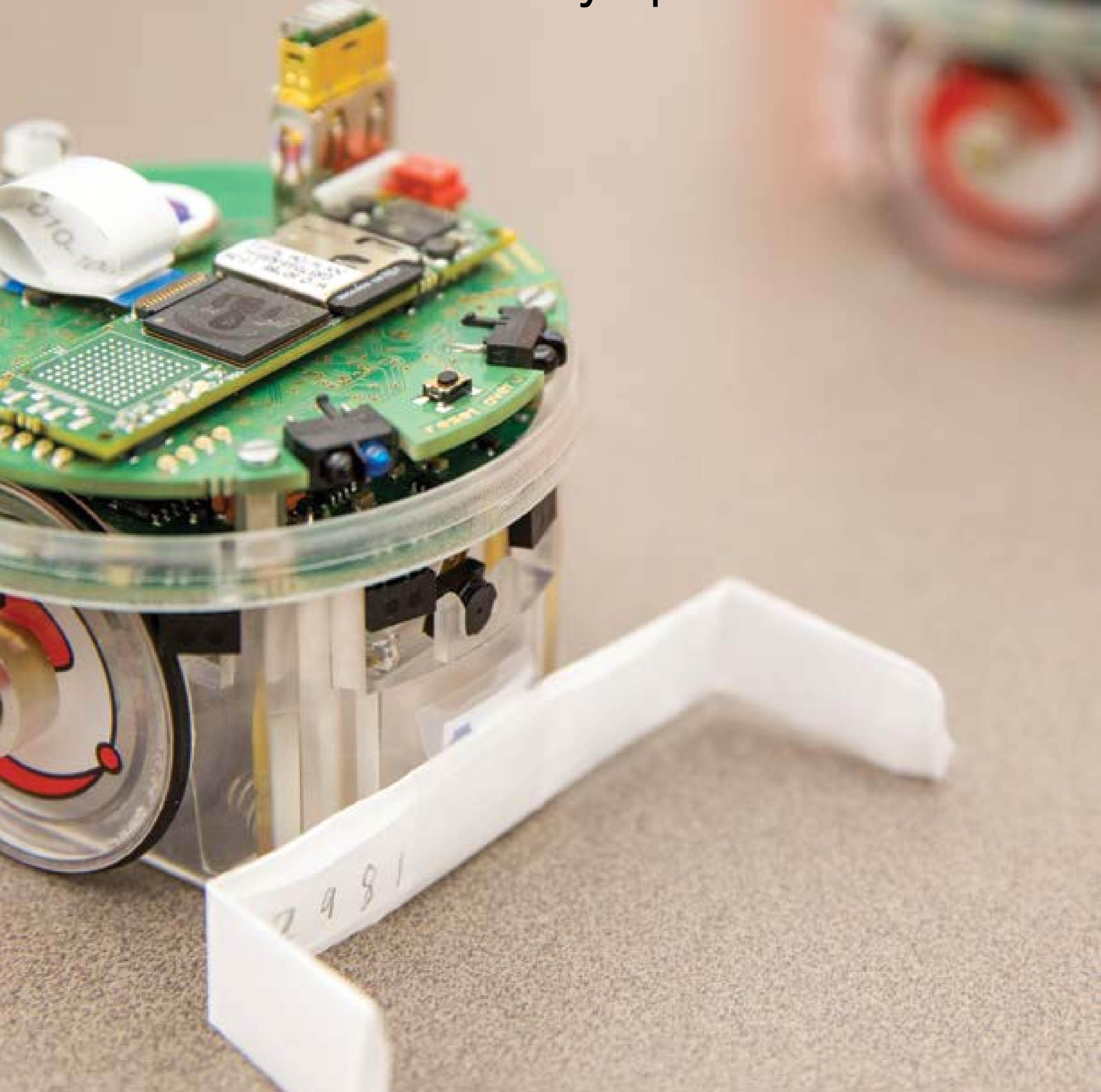
southwest robotics symposium



January 25-26, 2018

robotics.asu.edu | swrobotics.engineering.asu.edu

thursday january 25

8–8:20am	check-in opens
8:20–8:30am	WELCOME: **Kyle Squires | Panagiotis Artemiadis** arizona state university
8:30–9:30am	PLENARY SPEAKER: **Aaron Ames** caltech
9:30–9:50am	coffee break, company demos, posters

session I: soft and bio-robotics

9:50–10am	**Panagiotis Polygerinos** arizona state university
10–10:10am	**Hamid Marvi** arizona state university
10:10–10:35am	**Ian Walker** clemson university
10:35–11am	**David Remy** university of michigan
11–11:25am	**Rob Shepherd** cornell university
11:25–11:35am	**Zhen Wang** university of hong kong
11:35am–12pm	posters I – 3 minute pitch presentations x8
12–1pm	lunch on own

session II: rehabilitation and wearable robotics

1–1:15pm	**Hyunglae Lee** arizona state university
1:15–1:30pm	**Tom Sugar** arizona state university
1:30–1:55pm	**Joshua C. Kline** delsys
1:55–2:20pm	**Sunil Agrawal** columbia university
2:20–2:45pm	**Derek Kamper** university of north carolina/north carolina state university
2:45–3:15pm	coffee break, company demos, posters

session III: space robotics

3:15–4pm	**Robert Ambrose** NASA johnson space center
4–5pm	posters II – 3 minute pitch presentations x15

friday january 26

session IV: human-robot collaboration and interaction

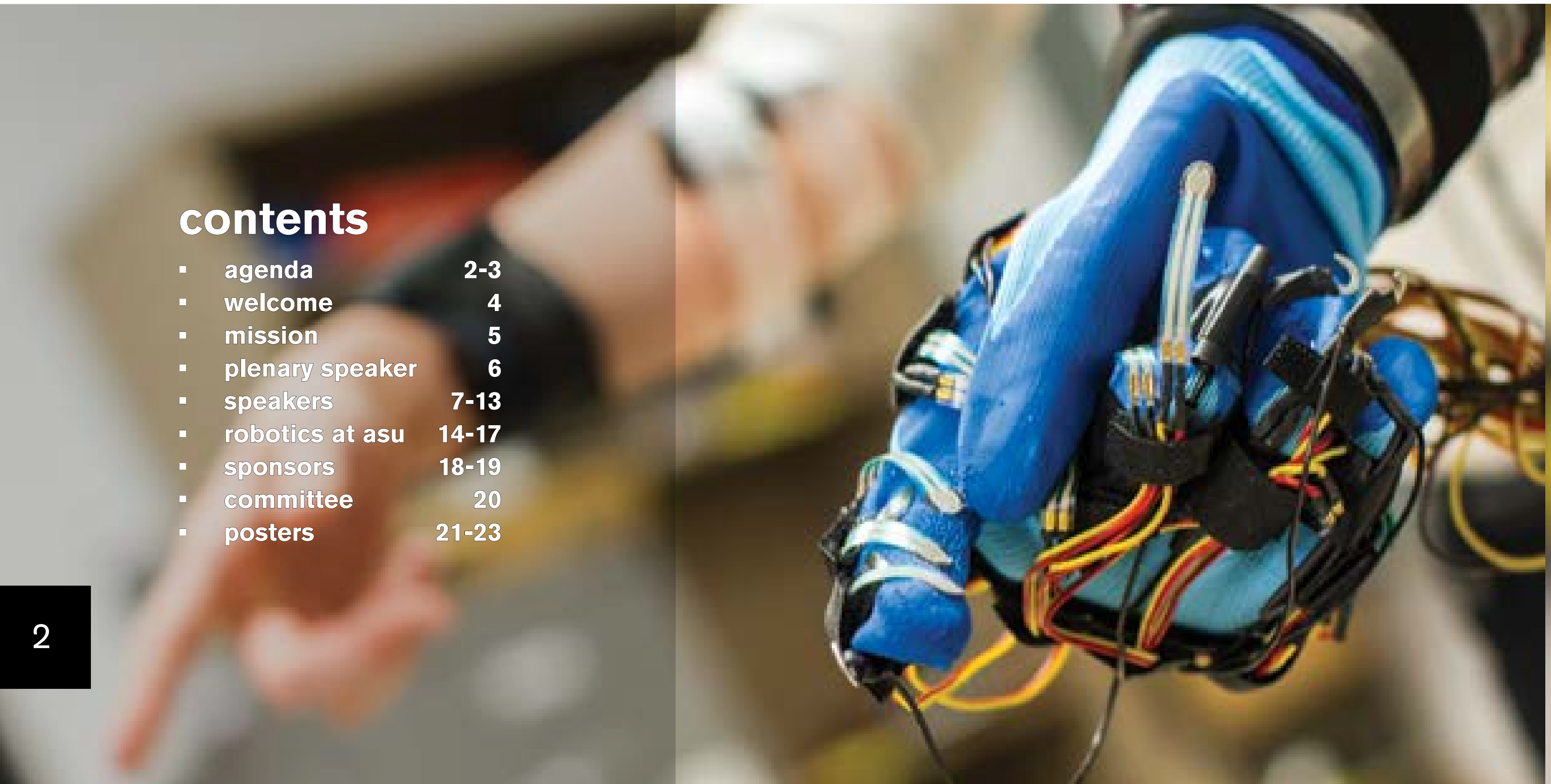
8:30–8:45am	**Panagiotis Artemiadis** arizona state university
8:45–9am	**Erin Chiou** arizona state university
9–9:25am	**Katia Sycara** carnegie mellon university
9:25–9:50am	**Luis Sentis** university of texas, austin
9:50–10:15am	**Günter Niemeyer** disney research
10:15–10:40am	**Jun Ueda** georgia institute of technology
10:40–11am	coffee break, company demos, posters

