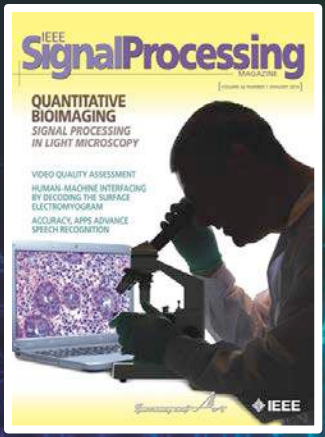
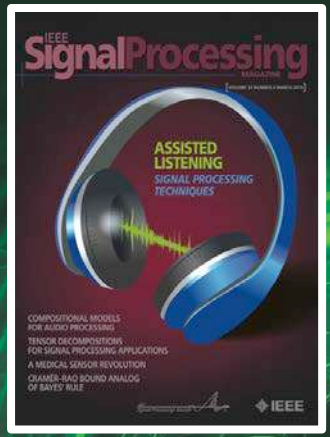
January 2015
Quantitative Bioimaging




March 2015
Assistive Listening




May 2015
Feature Article Collection

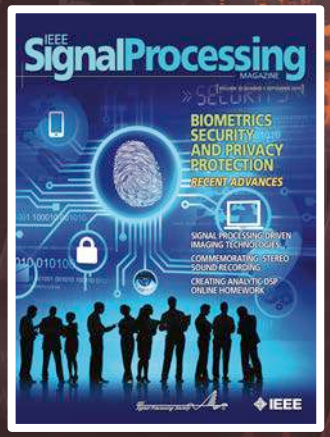

# Publish with IEEE Signal Processing Magazine

**HIGH IMPACT** among all electrical engineering publications

**REACH** a broad signal processing audience worldwide

**WELCOME** proposals for Special Issues and Feature Articles, and contributions to Columns


July 2015
Art Investigation




September 2015
Biometrics Security & Privacy


November 2015
Feature Article Collection

Min Wu
Editor-in-Chief
minwu@umd.edu

# Taking Up the Torch

It will almost be the start of a new year when you receive this issue of *IEEE Signal Processing Magazine* (*SPM*). Happy New Year to you all!

The new year accompanies major changes in *SPM's* management team. The 2012–2014 editor-in-chief, Abdelhak Zoubir, and his capable executive team of senior area editors—Fulvio Gini (special issues), Marc Moonen (feature articles), and Andrea Cavallaro and Andres Kwanski (columns and forums)—have successfully completed their terms in leading the magazine for the past three years. Given the production lead time required for the magazine, much of the technical material in this and the next several issues are attributed to their efforts. My sincere thanks are given for all of their hard work and also for their generous mentoring and assistance to help me ramp up the learning curve!

It is truly an honor and privilege for me to take on the editor-in-chief position of the magazine for the next three years. Joining me to form the new *SPM* executive team are four new senior area editors: Wade Trappe (special issues), Shuguang Robert Cui (feature articles), and Gwenael Doerr and Kenneth Lam (columns and forums), as well as Christian Debes, who was on board last year for the eNewsletter. Together with a dedicated group of associate editors and members of the senior editorial board, we are ready to take the journey to serve you.

*SPM* reaches over 20,000 readers worldwide across a diverse range of career sectors and is very different from the transactions-type of research journals with a focused scope and audience. I have been an *SPM* subscriber since my senior year in college. The magazine's tutorial surveys and overview articles gave a student like me a high-quality yet accessible way to take a peek into this incredible field. *SPM* traces its roots back to 1970 as *IEEE Audio and Electroacoustics Newsletter*. Accompanying the expanded technical scope and a then new name of the IEEE Signal Processing Society (SPS), *SPM* in its current name and form was first published in 1991. For a quarter of a century since then, six predecessors leading *SPM* before me have made strong marks in growing *SPM* into a premier publication to serve our signal processing community. As I take up the torch with awe, I ask myself: what more can be done?

**WHILE CITATION IMPACT IS AN IMPORTANT METRIC, THE ROLE AND IMPACT OF *SPM* IS MUCH MORE THAN SCORING WELL IN A CITATION RANKING.**

*SPM* has been a leader in citation impact among 200+ publications in electrical and computer engineering as indexed by the Thomson Reuters' annual *Journal Citation Report* (*JCR*). Over the past decade, *SPM* has made it to the top (multiple times) of *JCR's* "popularity measure" known as the *impact factor*, which is based on the average number of received citations in a given year for each article published in the preceding two years. Also by Thomson Reuters, a newer "prestige measure" known as the *article influence score* accounts for both the citation amount and the influences of the citing journals that have contributed to the citations; by excluding self-citations and considering a longer window of five years, the article influence score is more robust to intentional inflation and accounts for a longer-term influence. Currently, *SPM* ranks at the top in article influence score among all 250 electrical and computer engineering publications indexed by Thomson Reuters—what an achievement for *SPM*'s past editorial teams and authors!

To maintain a high citation impact, *SPM* needs to continue to identify topics of keen interest to the R&D community in the broad areas of signal processing and attract authors who can write timely and high-quality tutorial and survey articles on these topics. This is easier said than done. Citation statistics often have a few years' lag time, so actions taken by an editorial team may not be reflected in the citation until toward the end of a three-year term or well after. But help from you, our readers and community colleagues, can complement the effort by our editorial board, so that together we can sustain a high citation impact for *SPM*. For example, let us know the topics you are interested in learning about; offer us your feedback regarding the articles you see in *SPM*—what aspects you love and what aspects you hope we improve or do differently; for the articles that you find beneficial, help us spread the word by recommending them to colleagues and students, and cite these articles in your relevant writings and presentations. And if you are working on topic areas that may stimulate broad interests, consider proposing the topic for a special issue, a feature article, or a column, and publish in *SPM*!

While citation impact is an important metric, the role and impact of *SPM* is much more than scoring well in a citation ranking. A substantial number of our members and readers are not in academia or industrial academia and do not publish regularly as a major part of their jobs. They include, but are not limited to, industry practitioners as well as undergraduate and

*Digital Object Identifier 10.1109/MSP.2014.2363499*
*Date of publication: 5 December 2014*

nonresearch-track students. *SPM,* as the Society's only publication going to every member, has a distinguished tradition of offering valuable information to these readers. I will do my best to continue to serve you and make *SPM* an important part of your career advancement and personal enrichment.

In today's well-connected world, what are the best ways for *SPM* to bring signal processing-related information to you? We plan to explore ways both through the content in the traditional magazine format as well as complementary channels such as electronic, online, and social media platforms to bring you useful information. Some of these means may be in cooperation with other SPS publications, boards, and committees. I look forward to learning your thoughts on *SPM* and meeting you in the months to come through SPS conferences, Distinguished Lecturer tours, and other local Chapter events. Until then, I wish you all a healthy and productive new year!

[SP]

**ERRATA**

In the article "Location-Aware Communications for 5G Networks" by R. Di Taranto et al., *IEEE Signal Processing Magazine*, vol. 31, no. 6, pp. 102–112 [1], math was typeset incorrectly due to a production error in (2) and in the text directly following (5). In (2), a "1" should not appear before the "C" on the left-hand side of the equation. The correct way it should be displayed is as follows:

$$C(\mathbf{x}_i, \mathbf{x}_j) = \mathbb{E}\{\Psi(\mathbf{x}_s, \mathbf{x}_i)\Psi(\mathbf{x}_s, \mathbf{x}_j)\} = \sigma_\psi^2 \exp\left(-\frac{\|\mathbf{x}_i - \mathbf{x}_j\|}{d_c}\right), \qquad (2)$$

In the second line under (5) on page 106, the subscript asterisk should not be followed by a period. The correct way it should be displayed is as follows: in which $\mathbf{k}_*$ is the $N \times 1$ vector of cross-covariances $C(\mathbf{x}_*, \mathbf{x}_i)$ between $\mathbf{x}_*$ and the training inputs $\mathbf{x}_i$.

Also, two authors' names were misprinted. The corrected names are L. Srikar Muppirisetty and Dirk Slock. We apologize for the errors and any confusion they may have caused.

**Reference**

[1] R. Di Taranto, L. S. Muppirisetty, R. Raulefs, D. Slock, T. Svensson, and H. Wymeersch, "Location-aware communications for 5G networks," *IEEE Signal Processing Mag.*, vol. 31, no. 6, pp. 102–112, Nov. 2014.

*Digital Object Identifier 10.1109/MSP.2014.2364864*
*Date of publication: 5 December 2014*


The Third IEEE China Summit and International Conference on Signal and Information Processing (ChinaSIP 2015) will be held in Chengdu, China, on 12–15 July 2015. Sponsored by the IEEE Signal Processing Society, ChinaSIP is an annual summit and international conference held in China for domestic and international scientists, researchers, and practitioners to network and discuss the latest progress in theoretical, technological, and educational aspects of signal and information processing. The official language of the conference is English. Prospective authors are invited to submit up to 4 pages in length (with an optional 5th page containing only references). [**www.chinasip2015.org/**]

General Chairs: Dezhong YAO (China), Yingbo HUA (USA)
Technical Program Chairs: Ce ZHU (China), Wenjun ZENG (USA), Haizhou LI (Singapore)

Submission Deadlines: **31 January 2015** (regular full papers), **15 February 2015** (invited papers)

*Digital Object Identifier 10.1109/MSP.2014.2373471*

Min Wu
Editor-in-Chief
minwu@umd.edu

# Sharing Signal Processing with the World

I am writing this editorial for the March issue of *IEEE Signal Processing Magazine* (*SPM*) as 2014 comes to a close. My son's elementary school class just learned about the Jewish holiday of Hanukkah, the Muslim holiday of Ramadan, and the African-American celebration of Kwanzaa. This was in addition to the Thanksgiving and Christmas holidays that students are already keenly aware of. The school encourages parents to share any major holidays that their families celebrate as part of a cultural education for global citizenship. I volunteered to teach my son's class about the Lunar New Year celebrated by Chinese and several other Asian ethnic groups. Indeed, wherever we are and whatever ethnic roots we have, we are all proud of our cultural heritage. Through celebrations, not only do we enjoy this important time with our families and friends, but more importantly, we pass the cultural assets onto the next generation and share our cultures with the world.

This pride and desire to share are also common in our professional lives. Many professional groups, including the IEEE, have public outreach efforts to raise awareness of their (respective) professions and to attract more young people to join. One recent high-profile effort is CODE.org, which aims at expanding participation in computer science by making it available in elementary, middle, and high schools (known as K–12). With hands-on participation by celebrities and even U.S. President Barack Obama, this nonprofit organization developed accessible means to demystify computer programming. Within just a year from its launch, CODE.org reportedly prepared 3,000 new teachers in K–12 schools, brought an introductory course to 4 million students in 90,000 classrooms, and had tens of millions of people try an hour of programming. Even my son in elementary school proudly brought home a certificate that declared he completed an hour of coding!

This is one of many successful efforts by the computer science community in bringing excitement and the "cool factor" to the public as well as in attracting funding agencies' support. What can we learn from their efforts to advocate our field, i.e., to explain what signal processing is and to share the far-reaching contributions of signal processing with the world?

The leadership of the IEEE Signal Processing Society (SPS) has been working on this for a number of years. The most recent effort is an outreach video series led by SPS President-Elect Rabab Ward. The first video is now available on YouTube and shows the ubiquitous contributions of signal processing in our everyday life [1]. This 2-minute video uses multimedia to visualize "Signal Processing Inside," a notion coined in the September 2004 editorial by SPS Past President K.J. Ray Liu (who was editor-in-chief of *SPM* at the time). Check it out, and please share this cool video with your schools, colleagues, friends, and families.

