Multi-level data fusion

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In DTIM ONERA, research on data fusion and sensor management has been ongoing for years, covering applications from improved image resolution to ISR. The current research objectives concerns mainly the development of methods for adaptive networking of deployable sensors and the leveraging of distributed computing for the extraction of right and timely information from a sensor field, including detection, classification, and tracking of targets. In the last few years, a growing attention to open architecture allowing the fusion of heterogonous sensor data and to techniques involved in combining multisource data and coordinating multiple sensors and platforms, to enhance system effectiveness, has taken place. This research is an answer to some immediate defense needs (DGA France) as well as a preparation for future needs. In this research, we can distinguish the following thrusts:

1. Detection, classification and tracking

   In a sensor network, sensor nodes acting collaboratively can:

   - exchange data to enable better decisions and to derive other high level data from measurements
   - Fuse data from multiple sensing nodes and create timely reports in response to user needs
   - Minimize power consumption on sensor nodes for communications, signal processing and sensing

For these, techniques for data association from multiple nodes and sensor types are developed considering different architectures for fusion : from centralised one where all information is processed at the level of one centralized processing unit to distributed and mainly hierarchical distributed where part of the processing is done at a sensor level and only processed and confirmed information is exchanged between limited nodes of the network. Analyzing data from multiple sources presents many challenges. Among these, different observability conditions for the sensors, asynchronous data as well as constraints on communication between platforms. One technically challenging area especially relevant to collaborative processing is finding a balance between the amount of exchanged data and the cost of distributed computation. Several research projects and contracts related to data fusion and collaborative processing are tacking place at DTIM/ONERA. These projects cover fields from image fusion (PEA Efusion) to target localization and tracking (PEA TRAGEDAC, DEMAS, PRFs DORADA, SEXTANT...etc.)

2. High level fusion

Knowledge, belief, and uncertainty are three key notions of the situation analysis process. Belief and knowledge representations are crucial steps in transforming data to knowledge. The data coming from certain sources, operators or/and sensors, should be converted into a certain language or presented by such means to allow its use and integration so an operator can decide and act. A formal framework in which knowledge, information, and uncertainty can be represented , combined, managed and updated is necessary. In ONERA, research work is underway to model the situation -analysis process. We can distinguish two main classes :

- Qualitative approaches for reasoning about knowledge where logical frameworks for uncertainty and knowledge processing are introduced.
- Quantitative approaches which are better candidates for uncertainty representation and management are explored in different numerical frameworks for uncertainty. At this level, a lot of research work has been done in DTIM/ONERA on the theory of Dezert-Samarandache (DSmT), of plausible and paradoxical reasoning, which is a natural extension of the classical Dempster-Shafer Theory (DST) but includes fundamental differences with the DST. DSmT allows to formally combine any types of independent sources

of information represented in term of belief functions, but is mainly focused on the fusion of uncertain, highly conflicting and imprecise quantitative or qualitative sources of evidence. In DTIM/ONERA, contextual information and sensor reliability are incorporated into classical fusion operators. New contracts mainly from DGA (FUTHANE for example) are focusing on different aspects of these quantitative approaches.

3. Querying , tasking and system architecture

When several sensor systems and platforms are used in complex scenario, a centralized control system is hardly practicable. Challenges arise from simply and quickly querying sensor systems as well as tasking them with requirements. Researchers at DTIM/ONERA are studying techniques for information directed sensor querying. These techniques allow the intelligent selection of sensors based on information cost measure.

A modular network architecture that can be adaptable to a wide range of different requirements and applications is the objective of ongoing research work on different projects (DEMAS, FUTHANE, SEXTANT...etc.). This objective is mainly to ensure a "plug and sense" approach allowing a seamless extension of the sensor network as well as supporting dynamic querying and tasking. A team of DTIM/ONERA participated actively at NATO projects (CAESAR , MAJIIC and MAJIIC 2) mainly at the levels of tasking and track management.

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