

Guest Editorial

Robotics has traditionally been a laboratory-based subject, and indeed it continues to be so. However, with the increasing availability of diverse toy and hobbyist robots, sophisticated educational robot kits, and myriad high-fidelity, miniaturized sensing, actuation, control, remote communications and human-interface modules, the lab scene is fast changing. Students and educators now have affordable options to implement challenging new robotic scenarios, paralleling some of the most current research issues of the robotics field at large. These include interactive small surface and aerial autonomous mobile robotic platforms, coordinated mobility and manipulation, teleoperative and VR-augmented platform control, peer-to-peer networked wireless interactions of platforms and altogether remote on-line operations by single or distributed users. Further, educational robotics laboratories are fast moving beyond traditional engineering disciplines. Biologists, for example, increasingly use robots, perhaps constructed in-house, to motivate biomimetic design, sensing and control analogies in animal behaviour.

Given these changes and new experimental resources, the basic pedagogical questions still remain; namely, how to integrate practical laboratory experiments with classroom material, and how to set practical, manageable lab assignments that both challenge and motivate new students? The potential scope and depth of coverage is large. Robotics is no longer just about manipulator kinematics control or basic integration of simple vision with manipulation as it was in the 70 and 80s. Rather, there is interest and opportunity to explore ideas in robotic intelligence, high-level and behaviour based, biologically inspired, modular and networked. How are the relevant topics in intelligence to be presented to current students, and how are the newer robot toys and systems to be used to foster practical understanding of these topics? What is the definitive robotics course? Are there different flavours of robotics courses, what are these, and what is their disciplinary grounding? What are the important robotics techniques that students need to grasp, and how do we convey them? To what extent can we allow students to 'explore' and 'innovate' with robotics systems, and where do we draw the line between unstructured exploration and rigorous grounding in theoretical concepts? Who is the end student audience for these lab experiences, and are they best offered in one discipline or an interdisciplinary course?

The set of paper in this special issue represent efforts to grapple with these questions both at a strategic and a tactical level in the classroom and in the laboratory. A notable feature of these papers is the diverse settings in which robotics education is taking place. These include the traditional university programmes that build on a solid engineering base of theory and practice; programmes that incorporate online robot environments to support a diverse range of systems and practices in robotics; technology-oriented courses and competitions that emphasise design and team-working skills; teacher training courses facilitating robotics and engineering programmes at kindergarten level; and museum exhibits that bring robotics education to a wider audience. A notable feature of all these settings is the care with which the educational programme has been crafted, the importance of problem-oriented learning, the engagement with real robot systems, and the role of evaluation and reflection when assessing the impact on the target audience. The evaluation of the impact on student learning is addressed admirably in a number of the papers.

A further notable feature of the set of papers is the diverse set of robotics platforms that are being incorporated into the robotics education curriculum. These include toolkits that introduce students to mechanical, sensor, control, and programming components in the context of crafting robot systems. Such environments provide a lead-in to ready-built autonomous mobile robot systems that offer an experimental platform for studying advanced robot architectures and intelligence. The more traditional manipulator based robotics is now typically embedded within newer online laboratory frameworks that offer many more students access to limited resources. The good robotics laboratory now offers students a range of robotics toolkits to support their progressive development from basic awareness of robotics technology to advanced skills in programming, control and intelligence.

The papers in this special issue provide a timely statement of the state of robotics education. Much has been done and much has yet to be achieved. Robotics, for example, continues to be allied strongly with engineering programmes. This stranglehold needs to be challenged if robotics education is to reflect the diverse and growing interest in robotics among students. Chief among the open challenges for the robotics community is to establish its body of knowledge and for robotics educators to explore ways in which robotics education can be included into first degree programmes across a wide variety of disciplines.

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Dr McKee's primary research interests are in the area of network robotics, robot architectures, cooperative robot systems and telerobotics. He has developed online robot systems to support robotics education and AI teaching in undergraduate single honours and joint degree programmes. He has contributed to workshops on robotics education and has a number of conference and journal publications in the area.