MULTIMEDIA SUPPORT SYSTEM FOR AEROSPACE MONITORING OF EMERGENCY SITUATION BASED ON AI TECHNOLOGIES

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Abstract

Technological development, digitalization, cybersecurity, the use of artificial intelligence, all these areas are becoming part of the everyday life of society. Along with the task related to renewable energy, the republic is making its contribution to solving climate change issues. This year, the international conference COP29 will be held in Azerbaijan under the auspices of the UN Framework Convention on Climate Change. In this regard, the attention of the international community will be directed to our country, namely to activities in the field of environmental protection and climate change. Based on this, it is necessary to introduce new solutions and innovations that will help reduce the negative consequences of climate change. One of the important problems is global warming. It leads to disruption of the natural ecosystem, including the occurrence of hazardous natural phenomena and destructive natural disasters. Forecasting the occurrence and development of natural and man-made phenomena on Earth is of great relevance. Direct damage from all types of emergency events amounts to a huge amount. Preventing emergency situations (ES) based on monitoring their precursors is more economically profitable than responding to the consequences of emergencies. Thus, one of the main tasks of disaster risk management is monitoring and forecasting emergencies. The noted consists in constant monitoring of processes occurring in nature and the technosphere with the aim of scientific prediction of possible dangerous phenomena. The forecasting system includes information about the forecast object, which reveals its behavior in the past and present, as well as the patterns of this behavior. Information about these precursors should be sent to the monitoring and forecasting center using monitoring systems. Here, appropriate predictions are made based on heuristic and mathematical methods. According to the area of occurrence, emergencies are divided into natural and man-made ones. On the base of the above-mentioned facts, this paper is aimed of discussing several important features of multimedia support system for aerospace monitoring of emergency situation on the Caspian Sea using technologies AI.

Keywords: multimedia, support system, aerospace monitoring**,** emergency situation**,** AI technologies

I. Introduction

The major environmental issues in the 21st century include: climate change, freshwater scarcity, deforestation and desertification, freshwater and marine pollution, loss of biodiversity, air pollution, soil and natural resource depletion [2]. The environment is considered favorable if its condition meets the criteria and standards established by environmental legislation regarding its cleanliness (non-pollution), resource intensity, environmental sustainability, species diversity and aesthetic richness. The Republic of Azerbaijan is a party to a number of international conventions in the field of environmental protection, including the Convention on Environmental Impact Assessment (EIA) in a Transboundary Context (Espoo Convention) [1,4]. At its core, the Espoo Convention is a means to help Parties (states) cooperate, jointly discuss problems, exchange

opinions and experiences. This Convention represents a set of opportunities for countries in the Economic Commission for Europe region, but at the same time the way they implement them needs to be improved. The most important task at the present stage is to know the boundaries of

HOMEOSTASIS, that is, those critical values of the parameters of the biosphere, beyond which the unpredictable development and destruction of the biosphere begins. Information in the field of environmental protection includes the state of the environment, impacts on the environment, and regulation of environmental quality. An ecosystem of a certain type is preserved only with certain combinations of ecological components. Otherwise, if the balance of eco-components is disturbed, irreversible processes will be observed (classic example: degradation of the Aral Sea) [5]. The most significant changes in ecosystems are caused by significant reasons (accidents on oil pipelines, fires, soil degradation, deforestation, emissions of pollutants into the atmosphere, water bodies and seas, etc.). Within the framework of the scientific and technical work "Development of a multimedia model for aerospace monitoring of emergency situations based on expert systems technology", carried out at the Institute for Space Research of Natural Resources ANASA, three groups of issues are considered: characteristics of the Caspian Sea, oil production and transportation, aspects of emergency situations at sea. Remote research is carried out with the aim of confirming or rejecting a particular scientific hypothesis. Monitoring as a system includes a subsystem for collecting, accumulating and transmitting information, as well as a subsystem for processing, modeling, analyzing and forecasting data. At the monitoring and forecasting center, appropriate predictions are made based on heuristic and mathematical methods [6,9].

Promptly obtaining information about the coverage area, level and quality of the event in each geographic point of the emergency area is one of the main factors that can reduce the tension of the situation in the region. In this regard, the features of multimedia technologies are: the transformation of traditional maps into multimedia ones. Here, along with maps and texts for them, audiovisual information is important: pictures, animation, sound, 3d graphics; a visual representation of the process under study (its phase), for example, in the form of an animated film. Based on this, the "revival" of the components of the IF - THEN heuristics, in the form of static snapshots (pictures), was demonstrated for the first time. The objects of monitoring in this work are aspects of emergency situations. The purpose of monitoring is not a passive statement of facts. It should also include modeling of the processes under study, generalization of accumulated world experience in assessing and forecasting natural and man-made hazards, development of multimedia data banks on various aspects of emergency situations, etc.

