Poster Sessions

Tuesday 17th of September

2019 *Graduate Summer School on Intelligent Systems and Control*

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Poster Session I – Tuesday 17th of September

No.	*Poster Title/Astract*	*Authors*
1	*"The Effect of Inaccurate Load Composition on Power System Contingency Analysis and Planning"* *Abstract:* Power systems are experiencing major changes in their structure and operation that make them more complex in nature. Further, the ever-increasing electricity demand along with the high penetration of renewable energy sources push the power systems to work closer to the system limits. In this sense, there is a need for accurate analysis for assessing the power system operating condition. Since the loads are a source of uncertainty in the power system analysis, in this work an extended investigation of the effect of the inaccurate load composition on the frequency response of the system is performed. The composite load model is used to represent the loads on the IEEE 39-bus dynamic test system in which a protection scheme was added, including a high penetration of renewable energy sources is assumed in order to have a more realistic representation of the current power system case. The aim of this work is to underline the importance of the accurate load composition for contingency analysis and system planning.	Elena Polykarpou, Markos Asprou, Elias Kyriakides
2	*"Towards an Embedded and Real-Time Joint Human-Machine Monitoring Framework: Dataset Optimization Techniques for Anomaly Detection"* *Abstract:* Unmanned Remotely Operated Vehicles (ROVs) are widely used across many civil application domains including real-time monitoring, security and surveillance, and search and rescue missions. Most of these applications require the human operator to control the ROV under stressful conditions and harsh environments. As such, the remote-control operator is prone to sometimes issuing anomalous commands, because of either unwanted hand or finger motion or even irrational decisions, results of fatigue, stress, etc. To enable detection of such anomalies, we propose the use of a joint human-ROV monitoring framework, by monitoring the human operator's bio-signals and the ROV's sensory data. The framework is anticipated to run on the ROV, enabling it to recognize and possibly ignore anomalies, potentially paving the way for a shared control algorithm. In this paper therefore, we present a first step towards achieving this goal, focusing on optimizing the fused dataset consisting of the aforementioned signals and investigated different techniques such as feature extraction and statistical component analysis, in an effort to reduce the dimensionality of	Rafaella Elia, George Plastiras and Theocharis Theocharides

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	the dataset. To this end, we present a dataset constructed by surface Electromyography (sEMG) signals from various operators, fused with the ROV's inertial sensors. Through our proposed optimizations, we are able to reduce both the data size as well as the necessary features and signal components, while maintaining the ability to detect anomalies with at least 85% accuracy depending on the dimensionality reduction technique (over raw data). We evaluated our dataset over a variety of classifier configurations and embedded platforms with noteworthy energy and performance benefits.	
3	*"Automatic Detection and Classification of Breast Micro-calcifications in Digital Mammograms Using Temporal Subtraction"* *Abstract:* Breast cancer remains until today one of the most deadly cancers worldwide for women. Early detection is crucial in order to reduce the mortality rate. This study investigates if the use of temporal sequential mammogram pairs can improve the diagnosis of micro-calcifications (MCs). MCs are microscopic particles of calcium that appear in clusters and they are associated with breast cancer. For the purpose of this study, we created a new dataset, which includes sequential mammograms from two screening rounds with detailed marking on the locations of the MCs. Initially, the mammogram pairs were registered and subtracted. Using machine learning the falsely detected regions were removed and the true MCs were classified as benign vs. suspicious. For comparison, the developed algorithm was tested only on recent mammograms. With Support Vector Machines, we achieved 99.6% accuracy using temporal subtraction and with Ensemble of Decision Trees, 89.8% using only recent mammograms (p=0.032). These results demonstrate the effectiveness of temporal subtraction for the detection of MCs.	Kosmia Loizidou, Galateia Skouroumouni, Christos Nikolaou, Costas Pitris
4	*"Stochastic predictive perimeter control of uncertain multi-region urban traffic"* *Abstract:* A novel stochastic predictive control is introduced for perimeter control of uncertain multi-region urban traffic described through Macroscopic Fundamental Diagram (MFD). Macroscopic Fundamental Diagram is a fundamental relation between average flow (production) and density (accumulation) in urban regions. However, in practice there is a large scattering in MFD due to heterogeneity of traffic density in urban regions. Uncertainty is assumed on traffic accumulation measurements due to limited sources of measurements. Moreover, traffic demand is based on stochastic nature of drivers and is modeled by an uncertain parameter. Model predictive control (MPC) is employed for optimal perimeter control of traffic flow within boundary of regions. The stochastic uncertainty is modeled through assuming appropriate probability	Ehsan Harati, Stelios Timotheou, Christos G. Panayiotou