session V: advanced robotics manufacturing

11–11:25am	**Jesse Clayton** nvidia
11:25–11:40am	**Dan Aukes** arizona state university
11:40–11:55am	**Heni Ben Amor** arizona state university
11:55am–12:20pm	**Aaron Dollar** yale university
12:20–1:30pm	lunch on own

session VI: autonomous systems

1:30–1:45pm	**Georgios Fainekos** arizona state university
1:45–2pm	**Yezhou Yang** arizona state university
2–2:15pm	**Wenlong Zhang** arizona state university
2:15–2:40pm	**Soon-Jo Chung** california institute of technology
2:40–3:05pm	**Hadas Kress-Gazit** cornell university
3:05–3:30pm	**Douglas Summers-Stay** army research lab
3:30–3:45pm	coffee break, company demos, posters
3:45–4:10pm	posters III – 3 minute pitch presentations x15
4:10–4:15pm	wrap up session & discussion



contents

Panagiotis Artemiadis
Committee Chair
Associate Professor
School for the Engineering of
Matter Transport and Energy

Kyle Squires
Dean
Ira A. Fulton Schools of Engineering

Welcome to the first Southwest Robotics Symposium and to ASU!

We are excited about the symposium and hosting you at Arizona State University. We sincerely hope you enjoy this opportunity to interact with leading researchers, engineers, technology adopters, and learn about state-of-the-art applications of robotics and autonomous systems.

The Fulton Schools of Engineering continues to make significant investments in robotics and autonomous systems as we build the faculty expertise and unique capabilities needed to create innovative learning opportunities for students and a broadly based research portfolio characterized by foundational excellence and translational impacts.

This symposium has been conceived to foster effective dialogue among key stakeholders in robotics and autonomous systems that will help seed the ideas critical to new research initiatives while also increasing visibility and awareness of these very dynamic fields with their ever increasing array of applications.

We are particularly grateful to our keynote and invited speakers for joining our symposium and sharing their experiences with us, and to our faculty and students and industry sponsors for their generous support of our initiatives in robotics and autonomous systems.

Enjoy the symposium!

Panagiotis Artemiadis   Kyle Squires

our mission

make change
Help drive positive change in society by connecting researchers at Arizona State University to collaboratively pursue advancements in robotics technologies, systems and education that will serve our most critical needs.

solve problems
Explore the potential of robotics to help meet an array of challenges in the realms of health care, education, transportation, manufacturing, national defense, public safety, environmental health, communications, sustainable energy systems and earth and space exploration.

leverage our community
Solve our problems more quickly and effectively by utilizing ASU's growing, multidisciplinary research community and expanding its impact by establishing high-quality research relationships with industry, government and the public.

nurture the future
Nurture the next generation of robotics researchers through innovative educational practices, in-lab experiences and mentoring in entrepreneurship that create opportunities for students to develop their creative abilities, trains them to be skilled problem solvers and prepares them to establish themselves in the robotics community and in industry.

southwest robotics symposium

The Southwest Robotics Symposium will focus on the rapidly growing field of robotics. This 2-day event will include six sessions, posters, lab tours and demos, industry demos etc. Each session is focused on high-impact topics related to robotics and automation and will host talks from renowned researchers to discuss the state-of-the-art and future directions.

The topics include:

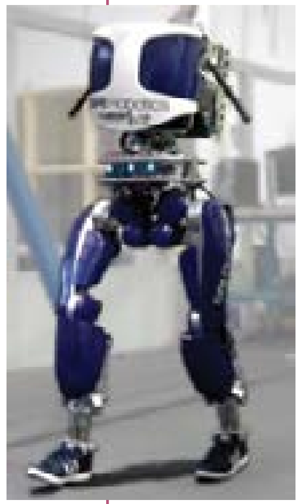
- Soft and Bio-Robotics
- Rehabilitation and Wearable Robotics
- Space Robotics
- Human-Robot Collaboration and Interaction
- Autonomous Systems
- Advanced Robotics Manufacturing

AARON AMES

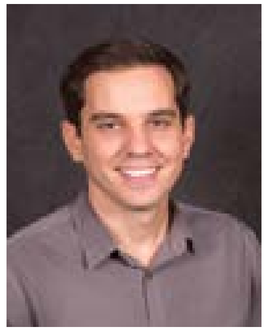
The California Institute of Technology

Aaron D. Ames is the Bren Professor of Mechanical and Civil Engineering and Control and Dynamical Systems at the California Institute of Technology. Prior to joining Caltech, he was an Associate Professor in Mechanical Engineering and Electrical & Computer Engineering at the Georgia Institute of Technology. Dr. Ames received a B.S. in Mechanical Engineering and a B.A. in Mathematics from the University of St. Thomas in 2001, and he received a M.A. in Mathematics and a Ph.D. in Electrical Engineering and Computer Sciences from UC Berkeley in 2006. He served as a Postdoctoral Scholar in Control and Dynamical Systems at Caltech from 2006 to 2008, and began is faculty career at Texas A&M University in 2008. At UC Berkeley, he was the recipient of the 2005 Leon O. Chua Award for achievement in nonlinear science and the 2006 Bernard Friedman Memorial Prize in Applied Mathematics. Dr. Ames received the NSF CAREER award in 2010, and is the recipient of the 2015 Donald P. Eckman Awared recognizing an outstanding young engineer in the field of automatic control. His research interests span the areas of robotics, nonlinear control and hybrid systems, with a special focus on applications to bipedal robotic walking—both formally and through experimental validation. His lab designs, builds and tests novel bipedal robots, humanoids and prostheses with the goal of achieving human-like bipedal robotic locomotion and translating these capabilities to robotic assistive devices. The application of these ideas range from increased autonomy in robots to improving the locomotion capabilities of the mobility impaired.

The Quest for Autonomy on Dynamic Robotic Systems



Abstract: Science fiction has long promised a world of robotic possibilities: from humanoid robots in the home, to wearable robotic devices that restore and augment human capabilities, to swarms of autonomous robotic systems forming the backbone of the cities of the future, to robots enabling exploration of the cosmos. With the goal of ultimately achieving these capabilities on robotic systems, this talk will present a unified control framework for realizing dynamic behaviors in an efficient, provably correct and safety-critical fashion. The application of these ideas will be demonstrated experimentally on a wide variety of robotic systems, including swarms of rolling and flying robots with guaranteed collision-free behavior, bipedal and humanoid robots capable of achieving dynamic walking and running behaviors that display the hallmarks of natural human locomotion, and robotic assistive devices aimed at restoring mobility. The ideas presented will be framed in the broader context of seeking autonomy on robotic systems—a vision centered on combining able robotic bodies with intelligent artificial minds



PANAGIOTIS POLYGERINOS, Arizona State University

Soft Wearable Robots

Abstract: The inherent compliance in soft material robotic systems can enable capabilities and task versatility not found in traditional rigid-bodied robotic systems. The robots of the future will use soft design approaches to provide a more conformal, unobtrusive and compliant means to interface and interfere with the human body, and will be able to monitor, assist, or augment capabilities of individuals. For example, elastomeric and textile actuators powered by pressurized fluids (i.e. pneumatics or hydraulics) can offer several desirable features including robust, lightweight structures, inexpensive development, proven fabrication methods, and simple as well as complex motion paths with simple inputs. Furthermore, these actuators can provide compliance, fast actuation speeds, and most importantly safe human interaction, making them ideal for wearable applications. This talk will focus on soft components as well as soft integrated systems that are tested in realistic settings.

HAMID MARVI, Arizona State University

An Experimentally Verified Nonlinear PDE Model for Ferrofluid

Abstract: Ferrofluids have traditionally been used in rotary and exclusion seals, inertia dampers, audio speakers, stepper motors, gauges, and sensors. While ferrofluids are used passively in these applications, they also have the potential to be precisely controlled. For instance, ferrofluids can be subdivided into smaller droplets, which can collectively perform a diversified series of tasks for medical or manufacturing applications. Their ability to be deformed and reshaped would allow them to recombine after being divided. Ferrofluids can be activated through the usage of electromagnetic fields and gradients. In a step toward developing a rigorous framework for controlling ferrofluids, we will formulate a control-oriented nonlinear Fokker-Planck partial differential equation (PDE) model of the magnetic nanoparticle dynamics in a ferrofluid that is suspended in static fluid environments. We will model the cohesive and dispersive behavior of the ferrofluid due to inter-particle forces using a nonlinear function of the nanoparticle density field in the advection term. We will numerically solve this model to predict the effect of currents through external electromagnetic coils on the motion and shape of the ferrofluid, and we will experimentally validate the model using an electromagnetic coil system with eight stationary electromagnetic coils and a workspace of 2.5×2.5×2.5 cm3. The results of this study will guide us in synthesizing magnetic field control inputs that drive ferrofluid droplets to achieve complex 3D shapes, subdivide, and recombine in real-time. Our experimentally verified model could be utilized to control ferrofluids to perform diverse medical procedures, such as drug encapsulation and delivery, engulfment of cancerous or damaged tissues, and expansion of clogged arteries and blood vessels.