II. Methods

A cognitive multimedia monitoring model (CMMM) is proposed in the form of a set of interconnected elements

$B=B_k$, $\quad B_k=R_1^k \cup R_2^k \cup R_3^k \cup \ldots \cup R_{l-1}^k \cup R_l^k = \bigcup_{j=1}^{l} R_j^k$

The model characterizes the various phases of the study, where: R_j is the set of elements of the j-th group model; here $K=m,n,p$: m – number of elements, $m=\overline{1,M}$; l - number of groups, $l=\overline{1,L}$; n – form of representation of semantic information, $n=\overline{1,N}$ (with $N=4$ we have t, S, g and C – forms, where t – text form, S – audio form, g – dynamic (dynamic video images) form, C – graphic (static images: maps, aerospace images, graphs, diagrams, etc.) form; p – type of observations (*2d or 3d*).

CMMM from the position of a researcher represents a certain task, which has conditions, a goal and means of achieving it. Solving a problem is a process of dialogue interaction between a researcher and a complex that has access to the Internet according to a pre-formed strategy. During the dialogue, the current state of the object model is displayed. The course of the process is assessed according to an established criterion (for example, extremes: signal/noise ratio, time to reach the goal, etc.).

The CMMM identifies three functional components: a multimedia model of the subject area (technological process), phases of the technological process, interactive interaction of the researcher with the complex and dialogue with experts on the Internet.

CMMM elements are associated with specific indicators of technical means (for example, on-board sensor systems) [7] ; data from simulation modeling, mobile environmental laboratories.

A multimedia model of a subject area is a set of audiovisual forms of the phases of a technological process and the laws of change in their content. Process phases, i.e. multimedia images of source data are relationships and conditions that define the task for studying a given situation [8]. The multimedia model is designed to display the parameters and states of various research objects, i.e. information models (IM).

III Results

Thus, the developed cognitive multimedia monitoring model is a set of interconnected static and dynamic information models of objects (processes, phenomena) and background images.

Forms of representation of semantic information. Based on the theory of semantic networks, homogeneous and complex forms of representation of semantic information are distinguished. The set of homogeneous forms is determined by the expression

$$N_1 = \{t, S, g, C\}$$

The complex form of representation of semantic information consists of several homogeneous forms, namely: text and auditory, text and graphic, graphic and visual, etc. In the general case, many options for complex forms of representing semantic information are determined analytically. To do this, using the operation of direct product of sets, from the elements of set N1 they form set N2, which contain double elements

$$N_2 = N_1 \cdot N_1 = \{(t,t),(t,S),(t,g),(t,C),(S,t),(S,S),(S,g),(S,C),$$
$$(g,t),(g,S),(g,g),(g,C),(C,t),(C,S),(C,g),(C,C)\}.$$

As a result, the resulting expression defines a list of complex forms of representation of semantic information that simultaneously combine two homogeneous forms (16 double elements). These complex forms are binary forms of expressing semantic information.

In order to obtain further diversity, ternary forms are used, which simultaneously combine three homogeneous forms

$$N_3 = N_1 \cdot N_1 \cdot N_1 = \{(t,t,t),(t,S,t),(t,g,t),(t,C,t),...,(S,S,S),...,(S,C,t),...,(g,g,g),...,\}$$

As a result, 64 ternary elements are obtained. Thus, it is possible to obtain complexes containing four, five, six or more simultaneously combined forms of representation of semantic information.

IV Discussion

Current emergency issues [3] are important for both scientific and practical activities. As part of our research, we have identified and selected the main aspects of emergency situations in the Caspian Sea.

The Fig.1: shows a general scheme of emergency situation at sea.

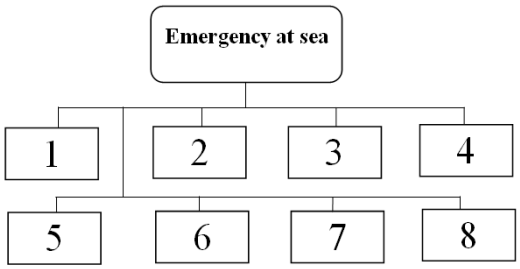

Figure 1: *General scheme of emergency situation at sea*
Legend: 1 - Oil spills; 2 – Fire on a fixed platform; 3 – Volcanic activity; 4 – Ice; 5 – Storm; 6 – Oil transportation problem; 7 – Sea level change; 8 - Earthquake

The selected material is the basis for the subsequent creation of multimedia data banks for a multimedia support system for aerospace monitoring.

