ELECTRICAL & COMPUTER ENGINEERING
UNIVERSITY of WASHINGTON

Thursday,
March 12, 2020
6 - 8 p.m.

UW ECE Research Day | HUB North Ballroom | Event Program


Modeling Charge Transport Th
Nucleic Acid Structures
Nucleobase Mismatch Detection
DNA Strand as
UWECE RESEARCH REVIEW
University of Washington
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Traditional ADC vs Time o
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Conclusions

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INNOVATION STARTS HERE.

Mechanisms for Resistive Memory Operation

01

AUTHOR
XU XU

ADVISOR
M. P. ANANTRAM

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WINBOND

We model resistive memory devices where logic states 0 and 1 are stored in the location of atoms. From a theoretical point of view, the atomic scale mechanism for the operation of these memory devices to set, reset and retain the memory states has been controversial. In this study, we use Kinetic Monte Carlo simulations of resistive memory devices to study the roles of vacancy–interstitial generation (i) near the Hafnia-metal electrode interface and (ii) in bulk Hafnia. In our model, an oxygen vacancy is generated in Hafnia near the interface, with the corresponding oxygen atom residing in the metal electrode. These oxygen atoms form a thin insulating oxide layer at the Hafnia-active electrode interface. We find that this interfacial layer is essential to thicken the filament, even after the filament bridges the two metal electrodes at low current levels, a feature that the bulk generation model misses. This thickening of the conducting filament naturally explains the trend of resistance decrease with an increase in compliance current. Simulations show a large increase in retention time with an increase in bonding energy. We also find that as the compliance current increases, the morphology of the filament transitions from conical to dumbbell-shaped. This uniqueness of this study is that captures the processes of SET, RESET, and retention.

A Generalized PSS Architecture for Balancing Transient and Small-Signal Response

02

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PAYMAN ARABSHAHI

For decades, power system stabilizers paired with high initial response automatic voltage regulators have served as an effective means of meeting sometimes conflicting system stability requirements. Driven primarily by increases in power electronically-coupled generation and load, the dynamics of large-scale power systems are rapidly changing. Electric grids are losing inertia and traditional sources of voltage support and oscillation damping. The system load is becoming stiffer with respect to changes in voltage. In parallel, advancements in wide-area measurement technology have made it possible to implement control strategies that act on information transmitted over long distances in nearly real time. We present a power system stabilizer architecture that can be viewed as a generalization of the standard delta-omega type stabilizer. The control strategy utilizes a real-time estimate of the center-of-inertia speed derived from wide-area measurements. This approach creates a flexible set of trade-offs between transient and small-signal response, making synchronous generators better able to adapt to changes in system dynamics. The phenomena of interest are examined using a two-area test case and a reduced-order model of the North American Western Interconnection. To validate the key findings under realistic conditions, we employ a state-of-the-art co-simulation platform to combine high-fidelity power system and communication network models. The benefits of the proposed control strategy are retained even under pessimistic assumptions of communication network performance.

Changes in Cortico-Hippocampal Functional Networks as a Result of Stroke-Induced Diaschisis

03

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ADVISOR

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Stroke is a leading cause of disability globally; 15 million people suffer from stroke worldwide each year. Impaired cognition is a common outcome of stroke. The relationship between cortical stroke and cognitive deficient is not well understood. To study this we induced ischemic stroke in the left hemisphere of rats and used linear μ-electrode arrays to record local field potentials from cortex & hippocampus simultaneously two weeks & one month following stroke.

We analyzed signal power, stability of brain states, cross frequency coupling, and sharp wave associated ripples (SPW-Rs) to assess changes to functional networks. We have found that after stroke, all frequency bands increase in power except for delta. Theta/delta (TD) states are destabilized, and during high TD states theta-gamma coupling is lowered. SPW-R duration transiently increases at two weeks before lowering below control levels after one month. SPW-R power is lower ipsilaterally, but higher contralaterally. The current source density aligned to a ripple shows a decrease in amplitude in both hemispheres. These results show that remote ischemic lesion causes significant change to cortico-hippocampal communication.

04

AUTHOR

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UW REALITY LAB,
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Single-Shot Three-Dimensional Imaging with a Metasurface Depth Camera

Imaging in three dimensions is vital for many emerging technologies with applications that demand compact and low-power systems beyond the capabilities of state-of-the-art depth cameras. Here, we exploit a single spatially multiplexed aperture of nano-scatterers to demonstrate a passive and compact solution that replicates the functionality of a high-performance depth camera typically comprising a spatial light modulator, polarizer, and multiple lenses. Our visible wavelength and polarization-insensitive metasurface simultaneously generates focused accelerating and rotating beams that utilize propagation-invariance to produce paired images with a single snapshot. We computationally recover a focused image coupled with a depth map achieving a fractional ranging error of 1.7% after accounting for the change in Gouy phase over the field of view.

05

AUTHORS

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ADVISORS

MO LI, ARKA MAJUMDAR

Nonvolatile Electrically Reconfigurable Integrated Photonic Switch

Reconfigurability of photonic integrated circuits (PICs) has become increasingly important due to the growing demands for electronic-photonic systems on a chip driven by emerging applications, including neuromorphic computing, quantum information, and microwave photonics. Success in these fields usually requires scalable photonic switching units as essential building blocks. Current photonic switches, however, mainly rely on weak, volatile thermo-optic or electro-optic modulation effects, resulting in a large footprint and high energy consumption. As a promising alternative, chalcogenide phase-change materials (PCMs) provide strong modulation and static, self-holding characteristics for nonvolatile integrated photonic applications. Here, we demonstrate nonvolatile electrically reconfigurable photonic switches using PCM-clad silicon waveguides and microring resonators that are intrinsically compact and energy-efficient. With phase transitions actuated by in-situ silicon PIN heaters, near-zero extra loss and reversible switching over more than 1,000 times are obtained in a complementary metal-oxide-semiconductor (CMOS)-compatible process. Our work can potentially enable very large-scale integrated programmable photonic mesh processors.

Integrated CMOS Millimeter-Wave Phased Array Transceivers with Highly-Digital Elements for Radar and Communication Applications

06

AUTHORS

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Phased-array transceivers at millimeter-wave frequencies have received lots of attention for high-speed data communications and radar applications. However, some challenges of millimeter-wave CMOS integrated circuit still remain unsolved, including low available gain, bulky passive components, and low energy efficiency. Moreover, conventional analog beamforming can provide only one directional beam. In this collaborative project, our goal is to combine a novel mmWave receiver front-end with digital backend to allow for seamless integration for next generation communication and radar systems.

From Intention to Movement: Low-Power, High Performance Communication Protocol for Backscattered-Based Neural Implants

07

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INSTITUTE FOR NEUROENGINEERING, CENTER FOR NEUROTECHNOLOGY (CNT)

Neural implants have the potential for significant impact in medicine, highlighting the restoration of the use of limbs after a spinal cord injury. The main challenges in realizing neural implants are the need to transmit large amounts of data at high rates using very low power, and performing bi-directional communication with low latency. My work focuses on developing a custom high-performance protocol and reader for bi-directional communication with neural implants, that will eventually enable a closed-loop operation.

08

A Toolbox for Studying Ischemic Stroke in Non-Human Primate Cortex

AUTHORS

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NATIONAL SCIENCE FOUNDATION (NSF)

Stroke is a leading cause of chronic disability among adults in the United States, indicating a strong need for long-term rehabilitative therapies for stroke survivors. We introduce a toolbox to study stroke in non-human primates as a pre-clinical model. Our toolbox enables inducing targeted focal ischemic lesions informed by a computational model in a platform that allows for simultaneous neurophysiology recordings and microvasculature imaging in cortex. The combination of these tools can provide critical insight into the mechanisms of ischemic stroke and advance the development of stimulation-based stroke therapies.

