

## SUMMARY REPORTS

### INTRODUCTION

The International Society of Information Fusion (ISIF) works to advance the field of information fusion by supporting a number of working groups and workshops. These activities, organized by groups or societies other than ISIF, play an important role in the advancement of the field. The supported workshops defy strict categorization, but they have a number of characteristics in common. Most importantly, they are scientific meetings with a single track for presentations and discussions, and the proceedings of the events are published for future reference. They often focus on a specific aspect of information fusion, and attendance is generally on the order of 50 participants, many of whom come from the local geographic region. They also have generally lower registration fees, which makes them attractive to potential end-users.

ISIF supports events by emailing announcements to ISIF members and adding links on the ISIF website. It also may provide financial support, typically structured to support students and new researchers. This may be a grant for student travel to the event or a best student paper award. ISIF is then recognized as an official sponsor in the event materials and event website.

If you are organizing a workshop, conference, or other scientific or technical event related to information fusion and would like to learn more about possible support from ISIF, contact the VP Working Groups or any other ISIF board member. Applications should be submitted six months before the event to allow time for the board to discuss and vote on your proposal.

This issue of *Perspectives* includes three event reports for events held in 2014. There are:

- ▶ IET Data Fusion and Target Tracking Conference 2014,
- ▶ CTFG Workshop 2014, and
- ▶ BELIEF 2014.

These reports are followed by a brief report on SDF 2014. Reports on ISIF-sponsored events in 2015 will appear in later issues of *Perspectives*.

### IET DATA FUSION AND TARGET TRACKING

#### CONFERENCE 2014: ALGORITHMS AND APPLICATIONS<sup>1</sup>

The Tenth IET Data Fusion and Target Tracking Conference was held April 30, 2014 at the University of Liverpool, United Kingdom. This conference series is a biennial event providing an opportunity for researchers, developers, and operators to discuss advances in and applications of data fusion technolo-

gies. Participation in this conference presented an opportunity for developers to hear from and speak directly with a broad spectrum of their end-users, and offered academics working in this field a platform from which to present their short- to near-term technology. With its dual focus on algorithms and applications, the conference was an opportunity to identify potential collaborations among researchers, users, and developers who are marketing products and tools employing data fusion.



The conference included two keynote speakers and 12 regular presentations in a single, oral track. There were 47 participants. Neil Gordon, head of the Tracking and Sensor Fusion Group at the Defence Science and Technology Organization, gave a keynote lecture titled “One, two, infinity... approximate Bayes for tracking and sensor fusion.” In this talk, he contrasted the elegance of the Kalman filter with the nonlinear, non-Gaussian real world, which limits and frustrates those who wish to apply the Kalman framework. Many approximate methods have been developed in response, ranging from those attempting to retain the Kalman solution structure to those attempting to retain a more complete representation of the density function than just the first- and second-order moments. His talk focused on recent developments in Bayesian approximation methods and future requirements to help bridge the gap between low- and high-level fusion.

The second keynote speaker was Fred Daum, principal fellow at Raytheon, with a lecture titled “Particle flow for nonlinear filters, Bayesian decisions and transport.” In this talk, he explained what particle filters are and why they are popular with engineers addressing real-world problems, despite their exponentially increasing cost to process. He then presented a new nonlinear filter theory that used particle flow to compute Bayes’s rule. This filter theory was described as being many orders of magnitude faster than standard particle filters for the same accuracy, beating the extended Kalman filter by several orders of magnitude for nonlinear problems.

The rest of the day was filled with 12 shorter presentations. In addition to the many papers describing applications of particle filters, there were papers discussing belief functions, Bernoulli processes, Kalman filters, and probability hypothesis density (PHD) filters. The conference program and the presented papers are available on IEEE Xplore at <http://ieeexplore.ieee.org>. The papers are available in book form from Curran Associates at <http://www.proceedings.com>.

The best paper award of £300, sponsored by ISIF, was presented to Fredrik Gunnarsson of Ericsson Research and Linköping University and Fredrik Lindsten of Linköping University, Sweden for “Particle filtering for network-based posi-

<sup>1</sup> By Garfield Mellema, with material from the conference organizers.

tioning terrestrial radio networks.” The paper described how the distance of a wireless mobile terminal from its base station and the signal direction of departure from that base station could be estimated from information already available in the network, as well as how particle filters and smoothers could be used to postprocess those measurements. An ISIF-sponsored travel grant was also awarded to cover the costs of a student’s travel to the conference. The recipient, Shimin Feng of the University of Glasgow, presented the paper “Fusing Kinect sensor and inertial sensors with multirate Kalman filter,” which he cowrote with Roderick Murray-Smith, also of the University of Glasgow.

