Proposal of a General-purpose Algorithm of Split Delivery Vehicle Routing Problems for Multiple Agricultural Machines

In recent years, there has been growing attention towards smart agriculture to enhance the efficiency of agriculture[1]. Farmers utilize multiple agricultural machines to work on several fields. In this process, it is necessary to decide (a) the assignment of tasks to agricultural machines for each field, and (b) the touring route of each agricultural machine for the fields they are responsible for.

Although various methods have been proposed in previous studies to address this problem, it is not clear which method is appropriate when conditions are specified according to the individual situation of a farm, leading to a lack of versatility in the dispatch system. Furthermore, in each method, hyperparameters (parameters set from outside that affect the algorithm's operation or performance) are empirically given, making it difficult to say that the full potential of each method has been utilized. For these reasons, the development of a versatile task allocation system has not been achieved. Therefore, this study aimed to develop a general-purpose task allocation system for agriculture.

In order to reach this objective, we developed a versatile task allocation system and verified its effectiveness. The results of the simulation are shown in Table 1. It was demonstrated that the simulated annealing method performs well for small agricultural field scales, while local search methods are superior for large scales with short calculation times, and the values of hyperparameters suitable for the scale of the agricultural field were derived. Going forward, further experiments will be conducted targeting more agricultural field conditions and metaheuristics to further develop a versatile agricultural task allocation system, including the extraction of features necessary for selecting the appropriate algorithm.

Table 1. Best optimization methods and hyperparameter combinations according to farmland size and maximum calculation time

Farmland size \ Max calculation time (sec)	1	10	100	1000
large	Local search	Local search	Local search	SA (Initial temperature, Cooling rate) =(25, 0.999)
medium	ACO (Evaporation rate, Initial pheromone, Secreted pheromone) =(0.9, 10, 0.1) etc.	SA (Initial temperature, Cooling rate) =(25, 0.99999)	SA (Initial temperature, Cooling rate) =(25, 0.9999)	SA (Initial temperature, Cooling rate) =(25, 0.999)
small	SA (Initial temperature, Cooling rate) =(25, 0.999)	SA (Initial temperature, Cooling rate) =(50, 0.9999)	SA (Initial temperature, Cooling rate) =(25, 0.99999)	SA (Initial temperature, Cooling rate) =(25, 0.999)

Keywords: Smart agricalture, Multi-agent system, Split delivery vehicle routing problem, metaheuristic

References

[1] Ju, C., Kim, J., Seol, J., & Son, H. I. (2022). A review on multirobot systems in agriculture. Computers and Electronics in Agriculture, 202, 107336.