AEROSPACE MONITORING OF SEA OIL POLLUTION BASED ON TECHNOLOGIES OF COGNITIVE AND EXPERT SYSTEMS

Nazif Sattarov
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Azerbaijan National Aerospace Agency
nsattarov@gmail.com

Abstract

Azerbaijan is geographically located at the intersection of West and East. It has unequivocally made a choice towards innovation. The swift diversification of the economy into processing, industrial, and further into the informational sphere is a defining condition for the competitiveness of Azerbaijan's sustainable development. The issue of selecting the necessary information and making optimal decisions based on it is particularly essential in various emergency situations. In the 21-st century it has become crucial to exercise local and regional control of the Caspian region environment's condition. This can be explained by the intensive development and exploitation of oil fields as well as by natural changes (sea level fluctuations in the coastal zone, etc.). At the same time, with the increasing volume of oil transportation through pipelines and with the help of oil tankers, anthropogenic pressure on the region will be steadily increasing. In this context, the development of new technologies and methodologies that provide information support for ecological observations (in particular, environmental audit and risk analysis), is of decisive importance. In this regard, remote sensing from orbiters exemplifies a powerful method of planetary exploration. Onboard sensors provide unique views of the Earth's surface combined with a large range. On the base of the above-mentioned facts, this paper is aimed at discussing several important features of aerospace monitoring of the oil pollution of the Caspian Sea surface using technologies of cognitive and expert systems.

Keywords: aerospace monitoring, oil, sea pollution, cognitive systems, expert systems

I. Introduction

Azerbaijan has clearly made a choice towards innovation recently. The fastest diversification of the economy into the processing, industrial and further into the information area is the decisive condition for the competitiveness of our sustainable development. The problem of choosing correct data and making optimal decisions based on those is particularly important in the course of various emergency situations [5]. Current ecological crisis in the world is developing unprecedently: oil spills in the sea (Gibraltar, Bosporus, Black Sea), on land (Keystone oil pipeline, USA, Canada; accidents on oil tanks (the state of Ohio), fire on the fixed platform in the Gulf of Mexico, eruption of a mud volcano in the Caspian Sea. One of the main questions to be asked in this case is how a fragile ecosystem of the Azerbaijani sector of the enclosed Caspian Sea will react? It is not easy to answer this challenging question, but one fact is already possible to mention: experts have been already observing a sharp decline in the number of birds and fish in the region. Safety improvements in oil and gas exploration, oil production and transportation methods have unfortunately not reduced the risk of negative environmental impact yet as they had been hoped to do. At the same time, remote observation methods have made it possible to significantly expand the range of possibilities to solve at least some of the existing ecological problems.

After a large-scale accident of the oil spill on the sea surface in the Gulf of Mexico (2010), a number of ecological issues became very important, namely:

1. The importance of correct joint use of radar and optical data in emergency situations [1, 2].;
2. Necessity of development of a new concept of information support system of aerospace monitoring based on a cognitive model [4].

Our previous researches have already touched upon the problem of a lack of cognitive coordination between a person and a computer. Taking this into consideration, the purpose of the given study is to develop a methodology most suitable for the water area of the Absheron peninsula in the Caspian Sea.

Oil pollution in the water area of the region is formed as a result of both anthropogenic activities and spills of natural origin. Systematic monitoring of the water area is currently not carried out. In general, in order to detect oil slicks on the sea surface, satellites equipped with radars are used. Due to the fact that oil smudges the waved sea surface, the obtained images of slicks are usually high-contrast. Optical data carry important information about an oil spill only in cloudless weather. At the same time, radar and optical data have both advantages and disadvantages, which will also be discussed below. As a result of the performed research, **a cognitive model of peculiarities of radar and optical data usage** is proposed**.**

On the base of the above-mentioned it is possible to conclude that scientific knowledge should be cognitive, lucid, and comprehensible. Remote observation methods, particularly those involving space technology, have ushered in a qualitatively novel phase in the informational support of Earth sciences and economic practice [6]. Contemporary means of remote sensing (panoramic video spectrometers, microwave radars, optical systems, lidars, and other electronic technology devices) alongside diverse platforms (Landsat, SPOT, Sentinel, etc.) have facilitated the broadening of the spectrum of addressable inquiries.

When addressing a conservation-oriented task and selecting a strategy with minimal risk factors, the pursuit should aim for maximizing the likelihood of attaining results and optimizing their utility to the greatest extent. These pieces of information, encapsulating diverse perspectives on the studied problem, can be derived from past experiences, scientific satellite-based experimentation, and multivariate cognitive computer simulations. Given that the situation (pertaining to resource utilization, conservation, etc.) exhibits inherent dynamics, proactive monitoring is imperative to stay ahead of emergency situations.

II. Methods

Fig.1 shows the cognitive triad: subject area, goal, means.