IAN WALKER, Clemson University

Biologically Inspired Continuum Robot Trunks and Tentacles

Abstract: This talk will provide an overview of research in biologically inspired compliant continuous backbone "trunk and tentacle" continuum robots. In particular, robots inspired by octopus arms and plants (vines) will be discussed. Use of these robots for novel inspection and manipulation operations, targeted towards Aging in Place applications and Space-based operations, will be discussed.

DAVID REMY, University of Michigan

Gaits and Natural Dynamics in Robotic Legged Locomotion

Abstract: My research seeks to systematically exploit mechanical dynamics to make future robots faster, more efficient, and more agile then today's kinematically controlled systems. Drawing inspiration from biology and biomechanics, I design and control robots whose motion emerges in great part passively from the interaction of inertia, gravity, and elastic oscillations. Energy is stored and returned periodically in springs and other dynamic elements, and continuous motion is merely initiated and shaped through the active actuator inputs. In this context, I am particularly interested in questions of gait selection. Should a legged robot use different gaits at different desired speeds? If so, what constitutes these gaits and what causes their existence? How do they relate to gaits observed in biology?

We study these questions in conceptual models, in hardware implementations, and through biomechanical experiments. In the long term, this research will allow the development of systems that reach and even exceed the agility of humans and animals. It will enable us to build autonomous robots that can run as fast as a cheetah and as enduring as a husky, while mastering the same terrain as a mountain goat. And it will provide us with novel designs for prosthetics, orthotics, and active exoskeletons that help restoring the locomotion skills of the disabled and can be used as training and rehabilitation devices for the injured.

ROBERT SHEPHERD, Cornell University

Bioinspired Design & Additive Manufacturing of Soft Materials, Machines, Robots, and Haptic Interfaces

Abstract: This talk will present multidisciplinary work from material composites and robotics. We have created new types of actuators, sensors, displays, and additive manufacturing techniques for soft robots and haptic interfaces. For example, we now use stretchable optical waveguides as sensors for measuring strain to high precision, repeatability, and material compatibility with soft actuators. For displaying information, we have created stretchable, elastomeric light emitting displays as well as texture morphing) skins for soft robots. We have created a new type of soft actuator based on molding of foams, new chemical routes for stereolithography printing of silicone and hydrogel elastomer based soft robots, and implemented machine learning in stretchable membranes for interpreting touch. All of these technologies depend on the iterative and complex feedback between material and mechanical design. I will describe this process, what is the present state of the art, and future opportunities for science and engineering in the space of additive manufacturing of elastomeric robots.

ZHENG WANG, The University of Hong Kong

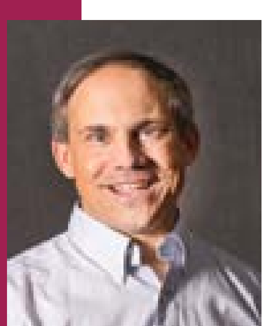
Soft Robotics: Between Rigidity and Compliance

Abstract: Soft robotics is quickly emerging in recent years. With their distinctive features, soft robots show promising potentials in various applications, especially with unknown environments and with humans involved. The current wave of soft-robotic upsurge has remarkably expanded the areas of applications for soft robotic actuators and devices. However, due to the unique characteristics and mechanisms of such machines, their design, fabrication, characterization, and validation methods are all somewhat distinctive from conventional accumulation of methodologies. This talk will tackle some of the challenges we have encountered in the past years with understanding soft robotic design and actuation, with some real-world examples of systems and devices. Moreover, we will explore some of the biomimetic factors that would bring soft robots closer to the real world, and suit for some of the application areas otherwise very challenging for rigid-bodied robots.

HYUNGLAE LEE, Arizona State University

A New Robotic Approach to Characterize Ankle Mechanics During Postural Balance and Locomotion

Abstract: Understanding how human ankle mechanics are modulated during physical interaction is essential to develop reliable and robust lower extremity robots that mimic behavior of the human ankle. In this presentation, I introduce a new robotic approach to characterize neuromuscular properties of the ankle during postural balance and locomotion. A multi-axis robotic platform was developed for the quantification of ankle mechanics in a 2-dimensional space consisting of the sagittal and frontal planes. The robotic platform is capable of simulating various haptic environments as well as providing precisely controlled perturbations to the ankle in 2 degrees-of-freedom. These unique capabilities allow for the quantification of both intrinsic and reflexive ankle mechanics when human subjects interact with a wide range of mechanical environments. Preliminary studies characterizing multi-dimensional ankle mechanics during postural balance in healthy and neurologically impaired patients will be presented.

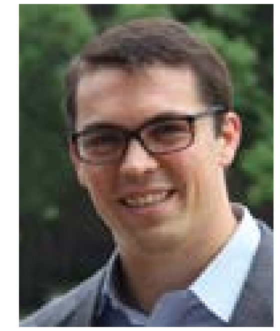


THOMAS SUGAR, Arizona State University

Wearable Robotics: A User Perspective

Abstract: A description of wearable exoskeletons used in industry and healthcare will be provided. System deisgns are moving towards lightweight, soft, wearable systems that assist the user in mobility and reduce fatigue.

speakers



JOSHUA C. KLINE, Delsys

Motor Unit Drive (MU Drive) for Upper Limb Prosthetic Control

Abstract: Modern prosthetic limbs have made strident gains in recent years, incorporating terminal electromechanical devices that are capable of mimicking the human hand with multi-articulated grasps and coordinated movement. But people with limb loss have been prevented from accessing these advanced control capabilities because the fundamental technology used to interface the prosthesis with the nervous system has not changed for nearly 5 decades. Consequently, among the 41,000 people in the US with traumatic or congenital limb loss, nearly 23-35% abandon regular use of their myoelectric prosthesis. To meet the immediate healthcare need of people with limb loss, we are developing advanced neural interface technology that is both non-invasive and measures neural firings without implantation. Our technology utilizes automated algorithms for measuring motor unit (MU) activity in real-time from surface electromyographic (sEMG) signals recorded from residual muscles of the amputated or congenitally missing limb, and transforms the extracted firings into control signals that can be used to drive an upper-limb prosthesis. We analyzed the control properties of the motor unit drive (MU Drive) control signal compared with typical amplitude-based (RMS) myoelectric control signals measured in both control subjects and subjects with congenital or traumatic trans-radial limb loss. Our comparative analysis established a vital proof-of-concept: MU Drive improved the dynamic range, proportional smoothness and precision of natural control. The impact of this innovation provides first-time, non-invasive access to natural physiological mechanisms of control for upper-limb prostheses and holds promise for improving the sense of embodiment, increasing function and reducing prosthesis rejection for people with limb loss while maintaining lower costs and reduced risks than implantable alternatives.

SUNIL AGRAWAL, Columbia University

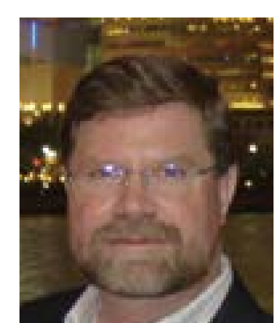
Robotics to Restore and Retrain Human Movements

Abstract: Neural disorders limit the ability of humans to perform activities of daily living. Robotics can be used to probe the human neuromuscular system and create new pathways to relearn, restore, and improve functional movements. Dr. Agrawal's group at Columbia University Robotics and Rehabilitation (ROAR) Laboratory has designed innovative robots for this purpose and tested these on human subjects. Human experiments have targeted patients with stroke, cerebral palsy, Parkinson's disease, ALS, Vestibular disorders, elderly subjects and others. The talk will provide an overview of some of these scientific studies.

DEREK KAMPER, University North Carolina | North Carolina State University

A Multimodal Approach to Hand Rehabilitation after Stroke

Abstract: While repetitive practice is vital component of therapy, this movement practice alone is typically insufficient to achieve full recovery following stroke, even when facilitated by robotic devices. The need for multiple interventions to target different impairment mechanisms has become increasingly apparent. In this presentation, I will describe ongoing efforts to combine administration of pharmacological agents with participation in a therapy regimen to improve hand motor control in stroke survivors with chronic hemiparesis. To date, we have enrolled 50 stroke survivors with severe hand impairment in the 13-week study. Participants receive either cyproheptadine, an anti-serotonergic agent, or placebo. Dosage is titrated over the first three weeks to a chronic level which is maintained for the following 6 weeks. During these 6 weeks participants either receive cyclical stretching of the finger muscles while they remain passive or they participate in active therapy focusing on muscle activation patterns. The passive and active therapy both utilize the Voice and EMG-Driven Actuated (VAEDA) Glove. This portable, cable-driven orthosis provides assistance to finger extension and resists undesired finger flexion. Rationale for study design and preliminary results will be discussed.



