IEEE 2025-26 PROJECT LIST	
Robotics	
CODE	TITLE AND ABSTRACT
26-ANSP-RB-001	**A Dexterous and Compliant (DexCo) Hand Based on Soft Hydraulic Actuation for Human-Inspired Fine In-Hand Manipulation** Human beings possess a remarkable skill for fine in-hand manipulation, utilizing both intrafinger interactions (in- finger) and finger–environment interactions across a wide range of daily tasks. These tasks range from skilled activities like screwing light bulbs, picking and sorting pills, and in-hand rotation, to more complex tasks such as opening plastic bags, cluttered bin picking, and counting cards. Despite its prevalence in human activities, replicating these fine motor skills in robotics remains a substantial challenge. This study tackles the challenge of fine in-hand manipulation by introducing the dexterous and compliant (DexCo) hand system. The DexCo hand mimics human dexterity, replicating the intricate interaction between the thumb, index, and middle fingers, with a contractable palm. The key to maneuverable fine in-hand manipulation lies in its innovative soft hydraulic actuation, which strikes a balance between control complexity, dexterity, compliance, and motion accuracy within a compact structure, enhancing the overall performance of the system. The model of soft hydraulic actuation, based on hydrostatic force analysis, reveals the compliance of hand joints, which is also further extended to a dedicated robot operating system (ROS) package for DexCo hand simulation, considering both motion and stiffness aspects. Dedicated velocity and position teleoperation controllers are designed for implementing real physical manipulation tasks. The benchmark results show that the fingertip achieves a maximum repeatable finger strength of 34.4 N, a grasp cycle time of less than 2.04s, and a maximum repeatability accuracy of 0.03 mm. Experimental results demonstrate the DexCo hand successfully performs complex fine in-hand manipulation tasks, providing a promising solution for advancing robotic manipulation capabilities toward the human level.
26-ANSP-RB-002	**Automated Seeding in Hydroponic Greenhouse With a Dual-Arm Robotic System** Automation in agriculture, often referred to as Agriculture 4.0, has attracted significant interest in recent decades. The integration of technologies like artificial intelligence, robotic manipulation, and autonomous navigation, commonly used in industrial automation, also shows great potential in the agricultural sector. While these technologies are being extensively applied to automate tasks such as fruit harvesting, there is a notable lack of research focused on their application to other essential tasks, such as seeding. In this context, this article introduces an autonomous bi-manipulator robot designed to automate the seeding process in a hydroponic greenhouse. The dual-arm robotic system is capable of perceiving the environment to accurately identify the location of growing cubes within planters, securely position the cubes without causing collisions within the hydroponic system, collect seeds, and deposit them directly into the small holes of the growing cubes. Several perception and manipulation strategies are proposed and experimentally evaluated to enhance the overall process. The results demonstrate that automating this task with a dual-arm mobile robot is both feasible and

	efficient, achieving an average seeding time of 75 s per rock-wool cube with the most efficient strategy, including cube positioning and verification of proper seed placement.
26-ANSP-RB-003	**Autonomous Powered Ankle Exoskeleton Improves Foot Clearance and Knee Hyperextension After Stroke** Hemiparetic gait is often characterized by ankle weakness, resulting in decreased propulsion and clearance, as well as knee hyperextension. These gait deviations reduce speed and efficiency while increasing the risk of falls and osteoarthritis.Powered ankle exoskeletons have the potential to address these issues. However, only a handful of studies have investigated their effects on hemiparetic gait. The results are often inconsistent, and the biomechanical analysis rarely includes the knee or hip joint or a direct clearance measure. In this case study, we assess the ankle, knee, and hip biomechanics with and without a new autonomous powered ankle exoskeleton across different speeds and inclines. Exoskeleton assistance resulted in more normative kinematics at the subject's self-selected walking speed. The paretic ankle angle at heel strike increased from 10° plantarflexed without the exoskeleton to 0.5 dorsiflexed with the exoskeleton, and the peak plantarflexion angle during swing decreased from 28° without the exoskeleton to 12° with the exoskeleton. Furthermore, stance knee flexion increased from 7° without the exoskeleton to 20° with the exoskeleton. Finally, foot clearance increased with the exoskeleton for all conditions between 3.1 cm and 5.4 cm. This case study highlights new mechanisms for powered ankle exoskeletons to improve hemiparetic gait.