The use of complex forms to express semantic information is of great practical importance in solving various remote sensing problems, since the degree of knowledge of an object increases with the simultaneous (complementary) representation of its aspects by multiple forms.

Azerbaijan is both an oil-producing country and a transit territory for the transportation of petroleum products, which creates an additional burden on ecosystems. The main stages of oil use are considered: 1. Exploration of oil fields. 2. Oil production. 3. Oil transport. 4. Refining and petrochemicals. 5. Use of petroleum products. 6. Waste disposal. All of these stages are associated with environmental pollution. In particular, when transporting oil, dangers are associated with transportation (by sea, land) and with pipeline rupture.

At the same time, the anthropogenic load on the marine ecosystem, coastal zone ecosystems, and ecosystems along the pipeline route increases. As a result, an extensive set of possible problematic situations and contradictions between human intentions and the capabilities of nature emerges. The Caspian region can be represented as a set of interconnected ecosystems.

Knowledge of the patterns of ecosystem behavior and factors that influence ecological balance is important.

Characteristics of the Caspian Sea.

Sea coordinates:

1. North latitude: $36^0 33' – 47^0\ 07'$ N
East longitude: $45^0\ 43' – 54^0\ 03'$ E
2. Its length ---------- 1200 km
3. Width ----------310 km (average)
435 km (max)
4. Depth --------- ----208 m (average)
1025 m (max)
5. Division of the Caspian
1. -- north
2. – average
3. – south
6. The area of the Caspian Sea ---------- 3.5 million km^2
7. The area of the sea water area ----- 386.4 thousand km^2

The Fig.2: shows the general scheme of oil transportation.

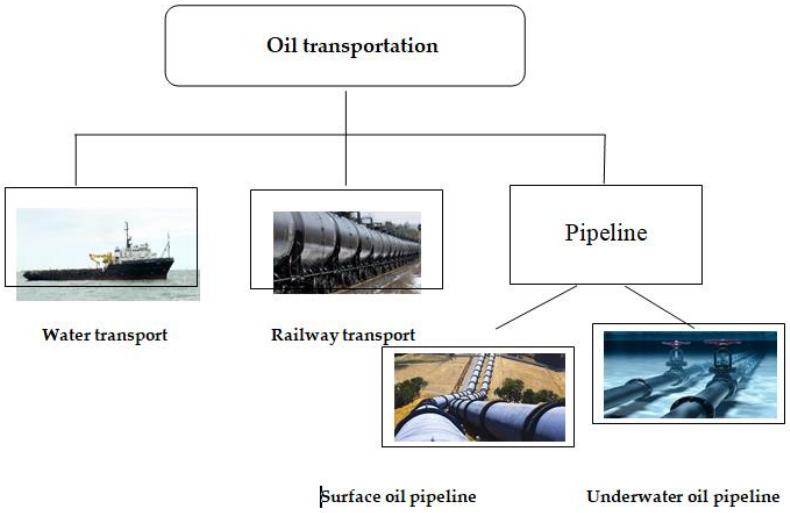

Figure 2: *General scheme of oil transportation*

We analyzed incidents of aspects of emergency situations in the Caspian Sea: 1. Mercury tanker accident; 2. Freezing (covering with ice) of the northern part of the sea. A broken block of ice in the area of the Neft Dashlari field; 3. Fire on the Guneshli oil platform; 4. Storm at sea in the area of stationary platforms; 5. Volcano activity at sea; 6. The problem of oil transport at sea; 7. Fluctuations in sea level and the Kura River; 8. Oil stains on the surface of the sea.

Along with incidents of aspects of emergency situations in the Caspian Sea, we separately examined incidents in other regions of the world:

1. The problem of a Japanese oil tanker that ran aground near the island of Mauritius;
2. Fire on the fixed oil platform "Deepwater" in the Gulf of Mexico.

Development of informative heuristics based on IF-THEN constructions. Visual forms of heuristics.

Heuristics 1.

1. IF a fire breaks out on a large oil platform and the platform collapses,
2. THEN there is a high probability that an oil spill will spread to the surface of the sea.

Figure 3: *A visual form of heuristics 1(IF component)*

Heuristics 2.

1. IF an oil pipeline accident occurs,
2. THEN the probability of an oil spill spreading is high.

Figure 4: *A visual form of heuristics 2 (THEN component)*

Let's consider a fragment of a visual database for generating heuristics for the problem under study.

