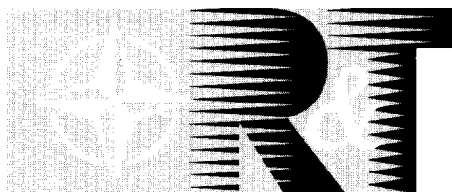


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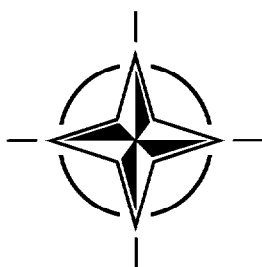
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Application of Mathematical Signal Processing Techniques to Mission Systems

(l'Application des techniques mathématiques du traitement du
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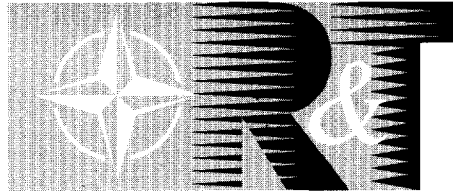
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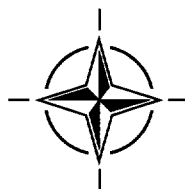
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Application of Mathematical Signal Processing Techniques to Mission Systems

(RTO EN-7)

Executive Summary

Signal processing techniques must develop substantially, on the one hand in order to respond in a more relevant way to more demanding operational requirements, and on the other to obtain maximum benefit from improvements in the technologies on which they are based, whether it be for the sensors which supply them, or the data processing techniques which enable their implementation.

With regard to sensors in particular, the trend is to use the signal for imaging, at increasingly fine resolution, with generally much larger fields. Moreover, processing commonly concerns sequences of images, with close integration of spatial and temporal dimensions. Present day systems in fact tend to multiply the number of sensors and frequency bands operated in close synergy, leading to multi-resolution and non-uniform data (reference systems, reliability,...). The data available are thus increasing in volume, in density and in irregularity, and as a result are becoming more difficult to use.

Operational situations require the generation of increasingly accurate, undeformable and summarised information, to be generated under more and more difficult conditions with shorter and shorter reaction times. The data and the interconnections which result from it, must therefore be treated with care, while at the same time attempting to ensure the highest possible level of automaticity.

There are a number of emerging techniques which could meet these requirements, mostly originating in mathematical theories as diverse as wavelets, variational methods or the theory of evidence. These techniques cover the whole processing chain fairly evenly, and in particular signal compression and transmission, data extraction and interpretation, and decision-making aids.

JUSTIFICATION: The complementarity of the different emerging techniques, presented in the most varied mathematical frameworks, so as to respond to what is a critical development in sensor system integration requirements, should produce a series of tools capable of meeting the needs expressed at all levels of the processing chain.

SUBJECTS EXAMINED: This Lecture Series presents a whole range of perspectives for different levels of processing, based on some of the most promising techniques. Particular attention will be paid to the following subjects:

- Wavelet analysis: summary of the possibilities; application to detection in natural background radiation and extraction of primitive invariants.
- The concept of Multirate Filter Banks in conjunction with the various transforms which this technique enables; applications to compressed video image and sequence transmission, to noise rejection, to jamming and to encoding.
- Variational methods based on partial derivative equations for image processing and multi-scale video sequences; presentation of different image segmentation approaches.
- Multi-sensor processing based on the theory of evidence: processing of the functions of detection, classification, matching of ambiguous observations, or tracking, with the aim of solving problems such as data modelling, decision making, the management of non-uniform reference systems, or the integration of contextual knowledge.

The material in this publication was assembled to support a Lecture Series under the sponsorship of the Systems Concepts and Integration Panel (SCI) and the Consultant and Exchange Programme of RTA presented on 1-2 November 1999 at DLR Koln, Germany, on 4-5 November 1999 at ONERA, Paris, France, and 9-10 November 1999 at the Naval Post Graduate School, Monterey, United States.