ROBERT AMBROSE, University North Carolina | North Carolina State University

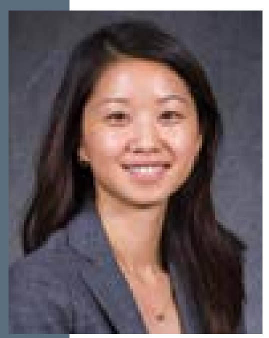
The Pre Deployment Strategy for Human Space Exploration

Abstract: NASA today has three waves of exploration underway: 1) telescopes seeing far into the universe, 2) robots exploring our local solar system, and 3) human exploring the cis lunar space near the moon and Earth. All three continue to expand deeper into space, making great discoveries as technology advances. This talk will focus on the human exploration campaign, and in particular the use of robotics and autonomy to enable the pre deployment of equipment and operational spacecraft ahead of crew arrival. This new approach, which will be described as pre deployment, uses new technology to manage logistics ahead of human arrival, and potentially provide caretaking between human crews reusing the equipment for multiple missions. This approach will require spacecraft to be launched, mated, assembled, managed and upgraded for months (and years) with no humans onboard, then seamlessly transition from dormancy to support crew when they arrive. NASA robots in development will be shown undergoing ground testing and onboard the International Space Station as a proving ground for this new adventure.

PANAGIOTIS ARTEMIADIS, Arizona State University

Advanced Human-Robot Control and Interaction Interfaces

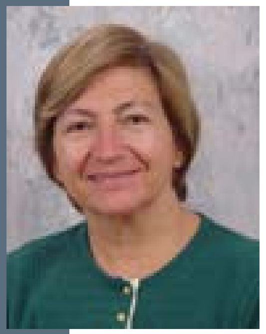
Abstract: This talk will focus on interfaces between humans and robotic platforms. The first part of the talk will present current work at the Human-Oriented Robotics and Control (HORC) Lab in ASU on myoelectric control interfaces used for controlling robotic devices. A novel method for robust myoelectric control of robots will be presented. This work supports a shift in myoelectric control schemes towards proportional simultaneous controls learned through development of unique muscle synergies. The ability to enhance, retain, and generalize control, without needing to recalibrate or retrain the system, supports control schemes promoting synergy development, not necessarily user-specific decoders trained on a subset of existing synergies, for efficient myoelectric interfaces designed for long-term use. The second part of the talk will focus on a novel control interface between humans and multi-agent systems. The human user will be in control of a swarm of Unmanned aerial vehicles (UAVs) and will be able to provide high-level commands to these agents. The proposed brain-machine interface between the swarm and the user will allow for research on swarm high-level information perception, leading to augmentation of decision capabilities for the state-of-the-art systems.



ERIN CHIOU, Arizona State University

Social Exchange and Accountability in Human-Agent System Resilience

Abstract: Much of our understanding of human-automation interaction comes from research on supervisory control automation, where human operators are relegated to a monitoring role and are responsible for intervening in the event of automation failure. However, recent advances in "autonomy" have shifted the human-automation relationship from supervisory roles to more peer-like roles in complex work domains as diverse as healthcare, defense, and transportation. In anticipation of these new roles with automation, and the Future of Work, this talk describes a new framework for human-automation interaction research and design that considers bilateral social factors in tightly coupled human-automation cognitive work.



KATIA SYCARA, Carnegie Mellon University

Effective Human Interaction with Multi-Robot Systems

Abstract: Robots are increasingly entering human society in multiple roles, e.g. service robots at home and work, self-driving cars in the highways and city streets, emergency responder robots in natural disasters, intelligent monitors for environmental exploration, mobile sensors for civilian and military applications. Enabling human operators to effectively interact with multiple robots, as many of this applications demand, is a challenge that has not been addressed. One difficulty is that many different types of human interactions may be necessary to cooperate and control multi-robot systems. Additionally, the coordination scheme that is used by the multiple robots has different consequences on the operator(s) difficulty of interaction. We have developed a characterization of human-robot tasks, and appropriate human robot interaction modes, based on the task's cognitive complexity of control. This scheme helps explicate the forms of interaction likely to be needed and the demands they pose on human operators. This talk will present lines of research following from this characterization as well as the role transparency and trust in such interactions.

LUIS SENTIS, University of Texas, Austin

Sustainable Human-Centered Robots

Abstract: As new embedded systems and machine design methods are devised, the number of actuators and sensors on robots steadily increases. These new generation of robots are required to blend around with humans, fulfill missions quickly, and guarantee safety. One question that arises is what will be the gold standard of human-centered robots in terms of sustainability and performance. For this reason I will discuss recent advancements on new embodiments of robots such as the use of liquid cooled viscoelastic actuators to enhance proprioception, power density and position controllability in humanoid robots. I will then proceed to discuss key issues in distributed control embedded architectures for human-centered systems, interventional safety, and whole-body legged locomotion and manipulation.

GÜNTER NIEMEYER, Disney Research

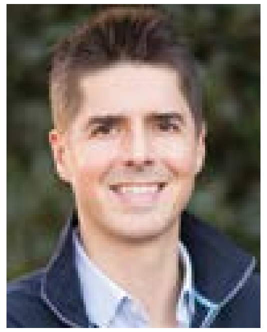
Human Operators and Partners: A Touchy Topic for Robots

Abstract: When push comes to shove, both figuratively and literally, we need to endow robots with a sense of touch as well as the ability to physically interact with us. This applies both to telerobotics, with a human operator, and direct interactions, with a human partner. But simultaneously controlling interaction forces and motion leads to the classic stability problems and performance trade-offs. Impedance control and passivity are standard and robust tools, using minimal assumptions, but can lead to conservative solutions. And often feel robotic. So we ask ourselves: what assumptions should we be make, what models are appropriate, and how do we create behaviors that make robots act and feel more natural? Can we get robots ready for up-close human interactions?

JUN UEDA, Georgia Institute of Technology

Human-Robot Physical Interaction for Neuromuscular Adaptive Robot Co-workers

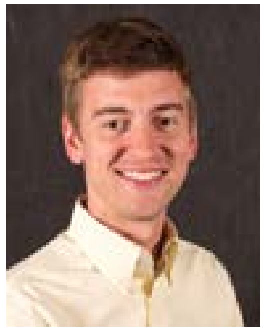
Abstract: This talk will introduce the speaker's recent research effort that aims to apply a systems engineering approach to the design and control of co-robots for industry and medical applications. The research approach is threefold: (1) design of high-precision mechanisms, (2) understanding of the mechanisms of neuromotor adaptations in humans, and (3) adaptive control of physical human-robot interaction (pHRI). A project supported by the National Science Foundation aims to understand association between physiological measures such as electromyography and system performance characteristics in robot-assisted assembly tasks. A machine learning method is applied to achieve effective prediction of operator intent during tasks to proactively adjust the contact impedance between the operator and robotic device for high performance and stability. Another project studies temporal dynamics of cortical facilitation with afferent stimulation for the assessment of stroke rehabilitation. A robotic device that combines magnetic brain stimulation and peripheral mechanical stimulation has been developed to reproduce paired associative simulation (PAS). The research reveals that precise timing control of actuation is the key for successful robotic neuromodulation. Mechanical stimulation and induced adaptation can also improve sensory and motor performance in dexterous manual hand tasks.



JESSE CLAYTON, NVIDIA

AI at the Edge for Industrial IoT

Abstract: Artificial intelligence is impacting almost every part of the industrial and agricultural supply chain. From robots that quickly adapt to build new products, to automated vehicles that address last-mile challenges for product delivery, to UAVs that can automatically detect failing infrastructure, the world is transitioning from processes that are largely manual to ones that are largely automated. We'll discuss how AI and deep learning are enabling these advances. We'll also analyze a sampling of early successes across different applications. And finally we'll describe some of the remaining challenges to wide-scale deployment, and the work NVIDIA is doing to address those challenges via its Isaac initiative.



DANIEL AUKES, Arizona State University

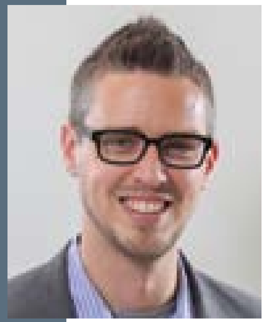
Low-cost Robots in the Field and in the Classroom

Abstract: In this talk we present new ways of making complex active devices and robots using non-traditional fabrication techniques, with materials as accessible as cardboard and plastic. We discuss design tools, simulation techniques, and workflows which leverage rapid prototyping and experimental evaluation to quickly identify good design candidates. Using new tools and algorithms, manufacturability analysis and optimization can be automated to suit the fabrication constraints and limitations of a variety of scenarios. We also report on recent work on the development of robotic systems which leverage these techniques, from robotic hands and swimming fish to UAV's and terrestrial robots. And finally, using robots drawn from recent classes as examples, we discuss how merging design, simulation, and manufacturing theory can improve the classroom experience for those about to embark into the field of robotics.

