Academic Corner
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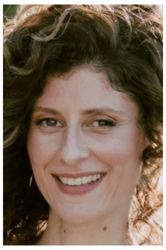

In this issue, we are pleased to feature an interview with Dr. Antonia Tzemanaki. She is a Senior Lecturer in Robotics at the School of Engineering Mathematics and Technology at the University of Bristol and a core member of the Bristol Robotics Laboratory, where she leads the Dexterous Manipulation and Wearable Robotics group. Her research spans medical robotics, dexterous manipulation, wearable and haptic technologies, robot hands and hand exoskeletons, soft and bio-inspired robotics, surgical and rehabilitation applications, and teleoperation in healthcare and extreme environments, with a strong focus on end-user benefit. Dr. Tzemanaki holds an MEng in Electrical and Computer Engineering from the Aristotle University of Thessaloniki, Greece, an MSc in Robotics from the University of the West of England (UWE), Bristol, and a Ph.D. in Medical Robotics from UWE Bristol, UK and the Bristol Robotics Laboratory. She contributes to the committees of major conferences including IEEE ICRA, IEEE IROS, and the Hamlyn Symposium on Medical Robotics, serves as General Co-Chair of IEEE Telepresence 2026, leads Medical Robotics teaching, and is Programme Director for the Biorobotics MSc at the University of Bristol. She was shortlisted among the "50 women in robotics you need to know about" in 2021.

(1) Please tell us a bit about yourself and your academic/professional background. How did your path from electrical and computer engineering, robotics, and medical robotics lead you to dexterous manipulation, wearable robotics, and haptic human-machine systems?

I am a Senior Lecturer at the University of Bristol, where I lead the Dexterous Manipulation and Wearable Robotics group at the Bristol Robotics Laboratory. I completed my MEng in Electrical and Computer Engineering in Greece before relocating to the United Kingdom in 2009 to pursue an MSc in Robotics, followed by a PhD in Medical Robotics. Upon completing my doctoral studies, I was part of a European research project before taking up my first faculty appointment at the University of the West of England. In 2019, I joined the University of Bristol in a permanent faculty role, where I have continued to develop my research programme to the present day. My initial interest lay in computer engineering; however, this evolved considerably as soon as I encountered the captivating field of robotics, automation and control engineering during my MEng studies, a compelling intersection of theory and real-world application. From that early stage, I maintained a strong focus on robotic hands and manipulation, and during my MSc in Robotics, I began applying this knowledge in healthcare contexts. That integration of dexterous robotics with clinical need has shaped the trajectory of my research ever since.

(2) Could you tell us about your current research? What are the main ideas connecting robot hands, hand exoskeletons, robot kinematics, haptics, wearable technologies, and bio-inspired robotics in your work?

My group's research centres on the question of how biological inspiration can endow robotic systems with the sensitivity and dexterity characteristic of the human hand, and how that capability can be deployed where it matters most. Our projects span medical robotics, wearable systems, and teleoperation, with applications across both healthcare and extreme environments such as nuclear and space. An illuminating aspect of our work has been identifying the commonalities across these seemingly disparate domains. We conducted a study interviewing expert operators of remote machinery from fields including nuclear reactor maintenance, robot-assisted surgery, underwater exploration, and ordnance disposal, and found that the end-user requirements across these applications converge to a remarkable degree.

Within the healthcare domain, our current projects include the development of robotic tools for the diagnosis and treatment of prostate cancer, sensors and robotic systems for breast examination, and robotic simulators for training surgeons in endourology and physiotherapists in pelvic floor assessment. We also investigate tool-tissue interaction patterns during bone grinding in neurosurgical procedures and we have developed BraillePen, a device designed to support individuals in learning and reading Braille. Across all projects, we maintain close collaboration with clinicians, which ensures that our research remains firmly grounded in clinical need and patient benefit.

(3) Your medical robotics projects include robotic palpation for breast examination, robotic tools and simulators for prostate cancer diagnosis/treatment, and haptic robotic simulators for endourology training. What are the key technical and translational challenges in moving these systems from laboratory prototypes toward clinical value?

