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Concerning: Evaluation of the dissertation thesis of Ing. Štěfan Knotek, the Ph.D. student of the Faculty of Electrical Engineering, Czech Technical University in Prague.

The current thesis studies cooperative design of estimator and controller in a distributed way for multi-agent systems. More specifically, the current thesis contains two research directions. The first direction is to design a distributed cooperative estimator. The second direction is to design an adaptive consensus protocol in a completely distributed way without any centralized data. In general, the thesis presents a nice piece of work on distributed control of multi-agent systems. It is well-written, easy-to-follow, and contains interesting results.

Relevance of the thesis to the current needs of the scientific community

Distributed control of multi-agent systems is an active research area with the applications in consensus, formation control, etc. The vast interest to this field is due to the successful application of distributed cooperative control in Unmanned Air Vehicles (UAVs), sensor networks, formation control of a group of mobile robots, satellites, heating, ventilation, and air conditioning in buildings, energy generation in microgrids, etc. There are many advantages for distributed control such as less computational complexity, high reliability and scalability due to the lack of a centralized decision-making center, which make this field challenging and interesting.

Fulfilling the main objectives of the work

The student has addressed the objectives of the thesis. One comment is that it is expected that a Ph.D. student studies a narrow research topic deeply and from different perspectives such that the research topic is known by the Ph.D. student and the Ph.D. student is known by the research topic. While the student has addressed the research objectives, I expected to see more results on each of these directions.

Methods in the thesis

The student uses graph theory, (cooperative) control theory, and adaptive control to address the objectives of the thesis. These are standard theories to study such research directions.

Main results and contributions

The current thesis studies cooperative design of estimator and controller in a distributed way for multi-agent systems. More specifically, the current thesis contains two research directions. The first direction is to design a distributed cooperative estimator. It is assumed that process and observation noises appear, communication failure may happen, and it is desired to have a low communication burden. The simulation results are neat and complete. The second direction is to design an adaptive consensus protocol in a completely distributed way without any centralized data. Note that the points in 2.b and 2.c in section 1.2 cannot be called goals. They are some technical properties related to the method to achieve the objective in 2.a. So, I will consider points 1.a-1.c as the goal for the first direction and point 2.a as the goal for the second direction.

Importance of the current work for the further development of science?

Surely, the current work is an important step towards autonomous, reconfigurable, and resilient multi-agent systems. Complex interconnected multi-agent systems create the need for novel team decision making, distributed control, optimization, and online computation methodologies. To achieve

these advances, one needs to ensure that the cooperative system is robust enough to noise and failure of the communication network. The current thesis studies the effect of noise and presents a completely decentralized structure for such systems.

Satisfaction of a creative scientific work?

The author of the thesis proved to have an ability to perform research and to achieve scientific results. I do recommend the thesis for presentation with the aim of receiving a Ph.D. degree.

General Comments/Questions

- The term "plants" has been used several times, yet it is not clear to me what plants refer to. For example, in section 1.1, Stefan mentioned that he designs a distributed observer to estimate the state of plants. Is it the leader or the synchronized trajectory or the whole state of the multi-agent system?
- One aspect of doing a Ph.D. is self-awareness. What I think is missing in this thesis is to list the shortcoming of the proposed methods. Do they solve every single issue in this field? The student needs to clarify the shortcoming and the positive parts of the proposed methods.

Technical comments on Section 3

- Thinking at a logical level, you are aiming to use some consensus protocol to estimate the state of the leader or the synchronized trajectory and then, to use the state estimation in the controller design. Since you consider MAS, I assume the controller is for some collective behavior. In comparison with a classical way of solving this problem, the consensus protocol is used in the controller level. So, the main idea is to use consensus in the observer design rather than the controller design. What does (what technique) help you to achieve consensus in observer design without global information which is not applicable in consensus in the controller design?
- Section 3.1: One basic difference between Kalman Filter and Luenberger observer is the error function they are minimizing. More discussion needs to be added. Also, it can express a little about the (sub)optimality of the approach. What is the cost that your proposed observer is minimizing? Is it between Kalman and Luenberger or worse than both?
- On page 28, it is not clear to me how to design an observer for a node that senses nothing?
- What does state-group mean in Definition 4 on page 29?
- On page 31, it is mentioned that the covariance of the observer is finite. Is there any measure on the covariance matrix?
- How do you justify the centralized information in the preliminary steps in Algorithm 3.2?
- The observer convergence is proved for the noise-free system. What happens when the process and observation noise appear? Do you only guarantee finiteness? A discussion on the measure of finiteness might be good to add.

Technical comments on Section 4

- I am curious: why the system setup is changed in Section 4? Why don't you consider process and measurement noises? Similar to Section 3, you can bring the analysis for the noise-free system.
- What is the advantage of having adaptive gain associated with the agents rather than the gains? Remark 24 on page 70.
- On page 86: "We omit the proofs for brevity." You can have the proof here, it is your thesis, not your paper and you as much as I know, there is no page limit for a thesis. The proof should be included.

- The behaviors of c_i for different i in Fig. 4.4 are similar. Any intuition?

Sincerely,
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