26-ANSP-RB-004	**Behavior Modeling and Bio-Hybrid Systems: Using Reinforcement Learning to Enhance Cyborg Cockroach in Bio-Inspired Swarm Robotics** Bio-inspired swarm robotics is an emerging field at the intersection of biology, robotics, and artificial intelligence, offering novel capabilities by integrating living organisms with robotic systems. This paper presents a groundbreaking approach to behavior modeling and enhancement for biological hybrid cockroach robots using reinforcement learning (RL). The study focuses on developing a hybrid system that combines the natural adaptability of cockroaches with the precision of robotics. The RL method predicts and optimizes cockroach movements to enhance task performance in bio-inspired swarm robotics. The proposed methodology includes modeling cockroach behaviors through data-driven techniques, designing a control framework using RL, and integrating these systems into a swarm robotics architecture. By defining precise state-action spaces and reward functions, the RL model effectively learned to influence cockroach behavior via electrical stimulation of their antennae, guiding them to perform complex navigational tasks. Experimental results demonstrate the efficacy of the system in both simulated and real-world environments. The RL framework achieves high prediction accuracy and control fidelity, significantly enhancing the operational capabilities of the bio-hybrid system. Swarm-level tests reveal the potential of this approach for collaborative tasks, such as obstacle avoidance and collective decision-making. This research contributes to the advancement of bio-hybrid systems by bridging biological adaptability and robotic precision, with implications for search-and-rescue missions and environmental monitoring. We discuss ethical considerations to address the challenges of using live organisms. Future work will explore scaling the swarm system and integrating advanced sensors and AI algorithms.

26-ANSP-RB-005	**CliReg: Clique-Based Robust Point Cloud Registration** We propose a branch-and-bound algorithm for ro- bust rigid registration of two point clouds in the presence of a large number of outlier correspondences. For this purpose, we consider a maximum consensus formulation of the registration problem and reformulate it as a (large) maximal clique search in a correspondence graph, where a clique represents a complete rigid transformation. Specifically, we use a maximum clique algorithm to enumerate large maximal cliques and a fitness procedure that evaluates each clique by solving a least-squares optimization prob- lem. The main advantages of our approach are 1) it is possible to exploit the cutting-edge optimization techniques employed by cur- rent exact maximum clique algorithms, such as partial maximum satisfiability-based bounds, branching by partitioning or the use of bitstrings, etc.; 2) the correspondence graphs are expected to be sparse in real problems (confirmed empirically in our tests), and, consequently, the maximum clique problem is expected to be easy; 3) it is possible to have a *good* control of suboptimality with a k-nearest neighbor analysis that determines the size of the cor- respondence graph as a function of k. The new algorithm is called CliReg and has been implemented in C++. To evaluate CliReg, we have carried out extensive tests both on synthetic and real public datasets. The results show that CliReg clearly dominates the state of the art (e.g., RANSAC, FGR, and TEASER++) in terms of robustness, with a running time comparable to TEASER++ and RANSAC. In addition, we have implemented a fast variant called CliRegMutual that performs similarly to the fastest heuristic FGR.