HENI BEN AMOR, Arizona State University

Machine Learning for Interactive Robots in Advanced Manufacturing

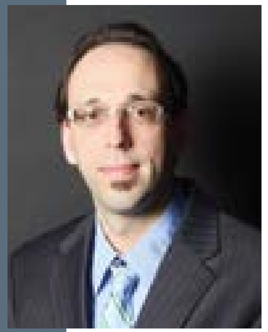
Abstract: In this talk, I will present our recent progress in developing learning methods that allow industrial robots to acquire and refine a rich set of motor skills. The developed systems are highly efficient, scale to robots with many degrees of freedom, and can be used to learn dexterous and collaborative manipulation. I will discuss novel imitation learning and reinforcement learning methods that allow robots to learn from both human demonstrations, as well as trial-and-error exploration. To this end, I will introduce the concept of "Interaction Primitives" and will show how they can be used to extract data-driven models of collaborative behavior. In addition to machine learning methods, augmented reality will also be discussed in the context of human-robot collaboration. Applications of these techniques to various assembly and manufacturing tasks will be presented.



AARON DOLLAR, Yale University

Design for Open Source Robot Hardware: The Yale OpenHand Project

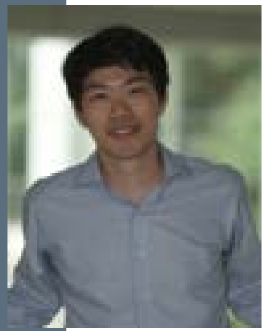
Abstract: The open-source movement has already revolutionized a number of industries by empowering end-users to contribute to the products that they need and want, and fueling grass-roots development of projects in completely new areas, as well as their continual improvement. While there have been innumerable successes in software and electronics hardware, open mechanical hardware is taking longer to catch on. There are a number of likely reasons for this, including the complexity, expense, and time associated with fabricating mechanical components, as well as the challenge and reliability of assembling the wide range of mechanical and electronic components required to produce a fully-functional system. In comparison with open-source software efforts, open hardware has numerous additional practical challenges associated with dissemination and evolution of the product driven by end-users. However, rapid fabrication technologies have improved to the point of being able to produce parts that are strong, robust, and precise enough for practical robotic systems, and the pricing of the systems and supplies have lowered to the point that many of these machines are available in fabrication facilities at most universities. In this talk, I will discuss some of the practical challenges associated with designing and fabricating useful hardware by non-experts utilizing rapid fabrication processes such as FDM focus particularly on our efforts related to the Yale OpenHand Project, which has been utilized by hundreds of researchers and students to fabricate their own robotic hands.



GEORGIOS FAINEKOS, Arizona State University

On-line and off-line Temporal Logic Planning under Incomplete or Conflicting Information

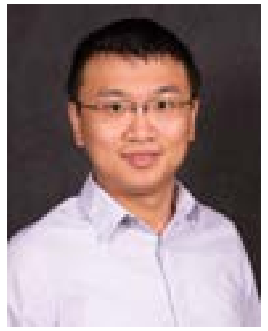
Abstract: Temporal logic planning methods have provided a viable path towards solving the single- and multi-robot path planning, control and coordination problems from high level formal requirements. In the existing frameworks, the prevalent assumption is that there is a single stakeholder with full or partial knowledge of the environment that the robots operate in. In addition, the requirements themselves are fixed and do not change over time. However, both of these assumptions may not be valid in both off-line and on-line temporal logic planning problems. That is, multiple stakeholders and inaccurate sources of information may produce a self-contradictory model of the world or the system. Classical planning temporal logic methods cannot handle non-consistent model environments even though such inconsistencies may not affect the planning problem for a given formal requirement. In this work, we show how such problems can be circumvented by utilizing multi-valued temporal logics and system models.



YEZHOU YANG, Arizona State University

Active Perception Beyond Appearance: Drawing on the Strengths of the Symbolic Approach, Connectionism, and Dynamicism

Abstract: The goal of Computer Vision, as coined by Marr, is to develop algorithms to answer What are Where at When from visual appearance. The speaker, among others, recognizes the importance of studying underlying entities and relations beyond visual appearance, following an Active Perception paradigm. The talk will present the speaker's efforts over the last several years, ranging from 1) hidden entities recognition (such as action fluent, human intention and force prediction from visual input), through 2) reasoning beyond appearance for solving image riddles and visual question answering, till 3) their applications in a Robotic visual learning framework as well as for Human-Robot Collaboration. The talk will also feature several ongoing projects and future directions among the Active Perception Group (APG) with the speaker at ASU School of Computing, Informatics, and Decision Systems Engineering (CIDSE). circumvented by utilizing multi-valued temporal logics and system models.



WENLONG ZHANG, Arizona State University

Estimation, Planning, and Control of Autonomous Unmanned Aerial Vehicles

Abstract: The ASU Robotics and Intelligent SystEms Lab (RISE Lab) is working on various control and optimization problems for autonomous robots. This presentation focuses on one project about precision motion control of autonomous unmanned aerial vehicles (UAVs). The ASU RISE Lab works on both rigid-frame quadcopters as well as origami-based foldable quadcopters, and this talk will discuss the design, estimation, planning, and control of those autonomous UAVs. It is expected that those UAVs will have wide applications in search and rescue, law enforcement, environmental monitoring, and national defense.

SOON -JO CHUNG, California Institute of Technology

Robotics Technology Building Blocks for Realizing an Autonomous Flying Ambulance

Abstract: Recent advances in autonomous car and drone technologies and electric fans are turning a century-old dream of vertical-take-off-landing (VTOL) personal transportation vehicles into reality, with many existing projects. One such example is Caltech's Autonomous Flying Ambulance (AFA) project that can overcome the bottlenecks of the current ground-based transportation systems. Caltech's Center for Autonomous Systems and Technologies (CAST) has established a research program to lay the groundwork of realizing fully-autonomous flying ambulances. We have already built a 1/5 scale model with innovative design ideas and successfully tested autonomous flight in our one-of-kind drone arena with an open-air distributed-fan array. The same technology can be used to realize autonomous flying cars or package-delivery drones that are aimed at short-distance travel from one location to another. A short overview of AFA and some relevant prior work will be discussed.

HADAS KRESS-GAZIT, Cornell University

Synthesis for composable robots: guarantees and feedback for complex behaviors

Abstract: Getting a robot to perform a complex task, for example completing the DARPA Robotics Challenge, typically requires a team of engineers who program the robot in a time consuming and error prone process and who validate the resulting robot behavior through testing in different environments. The vision of synthesis for robotics is to bypass the manual programming and testing cycle by enabling users to provide specifications – what the robot should do – and automatically generating, from the specification, robot control that provides guarantees for the robot's behavior. This talk will describe the work done in the verifiable robotics research group towards realizing the synthesis vision and will focus on synthesis for composable robots - modular robots and swarms. Such robotic systems require new abstractions and synthesis techniques that address the overall system behavior in addition to the individual control of each component, i.e. module or swarm member.

DOUGLAS SUMMERS-STAY, Army Research Lab

Deductive and Analogical Reasoning on a Semantically Embedded Knowledge Graph

Abstract: Representing knowledge as high-dimensional vectors in a continuous semantic vector space can help overcome the brittleness and incompleteness of traditional knowledge bases. We present a method for performing deductive reasoning directly in such a vector space, combining analogy, association, and deduction in a straightforward way at each step in a chain of reasoning, drawing on knowledge from diverse sources and ontologies.

human-robot control interfaces

The human-machine control interfaces research programs in ASU address challenges related to devices and algorithms for effective and robust control interfaces between humans and robots. Our faculty pursue topics such as accurate and robust decoding of electromyographic and electroencephalographic signals to control prosthetic and orthotic devices. We also work on central and peripheral neural interfaces for closed-loop control of prosthetics for upper and lower limb amputees.

Panagiotis Artemiadis
Marco Santello
Tom Sugar

rehabiliation robotics

The robotics rehabilitation research programs in ASU address the development and control of novel devices for rehabilitation and assistance while advancing our knowledge of brain function and human sensorimotor control. Our faculty pursue topics such as the utilization of novel models of human gait utilized in robotic devices for providing gait rehabilitation at impaired walkers, primarily stroke survivors.

Panagiotis Artemiadis
Hyunglae Lee
Tom Sugar
Thurmon Lockhart
Claire Honeycutt

wearable and assistive robotics

The wearable and assistive robotics research programs in ASU address challenges related to robotic systems that efficiently interact with the human body for augmentation of capabilities via intelligent and adaptive orthoses.

Panagiotis Polygerinos
Tom Sugar
Panagiotis Artemiadis
Wenlong Zhang

bio-inspired robotics

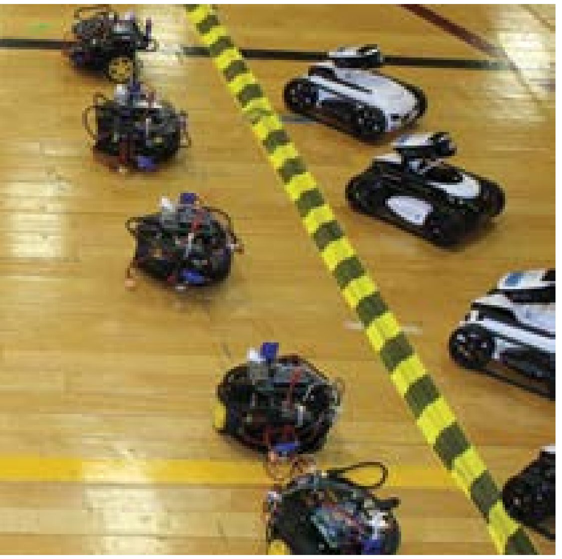
The bio-inspired robotics research programs in ASU address the development of new technologies inspired by nature and embed these in robotics and autonomous systems. Our faculty study fundamental physics behind interactions of biological systems with their surrounding solid, granular, and fluidic environments. Utilizing biological insights derived from these studies, we develop bio-inspired robotic systems and smart interfacial structures for search and rescue, exploratory, and medical applications.

