2015 IEEE RAS Summer School on Agricultural Robotics

By Robert Fitch, Salah Sukkarieh, Marcel Bergerman, and Eldert van Henten

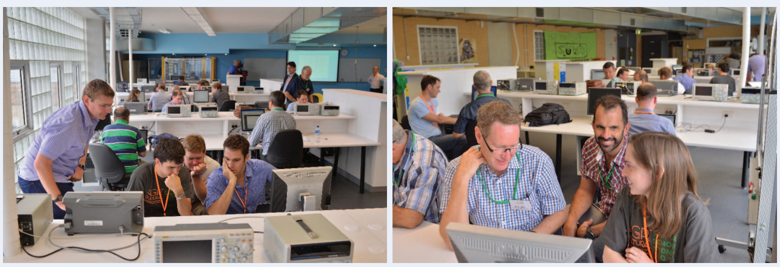
The IEEE Robotics and Automation Society (RAS) Summer School on Agricultural Robotics (SSAR 2015) was held in Sydney, Australia, 2–6 February 2015 (during the southern hemisphere's summer). The school was hosted by the Australian Centre for Field Robotics (ACFR) at the University of Sydney and was supported in part by the IEEE RAS Technical Education Program. The main aim of the school was to promote robotics research that will enable safe, efficient, and economical production in agriculture and horticulture.

Agricultural robotics is an area of growing interest with the potential to bring about profound economic and social benefits. Interest in this area is motivated by the need to improve the industries and processes that feed the planet. Agriculture has historically benefited from a stream of technical innovations, and now it must respond to significant new demands and pressures to increase efficiency with the limited or decreasing availability of human and environmental resources. In particular, the number of people involved in agriculture and horticulture in several major areas of the world has rapidly decreased over the past three decades. Robotics can play a significant role in improving the efficiency of existing agricultural methods, in introducing fundamentally new methods, and, perhaps most importantly, in helping to increase the number of people involved in the agricultural sector. Autonomous systems are currently being developed for tasks such as pruning, thinning, harvesting, mowing, targeted spraying, nonchemical weed control, and high-resolution crop surveillance. A new cohort of people in agriculture will develop, commercialize, and operate such systems.

The program consisted of presentations, hands-on activities, a farm visit, a robot demonstration, and social events.

(a) (b)

Figure 1. The speakers came from a variety of backgrounds. (a) Simon Blackmore (Harper Adams University, United Kingdom) talks about successes, motivation, and challenges in agricultural robotics. (b) Andrew Bate (SwarmFarm Robotics), a farmer-turned-robotics entrepreneur, talks about commercializing a multirobot system for broadacre agriculture. (Photos courtesy of The University of Sydney.)



(a) (b)

Figure 2. (a) The attendees participating in hands-on activities with algorithms for estimation and navigation among corn rows. (b) Many new friendships were formed within the working groups. (Photos courtesy of The University of Sydney.)

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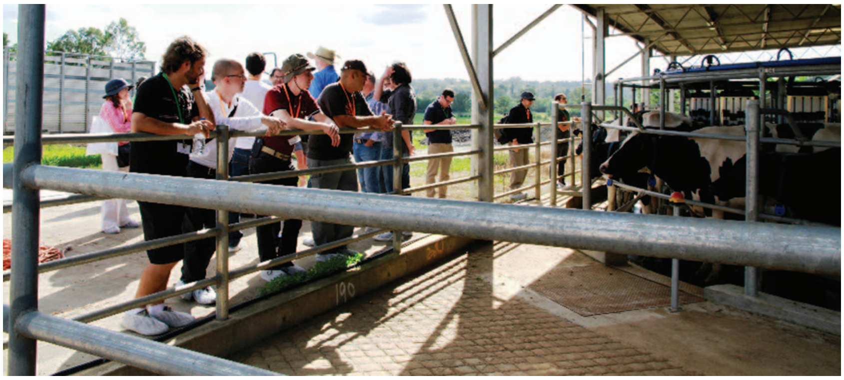

Figure 3. The participants visited Camden, New South Wales, to view a demonstration of an operational robotic rotary milking system. (Photo courtesy of The University of Sydney.)

