2021 IEEE RAS Winter School on SLAM in Deformable Environments

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Simultaneous localisation and mapping (SLAM) is an important research problem for robot navigation in unknown environments, particularly when a global positioning system (GPS) is not available. SLAM requires a robot to be able to build a map of the environment in real-time and simultaneously estimate its own location within the map. In the last two decades, significant progress has been made in the research for SLAM in static environments. However, when the environment has deformations such as when a surgical robot is navigating in internal body environments, SLAM needs to build a time-varying 3D map of the soft tissues and estimate the location of the robot/sensor within the map. This poses a very challenging problem since the robot/sensor is moving whilst the environment is deforming.

SLAM in deformable environments is an area of growing interest within IEEE Robotics and Automation Society (RAS) and has the potential to bring about profound economic and social benefits. SLAM in deformable environments have very important applications in many different areas such as: (1) minimally invasive robotic surgery; (2) animal body shape reconstruction; (3) human body motion tracking (e.g. for sports performance analysis); and (4) motion capture in virtual reality and computer games.

The 2021 IEEE RAS Winter School on SLAM in Deformable Environments is the first winter school on this topic. The School aims to promote education and research of robot localisation, mapping and navigation in deformable environments. It is supported by IEEE RAS Technical Committee on Computer and Robot Vision. The School is hosted by the Robotics Institute at the University of Technology Sydney (UTS), Australia, over five days from 5 July to 9 July, 2021 (during the southern hemisphere winter). The School is co-sponsored by IEEE Robotics and Automation Society and Australia Robotics and Automation Association. It runs virtually due to the COVID-19 restrictions.

I. Technical and social program overview

The School is organised with nine keynotes, four lectures, four tutorials, eleven group projects, one panel discussion and four social networking sessions. The lectures and tutorials cover the fundamentals of SLAM, nonrigid structure from motion, deformable SLAM and surgical vision. The open source SLAM algorithms are used in the tutorials. We have also developed eleven group projects which are closely related to SLAM in deformable environments. All the projects require the fundamental algorithms from the lectures and tutorials and involve practical datasets. We have allocated four one-hour sessions for social networking, where students introduce themselves and know each other's research interests. On the last day, we organised the award ceremony and a panel discussion about the challenges and future of SLAM in deformable environments.

Manuscript received January 15, 2022.

II. Participants

The strong technical program including keynotes from leading researchers and high quality lectures/tutorials/projects have significantly helped to attract the participants. We have also done a lot of publicity work, such as designing the winter school web page, designing publicity poster, and publishing advertisements on social platforms (robotics-worldwide, LinkedIn, Facebook, Twitter, and Wechat). Finally, the School has attracted 228 registrations from 29 different countries in different time zones. Fig. 1 shows the distributions of the participants and some group photos after the keynotes.

III. Keynotes, lectures and tutorials

The School invited nine world-leading robotics scholars from academia and industry to give keynotes (Fig. 2). They elaborated on the research of robot localisation, mapping and navigation in a deformable environment from different perspectives, including traditional SLAM, intracorporeal visual SLAM, how to deform rigid structures, endoscopic vision research, surgical navigation, and vision for surgical robotics.

The School includes four lectures and four corresponding tutorials (Fig. 3). They disassembled the complex deformable SLAM problems, starting from the basic theoretical knowledge and extending it to specific practical applications. The lectures and tutorials cover the fundamentals of SLAM, nonrigid structure from motion, deformable SLAM and surgical vision. To improve the quality of teaching, especially for students with weak basic knowledge, the slides are shared in the OneDrive folder in advance.

Due to the different time zones, the keynotes, lectures/tutorials delivered by people from Europe are scheduled in the afternoons and evenings, while the others are scheduled in the mornings. Another strategy for solving the time zone problem is that we recorded the keynotes/lectures/tutorials. The videos of the day were uploaded and shared with all participants every evening to ensure that the participants can keep up with our program.

