General structure of experiments for comfortable laboratory automation

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Introduction

For large-scale laboratory automation, dynamic experiment management software that adapts to various types of experiments is essential. However, most automation software is designed for specific research or experimental methods(1-3). In addition, no experimental structure exists for the purpose. To address this, **we define a flexible experimental structure** capable of representing dynamic progress and develop the General Experiment Management Software **(GEMS)** to manage it.

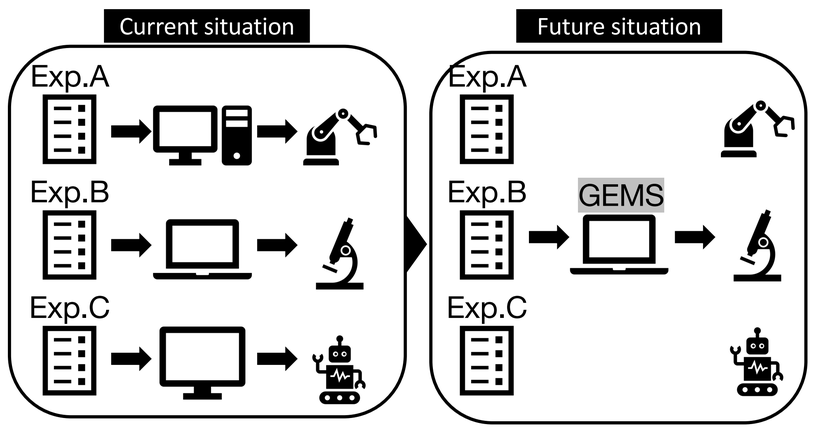


Fig.1 Current and future situation

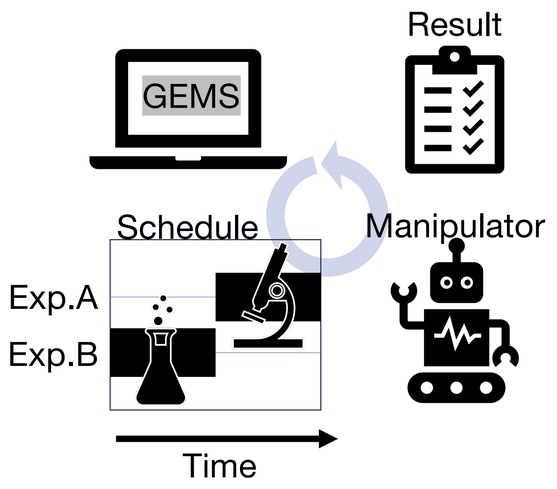


Fig.2 Autonomous experiments with GEMS.

Methods

General structure of an experiment

- Experiments consist of multiple states.
- Specific tasks, and a formula for calculating the optimal execution time, are defined for each state.
- Transition rules between states are predefined for each state.

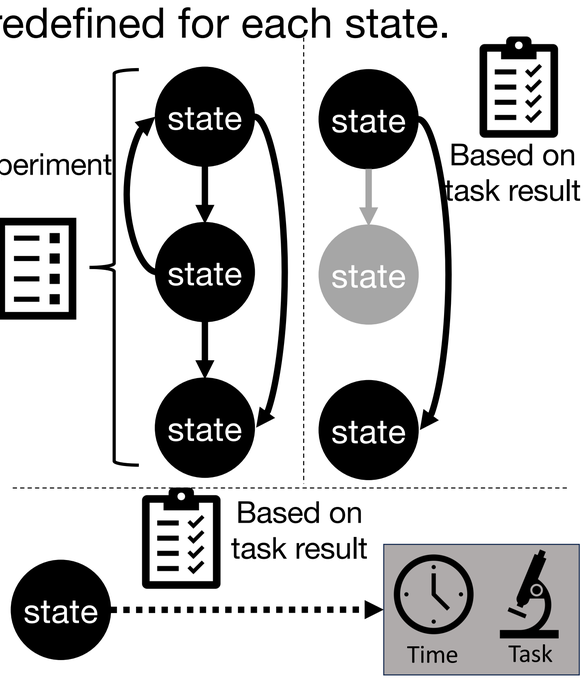


Fig.3 General structure of an experiment

Software configuration

- Transition Manager updates the state of the experiment(s).
- Task Generator calculates the optimal time of the next task.
- Task Scheduler schedules all the tasks.

