W ELECTRICAL & COMPUTER ENGINEERING

UNIVERSITY *of* WASHINGTON

RESEARCH SHOWCASE

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5-7 P.M.

INNOVATION

CREATION

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ELECTRICAL & COMPUTER ENGINEERING
UNIVERSITY of WASHINGTON

2023 RESEARCH SHOWCASE

Acoustic Balance: Weighing in Ultrasonic Non-Contact Manipulators

01

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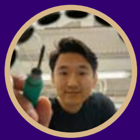

Acoustic traps and levitation systems can lift, translate and manipulate a wide range of objects and materials without contact. This enables new manipulation capabilities for robots that may not be possible otherwise. This paper presents an acoustic balance, a contactless method for weighing acoustically trapped objects in air. The method works by measuring a step response: the system commands a change in the phase of the acoustic emitters, which results in a sudden change in the equilibrium position of the trap. The object held within the acoustic trap undergoes damped oscillation as it settles into the new equilibrium point. The mass of the trapped object can be determined from the frequency of oscillation. Combined with methods for adding and merging materials in the trap, the method presented here can potentially enable a robot to operate a closed-loop process to acquire or maintain a desired quantity of material. Using weight as an error signal, material could be added by the acoustic system until the required quantity is in the trap.

02

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Hamiltonian Engineering using Coupled Cavity Array

Analog quantum simulators rely on programmable quantum devices to emulate Hamiltonians describing various physical phenomenon. Photonic coupled cavity arrays are a promising platform for realizing such devices. Using a silicon photonic coupled cavity array made up of 8 high quality-factor resonators and equipped with specially designed thermo-optic island heaters for independent control of cavities, we demonstrate a programmable device implementing tight-binding Hamiltonians with access to the full eigen-energy spectrum. We report a ~50% reduction in the thermal crosstalk between neighboring sites of the cavity array compared to traditional heaters, and then present a control scheme to program the cavity array to a given tight-binding Hamiltonian.

Speech zones with self-assembling acoustic swarms

03

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We introduce the first self-assembling acoustic swarm where tiny robots cooperate with each other using acoustic signals to spread out across a surface (e.g., table). These swarm devices can also navigate back to a base station where they can automatically dock and be recharged, without any cameras or external infrastructure. The resulting swarm creates a distributed microphone system that is wirelessly synchronized and can self-localize the robots with centimeter-level accuracy. Using these distributed wireless microphones, we show how to separate an unknown number of concurrent human speakers into individual audio streams and localize them to different 2D regions in a room to create speech zones. To achieve this, we designed a joint localization and speech separation framework that uses attention-based neural networks. Our evaluations showed that the acoustic swarms could localize and separate 3-5 concurrent speech sources in real-world unseen reverberant environments with median and 90-percentile 2D errors of 13 cm and 37 cm, respectively. We also demonstrated proof-of-concept applications like mute zones, active zones and multi-conversation separation.

Wireless Power Transfer with Magnetically Coupled Resonators on the Lunar Surface

04

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Wireless power transfer using magnetically coupled resonators is well-established on Earth and will soon be introduced on the Moon as part of a NASA-sponsored lunar mission. The introduction of magnetic field-based systems on the Moon requires consideration of the interactions between the resonant magnetic field and the lunar soil (called regolith) which is known to contain iron, a ferromagnetic material. In this work, we present the first experimental data for wireless power transfer with magnetically coupled resonators in the presence of a lunar regolith simulant enriched with iron nanoparticles at a composition consistent with the amount of iron in the actual regolith samples from NASA's Apollo missions. Furthermore, we investigate the effects of particle size of the metallic iron content and reveal important insights about how electromagnetic coupling relates to particle size and skin depth for metallic iron. The technical contributions of this work are relevant to a broad audience of scientists and engineers working with electromagnetic fields at interfaces with particulate media, including ground penetrating radar (GPR), wireless networks such as cellular/LTE, WLAN, LoRa, IoT, and microwave/mm-wave power beaming networks.

