

Soft Data Fusion for the Industrial Application of Computer Vision

Aureli Soria

aureli.soria-frisch@ieee.org

Abstract: The relevance of information fusion methodologies increases due to the complementary development of computer and sensory technologies. Newly hardware and software facilities allow the inclusion of different information sources in a computer system. Information fusion basically attains the transformation of the information delivered by multiple sources into one representational form. The fused data does not only reflect information that can be extracted from the individual sources but also information not derivable from any of them on its own. Such an information gain characterizes the purpose of information fusion.

Operator research in the context of fuzzy systems has generated a fruitful set of aggregation operators, e.g. fuzzy connectives, weighted ranking operators, Ordered Weighted Averaging (OWA) operators, Fuzzy Integrals. So-called fuzzy aggregation operators constitute a flexible alternative to operators traditionally used in information fusion. Among them it is worth pointing out the role of the fuzzy integral.

The concept of fuzzy integral is due to Sugeno, who presented in 1974 a mathematical approach within Fuzzy Computing for the simulation of multi-criteria evaluation taking into consideration some cognitive aspects. Sugeno's hypothesis is that the process of multi-criteria integration undertaken by human beings subsumes the linear combination of the different criteria with numerically expressed priorities, i.e. weighted sum strategy. Due to its relationship with cognitive processes and to its positive features as fusion operator, the fuzzy integral is employed in different application fields, where Decision Making and Subjective Evaluation represent the most natural ones. Furthermore fuzzy integrals were used in Computer Vision problems, both on Image Processing and Image Analysis, in a very early stage of research. In this context the fuzzy integral is mainly used because of its mathematical properties as fusion operator, which will be elucidated in the tutorial.

In spite of the flexibility, robustness, and interpretability that the fuzzy integral presents when being used as fusion operator, few information fusion applications, especially in Computer Vision, are based on it. This may be due to the complex theoretical background and to the lack of successful implementations of the methodology. Therefore the tutorial brings the fuzzy integral from a mathematical domain to the engineering domain. This goal is achieved in different steps.

First, an engineering framework for all fuzzy fusion operators, which is denoted as Soft Data Fusion, is developed. Furthermore different processing frameworks with information fusion, which go beyond the application of the fuzzy integral on its own, are developed. These frameworks are eventually applied for edge detection on color images, for the industrial inspection of high reflective materials, for the processing of document images, the segmentation of color images and for the industrial inspection of end consumer goods.

Second the tutorial gives the guidelines underlying the development of different methodologies, which can be employed in the automated parameterization of the fuzzy integral within computational intelligence systems. In this context Soft Computing methodologies present the advantage of being data-driven, what facilitates the implementation of full automated systems for information fusion based on the fuzzy integral. Neurocomputing and Evolutionary Computing are the paradigms selected for the resolution of this problem in the here presented tutorial.

Outline

- Multi-sensory computer vision
 - Computer vision systems
 - Imaging as measuring in different spectral domains
- Data and multi-sensory fusion
 - Integration vs Fusion
 - Fusion taxonomy in computer vision
 - Application fields of data fusion in computer vision
 - Methodologies for data fusion
 - Soft Computing for data processing and fusion
- Cognitive inspiration
 - Sugeno's idea
 - Multi-sensory body
 - Multi-sensory fusion at a cognitive level
 - Multi-sensory fusion at a systemic level

- Multi-sensory fusion at a neuronal level
- Application of the fuzzy integral in computer vision
 - Intelligent multi-sensory fusion
 - Soft data fusion
 - Engineering in computer vision with the fuzzy integral
 - Extending the fuzzy integral for image processing
 - Non-automated construction of fuzzy measures
 - Automated construction of fuzzy measures
 - Supervised: genetic algorithms, neural networks, interactive
 - Unsupervised: self-organizing feature maps, statistical analysis
- Frameworks for image enhancement with soft data fusion
 - Highlights filtering in the industrial inspection of high-reflective materials
 - Color morphology based on the fuzzy integral in the industrial inspection of textiles
- Frameworks for image transformation with soft data fusion
 - Color edge detection
 - Seal segmentation on tax forms
 - Skin detection on video sequences
- Frameworks for image analysis with soft data fusion
 - Color image segmentation in market basket recognition
 - Industrial inspection system of collagen plates

About the speaker: Aureli Soria-Frisch was born in Barcelona in 1969. He received the 'Enginyer Tècnic en Telecomunicacions' degree (equivalent BSc) from the University Ramon Llull (Barcelona) in 1992 and the 'Enginyer de Telecomunicació' degree (equivalent MSc) from the Politechnical University of Catalonia – UPC (Barcelona) in 1995. Since 1996 he is at the Department for Security Technologies of the Fraunhofer IPK (Berlin), where he has participated in several research and industrial projects as research scientist and project leader. He has recently obtained the 'Dr.-Ing.' degree (equivalent PhD) from the Technical University Berlin with a dissertation entitled as "Soft Data Fusion for Computer Vision", which describes the application of the fuzzy integral in different industrial systems. He is author of three journal papers, three book chapters, and several conference papers. He has held different speeches on "Soft Data Fusion" and recently a tutorial at the First Latin-American Summer School on Computational Intelligence (Santiago, Chile). His research interest and expertise are focused on the fields: data and multi-sensory fusion, computational intelligence, soft computing for image processing and analysis, color image processing, texture analysis, and bio-inspired image processing.