There is, indeed, real complexity in translating laboratory robotics research into clinical practice. In robotic palpation for breast examination, for instance, detecting subtle variations in tissue stiffness that may indicate an underlying anomaly requires not only high-resolution tactile sensing, but also the ability to interpret spatially distributed force information in a clinically meaningful way. At the same time, it is important that such systems are comfortable and acceptable, i.e., designed for the patients who will use them. Miniaturising and embedding such sensing modalities into a safe, reliable, and ergonomically viable device remains an open and demanding engineering problem. Similarly, for our prostate cancer tools, achieving the accuracy required for diagnostic and therapeutic tasks in confined anatomical spaces demands tight integration of sensing, actuation, and real-time imaging, all within stringent constraints on device size. Then, we have the challenge of how and where we test those systems before involving humans. Medical and anatomical simulants are very expensive and often low fidelity; this is why a strand of our research focuses on developing representative and repairable anatomical phantoms that we can use and reuse for experimentation but also can be applied to medical education to train junior clinicians. For our haptic simulators, we also try to capture realistic tissue mechanics and render them convincingly through haptic feedback interfaces, while ensuring that the simulated experience is sufficiently close to clinical reality to be educationally valid.

The translational challenges are, of course, also demanding. Moving from a working prototype to a system of genuine clinical value requires rigorous validation studies, which in turn depend on sustained and trust-based collaboration with clinicians. My group is interested in this pathway, and we have been involved in funded accelerator programmes to turn research into spin-out companies or license agreements. The road to commercialisation is long and requires determination, appropriately so, to demonstrate safety and efficacy to the standards required. However, we believe that this must be planned for early in the research process. Integration into existing clinical workflows, navigating regulatory pathways, securing intellectual property, and engaging with industry partners add further layers of complexity. The journey from laboratory to clinical impact needs to be a sustained, iterative process.

(4) In haptic and wearable robotics, how do you decide what information should be sensed, displayed, or fed back to the user? What are the hardest open problems in creating touch, force, and tactile interfaces that feel useful, safe, and intuitive?

The question of what to sense, display, and feed back is important as the human sensorimotor system and specifically the human hand is extraordinarily sophisticated. There is often temptation to attempt to replicate this richness in its entirety, but that is not always necessary or desirable. Our approach is to ask what information is genuinely task-critical, and what the end user is capable of meaningfully processing in a given context, without cognitively overloading them, whether surgeons, teleoperators, or patients.

It also might not be technically feasible to replicate the information perfectly. For example, actuation remains a fundamental bottleneck when a wearable device must also be lightweight, safe, and comfortable over extended use. Soft actuator technologies are promising, but they present their own ongoing challenges in terms of controllability and force output. Tactile sensing presents a related example: there are many prototypes and commercial products that have excellent capabilities; that does not mean that they match the dynamic range of human skin mechanoreceptors.

Latency is another hard constraint, and a problem that our group has explored over several years, especially in terms of space teleoperation between Earth-Moon or even Earth-Mars. Even modest delays can produce unpredictable results and, hence, different methods have to be employed such as model-mediated teleoperation and shared autonomy between the human and the robotic system. One of the open problems that we have been thinking about in the course of this work is what systems users consider trustworthy and how we can improve this trust. How do users come to integrate an external haptic device into their sense of agency? These questions are at the intersection of robotics, neuroscience, and human factors.

(5) Bio-inspired and anthropomorphic design are prominent in robotic hands, hand exoskeletons, and assistive devices. When should robotic systems imitate human morphology and behavior, and when is it better to depart from human-like design?

The answer here is similar to the previous question: in the same way that we must exercise careful judgment about what to choose to sense, display and feed back, we have to choose what and how to design. The human hand represents millions of years of evolutionary optimisation, and when robots operate in unstructured environments or perform highly dexterous tasks, it makes sense to draw inspiration from biology.

