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# 論 文 要 旨

THESIS SUMMARY


専攻：
Department of 情報環境学 専攻

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申請学位（専攻分野）： 博士（Engineering）
Academic Degree Requested Doctor of

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）


As the size of systems to be controlled gets larger, distributed optimization is becoming one of the significant topics. This is because large systems take longer to solve in a centralized manner. With distributed optimization, the large system is divided into smaller subsystems and each local optimization problem is solved by an individual computer. This solution is then used by a lover level controller as reference. However distribution, by itself, is not enough as the subsystems have to share calculation results at each iteration and work in a synchronized manner. Former increases the communication costs which can affect systems where communication is handled via radio frequency communication protocols. Latter results in wasted calculation capability as simpler subsystems can solve their local optimization problem faster and have to wait for slower subsystems. Also clock synchronization in networked systems is hard and is another research topic by itself. Finally these systems require a supervisor which collects the convergence status of individual algorithms and signals the whole system to stop optimization if a certain criteria is met.

We can solve the first problem by using event-triggered communication where subsystems only communicate if a certain communication criteria is met. Subsystems use state estimates of their neighbor subsystems in their calculations. They also track their own state estimate and if the maximum error between the actual state and the estimate is over a certain threshold, they send the actual state as an update operation. The second problem can be solved by extending the event-triggered algorithm to run asynchronously. We remove the requirement for a synchronized clock so each subsystem can be at a different step of the algorithm during the optimization loop. We also modify our algorithm to check for stopping conditions during update event loop in order to catch subsystems which exited the optimization algorithm. This means all subsystems have converged to a solution and there is no need to update state estimates. Last problem can be solved by using a new stopping criterion called diffusion based stopping criterion. In this stopping criterion each subsystem tracks its own and its neighbors convergence status directly via a stopping criterion matrix. Other elements in the matrix indirectly contain convergence status of subsystems that are not its neighbor. This way the convergence status of all the subsystems diffuse through the network. This way subsystem can know if all the subsystems in the network have converged to a solution but cannot know the convergence status of a subsystem unless that subsystem is its neighbor.

In this thesis, we propose three parallel distributed optimization algorithms: a conventional dual decomposition based distributed optimization as the base case, a novel algorithm by extending the same algorithm with event-triggered communication to remove the requirement for exchanging states at each iteration thus minimizing communication cost, and a novel asynchronous optimization algorithm based on the event-triggered communication which does not require clock synchronization of subsystems and eases real world applications. We also propose a novel stopping criterion called diffusion based stopping criterion which does not need a supervisor but still can track the convergence status of the whole network by only communicating with its neighbors. We then combine all three parallel distributed optimization methods and two stopping criteria to get six different algorithms and compare them by numerical simulations on a dispatch problem.
From the numerical simulation results, we can say that two algorithms, the event-triggered distributed algorithm with diffusion based stopping criterion and the asynchronous algorithm with supervisor, are candidates for real world applications as they both have low calculation times and low communication cost due to low number of communication events. The asynchronous algorithm with diffusion based stopping criterion is not suggested as during simulations some subsystems stopped unexpectedly and optimization algorithms running on all the subsystems had to be restarted which resulted in increased calculation times for those time steps.