Eye in the Sky: Drone-Based Object Tracking and 3D Localization

09

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Drones, or general UAVs, equipped with a single camera have been widely deployed to a broad range of applications, such as aerial photography, fast goods delivery and most importantly, surveillance. Despite the great progress achieved in computer vision algorithms, these algorithms are not usually optimized for dealing with images or video sequences acquired by drones, due to various challenges such as occlusion, fast camera motion and pose variation. In this paper, a drone-based multi-object tracking, and 3D localization scheme is proposed based on the deep learning based object detection. We first combine a multi-object tracking method called TrackletNet Tracker (TNT) which utilizes temporal and appearance information to track detected objects located on the ground for UAV applications. Then, we are also able to localize the tracked ground objects based on the group plane estimated from the Multi-View Stereo technique. The system deployed on the drone can not only detect and track the objects in a scene but can also localize their 3D coordinates in meters with respect to the drone camera. The experiments have proved our tracker can reliably handle most of the detected objects captured by drones and achieve favorable 3D localization performance when compared with the state-of-the-art methods.

DeFINE: Deep Factorized Input Token Embeddings for Neural Sequence Modeling

10

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For sequence models with large vocabularies, a majority of network parameters lie in the input and output layers. In this work, we describe a new method, DeFINE, for learning deep token representations efficiently. Our architecture uses a hierarchical structure with novel skip-connections which allows for the use of low dimensional input and output layers, reducing total parameters and training time while delivering similar or better performance versus existing methods. DeFINE can be incorporated easily in new or existing sequence models. Compared to state-of-the-art methods including adaptive input representations, this technique results in a 6% to 20% drop in perplexity. On WikiText-103, DeFINE reduces total parameters of Transformer-XL by half with minimal impact on performance. On the Penn Treebank, DeFINE improves AWD-LSTM by 4 points with a 17% reduction in parameters, achieving comparable performance to state-of-the-art methods with fewer parameters. For machine translation, DeFINE improves the efficiency of the Transformer model by about 1.4 times while delivering similar performance.

Fixing Mini-Batch Sequences with Hierarchical Robust Partitioning

11

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COMPUTING ON NETWORK INFRASTRUCTURE (CONIX)

Machine learning on a network of devices is often constrained by limited and distributed computational resources, and datasets of limited sizes. Stochastic mini-batch gradient descent methods have achieved great success on a variety of tasks, especially when combined with deep neural networks. However, to sample a mini-batch of data points uniformly at random can be impractical, as randomly accessing data points from a centralized disk can be slow. This leads to a bottleneck in modern machine learning systems, especially for resource-limited systems such as mobile devices and computing at the edge. In practice, datasets are typically written to disk according to an arbitrarily generated sequence of indices. This makes sequential access of this chosen order possible with low overhead. On the other hand, there is a chance that the sequence is poor for machine learning (the chance of getting a poor sequence increases with smaller datasets), and since it is fixed over multiple iterations of training, performance can suffer appreciably. In this work, we propose a general and efficient hierarchical robust partitioning framework to generate a deterministic sequence of mini-batches, one that offers mathematical assurances of high quality, unlike a randomly drawn sequence. We compare our deterministically generated mini-batch sequences to randomly generated sequences and show that the deterministic sequences significantly beat the mean and worst performance of random sequences, and often outperforms the best of the random sequences. Specifically, on large datasets such as CIFAR100 and Imagenet, our deterministic sequences outperform the mean accuracy of random sequences by an absolute margin of 2-3%.

12

Electromagnetic Coupling in Mars Soil Simulants

AUTHOR
SHANTI GARMAN

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YASUO KUGA

EM coupling in Mars soils is important for water-extraction on Mars. We present new measurement data for thermal rise in Mars soil simulants across a range of microwave frequencies. Results show an inverse relationship between frequency and thermal rise. Data is collected at low temperature to simulate the Mars environment.

Multiclass Classification and Feature Analysis of FTM Drawing Tasks in a Digital Assessment of Tremor

13

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Essential tremor (ET) is degenerative neurological condition that most commonly results in uncontrollable rhythmic motions of the upper limb. The early diagnosis of ET and the tracking of symptom progression over time is required for the constructive treatment of the disease as well as expanding our understanding of this debilitating condition. Fahn-Tolosa- Marin (FTM) drawing tasks, such as tracing an Archimedes spiral or staying in between two lines, are well-grounded clinical techniques for evaluating ET symptoms. Although there are existing computational methods for the quantification of ET derived from the Archimedes Spirals, development of a straightforward system able to precisely classify the drawing tasks as well as different severity levels of ET is still a topic of study. Here we represent a promising quantitative approach to scale the variability of ET symptoms both for home monitoring and clinical applications. For our study, we collected data from three tremor patients implanted with an investigational DBS system and several healthy controls using a customized application which logged drawn spirals and lines for post-hoc analysis. For both drawing tasks, base features along with features based on statistics and signal processing algorithms were extracted separately. Thirty-seven final features were selected using a recursive feature selection algorithm. Linear discriminant analysis and logistic regression classification were used for classifying between groups: 'healthy', 'tremor: DBS stimulation turned on' and 'tremor: DBS stimulation turned off' from extracted features, which resulted in a of the classification accuracy of 94.44% and 96% respectively. While past systems were based on binary classification (healthy or tremor), the multi class classification used in this method strongly differentiates between patients in different stages of ET and healthy subjects. Future work will involve adding additional groups to this diagnostic method based on other useful parameters, for example, surgery timeline and medication usage.

14

Safe Exploration via a Safe Projection Layer

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We consider a Markov decision process (MDP), where the state should always be kept within the safety region during the training and policy execution process. To ensure such safety constraint, we design policy network with a projection layer as the last layer. We leverage model free policy gradient method to train our proposed policy network in an end to end fashion.

15

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Performance Analysis and Improvement on DSRC Safety Application of V2V Communication

In this paper, we mainly focus on the simulation and analysis of vehicle-to-vehicle (V2V) communication based on the DSRC (Dedicated Short Range Communication) system adopting IEEE 802.11P. We obtain results that compare the packet delivery ratio and mean packet delay between heavy and low vehicle load scenarios. Our analytical model is shown to provide a good match with simulation results. We then study on improvement on DSRC performance, proposing an analytical model of Semi-persistent Contention Intensity Control (SpCIC) scheme. The simulation result we obtained shows the packet delivery ratio in SpCIC scheme increases remarkably compared with that in CSMA and LTE Mode 4 protocol especially in heavy vehicle load scenarios.

16

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Monocular Visual Object 3D Localization in Road Scenes

3D localization of objects in road scenes is important for autonomous driving and advanced driver-assistance systems (ADAS). However, with common monocular camera setups, 3D information is difficult to obtain. In this paper, we propose a novel and robust method for 3D localization of monocular visual objects in road scenes by joint integration of depth estimation, ground plane estimation, and multi-object tracking techniques. Firstly, an object depth estimation method with depth confidence is proposed by utilizing the monocular depthmap from a CNN. Secondly, an adaptive ground plane estimation using both dense and sparse features is proposed to localize the objects when their depth estimation is not reliable. Thirdly, temporal information is taken into consideration by a new object tracklet smoothing method. Unlike most existing methods which only consider vehicle localization, our method is applicable for common moving objects in the road scenes, including pedestrians, vehicles, cyclists, etc. Moreover, the input depthmap can be replaced by some equivalent depth information from other sensors, like LiDAR, depth camera and Radar, which makes our system much more competitive compared with other object localization methods. As evaluated on KITTI dataset, our method achieves favorable performance on 3D localization of both pedestrians and vehicles when compared with the state-of-the-art vehicle localization methods, though no published performance on pedestrian 3D localization can be compared with, from the best of our knowledge.