Now comes the harder part: how can we go further to explain in accessible terms and engaging styles what signals and signal processing are? Published over a decade ago, the book *Engineering Our Digital Future: The Infinity Project* by Orsak et al. offered a unique curriculum for high school students and college freshmen to learn about digital technologies. Authored by active volunteers in the SPS community, it covered the creation, storage, and communications of various modalities of signals. Since then, digital cameras, broadband communications, and online platforms have become affordable and ubiquitous to everyone including kids and senior citizens. These advances have lowered the entry point for the general public to relate and appreciate signal processing technologies, but perhaps not through a systematic curriculum and hundreds of textbook pages.

Could and should *SPM*—known for its fine tutorials—fill in this gap to bring short stand-alone tutorials accessible to a broader audience (in addition to serving its traditional readership)? Such articles may supplement overview videos to raise awareness and the visibility of signal processing; they might serve as a bridge to invite interested students, teachers, and professionals to explore in-depth articles in the magazine (as well as the SigView online tutorials highlighted by SPS President Alex Acero in the January 2015 issue of *SPM*).

To quote Nobel Laureate Richard Feynman, the author of *The Feynman Lectures on Physics,* "If you can't explain something to a six-year-old, you really don't understand it yourself." Perhaps six-year-old readers are on the other extreme from the expert audience to which many of our authors are accustomed. As a compromise, how about explaining signal processing to a sixth grader? I invite you, our readers, to join our editorial team for this exercise, as we explore new opportunities to share signal processing with the world.

## REFERENCES

[1] IEEE SPS. "What is signal processing?" [Online]. Available: https://www.youtube.com/watch?v=EErkgr1MWw0

[2] G. C. Orsak, S. L. Wood, S. C. Douglas, D. C. Muson, J. R. Treichler, R. A. Athale, and M. W. Yoder, *Engineering Our Digital Future: The Infinity Project*. Englewood Cliffs, NJ: Prentice Hall, 2003.

[SP]

*Digital Object Identifier 10.1109/MSP.2014.2378014*
*Date of publication: 12 February 2015*

Min Wu
Editor-in-Chief
minwu@umd.edu

# Impact Beyond Numbers

When you receive this issue of *IEEE Signal Processing Magazine* (*SPM*), the International Conference on Acoustics, Speech, and Signal Processing (ICASSP) will be taking place in beautiful Brisbane, Australia. *SPM's* Editorial Board will meet in person during ICASSP. This is a valuable opportunity for the Editorial Board to reflect on the progress made so far, the plans being carried out, and to brainstorm ideas to bring the magazine to the next level.

Ten new Editorial Board members started their term this year: Sven Lončarić (University of Zagreb, Croatia), Brian Lovell (University of Queensland, Australia), Yi Ma (ShanghaiTech University, China), Henrique (Rico) Malvar (Microsoft Research), Athina Petropulu (Rutgers University), Peter Ramadge (Princeton University), Shigeki Sagayama (Meiji University and emeritus University of Tokyo, Japan), Shihab Shamma (University of Maryland), Gregory Wornell (Massachusetts Institute of Technology), and Dapeng Wu (University of Florida). Together with the continuing Editorial Board members, these colleagues have brought to our magazine a tremendous amount of collective knowledge and experiences. Knowing the many commitments that they already have, I greatly appreciate their willingness to serve on *SPM's* Editorial Board.

I would also like to welcome Dr. Andres Kwasinski, who was a devoted area editor for columns and forum for the past three years, as our area editor for social media and outreach. This newly created area editor position will help explore new types of content and provide effective outreach to members and readers.

The magazine has been a premier platform for researchers to contribute tutorial surveys and overviews on the latest advances in signal processing. This issue of *SPM* includes three clusters of feature articles centered on learning and classification, new advances in signal processing theories and methods, and interesting new signal processing applications. It is due to the tireless efforts of Prof. Marc Moonen, past area editor for feature articles, and Prof. Abdelhak Zoubir, *SPM's* past editor-in-chief, that we are able to bring this diverse set of articles to you in one issue. Prof. Shuguang (Robert) Cui, *SPM's* new area editor for feature articles, also contributed to assembling this issue. My sincere thanks to all of their efforts!

It is common today to characterize the impact of articles using citation statistics. Here, beyond numbers, I would like to share a personal experience of publishing with *SPM* that may shine some light toward the impact on authors and readers. My first article with *SPM* was in response to the call for papers to the special issue on digital rights management (DRM) more than ten years ago. I was working with several colleagues on tracing the leak of multimedia documents by embedding specially designed signals in image and video so that each copy is uniquely labeled. The guest editors reminded us of *SPM's* tutorial article style, which was in place to ensure that articles were to be understood by a broad audience.

One of the guidelines that I still remember today is the number of equations—no more than three—which sounded impossible at first: after all, we were planning to synthesize the work from a series of research papers by several representative groups, and the number of equations in each of these papers was in the double digits! This seemingly stringent constraint pushed us to think hard on how to present the ideas in accessible terms, with the minimum number of equations. For example, to explain the essential idea of a complex code construction from a seminal theoretical work, we developed a toy example and created step-by-step illustrations. This process of publishing a tutorial article with *SPM* helped me develop a deeper understanding toward the research problems and obtain valuable insights that inspired later research.

The article was published in the March 2004 issue of *SPM* as part of a timely and balanced article collection on DRM with beautiful artistic designs. The IEEE *Xplore* online library was in its infancy then. So I mailed hard copies of the issue to several researchers overseas, including one to Prof. Yanda Li, who led the signal and information processing program at my college alma mater, Tsinghua University, in China. Later that year, I received a phone call from a college friend with whom I hadn't been in contact for many years. As it turned out, this friend faced an antipiracy challenge when developing digital technologies for China's broadcasting industry, but few researchers in China at the time had worked on this problem. When he came to consult Prof. Li, my article in that special issue provided a starting point for discussion. The world is so small! Indeed, beyond citation numbers, *SPM* has served as a vehicle to connect researchers across mountains and oceans, and bring together signal processing professionals in academia and industry.

[SP]

*Digital Object Identifier 10.1109/MSP.2015.2404371*
*Date of publication: 6 April 2015*

Min Wu
Editor-in-Chief
minwu@umd.edu

# Art, Engineering, and Community

I wrote this editorial on my way back from ICASSP 2015, which was held in Brisbane, Australia, 19–24 April. I, along with *IEEE Signal Processing Magazine's* (*SPM's*) area editors, presented to the magazine's Editorial Board and the IEEE Signal Processing Society's (SPS's) Publication Board the progress our magazine has made and the plans being carried out in the first part of this year. We also discussed ideas on how we can bring *SPM* to the next level and best serve our broad community.

One idea that we are working on is to expand ways to enhance the engagement and participation of our readers. Thanks to the efforts of Andres Kwasinski, our area editor for social media and outreach, *SPM* is now present on several major social media channels (including LinkedIn, Twitter, and Facebook)—so please find us on your favorite social media platform, and bring along your friends and colleagues in cyberspace.

Inspired by *Science's* efforts in recent years to bring young scientists' voices to a wide audience, we are launching a pilot effort through social media platforms to invite you—our readers and members—to offer insight toward two questions about the career and essence of signal processing. See "Share Your Answers" for the questions and links to these discussions. Please concisely explain your thoughts, and provide your contact information (anonymous answers will not be considered). Our editorial team will select enlightening answers and publish excerpts in a future issue of *SPM* or *Inside Signal Processing e-Newsletter*. Whether you are a student, an educator, a researcher, or a practitioner, readers at all stages of their careers are welcome!

*Digital Object Identifier 10.1109/MSP.2015.2425151*
*Date of publication: 15 June 2015*

You may notice several summarizing highlights in this issue of *SPM* as well as in previous issues. We are experimenting with these highlights to bring your attention to various initiatives and resources that the SPS boards and committees are working on, especially those in electronic forms. For example, in this issue, you will see highlights of informative resources from the first quarter of the monthly e-Newsletters—in case you may have missed them (page 7)—and documents other colleagues may be talking about on the newly opened SigPort repository (page 16). We hope you will find these highlights and summaries helpful, as they point to more in-depth resources you will find in online venues.

**SHARE YOUR ANSWERS**

1) With signal processing training, what do you consider a successful career?
2) What is the most unexpected example of signal processing in our daily lives?

We want to hear from you! Visit:

- LinkedIn: http://linkd.in/1aEgGXd
- Facebook: http://www.facebook.com/ieeespm.

You will also find a pictorial summary accompanying the guest editorial of this special issue (page 14). These representative graphics, selected with input from the guest editors, are assembled to give you an at-a-glance view of the 11 articles in this intriguing special issue where signal processing meets art history. I'd like to extend my sincere thanks to the guest editors for their hard work to help bridge these two communities!

Speaking of art and engineering, I made a brief stop during my return trip transiting through Sydney, Australia, to visit one of the ultimate embodiments of art and engineering—the Opera House in Sydney Harbour. The elegance of this iconic landmark designed by the Danish architect Jørn Utzon is unparalleled—whether viewed up close from land or from the ferries traveling on the water, the curves and shape of the Opera House are always inviting and refreshing.

On a tour offered by the Opera House, I learned the dramatic story behind its vision and construction: the diverging architectural assessments among even the best-known architects on this daring idea versus a "circus tent," the skepticism and challenges on whether the curved roof could actually be built and how, the budget concerns and delay toward completion, and the resignation of the architect… yet ultimately, overcoming obstacles and controversy, the Opera House came to life from idea to icon, as a triumph of incredible creativity, perseverance, and collective effort by many!

As our signal processing community is exploring new ways to raise its visibility and strengthen its impact, we are surrounded by many ideas from devoted volunteers. Not all new ideas come easily accepted or are straightforward to implement. Perhaps the history behind the Sydney Opera House offers insights and encouragement for our community to embrace new ideas that help bring us closer and stronger, with a brighter future together!

[SP]

Min Wu
Editor-in-Chief
minwu@umd.edu

# Is Signal Processing a New Literacy?

It is summer as I write this editorial. I am leaving soon for Chengdu, a southwestern city of China known as the Land of Abundance, to attend the third edition of the IEEE China Summit and International Conference on Signal and Information Processing (ChinaSIP). This conference was the IEEE Signal Processing Society's (SPS's) first major outreach initiative to the emerging economies where there has been a large and growing base of signal processing professionals. ChinaSIP was envisioned to help colleagues in China engage with the global community and to offer global colleagues opportunities to network and develop international collaborations.

With community building and member outreach as a primary mission, ChinaSIP has explored ways to bring exposure and benefit to attendees, for example, through a series of panel discussions on career development, education, and industry perspectives. I was fortunate to be entrusted by the SPS boards and leadership to chair the ChinaSIP Steering Committee to help shape the early effort and to work with the organizing teams and numerous volunteers whose tremendous contributions have led to successful events. It is great to learn that SPS is working on leveraging the experiences from ChinaSIP and extending the community building to Asia and other areas in the coming years.

Speaking of outreach of a different kind, I also attended an interesting workshop that brought together university and industrial researchers of a diverse range of engineering backgrounds. A keynote speech given by Jim Tung, a MathWorks fellow, discussed building a new literacy. Jim shared with the audience his visits to South Korea, where he learned that the government has been making a strong effort to make computer programming/coding part of the required middle school curriculum.

At that moment of the talk, we would have thought of computer coding as a new literacy. Not surprisingly, this is in line with the computer science community's effort to bring computer programming to elementary and middle schools and to the general public (as noted in [1]). Introductory computer coding basically teaches logical thinking and expresses a solution into logical steps using the syntax of a particular computing language or platform. However, there appeared to be something missing in the coding advocacy. Through an outreach activity at an elite high school, I interacted with the lead computer science teacher, who seemed to care mostly about teaching students a particular language (be it Java or Python) and building a web page. It is common at this level that programming is treated fashionably but separate from other traditional subjects such as math, physics, and biology.

While I value the early exposure of programming (and having started mine during my elementary school years), for most students and the general public, a computer is primarily a tool to accomplish tasks and solve problems. To solve problems, we need ideas and methods, which often need to be built on top of solid foundations as well as domain knowledge. Programming then comes as an expression or implementation of those ideas and methods in a specific language or platform. This resonated very well with Jim's keynote talk, as he walked the audience through the proliferations of algorithms in almost every gadget and system we have today (such as in cars) and noted that we use algorithms to help us understand many things that surround us.