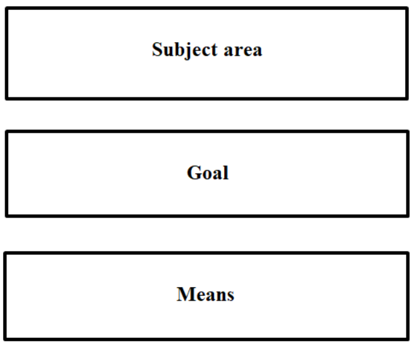


Fig. 1: *Scheme of the cognitive triad*

In the process of experimental research, a large scientific and practical material has been collected. Alongside, the analysis of human-made hazards in the oil sector in various regions of the world has been carried out [6]. Based on this material, informative heuristics of **IF - THEN** structures have been developed [3]. Let us give some examples:

1. **IF** the oil tanker hull is seriously damaged as a result of an accident,
THEN the probability of an oil spill into the sea and the formation of an oil slick is very high.
2. **IF** there is a fire in the tanker,
THEN the probability of an oil spill into sea and the formation of a burning oil slick is very high.
3. **IF** there is a fire on the oil platform,
THEN the probability of oil spilling into the sea and the formation of an oil slick is very high.

Now let us analyze the structure of the cognitive multimedia model of the aerospace monitoring process (Fig.2).

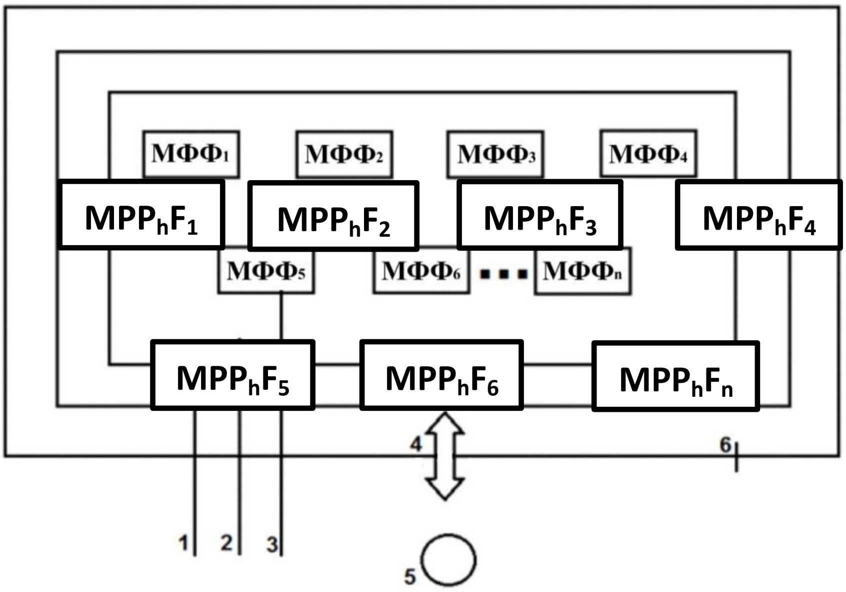


Fig. 2: *The structure of the cognitive multimedia model of aerospace monitoring*

Legend:
1. Screen
2. Cognitive multimedia model
3. Multimedia process phase form (MPPhF)
4. Dialogue interaction
5. Researcher
6. Software and hardware complex

There are three functional components in the cognitive model: a multimedia model of the problem area (technological process), phases of technological process, and dialogue interaction between the researcher and the complex. This also includes online audiovisual communication with experts. A multimedia model of the problem area is a set of audiovisual forms of phases of a given technological process. The phases of the technological process are multimedia images of source data. The multimedia model is designed to display the parameters and conditions of various research objects, that is, information models.

III. Results

The afore-mentioned facts made it possible to create a scheme for cognitive modeling of monitoring oil pollution of sea surface.

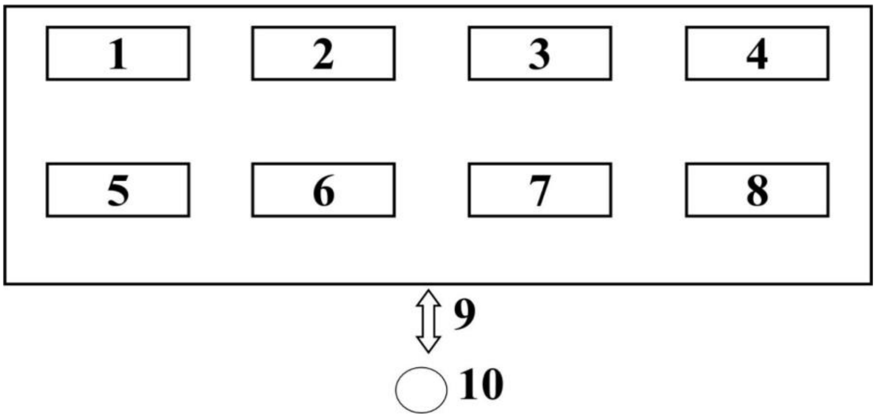


Fig. 3: *Scheme of cognitive modelling of sea oil pollution monitoring*

Legend:
1. Block of emergency situations in the world
2. Block of creation of heuristics of the occurred emergency situations
3. Characteristics of the Caspian Sea
4. Characteristics of the Absheron peninsula
5. Study area of the sea
6. Scheme of aerospace monitoring.
7. Model of the water area of the Absheron Peninsula based on the data of radar and optical surveys (cloudless weather)
8. Model of the water area of the Absheron Peninsula based on the data of radar and optical surveys (solid cloudy weather)
9. Researcher
10. Software and hardware complex.