17

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OFFICE OF NAVAL
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Feedback-Driven Learn to Reason for Improved Learning in Complex Environments

Reinforcement learning (RL) algorithms have been successfully implemented in many fields. However, it remains difficult for an RL agent to master new tasks in unseen environments. In our research, we use feedback and domain knowledge to reason about the behavior of learning-enabled autonomous cyber systems. In RL environments with sparse or delayed rewards, human players find it easy to obtain much higher rewards than state-of-the-art deep learning algorithms.

We develop FRESH (Feedback-based REward SHaping), a scheme to provide informative feedback in state spaces of high dimension (e.g. Atari games). A human operator provides feedback on actions at states in trajectories from game play, and this feedback is converted to a `shaping' reward. A neural network is used to allow the agent to determine optimal actions at unseen states during test time by generalizing feedback signals that were provided on similar states during training. FRESH significantly outperformed state-of-the-art deep RL algorithms in the Bowling and Skiing Atari games, and also outperformed a human expert player in Bowling.

We also used potential-based methods to encode knowledge of the RL agent's environment to modify rewards received during training. This modification accelerated learning of optimal policies, while at the same time, did not distract the agent from its original goal (by say, falling into a cycle to only accumulate the modified reward). We generalized potential-based methods to learn stochastic optimal policies in continuous state spaces, and established guarantees on the convergence of an algorithm which augmented these methods to an actor critic architecture. This algorithm enabled faster convergence and higher rewards, than in the case without advice. These contributions will advance the state-of-the-art in deep RL by leveraging insight from feedback given by human operators and integrate it with knowledge of the environment in order to accelerate the learning process and accumulate higher rewards.

18

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SEMICONDUCTOR RESEARCH
CORPORATION, KUWAIT
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Modeling Charge Transport Through Nucleic Acid Structures

Modeling and simulation of nanostructures is essential in developing new devices. Our group models electron transport in nanoscale devices. We look at charge transport through DNA to study its application as a material for electronic devices as well as possible bio devices for disease detection.

Physics-Based Security Analysis of Controller Area Network Protocols in Automobiles

19

AUTHORS

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Automobiles are equipped with Electronic Control Units (ECUs) that communicate via in-vehicle network protocol standards such as the Controller Area Network (CAN) protocol. Since these protocols were designed under the assumption that separating in-vehicle communications from external networks would be sufficient for protection against cyber attacks they do not have security mechanisms such as message authentication or encryption. This assumption, however, has been shown to be invalid by recent attacks in which adversaries were able to infiltrate the in-vehicle network. In order to secure the CAN protocol, anomaly-based Intrusion Detection Systems (IDSs) have been proposed to track physical properties and detect unexpected deviations from their normal behaviors. In our research, we proposed different classes of attacks on the ECUs attached to the CAN bus that bypass the current state of the art IDSs. The attacks we proposed were: (1) The cloaking attack - an intelligent masquerade attack in which an adversary modified the timing of transmitted messages to match the clock skew of a targeted ECU. The attack leverages the fact that, while the clock skew is a physical property of each ECU that cannot be changed by the adversary, the estimation of this skew can be easily manipulated; (2) The overcurrent attack - in which an adversary damaged the compromised ECU's microcontroller by letting the current that flowed into an analog pin exceed the maximum amount that the microcontroller could absorb; (3) The denial-of-service attack - in which an adversary prevented any message from being transmitted by setting the CAN bus to an idle state; (4) The forced retransmission attack - in which an adversary forced an ECU to retransmit by inducing an error during message exchange. We implemented the cloaking attack on two hardware testbeds- a prototype and a real vehicle. We then tested it on two IDSs, namely, the current state-of-the-art IDS and its adaptation to the widely used Network Time Protocol (NTP). We demonstrated that our cloaking attack was able to deceive both IDSs. We also introduced a new metric called the Maximum Slackness Index to quantify the effectiveness of a clock skew-based IDS in detecting masquerade attacks when the adversary was unable to precisely match the clock skew of the targeted ECU. Furthermore, we proposed a hardware-based Intrusion Response System (IRS) that disconnected the Voltage-based IDS (VIDS) from the CAN bus at the onset of the attacks (overcurrent attack, denial-of-service attack and forced retransmission attack). We demonstrated the proposed attacks on a CAN bus testbed and evaluated the effectiveness of the proposed IRS. In ongoing work, we are focusing on inter-vehicle security in truck platooning. We are currently working on designing secure platoon maneuvering protocols to tackle unexpected road incidents.

Instance Segmentation and Tracking of Surgical Instruments for Computer Aided Surgery

20

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Surgical instrument segmentation and tracking is beneficial in surgical workflow optimization, localization in surgical workspace and relative pose estimation, instrument collision prediction and other applications in monitoring autonomous, teleoperated or conventional surgery. Identifying and tracking instruments also provides contextual information about the phase of the surgical procedure. While a number of previous methods have addressed semantic segmentation of instruments, methods for instance segmentation and tracking of surgical instruments have been limited. This work presents our networks developed for instance segmentation and tracking. The performance is evaluated on the microneurosurgery dataset, NeuroID. A baseline performance was obtained by using heuristics to combine extracted features for segmentation and tracking. We extend the analysis to a publicly available robotic instrument segmentation and tracking datasets from MICCAI challenges (2017 and 2015 respectively) to show performance evaluation against previously published work.

21

Opponent Anticipation via Conjectural Variations

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We introduce a framework for multi-agent learning in which agents anticipate each others' reactions by forming conjectures about their learning processes. We devise gradient-based learning rules using a variational perspective relative to these conjectures. The learning schemes lead to an alternative equilibrium concept which generalizes the Nash equilibrium: a differential general conjectural variations equilibrium. When compared to simultaneous gradient play, we empirically observe that implicit conjecture learning leads to a more socially equitable solution, while gradient and fast conjecture learning decrease the rotational components of the joint dynamics. The framework provides techniques for future synthesis of novel heterogeneous multi-agent learning rules.

Consensus-Based Coordinated Control of Energy Storage Systems for Voltage Regulation in Distribution Networks with Uneven PV Integration

22

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High penetrations of rooftop photovoltaic (PV) systems can cause severe voltage quality problems in distribution networks. We assume that each node is equipped with a smart agent that is able to measure local variables, compute control signals and communicate with neighboring agents. A consensus-based distributed control strategy is then proposed to coordinate a large number of residential Energy Storage Systems (ESSs) for voltage regulation. This strategy employs a max/min-consensus algorithm for each agent to assess the global voltage status, which allows them to form into separate voltage regulation groups when upper and lower voltage limit violations occur at the same time within a feeder due to an uneven integration of PV capacity. Within each voltage regulation group, a consensus algorithm ensures that all the ESSs operate at an equal utilization ratio to promote an effective and fair use of the overall voltage regulation capacity. Case studies based on a typical distribution network and field-recorded data demonstrate the effectiveness of the proposed control strategy.

23

Droplet Manipulation Using AC EWOD- Actuated Anisotropic Ratchet Conveyors

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AMAZON CATALYST FUND, COMOTION INNOVATION FUND

We demonstrate an AC electrowetting-on-dielectric (EWOD) based platform to manipulate water droplets using anisotropic patterning of electrodes, without the need of complex control circuits. Only two electrodes are required to transport the droplet. Different droplet sizes (5~15 mL) have been tested and the droplet transport speed can reach 20 mm/s for 15 mL at 20 Hz external AC frequency. By introducing DC EWOD electrodes, we can perform multiple droplet manipulating functionalities including droplet synchronizing, merging, and mixing, which provides potential applications including active self-cleaning surfaces and lab-on chip instruments.

