

EARLY HISTORY OF INTERNATIONAL SOCIETY OF INFORMATION FUSION

Abstract—The International Society of Information Fusion (ISIF) was formed in 1998 to address the needs of the information fusion community. Several communities were involved in information fusion around that time but there was not a single technical society with focus on information fusion. FUSION'98 provided an opportunity for people with interests in fusion to get together. ISIF was formed to be a sponsor for FUSION'99 and future fusion conferences. Several individuals played key roles in the early history of ISIF.

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The International Society of Information Fusion (ISIF) was formed in 1998. Its main activity is sponsorship of the annual Fusion conferences. Conference attendees automatically become members because the registration fee includes the ISIF membership dues. Thus most people know ISIF through its conferences, but know little else about ISIF itself and its history.

This paper will discuss the early history of ISIF with emphasis on how it was formed. It will reveal interesting tidbits such as Fusion 1998 was not sponsored by ISIF, and a key player in its formation was not from the fusion community.

FUSION COMMUNITIES AROUND 1998

It is hard to pinpoint when sensor fusion, data fusion, or information fusion was established as a separate research area. However, fusion-related activities were performed as soon as multiple sensors or sources became available, initially by human operators, and then in autonomous systems such as robots. Several communities with fusion activity are discussed here.

DEFENSE AND AEROSPACE COMMUNITY

As in many fields, early research was funded mostly by government for defense and aerospace applications because there was a need to utilize the data available from multiple sources. By around the 1980s, there was a defense research community working on detection, tracking, target recognition, and identification with data from radar and other sensors.

Many researchers in the radar community had backgrounds in signal processing and control systems. Thus, papers on information fusion appeared in signal processing and control/estimation conferences and journals. These papers included the probabilistic data association filter (PDAF) [1] and multiple hypothesis tracking (MHT) [2], [3]. Because of its focus on aerospace and defense, the IEEE Aerospace and Electronic Systems Society gradually replaced the Control Society as the home for fusion researchers, with more papers appearing in the *IEEE Transactions on Aerospace and Electronic Systems*.

Within the US defense community, the MIT/ONR Workshop on Distributed Information and Decision Systems Motivated by Command-Control-Communications (C3) Problems (1978 to

mid-1980s) brought together researchers in academia, industry, and government. In 1987, two conferences dedicated to information fusion were started: the Tri-Service Data Fusion Symposium (1987–1995) and the National Symposium on Sensor Fusion (1987–1996). These two conferences restricted their attendance to researchers for the US government, and in 1997 merged into the National Symposium on Sensor and Data Fusion.



Even though there were meetings dedicated to fusion, there was no single group focused on data fusion. Around 1983, the Joint Directors of Laboratories (JDL) Technical Panel for C3 formed the Data Fusion Sub-Panel, chaired by Franklin White from Naval Ocean Systems Center (NOSC). This panel, later known as the Data Fusion Group (DFG), conducted surveys of the fusion research community to assess the state of the art and developed the well-known JDL data fusion model [4].

Data fusion in Europe had a late start when compared with the United States. However, the fusion community grew rapidly in the United Kingdom and continental Europe. Papers on fusion were published mostly in the Institution of Electrical Engineer (IEE) journals. The Eurofusion conference was held in the United Kingdom in 1998 and 1999.

In Australia, the Defense Science and Technology Organization (DSTO) was active in information fusion, including the development of data fusion lexicons [5]. The First Australian Data Fusion Symposium was held in Adelaide in 1996. While it was a successful conference, the second symposium was not held until 1999, when it became part of the Information, Decision and Control (IDC) Conference.

ROBOTICS, AUTOMATION, AND INTELLIGENT SYSTEMS COMMUNITY

Fusion of data from multiple sensors is needed to control robots and support automation [6]. The IEEE International Conference on Multisensor Fusion and Integration (MFI) for Intelligent Systems was started in 1994 to focus on problems and solutions of particular interest to this community. Sponsors of this conference include the IEEE Robotics and Automation Society (RAS) and

the IEEE Industrial Electronics Society (IES). This community involves more academic researchers than the defense and aerospace fusion community with many conferences held in Europe.