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	distributions on macroscopic fundamental diagram, traffic density and actuator model by application of Stochastic Model Predictive Control. Simulation results show the superiority of the method compared to deterministic MPC.	
5	*"Decentralized Search and Track with Multiple Autonomous Agents"* *Abstract:* When natural disasters occur, rapid search and rescue (SAR) is imperative. Unmanned Aerial Vehicles (UAVs) could be a perfect fit for these type of missions, and in this work a robust and scalable cooperative multi-agent search and track framework is proposed. Specifically, we study the problem of cooperative searching and tracking (SAT) of multiple moving targets by a group of autonomous mobile agents with limited sensing capabilities. We assume that the actual number of targets present is not known a priori and that target births/deaths can occur anywhere inside the surveillance region thus efficient search strategies are required to detect and track as many targets as possible. To address the aforementioned challenges we augment the classical Probability Hypothesis Density (PHD) filter with the ability to propagate in time the search density in addition to the target density. Based on this, we develop decentralized cooperative look-ahead strategies for efficient searching and tracking of an unknown number of targets inside a bounded surveillance area. Finally, the performance of the proposed approach is demonstrated through extensive simulation tests.	Savvas Papaioannou, Panayiotis Kolios, Theocharis Theocharides, Christos G. Panayiotou, Marios M. Polycarpou
6	*"Joint route guidance and demand management for real-time control of multi-regional traffic networks"* *Abstract:* In this work, we propose a joint route guidance and demand management strategy for multiregion networks with macroscopic traffic dynamics. Route guidance is used to identify the optimal transfer flows between neighbouring regions so that the trip completion rate across all regions is maximized. Demand management is utilized to control the traffic flows entering the network by forcing a portion of the traffic flows to wait at their origin. Towards this direction, we develop a Model Predictive Control (MPC) framework that aims to minimize the total time spent by all vehicles in the network (including the waiting time at the origin) by jointly optimizing the demand flows allowed in the network and the transfer flows between regions. To solve the resulting nonconvex and nonlinear optimization problem, by relaxing the nonconvex constraints, we develop a novel Linear Programming formulation that provides tight lower bounds on the optimal solution, as well as a feasible solution through the proposed MPC framework. Extensive simulation results demonstrate that the linear MPC scheme execute in real-time and yield near-optimal results even under heavy traffic scenarios.	Charalambos Menelaou, Stelios Timotheou, Panayiotis Kolios, Christos G. Panayiotou

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7	*"Towards Wide Area Control Enhancement for Robust Power Oscillation Damping"* *Abstract:* Power systems continually increase in size and complexity due to the growing demand, expansion in previously unserved regions, integration of new and diverse sources of energy and the interconnection of power systems between different areas. The power exchange among different areas resulted to the appearance of inter-area oscillations, which limit the power transfer capability of the system and they even deteriorate the security of the entire power system. Therefore, damping of inter-area oscillations is one of the main concerns for enhancing power transmission and improving power system stability. The emergence of Synchronized Measurement Technology and the fast deployment of PMUs in the transmission level of power systems provided a better observation of inter-area modes and laid the foundations for the development of wide area control (WAC) applications for the compensation of inter-area oscillations that may exist in the power system. More specifically, WAC aims to utilize the synchronized measurements in order to derive suitable coordination signals for the local controllers of all the generation units, increasing that way the power system stability.	Lazaros Zacharia, Elias Kyriakides
8	*"Power Flow for a Four-Wire Radial Low Voltage Distribution Grid with a Single Point Grounded Neutral"* *Abstract:* The forward/backward sweep is the most commonly used power flow method in radial Low Voltage Distribution Grids (LVDGs). In most cases, Kron's reduction is used to merge the neutral conductor with the phase conductors. However, important information can be lost by ignoring the effect of the neutral conductor through the Kron's reduction method, since in LVDGs the majority of loads are single-phase connected and are supplied through a phase conductor and the neutral. In this paper, a modification to the forward/backward sweep method is proposed to account for the neutral voltage as well. Test results indicate the significance of knowing the exact configuration of the neutral conductor in an LVDG before conducting power flow studies as it can affect greatly the accuracy of the results.	Andreas Kotsonias, Lenos Hadjidemetriou, Elias Kyriakides
9	*"Voltage Support Scheme for Low Voltage Distribution Grids Under Voltage Sags"*	Anastasis Charalambous, Lenos Hadjidemetriou, Elias Kyriakides

