Autonomous & Intelligent Systems Laboratory Research

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I. Distributed Consensus-Based Kalman Filter under limited Communication

Summary:

In summary, we show that when quantized information is communicated in the Kalman consensus scheme, the resulting estimation error covariance matrices do not significantly change in comparison with the uncompressed version. We note that the particular characterization of the quantizer used can affect the state estimates obtained and the resulting estimation error covariances.

Questions:

- What is a covariance Matrix?
- What are Bayesian Filters?

Notes:

- Fully distributed Kalman filtering algorithm where each agent shares a compressed version (Quantized) of its estimated state info with its neighboring nodes.
- A key element in enabling distributed-decision making is distributed estimation.
- In this work we consider the computation of the estimation error covariances in a distributed manner. This work focuses on fully distributed Kalman filter operating in an environment with limited communication. We are assuming a limited bandwidth.
- Our focus for limited communication is on quantizing or compressing information being broadcast to a few bits for communication.

Conclussion:

The proposed algorithm has been tested using an uniform quantizer. The results are positive in the sense that the estimation error is kept under acceptable value.

II. An Optimal Kalman-Consensus Filter for Distributed Implementation over a dynamic communication network.

Summary:

A distributed and optimal state estimator is presented for implementation through a dynamically switching, yet strongly connected, directed communication network to cooperatively estimate the state of a dynamic system.

Questions:

- White Gaussian?
- Eigen Values?
- Covariance Matrix?

Notes:

- Kalman Filter: Algorithm developed for state estimation of a system with noisy measurements.
- Centralized Kalman Filter: Primary node calculates the state estimate. Cons of this are there is a single point of failure in the system and we need a high speed processing computer.
- Decentralized Kalman Filter: Each node calculates the state estimate. Produce suboptimal precision as a result of all network connectivity.
- Main difficulty with this solution is a fully coupled covariance matrix.
- This research is focused on finding an optimal and dis-tributed solution to the cooperative Kalman filter utilizing state consensus while avoiding all-to-all network con-nectivity requirements.
- Each node will have its own independent sensors and information and will share its estimates with its neighbors through a communication network.

Conclussion:

An optimal solution was found where each node was calculating it's own estimates and sharing with it's neighbors. It was found through the architecture of our network that each node became aware of the overall architecture of the network which helped increase efficiency in communication.

III. Stability of a Distributed Consensus-Based Kalman Filter under limited communication

Summary:

Address the stability of a Quantized Distributed-Consensus Kalman Filter (Q-DCKF) operating in a limited communication environment. We are studying the effects of quantization of the states and the resulting estimation error covariances. We show, via passivity theory, that the Q-DCKF is stable under mild assumptions and validate the theoretical results obtained via numerical experiments..

Questions:

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Notes:

- Agents share a quantized version of their states estimates with neighboring nodes as they come to a consensus on a mobile target.
- Each sensor node in the set communicates its estimate with a subset of nodes (neighboring nodes) over a communication network and uses the estimates of other nodes to update their own.
- The objective is to create a consensus among the nodes of the state of the target system.
- Quantizer: Limits the number of bits transferred among nodes. Compresses information.
- In this paper, we specifically analyze the effects of quantizing the state estimates on the stability of the estimation process in a Distributed Consensus-Based Kalman Filter.
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Conclussion:

Using concepts on passivity shortness, we determine how the first momentum of the quantization error affects the stability of the Q-DCKF. If this statistic, which depends on the nature of the employed quantizer, is equal to zero, the Q-DCKF behaves similarly to its non-quantized version. We also study what happens for a uniform mid-tread quantizer, and explain that the performance degrades as the quantization step size increases because the first momentum of the quantization error cannot be assumed to be zero anymore.