Agile Data Fusion and Knowledge Base Architecture for Critical Decision Support

Zlatko Zlatev, University of Southampton IT Innovation Centre, Southampton, Faculty of Physical Sciences and Engineering, UK

Galina Veres, University of Southampton IT Innovation Centre, Southampton, Faculty of Physical Sciences and Engineering, UK

Zoheir Sabeur, University of Southampton IT Innovation Centre, Southampton, Faculty of Physical Sciences and Engineering, UK

ABSTRACT

This paper describes the architecture and deployment of a software platform for information fusion, knowledge hosting and critical decision support. The work has been carried out under the TRIDEC project (www.tridec-online.eu), focusing on geo-information fusion and collaborative decision making. Four technologies underpin the architecture: 1) A message oriented middleware, for distributed communications; 2) A leveraged hybrid storage solution, for efficient storage of heterogeneous datasets and semantic knowledge; 3) A generic data fusion container, for dynamic algorithms control; and 4) A single conceptual model and schema, as systems’ semantic meta-model. Deployment for industrial drilling operations is described. Agility is manifested with the ability to integrate data sources from a proprietary domain, dynamically discover new datasets and configure and task fusion algorithms to operate on them, aided by efficient information storage. The platform empowers decision support by enabling dynamic discovery of information and control of the fusion process across geo-distributed locations.

Keywords: Data Fusion, Data Fusion Architecture, Drilling Operations States, Echo State Network, Hybrid Data Storage, Industrial Subsurface Development, Information Fusion, OGC Sensor Web Enablement (SWE)

1. INTRODUCTION

This article describes our work on designing and developing a system for collaborative and critical decisions in evolving environmental crisis for the TRIDEC project (TRIDEC, 2013).

DOI: 10.4018/jdsst.2013040101

The project aims at establishing information fusion approaches and technologies for intelligent geo-information management for critical decision-making in Earth sciences. The TRIDEC project covers environmental application domains where large amount of information is continuously received at high frequency and needs to be processed in challenging times-
cales and in changing context. Two application domains are addressed in the project: Natural Crisis Management (grounded in Tsunami Early Warning scenario) and Industrial Subsurface Development (grounded in Well Drilling Monitoring scenario). Natural crisis management and tsunami early warning are discussed in (Wächter, et al. 2012) and (Moßgraber, et al. 2013). This current manuscript discusses the data fusion system architecture proposed by the TRIDEC project in the context of the Industrial Subsurface Development application domain.

In their seminal text on data fusion, Waltz and Llinas (1990) make the distinction between low level information fusion (LLIF) and high level information fusion (HLIF). LLIF concerns numerical data and at this level the functional processes support classification, identification and tracking. HLIF concerns abstract symbolic information, like threat, intent and goals, and at this level the functional processes support situation, impact and fusion process assessment and refinement. Based on the work of Waltz and Llinas, the Joint Directors of Laboratories (JDL) fusion model was proposed (White, 1991), which initially consisted of three fusion levels. The JDL model had a number of subsequent revisions adding new fusion levels to reflect new theoretical and practical developments (Steinberg, Bowman & White, 1999) (Llinas, et al., 2004)). The latest notable revision is by the Data Fusion Information Group (DFIG). The DFIG fusion model (Blasch, et al. 2006) consists of seven fusion levels, from 0 to 6, as follows:

**Level 0:** Data Assessment: estimation and prediction of signal/object observable states on the basis of pixel/signal level data association (e.g. data collection, missing values estimation, outliers treatment);

**Level 1:** Object Assessment: estimation and prediction of entity states on the basis of data association, continuous state estimation and discrete state estimation (e.g. data filtering and processing);

**Level 2:** Situation Assessment: estimation and prediction of relations among entities, to include force structure and force relations, communications, etc. (e.g. semantic information processing);

**Level 3:** Impact Assessment: estimation and prediction of effects on situations of planned or estimated actions by the participants; to include interactions between action plans of multiple players (e.g. assessing threats to planned actions and mission requirements, performance evaluation);

**Level 4:** Process Refinement (a Resource Management element): adaptive data acquisition and processing to support sensing objectives (e.g. sensor management and information systems dissemination, command/control);

**Level 5:** User Refinement (a Knowledge Management element): adaptive determination of information users and adaptive data retrieval and display to support cognitive decision making and actions (e.g. human computer interface adaptation);

**Level 6:** Mission Management (a Platform Management element): adaptive determination of spatial-temporal control of assets and route planning and goal determination to support team decision making and actions (e.g. theatre operations) over social, economic, and political constraints.

The DFIG’s model combines information fusion (IF) functions with resource management (RM) functions. Level 0 and 1 constitute LLIF and levels 2 and 3 constitute HLIF, whereas levels 4, 5, and 6 constitute the RM fusion levels and play different control and management functions for the available assets and resources. Importantly the RM fusion levels play control and refinement role for the information fusion processes at levels 0 to 3. This role is particularly important for focusing the fusion process on the most risk critical and time critical matters for the current operational context.

A significant effort for designing and standardising data and information fusion platforms and technologies with a focus on geospatial information, has been undertaken.
Introduction to Multi-Agent Simulation
www.igi-global.com/chapter/introduction-multi-agent-simulation/11295?camid=4v1a

A Study of Information Requirement Determination Process of an Executive Information System
www.igi-global.com/chapter/study-information-requirement-determination-process/11324?camid=4v1a