Hamid Marvi
Dan Aukes

neural engineering and neuro-rehabiliation

The neural engineering and neuro-rehabilitation research programs in ASU address the treatment of neural and cognitive deficits while pushing the boundaries of our knowledge of brain function. Our faculty pursues topics such as advancing treatments for stroke, improving adaptation to prosthetic devices, and exploring methods to prevent falls. We also work to expand our knowledge of healthy systems by investigating how neural circuits process sensory information, represent the state of the body in the world, and control complex actions like walking and using the hands to manipulate the environment.

Marco Santello
Jimmy Abbas
Chris Buneo
Bradley Greger
Claire Honeycutt
Steve Helms Tillery



swarm robotic systems

The swarm robotic systems research programs in ASU address the development of control and estimation strategies for robotic swarms that accommodate realistic constraints that will arise in practice. These strategies will enable swarms to perform tasks with a quantifiable degree of predictability in unknown environments with limited sensing, computation, localization, and communication. Our faculty also study the interaction between humans and swarms of robots for applications that range from military to search and rescue, surveillance and coverage.

Panagiotis Artemiadis
Spring Berman
Stephanie Gil
Ted Pavlic
Wenlong Zhang

cooperative robotic systems

The cooperative robotic systems research programs in ASU address cognitive challenges in human-robot collaboration by designing novel modeling and decision making methods that are transformative for human-robot interaction. Research is also done in distributed robotic systems that operate in complex and hazardous environments while advancing system autonomy via robust cooperative behaviors. Our faculty work on fundamental theories, practices and system integrations in human-aware and cognitive robotics, human-robot interaction and distributed robot systems with the goal to enable future robotic systems that augment human capabilities and enrich their lives.

Yu ("Tony") Zhang
Heni Ben Amor
Erin Chiou
Yezhou Yang

artificial intelligence

The artificial intelligence research programs in ASU focus on principles and applications of sequential decision making for interactive autonomous systems ranging from household robots to intelligent digital assistants. Our core research focuses on computationally efficient methods that would allow AI assistants to accomplish complex user-assigned tasks by reasoning and acting over extended time horizons. Research projects include indoor mobile manipulation, integrated planning and perception under uncertainty, and the development of general-purpose SDM solvers that use hierarchical abstractions for efficient learning and synthesis of autonomous behavior for robot assistants.

Siddharth Srivastava
Heni Ben Amor
Georgios Fainekos

human-systems integration

The human systems integration research programs in the Polytechnic School investigate and develop technologies and best practices for the composition, training, management, and evaluation of human-machine partnerships, including heterogeneous teams of humans, AI, and robots. Our faculty pursue topics such as social affordances of human-machine collaboration in physical and cognitive work environments, team dynamics in support of national security, and determinants of learning outcomes in human-machine interactions. The goal is to cultivate effective and ethical partnerships between humans, AI, and robots working together in support of quality, safety, sustainability, and resilience.

Erin Chiou
Nancy Cooke
Scotty Craig
Rod Roscoe

ATI Industrial Automation is the leading engineering-based world developer of robotic accessories and robot arm tooling, including Automatic Tool Changers, Multi-Axis Force/Torque Sensing Systems, Utility Couplers, Robotic Deburring Tools, Robotic Collision Sensors, Manual Tool Changers, and Compliance Devices. Our robot end-effector products are found in thousands of successful applications around the world. Since 1989, our team of mechanical, electrical, and software engineers has been developing cost-effective, state-of-the-art end-effector products and solutions that improve robotic productivity.

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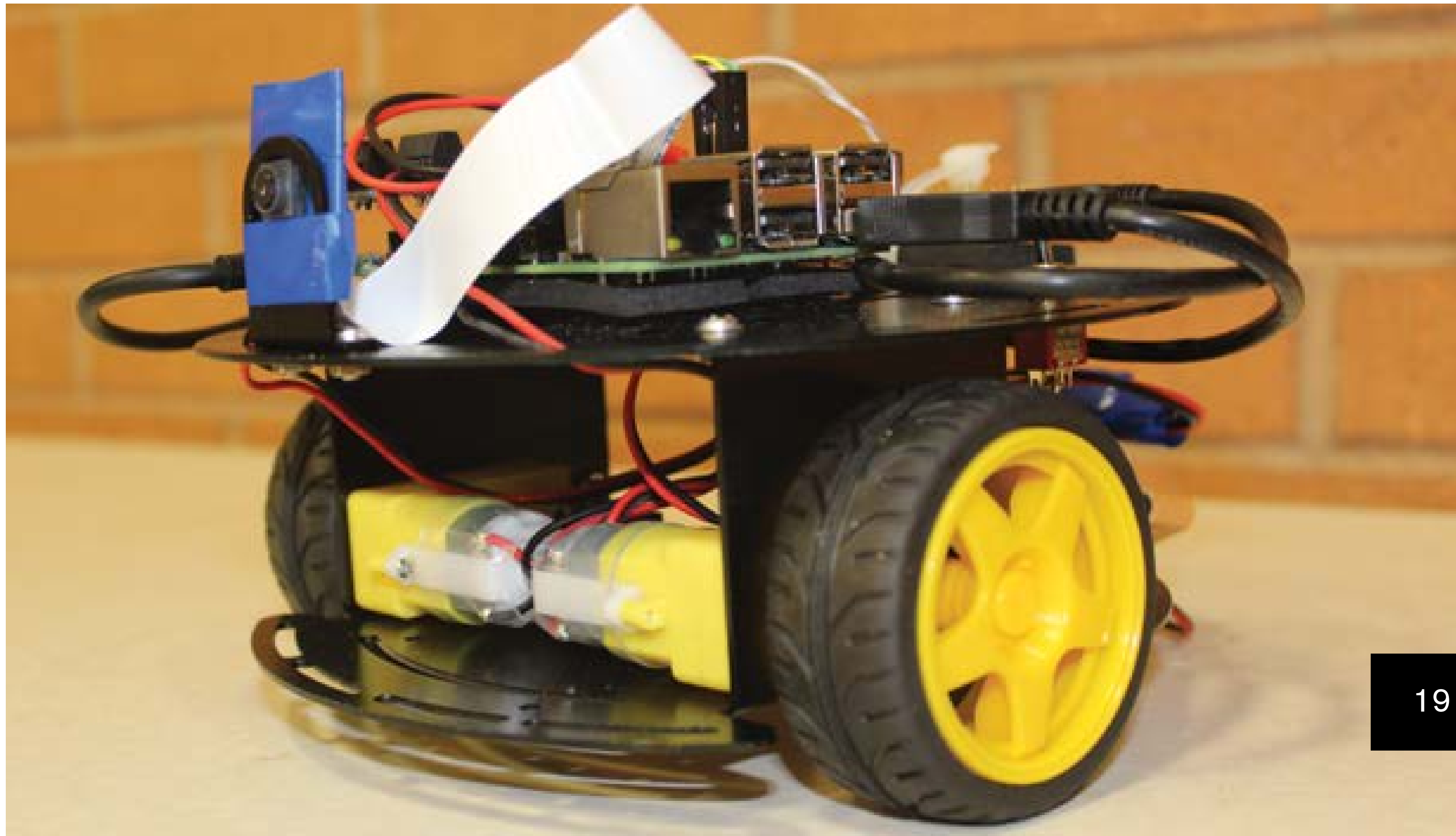
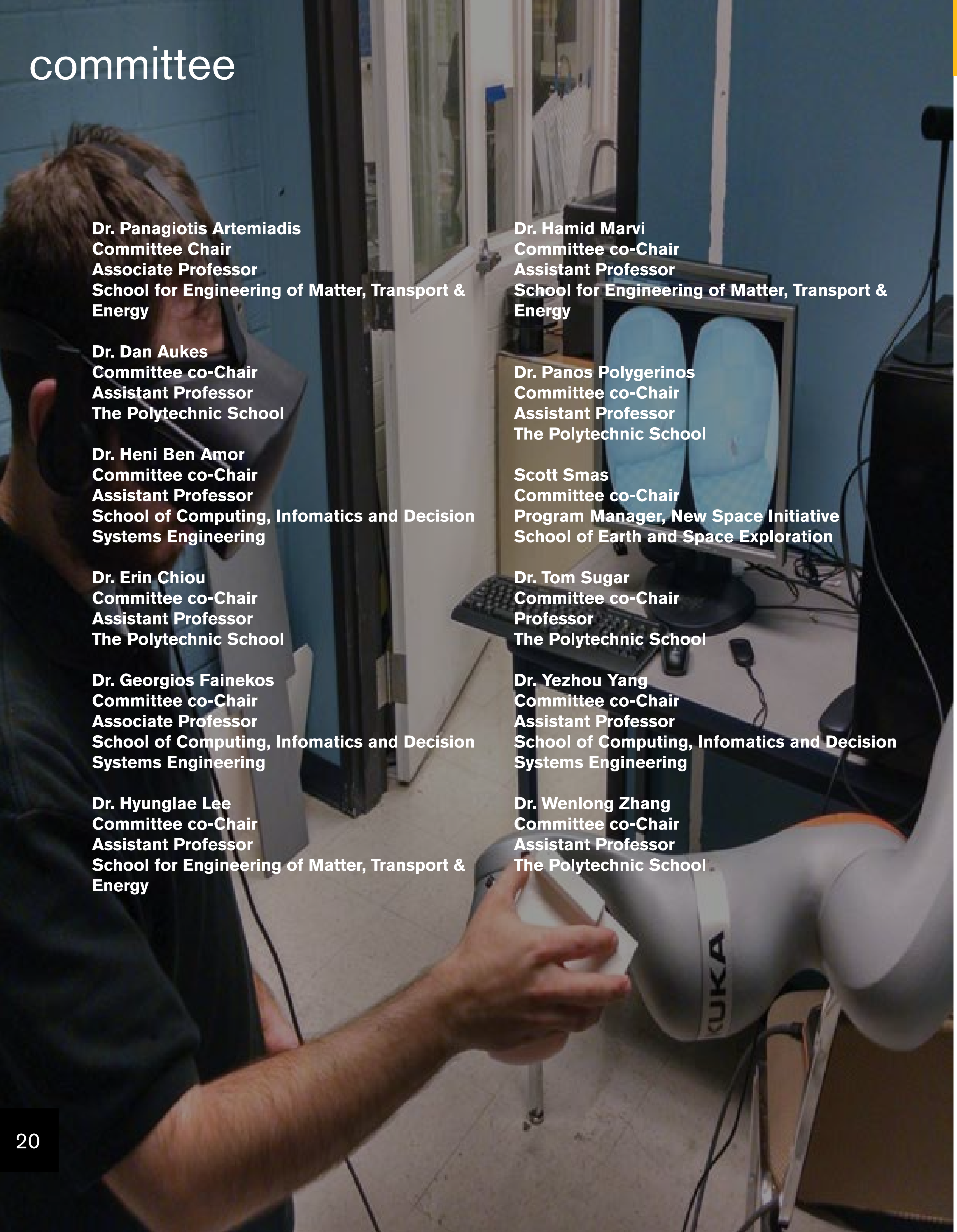