In my PhD, for example, I set out to design surgical instruments inspired by the human hand, so that the robotic tools adapt to the surgeon's hand, rather than requiring the surgeon to adapt to the tool, as is the case currently. The idea was that the surgeon could simply teleoperate those instruments using a wearable hand interface. For the surgical instruments, I implemented a three-finger configuration, informed by research that showed that most of our precision grasps involve the thumb, index and middle fingers only. Initially, the design had 13 degrees of freedom (DOF). After experiments and user studies, I realised that if the wearable interface could track the surgeon's hand in great detail, then the surgical instrument could perform effectively even with fewer DOFs with negligible error. Such investigations are important as they can simplify a system and make it more practically realisable.

When designing for extreme environments, or for tasks that benefit from capabilities beyond the human range, such as resistance to radiation or operation in vacuum, departing from human morphology may often be necessary. The key question we ask is whether human-likeness serves the function or merely appearance.

In our tactile sensing work, we draw on what we understand about the spatial and temporal encoding properties of skin mechanoreceptors alongside inspiration drawn from the pressure equalisation mechanism of the human ear, without attempting to replicate biology in miniature. This allows us to develop sensors with adaptive sensing capabilities suited to the object or tissue under examination.

(6) Your research also reaches beyond healthcare into dexterous teleoperation and extreme environments such as nuclear and space robotics. What lessons transfer across clinical, rehabilitation, assistive, and hazardous-environment applications, and where do the design requirements diverge?

One of the most striking findings from the elicitation study we conducted, interviewing expert operators across all of these areas, was the convergence of requirements. The top-priority, mandatory requirement identified across all applications, except surgery, was that operators must have a comprehensive engineering understanding of their system's capabilities and limitations. Further high-priority requirements, across application domains, clustered around improving situational awareness through multiple camera viewpoints and health monitoring systems and facilitating trust through staged training and extensive operational familiarity. Notably, technical features such as haptic feedback received mixed responses and were not universally prioritised.

Regarding latency, both surgical and nuclear operators demanded near-real-time control and expressed reluctance to operate under perceivable delay, due to the high cost of failure. Instead, underwater and ordnance disposal operators were more accepting, finding the tasks more challenging but potentially manageable, even with delays of two seconds, comparable to Earth-Moon communication delays, often adapting using strategies such as 'move-and-wait' and reduced movement speed. We have employed a range of approaches to address this, such as model-mediated teleoperation, predictive displays, and shared autonomy frameworks in which the system and operator collaborate on execution. These have direct relevance for surgical teleoperation, where sensors are often not possible to integrate due to miniaturisation, and real-time feedback is not possible, but the surgeon could use estimated information from pre-operative models.

(7) What role have IEEE and IEEE SMC played in your career so far, and what should the SMC community prioritize looking ahead?

I have been publishing in IEEE Robotics and Automation Letters and across a number of IEEE conferences since I was a student member, and I have been serving as Associate Editor for IEEE RA-L, IEEE ICRA, and IEEE IROS over the last six years. I am currently serving as General Co-Chair of IEEE Telepresence 2026, which will be held in Bristol this November. It is a privilege to help shape that programme with themes central to my work, i.e., teleoperation, haptics, human-robot interaction, and wearables, and to bring it to a city that has been central to my own career.

As for priorities for the SMC community, I would advocate strongly for greater investment in clinical and operational translation pathways. Much promising research stops at the prototype stage not because it lacks scientific merit, but because the route from laboratory demonstration to clinical or industrial tool is poorly understood or inadequately resourced. I would welcome more SMC activity at this interface.

Similarly, I would encourage the SMC community to invest further in interdisciplinary and inclusive practice. The most consequential problems at the boundary of robotics, cybernetics, and human factors are not solvable within a single discipline or a homogeneous research group. Diversity of background, perspective, and lived experience is an asset that we cannot afford to overlook. It is partly why I established the Bristol Women in Robotics network, because building inclusive communities is not peripheral to good research, but foundational to it.

(8) Any last words of advice you would like to share with the SMC Society, especially for early-career researchers?

The most important advice I can offer is to stay close to the problem and to the people it affects. It is easy to become absorbed in technical solutions that are increasingly remote from real-world need. And this is why we must not underestimate the value of interdisciplinary collaboration. Working effectively with specialists who have different assumptions, vocabularies, and standards of evidence can lead to results that are more durable than work conducted in disciplinary isolation.