Intelligent Supporting System to Building-Technical Expertise Process

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Abstract

Since February 24, 2022, a lot of buildings and structures in Ukraine have been destroyed and damaged as a result of the armed aggression of the russian federation with the support of the republic of belarus. The restoration of destroyed country's territory requires the development and implementation into Building-Technical Expertise Process of a specialized knowledge-based Supporting System. It is shown that the System must manipulate large data containing a variety of visualized information and must integrate with unmanned aerial vehicles and satellite surveillance systems. At this stage of study MongoDB model is proposed because it can provide a reliable support of system operations, and discuss some issues of creating ontology. The expediency of using the bottom-up ontology development methodology is substantiated. The formalization of the basic concepts of the domain «Building-Technical Expertise» is shown on the example of the concept of "Territory conditions".

Keywords

Database, knowledge formalization, ontology, technological disaster, territory conditions.

1. Introduction

In peaceful conditions the volume of construction activity increases due to of:

- Physical and moral aging of real estate;
- Rising prices;
- Changing real estate owners;
- Needing to reconstruct industrial enterprises, low-rise buildings;
- Intensifying of new construction in the areas of old buildings.

At the same time, a reliable assessment of the technical condition of buildings and structures stands out as an important area of construction activity.

Currently, the rapid growth of construction activity is caused by massive destruction of buildings, property and infrastructure objects (Fig. 1), that have been taking place on the territory of Ukraine since February 24, 2022 as result of the armed aggression of russian federation with support of the republic of belarus [1].

According to the estimate [2], as of May 2023, more than 163 thousand building were destroyed in Ukraine, excluding the losses caused by the explosion of Kakhovka hydroelectric power plant (HPP).

The explosion of the Kakhovka HPP led to environmental consequences of an extremely large scale. The area of impact of this technological disaster covers at least 5 thousand square kilometers (Fig. 2).

