Randomization pour le consensus de moyenne

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Résumé

A variety of problems in distributed control involve a networked system of autonomous agents cooperating to carry out some complex task in a decentralized fashion, e.g., orienting a flock of drones, or aggregating data from a network of sensors. Many of these complex tasks reduce to the computation of a global function of values privately held by the agents, such as the maximum or the average. Distributed algorithms implementing these functions should rely on limited assumptions on the topology of the network or the information available to the agents, reflecting the decentralized nature of the problem.
We present a randomized algorithm for computing the average in networks with directed, time-varying communication topologies. With high probability, the system converges to an estimate of the average in linear time in the number of agents, provided that the communication topology remains strongly connected over time. This algorithm leverages properties of exponential random variables, which allows for approximating sums by computing minima. It is completely decentralized, in the sense that it does not rely on agent identifiers, or global information of any kind. Besides, the agents do not need to know their out-degree; hence, our algorithm demonstrates how randomization can be used to circumvent the impossibility result established in [HT15].

Using a logarithmic rounding rule, we show that this algorithm can be used under the additional constraints of finite memory and channel capacity. We furthermore extend the algorithm with a termination test, by which the agents can decide irrevocably in finite time - rather than simply converge - on an estimate of the average. This terminating variant works under asynchronous starts and yields linear decision times while still using quantized - albeit larger - values.

HT15 : Julien M. Hendrickx, John N. Tsitsiklis: Fundamental limitations for anonymous distributed systems with broadcast communications. Allerton 2015: 9-16

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