05

Abnormality Detection with Smart Grasper Robot

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Lacking tactile feedback for surgeons in laparoscopic surgeries led to the development of artificial tactile sensors for palpating the patient's organs and tissue to sense different types of abnormalities. The majority of research done is related to improving the measurement of tissue compliance, it involved the development of versatile force sensing capabilities for surgical graspers. However, depending on the abnormality, different types of sensors could be used simultaneously on surgical graspers. In the current work, we show the recent development of a multi-sensorized surgical Smart Grasper instrument, which can measure force, temperature, displacement of grasper's jaws, and acoustic properties of tissue. Paired with time series deep learning algorithms, we run experiments with ex-vivo chicken tissue with and without placed phantom abnormalities.

Broadband Self-Interference Cancellation for Full-duplex Radios with Phase Noise Suppression and Machine Learning Augmented Adaptation

06

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The increased demand for wireless connectivity in both defense and commercial applications, continues to drive research towards increasing the bandwidth of mobile transceivers, while reducing power consumption, form-factor, and costs. Full Duplex (FD) communication, capable of simultaneously transmitting and receiving using the same channel, is a technique which could be used to achieve a new level of connectivity and sensing. The transmitter delivers a high-output power signal to the antenna, thus appearing as unwanted self-interference (SI) to the receiver. This demands a collection of techniques to suppress the SI. Our lab has built several single chip radio systems demonstrating a deep SI suppression across the widest bandwidth (+120MHz) and the longest delay spread. While these radios appear promising with respect to mitigating interference, the transceiver must operate in a highly interference dynamic environment. As such, the calibration of radio interference suppression circuits has become intractable using gradient descent algorithms. The proposed work will apply Machine Learning methods coupled with the vast amounts of electromagnetic data, to perform real-time background calibration to tune these radios and address spectral congestion. In addition, a phase noise reciprocal mixing suppression approach will be used to further enhance the self-interference cancellation.

Optomechanical ring resonator on hybrid piezo-optomechanical platform

07

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Photonic-phononic interaction provides an effective route to modulate lights using mechanical motions of the materials. Recent advances in tightly confined photonic and phononic circuits give new possibilities for co-integrated platforms. Here, we demonstrate the first propagating wave photonic-phononic optomechanical ring resonator(OMR), in contrast to a standing wave 1D optomechanical nanobeam cavity, using zinc oxide(ZnO) and boron-doped gallium phosphide(BGaP) as a hybrid integration platform in which highly confined acoustic and optical waves circulate and resonate simultaneously. The high mode scattering efficiency of the OMR paves the way for converting RF signals from superconducting qubits into telecom frequency range for future quantum information processing applications.

Non-volatile electrically programmable integrated photonics empowered by phase-change materials

08

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Programmable photonic integrated circuits (PICs) have enabled a plethora of novel applications beyond traditional optical communications, such as optical computing, and quantum information processing. The scales of current programmable PICs are mainly limited by the large photonic device footprint and energy consumption due to the commonly used weak and volatile thermo-optic or carrier dispersion effect. Phase-change materials have brought new opportunities to scale up programmable PICs further thanks to their strong optical modulation, zero static power consumption, and CMOS compatibility. We will show our work on using different phase change materials to realize electrically controlled, low-loss and power-efficient components. These devices is of paramount interest to the next generation programmable photonics with infrequent programming need.

CONQRR : Conversational Query Rewriting for Retrieval with Reinforcement Learning

09

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Compared to standard retrieval tasks, passage retrieval for conversational question answering (CQA) poses new challenges in understanding the current user question, as each question needs to be interpreted within the dialogue context. Moreover, it can be expensive to re-train well-established retrievers such as search engines that are originally developed for non-conversational queries. To facilitate their use, we develop a query rewriting model CONQRR that rewrites a conversational question in the context into a standalone question. It is trained with a novel reward function to directly optimize towards retrieval using reinforcement learning and can be adapted to any off-the-shelf retriever. CONQRR achieves state-of-the-art results on a recent open-domain CQA dataset containing conversations from three different sources, and is effective for two different off-the-shelf retrievers. Our extensive analysis also shows the robustness of CONQRR to out-of-domain dialogues as well as to zero query rewriting supervision.