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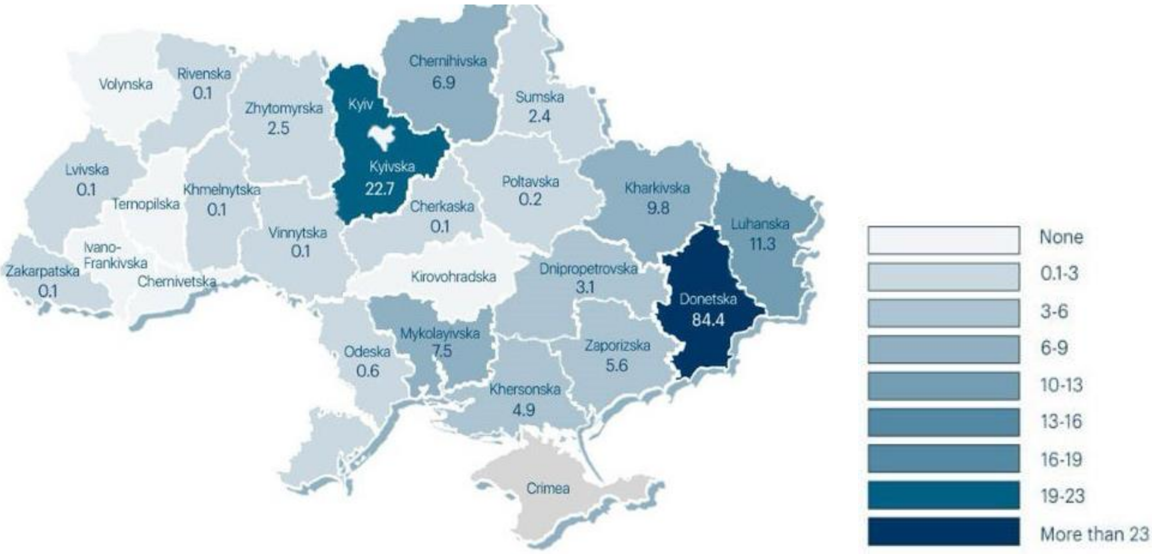
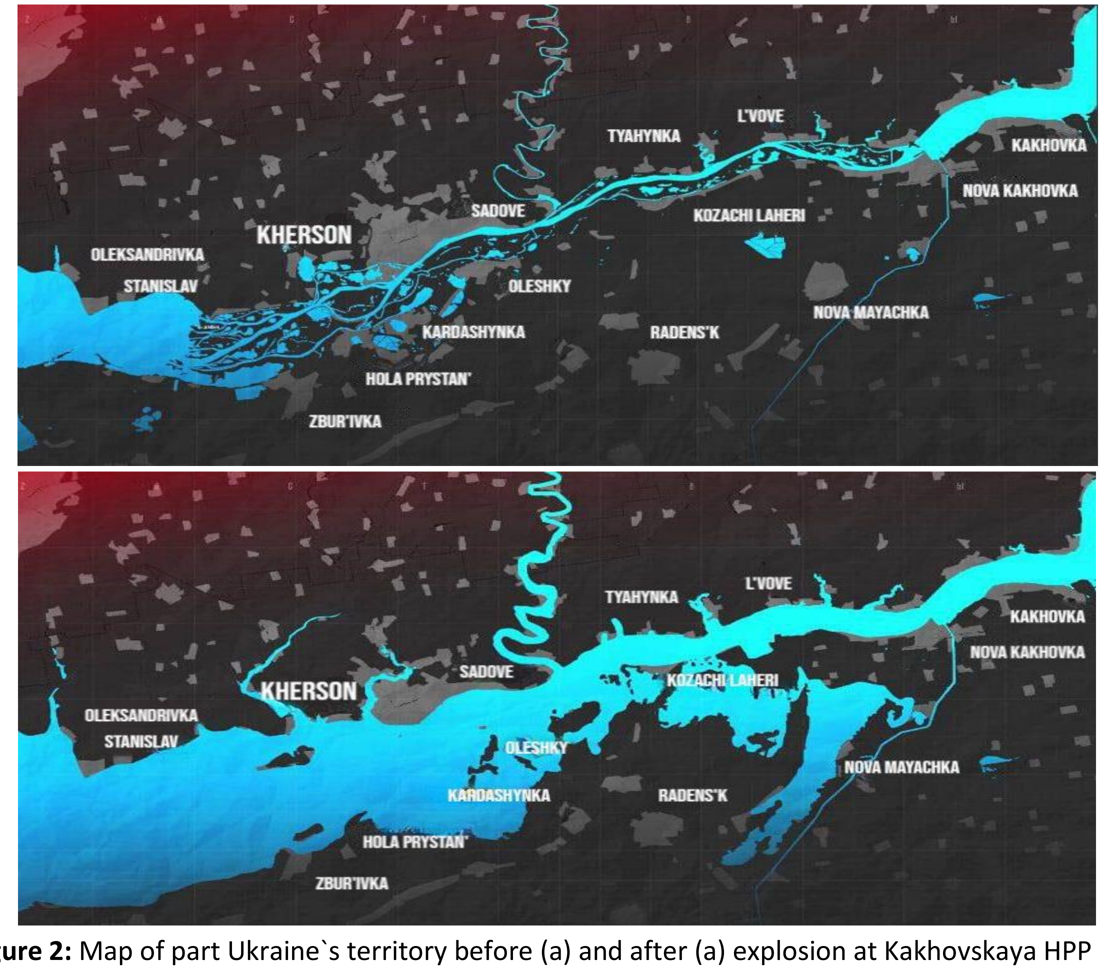


Figure 1: Distribution of regions by number of destroyed/damaged building in thousand units [2].



a

b

Figure 2: Map of part Ukraine`s territory before (a) and after (a) explosion at Kakhovskaya HPP [3].

48 settlements were damaged. Centralized water supply and sewerage in the adjacent populated areas were destroyed. Land in Kakhovskaya HPP area was flooded or drained by this man-made disaster. This has led to changes in the hydrogeological properties of the soil. Changed soil even after consequences are eliminated, will be unsuitable for the construction of new buildings for a long time. In such conditions, there are increasing cases of destroyed/damaged, disruptions in operation regime of buildings and structures that are not directly affected by shelling, the destruction of neighboring object, air defense installations work and the movement of heavy equipment.

At present, the number of destroyed/damaged buildings, structures and infrastructure object is very large and timing of building-technical expertise (BTE) is very critical. That's why the development and implementation of computerized systems and technologies for supporting BTE that are designed to minimize the participation of experts have become extremely important. Besides, it should be taken into account that identification of data on amount of BTE objects and the nature of their destructions are often based on the study of orthophotomaps that created on the basis of photo and video data.

