Workshop on

Networked Distributed Systems for Intelligent Sensing and Control

Filoxenia Hotel, Kalamata, Greece
Saturday, June 30, 2007

Organized by

Panos Antsaklis & Manolis Christodoulou
University of Notre Dame, USA & Technical University of Crete, GREECE

Sponsored by the Mediterranean Control Association

MCA

PREFACE

Thank you all for coming. This is a workshop small enough so you will be able to interact with everyone else, but also large enough to cover a wide range of interesting topics. In other words it is just right!

Kalamata

Welcome to Kalamata (located at 37°2′N, 22°7′E on Gulf of Messenia and reached using area code +30-27210), the harbor of Southern Peloponnesus, home of the world famous olives and olive oil!

The modern town is near the site of ancient Pharae. Many of the towns around Kalamata were specifically listed in Homer's "Iliad", and the area of Messenia was written about by the ancient writers Pausanias and Strabo. The town is surrounded by various sites of the Messinian wars with Sparta. Aristomenis is a hero of that era. Kalamata was a Byzantine center from the 10th century. French Crusaders established Kalamata as fief of Villehardouin family in 1208. It was ruled by Venetians, then Turks. Kalamata had the honor of being the town first liberated during the Greek war of independence in 1821. Kalamata suffered severe earthquake damage in 1986 but it has recovered completely. The area of Mani is nearby, as well as towns with medieval castles, Methoni Koroni. The Homeric palace of Nestor is in Pylos, Sparta is close by and Olympia, the birthplace of the Olympic Games, is not far. The city of Myceneas and the ancient theatre of Epidaurus are on the way to Athens.

To see the latest weather, check
http://www.wunderground.com/global/stations/16726.html weather

For more information check the websites
http://gogreece.about.com/od/peloponnese1/Areas_The_Peloponnese_Peninsula.htm
http://en.wikipedia.org/wiki/Kalamata

Networked Distributed Systems for Intelligent Sensing and Control

Networked control systems are control systems comprised of the system to be controlled and of actuators, sensors and controllers, the operation of which is coordinated via a communication network. These systems are typically spatially distributed, may operate in an asynchronous manner, but have their operation coordinated to achieve desired overall objectives.

Control systems with spatially distributed components have existed for several decades. Examples include control systems in chemical process plants, refineries, power plants, and airplanes. In the past, in such systems the components were connected via hardwired connections and the systems were designed to bring all the information from the sensors to a central location where the conditions were being monitored and decisions were taken on how to control the system. The control policies then were implemented via the actuators, which could be valves, motors etc. What is different today is that technology can put low cost processing power at remote locations via microprocessors and that information can be transmitted reliably via shared digital networks or even wireless connections. These technology driven changes are fueled by the high costs of wiring and the difficulty in introducing additional components into the systems as the needs change.

The changes in the scope and implementation of control systems have caused *two main changes* in the emphasis in control system analysis and design. The first has to do with the *explicit consideration of the interconnections; the network now must be considered explicitly* as it affects significantly the dynamic behavior of the control system. The second change has to do with a *renewed emphasis on distributed control systems*. Because of these changes in control systems, several new concerns need to be addressed. Several areas such as communication protocols for scheduling and routing have become important in control when considering for example stability, performance and reliability. Algorithms and software that are capable of dealing with hard and soft time constraints are very important in control implementation and design and so areas such as real-time systems from computer science are becoming increasingly important. There is also some re-ordering of priorities and importance of control concepts due to changes in importance to control applications. There had also been renewed emphasis on methodologies for increased autonomy that allows the system to run without feedback information for extended periods of time. At a more fundamental level, control theorists have been led to re-examine the open (feed-forward) versus closed loop (feedback) control issues.

Technology advances, together with performance and cost considerations are fueling the proliferation of Networked Control Systems, and in turn are raising fundamentally new questions in communications, information processing, and control dealing with the relationship between operations of the network and the quality of the overall system's operation. A wide range of research has recently been reported dealing with problems related to the distributed characteristics and the effect of the digital network in networked control systems.

The current state of the art of such research is the subject of the January 2007 Special Issue of the Proceedings of the IEEE. Note That the text of the above discussion on Networked Control Systems was taken from the Scanning the Issue introduction of that Special Issue.