The punch line of "creating algorithms is the new literacy" in Jim's talk brought us an insightful synergistic connection between computing and other science, technology, engineering, and mathematics (STEM) foundations. Developing ideas and methods requires us to model the problem with proper angles and abstraction, apply mathematical or scientific principles, and develop an effective way to solve the problem. The resulting algorithms will be expressed or implemented using a suitable programming language or higher-level tools and platforms that encapsulate some detailed tasks into convenient modules and packages. The hard work of learning math and science at grade school levels as well as the many foundation courses in engineering and science colleges would no longer be seen as out of fashion. In fact, they can and should be as fashionable and essential as coding, if not more.

Signal processing sits right at the intersection of a number of STEM disciplines. Traditionally, it arose from physics and mathematics, and it is increasingly connecting with a broad variety of disciplines, such as biomedicine, mechanical engineering, civil engineering, material science, social science, and, of course, computing. Modeling and algorithms have been essential in signal processing as are practical implementations involving both hardware and software. So I wonder, with its bridging capabilities, would signal processing be a new literacy?

## REFERENCE

[1] M. Wu, "Sharing signal processing with the world," *IEEE Signal Processing Mag.*, vol. 32, no. 2, p. 4, Mar. 2015.

*Digital Object Identifier 10.1109/MSP.2015.2449285*
*Date of publication: 13 August 2015*

Min Wu
Editor-in-Chief
minwu@umd.edu

# Engaging Undergraduate Students

Twenty years ago I joined the IEEE and the IEEE Signal Processing Society (SPS) as a Student Member. I still remember my excitement when I received my copy of *IEEE Signal Processing Magazine* (*SPM*) in the mail, which was a big deal for an undergraduate student! I probably only had the background to understand part of the content in the magazine, but still, it was valuable exposure to this exciting field.

Jack Deller was the editor-in-chief of the very first issue of *SPM* I received. It was only last year that I had the opportunity to meet him in person, but his leadership effort paved a foundation for the critical growth of *SPM* in 1991–1997. *SPM* was attractive to many young people, including me, to pursue signal processing.

My graduate study years coincided mostly with Aggelos Katsaggelos' term as editor-in-chief (1997–2002). *SPM* has served as an important reference for graduate students like me. I remember reading the wonderful series of overviews reflecting the past, present, and future of a number of technical areas in celebration of the 50th anniversary of SPS. Under the transformative leadership of K.J. Ray Liu (2003–2005), *SPM* reformed its operation with openness and diversity, expanded its content coverage, modernized its design, and topped the citation impact ranking. Since then, I was fortunate to have opportunities to become a part of the *SPM* team and work closely with three recent editors-in-chief, Shih-Fu Chang (2006–2008), Li Deng (2009–2011), and Abdelhak Zoubir (2012–2014). Through their collective efforts, these colleagues before me have brought about a high reputation for the magazine.

*Digital Object Identifier 10.1109/MSP.2015.2468691*
*Date of publication: 13 October 2015*

Given the depth and breadth of *SPM* articles, it is not surprising that this magazine contributes to the technical growth and enrichment of graduate students and researchers. Still, I can't help but recalling where I first started reading the magazine—as an undergraduate. What can *SPM* do to serve and engage undergraduate students, the future generation of our Society? Here are a few highlights.

This year, we engaged in active discussions with the magazine team and many readers on how to make articles accessible, particularly for students and practitioners. We reached a consensus to uphold *SPM*'s tradition in keeping the number of mathematical equations to the minimum amount necessary; combined with other practices on presentation styles, the goal is to make articles appealing to the majority of our readership. It's easier said than done, and this may take some time for authors to work on their articles. We appreciate their cooperation.

We have also been soliciting articles and special issues on timely topics that can draw readers' attention and stimulate their interests. Signal processing for computational photography and smart vehicles are two such examples that students and other readers can relate to their everyday lives. We look forward to sharing these with you in the coming year.

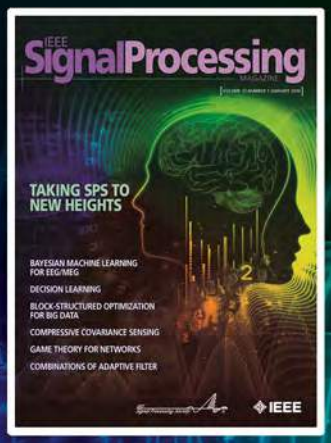
In parallel, we are bringing in-depth coverage of student activities. The July, September, and November 2015 issues of the magazine have featured a series of articles on the SP Cup competition, the Society's new initiative to engage undergraduate students. Special thanks to the past and current Student Service Directors Kenneth Lam and Patrizio Campisi, respectively, and the competition organizers, Carlos Sorzano and Zhilin Zhang, for their informative articles about the first two SP Cup competitions. The SP Cup is now open for the third edition. You can find more information in the "SP Education" column on page 113 in this issue.

We have also opened up the prestigious platform of the magazine to the students' voices and thoughts so that the magazine is not just a passive one-way communication to these burgeoning minds. For the first time, articles in the magazine included reflections in the students' own words as they participated in (and won) the SP Cup competition. Invitations have also been extended to the broad community to share their thoughts about career perspectives and signal processing in everyday life. In addition, we have been working with a group of volunteers to gather and compile contributions from undergraduate students and educators on exciting undergraduate design projects related to signal and information processing. Stay tuned for this content, and please encourage undergraduate students to contribute by answering the call for contributions that are open.

Beyond pursuing cutting-edge research, many undergraduate and graduate students with signal processing training usually join industry workforces. Students need to stay current, track the technical trends, gather practical tips and know-how, and build and extend their professional network. We are working on shaping timely, accessible, and informative content to meet their needs. It is a privilege for *SPM* to welcome undergraduates at the beginning of their careers and stay by their sides to offer them a helping hand. Please do not hesitate to give us feedback on how we are doing and suggestions on what we can do to serve you better.

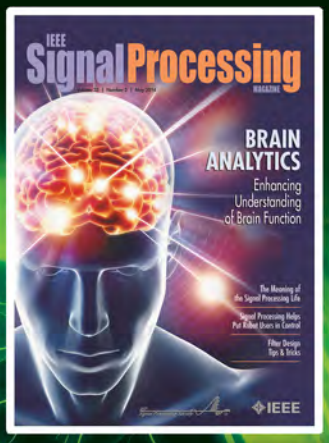
[SP]

January 2016
Feature Article Collection




March 2016
Assistive Living Technologies


May 2016
Brain Signal Analytics

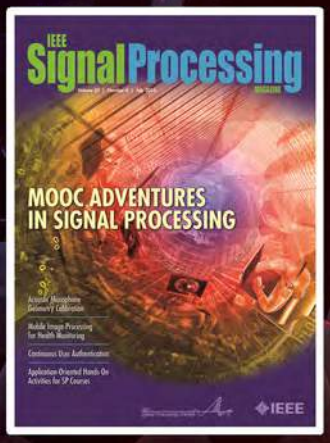



# Publish with IEEE Signal Processing Magazine

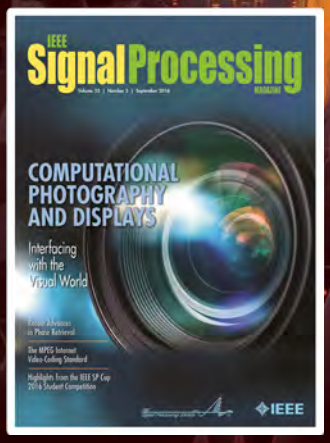
**HIGH IMPACT** among all electrical engineering publications

**REACH** a broad signal processing audience worldwide

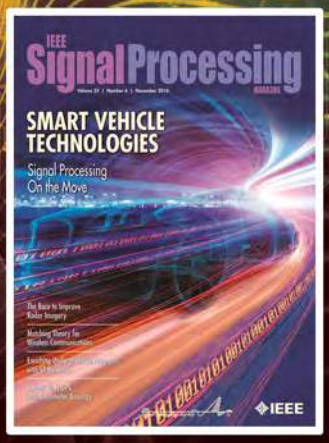
**WELCOME** proposals for Special Issues and Feature Articles, and contributions to Columns




July 2016
Feature Article Collection




September 2016
Computational Photography & Display




December 2016
SP for Smart Vehicle

Min Wu
Editor-in-Chief
minwu@umd.edu

# Women in Science, Engineering, and Signal Processing

It will almost be 2016 when you receive this issue of *IEEE Signal Processing Magazine*. Happy New Year!

I am writing this editorial during a season of harvesting. The scientific community of my native country of China experienced a breakthrough this past fall. Female scientist Youyou Tu, who has worked for over half a century at the intersection of pharmaceutical chemistry and Chinese traditional medicine, was awarded a Nobel Prize in Medicine. She was the very first citizen of mainland China who received a Nobel Prize in Natural Science.

Tu was recognized for her trailblazing contribution in extracting a core ingredient from Chinese herbs to treat malaria, saving millions of lives worldwide from this deadly disease. The key to the success was inspired by her studying ancient Chinese medicine literature from 340 AD, with modern chemistry interpretations and experimentations. Despite her leading role in carrying out the critical research, China's political turmoil during the cultural revolution put individual roles in research recognitions and publishing into such a taboo that Tu's contributions were marginalized for many years, and she has never been elected to the national academy. Yet her devotion to science and to saving lives as well as strong family support have propelled her throughout her career.

Speaking of women in science, another female Nobel Laureate, Marie Curie, widely known as Madame Curie, has been perhaps the most popular role model who inspired many girls to pursue science and engineering. In many ways, Marie Curie was seen almost like a goddess with incredible capabilities and personal strength: her trailblazing career as one of the first women to pursue scientific research when very few science colleges were open to women students and even fewer universities appointed females to their science faculty; her balanced life as both a leading scientist and a devoted wife and mother; and her ability to overcome the sudden tragic death of her husband, Pierre Curie, to continue making profound contributions in science while raising two daughters at the same time (her elder daughter later became a Nobel Laureate herself).

As I was reading a biography about this female pioneer, I learned that, throughout her childhood and professional development, she was surrounded by a strong support network: her father instilled in her interests in science since her childhood; she had supportive faculty mentors during her professional training; she had an incredible husband who treated her as a true partner in life and science; and the company of her family and friends gave her strength to live following the devastation of her husband's death. All played an important role to her triumph over many obstacles in her life and career.

Moving closer to home, our signal processing community has also seen a growing number of trailblazing women in recent decades. One fine representative of this is Prof. Rabab Ward, who will be taking the office of president of the IEEE Signal Processing Society (SPS) at the start of the new year. She was one of the first two female engineering Ph.D.s who graduated from the University of California at Berkeley and the first female winner of the SPS' highest honor, the Society Award. She became a role model as a female researcher and leader who is able to balance academic research, industrial impact, professional services, as well as be able to have a fulfilling family life with children, grandchildren, and a very supportive husband.

I know firsthand the challenges our female colleagues and students may face to balance career and life, as I am a mother of two young children myself. Strong support networks are crucial as we tackle these challenges. We can see from the aforementioned successful cases that such support networks do not just rely on women. Instead, the understanding, participation, and contributions from our male colleagues play an equally important role. On a related note, the SPS has formally created subcommittees for Women in Signal Processing and for Young Professionals under its Membership Board, and it has supported two Women in Signal Processing gatherings and a Young Professional reception at the ICIP and GlobalSIP conferences this past fall. As we bid farewell to Dr. Alex Acero, who is completing his term as SPS president, I express my sincere appreciation to him and the many SPS leaders and volunteers who have made these initiatives happen.