committee



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School of Computing, Infomatics and Decision Systems Engineering

Dr. Wenlong Zhang
Committee co-Chair
Assistant Professor
The Polytechnic School

posters

1. **Automated Synthesis Scalable Algorithms for Inferring Non-local Properties to Assist in Multi-robot Teaming**
   T. Choi, T. Pavlic, A. Richa
   Arizona State University
2. **Adaptive Multi-Degree of Freedom BCI using Online Learning: Towards Novel Methods and Metrics of Mutual Adaptation between Humans and Machines for BCI**
   C. Nguyen, G. Karavas, P. Artemiadis
   Arizona State University
3. **Next-Generation Autonomous Ground Vehicles with Distributed and Redundant Actuators**
   Y. Chen
   Arizona State University
4. **Deep Predictive Models for Collision Risk Assessment in Autonomous Driving**
   M. Strickland, C. Tamayo, G. Fainekos, H. Ben Amor
   Arizona State University
5. **Towards Semantic Policies for Human-Robot Collaboration**
   S. Stepputtis, C. Baral, H. Ben Amor
   Arizona State University
6. **Design, Fabrication and Control of an Assistive Robotic Shoe**
   Z. Qiao, M. Rezayat, W. Zhang
   Arizona State University
7. **Bio-Inspired Helical Actuators for Torsion Control in Robotic Tentacles**
   G. Olson, Y. Menguc,
   Oregon State University
8. **Human-Agent Interactions: Does Accountability Matter in Collaborative Control?**
   P. Salehi, E. Chiou, A. Wilkins
   Arizona State University
9. **Decentralized Controllers for Multi-Robot Cooperative Manipulation in Unknown Environments with Obstacles**
   H. Farivarnejad, S. Berman
   Arizona State University
10. **Intelligent Attention Management using Integrated Planning and Perception**
    V. Lakshminarayanan, D. Purwar, S. Srivastava, Y. Yang
    Arizona State University
11. **Variable Hydraulic Transmission for Rehabilitation Robots**
    S. Hashemi, W. Durfee
    University of Minnesota
12. **CHARTOPOLIS: A Testbed for Driver Interaction with Driverless Cars**
    S. Berman, N. Cooke, M. Demir, R. Gameros, S. Martin, T. Reagan, R. Subramanyam
    Arizona State University
13. **Mean-Field Stabilization of Markov Chain Models for Robotic Swarms: Computational Approaches and Experimental Results**
    V. Deshmukh, K. Elamvazhuthi, S. Biswal, Z. Kakish, S. Berman
    Arizona State University
14. **LMI Methods for Controlling a Beam Model of an Octopus Arm**
    A. Doroudchi, M. Ebrahimi, S. Berman, M. Peet
    Arizona State University
15. **Effects of Shared Mental Models and Restricted Language on Human-Robot Teaming**
    M. Demir, N. Cooke, E. Gran, A. Bradbury, J. Martinez, M. Niichel, K. Rahm
    Arizona State University
16. **Linkage Mechanism Based Perching for Foldable Quadcopters**
    D. Yang, S. Mishra, W. Zhang
    Arizona State University
17. **Octopus Sucker Adhesion and Suction Performance from Attached to Amputated Arm**
    H. Bagheri, A. Gendt, S. Cummings, S. Subramanian, S. Berman, M. Peet, D. Aukes, X. He, R. Fisher, H. Marvi
    Arizona State University
18. **Basilisk Lizards Transition Strategies from Land to Water**
    H. Bagheri, V. Jayanetti, H. Burch, H. Marvi
    Arizona State University
19. **Collision-free Trajectory Planning in Human-robot Interaction through Hand Movement Prediction from Vision**
    Y. Wang, Y. Xin, Y. Yang, W. Zhang
    Arizona State University
20. **Experimental Identification & Control of a Fish-inspired Laminated Robot Movement in Water**
    M. Sharifzadeh, R. Khodambashi, D. Aukes
    Arizona State University
21. **Robust Image Classification through Generation**
    Y. Ren, H. Yao
    Arizona State University
22. **Human-Autonomy Teaming in Remotely Piloted Aircraft Systems Operations Under Degraded Conditions**
    M. Demir, N. Cooke, N. Celmer, G. Lametta, E. Hamister, G. Yanikian, M. She, A. Chinzi
    Arizona State University
23. **Physical Human-Machine Coordination (pHMC)**
    Y. Wang, K. Rahm, C. Hsiung, C. Highwood
    Arizona State University
24. **AH-CNN: Adaptive and Hierarchical Convolutional Neural Networks**
    Y. Yang, M. Farhadi
    Arizona State University

25. **Soft-Inflatable Exosuit for Knee Rehabilitation**
S. Sridar, Z. Qiao
Arizona State University

26. **Explicit Reasoning over End-to-End Neural Architectures for Visual Question Answering**
S. Aditya, Y. Yang, C. Baral
Arizona State University

27. **An Integrated Design and Simulation Environment for Rapid Prototyping of Laminate Robotic Mechanisms**
M. Sharifzadeh, R. Khodambashi, D. Aukes
Arizona State University

28. **Assessing Screw-Generated Force in Glass Beads Utilizing Experiments, DEM, and Analytical Methods**
A. Thoesen, S. Ramirez, H. Marvi
Arizona State University

29. **Environment-Dependent Modulation of Human Ankle Stiffness and its Implication for the Design of Lower Extremity Robots**
H. Lee
Arizona State University

30. **Optimizing Stiffness of a Novel Parallel-Actuated Robotic Shoulder Exoskeleton for a Desired Task or Workspace**
J. Hunt, P. Artemiadis, H. Lee
Arizona State University

31. **Design and Development of an sEMG-based Silent Speech Recognition System**
S. Roy, G. Meltzner, J. Heaton, Y. Deng, G. De Luca, J. Kline
Delsys Inc. and Altec Inc.

