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1. Society News

Election of Members-at-Large of SPS Board of Governors -- Your Vote is Important!

The election of Members-at-Large of the IEEE SPS Board of Governors for the term 1 January 2008 through 31 December 2010 is now open. Ballots have been mailed to SPS members, including a slate of eight candidates supplied by the SPS Nominations and Appointments Committee, as well as a space for write-in candidates. This year's election offers SPS members the opportunity to cast their votes by mail, by fax, or by web for up to three candidates. This year is the first time that the Society is offering web balloting, and members are encouraged to take advantage of the new service. Instructions on these voting options are included in the ballot package. Ballots must be received at IEEE no later than **1 September 2007** in order to be counted.

The Board of Governors (BoG) is the governing body that oversees the activities of the IEEE Signal Processing Society. The SPS BoG has the responsibility of establishing and implementing policy, and receiving reports from its standing boards and committees. The SPS BoG is comprised of 17 SPS members: seven officers of the Society who are elected by the Board of Governors and nine Members-at-Large elected directly by the voting members of the Society. Members-at-Large represent the member view point 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 of the SPS organization can be found at this link.

Nominations Open for 2007 Major SPS Awards

The SPS Awards Board is now accepting nominations for 2007 major SPS awards. Each year, SPS honors outstanding individuals who have made significant contributions related to signal processing. The deadline for the Society Award, the Technical Achievement Award, the Education Award, and the Meritorious Service Award is **October 1, 2007**. The Society also recognizes outstanding publications in SPS journals and magazines through Best Paper Awards, Young Author Best Paper Awards, and Signal Processing Magazine Best Paper Award. The deadline for the paper awards is **September 1, 2007**.

The award nominations, which are submitted to the SPS Vice President-Awards and Membership, will be vetted by the appropriate technical committees. Prospective nominators are encouraged to submit nominations well in advance of the deadlines. Detailed information and nomination forms of SPS awards can be found online.

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2. Conference News

SPS Conference Call-for-Paper & Deadlines	Location	Date	Tutorial/Special Session	Submission Deadline
IEEE Automatic Speech Recognition and Understanding Workshop (ASRU'07)	Kyoto, Japan	Dec. 9-13, 2007	Sept. 24, 2007 (demo)	**July 16, 2007**
IEEE International Symposium on Signal Processing & Information Technology (ISSPIT'07)	Cairo, Egypt	Dec. 15-18, 2007	**July 31, 2007**	**July 31, 2007**

International Symposium on Communications, Control and Signal Processing (ISCCSP'08)	St. Julians, Malta	March 12-14, 2008		Oct. 1, 2007
IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP'08)	Las Vegas, NV	March 31 - April 4, 2008	**Aug. 17, 2007** (special session) Nov. 9, 2007 (tutorial)	Oct. 5, 2007

Upcoming SPS Conferences	Location	Advanced Registration	Conference Dates
IEEE Workshop on Statistical Signal Processing (SSP'07)	Madison, WI		Aug. 26-30, 2007
IEEE International Workshop on Machine Learning for Signal Processing (MLSP'07)	Thessaloniki, Greece		Aug. 27-29, 2007
IEEE International Conference on Advanced Video and Signal based Surveillance (AVSS'07)	London, UK	**July 19, 2007**	Sep. 5-7, 2007
Biometrics Symposium (BYSM'07)	Baltimore, MD	TBA	Sep. 11-13, 2007
International Symposium ELMAR (ELMAR'07)	Zadar, Croatia		Sep. 12-14, 2007
IEEE International Conference on Image Processing (ICIP'07)	San Antonio, TX	**August 1, 2007**	Sep. 16-19, 2007
NEW! Economic Strategy for Healthcare through Bio and Information Standards and Technologies (Sponsored by Biotechnology Council and NIST)	Gaithersburg, MD		Sep. 25, 2007
IEEE International Workshop on Multimedia Signal Processing (MMSP'07)	Chania, Crete	**August 10, 2007**	Oct. 1-3, 2007
IEEE Conference on Signal Processing Systems (SIPS'07)	Shanghai, China	**July 31, 2007**	Oct. 17-19, 2007
IEEE Workshop on Applications of Signal Processing to Audio and Acoustics (WASPAA'07)	New Paltz, NY	**August 31, 2007**	Oct. 21-24, 2007
Asilomar Conference on Signals, Systems, and Computers (Asilomar'07)	Pacific Grove, CA	TBA	Nov. 4-7, 2007
Picture Coding Symposium (PCS'07)	Lisbon, Portugal	Sept. 21, 2007	Nov. 7-9, 2007
International Packet Video Workshop (PV'07)	Lausanne, Switzerland	TBA	Nov. 12-13, 2007
IEEE International Workshop on Computational Advances in Multi-channel Sensor Array Processing (CAMSAP'07)	U.S. Virgin Islands	Nov. 11, 2007	Dec. 12-14, 2007

