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Undergraduate Students Compete in the IEEE Signal Processing Cup: Part 1

Signal processing is the key to success for the efficient storage, transmission, and manipulation of information. The liveliness of signal processing relies on having a large number of students who undertake this research and embark on this career path. Signal processing is part of the curriculum in many undergraduate engineering programs. Some of the students also do their capstone or final-year projects on signal processing. To increase students' interest in signal processing and to get them to better appreciate its applications in real life, the IEEE Signal Processing Society (SPS) has created an undergraduate competition, referred to as the *Signal Processing Cup* (*SP Cup*) [1], which provides undergraduate students with an opportunity to form teams and work together to solve a challenging and interesting real-world problem using signal processing techniques and methods. The first competition was held at the International Conference on Acoustics, Speech, and Signal Processing (ICASSP) 2014. Based on its success, it has now been instated as an annual event at ICASSP conferences.

This column will offer a series of articles that introduce the SP Cup, outline how graduate students are supported in the competition, how they apply their signal processing knowledge, what they have learned from the competition, and relay their feedback and experience. It is articulated into three parts, two of which will be published in upcoming issues of *IEEE Signal Processing Magazine*. In this issue, Part 1 introduces the SP Cup and the competition topics for the first and second editions. Parts 2 and 3 will describe the signal processing techniques used by the teams in the first and second competitions, respectively. We will describe how the students work together on their projects and present their feedback on key aspects of both competitions.

STUDENT TEAMS AND SUPPORT

To join the competition, undergraduate students are required to form a team. Each team must be composed of one faculty member (to supervise the team members), one graduate student (to assist the supervisor), and at least three but no more than ten undergraduate students. The teams can choose the programming language they prefer for the competition. As the competition is sponsored by MathWorks, each team that registers for the SP Cup is provided with complimentary software, including MATLAB and some selected toolboxes. The three top teams are selected to participate in the final competition at ICASSP, where the prizes are awarded. The teams are awarded prizes of US$5,000, US$2,500, and US$1,000 for first, second, and third places, respectively.

The three selected teams are also supported by the SPS with travel grants to attend the final competition at ICASSP. Each team member is offered up to US$1,200 for continental travel or US$1,700 for intercontinental travel. A maximum of three members per team are eligible for travel support. Furthermore, all attending members are given a complimentary registration so that they can also attend the conference, meet other researchers and professors, and experience the signal processing research world.

Through these SP Cup competitions, more undergraduate students can put their signal processing knowledge into practice in a real-world project. They will learn how to cooperate with other team members and develop their interest in signal processing research. The top teams also have the opportunity to expand their horizon by attending the largest signal processing conference—ICASSP. So far, two editions of the competition have been run, and both of the competition themes were proposed by the Bioimaging and Signal Processing Technical Committee of the IEEE SPS. In the first edition, students were challenged to enhance the resolution of a three-dimensional (3-D) model of macromolecular structures obtained by transmission electron microscopy and used in structural biology. Approximately 100 undergraduate students from all over the world registered for the competition and were grouped into 26 different teams. Finally, 12 teams submitted their work.

The theme for the second competition was "Heart Rate Monitoring During Physical Exercise Using Wrist-Type Photoplethysmographic (PPG) Signals." About 270 undergraduate students split among 66 teams registered for the competition. Ultimately, 49 teams submitted their work. Three teams were selected to participate in the final competition at ICASSP 2015. The following sections will briefly introduce the two competition themes, and how they were designed for undergraduate students.

THE COMPETITION THEME OF THE FIRST EDITION

The first edition of the SP Cup offered students the opportunity to design an algorithm to improve the resolution of biological macromolecules as observed in a transmission electron microscope. The goal was to provide structural biologists with tools capable of better showing the atomic structure of proteins, which determine the physiological and pathological

[FIG1] Members from the three selected teams, the judging panel, sponsors, and organizers of SP Cup 2014 attended the final SP Cup competition at ICASSP 2014.

[FIG2] Members from the three selected teams, the judging panel, sponsors, and organizers of the SP Cup 2015 attended the final SP Cup competition at ICASSP 2015.

behavior of our cells. By being able to analyze the 3-D structure of protein targets, pharmaceutical companies can design highly specific drugs that strongly interact with the target molecule of interest.

