Measurement-induced topology for distributed estimation

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Abstract

In this paper, we provide a novel measurement classification for distributed estimation of linear dynamics that leads to different connectivity requirements among the agents possessing these measurements. Contrary to the existing work, we show that the set of crucial measurements–required for observability, can be further subdivided into two categories–Type-α and Type-β; such that for stable estimation error: (i) Every agent possessing a Type-α measurement has to be *directly-connected* to every other agent; and (ii) Every agent should have a *directed-path* to every Type-β agent. These two conditions are derived by partitioning the set of system matrices into matrices with full S-rank (maximal rank of zeros and non-zeros), and matrices that are S-rank deficient.

In particular, we show that Type-α measurements only exist in S-rank deficient systems. In other words, for full S-rank systems, strong-connectivity is *sufficient* for stable estimation, as condition-(i) is not required, and condition-(ii) is always satisfied. However, strong-connectivity *may not* work in S-rank deficient systems, as condition-(i) is not necessarily satisfied. Combining the above arguments, we note that for any linear system (full S-rank or S-rank deficient), strong-connectivity is not necessary, i.e., there exist weakly-connected networks that result in stable estimation.

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