Automatic Target Identification using Data Fusion of Dissimilar Sensors

Identification Automatique des Cibles par Fusion des Données de Plusieurs Capteurs

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Abstract: This project defines an identity information process for a baseline Multi-Source Data Fusion (MSDF) system. The MSDF system shall fuse five Canadian Patrol Frigate (CPF) information sources. These are the two radars (SPS-49, SG-150), the two IFF systems, the ESM system (CANEWS), and the Link-11 remote track source. This project is concerned with the fusion of identity information through the use of statistical analysis rooted in the Dempster-Shafer theory of evidence to provide automatic target identification abroad the CPF.

Résumé: Ce projet porte sur le processus de fusion d'information d'un système de fusion multisource de base. Ce système devra fusionner cinq sources d'information disponibles sur la frégate de patrouille canadienne (FPC). Ces sources sont les deux radars de surveillance, les deux interrogateurs (Interrogateur Friend Foe), le système d'écoute électronique, et les données provenant d'un lien de communication HF (Link 11). Ce projet se concentre sur la fusion d'informations sur l'identité au moyen de la théorie de l'évidence de Dempster-Shafer pour obtenir l'identification automatique des cibles à bord de la FPC.

In today's naval warefare, Commanders and their staff, who are both users and active elements of command and control systems, require access to a wide range of information to carry out their duties. In particular, their actions are based on information concerning the position, identity and behavior of other vessels in their vicinty [1]. The position information determines where objects are, whereas the identity information determines what they are, Behavioral information is concerned with what the objects are doing.

In most fields of applications of data fusion, andin warefare in particular, no one piece of information can be accepted as complete truth. To lessen the damaging effects of poor quality evidence, the combination of information from every possible source is primary importance.

This combination process has often been carried out manually, but to cope with the ever increasing flow of information, automation has surfaced as a possible option for fusion of positional and identity information [2].

The objective of this project is to improve the statistical decision making techniques based on the Dempster-Shafer representation and to implement and evaluate an algorithm for automatic target tracking and identification for Canadian Patrol Frigate (CPF).