26-ANSP-RB-006	**Cloud-Native Fog Robotics: Model-Based Deployment and Evaluation of Real-Time Applications** As the field of robotics evolves, robots become increasingly multi-functional and complex. Currently, there is a need for solutions that enhance flexibility and computational power without compromising real-time performance. The emergence of fog computing and cloud-native approaches addresses these challenges. In this paper, we integrate a microservice-based architecture with cloud-native fog robotics to investigate its performance in managing complex robotic systems and handling real-time tasks. Addition- ally, we apply model-based systems engineering (MBSE) to achieve automatic configuration of the architecture and to manage resource allocation efficiently. To demonstrate the feasibility and evaluate the performance of this architecture, we conduct comprehensive evaluations using both bare-metal and cloud setups, focusing particularly on real-time and machine-learning-based tasks. The experimental results indicate that a microservice-based cloud-native fog architecture offers a more stable computational environment compared to a bare-metal one, achieving over 20% reduction in the standard deviation for complex algorithms across both CPU and GPU. It delivers improved startup times, along with a 17% (wireless) and 23% (wired) faster average message transport time. Nonetheless, it exhibits a 37% slower execution time for simple CPU tasks and 3% for simple GPU tasks, though this impact is negligible in cloud-native environments where such tasks are typically deployed on bare-metal systems.
26-ANSP-RB-007	**Data-Driven Methods Applied to Soft Robot Modeling and Control** Soft robots show compliance and have infinite degrees of freedom. Thanks to these properties, such robots can be leveraged for surgery, rehabilitation, biomimetics, unstruc- tured environment exploring, and industrial grippers. In this case, they attract scholars from a variety of areas. However, nonlinearity and hysteresis effects also bring a burden to robot modeling. Moreover, following their flexibility and adaptation, soft robot control is more challenging than rigid robot control. In order to model and control soft robots, a large number of data-driven methods are utilized in pairs or separately. This review first briefly introduces two foundations for data- driven approaches, which are physical models and the Jacobian matrix, then summarizes three kinds of data-driven approaches, which are statistical method, neural network, and reinforcement learning. This review compares the modeling and controller features, e.g., model dynamics, data requirement, and target task, within and among these categories. Finally, we summarize the features of each method. A discussion about the

	advantages and limitations of the existing modeling and control approaches is presented, and we forecast the future of data-driven approaches in soft robots.
26-ANSP-RB-008	**Design and Analysis of a Parallel Elastic Shoulder Joint for Humanoid Robotics Application** This is an innovative hybrid cable-driven shoulder joint for humanoid robotics application. A blend of a flexible central limb and three rigid lateral limbs, form a 2-degree-of-freedom (2 DOF) mechanism that connects the mobile platform to the fixed base. This design leverages both good mechanical stability and the integration of an elastic element, which mitigates vibrations up to 40% and allows the storage and release of elastic potential energy up to 1.9*J*. Initially, three alternative and incremental shoulder joint designs are presented and evaluated across two distinct experiments: 1) Energy storage analysis of the parallel mechanism during single cable motion and 2) Dynamic response and vibration damping. Following these experiments, a detailed analysis is performed on the stiffness properties of the proposed prototype, as it outperforms the other two designs. The dimension of the central elastic limb, made out of Thermo-Plastic Polyurethane (TPU), is optimized using Finite Element Analysis (FEA). The kinematic behavior of the proposed mechanism is approximated as a combination of linkages equipped with two universal joints, and its motion evaluated through numerical simulations and real experiments.