ARTIFICIAL INTELLIGENCE AND COMPUTER VISION COMMUNITY

Information fusion is a natural application for artificial intelligence (AI) because humans are expert fusers that combine information from sight and sound. In response to the Japanese Fifth Generation Computer project, the US government started the Strategic Computing Initiative to advance the state of the art in computing and machine intelligence, and fusion was one of the application areas [7]. Thus fusion papers started to appear in American Association of Artificial Intelligence (AAAI) conferences and International Joint Conference on Artificial Intelligence (IJCAI).

The AI community recognized very early that reasoning under and management of uncertainty is an important component in intelligent systems [8]. The first Uncertainty in AI Conference was held in 1985 with the Association for Uncertainty in AI (AUAI) as its sponsor. The AUAI community consisted mostly of researchers in probabilistic reasoning, but there were also conferences for evidential reasoning, possibility theory, and other approaches.

Computer vision is an important area in machine intelligence, and fusion in computer vision is an active area of research [9]. Papers are presented in Computer Vision and Pattern Recognition (CVPR) conferences and published in journals such as the *IEEE Transactions on Pattern Analysis and Machine Intelligence*.

OTHER INFORMATION FUSION COMMUNITIES

The International Society for Optical Engineering (SPIE) sponsors conferences on many popular topics. Conferences on fusion started to appear in the early 1990s. Examples include Signal Processing, Sensor Fusion, and Target Recognition since 1992 [10], and Sensor Fusion and Aerospace Application since 1993 [11].

The remote sensing and Earth science communities have the task of combining satellite data and other image data [12], [13]. They have their own society in IEEE, the Geoscience and Remote Sensing Society, which holds conferences and has its own journal. Although image fusion is an important problem in defense and security, there is little interaction between the two communities.

FUSION'98

By around 1997, information fusion was an active area of research with international involvement. There were several conferences on different aspects of fusion, but there was not a single international conference or a professional community dedicated to information fusion.

HOW FUSION'98 WAS STARTED

In January 1997, *Proceedings of the IEEE* published a special issue on data fusion with an introduction on multisensor fusion [14]. This issue is probably the first time that papers on

diverse fusion applications such as defense, robotics, and remote sensing appear in the same publication. The time was ripe for an international conference on information fusion.

Professor Hamid Arabnia of the University of Georgia is the founder and chair of the annual International Conference on Parallel and Distributed Processing Techniques and Applications (PDPTA), which was started in 1995. From 1995 to 1997, the conference received between 10 and 30 submissions each year on fusion of multisource and multisensor data, but was unable to accept all the papers because they were only marginally relevant to the PDPTA conference. At PDPTA in June 1997, it was decided to have a new conference in 1998 to accommodate the papers related to fusion. During an open panel discussion, Dr. Dongping (Daniel) Zhu from a small company called Zaptron, Inc., suggested to call the conference "Fusion". He offered to be, and in fact became, the General Co-Chair of the 1998 International Conference on Multisource-Multisensor Information Fusion (FUSION'98).

Daniel Zhu received his Ph.D. from Virginia Polytechnic Institute and State University in 1993 with a thesis on "A feasibility study of using CT image analysis for hardwood log inspection". According to his company website [15], his research experience includes image fusion in machine vision, satellite mobile telecom systems, sensor fusion in GPS navigation, hyper-space data mining in informatics, chemometrics, pharmacokinetics, econometrics, industrial process optimization, knowledge fusion in diagnostic expert systems, and neurofuzzy information fusion for financial forecasting and risk management. He worked for several companies and in 1997 founded Zaptron Systems, Inc. in Silicon Valley to focus on data mining and intelligent controls, with applications in search engines, network management, and controls. According to the company website, the company moved to Beijing, China, in 2004 and has products in business analytics and text mining for the financial industry.

Daniel saw the potential of information fusion but as a newcomer to the fusion community, he needed help in attracting papers and attendance. He started by searching the internet for fusion experts to serve on the organizing committee. The first call for papers (CFP) in Fall 1997 listed Belur Dasarathy, who had a website on information fusion, as publicity chair, but the rest of the team did not have enough members from the traditional fusion community. Daniel Zhu contacted Professor X. Rong Li (University of New Orleans), who was well known for his many publications in tracking, and asked him to chair a steering committee. After some initial hesitation because Daniel was not known to the fusion community, Rong decided that the fusion conference was a good idea and formed the steering committee in January 1998. Members included about 25 well-known researchers from academia, industry, and government. Several other committees were set up to involve as many people as possible. The advisory committee was smaller with 11 members. The international program committee had over 50 members. However, many members were not active and some names were included without contacting the individuals.