Students dived into the realm of image restoration, deconvolution, deblurring, denoising, superresolution, and sparse coding to produce state-of-the-art algorithms that allowed the resolution of the reconstructed volumes to increase by about 0.5 Å (an atom has a radius between 0.5 and 2 Å). This increase in resolution is another step forward in the scientific quest of being able of analyzing the structure and function of each of the pieces that comprises life.

THE COMPETITION THEME OF THE SECOND EDITION

In the second edition of the SP Cup, students were asked to design algorithms to estimate heart rate using PPG signals recorded from subjects' wrists during physical exercise. These algorithms can potentially be used in smart watches and wristbands for health monitoring and fitness tracking.

The challenge in this task was to overcome strong interference caused by body movements in exercise to accurately estimate heart rate. A successful system

architecture to solve this challenging problem generally consists of three components: motion-artifact removal, power spectrum estimation, and selection of spectral peaks corresponding to heart rate. Signal processing techniques for the first two components are generally taught in undergraduate signal processing courses, such as adaptive filtering for noise removal and nonparametric power spectrum estimation. For the third component, students have a lot of flexibility to design selection algorithms with full considerations to overcome various practical situations. In this competition, students can separately work on each of the parts. However, since the three components interplay with each other, students also need to collaborate in close relationship to design a successful system as a whole.

This competition not only provided an opportunity for students to solve an important practical signal processing problem tapping into their knowledge taught in class, but it also prepared them for entering related industries especially in the field of wearable health care.

COMPETITION RESULTS

The First SP Cup competition was held at ICASSP 2014 on 8 May. The judging panel

found it difficult to rank the final placement. Based on the performances of the algorithms developed and the presentations made by the three selected teams (Figure 1), the final results were as follows:

- *First place*: EPOCH (Anik Khan, Forsad Al Hossain, Tawab Ullas, Md. Abu Rayhan, and Mohammad Ariful Haque) from Bangladesh University of Engineering and Technology
- *Second place*: NtUeLsA (Kai-Wen Liang, Yen-Chen Wu, Guan-Lin Chao, Kuan-Hao Huang, Shao-Hua Sun, Ming-Jen Yang, Po-Wen Hsiao, Ti-Fen Pan, Yi-Ching Chiu, Wei-Chih Tu, and Shao-Yi Chien) from National Taiwan University
- *Third place*: Uchihas (Emroz Khan, Shiekh Zia Uddin, Mukhlasur Rahman Tanvir, and Md. Kamrul Hasan) from Bangladesh University of Engineering and Technology.

The second SP Cup competition was held during ICASSP 2015 on 20 April (Figure 2). The final results were as follows:

- *First place*: Signal Processing Crew Darmstadt (Alaa Alameer, Bastian Alt, Christian Sledz, Hauke Radtki, Maximilian Huettenrauch, Patrick Wenzel, Tim Schaeck, and Michael Muma) from Technische Universitaet Darmstadt

■ *Second place*: Supersignal (Sayeed Shafayet Chowdhury, Rakib Hyder, Anik Khan, Md. Samzid Bin Hafiz, Zahid Hasan, and Mohammad Ariful Haque) from Bangladesh University of Engineering and Technology

■ *Third place*: SSU (Gyehyun Baek, Minkyu Jung, Hyunil Kang, Jungsub Lee, Baeksan Ohn, Sunho Kim, and Sungbin Im) from Soongsil University.

From the first to the second edition of the competition, the number of undergraduate students participating in the event has increased from about 100 to 270. We foresee that students will become increasingly aware of this competition, and more and more students will get involved.

FORTHCOMING COMPETITIONS

In Parts 2 and 3, we will describe the approaches developed by the students and interview some who participated. We will report their feedback and the secrets of their successes. The third edition of the SP Cup will be held at ICASSP 2016. The theme of the 2016 competition will be announced in September of this year. We hope that this series of columns will help undergraduate students who are interested in the future competitions to gain a solid understanding of the SP Cup and help them prepare for it.

AUTHORS

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REFERENCE
[1] SP Cup Web page. [Online]. Available: http://www.signalprocessingsociety.org/community/sp-cup/

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