26-ANSP-RB-009	**Design and Characterization of a Low-Profile Haptic System for Telemanipulation** In telemanipulation, supplementary feedback can enhance operator perception and control precision. This study introduces a haptic interface designed to convey temporally discrete tactile cues when remotely controlling a robot. Low- profile piezoelectric sensors were integrated in the thumb of a robotic hand to capture the key events of the manipulation task (i.e., object contact and release). Synchronously with such events, pressure bursts were delivered to the operator's fingertip through a soft textile thimble equipped with inflatable pockets. Both this haptic display and the sensing module were individually evaluated. The pneumatic system responsible for pockets inflation was characterized in terms of reaction time, proving suitable for the application with a latency of less than 70 ms. Regarding the sensing module, the behavior of the sensorized thumb was first evaluated under static conditions, identifying contact and release events when grasping with the robotic hand differently shaped objects fixed on a table. Then, the accuracy of the touch event detection was assessed while performing a more complex manipulation task (i.e., a pick and lift task). This evaluation was conducted first with the robot programmed to grasp and lift an object following pre-defined trajectories, where we measured accuracy of 100% for contact and 90% for release event detection. Then, we performed a telemanipulation pilot study involving eight participants, where the system proved capable of correctly detecting object contact and release events with an accuracy of 100% and 86.4%. Despite preliminary, these results confirmed proper functioning of the system and paved the way for the exploration of a new haptic feedback policy in telemanipulation based on temporally discrete tactile events.
26-ANSP-RB-010	Development of an Intuitive Interface With Haptic Enhancement for Robot-Assisted Endovascular Intervention Robot-assisted endovascular intervention has the potential to reduce radiation exposure to surgeons and enhance outcomes of interventions. However, the success and safety of endovascular interventions depend on surgeons' ability to accurately manipulate endovascular tools such as guidewire and catheter and perceive their safety when cannulating patient's vessels. Currently, the existing interventional robots lack a haptic system for accurate force feedback that surgeons can rely on. In this paper, a haptic-enabled endovascular interventional robot was developed. We proposed a

	dynamic hysteresis compensation model to address the challenges of hysteresis and nonlinearity in magnetic powder brake-based haptic interface, which were used for providing high-precision and higher dynamic range haptic perception. Also, for the first time, a human perceptual-based haptic enhancement model and safety strategy were integrated with the custom-built haptic interface for enhancing sensation discrimination ability during robot-assisted endovascular interventions. This can effectively amplify even subtle changes in low-intensity operational forces such that surgeons can better discern any vessel-tools interaction
26-ANSP-RB-011	**Effects of Uni- and Bi-Directional Interaction During Dyadic Ankle and Wrist Tracking** Haptic human-robot-human interaction allows users to feel and respond to one another's forces while interfacing with separate robotic devices, providing customizable infrastructure for studying physical interaction during motor tasks (e.g., physical rehabilitation). For upper- and lower-limb tracking tasks, previous work has shown that virtual interactions with a partner can improve motor performance depending on the skill level of each partner. However, whether the mechanism explaining these improvements is identical in the upper and lower limbs is an open question. In this work, we investigate the effects of haptic interaction between healthy individuals during a trajectory tracking task involving single-joint movements at the wrist and ankle. We compare tracking performance and muscle activation during haptic conditions where pairs of participants were uni- and bidirectionally connected to investigate the contribution of real-time responses from a partner during the interaction. Findings showed similar improvements in tracking performance during bidirectional interaction for both the wrist and ankle. This was observed despite distinct strategies in muscle co-contraction between joints, as co-contraction was dependent on partner ability for the wrist but not the ankle. For each joint, bidirectional and unidirectional interaction resulted in similar improvements for the worse partner in the dyad. For the better partner, bidirectional interaction resulted in greater improvements than unidirectional interaction. While these results suggest that unidirectional interaction is sufficient for error correction of less skilled individuals during simple motor tasks, they also highlight the mutual benefits of bidirectional interaction which are consistent across the upper and lower limbs.