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### CTFG WORKSHOP 2014

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The Canadian Tracking and Fusion Group (CTFG) was established in 2010 with the objective of advancing awareness of information fusion and its use to address real-world problems, as well as to encourage collaboration among government, industry, and academia on problems of common interest related to information fusion. September 9–10, 2014 the CTFG held its fourth annual workshop, CTFG Workshop 2014, at the Communications Research Centre, Shirleys Bay, Ottawa, Canada. The workshop was well attended, with 55 participants from government, industry, and academia.

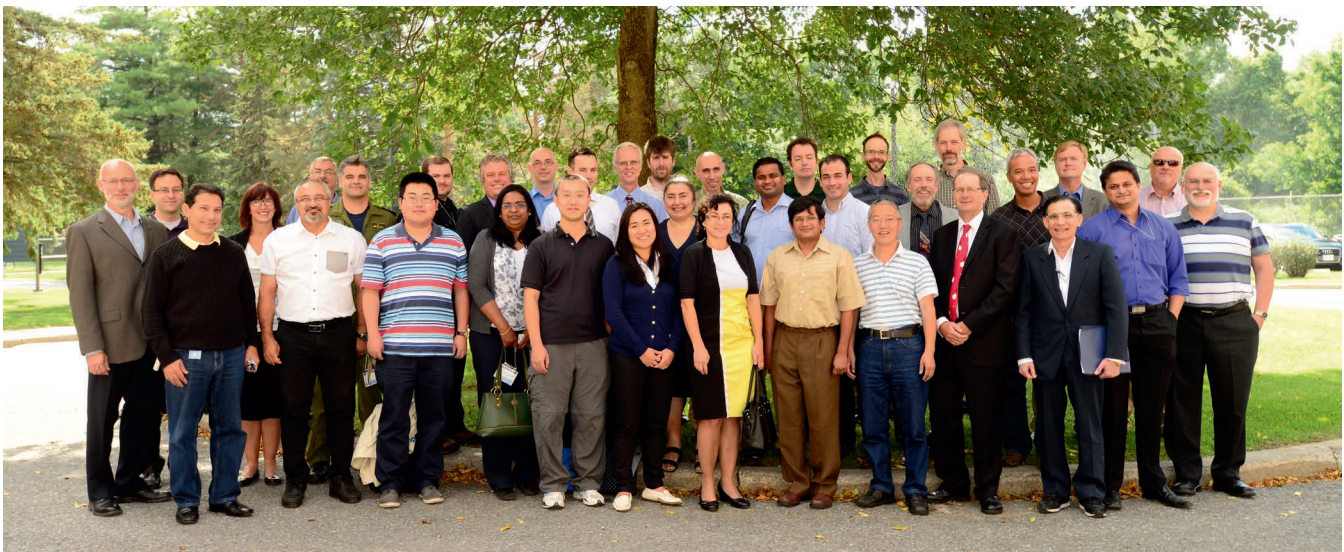
The format of the workshop was a single, oral track, with 14 authors presenting recent work of interest on topics such as source evaluation and performance, target tracking and filtering, detection and localization algorithms, and video processing and surveillance. In addition to these presentations, there was a talk by an invited speaker each day and a panel discussion at the end of the first day. A no-host dinner was held to encourage further discussion and collaboration.

The workshop was opened by Jocelyn Tremblay, who reflected on his early experiences as a defense scientist using Kalman filters for antisubmarine warfare late in the Cold War. In his

current position as director general of science and technology center operations at Defence Research and Development Canada (DRDC), he has had the opportunity to view defense science on both broad and narrow scales, and he spoke of the importance of information fusion to defense science at all levels.

The first invited speaker was Col. Gregory D. Burt, commander of the Canadian Forces Intelligence Group, with a talk titled “Information related challenges: a CFINTCOM perspective.” His view of information fusion was from the perspective of the end user, where the value of a system is determined by its end result and the value of information is determined by its effectiveness in achieving that result. In the context of defense intelligence, and from the perspective of the operator, Burt raised the question of how information fusion could provide more effective tools to shift the balance of human activities from searching to analyzing. The requirements of the analyst are improved collation, analysis, collaboration, information management (IM), and advanced tools. To achieve this will require more than just automation; it will require an improved methodology, taking into account modern and future information technology, IM, and knowledge management, always keeping the end purpose in mind.