IV. Discussion

At present, in the scientific world, the multilevel organization of the brain is beginning to emerge more and more clearly. In modern cognitive science it is assumed that a person has a cognitive picture of the world. This assumption is based on internal mental models. Thus, the brain is able to create and use symbolic (figurative) cognitive representations, or mental maps. The ability to generalize (cognitive representation) is the driving force behind human progress. The main task of the cognitive approach is to understand and explain how thought processes are arranged and work. A thought process is a process characteristic of a person, namely: perception, organization, coding, storage, retrieval of information. In our case, this is scientific information about emergencies. Cognitive learning methodology includes many different theories. As a part of our research, let us consider the following chain: individual cognitive picture of the world - subject area - problem area. The brain stores knowledge in long - term memory in the form of schemas, namely mental structures. Therefore, the supply of new scientific information contributes to:

- creation of new mental schemes;
- changing of existing schemes;
- expansion of existing schemes.

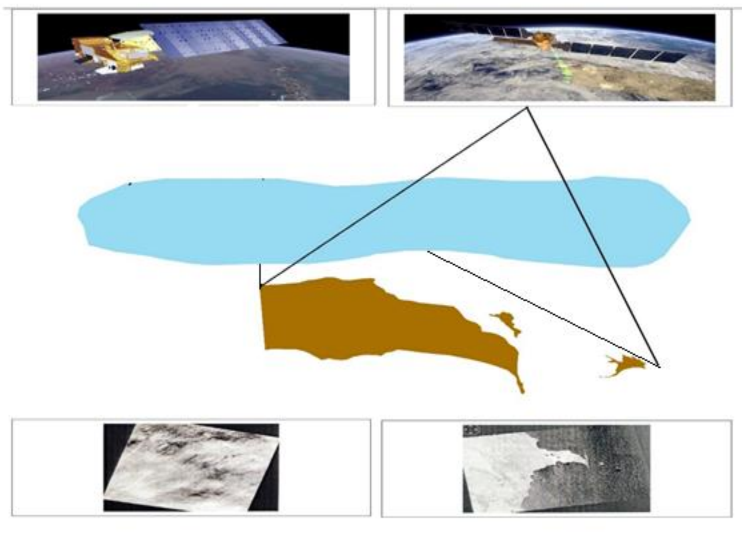
An example of new scientific information for emergency situations can be stages of development of a geographical map: paper map - electronic map - multimedia map. Effective analysis, research and modeling of any kind involves determining the cause of observed events.

Cause and effect relationships between different events underlie cognitive maps of reality. The researcher's accumulated experience must be systematized and structured. This facilitates orientation in heterogeneous information. The mentioned provisions form the basis of the developed scheme (Figure 3).

Now let us consider the features of the presented blocks:

1. The block of emergency situations in the world is designed to collect informative material about human-made hazards in the oil sector in various regions of the world.
2. The block for creating heuristics of occurred emergencies serves to fill the knowledge base.
3. The block characteristics of the Caspian Sea provides information on the physical-geographical and environmental features of the Azerbaijan sector of the Caspian Sea.
4. 4.The block characteristics of the Absheron Peninsula provides information on the geographical and ecological features of the water area on the Peninsula.
5. The sea area under study block provides information about the geographic coordinates of the problem area, etc.
6. The block scheme of aerospace monitoring provides information about the possibilities and tasks of remote sensing, types of aerospace monitoring, optical and radar satellite systems, etc.
7. The block model of the water area of the Absheron Peninsula based on the data of radar and optical survey (cloudless weather) provides a cognitive scheme for the monitoring process.
8. The block model of the water area of the Absheron Peninsula based on the data of radar and optical survey (solid cloudy weather) provides a cognitive scheme for the monitoring process.

As an example, let us consider the cognitive model of the water area of the Absheron Peninsula based on the data of radar and optical surveys (solid cloudy weather).



a) b)

Fig. 4: *Cognitive model of the water area of the Absheron Peninsula based on the data of radar and optical surveys (solid cloudy weather) made on the same day and at the same time.*

Legend: a) Landsat - 8 (21.12.2018); b) Sentinel - 1 (21.12.2018)

Fig.4a shows the optical space image of the air cover over the water area obtained from the Landsat - 8 optic satellite. In the image it can be seen how the water area of the Absheron Peninsula is covered with solid clouds. In this case it is impossible to obtain accurate information about the surface of the Earth. At the same time, with the help of the radar satellite Sentinel - 1, despite the cloudy weather, you can get all the necessary information. Thus, regardless of weather conditions and poor visibility, radar surveys are very convenient for displaying and studying the terrain.

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