Decentralized Markets versus Centralized Control: A Comparitive Study
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High Level Overview

- GOAL: Conduct an empirical study of advantages and weaknesses of multiagent solutions vs conventional ones

  In what respects and to what extent are multi-agent solutions better than 'conventional' alternatives?

- MAIN RESULT:
  - Local Information + Market Communication = Global Control
  - Test case: distributed temperature control in office buildings

- APPROACH:
  - Factor analysis of Clearwater and Huberman approach
  - Improved "truly local" algorithm

Many Approaches

Control – A:

$$F_{io} = F_{i-1,o} + \beta(T_{io} - T_o^{step})$$

$$P_{io}^{cons} = \begin{cases} F_{io} & F_{io} \leq \eta P_{io}^{avail} \\ \eta P_{io}^{avail} & F_{io} > \eta P_{io}^{avail} \end{cases}$$

Control – B:

$$F_{io} = F_{i-1,o} + \beta\left[\left(T_{io} - T_o^{setp}\right) - \left(\langle T \rangle_i - \langle T^{setp} \rangle\right)\right]$$

$$P_{io}^{cons} = \begin{cases} F_{io} & F_{io} \leq \eta P_{io}^{avail} \\ \eta P_{io}^{avail} & F_{io} > \eta P_{io}^{avail} \end{cases}$$

Market – A (C&H):

Auction with clearing price:

$$\min_{p_i} \left| \sum_{o|sell=true,B_{io}\leq p_i} v_{io} - \sum_{o|sell=false,B_{io}\geq p_i} v_{io} \right|$$

Market – B:

- Agent submits demand func $z_{io}(p)$
- Auctioneer computes eq. s.t.,

$$\left| \sum_o z_{io}(p_i) \right| \leq \varepsilon$$

Relation between Markets and Conventional Controller

Assume utility function for individual offices:

$$u(\Delta F_{io,m}) = -\alpha_0^2 (\Delta F_{io} - \phi_{io})^2 + m$$

- There exists a unique equilibrium price, allocation is Pareto optimal
- Any Pareto optimal outcome in a market with the above utility function is equivalent to an integrating controller that exploits global information
- Once we find the unconstrained optimum, this extends to constrained optimum, given that
  - Resources can be independently allocated among agents
  - Average values (global information) are available

MAS versus Conventional Algorithms

- What does this experiment say about the utility of MAS for control, i.e., do you think this has shown MAS to be far superior or is this saying conventional algorithms can match MAS if designed right?
  - What is wrong with conventional approaches?
  - How do MA solutions solve these problems?

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  - What is wrong with conventional approaches?
  - How do MA solutions solve these problems?
- Suppose that someone really skilled in the "conventional" approach came along and designed a better algorithm,
  - First of all, do you think that is possible?
  - What would that say about the results of this paper?

Conclusions & My Impressions

- Either MA or conventional algorithms with global information perform equivalently

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- PID controllers are rather simplistic controllers. In order to authoritatively claim superior performance, one needs to beat state of the art distributed optimization approaches

- HOWEVER, the key result continues to hold. Given equal performance, there is a significant advantage to algorithms that are able to function with purely local information.