The presentations are arranged so that the papers that focus on theory are earlier in the program, while the papers that focus on applications are placed later in the program.

Workshop on "Networked Distributed Systems for Intelligent Sensing and Control," in Kalamata, Greece, on Saturday, June 30, 2007
http://www.nd.edu/~pantsakl/kworkshop.htm

Acknowledgements
We would like to thank the Mayor of Kalamata, Mr. P. Nikas and the Vice-Mayor of Kitries, Mr. P. Koutivas for their generous hospitality.

Panos Antsaklis & Manolis Christodoulou, Workshop Chairs

Workshop
on
Networked Distributed Systems for Intelligent Sensing and Control

Filoxenia Hotel, Kalamata, Greece

Saturday, June 30, 2007

Schedule

There will be a Welcome Dinner on Friday evening at 9:00 in Kitries, a small seaside village near Kalamata. Transportation will be provided.

7:00-8:30 Morning Swim/Breakfast

8:45-9:00 Opening Session The scope of the Workshop-Challenges and Promise

9:00-11:00 Presentations-Session Alpha

11:00-11:30 Coffee on the Terrace

11:30-1:30 Presentations-Session Beta

1:30-4:00 Midday Swim/Lunch

4:00-5:40 Presentations-Session Gamma

5:40-6:00 Coffee on the Terrace

6:00-7:00 Round Table Discussion and Closing Remarks

7:00-8:30 Evening Swim

9:00 Dinner

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Presentation A α −Alpha-1   A1-Baras

**Effects of Graph Topology on Performance of
Distributed Algorithms for Networked Control and Sensing**

John S. Baras and Pedram Hovareshti
University of Maryland College Park

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Presentation A α −Alpha-2   A2-Voulgaris

Cooperative Control over Link-limited and Packet-dropping Networks

Shengxiang Jiang and Petros G. Voulgaris
University of Illinois at Urbana-Champaign

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Presentation A α −Alpha-3   A3-Xenofon Koutsoukos

**Time Synchronization for Multi-Modal Target Tracking
in Heterogeneous Sensor Networks**

Isaac Amundson, Manish Kushwaha, Branislav Kusy, Peter Volgyesi, Gyula Simon†,
Xenofon Koutsoukos, Akos Ledeczi
Vanderbilt University
† University of Pannonia, Hungary

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Presentation A α −Alpha-4   A4-Johansson

On Distributed Estimation for Sensor Networks

Alberto Speranzon, Carlo Fischione, and Karl Henrik Johansson
A. Speranzon is with Unilever R&D Port Sunlight, UK.
C. Fischione and K. H. Johansson are with the Royal Institute of Technology, SWEDEN.

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Presentation A α −Alpha-5   A5-Tzes

Networked Controlled Systems: Modeling Issues for Robust Control

Leonidas Dritsas and Anthony Tzes
University of Patras, GREECE

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Presentation A α –Alpha-6 A6-Antsaklis

**Control with Intermittent Sensor Measurements:
A New Look at Feedback Control**

Tomas Estrada and Panos J. Antsaklis
University of Notre Dame, USA

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Presentation B β – Beta-1 B1-Raisch

Consistency in Hierarchical Control Systems

Joerg Raisch[1,2] and Thomas Moor[3]
[1] Technische Universitaet Berlin,
[2] Max Planck Institute for Dynamics of Complex Techn. Systems
[3] Universitaet Erlangen-Nurnberg GERMANY

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Presentation B β – Beta-2 B2-Samad

Beyond Syntax and Semantics … the "Pragmatics" of Inter-agent Coordination and Control

Tariq Samad
Honeywell Labs

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Presentation B β – Beta-3 B3-Sauter

Adaptive thresholding for fault diagnosis of Networked Control Systems robust against communication delays

Dominique Sauter, Taha Boukhobza, F. Hamelin
Nancy University, FRANCE.