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3. Publication News

Upcoming Deadlines for **Signal Processing Magazine**: http://www.ieee-spm.org/?i=cfp

  SPM Columns/Forums rolling submission deadlines

Special Issue Deadlines of SPS Journals

- "MIMO-Optimized Transmission Systems for Delivering Data and Rich Content" - Deadline: **15 July 2007.**

(Journal of Selected Topics in Signal Processing)

- Special issue on "Multimedia Applications in Mobile/Wireless Context" - Deadline: **31 July 2007**.
  (Transactions on Multimedia)

- "Genomic and Proteomic Signal Processing" - Deadline: 1 September 2007.
  (Journal of Selected Topics in Signal Processing)

- "Distributed Processing in Vision Networks" - Deadline: 15 October 2007.
  (Journal of Selected Topics in Signal Processing)

Recent Issues of SPS Sponsored and Co-sponsored Publications

Journal Title	Latest Issue	Cover/ Contents (in PDF)	Xplore Link
IEEE Signal Processing Magazine • Special Issue on the Bootstrap Method • Column on Social Signal Processing • Column on SP for Humanitarian Mine Action • Feature Article on The Advent of Frame	vol. 24, no. 4	PDF	Html
IEEE Transactions on Audio, Speech, and Language Processing	vol. 15, no. 5	PDF	Html
IEEE Transactions on Image Processing	vol. 16, no. 7	PDF	Html
IEEE Transactions on Information Forensics and Security	vol. 2, no. 2	PDF	Html
IEEE Transactions on Signal Processing	vol. 55, no. 7	Part 1 Part 2	Html
IEEE Signal Processing Letters	vol. 14, no. 6	PDF	Html
Journal Title	Latest Issue	Cover/ Contents (in PDF)	Xplore Link
IEEE Transactions on Medical Imaging	vol. 26, no. 6	PDF	Html
IEEE Transactions on Mobile Computing	vol. 6, no. 8	PDF	Html
IEEE Transactions on Multimedia	vol. 9, no. 4	PDF	Html
IEEE Sensors Journal	vol. 7, no. 8		Html
IEEE Transactions on Wireless Communications	vol. 6, no. 5	PDF	Html
Computing in Science & Engineering Magazine	vol. 9, no. 3		Html
IEEE MultiMedia	vol. 14, no. 2	PDF	Html

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4. Chapter News and Distinguished Lectures

Do you know? IEEE SPS provides travel support for local chapters to invite **SPS Distinguished Lecturers**. See a list of 2006 and 2007 SPS DLs, and check below for upcoming **SPS Distinguished Lectures** near you.