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	Abstract: A grid-connected power electronics based distributed generator can act as an active element by providing support to the grid under various disturbances. In this paper, a voltage support scheme dedicated for distributed generators installed in the low voltage distribution network is proposed. The voltage support considers the resistive characteristics of the distribution line grid impedance in order to maximize its effectiveness. Therefore, the optimal active and reactive current references are estimated based on the resistance to reactance ratio (R/X). Moreover, a droop curve is suggested such that the intensity of voltage support will be defined according to the voltage drop conditions. The proposed voltage support concept is applied on a photovoltaic system to validate its operation. The effectiveness of the proposal is confirmed by means of simulations in a realistic low voltage distribution network.	
10	*"Denoising of PMU Measurements for Accurate Calculation of Transmission Line Parameters"* *Abstract:* Power system transmission line parameters are essential in monitoring and control applications. More specifically, the values of the transmission line parameters are used in state estimation, contingency analysis, and as settings in protection relays. However, the stored transmission line parameters in the control center database often deviate from their actual values. This impacts negatively the applications of the power system control center. The use of PMU (Phasor Measurement Unit) measurements is the most convenient and simple way for refining the parameters of the transmission line; however, the contamination of the PMU measurements with noise from the instrument transformers and the communication channels could sometimes deteriorate the accuracy of the calculated parameters. In this work, the denoising of the PMU measurements using wavelets is proposed prior to the calculation of the transmission line parameters. The proposed approach is used for calculating the transmission line parameters of the IEEE 14-bus system.	Markos Asprou, Elias Kyriakides
11	*"Index of refraction estimation using dual-angle Optical Coherence Tomography"* *Abstract:* The index of refraction (*n*) is an intrinsic parameter of materials and tissues that has recently been proven useful as a biomarker for the diagnosis disease. It can also serve as a source of optical contrast for imaging and provides invaluable information on disease and cell dynamics for studies in various fields such as hematology, oncology, etc. There are many methods to experimentally measure *n*, e.g. using prisms or interferometers. Optical coherence tomogra-	Christos Photiou, Costas Pitris

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	phy (OCT) has also been used in the past to measure the index *ex vivo*. However, the methodologies reported to date are not appropriate for *in vivo* imaging since they require either a mirror below the sample or an otherwise complicated imaging setup and algorithm. In this summary, we propose a new measurement technique that could be deployed for *in vivo* estimation of *n*. This technique uses two OCT images obtained at different incidence angles. The path-lengths observed, in the sample, are different in the two images and directly depend on *n*. Measuring the path length changes and the incidence angles can provide an estimate of the index. The dual-angle method was validated experimentally using both clear and scattering samples. The resulting measurements of *n* were within a mean of ~1 % of the expected values. These initial results are promising and provide evidence that this method should be further investigated and validated on human tissues so that, in the future, it could be developed into a clinically useful diagnostic tool.	
12	*"Grid Friendly Operation of a PV-Storage System with Profit Maximization and Reliability Enhancement"* *Abstract:* The intermittent character of renewable energy sources (RES) creates market potentials for the emerging energy storage technologies. Energy storage systems can be utilized to support the grid, compensate the intense variation of RES production, and create opportunities for prosumers to maximize their profit under a variable electricity pricing scheme. In this paper, an optimal scheduling method is designed for a hybrid photovoltaic-storage system in a non-residential building. The scheduling scheme defines the utilization of a flywheel based storage device to minimize the cost of the electricity bill and simultaneously reduces the peak power exchange with the grid for a smooth power interaction. Further, the method considers the lifetime extension of the hybrid system grid-tied inverter by limiting the maximum output power of the inverter, without any energy shedding of solar power. The proposed optimization problem is solved for the day ahead using predicted input data. Several case studies are examined and useful results are obtained according to the profit and the grid interaction of the prosumer.	Lysandros Tziovani, Panayiotis Kolios, Lenos Hadjidemetriou, Elias Kyriakides
13	*"Optimizing the trade-off between fuel consumption and travel time in an unsignalized autonomous intersection crossing"* *Abstract:* Connected and autonomous vehicles (CAVs) have the potential to disrupt road transportation. CAVs provide several attractive features, such as seamless connectivity and fine-grained control, which can be exploited to improve the efficiency of traffic networks. In this work, the problem of CAV	Andreas Hadjigeorgiou, Stelios Timotheou