Evaluation of Indoor Localization Methodologies: A Comparative Study of Trilat-eration, LSTM, and Forest Regression

10

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Indoor localization, also known as indoor positioning, is a crucial aspect of the growing smart technology industry, particularly in areas where Global Positioning System (GPS) signals are unavailable. As more households and commercial buildings adopt smart technologies for various applications, the need for accurate and reliable indoor localization solutions is becoming increasingly important. The widespread use of mobile phones and other smart devices has also led to an increased demand for location-responsive applications that can be used indoors. Indoor localization is more challenging than outdoor localization due to the need for a clear line of sight and the presence of obstacles that can block or reflect signals. This paper evaluates various indoor localization methodologies, including trilateration, long short-term memory (LSTM), and Forest Regression to achieve a goal error of fewer than five meters. Through experimentation, Forest Regression was the preferred method, resulting in an average error of 1.123 meters. In comparison, trilateration resulted in an error of 5.648 meters, LSTM and resulted in an error of 1.584 meters. Trade-offs and comparisons are further discussed in the conclusion section.

Uncontrolled manifold emerges from coordinated feedback in multimodal human-machine interactions

11

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Humans interact with dynamic machines like vehicles, smartphones, and powered prosthetics through interfaces such as conventional manual (e.g. joysticks, mice) or more novel neural (e.g. electromyography) modalities. Appending modalities creates motor redundancy, which is beneficial in human sensorimotor systems as it provides abundant solutions to perform tasks. However, how humans integrate multiple distinct modalities to control dynamic machines remains unanswered. In this work, we seek to understand how people coordinate disparate motor pathways when interfacing with two distinct modalities (manual and neural) to collectively control a 1-degree-of-freedom trajectory-tracking and disturbance-rejecting task. Our central hypothesis is that multiple modalities enable the motor system to overcome limitations of single-mode interfaces. We introduced novel control-theoretic methods based on linearity and the Uncontrolled Manifold hypothesis to analyze the effect of sensorimotor noise from the two motor pathways. In a human subjects experiment with 15 participants, we found significant reduction in the effect of noise in multimodal interfaces compared to single-mode interfaces. We demonstrate that humans suppress the effect of internal noise by coordinating feedback control between motor pathways. Our findings can benefit integration of modalities with enhanced stability, especially for machine interactions such as navigating wheelchairs or controlling prostheses in rehabilitation.

Frequency-angular resolving LiDAR using chip-scale acousto-optic beam steering

12

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Non-mechanical, solid-state optical beam steering is critical to the next-generation light detection and ranging (LiDAR) technology that is indispensable for 3D imaging in automation, navigation, and robotics. Here, we report a new beam steering technique and the LiDAR system it enables, based on acousto-optic beam steering (AOBS) integrated on a chip where gigahertz frequency acoustic waves are generated to scatter light from a planar waveguide into free space. The physics of the Brillouin scattering enables the control of light scattering angle by the acoustic frequency using a single transducer and "labels" beams steered at different angles with unique frequency shifts. The latter allows using a single receiver to resolve the reflecting object's angular position from the frequency of the reflected light and thus enables a new LiDAR imaging scheme, which we name frequency-angular resolving (FAR) LiDAR. Moreover, FAR LiDAR also has enough bandwidth to afford frequency-modulated continuous-wave (FMCW) ranging simultaneously and thus 3D imaging. A single AOBS device achieves an 18° angular field of view (FOV) and 0.12° angular resolution for near-infrared light. The FAR LiDAR architecture requires only a single microwave drive without the need for sophisticated control electronics, affords broadband operation, and uses simple fabrication processes for monolithic integration.

A Millimeter-Wave Digital Beamforming Receiver using Low-Resolution ADCs

13

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There is an on-going pursuit to design wireless systems that achieve ever higher data rates for multiple users. Phased-array beamforming receivers (RXs) have been demonstrated to support multi-gigahertz bandwidths across the millimeter-wave spectrum. The digital beamforming (DB) architecture is attractive in that it can support the most beams per antenna element compared to the hybrid and analog architectures. However, a DB RX requires an identical set of analog-to-digital converters (ADCs), downconverters, filters and amplifiers per element, which, relative to other beamforming architectures, can significantly increase the system area, power consumption and complexity, and in turn limit the system scalability if conventional circuit topologies are used. This work studies the utilization of a dithered and oversampled open-loop 1-bit ADC in a DB RX to reduce the front-end power consumption and complexity while maintaining a high signal bandwidth and preserving the system array gain. A behavioral model of a 1-bit ADC is developed and the impact of dithering 1-bit ADCs in a DB RX is analyzed. The circuit design of an oversampled 1-bit ADC in TSMC 28-nm CMOS is described, along with standalone and system-level measurements of the ADC implemented in a 4-element V-band DB RX.