Chapter	Dates	SPS Distinguished Lectures
Dallas, TX	17-Sep-2007	Georgios Giannakis: "Distributed Estimation Using Wireless Sensor Networks," 11am, at TI Auditorium, ECS Building South, University of Texas at Dallas. See event details.
Colombia	27-Sep-2007	Aggelos Katsaggelos: "Image and Video Recovery," invited DL talk at 12th Symposium on Signal Processing, Image Processing and Machine Vision (XII STSIVA), 9am. See event details. Contact: [xii_stsiva AT uninorte.edu.co]
Chapter	Dates	Other Upcoming Events
Central Texas	19 July, 2007	Steve Crowl: "China's 3G Mobile Services Industry," at 7pm, AT&T (formerly SBC) Labs. Check more information online. Contact: <scrowl AT ieee.org>.
United Kingdom & Republic of Irelandd	25-27 July, 2007	Co-sponsoring Visual Information Engineering 2007 Conference, to be held at the Royal Statistical Society, London, UK. Visit the UKRI chapter website and the conference website for more information.
Central Texas	8 August, 2007	"2007 Wireless Hive Network Symposium," Hilton Hotel, Austin, TX. Check more information online.

If you are interested in organizing a new SPS chapter, or participating in activities in a SPS local chapter near you, please check out **Local Chapter Resources**. Additional questions and comments can be addressed to the SPS Chapters Committee.

5. New Initiatives and Trends

USPTO Peer-to-Patent Project Invites Public Participation

The IEEE-USA *Today's Engineer Online* reports a historic initiative by the United States Patent and Trademark Office (USPTO) and calls for participation by IEEE members. In June 2007, the USPTO opened the patent examination process for online public participation for the first time. With the consent of the inventor, the *Peer-to-Patent: Community Patent Review* pilot will enable the public to submit prior art and commentary relevant to the claims of 250 pending patent applications in Computer Architecture, Software and Information Security. Peer-to-Patent involves (1) review and discussion of posted patent applications, (2) research to locate prior art references, (3) uploading prior art references relevant to the claims, (4) annotating and evaluating submitted prior art, and (5) top ten references, along with commentary, forwarded to the USPTO.

Participation is open to the public. IEEE members are encouraged to participate in this initiative. More information about Peer-to-Patent can be found at this link. Email questions to <info AT peertopatent.org>.

Reproducible Research in Signal Processing

As described on Wikipedia, reproducibility is one of the basic principles of the scientific method. It refers to the ability of an experiment to be replicated by another researcher working independently. While such a definition is applicable to science in general, what does it mean for signal processing research specifically? Should all the research presented in our journals be reproducible? For which types of signal processing research is reproducibility most important? And what does reproducibility require?

Learn more about the recent activities on reproducible research in signal processing and an invitation to share your thoughts on an online discussion forum.

Signal Processing for Future Radio Telescopes

Radio astronomy forms an interesting application area for array signal processing techniques. Traditionally, radio telescope design was in the forefront of electrical engineering technology. Technological advances in the last decade have created possibilities for large distributed interferometric radio telescopes with very large receiving areas and a sensitivity which is one to two orders of magnitude better than the current generation. Increased sensitivity implies receiving more interfering signals, and therefore RFI detection and removal is now an important topic in radio astronomy.

Learn more about signal processing challenges and advances in the design of future radio telescopes through this **in-depth article**.

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6. New PhD Theses

Thibaut Ajdler (Ecole Polytechnique Fédérale de Lausanne)
"**The Plenacoustic Function and its Applications**," 2006.
Advised by Prof. Martin Vetterli.

This thesis is a study of the spatial evolution of the sound field. We first present an analysis of the sound field along different geometries. In the case of the sound field studied along a line in a room, we describe a two-dimensional function characterizing the sound field along space and time. Calculating the Fourier transform of this function leads to a spectrum having a butterfly shape. The spectrum is shown to be almost bandlimited along the spatial frequency dimension, which allows the interpolation of the sound field at any position along the line when a sufficient number of microphones is present.

We describe a similar theory for circular arrays of microphones or loudspeakers. Application of this theory is presented for the study of the angular sampling of head-related transfer functions (HRTFs). With the Fourier representation of the sound field, it is then shown how one can correctly obtain all room impulse responses measured along a trajectory when using a moving loudspeaker or microphone. In the last part, we model spatio-temporal channel impulse responses between a fixed source and a moving receiver. The trajectory followed by the moving element is modeled as a continuous autoregressive process.