24

MEMS-Actuated Metasurface Alvarez Lens

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TUNOPTIX INC.

Miniature lenses with tunable focus are essential components for many modern applications involving compact optical systems. While several tunable lenses have been reported with various tuning mechanisms, they often still face challenges in power consumption, tuning speed, fabrication cost, or production scalability. In this work, we have adapted the mechanism of an Alvarez lens – a varifocal composite lens in which lateral shifts of two optical elements with cubic phase surfaces give rise to a change in optical power – to construct a miniature, MEMS-actuated metasurface Alvarez lens. The implementation based on electrostatic microelectromechanical systems (MEMS) generates fast and controllable actuation with low power consumption. The utilization of metasurfaces, ultrathin and subwavelength-patterned diffractive optics, as the optical elements greatly reduces the device volume compared to systems using conventional freeform lenses. The entire MEMS Alvarez metalens is fully compatible with modern semiconductor fabrication technologies, granting it the potential to be mass-produced at a low unit cost. In the reported prototype to operate at 1550 nm wavelength, a total uniaxial displacement of 6.3 µm is achieved in the Alvarez metalens with direct-current (DC) voltage application up to 20 V, modulating the focal position within a total tuning range of 68 µm, producing more than an order of magnitude change in focal length and 1460 diopters change in optical power. The MEMS Alvarez metalens has a robust design that can potentially generate a much larger tuning range without substantially increasing device volume or energy consumption, making it desirable for a wide range of imaging and display applications.

25

Escaping from Saddle Points on Riemannian Manifolds

AUTHORS
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We consider minimizing a nonconvex, smooth function $f(x)$ on a smooth manifold $x\in\mathcal{M}$. We show that a perturbed Riemannian gradient algorithm converges to a \emph{second-order} stationary point in a number of iterations that is polynomial in appropriate smoothness parameters of f and $\mathcal{M}$, and polylog in dimension. This matches the best known rate for unconstrained smooth minimization.

Online Continuous DR-Submodular Maximization with Long-Term Budget Constraints

26

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In this paper, we study a class of online optimization problems with long-term budget constraints where the objective functions are not necessarily concave (nor convex) but they instead satisfy the Diminishing Returns (DR) property. Specifically, a sequence of monotone DR-submodular objective functions $\{f_t(x)\}_{t=1}^T$ and linear budget functions $\{\langle p_t,x \rangle \}_{t=1}^T$, $p_t \succeq 0$, arrive over time and assuming a total targeted budget B_T, the goal is to choose points x_t at each time $t\in\{1,\dots,T\}$, without knowing f_t and p_t on that step, to achieve sub-linear regret bound while the total budget violation $\sum_{t=1}^T \langle p_t,x_t \rangle -B_T$ is sub-linear as well. Prior work has shown that achieving sub-linear regret and total budget violation simultaneously is impossible if the utility and budget functions are chosen adversarially. Therefore, we modify the notion of regret by comparing the agent against a $(1-\frac{1}{e})$-approximation to the best fixed decision in hindsight which satisfies the budget constraint proportionally over any window of length W. We propose the Online Saddle Point Hybrid Gradient (OSPHG) algorithm to solve this class of online problems. For $W=T$, we recover the aforementioned impossibility result. However, when $W=o(T)$, we show that it is possible to obtain sub-linear bounds for both the $(1-\frac{1}{e})$-regret and the total budget violation.

Integrating Bidirectional Brain-Computer Interfaces in Low-Voltage CMOS

27

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Bidirectional neural interfaces are tools for investigating the nervous system and treating neurophysiological disorders. This work compresses the analog and digital functionality for a medically relevant neural interface into a single low-voltage CMOS chip, paving the way for economically viable and minimally invasive implants. The presented 65nm CMOS test chip leverages resonant power generation circuits to shrink the otherwise prohibitive stimulation electronics. A novel multiplexed adaptive stimulation artifact canceller allows for simultaneous recording and stimulation on multiple channels with minimal added power consumption.

28

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Curriculum Learning with Dynamic Instance Hardness

We introduce {\it dynamic instance hardness} (DIH) to facilitate the training of machine learning models. DIH is a property of each training sample and is computed as the running mean of the sample's instantaneous hardness as measured over the training history. We use DIH to evaluate how well a model retains knowledge about each training sample over time. We find that for deep neural nets (DNNs), the DIH of a sample in relatively early training stages reflects its DIH in later stages and as a result, DIH can be effectively used to reduce the set of training samples in future epochs. Specifically, during each epoch, only samples with high DIH are trained (since they are historically hard) while samples with low DIH can be safely ignored. DIH is updated each epoch only for the selected samples, so it does not require additional computation. Hence, using DIH during training leads to an appreciable speedup. Also, since the model is focused on the historically more challenging samples, resultant models are more accurate. The above, when formulated as an algorithm, can be seen as a form of curriculum learning, so we call our framework DIH curriculum learning (or DIHCL). The advantages of DIHCL, compared to other curriculum learning approaches, are: (1) DIHCL does not require additional inference steps over the data not selected by DIHCL in each epoch, (2) the dynamic instance hardness, compared to static instance hardness (e.g., instantaneous loss), is more stable as it integrates information over the entire training history up to the present time. Making certain mathematical assumptions, we formulate the problem of DIHCL as finding a curriculum that maximizes an unknown multi-set function $f(\cdot)$ from its partial observations, and derive an approximation bound for a DIH-produced curriculum relative to the optimal curriculum. Empirically, DIHCL-trained DNNs significantly outperform random mini-batch SGD and other recently developed curriculum learning methods in terms of efficiency, early-stage convergence, and final performance, and this is shown in training several state-of-the-art DNNs on 11 modern datasets.

29

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Metasurface Optics for Ultra-Compact Augmented Reality Visors

The next generation of metasurface near-eye visors which will circumvent real-world distortions and provide a large field of view, as needed for an immersive AR experience is designed.

30

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Multisensory Tissue Classification using “Smart” Grasper Robot 2.0

Compared to open surgery, minimally invasive surgery has the benefits of faster recovery and reduced blood loss. One particular challenge of minimally invasive surgery is tissue classification - the identification of the type and state of tissue being grasped by a surgical instrument. The “Smart Grasper” minimally invasive surgical robot, which is the subject of this work, addresses this need through a novel combination of sensors on its tip. Its sensors include an ultrasonic transducer, a thermistor, an RGB borescope camera, a pulse oximeter and an indirect force measurement load cell. The measurements from these sensors are fused through a Support Vector Machine algorithm to classify the tissue.





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Frequency Stability Using Inverter Power Control in Low-Inertia Power Systems

The electrical grid is evolving from a network consist- ing of mostly synchronous machines to a mixture of synchronous machines and inverter-based resources such as wind, solar, and energy storage. This transformation has led to a decrease in mechanical inertia, which necessitate a need for the new resources to provide frequency responses by controlling their inverter interfaces. In this work we propose a new strategy based on model predictive control to determine the optimal active- power set-point for inverters in the event of a disturbance in the system. In contrast to existing methods, our framework explicitly takes the hard constraints in power and energy into account. We show that it is also robust to measurement noise and limited communications by using an observer to estimate the model mismatches in real-time. We demonstrate that our proposed controller significantly outperforms an optimally tuned virtual synchronous machine on standard IEEE 9-bus and 39- bus systems under a number of scenarios.