14

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Design and Optimization of Metal-Halide Perovskites through Deep Learning

Metal-halide perovskites are an emergent optoelectronic material with commercial viability for display and lighting applications. Perovskites demonstrate high color purity and bright light emission across the entire visible spectrum that positions them as a leading candidate for optoelectronic devices such as solar cells, micro-LEDs, and lasers. Currently, perovskites suffer from stability issues in ambient conditions which prevent their commercial success. To address this deficiency, our research focuses on novel perovskite compositions to simultaneously improve the stability and performance of perovskites for efficient LED devices (PeLEDs). Bulk perovskite thin films are synthesized and their salient characterization data are optimized via a deep learning model.

15

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Automated anti-reflection structure for perfect transmission through complex media

In many optical and radio frequency communication and imaging scenarios, the performance of the system is limited by unwanted scattering in the environment, such as multipath propagation in wireless communication channels or imaging through smoke or fog in the optical domain. This has led to many different attempts to reverse the effects of unwanted scattering, for example by conjugate wavefront shaping. In the radio frequency domain, previous work has shown that disordered propagation in a complex waveguide structure can be mitigated using manually placed metal and dielectric scattering elements. These elements form a conjugate medium that corrects for disordered propagation elsewhere in the waveguide structure and enables "perfect" transmission. We are developing an array of digitally controlled scattering elements that will be used to demonstrate automated correction of electromagnetic propagation within a waveguide containing unwanted scattering, across the 6 GHz to 12 GHz frequency band. This array consists of 104 individually addressable scattering "pixels" formed by waveguide probes, whose impedances can be controlled by digital-to-analog converters yielding a tunable reflection coefficient at the location of each "pixel". We will use this pixel-level control to demonstrate automated correction of disorder elsewhere in the waveguide.

EarSteth: Cardiac Auscultation Audio Reconstruction using Earbuds

16

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Heart auscultation is a critical component of most primary care examinations, yet this procedure is currently infeasible in telehealth settings because it requires that physicians use a stethoscope while physically present with patients. We address this gap with EarSteth — a system that leverages consumer active noise-cancelling earbuds to reconstruct cardiac auscultation audio signals. The system processes audio captured by the earbuds' inner microphone with a CNN-based model architecture called EarStethNet that is specifically designed for cardiac auscultation audio reconstruction. We trained EarStethNet using synchronous audio collected from 15 healthy adult participants using an earbud and a digital stethoscope. We then evaluated EarStethNet's outputs using quantitative metrics and a survey in which 15 clinicians were asked to assess the suitability of the audio for auscultation and medical diagnoses. Our results show that EarStethNet outperforms baseline models in reconstructing cardiac auscultation audio, achieving a mean absolute interbeat interval error of 37.6 ± 61.5 ms compared to a digital stethoscope and 40.5 ± 63.1 ms compared to an ECG. Surveyed clinicians also significantly preferred the recordings from EarSteth with EarStethNet.

A Rolling Horizon Restoration Framework for Post-disaster Scheduling of Electrical Distribution Networks

17

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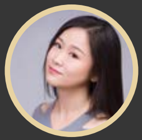

Severe weather events can cause extensive damage to electricity distribution networks, disrupting supply to thousands of customers. Immediately following the disaster, utilities have the twin tasks of first assessing and localizing the damage, followed by a staged repair process with an aim to restoring power to the affected consumers as quickly as possible. Two factors complicate the recovery phase. First, initial damage assessment is neither comprehensive nor accurate and damage information, possibly more accurate, typically streams in over time. Second, repairs need to commence as soon as feasible, even with incomplete damage information. Time overruns on scheduled repairs, as well as possible late arrival/update of information about damage on equipment supplying critical loads, mean that repair schedules may need to re-optimized on the fly. Coupled with the actual restoration process is an expectation on the part of affected customers to be kept informed about tentative times when they might expect power to be restored. If utilities can estimate and disseminate the restoration times reasonably accurately, an ability they currently lack, affected customers can make or alter their plans accordingly, particularly if bad weather is imminent and the projected outage duration is long.