Click here to download the dissertation, or contact the author <ajdler AT gmail.com> for more information.

Arijit Biswas (Technische Universiteit Eindhoven, The Netherlands)
"**Advances In Perceptual Stereo Audio Coding Using Linear Prediction Techniques**," May 2007.
Advised by Prof. Robert J. Sluijter and Dr. Albertus C. Den Brinker.

Traditionally audio coders are based on subband/transform coding techniques that are not easily reconcilable with a low-delay requirement. In contrast, speech coders typically use linear prediction (LP) which is compatible with attributes like low-delay and low computational complexity. However, several issues need to be resolved in order to make LP an adequate and attractive tool for audio coding.
These issues stem from the fundamental differences between speech and audio signals. This thesis addresses these issues.

The most important contributions in this thesis are: a proposal for the "best" generalization of the single-channel LP system to a stereo/multi-channel LP system such that the essential single-channel LP properties carry over to this generalized case; complexity reductions for Laguerre-based LP systems; a quantization strategy for stereo LP parameters; and the concept of perceptually biased LP. It thereby gives contributions to the field of low-delay, low-complexity coding of audio by the use of LP.

Click here to download the dissertation, or contact the author <arijit.biswas AT codingtechnologies.com> for

more information.

Rajbabu Velmurugan (Georgia Institute of Technology, USA)
"**Implementation Strategies for Particle Filter based Target Tracking**," May 2007.
Advised by Prof. James H. McClellan.

This thesis contributes new algorithms and implementations for particle filter-based target tracking. From an algorithmic perspective, modifications to improve a batch-based, acoustic direction-of-arrival (DOA), multi-target, particle filter tracker are presented. The main improvements are reduced execution time and increased robustness to target maneuvers. Using an approach similar to the acoustic tracker, a radar range-only tracker is also developed. From an implementation perspective, this thesis provides new low-power and real-time implementations for particle filters.

First, to achieve a very low-power implementation, two mixed-mode implementation strategies that use analog and digital components are developed. The mixed-mode implementations use analog, multiple-input translinear element (MITE) networks to realize nonlinear functions. The mixed-mode method that uses predominantly analog components is shown to provide a factor of twenty improvement in power savings compared to a digital implementation, for a simple bearings-only particle filter tracker. Next, digital signal processor (DSP) and field-programmable gate array (FPGA) implementation strategies for the batch-based acoustic DOA tracker are developed.

Click here to download the dissertation, or contact the author <rajbabu AT ece.gatech.edu> for more information.

Interested in submitting or recommending a recent Ph.D. thesis?
Please prepare the following material and email Associate Editor at <piva AT lci.det.unifi.it>:
(1) thesis author's information (full name, contact, current affiliation, URL if available), Ph.D granting institution, thesis advisor's name and contact information;
(2) title, URL, and a short summary of the thesis (100-150 words); and
(3) an email from the thesis advisor confirming that the author has already successfully defended the Ph.D. thesis and that a final version of the thesis has officially been submitted according to the Ph.D. degree requirements of the author's institution.

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7. New Books

Wavelets and Subband Coding, by Martin Vetterli and Jelena Kova•evi•. Open Access Edition.

Book Description: First published in 1995, *Wavelets and Subband Coding* offered a unified view of the exciting field of wavelets and their discrete-time cousins, filter banks, or subband coding. The book developed the theory in both continuous and discrete time, and presented important applications. During the past decade, it filled a useful need in explaining a new view of signal processing based on flexible time-frequency analysis and its applications.

In the last 12 years, the field has matured, the teaching of these techniques is more widespread, and publication practices have evolved. Specifically, the World Wide Web, which was in its infancy a dozen years ago, is now a major communications medium. Thus, in agreement with the original publisher, Prentice-Hall, the authors now retain the copyright, and have decided to allow open access to the book online (protected under the by-nc-nd license from Creative Commons). In addition, the solutions manual, prepared by G. Chang, M. Goodwin, V. K Goyal and T. Kalker, is also available upon request for teachers using the book.