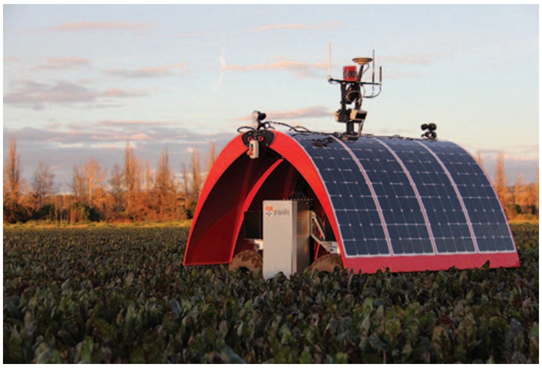

Figure 4. The Ladybird robot, designed for operation in vegetable crops, shown here at a field trial in Cowra, New South Wales. (Photo courtesy of ACFR, The University of Sydney.)

SSAR 2015 was endorsed by the RAS Technical Committee on Agricultural Robotics and Automation and was conceived as an educational event that would both collect and disseminate technical information and help to foster a cohesive and collaborative research community. The program consisted of presentations, hands-on activities, a farm visit, a robot demonstration, and social events. The school was officially opened by New South Wales Minister for Primary Industries Katrina Hodgkinson.

There were 18 presentations given by speakers spanning six different countries. The backgrounds of the speakers were diverse, ranging from roboticists to government and industry leaders (Figure 1). The technical lectures covered topics in sensing and perception, planning and control, manipulation and grasping, and systems engineering in an agricultural context. Participants also heard about major projects in the United States, United Kingdom, Europe, Australia, and Pakistan. Government and industry leaders spoke about industry-specific challenges, including a presentation by Daniel Schmoldt from the U.S. Department of Agriculture.

The hands-on activities consisted of lab-based exercises in estimation and navigation (using data from a corn field) and in perception algorithms for plant detection and classification from camera images (Figure 2). Participants also visited an operational robotic rotary milking system installation at the University of Sydney's Camden campus (Figure 3). On the final day of SSAR 2015, we toured the ACFR's field lab and saw a demonstration of the ACFR's Ladybird robot designed for operation in vegetable crops (Figure 4).

Social events played an important part in the success of the school. On the first day, participants introduced themselves via a lightning round that consisted of a rapid sequence of single-slide, 60-s presentations. A participant poster session followed, promoting informal discussion in a semistructured environment. This introductory session set the stage for further discussion throughout the week during coffee breaks, a group dinner, and the closing reception.

The 40 student participants came from a mix of backgrounds and countries. In addition to robotics graduate students and researchers, there were many participants new to the IEEE. A group photo is shown in Figure 5.

One of the main goals of the school, aside from technical education, was to create a new feeling of community among the variety of participants. There is now a clear desire to meet again through future summer schools and potentially new specialized conferences and workshops.

The school received considerable attention from Australian and international media. Several journalists attended

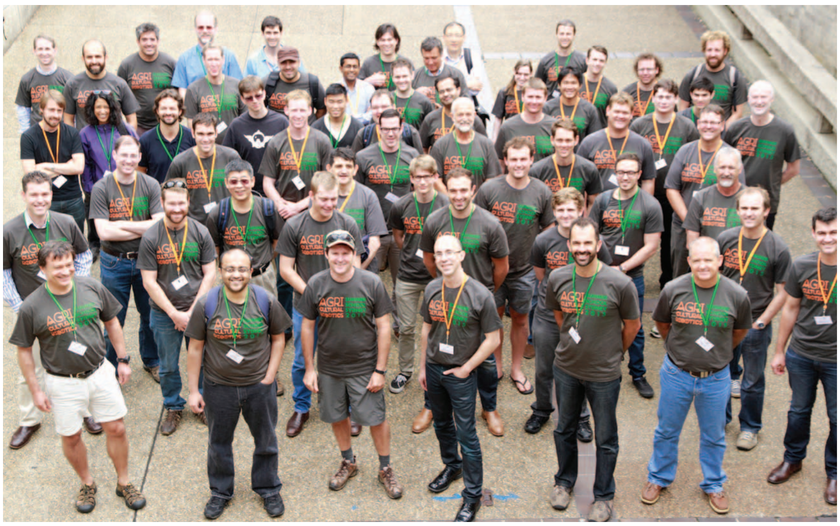

Figure 5. The SSAR 2015 participants. (Photo courtesy of The University of Sydney.)

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/

From the Guest Editors *(continued from p. 22)*

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.