26-ANSP-RB-012	**Enhancing Dual-Loop Pressure Control in Pneumatic Soft Robotics With a Comparison of Evolutionary Algorithms for PID & FOPID Controller Tuning** The control of pneumatic soft robotics is challenging due to non linearites arising from many factors including pneumatic system components and material properties of the soft actuator. Manual methods for PID controller tuning are inadequate for the nonlinear and time-variant dynamics present in soft robotics. Affordable pneumatic components such as on/off valves cause dis- continuities in flow rate, introducing nonlinearities and oscillatory fluctuations into the system. This study proposes a dual-loop control system: one for PID and Fractional-Order PID (FOPID) control of a solenoid valve that feeds air into the actuator, and another for PID control of the pump upstream of the valve. The PID and FOPD parameters are optimized using evolutionary algorithms: Genetic Algorithm (GA), Particle Swarm Optimization (PSO), and Sim- ulated Annealing (SA). Simulations and real-world experiments are conducted to validate the optimized parameters. Our results demonstrate that the dual-loop hardware configuration reduces fluctuations from the valves compared with a single-loop control scheme. The experimental statistical analysis confirms that FOPID achieves the highest significant improvements in rise time (PSO) and peak time (GA, PSO), while PID performs better for overshoot (GA, PSO). These findings highlight the importance of selecting an

	appropriate optimization algorithm based on the specific control objective, as FOPID does not outperform PID in every metric across all methods.

26-ANSP-RB-013	**LimbMATE: A Versatile Platform for Closed-Loop Research in Prosthetics** The rapid advancements in machine learning methodologies carry a wide potential to match the increasing control demands of modern robotic hands. In particular, myoelectric pattern recognition is recognized nowadays as a viable means to facilitate the multi-functional con- trol of prosthetic devices, for both lower and upper limb amputations. However, such solutions require dedicated and specific hardware: versatile yet robust, low-power yet computationally powerful. Here, we present LimbMATE: a compact and modular embedded system for the intuitive real-time control of prostheses by decoding either differential or pre-amplified bioelectric signals. It is compatible with various prosthetic components and feedback actuators, disposing of major communication peripherals to adapt to other devices' proprietary protocols. Moreover, it includes Bluetooth capabilities, and it implements an advanced real-time clock calendar-based logging system for tracking prosthesis usage, opening for long-term at-home longitu- dinal studies. The LimbMATE system was bench-verified to prove suitable power consumption (<200 mW), real-time operation, and long-term data storage (1 sec/day tolerance). Finally, it was validated with twelve non-disabled partici- pants and two end-users with upper limb amputation via both virtual and real-life-inspired functional assessments. LimbMATE showed the capability for robust and responsive inference of the intended movements to enable intuitive bidirectional control of a multi-articulated prosthesis.
26-ANSP-RB-014	**PAROS: Multi-Component Robotic System and an Image-Guided Patient Alignment for Robot-Assisted Ophthalmic Surgery** Advancements in robot-assisted eye surgery have significantly enhanced precision in delicate procedures by enabling controlled movement of surgical instruments through a small entry point (trocar) placed on the outer layer of the eye (sclera). However, before these procedures can begin, the robot must first be prepared, draped, and calibrated. Then, it is positioned near the patient, where precise patient alignment is performed. Finally, the system ensures accurate alignment between the surgical instrument and the trocar, a critical step for safe and effective instrument insertion and surgical execution. Despite these advancements, integrating robotic systems into clinical practice remains challenging. The current manual preparation and alignment process is time-consuming and error-prone, emphasizing the need for a more automated and adaptive solution. Patient alignment time has been identified as a key factor differentiating robot-assisted and manual surgeries in overall procedure duration, with robot preparation and patient alignment extending surgery time by an average of 51 ± 6 minutes compared to manual methods. To address these challenges, this paper introduces a multi-component robotic system combined with an image-guided patient alignment methodology designed to reduce preparation and alignment time in robotic eye surgery while maintaining surgical efficiency. The robotic system consists of a 2D-Cart carrying a 4-degree-of-freedom (DOF) frame robot holding a 5-DOF micro-manipulator. It utilizes an image-guided, multi-stage alignment approach, enabling the system to efficiently be localized and stabilized in an optimal position beside the surgical bed and ensuring precise and adaptive positioning relative to the patient in the surgical draped condition. The proposed end-to-end robotic system preparation and patient alignment are validated through a user study involving eight medical experts in a simulated surgical environment

	using a draped phantom eye. The results demonstrate successful robot-patient alignment in all cases, with the additional setup time significantly reduced to 272 ± 84 seconds, highlighting the high precision of the system and clinical feasibility. To further assess the effectiveness of the image-guided alignment in real surgical settings, eye detection experiments are conducted on five patients under surgical draped conditions, achieving 90% eye detection accuracy and 75% iris detection accuracy. This study introduces a robust, semi-automated approach to robot-patient alignment, offering a more efficient and adaptable alternative to current manual methods by reducing setup time and enhancing surgical accuracy.