Visit the book's website for detailed Table of Contents and download information.

Speech Enhancement: Theory and Practice, by P. Loizou, CRC Press, 2007.

Book Description From the Publisher: The first book to provide comprehensive and up-to-date coverage of all major speech enhancement algorithms proposed in the last two decades, Speech Enhancement: Theory and Practice is a valuable resource for experts and newcomers in the field. The book covers traditional speech enhancement algorithms, such as spectral subtraction and Wiener filtering algorithms as well as state-of-the-art algorithms including minimum mean-squared error algorithms that incorporate signal-presence uncertainty and subspace algorithms that incorporate psychoacoustic models. The coverage includes objective and subjective measures used to evaluate speech quality and intelligibility.

Divided into three parts, the book presents the digital-signal processing and speech signal fundamentals needed to understand speech enhancement algorithms, the various classes of speech enhancement algorithms proposed over the last two decades, and the methods and measures used to evaluate the performance of speech enhancement algorithms. The text is supplemented with examples and figures designed to help readers understand the theory. MATLAB® implementations of all major speech enhancement algorithms and a speech database that can be used for evaluation of noise reduction algorithms are included in an accompanying DVD-ROM.

Visit the book's website for detailed Table of Contents and ordering information.

Books Featured in Previous Issues [details]

Blind Image Deconvolution: Theory and Applications, by P. Campisi and K. Egiazarian (editors), CRC, 2007.

VLSI DESIGN OF WAVELET TRANSFORM -Analysis, Architecture, and Design Examples,
by Liang-Gee Chen, Chao-Tsung Huang, Ching-Yeh Chen and Chih-Chi Cheng, World Scientific, 2006.

Multirate Statistical Signal Processing, by O.S. Jahromi, Springer, April 2007.

Local Approximation Techniques in Signal and Image Processing, by V. Katkovnik, K. Egiazarian, and J. Astola, SPIE Press, September 2006.

Embedded Image Processing on TMS320C6000 DSP:
Examples in Code Composer Studio and Matlab, by Shehrzad Oureshi, Springer, 2005.

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8. Research Opportunities

R&D positions in Navigation and Wireless Terrestrial Communications

Positions are available for carrying out R&D activities within the Signal Processing Group of the Telecommunications and Systems Engineering Department at Universitat Autonoma de Barcelona (UAB), Spain. Activities to be involved in are related with the design of high-sensitivity algorithms for GNSS, positioning with ultra-wideband and Zigbee systems, cooperative communications, and design of WiMAX networks.

Candidates' requirements: (1) A degree in Telecommunications or Electrical Engineering (the degree must be completed or very close to completion); (2) Very good academic qualifications; (3) Interest in signal processing, navigation receivers and communications systems; and (4) Matlab programming skills.

Candidates are encouraged to submit a detailed curriculum vitae (including university grades) and a very brief explanation of their interests to the email address: gonzalo.seco AT uab.es (tel: +34.93.581.4734).

More information is available at this link.

PhD Scholarships in Multimedia Signal Processing area

The Communication Systems Group led by Prof. Dr.-Ing. Thomas Sikora at TU Berlin (Germany) offers several PhD scholarships in the following research fields: (1) Single- and Multi-view Video Coding; (2) 2D/3D/stereoscopic Image Processing; (3) Audio Analysis; and (4) Description of Humans in Video Sequences.

Please submit your full application until 2007-07-31. Click here for more information.

Research Opportunities Featured in Previous Issues [details]

- Post-doc Position on Wireless Biomedical Sensor Network at National Hospital of Norway in Oslo and Norwegian University of Science and Technology in Trondheim.

- Vice Chancellor's Strategic Research PhD Scholarship at Victoria University of Wellington, New Zealand.

- Post-doc positions in Network Science at Army Research Laboratory (ARL), Adelphi, MD, USA.