32. **Incognizant Collective Decision Making in Ant Colonies**
J. Hanson, S. Walker, T. Pavlic, G. Valentini, S. Pratt
Arizona State University

33. **Muscle Powered Walking Exoskeleton for People with Spinal Cord Injury**
V. Katti, W. Durfee
University of Minnesota

34. **Towards the Design of Soft Poly Limb for Assisted Living Tasks**
P. Nguyen, P. Polygerinos
Arizona State University

35. **3D Assessment of Upper Limb Proprioception**
J. Klein, B. Whitsell, P. Artemiadis, C. Bueno
Arizona State University

36. **An Experimentally Verified Nonlinear PDE Model for Ferrofluids**
M. Ilami, K. Elamvazhuthi, R. Ahmed, M. Kintscher, S. Berman, H. Marvi
Arizona State University

37. **Laminate Robotic Hand with Embedded Force Sensor**
D. Aukes, D. Carlson
Arizona State University

38. **Case Study: A Bio-inspired Control Algorithm for a Robotic Foot-Ankle Prosthesis Provides Robust Control of Level Walking and Stair Ascent**
U. Tahir, A. Hessel, D. Rivera, J. Tester, Z. Han, K. Nishiakwa
Northern Arizona University

39. **Modeling Human-Robot Interaction as a SLAM Problem**
J. Campbell, H. Ben Amor
Arizona State University

40. **Gesture Communication in a Disaster: Toward Seamless Human-Drone Interaction in Emergency Search and Rescue**
C. Hsiung, G. Yanikian, E. Chiou
Arizona State University

41. **Stability of the Human Ankle with Respect to Environmental Mechanics**
H. Hanzlick, H. Lee
Arizona State University

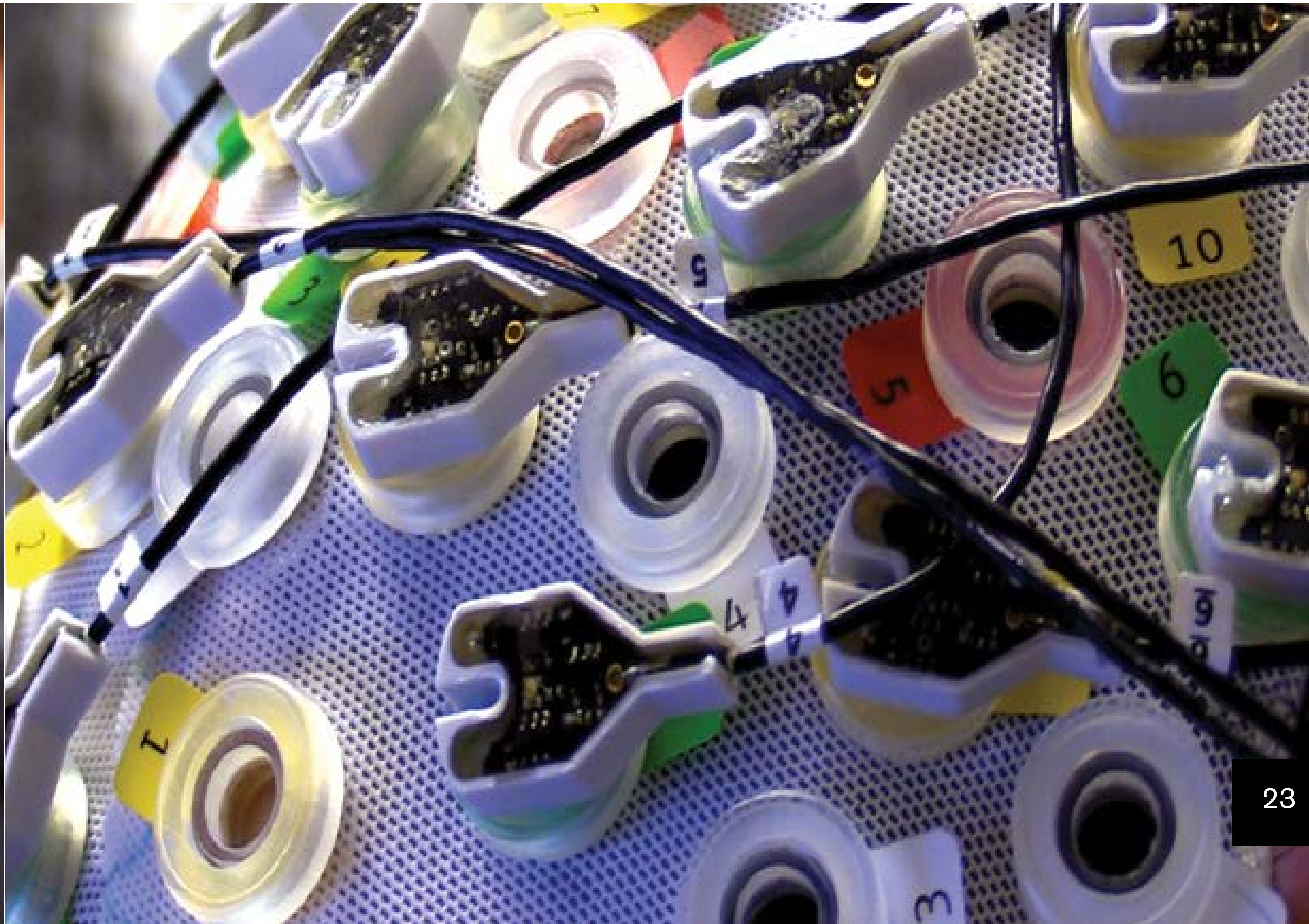
42. **Autonomous Driving Bicycle**
S. Moore, M. Mabey, J. Bush, W. Deng, W. Zhang
Arizona State University

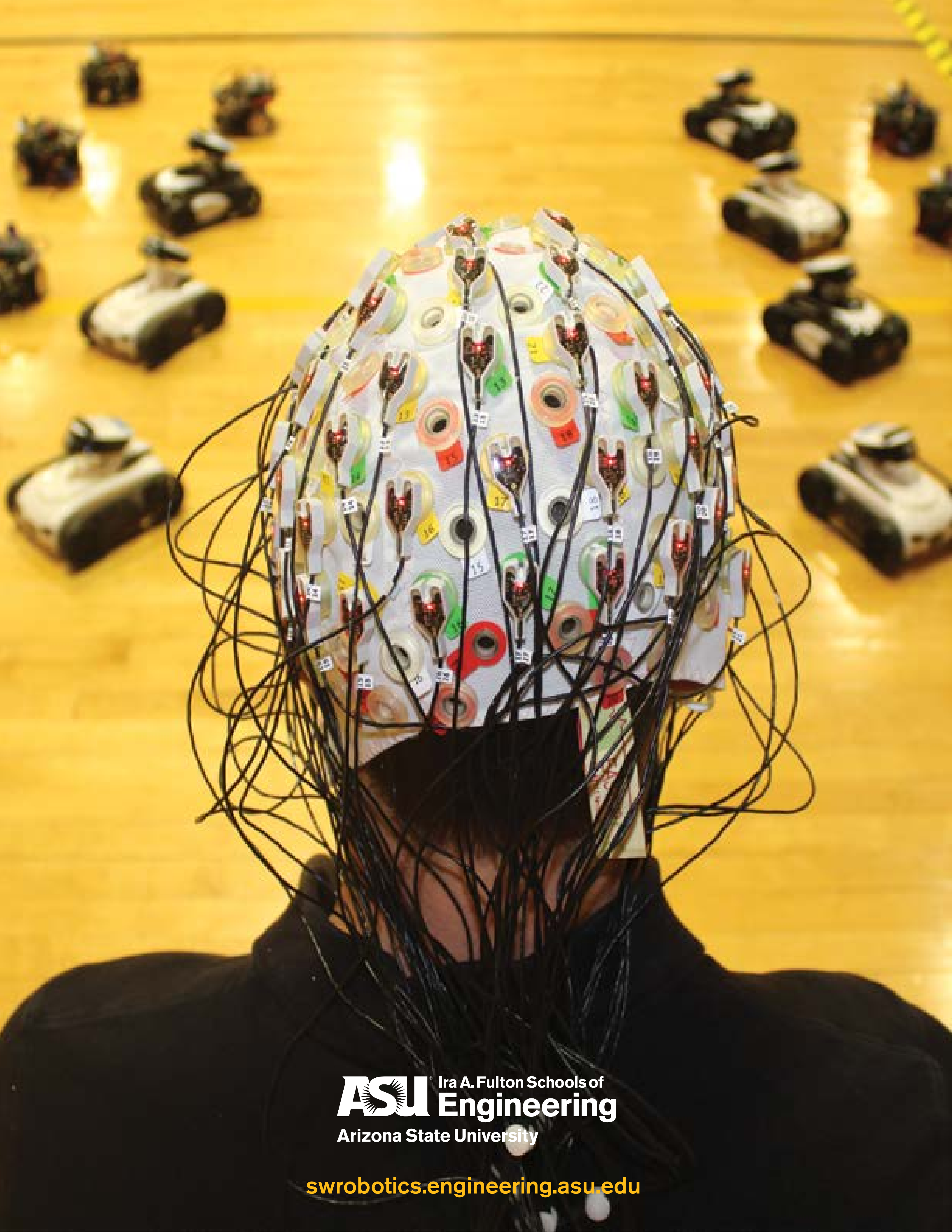
43. **Optimizing Small-scale, Multi-actuator Hydraulic Systems**
J. Neuharth
University of Minnesota

44. **Development of a Jumping Platform Utilizing Laminate Construction**
J. Knaup, D. Aukes
Arizona State University

45. **Revisiting Screw-propelled Vehicles Utilizing Experimental and Computational Methods**
A. Thoesen, S. Ramirez, H. Marvi
Arizona State University

46. **CHART: Center for Human, Artificial Intelligence, and Robot Teaming**
N. Cooke, S. Berman
Arizona State University

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