Fusion 2008 Tutorial

Computational Approaches to Situation Assessment and Decision Support

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This tutorial is intended to provide a detailed account of both the cutting-edge and the most commonly used computational approaches to situation assessment (a.k.a. level 2 fusion) and the associated generation of appropriate response recommendations for decision making under uncertainty. The tutorial materials are based on the following two books:

- Subrata Das. (2008). "Foundations of Decision Making Agents: Logic, Probability and Modality," World Scientific/Imperial College Press. (http://www.worldscibooks.com/compsci/6688.html)
- Subrata Das. (June 2008, forthcoming). "High-Level Data Fusion," Artech House, (http://www.scitechpublishing.com/index.asp?PageAction=VIEWPROD&ProdID=459)

A diverse range of level 2 fusion techniques, including Bayesian belief networks, fuzzy logic, and the theory of belief function, will be covered in the tutorial. These techniques are suitable for modeling uncertain knowledge under different situations, and their suitability will be discussed in each case. A number of temporal modeling techniques, such as dynamic belief networks and hidden Markov models will also be presented. The tutorial will discuss interactions between level 1 and level 2 fusion processes. Special emphasis will be given to a discussion on particle filtering techniques as unifying methods for both filtering under level 1 fusion and inferencing in dynamic Bayesian networks for Level 2 fusion. Finally, distributed level 2 fusion techniques, as appropriate within network centric warfare environments, will be discussed.

For the response recommendations part of the tutorial, traditional expected utility theory, rule-based expert systems, and influence diagram based decision-making processes will be described. Then a symbolic argumentation technique using first-order and non-classical modal logics will be presented. Various techniques for aggregating arguments including probability, possibility, and Dempster-Shafer theories will be covered. The argumentation technique and probabilistic aggregation are the major focus of the speaker's recent book on symbolic decision-making and a forthcoming book on the foundations of decision-making agents.

As for software tools, an in-house 5th generation application development platform (Prolog and Lisp) and argumentation building engine (Reason), and an in-house belief network engine (BNet^{TM}, with its temporal extension) will be used for illustrating response recommendations and situation assessment respectively. The commercial-off-the-shelf tools Matlab and Hugin will be used for illustrating Kalman/particle filtering for level 1 fusion, fuzzy inferencing, and influence diagrams for decision-making. Military examples and prototype demos involving tasks of determining relationships among entities and events, target classification, and target identification will be provided throughout the tutorial.

Tutorial Outlines

Lesson 1: Architectures – JDL Model and other architectures
Lesson 2: Application Scenarios – Conventional, MOUT, OOTW, Bioterrorism,
Lesson 3: Background – Uncertainty, Probability and Statistics, First-Order and Modal Logics, INTs

Lesson 4: Brief Introduction to Level 1 Fusion – Data Association, Single and Multi-target Tracking, Kalman Filtering and Extensions, Particle Filtering, Rao-Blackwellised Filtering

Lesson 5: Situation Assessment – Bayesian Belief Networks, Message Passing and Junction Tree Algorithms, Theory of Belief Function, Fuzzy Logic, Hidden Markov Model, Dynamic Belief Networks, Approximate Inferencing via Particle Filtering

Lesson 6: Decision Making – Expected Utility Theory, Rule-based Expert Systems, Influence Diagrams, Dempster-Shafer Theory, Certainty Factor**,** Symbolic Argumentation

Lesson 7: Foundational Tools – Bayesian Belief Network Engine, 5^{th} Generation Application Development Environment (Prolog and Lisp), Argumentation Building Engine (Reason)

Lesson 8: Future – Network Centric Warfare and Distributed Fusion

Lesson 9: Selected References

Lecturer's Bio

Dr. Subrata Das is the Chief Scientist at Charles River Analytics, Inc. (www.cra.com) in Cambridge, MA. Subrata leads research projects in the areas of high-level and distributed information fusion, decision-making under uncertainty, intelligent agents, planning and scheduling, and machine learning. His technical expertise includes mathematical logics, probabilistic reasoning including Bayesian belief networks, symbolic argumentation, particle filtering, and a broad range of computational artificial intelligence techniques. Subrata held research positions at Imperial College and Queen Mary and Westfield College, both part of the University of London. He received his PhD in Computer Science from Heriot-Watt University in Scotland and a M.Tech. from the Indian Statistical Institute.

Subrata has published many journal and conference articles. He is the author of the book "Deductive Databases and Logic Programming," published by Addison-Wesley, and "Foundations of Decision Making Agents: Logic, Modality, and Probability," published by the World Scientific/Imperial College Press. Subrata has also co-authored the book entitled "Safe and Sound: Artificial Intelligence in Hazardous Applications," published by the MIT Press. His forthcoming book entitled, "High-Level Data Fusion," is due shortly for publication by the Artech House.

Subrata is a member of the editorial board of the journal, "Information Fusion", published by Elsevier Science. He is in the process of editing a special issue for the journal relating to agent-based information fusion. Subrata has been a regular contributor, a technical committee member, a panel member, and a tutorial lecturer at each of the last four International Conferences on Information Fusion. He has also been giving a series of tutorials on multi-sensor data fusion on behalf of the Technology Training Corporation.