**agenda**

**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

**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**

- 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 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**

- agenda 2-3
- Welcome 4
- mission 5
- plenary speaker 6
- speakers 7-13
- robotics at asu 14-17
- sponsors 18-19
- committee 20
- posters 21-23
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

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

Dean
Ira A. Fulton Schools of Engineering

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
plenary talk

**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 Award 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 biapedal robotic walking—both formally and through experimental validation. His lab designs, builds and tests novel biapedal robots, humanoids and prostheses with the goal of achieving human-like biapedal 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, biapedal 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.

**Speakers**

**PANAGIOTIS POLYGHERINOS,** 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 interface 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 2.0×2.0×2.5 cm$^3$. 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 than today’s kinematically controlled systems. Drawing inspiration from biology and biomechanics, I design and control robots whose motion emerges in 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 gait 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 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.
A New Robotic Approach to Characterize Ankle Mechanics During Postural Balance and Locomotion

Abstract: Understanding how 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 novel 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.

Soft Robotics: Between Rigidity and Compliance

Abstract: Soft robotics is quickly emerging in recent years. With its 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.

Soft Robotics: Between Rigidity and Compliance

Abstract: Soft robotics is quickly emerging in recent years. With its 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.

Soft Robotics: Between Rigidity and Compliance

Abstract: Soft robotics is quickly emerging in recent years. With its 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.

Soft Robotics: Between Rigidity and Compliance

Abstract: Soft robotics is quickly emerging in recent years. With its 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.

Soft Robotics: Between Rigidity and Compliance

Abstract: Soft robotics is quickly emerging in recent years. With its 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.

Soft Robotics: Between Rigidity and Compliance

Abstract: Soft robotics is quickly emerging in recent years. With its 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.
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.

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.

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 these 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.

Robots in the Field and in the Classroom

Abstract: In this talk we 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 treefold: (1) design of high-precision mechanisms, (2) understanding of the mechanisms’ behavior and how to drive adaptations in humans, and (3) adaptive control of physical human-robot interaction (hHR). 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 stimulation (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.

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

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 will discuss how AI and deep learning are enabling these advances. We 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.

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 UAVs 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, scalable 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 explorations. 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 extraction, 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 focusing 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 Dynamism**

*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 relational 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 puzzles 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-and-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-a-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.
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

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

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

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-rehabilitation

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  Bradley Greger
Jimmy Abbas  Claire Honeycutt
Chris Buneo  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  Ted Pavlic
Spring Berman  Wenlong Zhang
Stephanie Gil

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  Erin Chiou
Heni Ben Amor  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  Scotty Craig
Nancy Cooke  Ted Pavlic
Rod Roscoe
HEBI Robotics is a spin-off from Carnegie Mellon University in Pittsburgh that produces Lego-like robotic building blocks. The HEBI platform consists of hardware and software that make it easy to create world-class robots, of virtually any configuration, quickly and cost-effectively.

www.hebirobotics.com

Bertec is manufacturer and world wide leader that makes force measuring instruments used for research, rehabilitation and sports applications. Bertec was founded in 1986 in Columbus, Ohio. Bertec products consists of force plates, load cells, balance plates, instrumented treadmills and virtual reality with the balance plate and instrumented treadmill.

www.bertec.com

Epilog Laser is the leading designer and manufacturer of CO2 and fiber laser cutting, engraving, and marking systems. Used extensively in the robotics industry, Epilog's powerful, easy-to-use systems allow users to quickly cut parts, gears, and other components for robotic systems, prototypes, etc. From compact desktop units to larger-format systems, Epilog has the right laser for your cutting and engraving applications. Stop by for a hands-on demonstration and laser samples today!

www.epiloglaser.com

Maxon Precision Motors is a leading supplier of high-precision DC brush and brushless servo motors and drives. maxon's hombic wound ironless rotor motors provide exceptionally high efficiency, low EMI emissions, fast acceleration, no preferred rotor position, linear speed and torque constant (accurate control) and long life. These motors range in size from 4 – 90 mm.