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ADAPT: Analytical Framework for Actionable Defense against Advanced Persistent Threats

Advanced Persistent Threats (APTs) are stealthy, sophisticated, and long-term attacks that threaten the security of sensitive information in various organizations, including, but not limited to, national defense, manufacturing, and financial industry. In the field of computer systems security, Dynamic Information Flow Tracking (DIFT) has being emerged as a promising defense mechanism against APTs. DIFT taints information flows from suspicious input channels, track the propagation of the tainted flows through the system and performs security analysis when a tainted information is used in an unauthorized manner. However, widespread deployment of DIFT across various cyber systems and platforms is heavily bottlenecked by the resource and performance constraints such as memory, storage and processing power, associated with employing DIFT in the underlying system. In our research, we use game theory as a foundation to model the strategic interactions between an APT adversary and a DIFT-based defender. The game models we developed provide an analytical framework of DIFT which enables the study of trade-off between resource efficiency and the quality of detection. We use graph theory, discrete and continuous submodular optimization and linear programing-based techniques to study the underlying game from the point of view of each player. We propose Nonlinear programing, reinforcement learning and machine learning based algorithms to find and characterize the Nash and Stackelberg equilibrium of the game and provide theoretical guarantees on the convergence of the proposed algorithms. Moreover, we simulate and evaluate the proposed algorithms on real-world attack datasets.

33

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A Unified Power+Clock Compiler: Enabling Rapid IVR-IP Integration into Energy-Efficient SoCs

System on Chip (SoC) design is sophisticated, which contains multiple accelerators and high efficiency for fine-grained voltage domains. As a result, it is a challenge for small team to implement design SoC efficiently. Therefore, we proposed a SoC compiler, which will automatically convert non-voltage regulated and non-clock regulated designs into physical design of all-digital design with regulated voltage and clock. In other words, this poster propose a automated, all digital design flow for rapid design, which can be beneficial for small team to develop SoC design.

Control Synthesis to Satisfy Complex Temporal Objectives in Adversarial Environments

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Cyber-physical systems (CPSs) are entities in which the working of a physical system is governed by its interactions with computing devices and algorithms. Such systems are ubiquitous, and are often safety-critical. Examples of CPSs include drones, power networks, and medical devices. The integration of cyber and physical components introduces attack surfaces which can be exploited by an intelligent adversary. At the same time, the CPS will be required to meet certain objectives or goals (for e.g., safety, stability, surveillance) during nominal operation. Temporal logic frameworks enable the succinct representation of these objectives. However, there is a wide gap between the representation of these goals and the translation of security as a concept to these frameworks, which is what we seek to bridge in our research. We leverage techniques from game theory, formal methods, and control to dynamically ensure secure satisfaction of CPS objectives over durations of time, in the presence of an adversary. The interaction of the CPS with the adversary is modeled as a stochastic game, and we demonstrate that solving this game realizes the desired temporal objective and ensures that the CPS is secure against adversarial actions. In our research, we have examined this problem in a broad variety of settings, including partially observable environments and the satisfaction of time-critical objectives. These contributions will help to solve challenging problems in the emerging research paradigm of software-defined secure verification and control design.

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A 25 Mbps, 12.4 pJ/Bit DQPSK Backscatter Wireless Uplink for the NeuroDisc BCI

Multi-day neural plasticity experiments in non-human primate (NHP) models require wireless neural recording with a high rate uplink and minimal power consumption. We introduce a 25 Mbps differential quadrature phase-shift keying (DQPSK) backscatter wireless uplink for the NeuroDisc brain-computer interface (BCI), operating in the 902-928 MHz industrial, scientific, and medical (ISM)-band. The backscatter uplink consumes 310 µW, yielding a communication energy efficiency of 12.4 pJ/bit.

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Disturbance Decoupling in Gradient-Based Multi-Agent Learning

Motivated the problem of learning in multi-agent settings, we study the robustness of gradient-based learning dynamics with respect to gradient noise. While noise of arbitrary magnitude injected along a coordinate corresponding to any individual player can always destabilize the overall learning dynamics, a subset of players are disturbance decoupled---i.e., such agents are completely unaffected by the injected noise. For games with quadratic cost functions, we provide necessary and sufficient conditions for guaranteeing disturbance decoupling. Specifically, we characterize disturbance decoupling in terms of both algebraic and graph-theoretic conditions on the learning dynamics, the latter of which are obtained by constructing a game graph based on gradients of players' cost functions. We provide stronger results for finite LQ games: we show that disturbance decoupling between two players result in conditions on the controllability and observability of each player's dynamics. Additionally, we show that in distributed multi-agent reinforcement learning (MARL) policy evaluation, disturbance decoupling between two players cannot occur.

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Smart Step: Mobility Assistance using Machine Learning and Haptic Cues

Smart step aims to assist people with mobility impairments, especially those with prosthetic limbs to walk down the staircase better and more intuitively. Stair descent is a challenge for prosthesis users due to the absence of sensation underneath the foot and the absence of ankle flexion. We use body-worn sensors to measure real-time kinematic and kinetic information, and employ neural network algorithms to predict foot placement information in the future. Based on these predictions, we deliver simple informative haptic cues on the wrist of the user, informing them to take a longer or a shorter step.

    

   

An All-Digital Buck-Converter-Based Unified Clock and Power Architecture (UniCaP) with Autonomous CCM/DCM Transition Control

38

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Clocking and Voltage regulation have long been considered to be disparate, independent disciplines. As designers continue the push toward improved computational efficiency with lower supply-voltages and smaller voltage-domains, a significant source of dissipation are wasteful supply-voltage margins required to ensure robust operation in the presence of supply-noise, temperature variation and across-die variation. We present a Unified Clock and Power (UniCaP) architecture that demonstrates how joint power and clock design significantly enhances system efficiency by aggressively reducing supply-voltage margins in digital domains, and enables uninterrupted executing during Dynamic Voltage and Frequency Scaling (DVFS) events. The central feature of UniCaP is absorbing integrated voltage regulation into the clock generation loop (PLL or FLL), allowing the system to lock to a target frequency while simultaneously offering adaptive clocking for supply droop mitigation.

We deploy the general UniCaP architecture on a 65nm buck-converter test-chip powering a Cortex M0 microprocessor. Phase-lock recovers any resulting clock cycle gain or loss, and enables temperature variation tracking. Measurements on a 65nm CMOS test-chip indicate a 82% average voltage-margin and 55mV temperature margin reduction in a 0.6-to-1.0V Cortex-M0 processor.

A Systematic Trajectory Tracking Approach for Mechanical Systems Subject to Unilateral Constraints

39

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We present a principled approach to reference tracking in mechanical systems undergoing impacts. At every impact, the velocity of the trajectory changes discontinuously, introducing a sudden jump in the tracking error whenever the reference and plant impact at different times. We propose an approach where the trajectories used to compute the control signal are continuously extended past the point of impact and the velocity jump is captured with a piecewise linear projection operator. Then, utilizing techniques from Riemannian geometry of mechanical system, we generate a stabilizing controller for the extended switched system that, through the projection operator, guarantees reference tracking on the mechanical system away from impacts. We demonstrate our method on the bouncing ball problem.

