INTEGRATED CONCEPTUAL FRAMEWORK FOR MONITORING AND CONTROL OF RISK SITUATIONS IN THE SEA AREA

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Methods used to produce traditional cartography seem insufficient when dealing with an emergency response that requires a higher level of dynamism in creation and dissemination of maps. In order to be efficient in an emergency situation, those maps should contain real-time information and up-to-date data. Timeliness is crucial in the area of concern, and definitions of «rust» and «accuracy» significantly differ from those adopted in traditional cartography. in the case of an emergency response, also data of unknown quality and with a low level of accuracy can play an essential role, even higher than pre-qualified data and maps. Therefore, a new framework is necessary to be able to quickly and correctly integrate real-time observations, including ones received from automatic and human sensors.

The proposed integrated conceptual framework is based on the theory of structural dynamics control, system theory and system analysis, operation research and artificial intelligence techniques.

Development of knowledge-based models, methods and algorithms for the monitoring and control of natural and technological objects and for the reconfiguration of monitoring systems plays an important role in decision-making in the task of synthesis and intellectualisation of the monitoring technology and systems for complex technical objects under real-time dynamic conditions. [1]

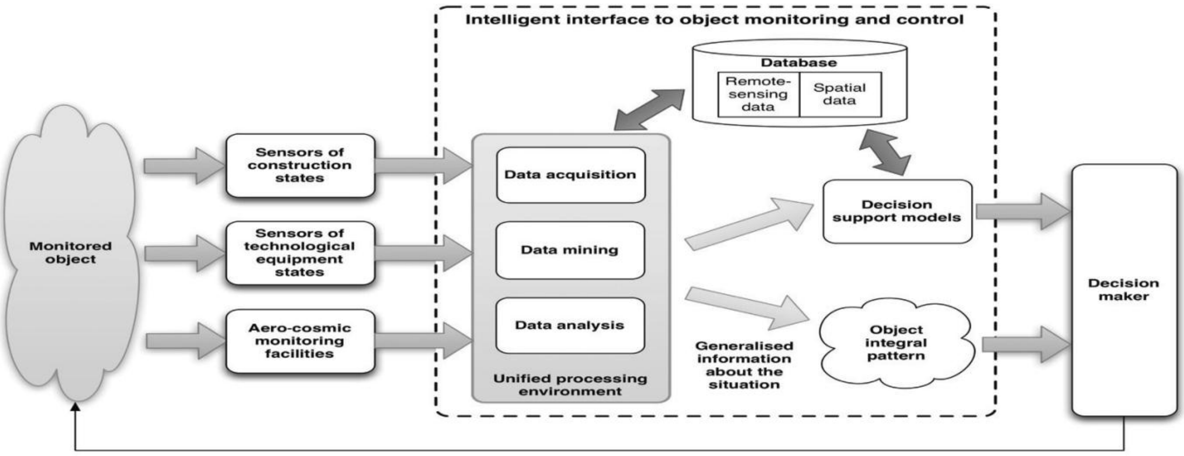

Fig. 1. General architecture of integrated remote sensing and monitoring system

This framework implements a unified approach to the integrated monitoring and control of complex systems that include natural, technological, economic and social elements and contain the following main components [2]:

- integrated real-time monitoring and control based on the analysis of heterogeneous information from space and ground-based facilities;
- unified processing environment for processing heterogeneous data from different sources and their integration;
- distributed, real-time database embedded into the monitoring and control system for creating a common information space;

- multi-models for behaviour analysis of complex objects in normal and emergency situations and decision support;

- intelligent interface to object monitoring and control;

- data-flow computing models for large-scale datasets executed in real-time and in territorially distributed computer networks.

A key component of the conceptual framework is a unified processing environment that provides data mining, processing and analysis functionality. The processed data are used by the decision support component for modelling, optimisation and visualisation of the monitored systems.

The main problem of analysis and synthesis of monitoring and control systems for natural and technological objects is making effective decisions. The proposed framework structure allows combining analytical, simulation and knowledge-based approaches to the modelling, monitoring and control of natural and technological systems [3].