To our male colleagues—please (continue to) make supporting female colleagues and students a priority: the thoughtful encouragement and understanding you offer, the supportive and constructive critiques you make, the referral you give when a suitable opportunity comes, and the benefit of the doubt you provide, all of these contribute to building these support networks. To our female colleagues—we are not alone in career and life, and together, we can do both!

[SP]

*Digital Object Identifier 10.1109/MSP.2015.2501440*
*Date of publication: 29 December 2015*

Min Wu | Editor-in-Chief | minwu@umd.edu

# New Season, New Look

In many cultures, spring is a symbol of renewal. For the majority of our readers (who live in the Northern Hemisphere), it will be the start of spring when you receive this issue of *IEEE Signal Processing Magazine*. You will find a different look to the magazine from what you have become so familiar. Indeed, we are welcoming the new season with a new magazine design.

The design that we are replacing has served our members and readers for more than a decade. I still remember the refreshing look and feel of that change led by the then Editor-in-Chief K.J. Ray Liu—the font was updated, the graphics options were expanded, and, for the very first time, the magazine had a professional "perfect binding," which allowed the topic name and volume number to be printed on the magazine's spine for an easy at-a-glance view while on a bookshelf.

About a year ago, the IEEE Magazines Department brought to my attention that a redesign frequency of every three to five years is a common practice in the magazine world to keep the look and feel of a magazine up to date and stimulating. We were long overdue for a redesign by this standard. Although personally I was happy with many parts of the elegant design we had, I saw the need for more flexible templates to support appealing and informative visual content. Still, when Senior Art Director Janet Dudar told me the redesign would be a completely new design, including the cover's iconic magazine title, I was a bit hesitatant at first about the change. Like many of you, the magazine's title at the top of the front cover had been imprinted in my mind as a symbol of our magazine. But in the professional world of publishing, the decade-old font and design had begun to show some "age," while other magazines within and beyond the IEEE have embraced more modern font families and designs. Even the Google logo had undergone various redesigns, with the latest update as recent as last fall. So came the journey for our magazine to explore different design options and critique and iterate the designs to reach a new balance.

Thanks to our hardworking Area Editors Gwenaël Doërr and Kenneth Lam and associate editors, we have also experimented with new columns to complement the existing ones. For example, the traditional platform for the magazine to highlight new books is to invite volunteers who have a strong expertise in related areas to read through a whole book and write a thoughtful review, which can be a relatively slow process. Given the magazine's large readership with diverse interests, we piloted out a complementary "lightweight" version to the "Book Review" column to inform readers of more recently published books in a timely fashion. This new "Book Digest" column is intended to provide a visually appealing summary of the books that have been selected by a group of senior editors based on such criteria as timeliness of the topic, track record of the authors, training material for students, signal processing focus, and other considerations beneficial to readers. You may have seen the first "Book Digest" column in the January 2016 issue of the magazine.

Another example is a new column called "Perspectives." Several influential magazines from sister Societies routinely publish commentary sections that present analysis by technical experts or policy gurus on issues of interest to the readers. These commentaries complement the existing editorials by offering readers valuable perspectives on a broader range of issues. Inspired by the values of commentaries, we initiated this new column to highlight an area of recent exciting research and project its potential technological impact to our everyday life. You will find the first "Perspectives" column article on the prospects of time reversal techniques in the 5G wireless communications in this issue.

I would like to take this opportunity to thank the IEEE Magazines Department staff for their efforts during this redesign. Special appreciation is given to Senior Art Director Janet Dudar, Associate Art Director Gail A. Schnitzer, Managing Editor Jessica Barragué, and Senior Managing Editor Geri Krolin-Taylor—the redesign could not be completed so efficiently without their thoughtful insights!

As professionals advancing technologies, we constantly benefit from going out of the status quo and trying out different things or in different ways with an open mind. Innovations often start from that moment of willingness to try something different. We hope you feel refreshed from this new design of the magazine, and perhaps venture out from your comfort zone to explore something different in this new season. Happy reading!

SP

*Digital Object Identifier 10.1109/MSP.2015.2512339*
*Date of publication: 7 March 2016*

Min Wu | Editor-in-Chief | minwu@umd.edu

# Silk Road in the New Millennium

I am writing this editorial just days before heading to Shanghai, China, to attend ICASSP 2016. This is the first time that the IEEE Signal Processing Society (SPS) has held its flagship conference, the 41st in the series, in Mainland China. ICIP will follow the footsteps of ICASSP and be held in Beijing, the capital city of China, in September 2017. And, for the first time, ICASSP will be held in South Korea, in 2018. In a sense, major SPS conferences are paving the way for the SPS to develop a strong presence in Asia and encourage engagement between communities in the East and the West, playing a role of what the Silk Road once achieved.

For colleagues in North America and Europe, traveling to conferences in Asia often takes nearly a whole day. When we frown about the long travels for these major conferences increasingly being held in Asia, have we thought about when the tables were turned? Colleagues from Asia (as well as such regions as Australia, New Zealand, and South America) have had to travel that far for the vast majority of past conferences that were held in North America or Europe!

Growing up in China, Asia is undoubtedly special to me. Emotional attachment aside, we have seen a rapid growth of SPS membership and our magazine's readership in Asia, now accounting for nearly 30% of total SPS members. I want to share with you what I recently learned from two efforts related to Asia, as they brought enlightening thoughts about the spectrum of future SPS activities and magazine contents.

The first event in my ICASSP trip is to organize the final competition of this year's IEEE Signal Processing Cup (SP Cup) global competitions. The SP Cup provides undergraduate students with an opportunity to form teams and work together to solve a challenging and interesting real-world problem using signal processing methods. SP Cup 2016 has seen participations from 28 countries, covering every habitable continent. For three years in a row, we have seen enthusiastic involvement of undergraduate students from Asia. Not only are more than half of the team submissions in 2016 from Asia, but at least two out of three finalists in each SP Cup so far came from Asia.

The second effort I'd like to share addresses a traditional conference model that has focused on publishing the latest original research work. With its selective nature on paper acceptance as well as a nontrivial registration fee, attendees would be limited to primarily researchers and doctoral students in well-funded research institutions. But last summer, I learned of a grassroots effort by an enthusiastic group of mid-career Chinese colleagues. They initiated an annual gathering of Vision and Learning Seminars (VALSE), which aims to help researchers, practitioners, and graduate students in China acquire the latest knowledge and elevate the overall technical levels. To lower the engagement barrier, VALSE is free to attend and uses local language in oral communications; to reduce overhead and seek to complement, instead of compete for papers with highly established conferences, VALSE does not have submission of new papers, and instead the focus is on invited talks by active researchers and rising stars and highlights of recently accepted papers in major journals and conferences. Within just six years, VALSE has energized the computer vision community in China and attracted more than 1,000 participants and numerous industry sponsors. It also utilizes social and online platforms to engage people at different career stages and is extending its activities to provide webinars and learning resources throughout the year.

Seeing the encouraging responses toward these activity models, I wonder: can a new model of community learning in a geographic region address what's missing between traditional research conferences and one-time local Chapter events? Will the SP Cup complement the traditional classroom learning and connect signal processing students around the world to develop a global community? *IEEE Signal Processing Magazine* has technical readership spanning broad backgrounds and needs, so what can we learn from the enthusiastic responses of undergraduate and professionals in Asia toward these events? Perhaps insights on these questions will shine a light on this modern-times Silk Road between the East and the West for the signal processing community.

SP

*Digital Object Identifier 10.1109/MSP.2016.2531039*
*Date of publication: 27 April 2016*

Min Wu | Editor-in-Chief | minwu@umd.edu

# Journey of Learning

For many of our readers, a career in signal processing may have started from a course, a (text)book, or an article that introduced signal processing to us. With roots in mathematics and physics, signal processing has grown tremendously over the past century; especially after being combined with digital and computing technologies, it has become a vital field that powers our digital life.

One of the missions of *IEEE Signal Processing Magazine* (*SPM*) is to provide educational value to our community. We appreciate that many readers consider the magazine their first stop in learning about a topic relatively new to them through the magazine's tutorial-style survey and overview articles. This issue of the magazine brings to you several technical features and columns covering a variety of topics.

Advances in multimedia and communications technologies, in which signal processing has played important roles, has enabled new ways to deliver course material beyond traditional textbooks and in-person lectures. Massive open online courses, or MOOCs, became a popular mode of online distance learning a few years ago. *The New York Times* called 2012 "the year of the MOOC," when several well-financed providers emerged with close collaboration with a number of top universities. Courses on these platforms have an impressively high enrollment of learners worldwide. Although the overall participation rate of serious learners who persist to complete course requirements was debatable, one thing is clear: technologies have changed the ways educational content is presented and shared.

Three groups of signal processing experts from EPFL, the Massachusetts Institute of Technology, and Rice University, widely known for their research and educational contributions to our community, have taken part in creating MOOC educational content on signal processing. In this issue of the magazine, Baran et al. teamed up to reflect on their efforts: What efforts were tried? What worked? What were the commonalities and differences between their MOOCs as well as their on-campus courses? Their special feature article will address these questions.

Going beyond foundational courses, signal and information processing also play an important role in many engineering design projects. Yet there have been few platforms to survey these seemingly adhoc efforts done independently at many institutions. A new article series is being developed by a guest editor team to provide a focused opportunity to share experiences and best practices on undergraduate design projects and hands-on training that incorporates a strong element of signal and information processing. The first article of this series appears in this issue on page 84 and is on application-oriented hands-on activities for learning continuous signal processing. I appreciate the willingness and dedication from the guest editors and the authors to tackle such a topic that is quite different from the usual research articles and is often challenging to put together.

Also, as part of this article series, for the first time, *SPM* is inviting our broad community to share their input on recent undergraduate design projects related to signal and information processing. The guest editor team will review the submissions to select representative projects based on quality, originality, topic coverage, and diversity, and then they will compile an article to include the highlights of the projects for an upcoming issue of *SPM* with an acknowledgment of project authors and mentors. Please see the announcement on page 102. We look forward to receiving your submissions.

In a broad sense, signal processing education extends beyond degree-oriented education and the walls of universities. Among activities supported by the IEEE Signal Processing Society (SPS) are popular tutorial programs in major conferences; Chapter events and seasonal schools that run multiple times a year worldwide; a signature series of invited talks on technical trends and overviews at SPS's outreach effort of ChinaSIP and the Signal and Data Science Forum, and more. Now, teaching notes and lecture slides are also hosted on the IEEE SigPort repository, and videos and webinars of tutorials and technical talks can be found on the SigView resource center.

According to an old saying, it is never too late to learn. Whether you prefer the old-style learning or are open to trying some fashionable new ways, I hope you will find *SPM* and other mechanisms provided by SPS a trusted source to help your lifelong journey of learning signal processing.

SP

*Digital Object Identifier 10.1109/MSP.2016.2566398*
*Date of publication: 1 July 2016*

Min Wu | Editor-in-Chief | minwu@umd.edu

# Blurred Boundaries

What is signal processing and what isn't? From time to time, I would come across comments related to this question from independent reviews regarding whether an article that was submitted to *IEEE Signal Processing Magazine* fit the scope. I have seen reviewers recommending an article surveying signal processing techniques for wireless communications to a communications-related publication instead, or an article related to imaging or image analysis to a computer vision-related venue.

This would have been commonly accepted several decades ago when various fields under the IEEE umbrella were well partitioned into different technical Societies. The IEEE Signal Processing Society (SPS) traces its roots to 1948 as the IEEE's first Society, with the name and scope as the Professional Group on Audio of the then Institute of Radio Engineers (IRE), the predecessor of the IEEE. Looking at the historic roster of the SPS's technical committees (TCs) (as shown in "SPS Technical Committees Then and Now: Evolved and Broadened Scope of Signal Processing"), we can see that just 40 years ago in 1976 when the Society's first flagship conference, the International Conference on Acoustics, Speech, and Signal Processing (ICASSP), was launched, there were only five SPS TCs, and they were dealing with either signal processing theories and methods, or speech and acoustics. There was little mention of communications nor much presence of visual processing in the SPS TC structure, even though many fundamental signal processing theories and techniques had been used rather extensively in those areas and further extended and adapted to solve the problems there. Moving forward about ten years, we see that visual aspects in a more general sense of multidimensional signal processing were added to the TC list by the mid-1980s. And now, 40 years later, we see more than a dozen TCs in the SPS, with a diverse range of "new" areas explicitly embraced, including communications and networking, multimedia signal processing, biomedical-related signal processing, and information forensics and security.