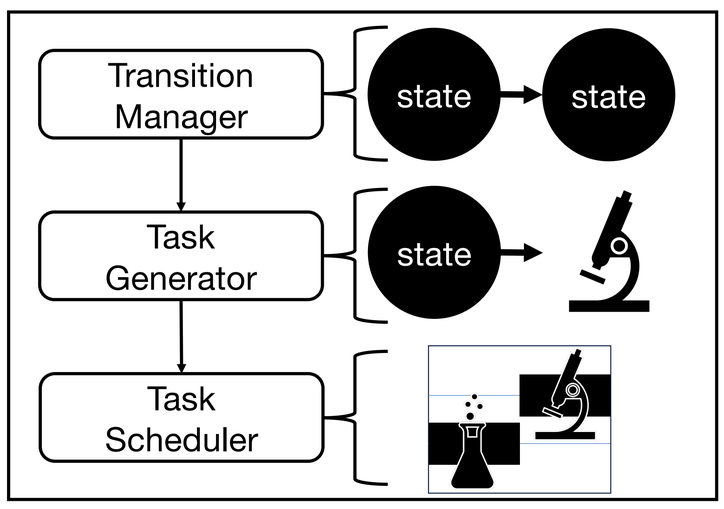


Fig.4 GEMS configuration

Settings of simulation experiment

[Maintainance of multiple cell lineages]

- Each cell line has a unique growth curve.
- All cell lines start in the same initial state.
- The optimal passage time is when the cell count reaches 0.3 and 0.7 for iPS cells and HEK293A cells, respectively.
- Regular task: restocking reagents.
- Priority: passages of iPS cells over HEK293A cells.

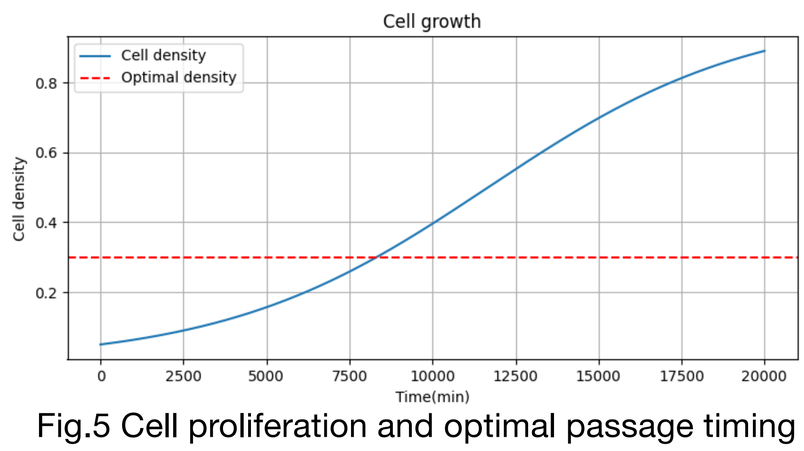
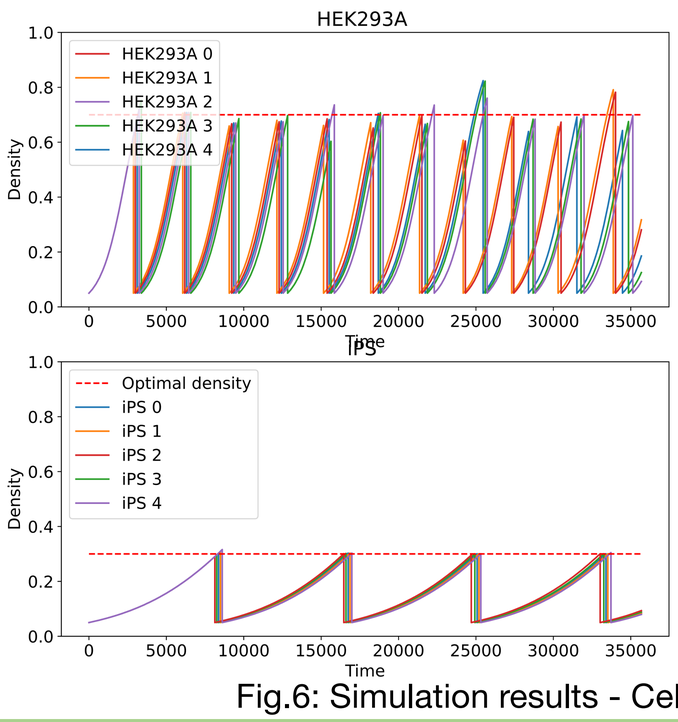


Fig.5 Cell proliferation and optimal passage timing

Results

Simulation result

- Maximum and minimum densities of iPS cells: 0.32 and 0.29.
- Maximum and minimum densities of HEK293A cells: 0.86 and 0.57.
- Culture timing of iPS cells maintained within ± 0.02 of target density.
- GEMS could consider the priority successfully.
- GEMS proceeded with the experimental group with reagent restocking without affecting passages.



