

# Chapter 2

## Multi-Sensor Data Fusion (MSDF)

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### ABSTRACT

*The Data Fusion Model maintained by the JDL (Joint Directors of Laboratories) Data Fusion Group is the most widely-used method for categorizing data fusion-related functions. This paper discusses the current effort to revise and expand this model to facilitate the cost-effective development, acquisition, integration and operation of multi-sensor/multi-source systems. Data fusion involves combining information in the broadest sense to estimate or predict the state of some aspect of the universe. These may be represented in terms of attributive and relational states. If the job is to estimate the state of a people (or any other sentient beings), it can be useful to include consideration of informational and perceptual states in addition to the physical state. Developing cost-effective multi-source information systems requires a standard method for specifying data fusion processing and control functions, interfaces, and associated data bases. The lack of common engineering standards for data fusion systems has been a major impediment to integration and re-use of available technology. There is a general lack of standardized or even well-documented performance evaluation, system engineering methodologies, architecture paradigms, or multi-spectral models of targets and collection systems. In short, current developments do not lend themselves to objective evaluation, comparison or re-use. This paper reports on proposed revisions and expansions of the JDL Data Fusion model to remedy some of these deficiencies. This involves broadening the functional model and related taxonomy beyond the original military focus, and integrating the Data Fusion Tree Architecture model for system description, design and development.*

### 1. INTRODUCTION

The Data Fusion Model maintained by the JDL (Joint Directors of Laboratories) Data Fusion Group is the most widely-used method for categorizing data fusion-related functions. This chapter discusses the current effort to revise and expand this model to facilitate the cost-effective development, acquisition, integration and operation of multi-sensor/multi-source systems. Data fusion involves combining informa-

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tion in the broadest sense to estimate or predict the state of some aspect of the universe (Waltz, & Llinas, 1990; Elmenreich, 2002). These may be represented in terms of attributive and relational states. If the job is to estimate the state of a people (or any other sentient beings), it can be useful to include consideration of *informational* and *perceptual* states in addition to the *physical* state. Developing cost-effective multi-source information systems requires a standard method for specifying data fusion processing and control functions, interfaces, and associated data bases. The lack of common engineering standards for data fusion systems has been a major impediment to integration and re-use of available technology. There is a general lack of standardized or even well-documented performance evaluation, system engineering methodologies, architecture paradigms, or multi-spectral models of targets and collection systems. In short, current developments do not lend themselves to objective evaluation, comparison or re-use.

The end users of this integrated technology of MSDF (Multi-Sensor Data Fusion) (Mitchell, 2007) will be systems, aero control, mechanical, and civil educational institutions; several research and development laboratories; aerospace and other industries; medical diagnostic and biomedical units; civil–military transportation; the automation and mining industries; robotics; and mobile intelligent autonomous systems.

This chapter reports on proposed revisions and expansions of the JDL Data Fusion model to remedy some of these deficiencies. This involves broadening the functional model and related taxonomy beyond the original military focus, and integrating the Data Fusion Tree Architecture model for system description, design and development.

## **2. WHAT IS DATA FUSION?**

The human brain routinely and almost spontaneously carries out a lot of information processing and fusion. This is possible due to the biological neural networks in our brains, which are actually parallel processing systems of adaptive switching (chemical circuits) units. Humans accept input from five sense organs and senses: touch, smell, taste, sound, and sight in different physical formats (and even the sixth sense as mystics tell us). By some incredible process, not yet fully understood, humans transform input from these organs within the brain into the sensation of being in some “reality.” We need to feel or be assured that we are somewhere, in some coordinates, in some place, and at some time. Thus, we obtain a more complete picture of an observed scene than would have been possible otherwise (i.e., using only one sense organ or sensor). The human activities of planning, acting, investigating, market analysis, military intelligence, complex art work, complex dance sequences, creation of music, and journalism are good examples of activities that use advanced data fusion (DF) aspects and concepts that we do not yet fully understand (Dasarathy, 2001, 1994). Perhaps, the human brain combines such data or information without using any automatic aids, because it has a powerful associative reasoning ability, evolved over thousands of years.

In this information technology (IT) age, and in this context multisource multi-sensor information fusion (MUSSIF) encompasses the theory, methods, and tools conceived and used for exploiting synergy in information acquired from multiple sources (sensors, databases, information gathered by human senses, etc.). The resulting final understanding of the object (or a process or scene), decision, or action is in some sense better, qualitatively or quantitatively, in terms of accuracy, robustness, etc., and more intelligent than would be possible if any of these sources were used individually without such synergy exploitation. The above seems to be an accepted definition of information fusion (IF).

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