Emerging Advances in Automation

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We are grateful for the opportunity to organize this special issue to highlight exciting new directions in automation. The IEEE Robotics and Automation Society (RAS) publishes two transactions, *IEEE Transactions on Robotics* and *IEEE Transactions on Automation Science and Engineering (T-ASE)*. The latter was established in 2004 to encourage research on the ways to sustain performance for robotic and automation systems, especially on systems that operate autonomously, often in structured environments and over extended periods, and on the explicit structuring of the corresponding environments. Sustained performance requires new theory, analysis, models, and experimental techniques for automation and the ability to provide performance guarantees. Furthermore, the corresponding results must address concepts relating to robustness, stability, productivity, efficiency, completeness, optimality, convergence, time complexity, sensitivity, verification, and reliability.

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T-ASE is widely read in China, where more than 100 universities have established automation departments. *T-ASE* and the associated annual Conference on Automation Science and Engineering (CASE) were both established in 2004 and recently celebrated their tenth anniversary. Automation has expanded beyond its roots in manufacturing to many other application domains, including health care, security, transportation, agriculture, construction, and energy. Recently, there has been a surge of international interest in how the cloud can enhance automation, e.g., the Internet of Things, industrial Internet, industry 4.0, and multiplicity (see the corresponding editorial in the April 2015 issue of *T-ASE*). There are also many exciting new applications in biology labs, warehouses (e.g., Amazon's purchase of Kiva Systems), and homes (e.g., Google's purchase of Nest). Upcoming special issues of *T-ASE* will focus on cloud robotics and automation, networked cooperative autonomous systems, the 2014 Workshop on the Algorithmic Foundations of Robotics, the 2014 CASE, home automation, human-centered automation, emerging advances in logistics, and the Internet of Things.

The following articles and tutorial were carefully reviewed and revised to provide a sample of the emerging ideas, developments, and applications outlined in the previous paragraphs.

In "Flying Smartphones," Giuseppe Loianno, Gareth Cross, Chao Qu, Yash Mulgaonkar, Joel A. Hesch, and Vijay Kumar describe how an emerging consumer electronics technology can be used to control personal drones for home automation. When the sensing and computation for a robot is performed on a smartphone, as shown in the article, the robot unit cost is decreased, and the capability of integration and reprogramming for home automation is enhanced. This article examines, in particular, how autonomous quadrotors can reliably navigate an unstructured, indoor environment to create 3-D maps.

In "Automated Vitrification of Embryos," Jun Liu, Chaoyang Shi, Jun Wen, Derek Pyne, Haijiao Liu, Changhai Ru, Jun Luo, Shaorong Xie, and Yu Sun describe an emerging application of laboratory automation for vitrification for the cryopreservation of oocytes and embryos in clinics for in vitro fertilization (IVF). Currently, vitrification is conducted manually in IVF clinics by highly skilled embryologists. Manual vitrification is a laborious and demanding task, and due to poor reproducibility and inconsistency across operators, success rates and cell survival rates vary significantly. An automated embryo vitrification system is embedded with two contact detection methods to determine the relative Z positions of the vitrification micropipette, embryo, and vitrification straw. A three-dimensional (3-D) tracking algorithm is developed for visually servoed embryo transfer and real-time monitoring of embryo volume changes during vitrification. The excess medium is automatically removed from around the vitrified embryo on the

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selected presentations and interviewed speakers, resulting in multiple articles in print and online. Representative examples include [1]–[3].

SSAR 2015 was organized by Robert Fitch (ACFR), Salah Sukkarieh (ACFR), Marcel Bergerman (Carnegie Mellon University), and Eldert van Henten (Wageningen University). We would like to thank all the participants, speakers, and volunteers for their help. Special thanks go to Ruth Olip, Claire Devonport, and Dannielle Williams for superb local arrangements and administration and to the IEEE RAS Technical Education Program for its generous support. More information about the school can be found on its Web site, http://www.acfr.usyd.edu.au/education/ssar2015.shtml.

References

[1] S. Locke. (2015, Feb.). Robotics to revolutionise farming and attract young people back to agriculture says Australian Centre for Field Robotics at Sydney University. [Online]. Available: http://www.abc.net.au/news/2015-02-04/agricultural-robotics-future-jobs/6068450/

[2] J. Becker. (2015, Feb.). Dutch robot expert developing a robot to collect eggs in free range egg farms. [Online]. Available: http://www.abc.net.au/news/2015-02-10/nswrobot-chicken-collecting-free-rangeeggs/6083152/

[3] S. Locke. (2015, Feb.). Robots for agriculture will require new start-up companies to manufacture them. [Online]. Available: http://www.abc.net.au/news/2015-02-12/robotics-for-agriculture-leave-large-machinerybehind/6088112/

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vitrification straw to achieve a high cooling rate. Tests on mouse embryos demonstrate that the system is capable of performing vitrification with a throughput at least three times that of manual operation and achieved high survival and development rates of 88.9 and 93.8%, respectively.

In "Cloud Automation," Kostas E. Bekris, Rahul Shome, Athanasios Krontiris, and Andrew Dobson address the problem of precomputing optimal motion plan graphs and recalling them on an as-needed basis from the cloud via ubiquitous networking. The authors focus on the tradeoff between the size of the graphs that must be transmitted and suggest a compact but optimized roadmap.

A new cohort of people in agriculture will develop, commercialize, and operate such systems.

In "Radiation Queue," Siqiao Li, Na Geng, and Xiaolan Xie describe a health-care application where radiotherapy capacity is assigned to patients differentiated by their required service duration, quantity, and urgency. Through an innovative patient queuing and pooling operation, the presented method allows for efficient evaluation using queuing semantics where time slots are treated as servers.

In "Short-Term Scheduling of Crude-Oil Operations," NaiQi Wu, MengChu Zhou, and ZhiWu Li address scheduling of crude-oil refinery processes, where widely used heuristics and metaheuristics are not applicable. This article develops a hybrid model and establishes schedulability conditions. The authors propose a hierarchical method that can be decomposed into subproblems with either continuous or discrete variables.

Spyros Reveliotis' tutorial "Coordinating Autonomy" presents a rigorous, comprehensive, and practical theory for resource allocation problems, capitalizing upon and extending formal frameworks from discrete event systems theory. In many contemporary applications, especially those of a more integrative nature, automation takes on the task of the allocation of a finite set of reusable resources to a set of processes that execute concurrently and in a staged manner. This allocation must observe typical performance requirements, like throughput maximization and congestion control for the constituent processes, but it must also ensure further notions of safety and liveness that are required by an autonomous operation.

There are many exciting emerging applications for automation, and this issue can only present a snapshot. We thank Editor-in-Chief Eugenio Guglielmelli, Editorial Assistant Rachel O. Warnick, all the authors and reviewers, and the RAS for this opportunity. We also encourage the readers to visit the *T-ASE* Web site to review the latest articles and editorials and to submit their own exciting research papers: http://www.ieee-ras.org/publications/t-ase.