MULTI-SENSOR DATA FUSION: AN OVERVIEW WITH EMPHASIS ON RECENT DEVELOPMENTS

H.B. MITCHELL
Section 6174
ELTA Systems Ltd
ASHDOD, Israel
hmitchell@elta.co.il

TARGET AUDIENCE

The target audience includes graduate students in electrical engineering and computer science and researchers who have only recently started work in multi-sensor data fusion as well as professional engineers who wish to obtain a systematic overview of the subject

ABSTRACT

Although conceptually simple, the study of multi-sensor data fusion presents challenges that are unique within the education of the electrical engineer or computer scientist. To become competent in the field the engineer or scientist must become familiar with tools taken from a wide range of diverse subjects, including: neural networks, signal processing, statistical estimation, tracking algorithms, computer vision, and control theory. All too often the engineer or scientist views multi-sensor data fusion as a miscellaneous assortment of different processes and techniques which bear no relationship to each other. In this tutorial we present a systematic overview of the subject: The processes and techniques are described using a common statistical, or Bayesian, framework. In this way the theories and techniques are clearly integrated and the underlying pattern of relationships that exists between the different methodologies is emphasized. We emphasize recent developments in the field and include an extended discussion of ensemble learning and boosting algorithms. The tutorial closely follows the author's textbook on the subject (Multi-Sensor Data Fusion: An Introduction, Springer 2007) and is illustrated with many real-life

applications. In the tutorial details of relevant matlab code which are available are given.

DETAILED OUTLINE

The tutorial closely follows the author's textbook on the subject (Multi-Sensor Data Fusion: An Introduction, Springer, 2007).
The main list of topics include:

1. Introduction. We emphasise the Bayesian approach in to multi-sensor data fusion. The framework used is based on the distributed model of Luo and Kay. However other models are briefly discussed including JDL and Omnibus model.

2. Sensors. We briefly present a Bayesian sensor model which is used throughout the course

3. Common Representational format. To a large extent the performance of a multi-sensor data fusion system depends on the correct choice of a common representational format. In this lecture we emphasize the importance of the common representational format and provide an extensive discussion of the techniques used in generating such a format.

4. Spatial and Temporal alignment. These are two important techniques which are used to generate a common representational format. We discuss some of the techniques used in spatial and temporal alignment, where the main emphasis is on multi-modal techniques based on mutual information.

5. Sensor Value Normalization or Semantic Alignment. A major topic of importance in forming a common representational format is to ensure that all sensor values and measurements are commensurate. This we do by normalization. Although of critical importance in any multi-sensor data fusion system, this topic is often not discussed. Here we discuss the topic in great depth including a discussion of many newly-developed statistical techniques.

6. Parameter Estimation. We discuss some of the methods used to estimate parameters. In many systems this is the primary fusion algorithm while in other systems it is of critical importance in the fusion process itself. In real multi-sensor data fusion systems the estimation methods must be robust against outliers and we discuss this topic at length.

7. Ensemble Learning. We consider the ensemble learning and in particular we consider the issue of ensemble learning in image fusion and consider topics such as multi-temporal change detection, pan-sharpening and multi-focus image fusion.

BIOGRAPHY

H.B,Mitchell was born and educated in England obtaining his BSc in Physics (1972), MSc in Quantum Electronics (1974) and PhD in Experimental Low Temperature physics (1977). After completing his post-doc at the Hebrew University in Jerusalem (1980-1983) he joined Elta Systems Ltd as a senior research scientist. At Elta he works in the IMINT (Image Intelligence) division working on electro-optical and SAR image fusion. He has published widely in the fields of image processing, fuzzy logic and sensor fusion and is the author of a recent textbook on data fusion (Multi-Sensor Data Fusion: An Introduction, Springer 2007).