Year after year, signal processing, together with other fields, have evolved, and the boundaries between several traditionally separate fields have been blurred. Many colleagues have been actively involved in multiple technical societies, fostering interaction and bringing beneficial aspects between fields. Innovations have often happened at the boundaries between traditionally separate fields.

(continued on p. 7)

**SPS Technical Committees Then and Now: Evolved and Broadened Scope of Signal Processing**

| Year: 1976 | Year: 2016 |
|---|---|
| Digital signal processing | Audio and acoustic signal processing |
| Digital measurement of noise | Bioimaging and signal processing |
| Electroacoustic transducers | Design and implementation of signal processing and systems |
| Speech processing | Image, video, and multidimensional signal processing |
| Underwater acoustics | Information forensics and security |
| | Machine learning for signal processing |
| **Year: 1987** | Multimedia signal processing |
| Audio and electroacoustics | Sensor array and multichannel |
| Digital signal processing | Signal processing for communication and networking |
| Multidimensional signal processing | Signal processing theory and methods |
| Spectral estimation and modeling | Speech and language processing |
| Speech processing | Industry DSP technology standing committee |
| Underwater acoustics | Special interest groups: Big Data, Computational Imaging, and Internet of Things |
| VLSI for signal processing | |

*Digital Object Identifier 10.1109/MSP.2016.2590603*
*Date of publication: 2 September 2016*

at the IEEE no later than 3 October 2016 to be counted. Members must meet the eligibility requirements at the time the ballot data is generated to be eligible to vote. To be eligible to vote in this year's Society election, you had to have been an active SPS member or affiliate (excluding student member) prior to 1 August 2016. This is the date when the list of eligible Society voting members was compiled. The candidates for regional director-at-large are

- *Regions 1–6*: Radhakrishna (Radha) Giduthuri and Zhengdao Wang
- *Region 8*: Sven Loncaric, John McAllister, and Ana Isabel Pérez-Neira.

The candidates for member-at-large are

- Abeer A.H. Alwan
- Homer H. Chen
- Shoji Makino
- Marc Moonen
- Antonio Ortega
- Beatrice Pesquet-Popescu
- Gaurav Sharma
- A. Lee Swindlehurst
- Zhi (Gerry) Tian.

The BoG is the governing body that oversees the activities of the SPS. The SPS BoG has the responsibility of establishing and implementing policy and receiving reports from its standing boards and committees and comprises 21 Society members: six officers of the Society who are elected by the BoG, nine members-at-large elected by the voting members of the Society, four regional directors-at-large elected locally by Society voting members of the corresponding region, as well as the Awards Board chair. The six officers are the president, president-elect, the vice president-conferences, vice president-membership, vice president-publications, and vice president-technical directions. The executive director of the Society shall serve ex-officio, without vote.

Regional directors-at-large are SPS members who are elected locally by Society voting members of the corresponding Region via the annual election to serve on the Society's BoG as nonvoting members and voting members of the Society's Membership Board.

Members-at-large represent the member viewpoint in the Board decision making. They typically review, discuss, and act upon a wide range of items affecting the actions, activities, and health of the Society.

More information on the SPS can be found at http://www.signalprocessingsociety.org/.

SP

## FROM THE EDITOR *(continued from page 3)*

And yet, worldwide, a number of signal processing programs and funding agencies still consider the narrow scope of signal processing as if it were the 1970s or 1980s. For example, in a country that I visited, the funding agencies and graduate programs treated image processing separately from signal processing. This unfortunately would constrain the breadth of students' preparation in their training and limit the potential source of innovations.

**While we welcome and appreciate articles on core signal processing areas, our magazine is uniquely positioned to convey and embrace this evolving scope of signal processing.**

While we welcome and appreciate articles on core signal processing areas, our magazine is uniquely positioned to convey and embrace this evolving scope of signal processing. Through engaging authors and publishing articles that reflect the crossbreed of multiple traditionally separated areas—both close and far—and bringing new advances from other areas that are of interest or benefit to signal processing professionals and vice versa, we hope the magazine will contribute to foster synergies and exchanges between areas and fields and help shape the future landscape of signal processing—the science behind our digital life.

This issue of the magazine showcases an example of a cross-disciplinary area—a special issue on fascinating advances of computational photography and display. The timing also coincides with the IEEE International Conference on Image Processing (ICIP) to be held in Phoenix, Arizona, which features a visual technology showcase and visual innovation award.

As a final note, I would like to take this opportunity to thank all of the reviewers who have been so generous in offering their precious time and efforts in providing critical and constructive comments to the articles being considered by the magazine. We appreciate their contributions that are essential to the success of the magazine!

SP

Min Wu | Editor-in-Chief | minwu@umd.edu

# Publishing Articles in *IEEE Signal Processing Magazine*

The 2016 update of *Journal Citation Report* (*JCR*) was recently released by Thomson Reuters. Based on 2015 citation data for literature within the sciences and social sciences, *IEEE Signal Processing Magazine* (*SPM*) has continued to score high in this annual citation study. Its journal impact factor in this 2016 release reached 6.67, the highest ever in *SPM*'s history! It is in the top 1% out of more than 250 publications in the electrical and electronics category examined by the *JCR* and continues to be the top-ranked magazine in the IEEE.

*SPM*'s sustained success could not be possible without the tireless effort from our area editors and associate editors on both the current team and the teams before. They work with prospective authors to solicit articles on timely topics of broad interests, oversee peer reviews, and polish the accepted articles until the final stage of production. The Publications Board of the IEEE Signal Processing Society (SPS) initiated an annual recognition to honor the contributions of outstanding editors and editorial board members. For this inaugural year, Dr. Fulvio Gini, area editor for special issues in 2012–2014, and Dr. Gwenael Doerr, area editor for columns and forum in 2015–2016, were recognized for their outstanding contributions. I extend my heartfelt congratulations and appreciation to them!

As another essential part of our team, senior editorial board members offer vital advice. I would like to take this opportunity to thank six retiring board members for their valuable contributions. We appreciate the prompt and thoughtful feedback by Dr. Isabel Trancoso and Dr. Hing Cheung So on nearly every proposal for special issues and feature articles sent to the editorial board; Dr. Pramod Varshney, Dr. Hamid Krim, and Dr. Patrick Flandrin offered constructive input on the magazine's policy and potential topics; Dr. Z. Jane Wang took the lead in organizing a wonderful pilot of a feature articles cluster—the May 2016 issue on brain analytics, allowing the magazine to develop a synergistic option between feature articles and a special issue. Thanks also go to two retiring area editors, Dr. Wade Trappe and Dr. Gwenaël Doërr, for their contributions to special issues and columns, respectively, and a warm welcome to Dr. Douglas O'Shaughnessy as our new area editor for special issues.

By far, the most important part of any successful publication is the authors, who, in our case, also include the guest editors proposing and organizing special issues and article clusters or series. They are the heroes behind the magazine's sustained high impact.

When welcoming authors from around the world, we note that many initial submissions often have to be declined for being out of scope, because our magazine is very different from other publications that focus on reporting new research results. Instead, *SPM* publishes tutorial-style surveys, overviews, and column articles of interest to the broad signal processing professionals and related communities. We do not consider papers proposing brand new algorithms that have not been sufficiently examined by the technical community, and these types of articles should be sent to journals. Articles also need to be written in an accessible style for a audience broader than experts only, using visually appealing illustrations and keeping mathematical equations and symbols to a minimum.

We strongly suggest prospective authors read *SPM*'s online "Information for Authors" [1] and refer to recently published articles in the magazine for examples. Before working on a full-length feature article or organizing a special issue/section on a central theme of sufficient technical interests and maturity, authors should first prepare a short proposal as outlined in the author guide. Complementing feature articles and special issue articles in each issue are shorter articles in columns and forums on a wide range of topics in signal processing, and they are divided in categories with different objectives and style. Authors wishing to submit an article or a proposal are encouraged to contact me or the respective area editor. We look forward to working with you and hope that you consider *SPM* as your top choice in which to publish when you have source material in the magazine's scope and style.

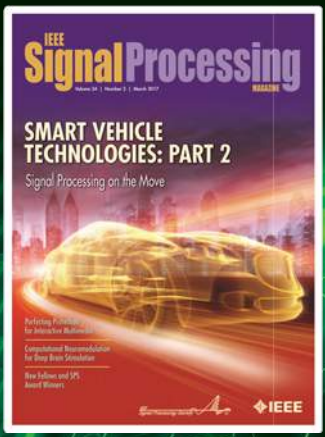
## Reference

[1] IEEE Signal Processing Magazine: Information for Authors. [Online]. Available: http://signalprocessingsociety.org/publications-resources/ieee-signal-processing-magazine/information-authors-spm

*Digital Object Identifier 10.1109/MSP.2016.2610482*
*Date of publication: 4 November 2016*

January 2017
Hands-on Learning/Design


March 2017
Smart Vehicle – Part 2




May 2017
Feature Article Collection

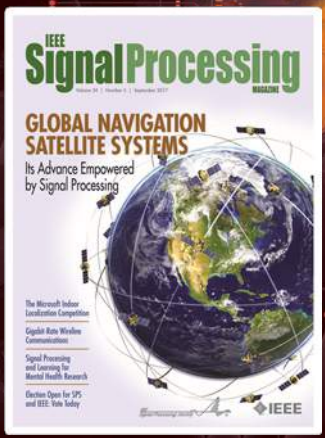

# Publish with IEEE Signal Processing Magazine

**HIGH IMPACT** among all electrical engineering publications

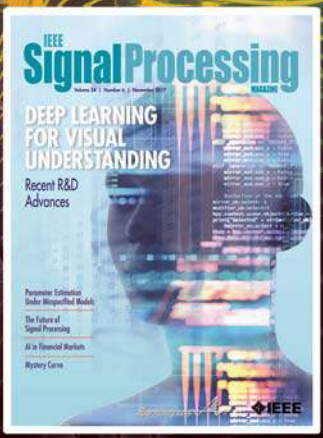
**REACH** a broad signal processing audience worldwide

**WELCOME** proposals for Special Issues and Feature Articles, and contributions to Columns


July 2017
Feature Article Collection




September 2017
Global Navigation Satellite Systems




December 2017
Deep Learning

Min Wu | Editor-in-Chief | minwu@umd.edu

# Signal Processing: The Expected and the Unexpected

It will be the start of another new year when you receive this issue of *IEEE Signal Processing Magazine* (*SPM*). Happy 2017 to all our readers, editors, and reviewers!

Not long before I began writing this editorial, the 2016 edition of the IEEE International Conference on Image Processing (ICIP) was successfully held in Phoenix, Arizona. In addition to the rich and timely technical sessions that ICIP is well known for, the ICIP 2016 team—led by General Chair Prof. Lina Karam, who is also serving on *SPM*'s senior editorial board, and Industrial Program Chair Dr. Haohong Wang—spearheaded the first Visual Innovation Award. Going over the finalists' roster, you may very well find yourself having been a user of some of these technologies: the YouTube video streaming service, the Lytro light-field camera, the Intel RealSense camera technology, the CUDA high-performance computing by NVIDIA, the Netflix movie streaming service, the Oculus virtual reality technology, and the Microsoft Kinect.

For many signal processing professionals, including those who regularly attend ICIP—a flagship conference of the IEEE Signal Processing Society (SPS)—it might almost have been taken for granted that signal processing plays a key role behind these visual innovations. Whether it is image formation, sensing, compression, or communications, signal processing provides the underlying technical foundation.

