution of final temperature deviation values.

The score of a heater increases if the heater moves to a better position. The correct positions are calculated by the reward of DRL. It can be seen from Figure 6 that the reward values of the four heaters converge and become better than the initial values.

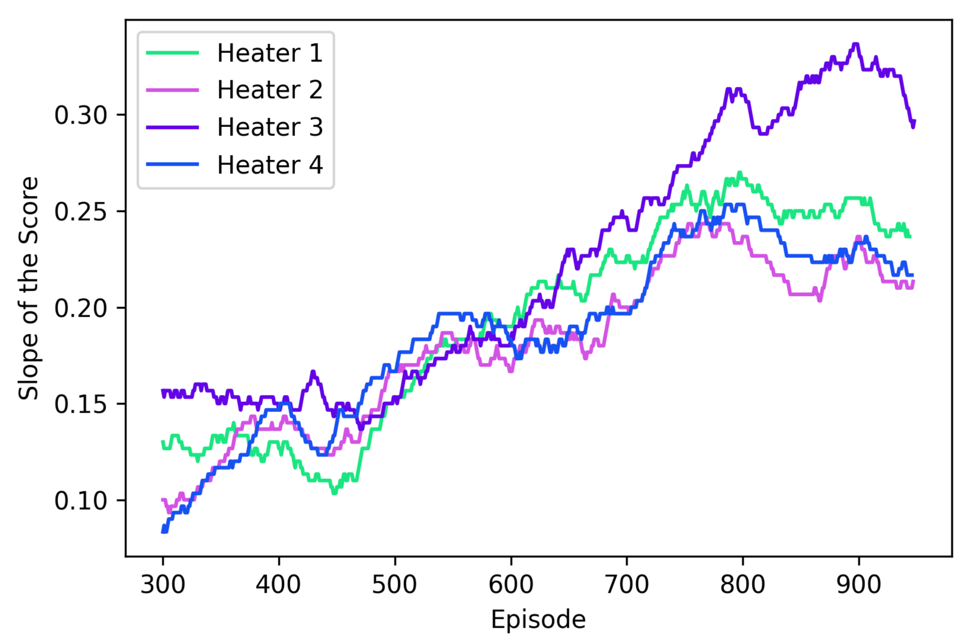

Figure 6. The converged DRL score from the four dynamic heaters.

Conclusions

- Dynamic heaters can improve the heating performance of greenhouses and save energy costs.
- AI can help to improve the adaptiveness performance of greenhouses.
- Using similar solutions, we can control other greenhouse structures, such as walls and ceilings.

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