The monitoring data can be produced by different sensor platforms (satellites, aircrafts, land or water based). Consequently, these data may vary in spatial and temporal resolution and internal structures. Integration of information received from numerous heterogeneous data sources provides possibilities to unify and simplify monitoring and control processes. Moreover, the proposed integrated framework and information technology will allow non-professional users to design and develop integrated real-time monitoring and control systems of natural and technological objects.

As an example, the risk situation, consider oil pollution of the sea areas. At present, the technology monitoring of oil pollution of the sea areas has reached a commercial exploitation level and is widely used in many countries. The most efficient approach to this monitoring [4] is based on the joint use of heterogeneous information.

Satellite information is integrated with the data delivered by other observation facilities (air, sea, coastal), providing control of the vast water areas in a detailed overview and shooting modes. Thus, the data are obtained from Earth remote sensing (ERS) supplement information from land-based sources: information on the anthropogenic activities, which is the potential source of pollution, as well as information about natural phenomena and processes that affect pollution. The information about the natural (native) oil showings should also be used.

Delivery of the results to a customer by the most expeditious method shall be the use of web services and geological portals. In this case, the obligatory information layers should be the following:

1) geospatial base – the map containing the most significant landmarks; the base is formed only for the region of concern;

2) outlining of the oil pollution areas, ranked by the dates of detection; for each contour, the attributive information such as date, size, additional data should be determined;

3) converting to the format suitable for use in a geoportal; the ERS data used in monitoring; remote sensing data should also be ranked according to the date of their receipt.

For the approbation of the software prototypes for the monitoring of oil pollution demonstration case have been developed – for the gulf of Finland [4].

The objective of oil pollution monitoring has been the detection of an oil stain in the gulf of Finland as of 30 June 2011 based on the historical data received from the satellite RADARSAT-1 (see Fig. 2).

Moreover, a benchmark result of detecting this oil stain was available (marked in Fig. 2). Detection has been performed using the technology described above, and the obtained result has been compared with the benchmark. The comparison has shown high coincidence of the result and its benchmark as seen in Fig. 3.

In this figure, the effect of «smoothing» of oil pollution of the sea surface can be observed. This effect is clearly detected on the ERS radar as an area whose texture characteristics are significantly different – visually it is perceived as more than one- ton stain dark tint on the background of the most variegated surface.

However, the same effect is given by natural phenomena, such as calm, wind shading, clusters of surface-active agents (surfactants) or algae. This can be seen as a factor interfering with oil pollution detection, which reduces the reliability of the results. To improve the reliability, it is necessary to use information from additional data sources, as discussed before. Besides, oil pollution has a characteristic shape.