*Digital Object Identifier 10.1109/MSP.2016.2632218*
*Date of publication: 11 January 2017*

Right after ICIP, I briefly stopped in the San Francisco Bay area, where I gave a keynote speech at a North American alumni forum of my college alma mater, Tsinghua University, in Beijing, China. Different from ICIP, I did not expect this forum to be a venue to see so much signal processing other than the talk on microsignals for media security that I would be giving. I did my undergraduate study in the Department of Automation at Tsinghua University. "Automation" as an engineering major covers a combination of control and robotics, electronic sensing and diagnosis, signal processing, and pattern recognition; within the department, different specialty directions were rather compartmentalized historically. Perhaps it was due to the difficulty to find an exact matching department in North American universities that college alumni from the department went in different ways when pursuing their graduate studies in North America. Among them, you will find experts on securing sensors and sensor network, on supply chain management behind some of the most wanted consumer products, on designing the next-generation mass spectrometry analyzer, and on international finance and policy making, just to name a few.

Yet through this stimulating day-long event, I learned a great deal about many broad applications of signal processing. For example, a keynote speech given before mine provided an overview on designing and analyzing sensing signals for fault-tolerant operations in such complex systems as the quality control and enhancement in steel manufacturing and the signaling in China's high-speed train systems. As it turned out, many challenging issues addressed by the keynote speech have benefited from signal processing theories and techniques. Two panel discussions on the recent hype of artificial intelligence and the Internet of Things also touched on such issues as sensing, denoising, and statistical learning from signals and data. In addition, several alumni who are successful in venture capital investment highlighted the important roles of data and data analytics that they saw in developing sustainable new businesses.

Most speakers at the alumni forum would not consider themselves to be professionals in signal processing, and not many have read our magazine. It reminded me of "Signal Processing Inside," a notion coined in *SPM*'s September 2004 editorial by then Editor-in-Chief Prof. K.J. Ray Liu, and the blurred boundaries between disciplines discussed in my September 2016 editorial. Inspired by those expected and unexpected venues where signal processing shines, I am working with our magazine editors to develop leads on informative articles for our readers in the coming months. We welcome your suggestions on topics that you would like to read about.

Best wishes to you all for a prosperous new year ahead—another year filled with exciting signal processing!

SP

Min Wu | Editor-in-Chief | minwu@umd.edu

# A Conversation About Signal Processing at Elementary School

When you receive this issue of *IEEE Signal Processing Magazine* (*SPM*), a number of readers will be heading to New Orleans, Louisiana, for the 42nd International Conference on Acoustics, Speech, and Signal Processing (ICASSP 2017). New Orleans is well known for its cross-cultural heritage embodied by its distinctive architecture, cuisine, and music. I look forward to this annual gathering and flagship conference of members of the IEEE Signal Processing Society (SPS), and I hope to see our magazine team and many readers there. A number of SPS boards and committees will meet at ICASSP. Among them, several are related to education and outreach for which the SPS has been making significant efforts to improve the understanding and appreciation of our field by outside communities.

Speaking of education, the public school system where I live has a tradition of encouraging parents' participation in their children's learning. One of the weekly activities that my son's elementary school invites parents to sign up for is called "Mystery Reader." This is a fun way for parents to spend some time reading a book or other appropriate material of their choice to the class. Adding to the mystery is the surprise factor: a parent does not share with his/her child that he/she is the mystery reader and instead provides a clue to the teacher who will then share the clue with the class and ask them to guess whose parent is coming to read.

*Digital Object Identifier 10.1109/MSP.2017.2650179*
*Date of publication: 3 March 2017*

When I did this last year, I picked a book from the "Who Was/Is?" series of biographies published by Random House tailored to elementary school readers. I read to students excerpts of *Who Was Dr. Seuss?* (by Janet Pascal and illustrated by Nancy Harrison). As some of our readers may know, Dr. Seuss is the pen name of Theodor Seuss Geisel, an American writer, cartoonist, and artist who authored some of the most popular children's books, many of which have been used in American elementary classrooms today. One of his most beloved books, *Green Eggs and Ham*, consists of just 50 different words from a simple vocabulary for beginning readers. With bouncy rhymes, an imaginary storyline, and fun visual characters, Dr. Seuss revolutionized children's reading material from the quite limited and boring collection of the past.

This time, I was inspired after seeing my son's class "publish" a book nearly every year, whereby students developed every page with a drawing and a few lines of writing. I thought it would be fun to bring something that I wrote during my studies to share with the class, such as *Multimedia Data Hiding* (Springer, 2003, with Prof. Bede Liu), a book extended from my doctoral thesis work; I also picked two issues of *SPM*, to serve as more recent examples.

As I entered the classroom, over two dozen third graders sat around a rocking chair with curiosity and eagerness on their faces. I started by showing them the book's cover, explaining in as simple language as I could about this research of putting invisible data in pictures. I then took a highly sparse "sampling" of a few pages in the book. I showed them a cartoonish block diagram outlining the data embedding process, a pictorial example to visualize the before and after of data embedding and extraction, and a page containing an illustration of groupings of colored balls drawn randomly from a bag and many equations modeling this game. These examples showed the students that grown-up researchers try various ways to explain their work to readers, and their skills are built on top of what they learned in elementary school.

Moving to the second half of my reading, I took out the two issues of *SPM*. When I explained the name of the magazine, which is also the field of our study, I asked the students whether they had heard of signal processing and any examples they knew. A girl sitting in the front raised her hand high: "It is about radar and the signals it has …" Thanks to a number of R&D labs and companies in the Greater Washington, D.C. area, some of our young people have picked up an amazing amount of technical terms. "Also the pictures! And music! And cell phones!" said several students, eager to contribute. Their minds are like a sponge—once stimulated, they are so absorptive that they had already related to what we had discussed a short while ago on the digital revolution and the gadgets they have.

I showed them the cover of *SPM*'s September 2016 special issue on researching new generations of cameras and displays. I flipped to the the guest editorial [1], a page containing a visual summary of the articles included in the

special issue. There, they saw a miniature camera that is smaller than a fingernail, a light-field camera that captures different focus and depth of a scene, a dissection of a virtual reality (VR) headset, and an analysis of the invisible signatures in paintings, just to name a few. The class was excited about these: "Oh, yes, I tried new goggles, and it's so cool!" said a boy about a VR headset he tested during the holiday season. "I have to have that camera," said a girl to me afterward.

I then turned to the first page of the magazine and told them that I had an essay assignment for each magazine issue, just like the writing tasks they regularly have, and that my editorials drew inspirations from interacting with other people, including them—my son's elementary school class. To calm the puzzled expressions on many of the students' faces, I read to them the first part of my editorial in the March 2015 issue of the magazine [2]. That particular editorial started by me sharing holiday traditions and cultural heritages that were done so well in my son's elementary school. Then the editorial discussed the sharing of our technical field with the general public. There I was inspired by the computing community's one-hour coding effort, including the enthusiastic reaction from the outreach at my son's school.

At the end of this reading session, I thanked the class for letting me share my technical area with them. To be honest, it was not an easy job in the traditional format of reading and conversation, without using a projector, slides, or board as in a professional presentation and teaching that many of us have gotten so used to. Yet, these young students participated with full curiosity and enthusiasm. A girl approached me right after and said, "You definitely should talk to our technology teacher," (who teaches them the basics about computing, including one-hour coding as early as kindergarten). She paused and added, "How about writing a children's book, a picture book about your signals, maybe about how it got the processing by that cool camera?" Well, while we might have thought that young minds would prefer video to print material, we as a community have just received a challenge from an eight-year-old: a signal processing book for children!

Many of us have seen, with awe and, maybe, also a hint of jealousy, the high profile of the computer coding initiatives. If Dr. Seuss could win a bet with his publisher over the seemingly impossible task of using just 50 simple words to write a fun story, perhaps there is some truth to this surprise "assignment" that is worth our pondering!

## References


[1] A. Agrawal, R. Baraniuk, P. Favaro, and A. Veeraraghavan, "Signal processing for computational photography and displays [From the Guest Editors]," *IEEE Signal Process. Mag.* vol. 33, no. 5, pp. 12–15, Sept. 2016.

[2] M. Wu, "Sharing signal processing with the world [From the Editor]," *IEEE Signal Process. Mag.* vol. 32, no. 2, p. 4, Mar. 2015.





*Digital Object Identifier 10.1109/MSP.2017.2673078*

Min Wu | Editor-in-Chief | minwu@umd.edu

# Content Ecosystem

*Serving diverse interests in our community*

I am writing this editorial just days after coming back from New Orleans, Louisiana, where the 42nd International Conference on Acoustics, Speech, and Signal Processing (ICASSP) was successfully held. It was an action-packed week, filled with technical presentations and exchanges as well as a broad range of discussions on our Society and community developments. About 50 committees and boards of the IEEE Signal Processing Society (SPS) met at ICASSP, engaging hundreds of volunteers from around the world.

My discussions with a number of colleagues during the conference were about our *IEEE Signal Processing Magazine (SPM*), either to explore ideas for potential articles as inspired by technical talks and panels or to brainstorm how the magazine can help support the initiatives or activities of the IEEE Signal Processing Society (SPS). For this latter role, a notion of "content ecosystem" was coined in my meeting with chief editors of the SigPort Repository, Dr. Yan Lindsay Sun, and of the Resource Center (formerly SigView), Dr. John McAllister, respectively, and the SPS staff members on public outreach and publications.

We have been seeing an increase in the diverse needs from our members, and SPS and IEEE have been developing multiple products and tools to address these needs. For example, SigPort offers an increasingly popular platform to archive slides and posters from the latest conferences as well as student theses and reports viewable by anyone free of charge, while the Resource Center hosts keynote videos and tutorial webinars from curated sources, such as ICASSP plenary talks, as an SPS member benefit and may be available for a fee for nonmembers (see page 109 for more information about the Resource Center). As the Resource Center expands its content, where could a constant stream of candidates come from systematically?

Our magazine's tutorial articles provide a pool of candidates for the Resource Center—authors can be approached and encouraged to create a multimedia companion to their article, which allows content to reach a bigger audience. In the meantime, the slides and posters provided by SigPort users include download statistics that shine a light on the community's interests toward more recent technical work and grassroots educational material. SigPort thus can offer an additional set of candidates for the Resource Center to explore. If a healthy mechanism is developed and coordinated well, the contents on all three platforms can work hand in hand as an ecosystem.

Another example of coordinating multiple platforms and developing a content ecosystem was piloted in 2016 when we solicited input on student hands-on projects, and this is currently being expanded in collaboration with the SPS Education Committee. More specifically, SigPort provides a handy platform for students to archive their project reports, which is perhaps the only worldwide repository for such grassroots material. Editors from *SPM* and the Education Committee can evaluate these archived documents on a rolling basis and periodically create a curated summary and a set of highlights to share with the community, for example, through the magazine's Inside Signal Processing e-Newsletter and/or through a column in *SPM*. Some of the selected projects may also feed into the content pool for the Resource Center. These recognitions and visibilities provide positive feedback and encourage the students to engage in interesting projects and share the projects with the community at large.

For researchers and frequent authors of original research publications, a repository to host and broadly share their preprints is attractive. In addition to SigPort, quite some signal processing authors are archiving their preprints on arXiv.org, which traces its roots to the science community. For various historical reasons, arXiv does not have an electrical engineering topic branch; topics such as information theory and control theory are put either as part of computer science or applied mathematics, and there was no explicit topic category of signal processing.

The SPS Board of Governors had a long discussion on this issue last fall on approaching the arXiv leadership to create a signal processing topic category. Although it is perhaps easier to create a signal processing category under the existing computer science or applied math categories, several board members,

*(continued on page 13)*

*Digital Object Identifier 10.1109/MSP.2017.2678380*
*Date of publication: 26 April 2017*

The atoms are imaged by shining a second, weak laser beam through the cloud. Because atoms in different energy states absorb light of different frequencies, the final energy state of the atoms can be detected. The resulting images show interference bands of atom populations in the two different energy states. The rotation rate and axis are measured by analyzing the spacing and direction of the interference bands across the atom cloud. Acceleration is deduced from changes in the central band. The interferometer is sensitive to acceleration along the direction of the light and sensitive to rotations perpendicular to the light.