The CFP in spring 1998 listed Professor Lotfi Zadeh (UC Berkeley) as Honorary Chairman, Daniel Zhu and Dr. Rabiner Madan (ONR) as General Co-Chairs. In addition to serving as General Co-Chair, Madan also arranged a grant from ONR to support student attendance. Other sponsors included the National Science Foundation, US Army Research Office, and the US Army Night Vision and Electronic Sensors Directorate. The list of keynote speakers included Professor Yaakov Bar-Shalom (University of Connecticut), Dr. Enrique Ruspini (SRII), and



Rabiner Madan (left) chairing a FUSION'98 session.



Yaakov Bar-Shalom giving the keynote at FUSION'98.



Rong Li (right) chairing a session.

Colin Johnson, editor of *Electrical Engineering Times*. The inclusion of Colin Johnson was intended to promote the conference beyond the traditional fusion communities, and reflected Daniel Zhu's ambitions about the fusion conference.

PAPERS AND ATTENDANCE

Since FUSION'98 was a new conference with no prior history and a very general CFP, it attracted papers in diverse areas such as defense and security, remote sensing, image fusion, air traffic control, robotics, industrial automation, finance, medical, etc. Papers in defense and security have become the mainstay for the fusion conferences, while industrial automation, finance, medical, are seldom found in later conferences. There were also more papers on fuzzy sets and neural networks in FUSION'98 than later conferences due to the composition of the committees. The conference proceedings had 136 papers in 29 sessions.

FUSION'98 was held at the Monte Carlo Hotel in Las Vegas from July 6 to July 9, 1998, with attendance of about 160 from North America, Europe, and Asia. Some participants attended this conference out of curiosity and stopped attending when they found out that the conference did not cover their research areas. Other attendees found the conference useful and continued their attendance of future conferences. There are probably a handful of people who have attended all conferences.

FORMATION OF ISIF

The idea of a fusion society first appeared in the FUSION'98 email to committee members from Daniel Zhu and Rong Li. The Las Vegas meeting provided an opportunity for people who shared common interests in information fusion to get together. Many attendees saw the need to continue the conference and to form a professional society for its sponsorship. Furthermore, the society had to be created as soon as possible because FUSION'99 needed a sponsor to sign the legal agreements with a hotel or conference center and publication house.

Activities shifted to a high gear from August 1998 to the end of 1998. Daniel was not too busy at the time with his business and wanted to move ahead as quickly as possible.



(From left) Rong Li, Jean Dezert, Vincent Nimier, and Alain Apriou.



(From left) Pramod Varshney, Rabiner Madan, and Nageswara Rao.



(From left) Shozo Mori, Chee-Yee Chong, and Jim Llinas.



(From left) Daniel Zhu, Yaakov Bar-Shalom, and Rong Li.

He immediately set up the website www.inforfusion.org to publicize the fusion society and FUSION'99. As a professor, Rong Li wanted to follow standard procedures and solicit inputs before moving ahead. He had already set up a website www.inforfusion.org for general fusion information and used this website to solicit inputs on a fusion society, FUSION'99, and a fusion journal. For a while, there were two websites on information fusion but the isif.org domain was not available until several years later.

Daniel started working on the incorporation of the International Society of Information Fusion (ISIF) after he returned to California from the conference. He asked an attorney in San Jose to file the necessary papers for incorporation and apply for non-profit status in the United States. He paid from his own pocket all the upfront expenses, which were not repaid until after FUSION'99. ISIF was officially incorporated in September 1998 and received tax exempt status in April 2000.

The newly formed ISIF needed a board of directors and officers to manage its business. Since ISIF did not have any members to elect to the board, Rong Li suggested the formation of an organizing committee to propose an initial board and officers. Rong invited many people to join, resulting in an organizing committee well represented by fusion experts in academia, industry, and government, and from North America, Europe, Asia, and Australia.

Erik Blasch and Jean Dezert held the first ISIF Board election in December 1998. The officers elected were Jim Llinas (USA) as president, Chee-Yee Chong (USA) as treasurer, and Daniel Zhu (USA) as secretary. Other board members were Mark Bedworth (UK), Yaakov Bar-Shalom (USA), Belur V. Dasarathy (USA), Alfonso Farina (Italy), X. Rong Li (USA), Daniel McMichael (Australia), Jane O'Brien (UK), and Pramod K. Varshney (USA). The predominantly aerospace and defense background of the initial board basically set the future direction of ISIF and the fusion conferences.