This proposal addresses the two issues discussed in the preceding paragraphs: (i) optimal restoration of a distribution network under a streaming damage information-logging environment and (ii) estimation of projected outage duration (or conversely, the projected restoration times) for affected customers. We demonstrate in the proposal that the restoration problem is closely related to a budget constrained profit maximizing multiple traveling salesman problem (TSP) on edge and node weighted (doubly weighted) graphs, a TSP variant that, to the best of our knowledge, has not been studied before. The outage duration estimation problem, on the other hand, can be interpreted as a fair clustering problem, or alternately, as a multiple TSP on doubly weighted graphs where the objective is to minimize the longest tour cost. Mathematical modeling of the two problems and proposed solution approaches are addressed in the proposal. Our work will be based on historical outage and repair data that will be sourced from a local electric utility company. Such data will enable us to estimate realistic repair times considering uncertainties into account, which in turn will ensure that the repair schedules are risk aware.

Uncertainty-aware Surgical Instrument Segmentation on a Budget

18

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Intraoperative tracking of surgical instruments is often a prerequisite for robotic surgical interventions. Precise visual tracking combined with surgical scene understanding increase the context-aware assistance provided to a surgeon. Instrument segmentation and identification is a key task in continuously monitoring the surgical workspace. Deep Learning models for instrument segmentation have helped with progress in segmentation but require a large dataset to train from. This may not necessarily generalize to an entire procedure either due to the manual selection of sequential frames. In our work, we study deep active learning for selecting data for annotating surgical tools. We use a modified version of Monte Carlo Dropout to estimate model uncertainty without increasing the computational complexity or sacrificing test accuracy of the model. Using the uncertainty estimate as a base acquisition function, we perform batch active learning with deep neural network models for segmentation. We achieve comparable performance with less than 60% of data for the MICCAI 2017 Surgical Instrument Segmentation Dataset.

Using a rigid gripper to detect, characterize and grasp objects of different compliances

19

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A great deal of research has been focused on soft robotics as a way to grasp delicate objects or species without damaging them. While soft-grippers provide a more gentle grasp, they are limited by a smaller grasping force than traditional rigid grippers made of metal or plastic. We propose an algorithm for detecting, characterizing, and grasping objects with an off-the-shelf rigid gripper, with no external tactile sensors or cameras, allowing for a multipurpose gripper capable of assisting in a wide variety of missions or tasks. We have successful held brittle objects such as a potato chip and have had success in detecting a variety of objects, including highly compliant objects such as a paper cup. Efforts are underway for developing a method to characterize unknown objects to make informed grasps.

Dual-Polarized Electronic Mode Stirring for Improved Backscatter Communication Link Margin in a Reverberant Cavity Animal Cage Environment

20

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It has previously been shown that the metal cages used for housing research animals such as the non-human primates often used in neuroscience research with brain-computer interfaces (BCIs) resemble a reverberant cavity presenting dense multipath interference for communication channels within the cage. This is due to the metal walls of such cages forming a resonant cavity having deep nulls at many locations within the cage volume. Prior work has shown that electronic mode stirring can be used to mitigate the deep nulls by selectively changing the electromagnetic boundary conditions on the cage walls. We present a novel dual-polarized 2.4 GHz electromagnetic mode stirring system consisting of integrated dual-polarized air dielectric patch antennas with CMOS RF switches enabling each polarization to be terminated in either a short or open condition and thus selectively changing the phase of reflection from the antennas.

UW Industrial Assessment Center

21

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The University of Washington Industrial Assessment Center (UW IAC) serves as a hub for energy efficiency for students across all University of Washington Campuses. The UW IAC employs and develops new resources to maximize both industry improvement and student training. Collaborating as a team, students work with industry professionals to perform assessments in manufacturing facilities throughout Washington State. These student-driven industrial audits provide the manufacturers, specifically small- and medium-sized, with energy savings, waste reduction, and sustainable energy practices to reduce their costs and improve their efficiency. To date, the UW IAC has provided 250+ recommendations and 50+ assessments to the industrial community, saving 1.49+ TBtu of energy. The UW IAC focuses on communication and cooperation with industry to create resources for improving energy efficiency and training the next generation of energy savvy engineers. Students specialize in various areas including, but not limited to, air compressors, HVAC, solar, automation, and wastewater and give recommendations within their expertise. As a whole, the UW IAC trains the future engineers of tomorrow to research and develop solutions from beginning to end by detecting the problems in audits, analyzing the best solutions with accredited recommendations, and presenting the benefit analysis to corporations in professional reports.