"The signal processing challenge in our experiment is to take images of the transition probability and estimate the wavelength of the fringe pattern," Hoth says. "To use the system as a gyroscope, you would use the wavelength of the fringe pattern to infer the unknown rotation rate." In experiments to date, the researchers' goal has been to quantify the relationship between the rotation rate and the wavelength of the fringe pattern so they can compare that relationship to theoretical predictions. "We do that by applying a known rotation rate and measuring the wavelength of the observed fringe pattern," Hoth says.

The process requires three images. "Each image has a fringe pattern with the same wavelength, but we vary the phase so that we see different parts of the fringe pattern," Hoth says. "By combining the three images, we can get the fourth image, which shows the spatial variation of the interferometer phase." The fringe pattern is equivalent to a slope or gradient in the interferometer phase. "By calculating the spatial phase, we solve both of our problems," Hoth continues. "The unwanted structure is suppressed and the hard problem of estimating a fringe wavelength has turned into the easy problem of estimating a best fit slope."

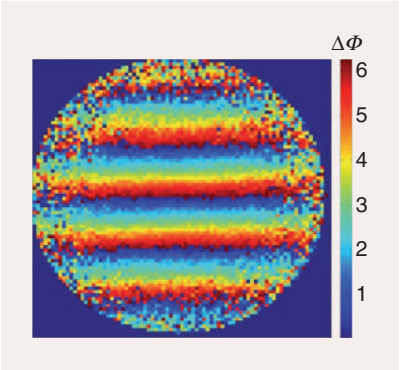



**FIGURE 3.** NIST's compact gyroscope measures rotation by analyzing patterns of interfering matter waves in an expanding cloud of atoms transitioning between two energy states. Each atom's speed determines both its final position in the cloud and the size of the rotational signal that shifts the interference patterns. Thus, rotations generate interfering bands of atoms across images of the final cloud. The color coding indicates how much the interference patterns shift in radians, the standard unit of angular measure. The orientation of the interfering bands (horizontal in the image) indicates the rotation axis. The rotation rate, determined by an analysis of the band spacing, is 44 milliradians/s. (Figure used courtesy of NIST.)

"The basic idea is that the part of the signal we're interested in changes when we modulate the phase, but the parts that we want to suppress stay the same," Hoth says. "So, by combining multiple images, we can separate the signal we want from the structure that we don't want."

Hoth goes on to say that the researchers are still experimenting with different ways of implementing the signal processing strategy. "It's mostly variations on the idea of modulating the phase and looking at the response," he says.

Although Stanford researchers were the first to demonstrate the technique of using an expanding cloud of laser-cooled atoms, they presented it in a 10-m-tall "atomic fountain" that was designed to be the world's most sensitive accelerometer. "In contrast to their work, our system was designed to be compact to open up the possibility of portable applications," Hoth says. The current experimental system is tabletop sized, but the researchers plan to eventually shrink the apparatus down to a portable cube approximately the size of a mini refrigerator. "There's a lot of very exciting work on atom interferometry being done all over the world," Hoth says.

## Author

***John Edwards*** (jedwards@johnedwardsmedia.com) is a technology writer based in the Phoenix, Arizona, area.

SP

## FROM THE EDITOR

*(continued from page 3)*

myself included, argued for a strategy that interacts with arXiv to put signal processing under a more appropriate topic branch, which may also need to be created. Thanks to the efforts led by SPS Vice President for Membership Dr. Nicholas Sidiropoulos, we learned that the arXiv scientific board has agreed to work toward creating an electrical engineering topic branch under which signal processing, information theory, and control theory will be hosted. This would be a wonderful development as SPS enriches its content ecosystem. Ultimately, our hope is that you, our readers and members, will find the content ecosystem beneficial to your professional development and be a regular contributor to the ecosystem.

SP

Min Wu | Editor-in-Chief | minwu@umd.edu

# Innovations Powered by Signal Processing

To many people around the world, Abraham Lincoln was a highly regarded president of the United States whose pursuit of social justice paved the way to end the slavery in this country. Fewer people, however, know his distinction as an engineering innovator and that he was the first and only U.S. president thus far to hold a patent. President Lincoln received the U.S. Patent 6469 in May 1849 titled "Buoying Vessels over Shoals," which was inspired by his experience navigating boats on the Ohio and Mississippi Rivers. When commenting on the role of the patent system that offers the inventor the exclusive use of his/her invention for a limited time, President Lincoln noted that the patent system "added the fuel of interest to the fire of genius, in the discovery and production of new and useful things."

From about a century after Lincoln's invention and throughout the next several decades, signal processing has contributed significantly to technology innovations and changed how we work and live. Smartphones, digital photography, the global positioning system, and medical diagnosis are tangible examples around us, and our magazine has touched on them through special issues and column articles. What many of us take for granted and wouldn't pause to think about are numerous examples that we don't see, such as when we store our data on hard drives. This is one of the best examples that recently comes to mind to showcase the profound impact of signal processing research.

Aleksandar Kavcic and José Moura's academic research at Carnegie Mellon University in the 1990s studied the effect when data would become densely packed in magnetic disk drives, and they proposed signal processing algorithms to enable the accurate detection of data stored in high-density disks—which became the norm a decade later in billions of computers. Their pioneering research also made front-page news when a US$750 million settlement was announced concerning the infringement of their corresponding patents, the second-largest payment over any technology patents to date. You can read more about the Kavcic–Moura detector for high-density magnetic recording on the IEEE Signal Processing Society's online blog: http://signalprocessingsociety.org/publications-resources/blog/why-signal-processing-pioneer-takes-road-less-traveled.

Innovations have continuously come from both industry and universities, often in complementary ways, although there may be stereotypical views on the roles that each side plays. Every once in a while, I have friends working in industry questioning the practical values of university research beyond writing papers and training students. Indeed, many publications may not see widespread real-world use. More often, we see academic publications as well as industrial products making incremental improvements over the prior art as opposed to making revolutionary advances, and it is common that exploratory research has been carried out well before the market ecosystem or the supporting technologies to become ready.

The immediacy of deployment is perhaps one of the differentiating factors between product development and exploratory research, but as history reveals, it is not the primary indicator of the impact of innovations. Kavcic and Moura showed to the world the impact of their innovations from what started out as exploratory research in signal processing. One attribute that enables their impact (as opposed to a purely intellectual exercise or a bean-counting effort to add to one's publication list) is the educated anticipation of the technological trends (in their case, the increasing density of the data being packed in storage drives) and the willingness to tackle challenges beyond making epsilon-delta improvement.

To qualify my words here, incremental improvements have their important roles in technological advances, and many progresses made—big or small—are standing on the shoulders of giants; we continuously build on the efforts of our technical community in direct and indirect ways. But the willingness to go beyond, to nurture out-of-the-box thinking, and to encourage taking higher risks opens up opportunities for bigger leaps in innovation, even if we may not succeed at most attempts.

*(continued on page 9)*

*Digital Object Identifier 10.1109/MSP.2017.2705258*
*Date of publication: 11 July 2017*

The Overview Paper Award was renamed the Donald G. Fink Overview Paper Award. The award description remains untouched; just the name of the award was modified.

The Society Award was modified to incorporate a presentation of an International Conference on Acoustics, Speech, and Signal Processing (ICASSP) plenary lecture, which will be called the "Norbert Wiener Lecture." Each Society Award recipient is expected to present a Norbert Wiener lecture at the 2018 ICASSP. This lecture is one of the plenary lectures given on the day of the banquet of ICASSP, but it is not a banquet speech.

As a reminder, for the Young Author Best Paper Award, a board or committee cannot nominate one of its members for the award. Please note that this includes nominating an author of a paper where a member of a nominating board or committee is also an author on the paper, even though this member is not the "young author" being considered for the award.

The paper awards nomination form requests citation impact information, so please provide this valuable information. The Awards Board will continue to review the nominations and make selections on paper awards.

For all major awards other than paper awards, the Awards Board will be responsible for vetting the nominations and producing a short list of no more than three nominations per award. The Board of Governors will continue to vote on the selection of the major awards.

A board or committee cannot nominate one of its current members for an award. However, the board/committee member can be nominated by another board or committee. Current elected members of a committee/board may participate as individual nominators for other members of the same board/committee. In the case of major award nominations, please note: boards or committees that submit nominations, but have voting Board of Governors members sitting on their boards or committees, must ensure that Board of Governors voting members do not participate in the board/committee award nomination or selection process.

Individual nominations can have multiple conominators listed on the nomination form. In addition, individual nominations can include up to two endorsements to strengthen the nomination from two other individual members. Nominations supported by committee/boards cannot be accompanied by endorsements. IEEE SPS membership is no longer required for endorsements. All endorsements must be submitted via e-mail to the specified address, which will provide the nomination with a date and time stamp. If more than two endorsements are submitted, only the first two received endorsements will be forwarded to the SPS Awards Board for consideration. A nominator cannot serve as an endorser for a nomination he/she is submitting. If the Society policies state that a particular board/committee/individual is not eligible to nominate for a particular award, then members of that same group of individuals are not eligible to be endorsers.

Technical committee and special interest group award nomination procedures have been approved with suggested award nomination and voting procedures. For full details on each award as well as the new Society and technical committee/special interest group awards policies and endorsement form, please visit http://signalprocessingsociety.org/get-involved/awards-submit-award-nomination.

If you have any questions regarding the process, please do not hesitate to contact Awards Board Chair H. Vincent Poor at poor@princeton.edu.

SP

## FROM THE EDITOR *(continued from page 3)*

As in almost any litigation, for colleagues who either work for or hold shares and other interests in the opposing company involved in the patent dispute, the success of the inventors and their institution in this high-profile litigation may be rather bitter. This is understandable as one's judgment can be influenced when such personal interests are involved. Still, I hope as professionals working on the forefront of technology advances, we can look beyond our personal gains or losses to celebrate the positive impact of innovations powered by signal processing.

Perhaps our discussions on the innovations powered by signal processing have stimulated reflections from you. To help capture the thoughts of our readers, we formally launch the "Community Voices" column on page 10 in this issue. The first discussion topic is "What is considered a successful career for signal processing trained professionals?" *SPM*'s Area Editor Dr. Andres Kwasinski took the lead and gathered input from the community and compiled highlights. My appreciation also goes to Dr. Charles Casimiro Cavalcante, a reader in Brazil, who was the very first to respond to the open calls on this new initiative, and to several readers from a variety of sectors together with our retired veterans of the magazine editorial board who kindly share their perspectives.

The second topic for the "Community Voices" column is "What's the future of signal processing?" Please take a moment to share your views on this web form https://www.surveymonkey.com/r/SPSCommunityVoices2. We look forward to reading your input and sharing highlights in a future issue of *SPM*.

SP

Min Wu | Editor-in-Chief | minwu@umd.edu

# Cameras, Music, and Synergy in Signal Processing

When you receive this issue of *IEEE Signal Processing Magazine* (*SPM*), the 2017 edition of the IEEE International Conference on Image Processing will soon be taking place in Beijing, China. This is the first time this flagship conference of the IEEE Signal Processing Society (SPS) will be in mainland China, marking a milestone of more than five years of strong effort by the SPS to strengthen membership development and engagement in China (which includes three annual summits and conferences of ChinaSIP in 2013–2015, followed by a successful ICASSP held in Shanghai last year).