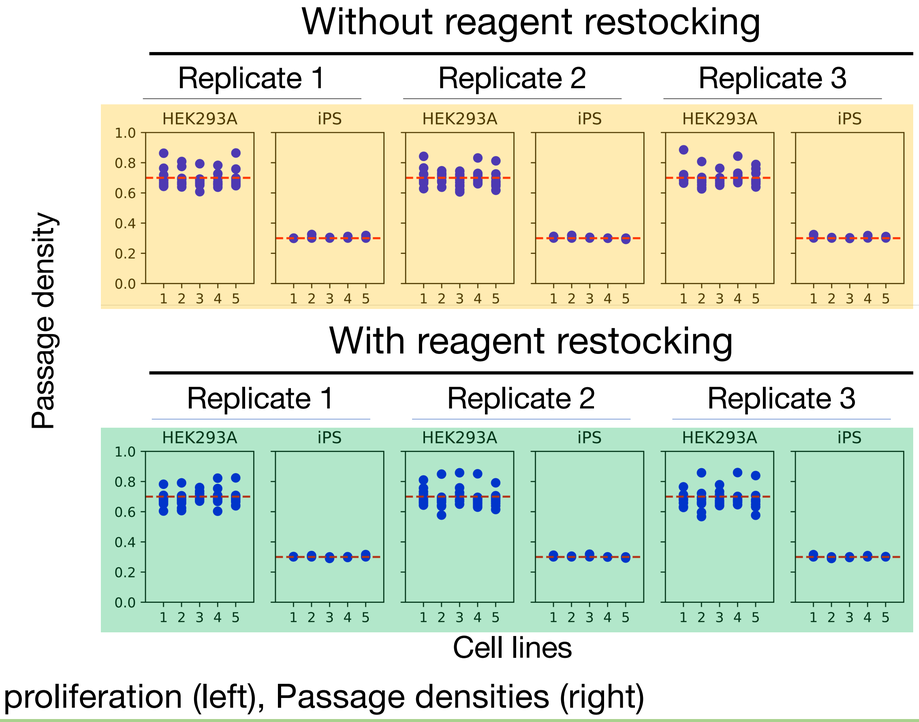


Fig.6: Simulation results - Cell proliferation (left), Passage densities (right)

Future plan

1.Simulate other experiment

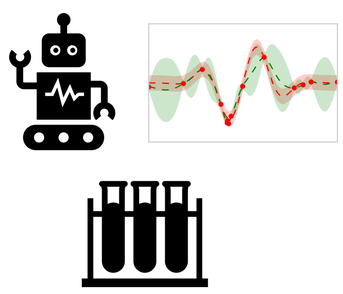
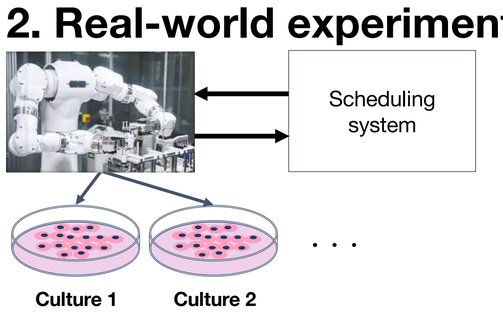


Fig.7 Colour water optimisation

2. Real-world experiment



Picture from Maholo image from G. N. Kanda *et al.*, *Elife*, vol. 11, p. e77007, Jun. 2022.

Fig.8 Real-world experiment Image

3. Extension of GEMS

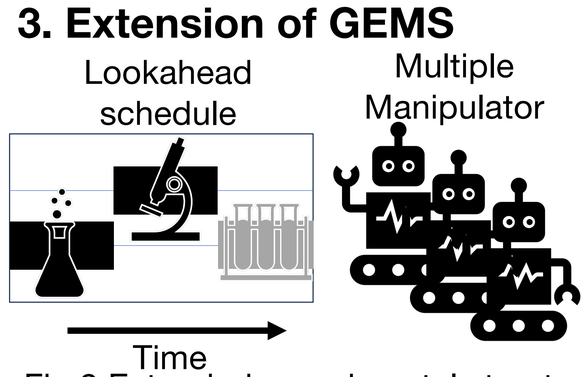


Fig.9 Extended experimental structure

References

1) M. M. Hielscher et al., *Chem. Asian J.*, vol. 18, no. 14, p. e202300380, Jul. 2023.
2) I. Namatame et al., *SLAS Technol*, Apr. 2023, doi: 10.1016/j.slast.2023.04.002.
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