Job Posting Portals

http://careers.ieee.org/
http://jobs.phds.org/jobs/engineering/
http://engineering.academickeys.com/seeker_job.php

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Contributors of articles in this issue:

Jelena Kovacevic, Amir Leshem, Alle-Jan van der Veen, Patrick Vandewalle, and Martin Vetterli.

About SPM e-Newsletter

Since April 2007, the IEEE Signal Processing Magazine has introduced a new form of publication - a Monthly Electronic Newsletter. The e-Newsletter will complement the bi-monthly Magazine to serve the members in the IEEE Signal Processing Society (SPS). Through email notification and expanded coverage on its website, the e-Newsletter will provide members with timely updates on:

- society and technical committee news,

- conference and publication opportunities, new books, and Ph.D. theses,

- signal processing related research opportunities, and

- activities in industry consortiums, local chapters, and government programs.

The e-Newsletter is a gateway to reach out to signal processing professionals around the world. We invite you to contribute and share your news with tens of thousands of SPS members through this monthly electronic publication with fast turn-around cycle. IEEE members may manage their subscription of the email notification of the eNews and related SPS announcements at this page. Please bookmark <http://enews.ieee-spm.org> for current and archived issues of eNews.

Submission Instructions - Contribution for the August-September '07 Issue Due August 15, 2007

Please contact the Associate Editors of the corresponding sections as listed below to provide your input or if you have questions. Make sure that you include your name, affiliation, and email and phone contact information. Contributions submitted by **August 15, 2007** will be considered for inclusion in the **next issue** of the SPM e-Newsletter.

Contact Information of the SPM e-Newsletter Team

Min Wu, *SPM Area Editor for e-Newsletter*, University of Maryland, College Park, USA (minwu AT umd.edu)

Huaiyu Dai, *Associate Editor*, North Carolina State University, Raleigh, USA (huaiyu_dai AT ncsu.edu)
   Conference and publication news

Alessandro Piva, *Associate Editor*, University of Florence, Italy (piva AT lci.det.unifi.it)
   News and activities in local chapters and research groups (including new Ph.D. theses)

Mihaela van der Schaar, *Associate Editor*, University of California, Los Angeles, USA (mihaela AT ee.ucla.edu)
   News and activities of SPS Technical Committees, industry consortiums and international standards

Nitin Chandrachoodan, *Digital Production Editor*, Indian Institute of Technology – Madras (nitin AT ee.iitm.ac.in)
   Online submission and production system

Shih-Fu Chang, *SPM Editor-in-Chief*, Columbia University, New York, USA (sfchang AT ee.columbia.edu)

* Please replace "AT" in the email addresses with @.

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In-Depth Articles of July 2007 SPM eNews

Reproducible Research in Signal Processing

Contributors: Patrick Vandewalle, Jelena Kovacevic, and Martin Vetterli

   As described on Wikipedia, reproducibility is one of the basic principles of the scientific method. It refers to

the ability of an experiment to be replicated by another researcher working independently. While such a definition is applicable to science in general, what does it mean for signal processing research specifically? Should all the research presented in our journals be reproducible? For which types of signal processing research is reproducibility most important? What do we do when working on a project with industry? And what does reproducibility require: do the code and data have to be made accessible, or is it sufficient to describe an algorithm accurately in a paper?

One way of approaching the issue is the reproducible research setup developed by J. Claerbout and D. Donoho in their labs at Stanford in the early nineties. With a publication, members of these labs also publish their code and data that were used to produce the results presented. This allows other researchers to easily reproduce results, and compare them to their algorithms using their own data.

At the latest ICASSP conference, a special session was held on this topic, and raised interesting discussions. Papers were presented on issues ranging from standardized data sets, practical setups for reproducible research, publishing aspects, to case studies of actually reproducing certain results. We would be very interested in continuing these discussions online in a discussion forum. Here are some issues to discuss: Would you consider most of the current signal processing research as reproducible? Do you have personal experiences on making research reproducible? Does your lab have a particular setup for sharing code or data? Do you have a personal opinion about the current state of reproducibility in signal processing research and the need (or the absence thereof) to take particular actions? We would be happy to hear your opinion on the discussion forum!