The digital camera is perhaps one of the most tangible impacts of image processing that can be felt by an ordinary citizen. By just counting the number of pixels per U.S. dollar of cost, one could already appreciate the paradigm-shifting advances of the underlying technologies. In 2000, the first consumer-level digital point-and-shoot camera that I put my hands on was a 1-million-pixel unit that my research group received from an industry collaborator. The manufacturer's suggested price was US$1,000, excluding memory cards, which cost at least another $US100 for just 32 megabytes. Today, a decent digital camera over 10 million pixels is priced below US$100. Another indicator was an informal poll on digital versus film cameras. Even in the mid-2000s when price had significantly dropped and image quality and features had improved, if you asked an amateur photographer, more often than not he/she would favor a film camera, citing its dynamic range, naturalness, richness in color, among other qualities. It was not uncommon to hear their prediction that digital may never catch up with film technologies.

Today, however, even serious professionals by and large have adopted the use of digital cameras. Handling higher dynamic range, providing color calibration, and having nearly imperceptible effect from superb compression are just a few of the advances contributed by the signal processing community. If you haven't already done so, check out the September 2016 issue of *SPM* featuring a special section on computational photography and display.

A similar "never catch up" statement regarding digital technologies can be found in another form of artistry—musical instruments, such as the piano. A digital piano today has progressed from the electronic keyboards you may have seen in a toy store. In many ways, it is trying to mimic a traditional acoustic piano without having physical strings being struck by hammers and resonated by a soundboard. From the sensors used to record the manner of a key being pressed by a player (known as *touch*), to music synthesis, to storing the music in compact files for archival, signal processing plays a critical role in this mimicking game. Traditional piano teachers tend to almost habitually favor acoustic pianos, yet increasingly many of them praised the touch and sound of high-end digitals in blind tests. Perhaps the paradigm shift from the acoustic to digital piano is already starting, despite at a slower pace compared to the takeover of film cameras by digital cameras. This may be partly due to the durable nature of pianos and the price point of about an order of magnitude higher than cameras.

Among the various modules in a digital piano, touch is perhaps the hardest to achieve perfection. One of the leading design frameworks is by industry giant Yamaha. Yamaha approached the touch problem in its high-end products by implementing a hybrid design to take advantage of the best in both the physical and digital worlds: in particular, it has retained the mechanical design of the actual keyboard part (yes, you read it right: the keyboard part is the same as Yamaha's acoustic grand piano). Instead of striking a string, the key action will be sensed by multiple optical sensors and sent to a central processing unit to analyze the fashion of each key action. In highly simplified terms, the analyzed key action will guide a comparison of the typical ways a key would sound on Yamaha's best grand piano by its corresponding touch and then render into the actual sound by sophisticated sound synthesis and projected out by a speaker system. This is just one of the many examples showcasing the advances in music signal processing.

*Digital Object Identifier 10.1109/MSP.2017.2730938*
*Date of publication: 6 September 2017*

There are two takeaways from the digital paradigm shift in photography and musical instruments. The first is the significant role that signal processing plays, of which I've already given examples. The second is the synergy with other technological areas. Often, signal processing couples with other technologies (such as the physical/mechanical design of the keyboard action in a digital piano and the imaging sensor design down to fabrication details in digital camera), serving as a bridge or an enabler to connect the physical part of the system with the digital ones. Synergy has been essential to the success of signal processing.

Since we touched on China and musical instruments, let me share with you the growth of a popular Chinese traditional instrument, the guzheng, to shine a light on the power of synergy. If you Google the term *guzheng* and watch some videos online, you will see that it looks somewhat like a horizontal version of a harp. Whether it is to express flowing water or mimic blowing wind, you may find the sound of the guzheng very captivating. We can trace its origin to more than 2,500 years ago, shortly after Confucius' time, and it inspired other Asian instruments such as the Japanese koto and the Korean gayageum. Considering that some of today's most popular western musical instruments, such as the piano and violin, were developed and flourished in the last three to five centuries, I often marveled at the Chinese cultural heritage of over 2,000 years of guzheng playing.

History aside, it is during the recent half century that the guzheng has undergone significant development and also become the most popular Chinese instrument being played. The strings, made of silk in ancient times, have been replaced by steel-coated nylon, with leading brands adopting those made in Europe, to increase the instrument's sound volume and refine its timbre. The way it is played has also incorporated the two-hand coordination of the main melody and left-hand chords commonly seen in the piano, which substantially enhanced the richness of the expression. Faster fingering techniques were invented with reference to human hand kinesiology, and sustaining the sound is achieved with beneficial techniques from other Chinese instruments. Through inspiration and synergies across nations' boundaries and across technical fields, the guzheng has undergone an amazing transformation. In analogous ways, isn't that what our signal processing community is experiencing?

SP



*Digital Object Identifier 10.1109/MSP.2017.2743720*

Min Wu | Editor-in-Chief | minwu@umd.edu

# Signals and Signal Processing: The Invisibles and the Everlastings

When you receive this issue of *IEEE Signal Processing Magazine,* a symposium, "The Future of Signal Processing," was just held at the Massachusetts Institute of Technology (MIT). The symposium honored the career of Prof. Alan Oppenheim as one of the pioneers in signal processing research and education. Attendees from various organizations around the world discussed and shared insights of the profound roles that signal processing have played and envisioned the future trends of signal processing.

I delivered a talk with the same title as this editorial at the MIT symposium. The term *invisibles* has a dual meaning to me. A central theme of my research has been dealing with "micro signals" that are small in strength or scale by at least an order of magnitude and are nearly invisible, yet developing the theory and techniques to extract and utilize these invisible micro signals opens up new opportunities in a broad range of applications from security and forensics to data analytics to entertainment. One class of micro signals provides telltale traces of evidence in determining the origin and integrity of images, which is an active research area investigated by the Information Forensics and Security Technical Committee (IFS TC) of the IEEE Signal Processing Society (SPS) and the subject of the ongoing SP Cup 2018 competition (see page 175) and the latest outreach video "Multimedia Forensics," available online at the SPS Resource Center; please visit http://rc.signalprocessingsociety.org/sps/product/conference-videos-and-slides/SPSVID00194. Meanwhile, the profound role and contributions of signal processing are often invisible to the public, leading to the notion of "Signal Processing Inside." In this issue, the second edition of the new "Community Voices" column presents the thoughts on such a topic by our magazine readers who are at various career stages and come from different regions and backgrounds.

Several other formal and informal gatherings have been held this year, celebrating the careers of signal processing pioneers and significant contributors: among them are Prof. Sanjit Mitra, who had a broad range of research interests over the years and nurtured signal processing activities in a number of underrepresented countries and regions; Prof. Mos Kaveh, who played a key role in developing statistical signal processing and served as the IEEE SPS president in 2010–2011; and Dr. John Cozzens, who led the signal processing program at the U.S. National Science Foundation for many years, just to name a few. Thanks to the persistent contributions of them and many others over the past decades, the field of signal processing has grown and our community has expanded both technically and geographically.

It has been a year and half since we launched the redesign of the print version of the magazine. I hope you enjoy the modern look and enhanced graphics of the magazine and its corresponding electronic version. The second part of the redesign effort is for the online presence of our magazine. Although the timetable of the magazine's web design was deferred to give priority to the major redesign of the SPS's website, I am happy to report that the matching design for our magazine's website is well underway. The first phase has been completed and launched this summer for the monthly "Inside Signal Processing eNewsletter" that complements the print version of the magazine. If you haven't already, please check it out at http://signalprocessingsociety.org/newsletter/. My sincere thanks to Christian Debes, the area editor for eNewsletter, and Ervin Sejdic, who succeeded Christian in June 2017, and SPS Web Administrator Rupal Bhatt for their dedicated efforts.

The second phase of the website redesign is currently being implemented with the goal of creating a modern landing page that can host timely updates based on the magazine's bimonthly content and well-organized resources for prospective authors.

This is the magazine's final issue of 2017 and the last issue for which I serve as editor-in-chief. Looking back, this three-year journey has been a huge undertaking, and it could not have been possible without the hard work and support of many colleagues. A number of unsung heroes, whom ordinary readers may not have seen or known, contributed to the success of our magazine.

*(continued on page 7)*

*Digital Object Identifier 10.1109/MSP.2017.2750306*
*Date of publication: 13 November 2017*

Furthermore, signal processing has now become much larger and diverse. It has permeated a vast number of technologies and applications. Watch, for example, our video "What Is Signal Processing?" at https://www.youtube.com/watch?v=EErkgr1MWw0 for some examples of these applications. The scope of our journals range from speech to networks, from forensics to imaging, from biomedical to multimedia, and so on. We have more than 185 Chapters in approximately 120 countries. This compels me to appreciate the good comments and relevant points made by those who advocate for keeping our current name, as well as feel their devotion to the name. Whether or not we change our name, we should continue to expand our activities to stress our wide scope, for example, by initiating a new journal, workshop, distinguished speakers, summer schools, and educational material related to data science. I consider myself fortunate that I have been working in this exciting field and am equally proud to be attached to our beloved name *signal processing.*

Let us continue this important discussion. Please add your comments to https://signalprocessingsociety.org/get-involved/signal-processing-larger-its-beloved-name

## Reference

[1] R. G. Lyons and D. Lee Fugal, *Essentials of Digital Signal Processing*. Englewood Cliffs, NJ: Prentice Hall, 2014.

SP

---

## FROM THE EDITOR *(continued from page 4)*

Managing Editor Jessica Welsh and the IEEE Magazines Department production team are a driving force in interacting with authors and creating a professional look and feel for the articles. In addition, Senior Art Director Janet Dudar and Associate Art Director Gail Schnitzer help bring eye-catching artistic elements to each issue of the magazine.

I have also had the privilege to work very closely with a team of area editors who play a key role in the magazine operations: Shuguang Robert Cui screens dozens of feature article proposals each year and tirelessly coordinates the proposal reviews; Kenneth Lam leads a team of dedicated column associate editors to enrich the magazine content to serve our broad readership; Douglas O'Shaughnessy coordinates the special issue efforts, a signature tradition of the magazine; Andres Kwasinski, Erwin Sejdic, Christian Debes, and the associate editors on their teams who contributed to the electronic efforts that complement the print version of the magazine.

Our senior Editorial Board members bring a diverse set of expertise and perspectives and provide candid feedback and guidance; special thanks to 13 members who are completing their three-year services: Mounir Ghogho, Lina Karam, Sven Lončarić, Brian Lovell, Stephen McLaughlin, Yi Ma, Henrique (Rico) Malvar, Athina Petropulu, Peter Ramadge, Shigeki Sagayama, Erchin Serpedin, Shihab Shamma, Gregory Wornell, and Dapeng Wu. In addition, special issue and cluster organizers work intensively to bring timely content to our readers, and each special issue, cluster, or series is a major undertaking by itself. My sincere thanks to all authors for contributing to the magazine, especially for the time and hard work it takes to make content accessible, and to the many reviewers who provided timely assessments and constructive comments to ensure the high technical and presentation quality of the articles. You can find an annual index of authors and articles associated with each year-end issue of the magazine in IEEE *Xplore*. The collective effort by authors, reviewers, and editors helped our magazine reach an all-time high in impact factor (9.65) and article influence score (4.02) in the most recent *Journal Citation Report*. Last but not the least, I thank SPS staff members Rebecca Wollman, Richard Baseil, Theresa Argiropoulos, Jessica Perry, and Deborah Blazek for their assistance, and I appreciate the thoughtful feedback and support from our readers.

The SPS Executive Committee has appointed Prof. Robert Heath as the next editor-in-chief of the magazine, effective January 2018. Robert is a world-renowned expert and proliferate researcher on signal processing for communications. Please join me in welcoming him. As I pass the baton, I take this opportunity to thank all supporters of the magazine in the past and appreciate the continued support in the years to come. Together, we can continue to build this premier publication with a strong technical impact as well as indispensable benefits to our members and readers.

To quote Prof. Oppenheim: "There will always be signals, they will always need processing, and there will always be new applications, new mathematics, and new implementation technologies." Let *IEEE Signal Processing Magazine* be your helpful companion in this everlasting journey of signal processing!

SP