We combine electric motors, gears and DC motor controls into high-precision, intelligent drive systems that can be custom-made to fit the specific needs of customer applications.

www.maxonmotorusa.com

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.

www.ati-ia.com

Epilog Laser is the leading designer and manufacturer of CO2 and fiber laser cutting, engraving, and marking systems. Used extensively in the robotics industry, Epilog's powerful, easy-to-use systems allow users to quickly cut parts, gears, and other components for robotic systems, prototypes, etc. From compact desktop units to larger-format systems, Epilog has the right laser for your cutting and engraving applications. Stop by for a hands-on demonstration and laser samples today!

www.epiloglaser.com

Epilog Laser is the leading designer and manufacturer of CO2 and fiber laser cutting, engraving, and marking systems. Used extensively in the robotics industry, Epilog's powerful, easy-to-use systems allow users to quickly cut parts, gears, and other components for robotic systems, prototypes, etc. From compact desktop units to larger-format systems, Epilog has the right laser for your cutting and engraving applications. Stop by for a hands-on demonstration and laser samples today!

www.epiloglaser.com

Southwest Research Institute® (SwRI®) is an independent, nonprofit applied research and development organization that develops, packages, and transfers technologies for government and industry. With nine technical divisions, we offer multidisciplinary services leveraging advanced science and applied technologies. Since 1947, we have provided solutions for some of the world’s most challenging scientific and engineering problems. We have a long history of delivering state-of-the-art industrial robotic, unmanned systems, and automated driving solutions. Our robotics teams are deep in advanced perception, localization, and control/navigation technologies.

www.swri.org

NVIDIA’s invention of the GPU in 1999 sparked the growth of the PC gaming market, redefined modern computer graphics, and revolutionized parallel computing. More recently, GPU deep learning ignited modern AI — the next era of computing — with the GPU acting as the brain of computers, robots, and self-driving cars that can perceive and understand the world. The GPU has proven to be unbelievably effective at solving some of the most complex problems in computer science. It started out as an engine for simulating human imagination, conjuring up the amazing virtual worlds of video games and Hollywood films. Today, NVIDIA’s GPU simulates human intelligence, running deep learning algorithms and acting as the brain of computers, robots, and self-driving cars that can perceive and understand the world. This is our life’s work — to amplify human imagination and intelligence.

www.nvidia.com

Santifico Technology (Shenzhen) Limited is a technology driven company devoted to robotics, focused in the design, manufacturing and sales of robotic products. Our core team has a complete, in-depth understanding of all aspects of robotics including design and manufacture technology, robot control algorithms, speech and computer vision technology etc. Our team is equipped with all-round product development capability and is capable to satisfy diversified and customized demand.

www.santifico.com
1. Automated Synthesis Scalable Algorithms for Inferring Non-local Properties to Assist in Multi-robot Teamwork
   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

   M. Strickland, C. Tamayo, G. Fainekos, H. Ben Amor
   Arizona State University

5. Towards Semantic Policies for Human-Robot Collaboration
   S. Appollito, 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, P. Subramamy
    Arizona State University

13. Mean-Field Stabilization of Markov Chain Models for Robotic Swarms: Computational Approaches and Experimental Results
    V. Deshmukh, K. Elamvazuthi, S. Biswal, Z. Kakeish, 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. Nichel, K. Rahn
    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. Yang, Y. Xin, Y. Yang, W. Zhang
    Arizona State University

20. Experimental Identification & Control of a Fish-inspired Laminated Robot Movement in Water
    M. Shafizadeh, P. Khodambash, 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. Celm, G. K. Lami, E. Harnister, G. Yanikman, M. She, A. Chinz
    Arizona State University

23. Physical Human-Machine Coordination (pMHC)
    Y. Wang, K. Rahn, C. Hsiung, C. Highwood
    Arizona State University

24. AH-CNN: Adaptive and Hierarchical Convolutional Neural Networks
    K. 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. Heath, 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. Whitesell, P. Artemiadis, C. Bueno
ARIZONA STATE UNIVERSITY

36. An Experimentally Verified Nonlinear PDE Model for Ferrofluids
M. Ilami, K. Elamvazuthi, 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. Yankian, 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. Maley, 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