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Distributed Image Processing

The emergence of image processing systems with multiple visual sensors has created the need for novel signal processing algorithms that are able to cope with the specific constraints imposed by distributed architectures. For example, large-scale camera networks have been deployed for a variety of applications including video surveillance in buildings and public spaces, as well as monitoring roadways and environmental conditions. Given the bandwidth limitations imposed by the network as well as computation constraints at nodes of such networks, solutions based on distributed processing become particularly attractive from the point of view of communication and computational costs as well as system scalability.

Distributed processing, coding, and communication of visual information has therefore attracted much interest from the research community in recent years. In a distributed processing system, images are efficiently processed and transmitted without the help of any global knowledge of the actual visual information or of the full system. The computational load in processing image sequences can typically be distributed over several nodes that collaborate in solving the task at hand. The ultimate objective is to minimize the penalty compared to a centralized solution, while respecting the resource constraints imposed by the vision sensor network. This special section provides an overview of recent distributed image processing algorithms and discusses the numerous challenges towards designing efficient distributed imaging applications in realistic and imperfect sensing systems. Four articles are included in the special section, covering distributed scene analysis, distributed computer vision and distributed tracking algorithms, as well as cloud computing aspects of multimedia and imaging applications.

In the first article by Song et al., "Distributed Camera Networks," the authors advocate for an integrated sensing and analysis framework for dynamic scene analysis in a reconfigurable and distributed camera network. In particular, the framework that is described aims to optimize various scene analysis performance criteria through distributed control of the reconfigurable camera network. The article considers three fundamental tasks including distributed data association, dynamic camera control, as well as distributed tracking. The work leverages existing work in autonomous multi-agent systems including distributed optimization algorithms based on game theory for dynamic camera network reconfiguration, and consensus algorithms for scene analysis. Such algorithms are expected to serve as the basis for more sophisticated scene understanding schemes that incorporate semantic models and behavior recognition.

In the second article, titled "Distributed Computer Vision Algorithms," Tron and Vidal consider a camera sensor network (CSN) and show that automatic analysis can be achieved by distributed computer vision algorithms, where all cameras collaborate and fuse local information with analysis results from neighboring cameras. It identifies the main challenges in building efficient distributed processing solutions in realistic and imperfect CSN settings. The article then reviews the main distributed processing algorithms that have been proposed recently, such a spanning tree, consensus, and belief propagation algorithms. The application of such algorithms is then discussed in distributed computer vision algorithms such as distributed object pose estimation, distributed CSN localization, distributed CSN calibration, vision graph discovery, and distributed tracking and activity recognition.

In the survey article by Taj and Cavallaro, "Distributed and Decentralized Multicamera Tracking," the authors describe several state-of-the-art multicamera tracking algorithms. This article distinguishes different types of algorithms including distributed, decentralized, and centralized algorithms and presents core processing steps of the various approaches including calibration, synchronization, and the selection of fusion centers. The article outlines several challenges in the design of decentralized and distributed tracking algorithms and provides a comparative analysis and discussion on the performance of different approaches in terms of communication and computation costs as well as tracking accuracy. This article underscores the importance of multicamera tracking algorithms as a key component for a variety of large-scale camera network applications, and provides a comprehensive and balanced review of related approaches.

Finally, the article, "Multimedia Cloud Computing," by Zhu et al., discusses the design and implementation of cloud computing as used for multimedia services, from the perspectives of multmedia-aware cloud and cloud-aware multimedia. The cloud is used for multimedia processing, manipulation,

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adaptation, and delivery to achieve good service quality. Some insights and future directions on this aspect are discussed and presented in the article.

Going forward, we expect distributed image processing and communication algorithms to extend towards an increasing number of applications where large-scale vision sensors are deployed in security, healthcare, or entertainment applications. Recent progresses in low-power imaging sensors coupled with the increasing needs for automatic observation and analysis of our environment are certainly the main drivers for such an evolution. While centralized processing systems do not offer viable options in large-scale resource constrained environments, distributed processing surely indicates the potential for significant benefits. However, there are still many unsolved challenges that arise as a result of the computational paradigm shift in vision sensor networks, where processing and communication tasks become collaborative and exchange of information is not always complete. We hope the articles in this special section provide an informative survey of important work in this area including current state-of-the-art techniques, as well as where future challenges and research opportunities exist.

Finally, we would like to thank the authors for their quality contributions as well as the numerous anonymous reviewers who helped ensure the quality of this special section. We would like to also thank Dan Schonfeld, Li Deng, and Geri Krolin-Taylor for their encouragement and support in organizing this special section. [SP]

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journals and conferences, the whole field is still not popular among students as compared to other fields such as telecommunications, power, and electronics. I find this as an opportunity for SPS and for us to try to do our part in reaching out to these regions and have a presence. Of course, several factors and arguments could explain the unpopularity of signal processing in such places; for example the industry need is in power and communications but not in signal processing. But from my interaction with the students and the faculty at those universities, it was very clear that there are some misconceptions about our field. Therefore, one way for SPS to have a presence in these regions is to recruit associate editors from these areas and let them be our messengers. I would like to request you, our readers, to suggest names of excellent colleagues in those regions. This could be one way to make SPS and *SPM* more popular in Africa and the Middle East.

Allow me to shift gears and talk about a different and yet interesting idea. In a recent NPR report by Robert Krulwich (http://www.npr.org/blogs/krulwich/2011/02/04/133440816/tools-never-die-yes-they-do), he talked about Kevin Kelly's (founding executive editor of *Wired Magazine*) claim in his new book *What Technology Wants* (http://www.kk.org/cooltools/archives/004749.php) that there is no species of technology that has ever gone globally extinct on the planet. The report lists a number of interesting innovations that one might think obsolete but, to Krulwich 's disappointment, Kelly discovers a manufacturer or more are still making these products or devices. Eventually, Krulwich, via his blog, requested all readers and listeners for suggestions of extinct factual (not fanciful) technologies or innovations and he received around 2,500 of them. In early February of this year, he reported three products or actual inventions that do not exist anymore: radium suppositories, roman corvus, and jukebox core. This report and blog made me think of the signal processing theories and algorithms that have been proposed, verified, implemented, and probably included into products and devices. Which of these algorithms or theories have gone extinct (if any), and which ones have the highest impact on our current products and technologies? Of course, in signal processing as a science, knowledge is cumulative where a theory or an algorithm is based on an earlier theory or algorithm, and thus it might be difficult to separate some algorithms from each other. In any case, if you think of an algorithm or a theory in signal processing that was popular at certain point in time and now is extinct, please let us know. Perhaps we could put these inputs into a "History" column (or "Forum") in an upcoming issue of *SPM*.

As we finalize the columns for the remaining issues in 2011, I would like to take this opportunity to thank you, our readers, who showed great interest in the columns we produced and in the new "Social Sciences" column that I introduced in the magazine in late 2010. A special thanks and gratitude to the IEEE SPS members who truly do outstanding jobs in producing the magazine in its current shape. They are the behind-the-scene heroes, and I will miss working with them. Also, I would like to thank our EIC for his continuous support. Last but not least, I would like to thank the wonderful group of associate editors I have had the privilege of working with over the last three years. Without their dedication and excellent jobs, the columns could not have been in the shape that pleases you, our readers. As always, your feedback, comments, and suggestions are very helpful to us, and I promise you many interesting columns in this issue and the remaining issues of 2011. [SP]