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Presentation B β – Beta-4 B4-Christodoulou

Adaptive Control in Cellular Signaling Sub-Systems using Backstepping Techniques and Recurrent high Order Neural Networks

M.A.Christodoulou, and G.M. Vassalos
Technical University of Crete, GREECE

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Presentation   Β β – Beta-5 B5-Boutalis

Building optimal Fuzzy Dynamical Systems description based on Recurrent Neural Network Approximations

M.A. Christodoulou[a], D.C. Theodoridis[b], Y.S. Boutalis[b*]
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Presentation   Β β – Beta-6 B6-Varvatsoulakis

Hierarchical Intelligent Machines and Entropy

G.N.Saridis, **M.N.Varvatsoulakis** and **P.N.Paraskevopoulos**

G.N.Saridis
Rensselaer Polytechnic Institute
M.N.Varvatsoulakis aand P.N.Paraskevopoulos
National Technical University of Athens

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Presentation Γ γ – Gamma-1 C1-Bogdan

Decentralized Decision Making in Multi-agent Systems

S. Bogdan, V. Grabovac, L. Miljak, D. Miklic
University of Zagreb, CROATIA

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Presentation Γ γ – Gamma-2 C2-Valavanis

A comparative Study of Classical / Intelligent Controllers for Non-Aggressive Flights of Small Unmanned Helicopters

M. Castillo-Effen, C. Castillo, W. Moreno, K. P. Valavanis
University of South Florida,

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Presentation Γ γ – Gamma-3 C3-Conte

Tuning and Optimizing Control Laws in Distributed Home Automation Systems

G. Conte - D. Scaradozzi - A. Perdon - M. Cesaretti - G. Morganti
Università Politecnica delle Marche, Ancona, ITALY

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Presentation Γ γ – Gamma-4 C4- Sigrimis

RFID, the access control technology for Industry and its use in food chain logistics and sentient environments

Nick Sigrimis
Agricultural University of Athens,

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Presentation Γ γ – Gamma-5 C5- Kovacic

Network-based System for Intelligent Video Surveillance, Control and Alarm Generation in Security Applications

Ivica Draganjac, Zdenko Kovacic, Davor Ujlaki, and Jurica Mikulic
University of Zagreb, CROATIA

Presentation A α –Alpha-1 A1-Baras

Effects of Graph Topology on Performance of Distributed Algorithms for Networked Control and Sensing

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Abstract

We consider distributed collaborative control and sensing as they frequently arise in networked control systems. The algorithms are constrained to use local information. We show by experiments that the performance of such distributed, local information based algorithms, can depend dramatically on the structure of the underlying topology (connectivity pattern) of the agents. We investigate the speed of convergence, accuracy, robustness and resiliency of such algorithms including consensus problems. We consider several graphs that can be used to represent collaborative control and communication patterns. We first show that small world topologies offer several advantages from a perspective of a favorable tradeoff between performance of collaborative behaviors vs costs of collaborative behaviors (or equivalently constraints for collaboration). Second, we show that a two level hierarchy consisting of carefully located and controlled 'leaders' at the higher level and the rest of the agents at the lower level, can provide a very efficient communication pattern with substantial improvement of performance. We close with a description of the possible topologies for this two tier structure and their performance.

Presentation A α –Alpha-2 A2-Voulgaris

Cooperative Control over Link-limited and Packet-dropping Networks

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Abstract
In this paper we consider cooperative control of *n* dynamic agents to optimize an overall system performance metric. Due to limited communication resources, there exist structured interconnections among the agents and the interest is placed in synthesizing a suitably distributed control law to provide a given performance level. Based on a Youla-Kucera parameterization approach, the problem of designing a distributed controller to deliver given performance levels for different network topologies is convex in the Youla-Kucera parameter *Q*. Furthermore, if in addition to structured interconnections packet drops exist in the transmission of information, we provide convex conditions to guarantee mean square stability and system performance. The proposed method is also extended to deal with systems of triangular structures.

Presentation A α –Alpha-3 A3-Xenofon Koutsoukos

Time Synchronization for Multi-Modal Target Tracking in Heterogeneous Sensor Networks

Isaac Amundson, Manish Kushwaha, Branislav Kusy, Peter Volgyesi, Gyula Simon†, Xenofon Koutsoukos, Akos Ledeczi

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Abstract

Heterogeneous sensor networks consisting of resource-constrained nodes as well as resource-intensive nodes equipped with high-bandwidth sensors offer significant advantages for developing large sensor networks for a diverse set of applications. Target tracking can benefit from such heterogeneous networks that support the use of sensors with different modalities. Such applications require tight time synchronization across the heterogeneous sensor network in order to improve both the estimation and real-time performance. In this paper we present a methodology for time synchronization in heterogeneous sensor networks. The synchronization methodology has been implemented as a network service and tested on an experimental testbed demonstrating an accuracy in the order of microseconds over a multi-hop network. In addition, we use the time synchronization method in a multi-modal tracking application for performing accurate sensor fusion of audio and video data collected from heterogeneous sensor nodes and we show that our method improves tracking performance.