Design of a Mixed-Signal CMOS-based Ising Machine for Combinatorial Optimization

22

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Classical computing algorithms are insufficient for solving NP-hard combinatorial optimization problems, such as MAXCUT, efficiently or accurately. The Ising machine is an emerging quantum-inspired paradigm that can accelerate these computations through a non-algorithmic approach. This approach implements the linear-nonlinear loop of a simulated bifurcation Ising machine through SRAM compute-in-memory and a strong-arm latch comparator. It aims to achieve faster speeds, all-to-all connectivity, easier integration with CPUs/GPUs, and improved re-programmability through applying analog computation to an inherently analog system.

Structured Neural-PI Control for Networked Systems: Stability and Steady-State Optimality Guarantees

23

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We study the control of networked systems with the goal of optimizing both transient and steady-state performances while providing stability guarantees. Linear Proportional-Integral (PI) controllers are almost always used in practice, but the linear parameterization of the controller fundamentally limits its performance. Learning-based approaches are becoming popular in designing nonlinear controllers, but the lack of stability guarantees makes the learned controllers difficult to apply in practical applications. This paper bridges the gap between neural network-based controller design and the need for stability guarantees. Using equilibrium-independent passivity, a property present in a wide range of physical systems, we propose structured neural-PI controllers that have provable guarantees on stability and zero steady-state output tracking error. If communication between neighbours is available, we further extend the controller to distributedly achieve optimal resource allocation at the steady state. We explicitly characterize the stability conditions and engineer neural networks that satisfy them by design. Experiments on traffic and power networks demonstrate that the proposed approach can improve both transient and steady-state performances compared to existing state-of-the-art, while unstructured neural networks lead to unstable behaviors.

Interpreting Primal-Dual Algorithms for Constrained Multiagent Reinforcement Learning

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Constrained multiagent reinforcement learning (C-MARL) is gaining importance as MARL algorithms find new applications in real-world systems ranging from energy systems to drone swarms. Most C-MARL algorithms use a primal-dual approach to enforce constraints through a penalty function added to the reward. In this paper, we study the structural effects of this penalty term on the MARL problem. First, we show that the standard practice of using the constraint function as the penalty leads to a weak notion of safety. However, by making simple modifications to the penalty term, we can enforce meaningful probabilistic (chance and conditional value at risk) constraints. Second, we quantify the effect of the penalty term on the value function, uncovering an improved value estimation procedure. We use these insights to propose a constrained multiagent advantage actor critic (C-MAA2C) algorithm. Simulations in a simple constrained multiagent environment affirm that our reinterpretation of the primal-dual method in terms of probabilistic constraints is effective, and that our proposed value estimate accelerates convergence to a safe joint policy.

Towards Real-Time Shadow and Reflection Artifact Rendering for Realistic Video Composition

25

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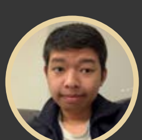

The aim of image composition, to effectively synthesize an image from separate pictures corresponding to foreground(s) and background, has long been hindered by the inability of existing algorithms to address visual inconsistencies which result in unrealistic composites. Of particular interest for this proposal is the need to generate shadows and reflections in scenes subject to directional lighting conditions or containing reflective surfaces. Recent literature suggests the lack of an algorithm which can produce such artifacts at real-time with sufficient resolution for modern applications. In an effort to satisfy the demand for video composition in media editing software, augmented/virtual reality, and, more recently, video conferencing, this paper explores potential mechanisms for yielding composites at real-time by harnessing spatio-temporal coherence to constrain the complexity of model architectures tasked with this endeavor. It is expected that the findings of this research will enable a more seamless pipeline for full composition, in conjunction with work focusing on image blending and harmonization.