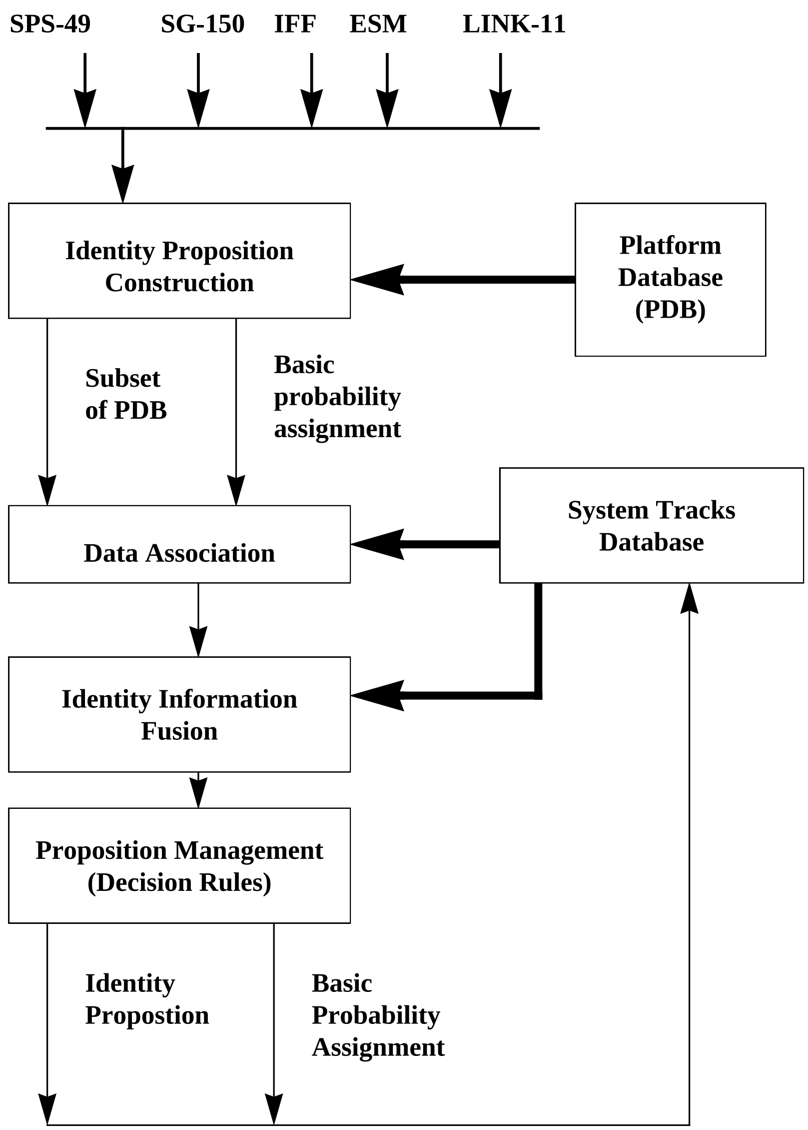

Figure 1 : The Identification Process

In general, radars provide positional information in terms of range, azimuth and velocity components. Electronic Support Measure (ESM) provides positional information as well as attribute information in the form of emitter type. The IFF system provides information (both in terms of position and identity) about a target when a cooperative target responds to the interrogation.

Dempster-Shafer evidential theory of fusing uncertain information proposes a combination rule, called Dempster's rule of combination, which synthesizes basic probability assignments and yields a new basic probabilty assignment representing the fused information.

Let $m_1$and m_2 be the basic probability assignments, on the same frame of discernment Θ, for belief function is Bel_1, Bel_2 respectively. If Bel_1's focal elements are $B_1,...,B_k$ and $C_1,....,C_n$, the total portion of belief exactly committed to A ($A \neq \varnothing$) is given by the orthogonal sum $m = m_1 \oplus m_2$:

$$m(A) = K \cdot \sum_{\substack{i, j \\ B_i \cap C_j = A}} m_1(B_i) \cdot m_2(C_j) \qquad (1)$$

$$1/K = 1 - \sum_{\substack{i, j \\ B_i \cap C_j = \varnothing}} m_1(B_i) \cdot m_2(C_j) \qquad (2)$$

In the automatic identification process (Fig.1), the attribute information obtained from various sensors is compared with a Platform Data Base containing all the possible identity values that the potential target may take. Each record of this database contains information related to the measured sensor attributes. Therefore, each sensor's attribute information is translated into a subset of the Platform Data Base and a confidence level for each subset is then computed. This database shall contain a list of platforms, the main characteristics of the platform (speed, size, type, lethality, list of emitters, etc.).

The second task is the data association process. This process determines to which MSDF track the received sensor information belongs. Following the conclusions of the data association process the Dempster-Shafer combining rules are applied to fuse the MSDF target track identity propositions list with sensor propositions. It is at this level that beliefs are calculated and new propositions may be obtained from the combination rules. The results of the combination are sent to the output proposition management function which is responsible for purning the "unessential" propositions, selecting the "best" identity propositions.

The Dempster-Shafer lacks a formal basis upon which decisions can be made in the face of ambiguity [3]. Different approaches have been studied like the Selzer & Gutfinger, the Liu &Yang methods and the modified Dempster-Shafer approach to overcome this lack. Unfortunately, all these approaches are ad-hoc. An approach based on the expected utility intervall (EUI) will be proposed.

Références

[1] G.B.Wilson, «Some aspects of data fusion » in Advances in Command, Control & Communication Systems *IEEE Computing Series*, vol. 11, 1987, pp. 321-338.

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[3] Thomas M.Strat, "Decision analysis using belief functions" in Advances in the Dempster-Shafer Theory of Evidence, John Wiley & Sons Inc., 1994, pp.275-305.