26-ANSP-RB-015	**Preliminary Assessment of Accurate Motion Detection via Magnetic Tracking Toward Wearable Technologies** Tracking permanent magnets represents a low-footprint and passive approach to monitoring objects or human motion by attaching or embedding magnets therein. Recent tracking techniques achieved high-bandwidth detection considering a simplified model for the magnetic sources, i.e., the dipole model.Nonetheless, such a model can lead to inaccurate results any time a non-spherical magnet approaches the sensor array. Here,we present a novel tracking algorithm based on an analytical model for permanent magnet cylinders with uniform arbitrary magnetization. By means of a physical system mounting 20 magnetometers, we compared the tracking accuracy obtained with our algorithm vs. results obtained by using the dipole model and with respect to a ground-truth reference. With a single magnetic target, our algorithm can significantly lower position (up to 0.68 mm) and orientation errors (up to 2.5) while enabling online tracking (computation time below 19ms). We also accurately tracked two magnets, by obtaining a reduction in position error (up to 0.92mm) vs. the dipole-based algorithm. These findings broaden the applicability of accurate magnetic tracking to real- time applications, facilitating the tracking of multiple magnetic targets in proximity of the magnetic sensors. This advancement opens avenues for applications in wearable devices, advancing the field of motion detection beyond traditional inertial measurement units.
26-ANSP-RB-016	**Preliminary Evaluation of a Soft Wearable Robot for Shoulder Movement Assistance** Spinal cord injuries (SCI) often lead to upper limb impairment, necessitating innovative solutions for daily assistance beyond traditional rigid robotics due to their impractical weight and size. Despite still preliminary, soft wearables are arising as a possible solution to fill this gap. Here, we demonstrated an enhanced version of a soft inflatable robot that assists the shoulder against gravity, previously tested with different neurological conditions. Noteworthy improvements include a single-layer actuator, simplifying manufacturing, a built-in bending angle and a nylon hammock, for better armpit conformity. We characterized the actuator (approximately 8Nm at 90 at 70kPa) and demonstrated its good transparency, both from a kinematic and a muscular standpoint. Then, on 11 healthy individuals, we showed reductions in shoulder muscle activity (both at the anterior and middle deltoid) while performing a lift and hold task, ranging from 16% to almost 60% of the maximum voluntary contraction. More importantly, we confirmed these effects on two SCI individuals SCI, at two different stages of recovery. While preliminary, considering the limited exploration of soft wearable robots for the shoulder in SCI cases, this is a significant advancement playing an important role in the development of future soft technology for SCI assistance.

26-ANSP-RB-017	**Semantically Safe Robot Manipulation: From Semantic Scene Understanding to Motion Safeguards** Ensuring safe interactions in human-centric environments requires robots to understand and adhere to constraints recognized by humans as “common sense” (e.g., “*moving a cup of water above a laptop is unsafe as the water may spill*” or “*rotating a cup of water is unsafe as it can lead to pouring its content*”). Recent advances in computer vision and machine learning have enabled robots to acquire a semantic understanding of and reason about their operating environments. While extensive literature on safe robot decision-making exists, semantic understanding is rarely integrated into these formulations. In this work, we propose a semantic safety filter framework to certify robot inputs with respect to semantically defined constraints (e.g., unsafe spatial relationships, behaviors, and poses) and geometrically defined constraints (e.g., environment-collision and self-collision constraints). In our proposed approach, given perception inputs, we build a semantic map of the 3D environment and leverage the contextual reasoning capabilities of large language models to infer semanti- cally unsafe conditions. These semantically unsafe conditions are then mapped to safe actions through a control barrier certification formulation. We demonstrate the proposed semantic safety filter in teleoperated manipulation tasks and with learned diffusion policies applied in a real-world kitchen environment that further showcases its effectiveness in addressing practical semantic safety constraints. Together, these experiments highlight our approach’s capability to integrate semantics into safety certification, enabling safe robot operation beyond traditional collision avoidance.
