PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

PhD Student: Alberto Petrillo

XXXI Cycle

Training and Research Activities Report – First Year

Tutor: Stefania Santini

1. Information

    a. Alberto Petrillo, MS degree in Automation and Control Engineering – University of Naples Federico II.

    b. XXXI Cycle- ITEE – Università di Napoli Federico II.

    c. Fellowship type: “Borsa di Ateneo”.

    d. Tutor: Stefania Santini.

2. Study and Training activities

    a. Courses

        - “Game theory and analysis of competitive dynamics for industrial systems”(3 CFU), Lecturer: Prof. Lina Mallozzi.

        - “The entrepreneurial analysis of engineering research projects “ (3 CFU), Lecturer: Prof. Luca Iandoli.

        - “Scientific writing “ (3 CFU), Lecturer: Prof. Chie Shin Fraser.

        - “Modelli, metodi e software per l’Ottimizzazione“ (8 CFU), Lecturers: Prof. Antonio Sforza and Claudio Sterle.

    b. Seminars

        - “Radar Adaptivity: Antenna Based Signal Processing Technique” (0.5 CFU). Lecturer: Prof. Alfonso Farina, 12/02/2016.

        - “Gielis Transformations in the Natural Sciences and Technology” (0.4 CFU). Lecturer: Prof. Johan Gielis, 17/02/2016.

        - “Adversarial Testing of Protocol Implementations”(0.4 CFU). Lecturer: Prof. Cristina Nita Notaru. 23/02/2016.

        - “Programmable network conjugations” (0.4 CFU). Lecturer: Dr. Roberto Bifulco, 26/02/2016.

        - “NetFlow ed IPFIX: Dalla teoria alla pratica” (0.8).

Lecturer: Prof. Maurizio Molina, 11/04/2016.

- "Challenging real-time measurement systems for immersive life-size augmented environment" (0.5 CFU).
  Lecturer: Dott. Giovanni Caturano, 29/04/2016.

- "European Control Conference 2016", Aalborg, Dk (2 CFU).
  28-29-30 June 2016.

3. Research activity

   a. Title: "Cooperative Synchronization of multi-agent systems in the presence of multiple communication time-varying delays: theory and applications"

   b. Study: Multi-agent system, synchronization, time-delay system, autonomous ground vehicles, network security, smart and autonomous system.

   c. Research description

Many real systems in nature and human society can be modeled as multi-agents systems, thus in the last two decades cooperative systems have received a compelling attention in different research fields such as physics sciences, energy systems, intelligent transportation systems, smart cities and communication networks. The coordinated motion of autonomous vehicles, the phase or frequency synchronization in power grids or the time synchronization of wireless networks, gives examples.

Many researchers, inspired by natural occurrence of flocking and formation forming, have focused their work on synchronization, consensus and coordination of networked dynamical systems. In this context, the synchronization problem has been addressed at first without considering the presence of a leading node, so all nodes are commanded to converge toward a common evolution which is not prescribed. Cooperative tracking control, or leader synchronization, has been then studied by adding a leader that communicates with a group of neighbors to impose a desired behavior, e.g. the motion along a command trajectory.

To reach the cooperative synchronization goal, agents share information through dedicated busses or wireless communication. Delays in information acquisition and transmission are unavoidable in realistic scenarios where the time-delay itself might obey its own dynamics (which possibly depend on the communication distance, total computation load and computation capability). Thus, in all practical cases, delays can not be assumed as uniform (homogeneous) and constant, but they have to be considered as time-varying functions depending from the specific communication link under investigation (multiple, or heterogeneous, time-varying delays).

In this framework, my study focus on the problem of cooperative synchronization in the presence of multiple time-varying communication delays and the design of control strategy, able to guarantee the synchronization behavior of all agents to the leader one.

One of the distributed solutions proposed in my work leverages on the adaptive control theory, so to provide robustness to closed-loop dynamics with respect to delays, unmodeled dynamics or uncertain parameters.

By exploiting the Lyapunov-Krasovkii method, it is proved that the adaptive strategy can guarantee the synchronization of the agents interacting with the leader, assumed to be globally reachable (i.e. there is a path, that can be directed or not-directed, that links the leading agent with the others). In my approach each communication link is characterized individually, (by assuming that each is affected by its time-varying delay). The stability criterion is expressed as an LMI criterion that also allows estimating the delays margin that ensures stability. Some numerical examples, also referring to the practical cases of frequency control of power systems and of vehicular platooning application, show the effectiveness of the approach.

4. Products

    a. Publications

        i. To be published: Alberto Petrillo, Giovanni Fiengo, Alessandro Salvi, Stefania Santini, and Manuela Tufo, "A control strategy for reducing traffic waves in delayed vehicular networks", in *IEEE 55rd Annual Conference on Decision and Control (CDC)*. IEEE, December 2016.

        ii. Adaptive Cooperative Tracking with time-varying multiple delays in the presence of cyber-attacks on communication channel.

5. Conferences and Seminars

    a. Details

    "European Control Conference 2016", Aalborg, Dk, 28-29-30 June 2016.

    b. Presentations made

    Presentation of the paper "On the effectiveness of the Extended Cooperative Adaptive Control Vehicles Platooning" at the European Control Conference 2016, Aalborg, Dk, June 2016.

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Cycle XXXI

	Credits year 1							
		1	2	3	4	5	6	
	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary
Modules	17		6		3	4	4	17
Seminars	5		1,7	1,3	2			5
Research	38	10	2,3	7,7	7	5	6	38
	60	10	10	9	12	9	10	60

	Credits year 2							
		1	2	3	4	5	6	
	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary
Modules	13							0
Seminars	5							0
Research	42							0
	60	0	0	0	0	0	0	0

	Credits year 3									
		1	2	3	4	5	6			
	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	Total	Check
Modules	0							0	17	30-70
Seminars	0							0	5	10-30
Research	60							0	38	80-140
	60	0	0	0	0	0	0	0	60	180