The second invited speaker was Capt. (Ret’d) Kurt Salchert of Beyond the Border Consulting. A veteran of 30 years in the Royal Canadian Navy with a long list of leadership positions, including his final years as commander of the North American Aerospace Defense Command, Kurt Salchert provided unique insight into the end user’s view of information fusion in the context of naval surveillance and security. A key challenge he cited is to provide the right information at the right points along a response-threat timeline. Information that is too early or too detailed is wasteful, as is information that is too late or insufficient. He also reinforced the need for international collaboration and information exchange to support maritime security. A grant from ISIF was used to pay the travel expenses of Kurt Salchert.



CTFG Workshop 2014 participants. (Photo by Janice Lang, DRDC)





Elisa Shahbazian of OODA Technologies opens the panel discussion at CTFG Workshop 2014 with a presentation on the roles and challenges of high- and low-level data fusion. (Photo by Janice Lang, DRDC)

At the end of the first day, there was a panel discussion on the theme “From low-level to high-level fusion: challenges in C4ISR applications.” The panel members were Kurt Salchert, Elisa Shahbazian of OODA Technologies, and Dan Brookes, defense scientist on the DRDC Northern Watch Technology Demonstration Project. The discussion began with a short presentation by Shahbazian that introduced the roles and challenges of high- and low-level data fusion. With increasing interest in the Canadian Arctic and the recent announcement of a proposed fiber-optic link to that region, it was no surprise that much of the discussion centered on the problem of arctic surveillance, in particular maritime surveillance. Subtopics of interest included the utility of information transfer between low and high levels and the differences in how performance is evaluated at the different levels.

The rest of the talks presented during the workshop were grouped into four sessions. The Source Evaluation and Performance session included three presentations dealing with information at a relatively high level of refinement and another on the very low, numerical measurement level. The Target Tracking and Filtering session included three presentations on the detection and tracking of targets at the sensor measurement level. The Detection and Localization Algorithms session continued on this theme but focused on the localization of a single target. Higher-level information fusion returned to the agenda in the final Video Processing and Surveillance session, in which the speakers addressed issues related to site surveillance using diverse sensors, including some preprocessed higher-level information streams.

An abridged copy of the workshop presentations was distributed to participants. More information about CTFG Work-

shop 2014 can be found on the CTFG website at <http://www.ctfg.ca>.

### BELIEF 2014<sup>2</sup>

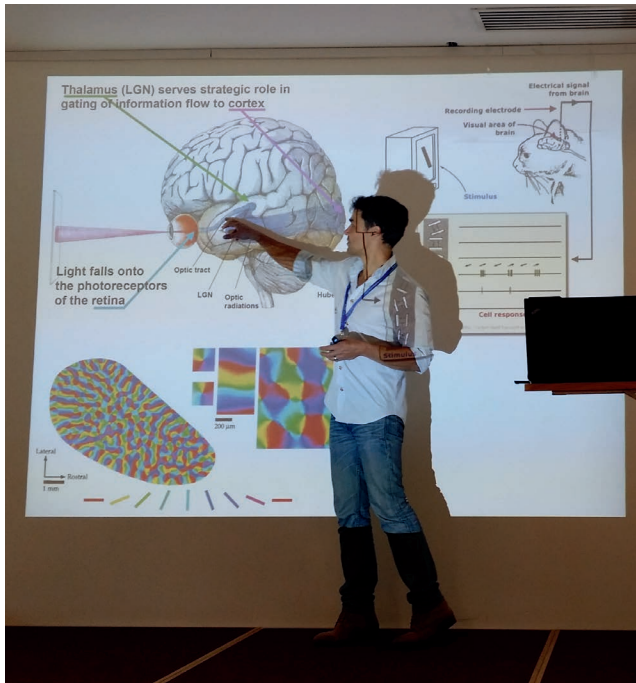
The theory of belief functions, also referred to as evidence theory or Dempster-Shafer theory, was first introduced by Arthur P. Dempster in the context of statistical inference and was later developed by Glenn Shafer as a general framework for modeling epistemic uncertainty. These early contributions have been the starting points of many important developments, including the transferable belief model, the theory of hints, and the Dezert-Smarandache theory. The theory of belief functions is now well established as a general framework for reasoning with uncertainty, and it has well understood connections to other frameworks, such as probability, possibility, and imprecise probability theories.