26-ANSP-RB-018	**SIS: Seam-Informed Strategy for T-Shirt Unfolding** Seams are information-rich components of garments. The presence of different types of seams and their combinations helps to select grasping points for garment handling. In this let- ter, we propose a new Seam-Informed Strategy (SIS) for finding actions for handling a garment, such as grasping and unfolding a T-shirt. Candidates for a pair of grasping points for a dual-arm manipulator system are extracted using the proposed Seam Feature Extraction Method (SFEM). A pair of grasping points for the robot system is selected by the proposed Decision Matrix Iteration Method (DMIM). The decision matrix is first computed by mul- tiple human demonstrations and updated by the robot execution results to improve the grasping and unfolding performance of the robot. Note that the proposed scheme is trained on real data with- out relying on simulation. Experimental results demonstrate the effectiveness and generalization ability of the proposed strategy.

26-ANSP-RB-019	**The Only Way Is Up: Active Knee Exoskeleton Reduces Muscular Effort in Quadriceps During Weighted Stair Ascent** Firefighters consistently rank stair ascent with gear, which can weigh over 35 kg, as their most demanding activity. Weighted stair climbing requires dynamic motions and large knee torques, which can cause exhaustion in the short term, and overuse injuries in the long term. An active knee exoskeleton could poten- tially alleviate the burden on the wearer by injecting positive energy at key phases of the gait cycle. Similar devices have reduced the metabolic cost for various locomotion activities in previous studies. However, no information is available on the effect of active knee exoskeletons on muscular effort during prolonged weighted stair ascent. Here we show that our knee exoskeletons reduce the net muscular effort in the lower limbs when ascending several flights of stairs while wearing additional weight. In a task analogous to part of the

	physical fitness test for firefighters in the US, eight participants climbed stairs for three minutes at a constant pace while wearing a 9.1 kg vest. We compared lower limb muscle activation required to perform the task with and without two bilaterally worn Utah Knee Exoskeletons. We found that bilateral knee assistance reduced average peak quadriceps muscle activa- tion measured through surface electromyography by 32% while reducing overall muscle activity at the quadriceps by 29%. These results suggest that an active knee exoskeleton can lower the overall muscular effort required to ascend stairs while weighted. In turn, this could aid firefighters by preserving energy for fighting fires and reducing overexertion injuries.
26-ANSP-RB-020	**Trident: A Multi-Functional Soft Appendage for Underwater Locomotion and Grasping** Soft underwater robots, designed to mimic the move- ment and adaptability of aquatic animals, use flexible materials like silicone and rubber to change shape and navigate complex environments. These robots can squeeze through narrow spaces and avoid obstacles, making them ideal for exploring underwater caves, coral reefs, and shipwrecks without harming marine life. Their embodied intelligence integrates sensing, actuation, and control, allowing adaptive responses to environmental stimuli and enabling complex tasks with minimal external control. In this letter, we introduce *Trident*, a novel hybrid soft-rigid robot developed by connecting three soft modules with integrated tendons. This multi-functional robot is capable of both swimming and grasping underwater objects. The robot's design and fabrication processes are detailed, alongside experimental analyses of its performance. This innovative design combines the flexibility of soft materials and the strength of rigid structures, providing a versatile solution for underwater exploration, environmental monitoring, and marine research.