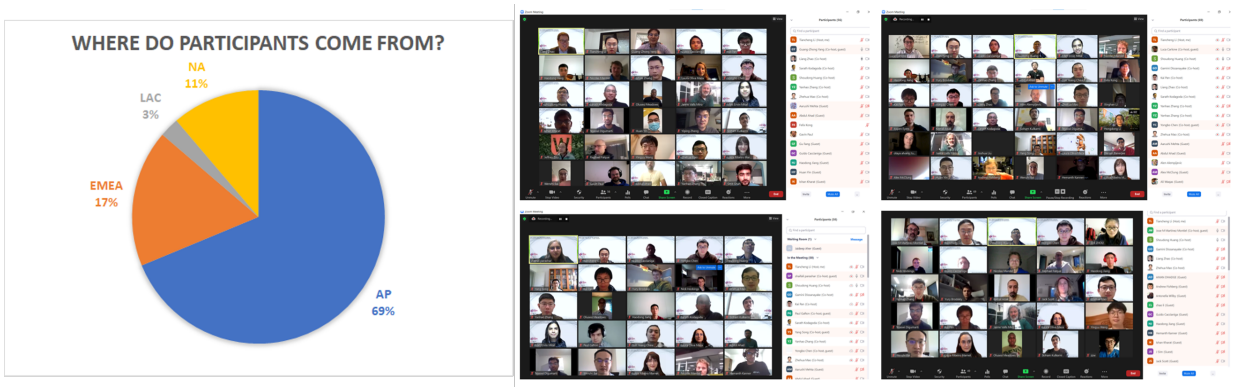


Fig. 1. The distribution of the locations of the 228 participants (AP: Asia Pacific and Japan, EMEA: Europe, the Middle East and Africa, NA: North America, including Canada, the United States of America and Mexico, LAC : Latin America and the Caribbean) and some group photos after the keynotes.

Fig. 2. Keynotes

IV. Group Project and Award Selection

We have developed eleven group projects which are closely related to the fundamental skills and algorithms from the lectures and tutorials. The developers and supervisors are from four different universities including University of Technology Sydney, University of Sydney, University of Zaragoza, and EPFL. To provide students more practical experience without physically using robots and sensors, we require each project to involve at least one practical dataset. In addition, open source codes and the datasets are provided to the students to get start on their group projects.

We have allocated ten time slots (one hour each) for students to form project groups, select projects, and work on their group projects under the supervision of the supervisors. We also created a Workspace in Slack (2021_SLAM_Winter_School) to help students to communicate with each other and discuss on their group projects. We asked the students to select three projects from the list and then our group project coordinator allocated one project to each group of students. Finally, 79 students have formed 19 groups and worked on the different group projects.

On the last day, students who worked on group projects gave presentations on their projects, and the award selection committee selected eight groups for different awards (Fig. 4) — one first prize, two second prizes, three third prizes, one best presentation prize, and one people's choice prize. The people's choice prize is based on an online vote from the audience. We have also issued "certificate of completion" to all the students who have completed a group project.

V. Panel Discussion and Social Networking

On the last day, we organised a panel discussion about the challenges and future of SLAM in deformable environments (Fig. 5). Four of the keynote speakers, Gamini Dissanayake,