These images are captured by unmanned aerial vehicles or satellite surveillance systems, thus requiring a BTE support system that:

- Will be integrated with unmanned aerial vehicles and satellite surveillance systems;
- Will be able to manipulate large data containing a variety of visualized information;
- Will be based on knowledge.

2. Related Works

Development, improvement and implementation in the BTE process of automated means, which are based on the special knowledge of experts, devoted works [4] – [10]. This study is continuation works [9], [10].

In [9] the model of a highly loaded distributed information and communication system was proposed to support the process of restoring damaged real estate. The ability of this system to manipulate large amounts of information coming from different sources and containing a large proportion of dynamic graphic information is ensured by the reliability and efficiency of its database. That is why in such systems the use of non-relational databases (DB) is advisable [10].

Based on a comparative analysis of modern non-relational databases like Cassandra, MongoDB, Redis and ArangoDB in [10] it is shown that MongoDB is best suited for the system proposed in [9]. This DB is an open source document-oriented database that is designed to store large amounts of data and allow you to work with them very efficiently.

The MongoDB environment provides the ability to create multiple databases on one server, and MongoDB works as follows [11]:

- Data is stored in collections and documents;
- The data is contained in documents that are part of collections;
- Documents are created using fields that are key-value pairs;
- Efficient processing and retrieval is achieved by enabling documents to store data and create complex relationships between them.

The main advantages of MongoDB that determined the choice are [12], [13]:

- Document-oriented;
- Replication;
- Multithreading;
- Indexing;
- Ability to interact with unmanned aerial vehicles and satellite surveillance systems.

The next section deals with the creation of ontology that will provide reliable support for the production activities of BTE implementation specialists in the future.

3. Analyzing Approaches to Ontology Creation

Ontology in computer science is the representation of knowledge of a subject area (domain) in a structured and organized way, usually using a set of concepts (concepts) and relations to define the terms and notions used within that area [14].

The development of the ontology provides [14]:

1. Domain definition.
2. Definition of the scope of ontology.
3. Definition of concepts.
4. Determine the ratio.
5. Choosing a formal language.

6. Develop ontology.
7. Check and improve ontology.

The domain in this work is Building-Technical Expertise.

The field of application of the ontology is the Intelligent Supporting System to BTE.

To develop ontologies, RDF and OWL languages are currently used [15], [16].

There are several different approaches to creating ontologies of subject areas, which are analyzed in studies. The [14] – [17] describes the classification of ontology development methodologies by the direction of construction. Depending on the needs of the program itself, it may be appropriate to use bottom-up, top-down, or mixed methodologies.

Bottom-up methodologies start with some domain descriptions. After that, the classification is obtained. Top-down methodologies start from an abstract view of the domain itself, which is given a priori. However, nowadays the construction industry needs urgent changes to the legal framework. At the same time, all responsibility for the consequences of these changes lies with industry specialists. The ontology, based on the bottom-up development methodology, contains the knowledge and experience of these specialists. This is the main prerequisite for adequate adaptation of the a priori regulatory framework of the industry to modern realities.

In addition, all these approaches have three main problems [14]:

- Providing the set of general terms describing the classes and attitudes to be used in description of the subject area itself;
- Organization of terms in the taxonomy of classes according to the ISA relationship;
- Express explicitly the constraints that make ISA pairs meaningful.

This work is aimed at creating ontology of the domain "Building-Technical Expertise." Reliability and adequacy of the theoretical basis of ontology is guaranteed by the appropriate sets of regulatory documents. That is why the ontology being developed for Intelligent Supporting System to BTE is based on a top-down development methodology.

4. Proposed Model

At this stage of the development of the Intelligent System, which is intended to support BTE process [4], the use of MongoDB is intended.

This DB consists of the following main collections of documents:

- "Damaged Buildings";
- "City Statistics".

The documents from "Damaged Buildings" collection contain the list of fields that describe in detail all necessary basic and technical characteristics of the damaged expertise object.

