Complexity Science mini-project:
Evolving Control Rules for Complex Systems

Background: Finding good decentralized control rules to optimise the performance of complex systems in a dynamic environment is a challenging task, because the complex system exhibits emergent behaviour that can not be captured in a simple analytic form. One way to tackle this is by simulation optimisation: Given a simulation model of the complex system, and a space of possible control rules, a search algorithm can try to find the control rule that yields the best result on the simulation model.

A powerful class of search algorithms would be Evolutionary Algorithms (EAs), i.e., heuristics inspired by the principles of natural evolution. We have already successfully applied EAs to automatically design dispatching rules that control the production process in a complex semiconductor factory [1].

Mini-project: In this project, the idea of automatically generating control rules by means of an evolutionary algorithm shall be applied to other similar problems. Any of the following applications could be considered:

- more complex scheduling environments, focusing, e.g., on parallel machines or the minimization of nervousness
- vehicle routing problems, e.g. for dispatching taxis or repairmen
- designing rules for movement of a team of robots that collectively need to catch an (faster but single) evader or need to move as a swarm from A to B in a plane with obstacles
- assigning calls to staff members in a call centre, where staff members have different skills
- deciding whom to vaccinate in case of an outbreak of an infection
- any other complex control system you would like to optimise.

For the first application (scheduling), we have a running simulation, for the other applications, a simulation model would have to be developed as part of the project (which would require some programming skills).

PhD prospect: The topic of simulation optimisation is a hot research topic . The topic can be expanded into a PhD either by moving into the application side and make the scenario more realistic, or by moving into the methodology side, e.g. by looking into the best use of simulation time (trade off between number of solutions that can be examined vs. accuracy of the simulation model)

Deliverables: Control rule for the problem considered.

Student's requirements: Some programming is necessary.

References

[1] Pickardt, C.; Hildebrandt, T.; Branke, J.; Heger, J.; Scholz-Reiter, B.: "Evolutionary generation of dispatching rule sets for complex dynamic scheduling problems". International Journal of Production Economics, Elsevier, 2013