Presentation A α –Alpha-4 A4-Johansson

On Distributed Estimation for Sensor Networks

Alberto Speranzon, Carlo Fischione, and Karl Henrik Johansson

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Abstract

Distributed estimators for sensor networks are discussed. The considered problem is on how to track a noisy time-varying signal jointly with a network of sensor nodes. We present a recent scheme in which each node computes its estimate as a weighted sum of its own and its neighbors' measurements and estimates. The weights are adaptively updated to minimize the variance of the estimation error. Theoretical and practical properties of the algorithm are illustrated. The results provide a tool to trade-off communication constraints, computing efforts and estimation quality.

Presentation A α –Alpha-5 A5-Tzes

Networked Controlled Systems: Modeling Issues for Robust Control

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Abstract

In this article1 modeling approaches for Networked Controlled Systems (NCS) with different types of uncertainly varying bounded transmission delays and static discrete–time control laws are presented. Different models are offered for each case, all linked to the objective of designing robust discrete-time controllers. It is analytically shown how the careful mixing of asynchronous (event–driven) and synchronized (clocked) signals can lead to discrete time uncertain (possibly switched) systems, where results form robust control analysis and synthesis can be applied. After showing the implications of these modeling results for control synthesis purposes, sufficient conditions for the robust stability are given for each approach and a comparison of the conservatism of results is discussed. The special case of constant and unknown delays is also handled.

Presentation A α –Alpha-6 A6-Antsaklis

Control with Intermittent Sensor Measurements: A New Look at Feedback Control

Tomas Estrada and Panos J. Antsaklis
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Abstract

In many control systems, including networked control systems, feedback information is not necessarily continuous or instantaneous, but intermittent, where the loop is closed for finite time intervals. Intermittent feedback is not uncommon in applications, but it has not been adequately studied in control theory. The aim of this work is to explore theoretically the advantages (and disadvantages) of intermittent feedback. In this paper, we apply the concept of Intermittent Feedback to a class of networked control systems known as Model-Based Networked Control Systems (MB-NCS). We first introduce the basic architecture for model-based control with intermittent feedback, then address the cases with output feedback (through the use of a state observer) and with delays in the network, providing a full description of the state response of the system, as well as a necessary and sufficient condition for stability in each case. Extensions of our results to cases with nonlinear plants are also presented. Finally, we propose future research directions.

Presentation B β – Beta-1 B1-Raisch

Consistency in Hierarchical Control Systems

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Abstract

Complex networked systems typically involve distributed, hierarchically organised levels of control. Control levels often operate on different time scales that may be clock driven or event driven. Signals on different levels of the hierarchy are of different granularity representing phenomena like measurement aggregation when passing from lower to higher level control. In this context, from a theoretical point of view, consistency represents a key issue. It ensures that admissibility properties propagate through the hierarchy and is therefore a crucial ingredient when attempting to guarantee that suitably designed individual control units enforce desired overall specifications. The talk will highlight issues from recent joint work by the authors [3] and Jen Davoren (University of Melbourne) [2]. It is set within J.C. Willems' behavioural framework (e.g. [4, 5]) and uses ideas from abstraction based supervisory control of hybrid systems (e.g. [1]).

[1] T. Moor and J. Raisch. Supervisory control of hybrid systems within a behavioural framework. Systems and Control Letters, 38:157–166, 1999.
[2] T. Moor, J. Raisch, and J.M. Davoren. Admissibility criteria for a hierarchical design of hybrid control systems. In Proc. IFAC Conference on the Analysis and Design of Hybrid Systems (ADHS'03), pages 389–394, 2003.
[3] J. Raisch and T. Moor. Hierarchical hybrid control of a multiproduct batch plant. In Control and Observer Design for Nonlinear Finite and Infinite Dimensional Systems, LNCS 322, pages 199–216. Springer-Verlag, 2005.
[4] J.C. Willems. Models for dynamics. Dynamics Reported, 2:172–269, 1989.
[5] J.C. Willems. Paradigms and puzzles in the theory of dynamic systems. IEEE Transactions on Automatic Control, 36:258–294, 1991.