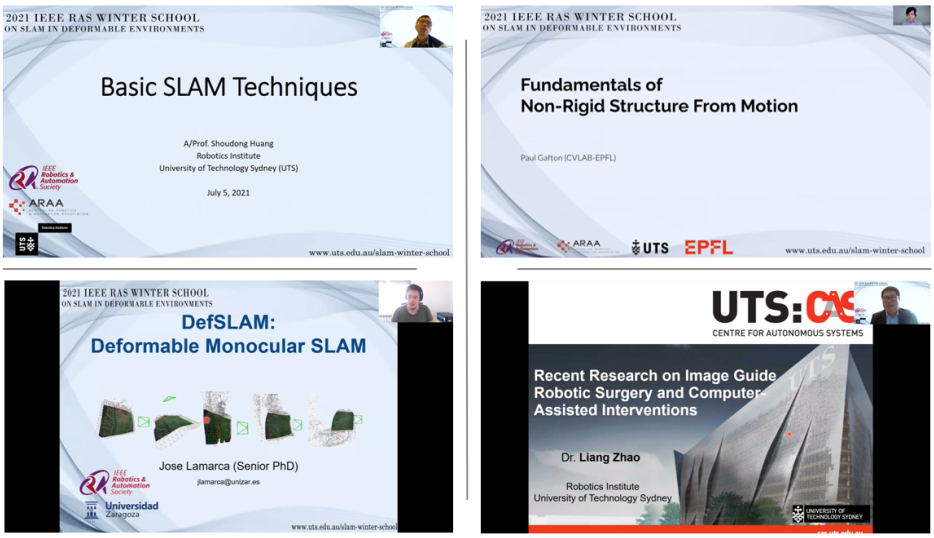


Fig. 3. Lectures

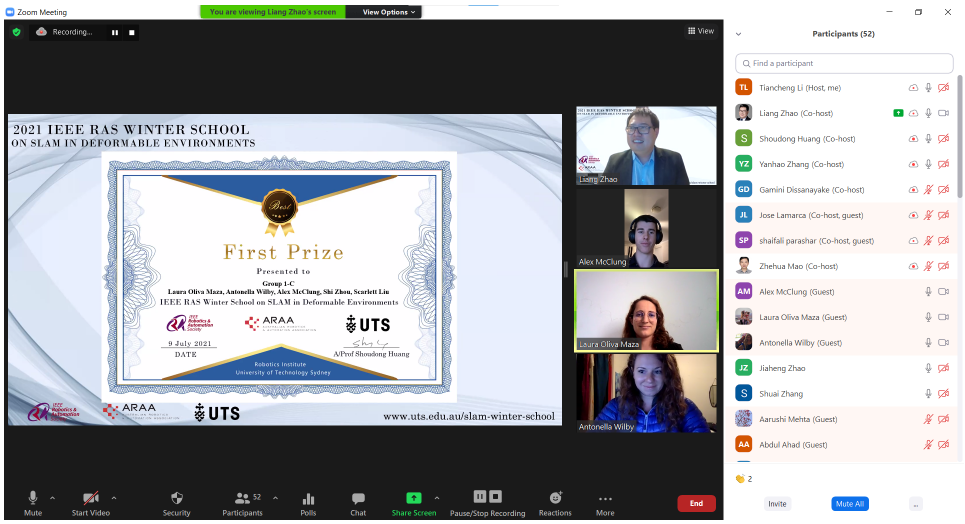


Fig. 4. Award ceremony

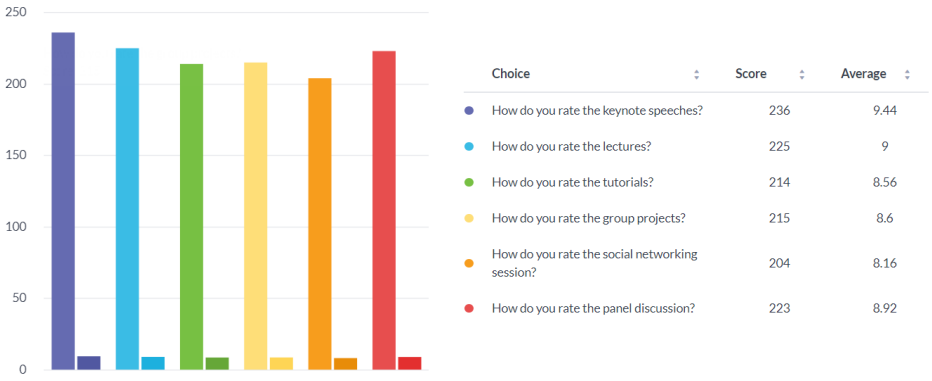
Jose M Martinez Montiel, Hongdong Li, Shaifali Parashar are the panelists. Shoudong Huang is the moderator. The panel members answered the questions from the students ranging from technical challenges of the research topic to the personal career development advices.

One important component of the School is social networking every day after lunch, where the students gave teaser/poster presentation about their research work to build up a research network with others. Students are asked to prepare three-minute presentation to introduce themselves and their current research. These sessions allow the students to know and interact with each other in a semi-structured setting. The other social component consists of informal opportunities to interact during virtual coffee breaks and lunches, where the students have access to discussions with lecturers and other students in a comfortable setting.

VI. Final Evaluation

At the conclusion of the Winter School, we evaluated the School through an online questionnaire distributed to students. The questionnaire asks students to rate the quality of keynotes, lectures, tutorials, projects, social networking, and panel discussion. Students are also asked to provide comments and suggestions on future schools to be organised in later years. The feedback results are summarised in Fig. 6. The keynote speech session is the most satisfactory part from the participants, with an average score of 9.44 out of 10. Satisfaction in the lecture part and panel discussion also get high rates (9.0 and 8.92, respectively). Many participants mentioned in the comments that the lectures and panel discussion are very helpful and meaningful. While the social networking session receives the lowest points (8.16). Some participants put forward some good suggestions for the social networking sessions, for example, people can be grouped according to

Fig. 5. Panel discussion



Choice	Score	Average
How do you rate the keynote speeches?	236	9.44
How do you rate the lectures?	225	9
How do you rate the tutorials?	214	8.56
How do you rate the group projects?	215	8.6
How do you rate the social networking session?	204	8.16
How do you rate the panel discussion?	223	8.92

Fig. 6. Feedback results

some classification criteria.

ACKNOWLEDGMENTS

We would like to thank the IEEE Robotics and Automation Society (RAS), Australia Robotics and Automation Association (ARAA), IEEE RAS Technical Committee on Computer and Robot Vision, and the Robotics Institute at the University of Technology Sydney (UTS:RI) for their strong support. We would also like to thank all the committee members, keynote speakers, lecturers and tutors, and the volunteers for their contributions and help in organising the School. We thank all the participants for their active engagement during the five days. More information about the school can be found on its website (https://www.uts.edu.au/slam-winter-school). The recorded video playlist is available on Youtube[1].

[1]https://youtube.com/playlist?list=PLVGebxYUHygtsz92WhO3nOIyaQX1FeWzD