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	coordination at an unsignalized intersection crossing is considered, aiming to select the CAV trajectories that minimize fuel consumption and/or travel time. Nonetheless, the minimization of travel time implies high fuel consumption and vice-versa. For this reason, this work considers the problem of simultaneously optimizing the fuel consumption-travel time trade-off for a set of CAVs that are expected to arrive at the intersection within a specific time-window. As the resulting problem is non-convex, we construct a Mixed-Integer Programming formulation that provides tight lower and upper bounds. We also develop a heuristic convex-concave procedure that yields fast, highquality solutions. Simulation results validate the effectiveness of the proposed approaches and highlight the importance of optimizing the fuel consumption-travel time trade-off, as small compromises in travel time produce significant fuel savings.	
14	*"A Sensor-less Control Scheme for Grid Tied Inverters to Provide Phase Balancing Services to the Distribution Grid"* *Abstract:* This work proposes a sensor-less controller for grid tied photovoltaic (PV) inverters to enable phase balancing functionalities for compensating asymmetric loading conditions imposed by building loads in low voltage distribution grids. For enabling such an advanced functional operation by PV inverter, the first step is to enable the inverter to estimate the equivalent grid impedance. Then, the grid impedance is utilized to approximate the nearby load asymmetries without using any additional current sensors. Finally, advanced control schemes have been developed for PV inverters in order to enable the new phase balancing operation mode, where the inverter can compensate the asymmetric loading conditions of a distribution feeder. The effectiveness of the proposed method has been experimentally validated in a prototype where the grid tied PV inverter is able to compensate nearby load asymmetries and maintain a purely symmetrical interaction with the grid. Further, a simulation-based investigation in a realistic distribution feeder has been performed in order to highlight the benefits of the proposed approach regarding the power quality, the energy losses and the effective utilization of distribution grid capacity.	Lenos Hadjidemetriou, Anastasis Charalambous, Lazaros Zacharia, Elias Kyriakides
15	*"Optimal Model-Free Stabilization of Interconnected Systems Using Game-theoretic Distributed Q-Learning"* *Abstract:* In this paper, a synchronous model-free distributed Q-learning is proposed for the stabilization of linear interconnected systems using a differential graphical game framework. The interconnected systems' stabilization is formulated as a cooperative graphical game and the distributed Q-learning algorithm learns	Farzaneh Tatari, Christos G. Panayiotou, Marios M. Polycarpou

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	the local controllers to reach the Nash equilibrium under unknown dynamics. The distributed Q-function for every subsystem is obtained as a parametrization of the distributed local available information for the associated subsystem. To avoid huge data storage, actor and critic neural network approximators are respectively employed to approximate the optimal distributed control policy and the Q-function for every subsystem. The closed-loop stability and the convergence to the Nash equilibrium are guaranteed based on Lyapunov stability theory. Finally, simulation results verify the effectiveness of the proposed algorithm.	
16	*"Resource Allocation in Flexible Optical Networks (REALFON)"* *Abstract:* The project "Resource Allocation in Flexible Optical Networks" (REALFON) aims at designing and developing innovative optimization algorithms for resource allocation in flexible optical networks (FONs). The optimization algorithms proposed by REALFON is based on four technical pillars: a) Routing and spectrum allocation (RSA) in FONs with traffic demand variations, b) RSA with physical layer impairments (PLIs) in spectrally spatially (SS)-FONs, c) Security and protection in FONs and d) Secure anycasting in FONs. These innovative solutions will reach a significant advance beyond the current state-of-the-art and will fulfil the requirements of future optical networks regarding scalability and security, as well as important savings on the spectrum utilization for network operators.	Konstantinos Manousakis, Giannis Savva, Georgios Ellinas
17	*"A Hardware-based Framework for Secure Firmware Updates on Embedded Systems"* *Abstract:* The ability to update the firmware in embedded systems allows end-users to patch device vulnerabilities and improve functionality. However, this process is often exploited by adversaries in order to inject malicious firmware code into embedded devices. In this paper, we present a framework that enables highly secure and fast firmware update delivery with minimal downtime on embedded devices. The proposed framework utilizes device intrinsic physical characteristics to authenticate firmware packages along with integrated cryptographic modules to ensure firmware confidentiality and integrity. A proof-of-concept design is implemented on FPGA, which demonstrates high performance with reasonable overheads, while our analysis shows strong security guarantees.	Solon Falas, Charalambos Konstantinou, Maria Michael
18	*"Efficient and Scalable Sensor Fault Diagnosis in Cyber-Physical Systems"*	Stavros Viktoros, Maria K. Michael, Marios M. Polycarpou