Presentation B β – Beta-2 B2-Samad

Beyond Syntax and Semantics … the "Pragmatics" of Inter-agent Coordination and Control

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Abstract

It is hardly controversial to assert that communication is central to coordinated control in multi-agent, networked systems. However, I submit that communication is viewed too narrowly in current research. We consider states, sensor readings, or commands being communicated, and such signals are supposed to have unambiguous connotations in the contexts considered. A setpoint or reference trajectory command is to be understood precisely as such; the state of the receiving agent is not supposed to influence the interpretation. The intent and interpretation of a communication are its literal meaning; there's nothing beyond semantics.

I present and discuss some examples from human coordination and communication to suggest how limiting this perspective is and to motivate a broadening of the notion of communication for distributed and cooperative control. As we endow increasing computational capabilities in the components of our multiagent systems, we need to incorporate extra-semantic, "pragmatic" aspects of communication within these systems. Intriguing topics include recursive/meta/self models (an agent needs to have some concept of what others think about it, of what others think about its belief about them, and so on); conversational implicature (an ability to understand implied intent in context); and negotiation through behaviors that others are able to interpret rather than via explicit communication. Incorporating pragmatics can permit more secure, more succinct, and more robust communication, with attendant benefits for system operation.

This is a speculative paper. I do not present any results but hope to generate some discussion on the need for, and approaches to, interweaving knowledge, reasoning, and communication in the intelligent control of networked distributed systems.

Presentation B β – Beta-3 B3-Sauter

Adaptive thresholding for fault diagnosis of Networked Control Systems robust against communication delays

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Abstract

In this paper, we are concerned by the problem of Fault diagnosis in Networked Control Systems (NCS). The effect of unknown networked induced delays on conventional observed based residual generator is studied. It is shown that the detection performances may be reduced due to the sensitivity of the residuals to the delays. With the assumption that the network delays belong to a given bounded set, in order to enhance the robustness of fault detection an adaptive evaluation procedure of the residuals is proposed. The detection thresholds which depend on the maximum influence of the network delays are estimated using an optimization approach.

Presentation Β β – Beta-4 B4-Christodoulou

Adaptive Control in Cellular Signaling Sub-Systems using Backstepping Techniques and Recurrent high Order Neural Networks

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Abstract

The present paper deals with the direct adaptive control of reaction systems that usually constitute part of more complicated reaction networks in the cell. We employ two well known methods in nonlinear adaptive control: The method of adaptive tracking, by applying the backstepping technique and the method of adaptive regulation, using Recurrent High Order Neural Networks (RHONNs).

Presentation Β β – Beta-5 B5-Boutalis

Building optimal Fuzzy Dynamical Systems description based on Recurrent Neural Network Approximations

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Abstract

The problem of approximating general nonlinear dynamical systems using the concept of Fuzzy Dynamical Systems (FDS) operating in conjunction with Recurrent High Order Neural Networks (RHONNs) is examined in this paper. The proposed methodology comprises two steps. In the first step it is shown that RHONNs can approximate the unknown fuzzy patches from training data, thus acting as and FDS generator. Then the rules or patches approximate the dynamical function of the system. The applicability of the method is tested on the well known Van der pole oscillator test system where it is shown that by following the proposed 2-level procedure one can obtain fairly accurate approximation using less than 10% of the number of the fuzzy rules that would be required by conventional look – up table techniques. The examined 2-level approach can be the first component in a neuro – fuzzy control scheme for complicated and possibly uncertain nonlinear systems.

Presentation Β β – Beta-6 B6-Varvatsoulakis

Hierarchical Intelligent Machines and Entropy

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Abstract

An analytical model for a class of Intelligent Machines operating in uncertain environments suitable for automated assembly scheduling applications is established. The problem is mathematically formulated as a minimum cost scheduling problem. A three level structure, proposed by Saridis, consisting of Organization, Coordination and Execution levels forms the architecture of the Intelligent Machine. The complete system will be able to issue high-level task plans and control all the subsystems in the lower level of the hierarchy. The system incorporates a learning algorithm to obtain asymptotically optimal task plans for control under stochastic environments. A case study on automatic assembly of a gearbox illustrates the proposed approach.

