Controlling Large Scale Systems by Reaction-Diffusion Equation on a Graph

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Yuasa proposes a method for modeling autonomous decentralized systems by reaction-diffusion equation on a graph. The whole system is represented as a graph, with each autonomous agent and the interaction between two agents corresponding to a vertex and an edge, respectively. The objective of the whole system is given as a potential function on a graph, and the behavior of each agent is governed by a gradient system of the potential. Having high generality, this model can be applicable to various research fields concerned with large scale systems. Currently we are studying the following two applications.

Controlling traffic signal network: The control of traffic signals has been researched as one of the countermeasures to improve traffic conditions. We have proposed a new method for controlling a large number of traffic signals in a decentralized manner. Traffic signals forming a network are modeled as a nonlinear coupled oscillator system. The behavior of each oscillator is governed by a reaction-diffusion equation on a graph. Each signal determines its parameters (i.e. split, offset, and cycle length) from its local traffic conditions. Simulation results have shown high stability in a stationary environments and a high adaptability in dynamic environments.

Job shop scheduling problem: We deal with a large scale job shop scheduling problem with various disturbances (e.g. addition or removal of jobs, delay of processing time, etc.) and practical constraints (e.g. release time constraints, setup time constraints, etc.) taken into account. Operations are regarded as autonomous agents, and the constraints are represented as potential functions. A feasible schedule is obtained by the dynamics of the gradient system along the potential functions. Combining the present method with the schedule improvement based on the permutation of operations, we aim to obtain a good feasible solution in a short time.

Keywords: Reaction-Diffusion Equation on a Graph, Traffic Signal Control, Job-Shop Scheduling

References

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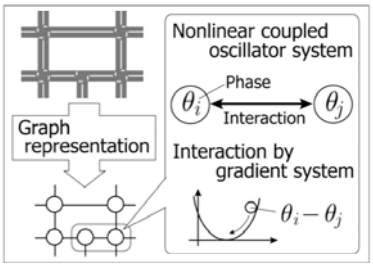

Fig. 1 Overview of Traffic Signal Control

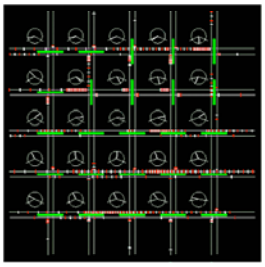

Fig. 2 Traffic Simulation

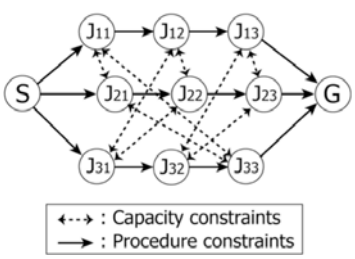

Fig. 3 Sample of Constraints with 3-job 3-machine problem