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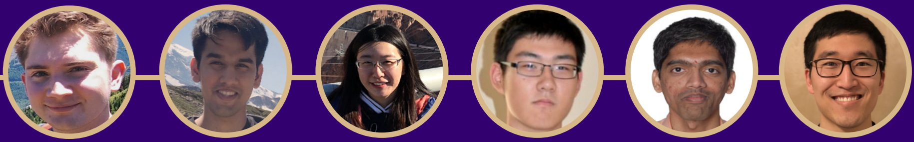
A Fully Integrated Side-Channel Attack Resistant AES with Run-time Adaptive Countermeasure Control

True Random Number Generators (TRNGs) play a central role in enabling cryptographic protocols that provide trust and security in communication and computing. Motivated by the need for improvements in throughput, efficiency, and ease of integration, recent work has focused on digital hardware TRNGs. However, these sensitive circuits constructed to extract physical circuit noise (Phy-RNGs) are also vulnerable to attacks that seek to influence their output. Prior demonstrations of attack resistance relied on a narrowly defined attack model. Most importantly, however, prior work provides no guarantees on the Quality of Randomness (QoR). Instead TRNG output entropy-rate (H) is sensitive to environmental parameters such as Process, Voltage, and Temperature (PVT) (Fig. 1a): A quantitative treatment of the variation-induced H-degradation is also missing. A TRNG architecture that can regulate QoR under PVT variations is needed to fulfill system-level security objectives.



41

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Data-driven Estimation and Property Testing

Estimation of information theoretic quantities such as mutual information and conditional mutual information has drawn interest in recent times due to its applications in representation learning, feature selection, conditional independence testing and quantifying strength of dependence between variables. In this work, we leverage techniques from classifiers and deep learning to estimate these information theoretic quantities.

An intuitive, Distributed Training System for Fully Implanted Closed Loop Deep Brain Stimulation with the Medtronic Activa PC+S Nexus-E System

42

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Introduction: Deep brain stimulation (DBS) is a safe and established treatment for essential tremor (ET), the world's most common movement disorder (MD) [1]. However, DBS side effects are well documented and battery replacements require revision surgery. Closed-loop DBS (CL-DBS) seeks to mitigate these concerns by using some form of feedback to modulate stimulation parameters, as opposed to the current clinical standard of leaving stimulation continuously active. The Medtronic Activa PC+S combined electrocorticography (ECoG) and DBS probe investigational device uses the Nexus-E framework as a wholly implanted CL-DBS system, in contrast to previously demonstrated distributed systems that preclude free patient movement [2]. Although freeing the patient to move freely, the fully implanted system can prove cumbersome and unintuitive to train.

Methods: N=3 patients (0 female, 3 right-handed) implanted unilaterally with the Activa PC+S participated. DBS probe was implanted in the ventral intermediate nucleus (VIM) and ECoG strip placed over the hand portion of the primary motor cortex (M1). A heterodyne-based estimate of the 12-28Hz bandpower from the ECoG strip, corresponding roughly to the β-band [3], was streamed to an experimental computer at a sampling rate of 2.5Hz while the patient was at rest and while they were conducting the finger-to-nose task of the Fahn-Tolosa-Marin (FTM) tremor rating scale [4], each for 30 seconds. This was repeated with stimulation on and off. A linear classifier biased towards keeping stimulation active was generated from these two minutes' data to differentiate between when stimulation was required (movement) and when it was not (rest). This classifier was uploaded using the Nexus-E on-board CL-DBS system.

Results: The classifier training process in each patient, including explaining protocol to patient, data collection, classifier generation analysis, and uploading classifier to on-board PC+S system, was completed in twenty minutes. Preliminary results revealed a 0.012 false negative rate for stimulation activation.

Discussion and Significance: This represents the first demonstration of a completely enclosed CL-DBS system trained using an intuitive and easily applied distributed training procedure. In contrast with the dominant methods for training the Activa PC+S, which are often imprecise and cumbersome, this represents a straightforward and reliable method for training. Adoption of this method will add to the growing consensus that CL-DBS methods are ready for more widespread deployment in MDs.

High-Density Neural Stimulation & Recording Interface for Closed-Loop Brain-Computer Interface

43

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Reverse-engineering the brain has been identified as a Grand Challenge by the National Academy of Engineering. Understanding brain function promises far-reaching benefits, from inspiring and informing radically new computing paradigms to transforming the fields of neurology and rehabilitation medicine through neuroprosthetics. Implantable neural interfaces are playing an increasingly critical role toward this effort by providing enhanced chronic visibility and control of brain function in untethered, freely moving subjects. Despite significant progress in the area of interface electronics, significant engineering barriers that hinder advances in neuroscience continue to exist. These include the need for finer neural stimulation and neural recording capabilities, and integrated ultra-low power low-latency computing to enable bi-directional neural interfaces. This project explores new, transformative concepts and ideas for implantable neural interfaces to overcome critical barriers, and enable continued advances in neuroscience, specifically in the areas of finer-grained neural stimulation and enabling computing for closed loop control.

Restricted Directed Information for Gene Regulatory Interactions Inference

44

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Here we present Scribe, a toolkit for detecting and visualizing causal regulatory interactions between genes and explore the potential for singlecell experiments to power network reconstruction. Scribe employs Restricted Directed Information (RDI) along with an enhanced version of it termed uniform Restricted Directed Information (uRDI) to determine causality by estimating the strength of information transferred from a potential regulator to its downstream target. We apply Scribe and other leading approaches for causal network reconstruction to several types of singlecell measurements and show that there is a dramatic drop in performance for "pseudo-time" ordered singlecell data compared to true time-series data. We demonstrate that performing causal inference requires temporal coupling between measurements. We show that methods such as “RNA velocity” restore some degree of coupling through an analysis of chromaffin cell fate commitment.

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Improving Performance of Direction-of-Arrival Estimation Using Signal Processing on Graphs

Estimating the direction-of-arrival (DOA) angle with just a single snapshot (in time), from measurements recorded by a uniform line array (ULA), brings a unique set of challenges and opportunities for research. Well-known multi-snapshot techniques like MUSIC and ESPRIT cannot be directly applied to the single-snapshot case, while the most studied and cited algorithm, the Bartlett method, suffers from large estimation bias. While some improve the performance of Bartlett with pre-windowing or spatial smoothing, our aim here is to improve performance by reconsidering the Bartlett method's main assumption that its input data must lie on a uniform line grid of points. We use principles from Signal Processing on Graphs (SPG) to reformulate the Bartlett method on a graph domain consisting of a set of vertices and edges, and then extend the algorithm to other graph topologies so that we can investigate opportunities for performance improvement. In this work, the estimation bias when using graphs with N = 3 vertices was studied. From this work, we identified a subset of graphs that had, for certain DOAs, improved estimation performance, and found conditions on when to select one graph topology over another.

46

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Sequential Experimental Design for Transductive Linear Bandits

In a number of applications, there is a set of items with underlying structure and the goal is to identify which of them maximizes a response transductively using noisy measurements from a set of probes. The transductive problem naturally arises when the set of measurement vectors is limited due to factors such as availability or cost. As an example, in drug discovery the compounds and dosages a practitioner may be willing to evaluate in the lab in vitro due to cost or safety reasons may differ vastly from those compounds and dosages that can be safely administered to patients in vivo. In contrast, in recommender systems for books, the set of books a user is queried about may be restricted to known best-sellers even though the goal might be to recommend more esoteric titles. This work formulates the transductive linear bandit problem and presents an algorithm based on sequential experimental design principles that achieves a near-optimal sample complexity. Finally, the empirical performance of the algorithm is demonstrated on a wide-range of problems.

47

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Data-Driven Control for Societal-Scale Cyber-Physical Systems

Decisions on how to best operate societal-scale cyber-physical systems (CPS) such as energy systems, transportation networks and robotics are becoming increasingly challenging because of the growing system complexity and environmental uncertainties. Recent years, with the explosion of data and rapid development of machine learning algorithms, data-driven control shows promise for addressing the aforementioned challenges. In this poster, we introduce some of our group's recent work in exploring the theoretical foundations and applications of data-driven control from two perspectives:

(1) How can we design data-driven control algorithms for societal-scale CPS?
(2) How we analyze the interactions between multiple intelligent agents and design better social platform?