- Fields describing main characteristics of the building:
- ID: mandatory unique identifier for each object. Type: Integer
- Location: coordinates, city, street. Type: String
- Purpose: administrative buildings, hospital, school, facilities, residential building, etc. Type: String.
- Date of damage: date of occurrence of the damage. Type: Date.
- Supporting materials: images, videos, or any other multimedia containing a description of the damage. Type: Array.
- Source of information: source of information about the damage (unmanned aerial vehicles, satellite surveillance systems, media reports, witness). Type: String.
- Contact name: The name of the contact associated with the structure or damage information. Type: String.
- Contact role: The role of the contact person (expert, witness). Type: String.
- Contact Organization: The organization, with which the contact is associated, if applicable. Type: String.
- Contact email: The email address of the contact. Type: String.
- Phone number: The phone number of the contact. Type: String.

Fields describing technical characteristics of the damaged object:

- Damage description: A detailed description of the damage to the structure. Type: String.
- Severity of damage: classification of the severity of damage (minor, moderate, major, emergency). Type: String.
- Cause of damage: cause(s) of damage (bombing, shelling, fire, etc.). Type: Array.
- Technical condition: assessment of the structure. Type: String.
- Technical assessment: if "No", the structure is not yet available for viewing in the system. Type: Boolean.

The document from "City Statistics" collection contains fields that describe analytical information about buildings destruction of in each city, namely:

- Percentage of damaged objects. Type: Double.
- Percentage of destroyed objects. Type: Double.
- Estimated cost of damage. Type: Double.
- Number of injured residents. Type: Integer.
- The number of dead residents. Type: Integer.

However, the further development of systems and technologies that can effectively support the work of experts in the process of performing BTE requires besides "Damaged Buildings" and "City Statistics" the creation of such ontology concepts as "Damage", "Methods for Assessment of Deterioration Degree ", "Methods for Assessment of Degree Damage", "Assessment Tools", "Assessment Models", "Loads and Impacts" and "Territory Conditions".

Fig. 3 shows the structure of the "Territory conditions" concept and the formalization of main its notions.

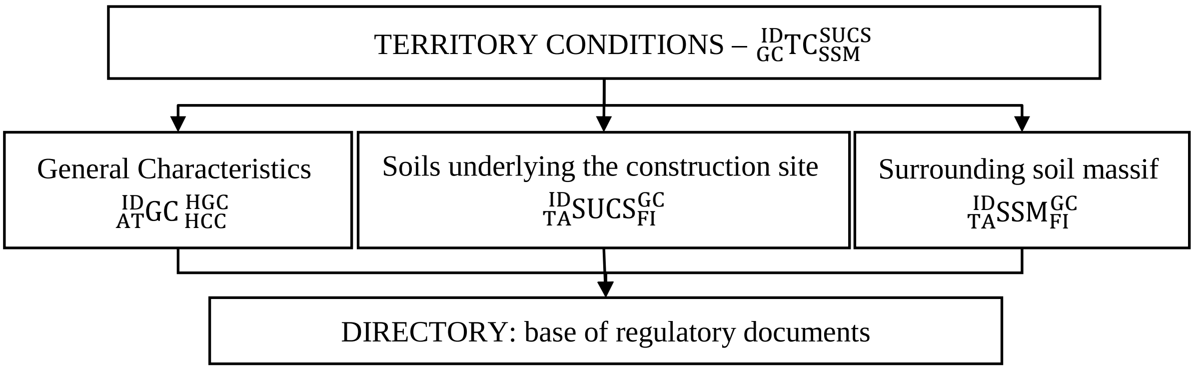


Figure 3: Structure of the ontology concept «Territory conditions»

In Fig. 3:

- ID – Identity Document;
- AT and TA – Area of the Territory and Territory`s Area of the object;
- GC – Geological Conditions of the territory;
- HGC and HCC – Hydro Geographical and Hydro Climatic Conditions of the territory;
- FI – Features and Impacts.

5. Conclusion

1. It is shown that the process of restoring the territories of Ukraine that were destroyed as result of the war requires the creation of an intellectual system that will provide reliable support for the production activities of specialists when performing building-technical expertise. The reliability and efficiency of such system is guaranteed by the use of MongoDB.
2. The main collections of MongoDB documents are defined and main concepts of the "Building-Technical Expertise" domain are given. The formalization of the main concepts of this ontology is shown on the example of the concept of "Territory conditions".
3. Further research is planned to be directed to the formalization of the concepts "Loads and impacts", "Damage" and determination the ratio between concepts of ontology domain.

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