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	Abstract: The increasing integration of Cyber-Physical Systems (CPSs) in complex large-scale environments requires efficient and scalable solutions for the new challenges being introduced. Sensor fault diagnosis has emerged as a priority in various CPSs, especially for critical infrastructure applications. In this work, we examine the problem of building a compact fault dictionary which can be used efficiently in model-based multiple sensor fault detection and isolation techniques for CPSs. The problem under consideration is formulated as a combinatorial set problem and then encoded efficiently using Zero-suppressed binary Decision Diagrams (ZDDs), which are specialized data structures based on Boolean theory. The proposed approach is highly scalable with respect to the total number of sensor faults supported, as using the respective ZDD as a fault dictionary helps to drastically reduce the memory requirements of the dictionary while allowing the detection and isolation process to occur in linear time to the size of the dictionary. The approach works complementary and can be easily integrated in existing sensor fault diagnosis schemes.	
19	*"Classifying network abnormalities into faults and attacks in IoT Systems Using Machine Learning Techniques"* *Abstract:* Cyber Physical Systems (CPS) integrate physical processes with electronic computing devices and digital communication channels. Their proper operation might be affected by two main sources of abnormality, security attacks and failures. The topics of fault diagnosis and security attack analysis in CPS have been studied extensively in a stand-alone manner. However, considering the co-existence of both sources of abnormality, faults and attacks, in a system and being able to differentiate among them, is an important and timely problem not yet addressed adequately. In this work, we study the internal communication environment of an Energy Aware Smart Home (EASH) system. More specifically, we formally define the problem of differentiating between component failures and network attacks in EASH, based on their effect on the communication behaviour. We formally show the correlation between such abnormality sources and provide a machine learning based framework for the differentiation problem. Our framework is evaluated using a simulation as well as a real-time testbed environment, demonstrating a promising accuracy in classification of over 85\%. Based on the obtained experimental results, we also provide a detailed analysis on the considered classes and features used in the proposed approach, which can further improve the classification accuracy.	Georgios Tertytchny, Nicolas Nicolaou, Maria Michael
20	*"Intelligent Patient Assessment & Monitoring System: Differentiating Amongst Various Emotional States via Empatica E4."*	Pettemeridou E., Georgiou P., Nikolaou, F., Theocharides, T., & Constantinidou, F.

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	Abstract: Research has attempted to capture the association between various emotions to changes in physiological indexes including heart rate, blood volume, skin conductance, and body temperature. Newly developed technological advancements have significantly contributed to these efforts by developing equipment that allows for interminable recordings of the aforementioned physiological signals. In this study, the aim was to detect differences in electro-dermal activity and temperature during the expression of different emotions. Another aim was to attest the ability of the Empatica E4 wristband to differentiate between emotions as these were expressed using a self-report measure. Two-way interactions were found indicating that different emotions elicited changes in electro-dermal activity, and temperature. A three-way interaction indicated that based on the emotion expressed both electro-dermal activity and temperature changed, simultaneously. Finally, E4's indexes significantly correlated to the self-report measures of emotions. These findings are of importance in using equipment such as Empatica E4 in detecting changes in emotional state in individuals who may present with difficulty in expressing their emotions otherwise (verbally or non-verbally) due to e.g. a traumatic brain injury, or other neurological conditions; and assist in rehabilitation services provided.	
21	*"Asymmetric Cell Transmission Model driven by Route Reservation Scheme in Tandem Transportation Networks"* *Abstract:* Traffic commute in big cities has been proven to be a difficult problem with adverse effects in terms of driver delay and frustration, cost and impact on the environment. The advances in information, communication and computation technologies enable the possibility to use shockwave theory on transportation systems in order to capture the impact of queue spillbacks, aiming to control and regulate traffic conditions over large scale areas. Most users situated in a transportation network prefer to utilize the given infrastructure to their own benefit and disregard the collective optimum of the network. Such actions might have an adverse effect on the efficiency of the network prospectively leading to greater waiting time intervals for each individual user. Mitigating the congestion in a transportation network could be achieved by maintaining the density of each link of the network close to its critical density. By doing so, we could attain an ameliorated performance in terms of throughput and travel time instances. In order to capture the traffic dynamics, we employ a scheme belonging to the Lighthill-Whitham-Richards family, known as Asymmetric Cell Transmission Model (ACTM). This model poses a modification of the original Cell Transmission Model first developed by Daganzo (1994), enabling greater flexibility in the evolution of the density across a given time horizon. We apply this model in a tandem network without the inclusion of bifurcation nodes.	A. Georgantas, C. Menelaou and C.Panayiotou

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	However, keeping the density of the links close to their respective critical density isn't a trivial task. The Route Reservation Scheme applied specifically in Tandem Networks is investigated for different values of the critical density in a brute force manner, to identify instances and circumstances under which we could further diminish the present congestion, by formulating the current paradigm as an optimization problem, incorporating appropriate performance metrics.	

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