L'application des techniques mathématiques du traitement du signal aux systèmes de conduite des missions

(RTO EN-7)

Synthèse

Les techniques de traitement du signal doivent évoluer de façon substantielle, d'une part pour répondre d'une façon pertinente à des besoins opérationnels de plus en plus exigeants, et d'autre part pour tirer tout le bénéfice de l'amélioration des technologies sur lesquelles elles reposent, qu'il s'agisse des senseurs qui les alimentent ou des moyens informatiques qui permettent leur mise en œuvre.

Au niveau des senseurs en particulier, le signal évolue de plus en plus vers l'imagerie dont la résolution est de plus en plus fine pour des champs généralement plus importants. Il faut traiter le plus souvent, des séquences d'images et ceci en intégrant étroitement leurs dimensions temporelle et spatiale. Les systèmes actuels multiplient de plus le nombre de senseurs et de bandes de fréquence qu'il convient d'exploiter en étroite synergie, conduisant notamment à des problèmes de multi-résolutions et d'hétérogénéité des données (référentiels, fiabilité,...). Les données disponibles croissent donc en volume, en richesse, en hétérogénéité, et en difficulté d'exploitation.

Les besoins opérationnels requièrent par ailleurs l'élaboration d'informations de plus en plus précises, robustes, synthétiques, ceci dans des conditions adverses souvent plus difficiles et avec des délais de réaction de plus en plus courts. Il convient donc d'exploiter de façon d'autant plus rigoureuse les données et leurs synergies, tout en cherchant un niveau d'automatisation le plus élevé possible.

Pour faire face à ces besoins, un certain nombre de techniques émergentes et porteuses ont pu être dégagées à partir de théories mathématiques aussi variées que les ondelettes, les méthodes variationnelles ou la théorie de l'évidence. Ces techniques couvrent de façon assez homogène l'ensemble de la chaîne de traitement, notamment la compression et la transmission des signaux, l'extraction d'information, l'interprétation, et l'aide à la décision.

JUSTIFICATION : Les complémentarités de différentes techniques émergentes et porteuses, élaborées dans des cadres mathématiques les plus variés pour répondre à une évolution critique des besoins en matière d'intégration de systèmes de senseurs, permettent d'envisager un ensemble d'outils propres à satisfaire tous les maillons de la chaîne de traitement.

SUJETS A TRAITER : Le cycle de conférences proposé vise à présenter un éventail des perspectives offertes aux différents niveaux du processus de traitement, en s'appuyant sur quelques techniques parmi les plus prometteuses. Les sujets suivants seront notamment abordés :

- Analyse par ondelettes : synthèse des possibilités offertes ; application à la détection dans des fonds naturels structurés et à l'extraction de primitives invariantes ;
- Concept de "Multirate Filter Banks" en liaison avec les différentes transformées qu'il permet de mettre en œuvre ; applications dans le domaine des transmissions à la compression d'images et de séquences vidéo, à la réjection de bruit, au brouillage, et au codage ;
- Méthodes variationnelles basées sur les équations aux dérivées partielles pour le traitement d'images et de séquences vidéo multi-échelles ; présentation de différentes approches en segmentation d'images ;
- Traitements multi-senseurs basés sur la théorie de l'évidence : traitement des fonctions de détection, classification, mise en correspondance d'observations ambiguës, ou pistage, visant à résoudre des problèmes tels que la modélisation des données, la prise de décision, la gestion de référentiels hétérogènes, ou l'intégration de connaissances contextuelles.

Cette publication a été rédigée pour servir de support de cours pour le Cycle de conférences 216, organisé par la Commission RTO sur les (SCI) du 1-2 novembre 1999, DLR, (Allemagne) et du 4 au 5 novembre 1999 à l'ONERA, (France), et du 9 au 10 novembre 1999 à Naval Post Graduate School, Monterey (Etats-Unis).

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