Secure FMCW LiDAR Systems with Frequency Encryption

26

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Recent advances in artificial intelligence (AI) have paved the way for autonomous applications, including self-driving cars and robots. Robust sensing and imaging capabilities ae necessary in autonomous vehicles for accurate navigation and accident prevention, and light detection and ranging (LiDAR) is a major technology used to do so. However, security vulnerabilities including hacking of the LiDAR system impose threats to both human safety and security. In this work, we present a study of the different security vulnerabilities found in today's LiDAR systems through elecro-optical co-simulation using MATLAB Simulink, while proposing frequency encryption (FE) to eliminate the possibility of hacking being done to the system. This technique, combined with a frequency modulated continuous wave (FMCW) LiDAR scheme and physically unclonable function (PUF) will further be explored in developing a secure FE-FMWC LiDAR system that is implementable on a single-chip, is low-cost, and energy-efficient.

Broadband Self-Interference Cancellation for Full-duplex Radios with Phase Noise Suppression and Machine Learning Augmented Adaptation

27

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The increased demand for wireless connectivity in both defense and commercial applications, continues to drive research towards increasing the bandwidth of mobile transceivers, while reducing power consumption, form-factor, and costs. Full Duplex (FD) communication, capable of simultaneously transmitting and receiving using the same channel, is a technique which could be used to achieve a new level of connectivity and sensing. The transmitter delivers a high-output power signal to the antenna, thus appearing as unwanted self-interference (SI) to the receiver. This demands a collection of techniques to suppress the SI. Our lab has built several single chip radio systems demonstrating a deep SI suppression across the widest bandwidth (+120MHz) and the longest delay spread. While these radios appear promising with respect to mitigating interference, the transceiver must operate in a highly interference dynamic environment. As such, the calibration of radio interference suppression circuits has become intractable using gradient descent algorithms. The proposed work will apply Machine Learning methods coupled with the vast amounts of electromagnetic data, to perform real-time background calibration to tune these radios and address spectral congestion. In addition, a phase noise reciprocal mixing suppression approach will be used to further enhance the self-interference cancellation.

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Multiplayer Performative Prediction

Learning problems commonly exhibit an interesting feedback mechanism wherein the population data reacts to competing decision makers' actions. This paper formulates a new game- theoretic framework for this phenomenon, called multi-player performative prediction. We focus on two distinct solution concepts, namely (i) performatively stable equilibria and (ii) Nash equilibria of the game. The latter equilibria are arguably more informative, but can be found efficiently only when the game is monotone. We show that under mild assumptions, the performatively stable equilibria can be found efficiently by a variety of algorithms, including repeated retraining and the repeated (stochastic) gradient method. We then establish transparent sufficient conditions for strong monotonicity of the game and use them to develop algorithms for finding Nash equilibria. We investigate derivative free methods and adaptive gradient algorithms wherein each player alternates between learning a parametric description of their distribution and gradient steps on the empirical risk. Synthetic and semi-synthetic numerical experiments illustrate the results.

Augmented Reality using Virtual Anchors to Improve Astronaut-robot-interaction On-Board International Space Station

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AUTHOR
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Augmented Reality (AR) has the potential to improve the manner in which astronauts interact with collocated robots. We intend to demonstrate how AR can be used to decrease the time and increase the accuracy of of robots in locating objects-of-interest (OOI), such as tools, and other equipment, via virtual tagging of OOIs, such that robots may more successfully navigate toward the objects, collect the OOI and bring it to the astronaut or deposit in the desired location, resulting in improved human-robot-collaboration (HRC).

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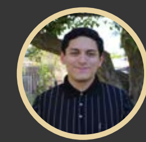

Smartphone-based Automated Wound Assessment

This project investigates a smartphone-based chronic wound management system for the purpose of enhancing the accuracy and efficiency of patient wound documentation and assessment. This system incorporates the use of depth imaging technology available on modern smartphones, providing a convenient and readily available platform to promote patient engagement in self-management.

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RHLab Scalable Software Defined Radio (SDR) Remote Laboratory

Development an open-source remote laboratory for teaching SDR (Software-defined radio).