The Belief Functions and Applications Society (BFAS) was created to promote teaching, research, application, and creation of knowledge in the domain of belief functions; their extensions; and the links they can share with other theories and techniques. Under that mandate, the BFAS organized a series of biennial conferences on belief functions to provide opportunities to exchange ideas and present new results on the theory of belief functions and related areas, such as random sets, imprecise probability, and possibility theory. BELIEF 2014 was held September 26–28, 2014 at St. Hugh’s College, Oxford, United Kingdom.

<sup>2</sup> By Garfield Mellema and Fabio Cuzzolin, with material from the BELIEF 2014 organizers.



About fifty participants attended Belief 2014.



The invited speaker Prof. Nando de Freitas from Oxford University's Computer Science department, during his talk about novel deep learning approaches.

The conference included two invited speakers and 47 regular presentations in a single, oral track. There were 58 registered participants. The conference began with an invited talk by Professor Nando de Freitas of the Computer Science Department of Oxford University, titled "Deep beliefs." He spoke at length about novel deep-learning approaches and the impact they are having in artificial intelligence and machine learning. Following a break for refreshments, there were sessions of regular presentations on belief combination, machine learning, and applications. The day concluded with a general meeting of the BFAS.

The second day opened with an invited talk by Professor Thomas Lukasiewicz, also of the Computer Science Department of Oxford University. In this presentation, titled "Uncertainty in the semantic web," he spoke about his work on uncertainty, noting that the logic-based approaches used in the field could find a natural generalization with the framework of belief functions logic. The day continued with sessions of regular presentations on theory, applications, and networks. In the evening, there was a conference banquet and award ceremony.

The final day of the conference featured a panel discussion, an open discussion session titled "The future of belief functions in the context of uncertainty theory." The question was raised of how to maximize the impact and visibility of work in this field. A tentative action list was proposed, including the launch of a series of methodological challenges to bring more focus to the work, advances toward completing the missing elements of belief theory, and improved means of communication among the scientists interested in belief functions. Regular presentations included sessions on theory, data association, information fusion, and geometry.

Two awards were presented. The Best Paper Award went to Thomas Reineking and Kerstin Schill of the University of Bremen, Germany, for their paper "Evidential object recognition based on information gain maximization." The paper, which proposed an active object recognition framework based on belief function inference and information gain maximization, was sig-



naled by the board to be an example of novelty and significant methodological contribution likely to spur further research.

The Best Student Paper Award, sponsored by ISIF, went to Ph.D. student Philippe Xu and his advisors, Franck Davoine and Thierry Dencœux, from the Université de Technologie de Compiègne, France, for the paper “Evidential logistic regression for SVM classifier calibration.” The paper proposes an interesting calibration method to transform the output of a classifier into a belief function, a significant methodological contribution. Thanks to the ISIF grant, Philippe Xu attended the Fusion 2015 conference in Washington, DC, and presented a paper titled “Evidential multinomial logistic regression for multiclass classifier calibration,” follow-up work of his BELIEF 2014 paper.

More information about BELIEF 2014, including the invited talks, can be found at the conference website at <http://cms.brookes.ac.uk/staff/FabioCuzzolin/BELIEF2014/>. The proceedings of BELIEF 2014 were published in book format by Springer’s Lecture Notes in Artificial Intelligence/LNCS series, Volume 8764, and are available online at <http://www.springer.com/computer/ai/book/978-3-319-11190-2>. More information about the BFAS, including conferences and schools, can be found on the society website at <http://bfas.iutlan.univ-rennes1.fr/>.

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## SDF 2014

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The ninth annual workshop on “Sensor Data Fusion – Trends, Solutions, Applications” (SDF 2014) was held October 8–10, 2014 at the University of Bonn, Germany. By design, the SDF workshops are not just about theories, equations, and data. They are also opportunities for workers in the field to meet one another, discuss areas of common interest, and explore potential collaborations. Designed to appeal to both newcomers to the field and experienced workers, SDF 2014 included a tutorial by Wolfgang Koch and a plenary lecture on maximum-likelihood methods by Peter Willett. There were 22 papers presented on a variety of topics related to information fusion at and near the sensor level. Sessions ranged from localization, tracking, navigation, and multisensor fusion to advances in pattern recognition, context fusion, and estimation theory. The Best Student Paper Award was sponsored by ISIF, and it was presented to Antonio Zea, a student of Uwe Hanebeck at the Karlsruhe Institute of Technology, Karlsruhe, Germany. Papers from the event are available on IEEE Xplore.

More information about SDF 2014, as well as photos of the event, can be found in the February 2015 review by Koch in the *IEEE Aerospace and Electronic Systems Magazine* at <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7063665&tag=1>.