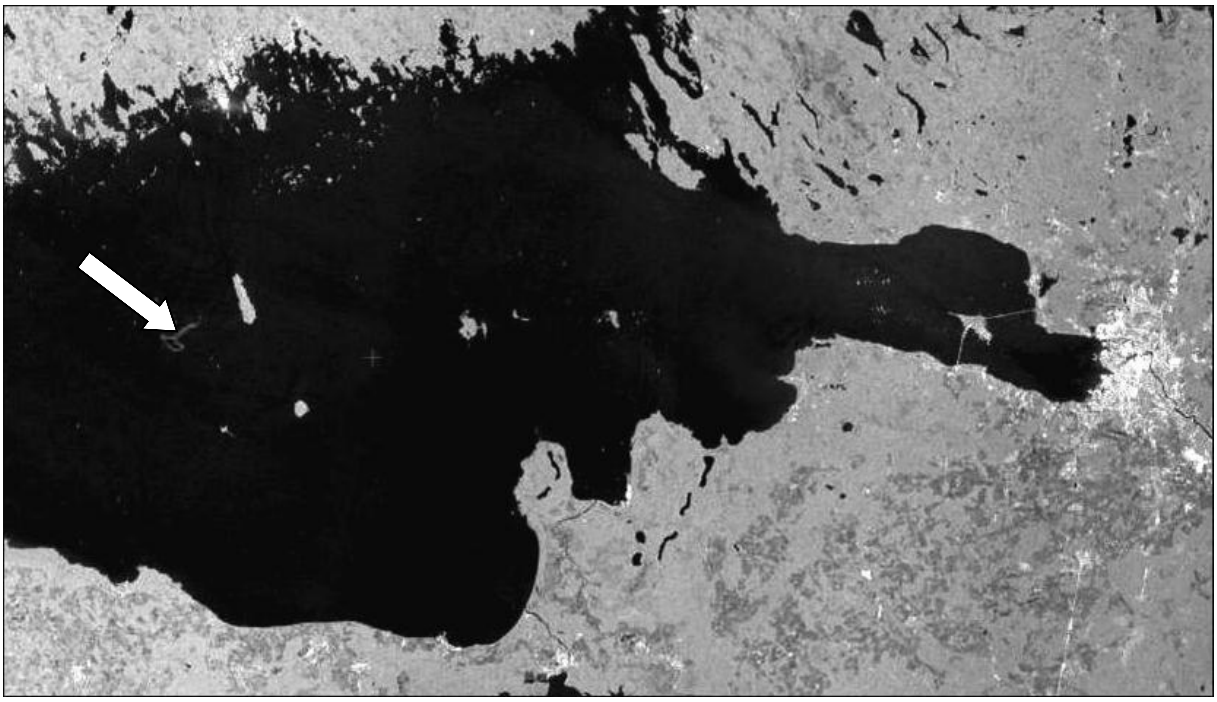

Fig. 2. A fragment of the photograph of the Gulf of Finland with an oil stain received from RADARSAT-1 (30 June 2011)

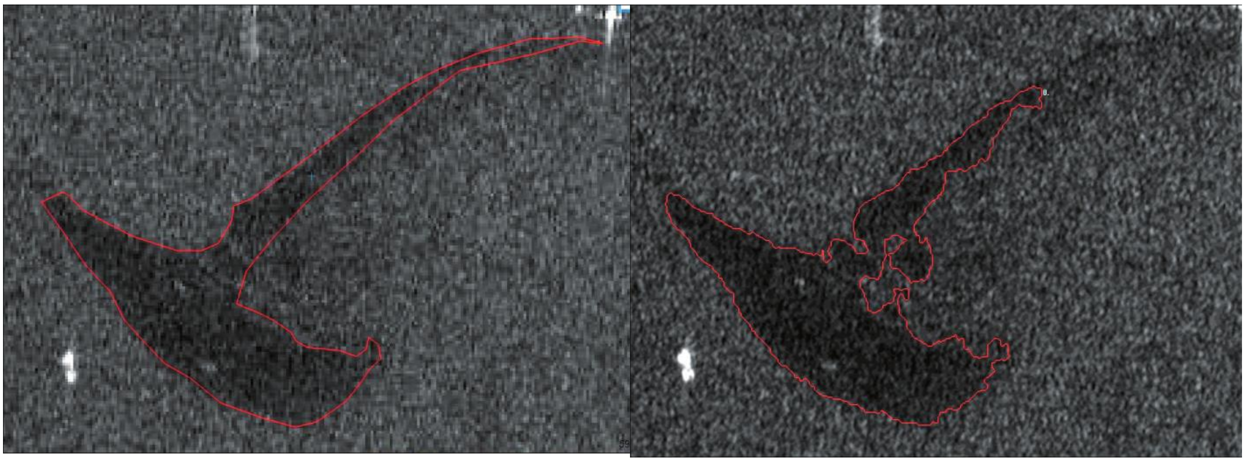

Fig. 3. Detection of oil pollution from the ERS radar data:
a) – the benchmarking data; b) – the obtained result

The solution to this problem is of great importance for the environmental sustainability. Timely detection of oil pollution allows taking measures to quickly eliminate and minimise environmental damage. Moreover, it allows identifying the potential source of pollution or narrowing the range of such sources, as well as estimating early targeted interventions whose results can be used to impose penalties for environmental damage.

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