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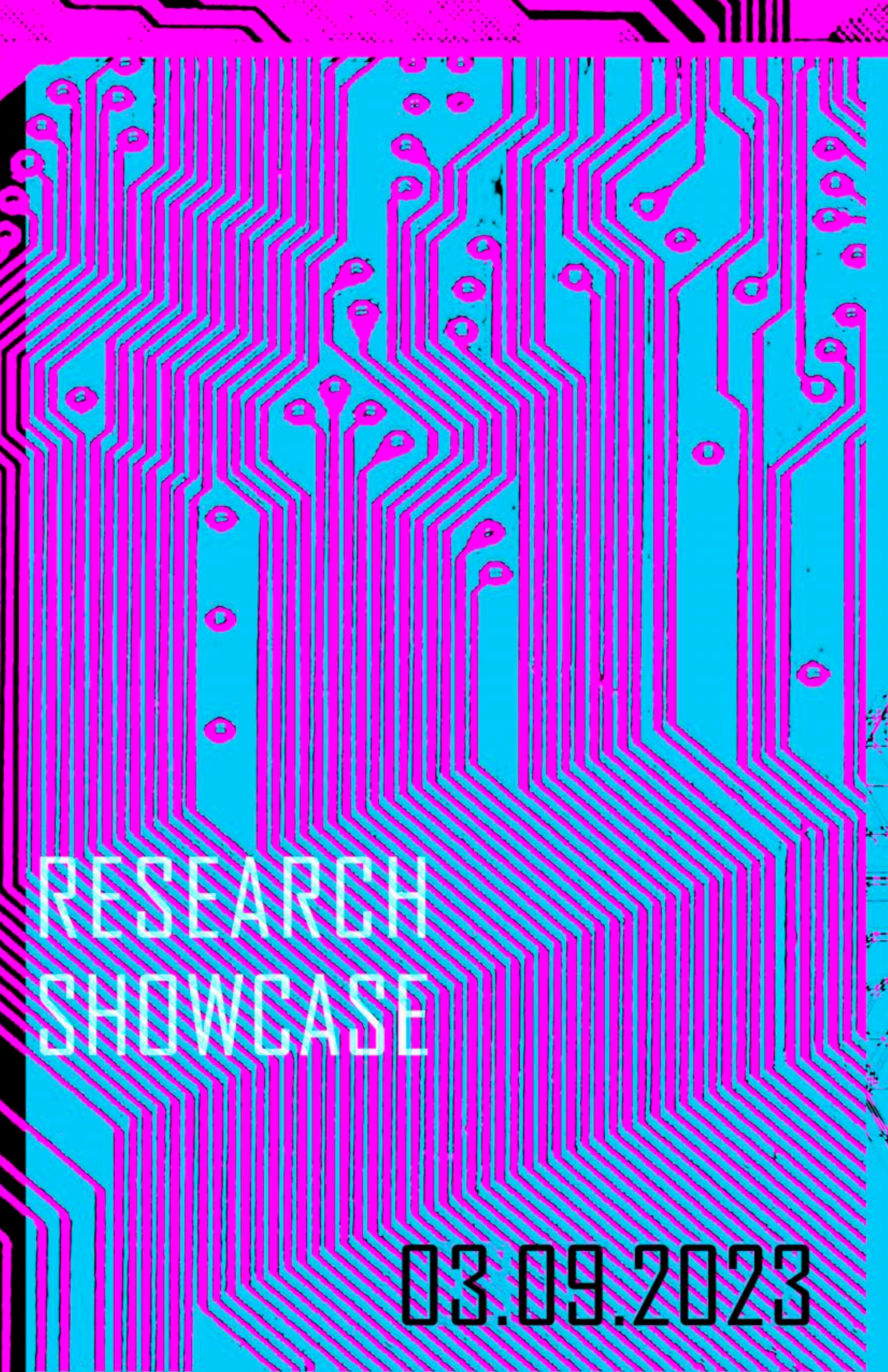
An Efficient Neural Solver for Two-Stage DC Optimal Power Flow with Guaranteed Feasibility

In this paper, we consider the two-stage formulation of stochastic DC optimal power flow (OPF) problem for optimal and reliable dispatch when the load is facing uncertainty. We proposes a learning method to solve the two-stage problem in a more efficient way. A technique called gauge map is incorporated into the learning architecture design to guarantee the learned solutions' feasibility to the network constraints. The simulation results on the IEEE 118-bus system show that, compared to applying the numerical solver, the proposed method not only learns solutions of good quality but also accelerates the computation by orders of magnitude.

NOTES


Oculus
and Radha Poovendran (UW)
EXPERIMENTAL RESULTS
RESULTS
CONCLUSIONS
REFERENCES


RESEARCH
SHOWCASE
03.09.2023