48

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Auto-Summarization: A Step Towards Unsupervised Learning of a Submodular Mixture

We introduce an approach that requires the specification of only a handful of hyperparameters to determine a mixture of submodular functions for use in data science applications. Two techniques, applied in succession, are used to achieve this. The first involves training an autoencoder neural network constrainedly so that the bottleneck features have the following characteristic: the larger a feature's value, the more an input sample should have an automatically learnt property. This is analogous to bag of-words features, but where the "words" are learnt automatically. The second technique instantiates a mixture of submodular functions, each of which consists of a concave composed with a modular function comprised of the learnt neural network features. We introduce a mixture weight learning approach that does not (as is common) directly utilize supervised summary information. Instead, it optimizes a set of meta-objectives each of which corresponds to a likely necessary condition on what constitutes a good summarization objective. While hyperparameter optimization is often the bane of unsupervised methods, our approach reduces the learning of a summarization function (which most generally involves learning 2n parameters) down to the problem of selecting only a handful of hyperparameters. Empirical results on three very different modalities of data (i.e., image, text, and machine learning training data) show that our method produces functions that perform significantly better than a variety of unsupervised baseline methods.

An Efficient Abstraction Method for Implementing TGn Channel and OFDM-MIMO Error Model in Ns-3

49

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The current ns-3 WiFi models implement IEEE 802.11 TGn SISO channels via pre-storing a large number of realizations and drawing a sample per coherent interval during simulation run. This implementation requires very large memory to store channel realizations and limits the accuracy with which low PER events can be simulated. This work provides a full implementation to allow ns-3 simulations to generate TGn fading channel instances for use in link-to-system mapping models and upgrades current ns-3 802.11SISO system into 802.11n OFDM-MIMO system. While the full implementation reduces memory costs, the OFDM-MIMO physical layer processing takes a lot of computational time. So, this work also provides a simpler abstraction to directly characterize the (output) effective SNR distribution; this requires only a very few model parameters to accurately characterize the full PHY.

Spinal Cord Stimulation Restores Hand Function after Cervical Spinal Cord Injury

50

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Hand and arm paralysis severely restricts independence and quality of life after spinal cord injury. Regaining control of hand and arm movements is the highest treatment priority for people with paralysis, 5-fold higher than restoring walking ability. Nevertheless, current approaches to improve upper limb function are largely ineffective. Spinal cord stimulation is one of the emerging neuromodulation strategies to restore motor function. Recent studies using surgically implanted electrodes demonstrate impressive improvements in standing and stepping. Here we show that non-invasive electrical stimulation of the spinal cord leads to rapid and sustained functional recovery of the hands and arms, even after complete paralysis of the hands and fingers. Notably, the magnitude of these improvements exceeded previously reported results from surgically-implanted stimulation. Additionally, muscle spasms reduced and autonomic functions including heart rate, thermoregulation, and bladder function were all improved. Perhaps most notable is that all six participants maintained their functional gains for at least three to six months beyond the stimulation. This demonstrates that non-invasive electrical stimulation of the spinal cord promotes long-term neuroplasticity and recovery of hand and arm function. This long-term recovery allowed our participants to resume their hobbies, such as playing the guitar and painting, up to 12 years after injury. Our findings demonstrate that non-invasive electrical stimulation of spinal networks restores movement and function of the hand and arm to people with both complete paralysis and long-term spinal cord injury.

51

Spinal Stimulation for Walking in Spinal Cord Injury

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Notably, our group and collaborators recently demonstrated that people with incomplete cervical spinal cord injury (SCI) realized substantial improvements in upper extremity function following transcutaneous spinal stimulation applied to the cervical spinal cord. In the study, we observed the improvement of leg functions even though the subject received only cervical stimulation and did not perform any leg exercise. In fact, cervical spinal stimulation presented some evidence to modulate lumbosacral spinal cord excitation. Lastly, recent studies revealed immediate restoration of blood pressure control and bladder function through transcutaneous spinal stimulation.

Our pilot study results demonstrate that combined cervical and lumbar high frequency transcutaneous spinal stimulation with intensive locomotor training improved locomotor function, sensory function, and autonomic systems in two cases of incomplete cervical SCI. The functional gains were sustained for more than three months after the stimulation and exercise. The level of locomotor recovery was comparable to the functional improvement with epidural stimulation in the same population. Based on our findings, we proposed that transcutaneous spinal stimulation with intensive locomotor training leads to neuroplasticity and sustained improvement of locomotor and autonomic function in people with chronic incomplete cervical SCI.

52

Towards Perovskite LED Display

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In recent years, organometal halide perovskites (OHP) have aroused great interests due to their excellent optical, electrical and chemical properties. Especially in the area of light emitting devices, perovskites show great potential because they have high photoluminescence efficiency, high color purity, high tolerance for defects, tunable bandgap and low fabrication cost. In this work, fabrication of perovskite light emitting diodes and a patterning technique utilizing photolithography is reported. With this patterning technique, interesting devices like multi-color display can be fulfilled.

Market Design in Zero-Marginal-Cost Power Systems: Energy Prices and Resource Adequacy

53

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Increasing penetrations of zero-marginal-cost, variable renewable energy sources present new technical and policy challenges for competitive electricity markets predicated on marginal-cost energy pricing. This work studies a hypothetical power system in which electrical generating resources incur only fixed costs, and assesses the impact of differing energy and ancillary service market structures, as well as technology availability, on electricity prices and system resource adequacy.

Optimized Large-Scale Optogenetic Interface for Non-Human Primates

54

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Background:
- Network dynamics of stimulation-induced plasticity across large regions of the cortex is poorly understood.
- Non-human primate brains are a translational platform for neuroscience research.
- Optogenetics offers high spatial and temporal resolution, artifact free recording, cell type specificity, and the ability to both excite and inhibit neurons.

Limitations:
- Our previous large-scale optogenetic interface for non-human primates had an effective stimulation time window of 2-3 weeks before neomembrane growth obstructed the optical window and required resection.
- Our interface was limited to 2-3 stimulation locations at a time.

Goals:
- Extend the effective optogenetic stimulation time window.
- Increase simultaneous optical stimulation locations.
- Ensure compatibility with imaging modalities.


GaP-on-Diamond Photonics Platform for Quantum Information Processing

55

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Solid-state qubits are emerging as a promising platform for quantum information processing. The nitrogen-vacancy (NV) defect in diamond is particularly attractive due to its optical accessibility and long electron spin-coherence time. However, a scalable platform to efficiently entangle multiple NV centers remains elusive. We present recent results on our Gallium phosphide on diamond photonic platform designed for efficient NV-NV entanglement.

Human 5' UTR Design and Variant Effect Prediction from a Massively Parallel Translation Assay

56

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The ability to predict the impact of cis-regulatory sequences on gene expression would facilitate discovery in fundamental and applied biology. Here we combine polysome profiling of a library of 280,000 randomized 5' untranslated regions (UTRs) with deep learning to build a predictive model that relates human 5' UTR sequence to translation. Together with a genetic algorithm, we use the model to engineer new 5' UTRs that accurately direct specified levels of ribosome loading, providing the ability to tune sequences for optimal protein expression. We show that the same approach can be extended to chemically modified RNA, an important feature for applications in mRNA therapeutics and synthetic biology. We test 35,212 truncated human 5' UTRs and 3,577 naturally occurring variants and show that the model predicts ribosome loading of these sequences. Finally, we provide evidence of 45 single-nucleotide variants (SNVs) associated with human diseases that substantially change ribosome loading and thus may represent a molecular basis for disease.