Presentation Γ γ – Gamma-1 C1-Bogdan

Decentralized Decision Making in Multi-agent Systems

S. Bogdan, V. Grabovac, L. Miljak, D. Miklic

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Abstract

In this paper we present a methodology for decision making in multi agent system comprised of agents driven by repulsive force, attracting force and self generated force. The goal of the proposed methodology is to move an agent from its initial position to its target destination in the same time avoiding collisions with other agents in order to create desired formation. Destination targets of agents in the group are dynamically changing as long as required formation is achieved. A simple methodology for decision making, used in the paper, has provided stable behavior of the group in the process of formation forming. Simulation results have demonstrated effectiveness of the proposed dynamic change of destination targets of agents in the group. Ongoing research is directed towards investigation of more complex conflict resolution and decision policies and determination of formal proof of stability in case of dynamic allocation of destination targets.

movie files can be downloaded from http://flrcg.rasip.fer.hr/movies/
files: circle_2.avi, flocking.avi, head-on.avi, rush_hour.avi

Presentation Γ γ – Gamma-2 C2-Valavanis

A comparative Study of Classical / Intelligent Controllers for Non-Aggressive Flights of Small Unmanned Helicopters

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http://www.csee.usf.edu/~kvalavan/

Abstract

This work presents several low-level control design techniques applied to autonomous flight of small scale unmanned aerial vehicles (UAV), in particular to those that are vertical take-off and landing (VTOL) type. Structures, common to all controllers, such as the decomposition in inner and outer loop are presented, as well as techniques to assess dynamic characteristics of the control system, namely: decoupling, robustness, and sensitivity. In all cases, a linearized model of the helicopter with 4 inputs, 4 outputs, and 13 states for the unstable hovering regime is used as a basis for the design of the controllers. Special emphasis is placed on computer aided control design (CACSD) tools to perform design, analysis, and simulation. The analysis of these controllers includes agility, robustness, and noise sensitivity tests. Several simulation experiments are performed, for instance: the application of several reference trajectories, attitude stabilization, and the introduction of sensor noise.

Presentation Γ γ – Gamma-3 C3-Conte

Tuning and Optimizing Control Laws in Distributed Home Automation Systems

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Abstract

This paper deals with the problem of designing and tuning efficient control laws for Home Automation Systems (HAS). Using a simulation environment, developed on the basis of a paradigmatic HAS theory, it is shown how the performances of a home automation system in exploiting limited resources (electricity, gas, hot water) can be described in terms of indices that depend on behavioral parameters of the individual appliances and can be practically evaluated. Different strategies for allocating resources and establishing priorities in their use can therefore be tested and compared, allowing a simple heuristics optimization of the system characteristics.

Presentation Γ γ – Gamma-4 C4- Sigrimis

RFID, the access control technology for Industry and its use in food chain logistics and sentient environments

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Abstract

The radio identification technology has emerged from the telemetry to track wild life, to exercise access control in security systems and to monitor livestock production. Recently it has advanced to a key technology to automate production and processes in the filed of logistics of businesses and services. The technology of contactless identification of objects, RFID or radio-frequency identification is the wizardry behind contactless smart cards, tracing assets in logistics companies and retailers, and production automation in industry and animal farming. With a view towards such futuristic innovations as the Supertag and the anticipated RFID replacement of the barcode, the presentation informs the audience on exactly how RFID systems work, its position in today's RF technology world and present collision (reader and tag) problems to solve, societal issues and examples of the technology's broad applications potential and benefits.

Presentation Γ γ – Gamma-5 C5- Kovacic

Network-based System for Intelligent Video Surveillance, Control and Alarm Generation in Security Applications

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Abstract

In this paper we present an integrated system for intelligent video surveillance, control and alarm generation in the security applications related to protection of public buildings (e.g. various financial institutions). By using only two networked cameras, video information is collected, dispatched via network and processed on-line with a group of integrated image processing algorithms able to detect humans in motion, track their motion, and check the visibility of their faces while approaching the building. In addition, the developed system counts people's traffic and keeps the record of a number of people in the protected area. The integration of given algorithms is made in order to raise the reliability of the threat recognition. The emphasis is on the fast detection of the invisible (masked) face of the approaching person. Based on the outputs of the algorithms, either alarm generation or adequate control actions may take place.