The Fig.5: shows a block diagram of the animation algorithm for an oil slick leaking from an underwater oil pipeline (phase 1) and the formation of an oil slick on the sea surface (Phase 2).

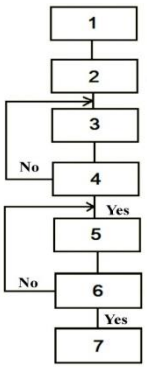

Figure 5: *Block - diagram of the animation algorithm for an oil slick leaking from an underwater oil pipeline (phase 1) and the formation of an oil slick on the sea surface (phase 2)*
Legend: 1. beginning; 2. animation; 3,4. phase 1; 5,6. phase 2; 7. end

The Fig.6 shows an animation diagram of an oil leak from an undersea pipeline.

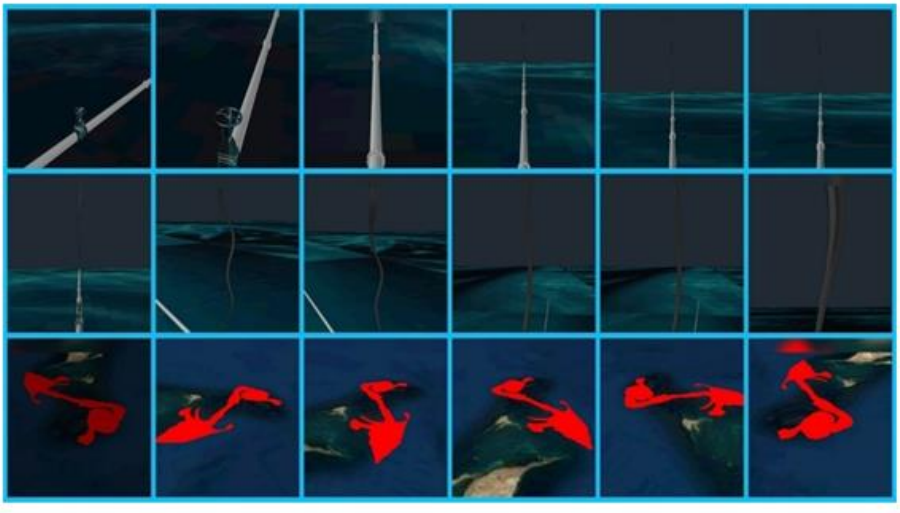

Figure 6**:** *An animated diagram of an oil spill from an undersea oil pipeline*

References

[1] Espoo convention (25.02.1991). https://www.un.org>env_assessment

[2]Global Environment Outlook (GEO 2000). Review. UNEP, 1999, 16 p.

[3] Mamedova G.G., Odzhagov G.O. Actual problems of emergency situation // International scientific-practical conference on modern problems of emergencies related to globalization. Baku, May 30-31, 2012, pp.3-7 (in Russian).

[4]Mehdiev A.Sh., Kajar C.O., Sattarov N.A. Priorities of the Azerbaijani space program and the practice of international cooperation //*Scientific Notes of NAA*,Baku,vol. 11, no. 3, 2009, pp. 39-46 (in Russian).

[5]Sadev A.V. Dynamics of ecosystems of the Aral basin based on space photography materials // IZiK, No. 4, 1981, pp. 18 – 26 (in Russian).

[6] Sattarov , N. (2023) Aerospace Monitoring of Sea Oil Pollution Based on Technologies of Cognitive and Expert Systems // Reliability : Theory and Applications, v.18. N5 (75), pp.483 – 488.https : //doi.org/10.24412/1932-2321-2023-575-483-488.

[7] Sattarov N.A., Hummetov R.M. Features of the correct use of radar and optical satellite data in the problem of improving the modern ecosystem of Azerbaijan // Materials of conf. " Solutions for improving the modern ecosystem of Azerbaijan". BSU, Baku, May 2024.

[8] Sattarov N.A., Odzhagov G.O., Kengerlinskaya T.K. Study of anthropogenic chemical sources of danger to public health with the aim of developing a multimedia data bank //Proceedings of the International. scientific-practical conf. Baku, 2012, pp. 285-288 (in Russian).

[9] Sattarov N.A., Vladimirsky E.I. Mathematical aspects of problems of aerospace monitoring of oil and gas complex objects // Materials of International scientific - practical conf."Estimation of the Accidents' Risks and Problems of Security in Oil and Chemistry Industry" 4-5 Dec. 2014. Baku. p.41-43 (in Russian).