Return to New Initiatives and Trends

Signal Processing for Future Radio Telescopes

Contributors: Amir Leshem and Alle-Jan van der Veen

Radio astronomy forms an interesting application area for array signal processing techniques. Traditionally, radio telescope design was in the forefront of electrical engineering technology. Technological advances in the last decade have created possibilities for large distributed interferometric radio telescopes with very large receiving areas and a sensitivity which is one to two orders of magnitude better than the current generation. Increased sensitivity implies receiving more interfering signals, and therefore RFI detection and removal is now an important topic in radio astronomy. Fortunately, massive digital phased array technology has also greatly advanced during this period and can provide increased flexibility to filter out interference as well as he possibility of directing multiple beams simultaneously.

Several major international research groups are working on next generations of phased array instruments. The most ambitious one falls under the framework of the Square Kilometer Array (SKA) program, with a target commissioning date of around 2020. A second instrument which is a distributed phased array radio telescope is the Low Frequency Array (LOFAR) which is currently under construction in The Netherlands, and slated for 2008.

Prior to this, the Allen radio Telescope Array (ATA) being built in California is serving as a prototype for one of the SKA concepts. It is based on large number of small steerable dishes phased together to form several stations. In contrast, the LOFAR design calls for an instrument consisting of about 13,000 "simple" omni-directional antennas (10--240 MHz), grouped in about 70 stations spread in spirals over an area with a diameter of about 300 km, as well as in a more densely populated central core.

The 200 antennas in each remote station are used as a phased array and are combined in such a way that a beam is formed into a desired look-direction. The resulting output of each beamformer is similar to the output of a telescope dish pointing into the same direction, but is obtained without the use of any moving parts. LOFAR can be seen as a stepping stone for SKA, which should have an effective aperture area of one
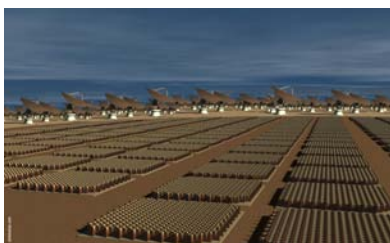
square kilometer, in the frequency range from 100 MHz up to 25 GHz. Just as as LOFAR, it will be a large distributed telescope with many individual elements. The telescope concept for SKA is not yet defined, but several designs are currently being worked out.

In terms of signal processing challenges for the ambitious design of these radio telescopes, we identify three main problems that should be solved in order to meet the design goals:

- *RFI mitigation.* The frequency bands of interest to radio astronomers contain many sources of RFI (radio frequency interference). RFI mitigation techniques will (necessarily) have to form an integral part of the system design. Interesting issues arise because of the hierarchy in the new generation of telescopes: RFI mitigation is possible at the station level (beamforming) but also at the central level (before or after correlation) [ref].

- *Calibration.* Initially the locations and frequency-dependent gains and phases of each receiver unit are unknown and need to be estimated. Additionally, the disturbance due to the propagation through the earth ionosphere (time- and space-varying) has to be measured and compensated for. For large distributed arrays, this is a challenging task [ref].

- *Imaging.* In its simplest form, image formation consists of a spatial Fourier transform of the received correlation data, followed by deconvolution to compensate for the subsampling of the spatial domain. Accurate array calibration parameters are needed to perform this step correctly. After initial image formation, iterative deconvolution algorithms are used to find the locations of the point sources and subtract their effect in the image, so that the more subtle structures become visible. This step can be combined with a gradient search to improve the calibration parameters. Current techniques such as self calibration need to be extended to the case of distributed arrays with millions of unknown parameters. Also the fact that calibration parameters change within the beam of each station introduces a space varying beam that needs to be considered in the imaging process. Finally new insights coming from real time RFI mitigation can be used to improve the quality of the image formation, by considering strong sources as spatially located interference. This leads to a new generation of image formation techniques [ref].

Return to New Initiatives and Trends