57

Massively Parallel Measurement of Protein-Protein Interactions

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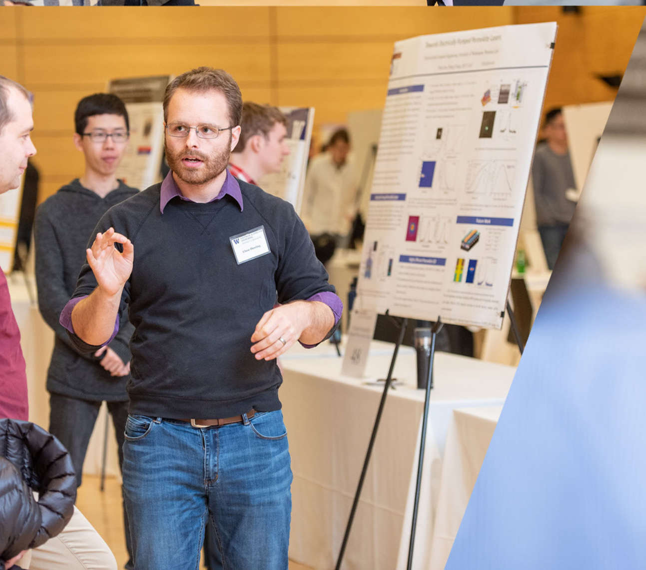
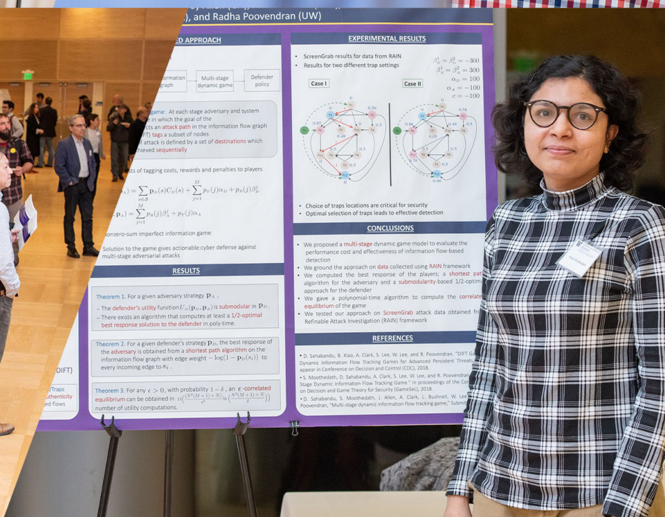
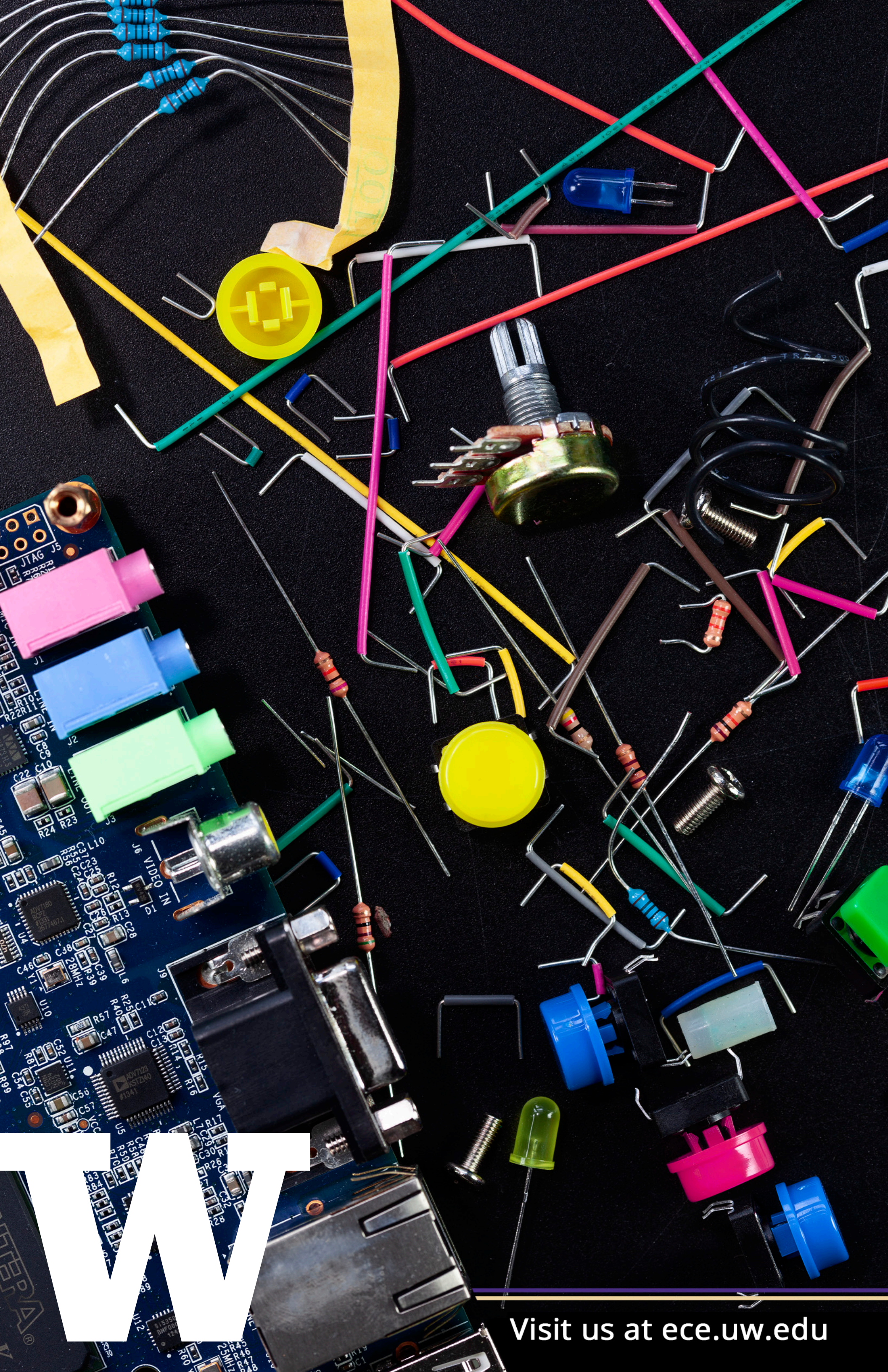
We developed an easy-to-use high-throughput method for measuring pairwise protein-protein interactions based on yeast two-hybrid technology. Our approach will allow the simultaneous screening of interactions between thousands of proteins—corresponding to millions of pairwise protein interactions in a single experiment. The identity of each protein is encoded in a DNA barcode and the abundance of a given barcode-barcode pair at the end of a selection experiment relative to its initial abundance serves as a proxy for the interaction strength. Our method thus effectively translates the problem of measuring protein-protein interactions into a next generation sequencing experiment.

NOTES


Oculus




), and Radha Poovendran (UW)
ED APPROACH
EXPERIMENTAL RESULTS
ScreenGrab results for data from RAIN
Results for two different trap settings
Case I
Case II
Multi-stage dynamic game
Defender policy
Choice of traps locations are critical for security
Optimal selection of traps leads to effective detection
CONCLUSIONS
We proposed a multi-stage dynamic game model to evaluate the performance cost and effectiveness of information flow-based detection
We ground the approach on data collected using RAIN framework
We gave a polynomial-time algorithm to compute the
We tested our approach on ScreenGrab attack data obtained
Refinable Attack Investigation (RAIN) framework
REFERENCES
RESULTS
Theorem 1. For a given adversary strategy
Theorem 2. For a given defender's strategy
Theorem 3.
Solution to the game gives actionable cyber defense against multi-stage adversarial attacks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