Another task of the organizing committee was to draft the constitution and bylaws for the management of the society. A subcommittee including Erik Blasch, Chee-Yee Chong, and others solicited inputs from many people. The task took longer than expected, and the final version was not approved until spring of 2000. One important decision was to include the membership fee in the conference registration fee because organizations usually pay for conference registration but not professional society membership. However, this has created some problems in recent years because moving the conference from continent to continent prevents some people from attending the conference every year, resulting in a lapse in their membership. There is now a way to join ISIF without attending the Fusion conference.

FUSION'99

FUSION'99 was the first fusion conference officially sponsored by ISIF. Daniel Zhu proposed FUSION'99 during FUSION'98 in Las Vegas. Again, Daniel wanted to move quickly and proposed himself as General Chair and Sunnyvale, California as



(From left) Jim Llinas, Mrs. Llinas, Ivan Kadar, and Galina Rogova.

the location. Rong wanted to solicit more inputs, but eventually agreed to serve as General Vice Chair and invited Pramod Varshney to be program chair. Since FUSION'99 was no longer related to Hamid Arabnia, who managed the logistics for FUSION'98, Daniel handled all the logistics of the conference and was compensated for his services. With the help of Rong Li, the conference had many co-sponsors, including several IEEE societies, the Army Research Office, and NASA Ames Research Center. In addition to a general chair, the conference also had an honorary chair, steering committee chair, and advisory committee chair to involve as many people as possible.

The conference was a great success with 203 attendees (up from 161 of FUSION'98) and 187 papers. More importantly, the conference provided the initial members for ISIF and the funds to support fusion activities such as conferences and the journal.

The plenary speakers were Professor Ren Luo (National Chung Cheng University, Taiwan), Dr. Ken Ford and Dr. Peter Norvig, NASA Ames Research Center, USA, and Dr. Franklin White, SPAWAR, USA. A meeting was held with Professor Luo to discuss cooperation with the IEEE International Conference on Multisensor Fusion and Integration (MFI), but no concrete actions resulted from the meeting.

JOURNAL OF ADVANCES IN INFORMATION FUSION

During FUSION'98, some attendees discussed the possibility of starting a journal on information fusion. Belur Dasarathy surprised everyone by announcing that he was starting a new



Oliver Drummond (2nd from left), and Shozo Mori (between Rong Li and Daniel Zhu).

journal called *Multi-Sensor Information Fusion* with Elsevier Science, with him as the editor in chief. After the conference, Belur submitted a proposal to ISIF to adopt *Information Fusion* as the official journal. The benefit to ISIF would be a discounted subscription that would be added to the membership dues. However, ISIF wanted to retain some editorial control. These difficulties were not resolved, and Elsevier's *Information Fusion* journal remains separate from ISIF, which in time started the *Journal of Advances in Information Fusion* (JAIF).

ISIF AFTER FUSION'99

With the members from the attendees of FUSION'99, the first election of the board of directors was held in fall 1999. The board for 2000 consisted of Yaakov Bar-Shalom, Pramod Varshney, Mark Bedworth, James Llinas, Erik Blasch, Chee-Yee Chong, Belur Dasarathy, Alfonso Farina, and Dongping (Daniel) Zhu. The officers were Yaakov Bar-Shalom as president, Chee-Yee Chong as secretary, and Erik Blasch as treasurer.

Daniel Zhu had hoped that ISIF and the fusion conferences would help him grow his business. Since the direction of ISIF no longer aligned with his business area, he lost interest in ISIF and did not attend Fusion 2000 in Paris. He completely cut his tie with ISIF in 2001.

Except for Belur Dasarathy, several other initial board members continued to be active in ISIF. Pramod Varshney was president in 2001, Yaakov Bar-Shalom again in 2002, X. Rong Li in 2003, and Chee-Yee Chong in 2004.

EPILOG

ISIF evolved naturally over the ensuing years, gaining new members with each FUSION conference and naturally new leadership as well. It is almost 20 years since the founding of ISIF, and its early years are not well known to the current membership. The challenges faced by those who recognized the need for an information Fusion community and founded ISIF in response to that need are outlined in this short note.

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