## Advances in Prototyping

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Recent developments in several emerging fields enable us to think of the field of prototyping for robotics and automation in new ways and to consider new applications. Today, besides introducing intelligence directly into equipment/systems through embedded microcomputers and providing virtual prototyping through enhanced computer-aided design (CAD)/computer-aided engineering (CAE) facilities, information flow has been well regarded as an essential part of the integrated design approach, whereby all members of the prototype development and manufacturing automation team can work closely together throughout the design and manufacturing cycle. This focused issue contains five articles: an overview article, two related to automation, and two on robotics.

There are two broadly defined types of information essential to ensure the optimum performance of automation; namely, offline knowledge databases and predictive models, and online sensing (or real-time feedback). The former provides a baseline of "in-advance" information, but if routine deviations are greater than can be tolerated, the latter is needed to augment this baseline information for feedback to controllers. The first article by Lee and Sobh emphasizes two subtopics: the development of prototyping discrete-event and hybrid systems and their applications and prototyping machine vision for real-time automation applications. Following the overview article, Bloomenthal et al. describe a method for automatically generating complete process plans, including CNC code, from a high-level shape feature part description. Their approach helps designers produce functioning machined parts from their designs and minimizes the time required to design fixture details. The third article, presented by Khoshnevis et al., describes a layered fabrication technique based on a combination of extrusion and filling processes to automate contour crafting. Their computer-controlled contour-crafting technique, which has a potential to replace traditional plaster handwork and sculpting, uses computer control of troweling tools to mechanically create various surface shapes. Laliberté et al. present a rapid-prototyping technology for design and fabrication of robotic mechanisms, a complex process involving geometric kinematics, dynamics, and tolerance and stress analysis. Using a commercially available CAD package and a fused-deposition modeling rapid-prototyping machine, several examples are given. In the last article, Hagras et al. discuss the method of prototyping outdoor mobile robots using small lab-based indoor robots (that enable rapid online and autonomous learning of controllers) to transfer the learned controllers from the indoor prototype to the outdoor vehicles.

The rapid advancement of computing and communication technology has enabled designers to create "virtual product" prototyping through enhanced CAD/CAE facilities for rapid customer feedback that eases revisions and lowers the cost for making changes. The evolution of rapid prototyping systems (that can create more complex, aesthetically shaped prototypes from virtual product in relatively short time) will further accelerate this trend. Recognizing the potential impact of prototyping on manufacturing automation, a new Prototyping for Robotics and Automation Technical Committee (TC) was formed in the IEEE/RAS in late 1999. The TC activities focus on prototyping methods, tools, and systems for robotics and automation frameworks and applications. Our first and very successful symposium on *Prototyping Design and Automation*, organized for ICRA 2000, motivated us to put together this focused issue. I would like to take this opportunity to thank the reviewers for their timely and quality review as well as the authors for their cooperation in working with us to meet this ambitious goal.

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