Adaptable software tools for searching objects-analogues tasks in NO-CODE concept

G.V. Prozorova

Abstract. The paper is devoted to the problem of methodological and software support for the search of object analogues, performed when solving the problems of modelling and designing the development of oil and gas fields. The article shows that there is no single generally accepted methodology for searching analogues, existing methodologies differ in applied similarity criteria and search algorithms, are adapted to the search conditions, and are modernised. With the inconsistency of methods computer programs for searching analogues are created at a low level of abstraction, for a limited range of tasks, the existing developments are integrated with corporate databases and in general do not solve the problem of providing analysts with pro-software tools. As a solution we propose the development of programs for searching analogues in the concept of "no-code" (without programming) on the basis of analytical platforms. The "no-code" approach will allow analysts without involving programmers to create software tools for searching analogues, implementing their own variant methods. The article presents the authors' algorithm for express analysis of data at the initial stage of analogue search and the software tool that implements it, created "no code" on the basis of the Russian analytical platform Loginom.

1 Introduction

At the initial stages of studying and designing the development of oil and gas fields at the lack of data on the object under study, the method of analogies is used. Analogy is similarity of objects (deposits, reservoirs, fields) by a number of parameters: geological structure, geological and geophysical characteristics, fluid properties, well placement systems, development systems, etc. It is believed that objects similar in several parameters have close values also in other parameters, and the same development systems implemented in similar geological and geophysical conditions will lead to close technological indicators.

On this basis, the missing data on the modelled object are obtained by borrowing the data of the analogue object and the results of the object development are predicted on the basis of the analysis of the analogue development indicators. Typical tasks in which the analogy method is applied are: assessment of unexplored characteristics of the object, express forecast of development indicators, selection of development strategy, methods of production stimulation, etc.

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Search for analogues is a process of analysis and systematisation of a large amount of data on geological and geophysical properties and technological indicators of field development. Corporate databases, reports, project documents, publications, thematic reviews, etc. are used as sources of information for the search. Non-automated search in various structured and unstructured data storages is very labour-intensive and low-productive. In this connection, the task of developing methods and computer programmes for effective search of analogues is topical.

2 Methodological and software solutions for analogue search problems

The issues of methodological support of analogue search were studied back in the 70s of the last century. The main classification features determining the type of a natural reservoir, its filtration-capacity properties and pore space structure were identified, and the tables of feature comparison were developed, allowing to select analogous deposits by geological and geophysical properties. The development of feature comparison tables is also presented in [1] (2019). When solving the problem of determining the development strategy, the authors rank the classification attributes of deposits into three classes. The first class is a feature of a group of rocks: reservoir rocks of the same type. The second class includes attributes of reservoir type and sedimentation conditions, and the third class includes all other attributes [1].

In the works of I.O. Orlova et al. (2014) in the selection of analogues in the task of choosing effective development strategies, the signs of similarity of fields are combined into three groups: structural and geological features (12 signs), properties of productive formations (7 signs), properties of formation fluids (11 signs). Each feature, both qualitative and quantitative, is divided into small ranges, which are assigned a conditional index. Thus, all attributes are converted into a dimensionless numerical format. Then we calculate correlation coefficients between pairs of fields for the whole set of attributes. On the basis of the obtained correlation coefficients, cluster analysis is performed using the dendrogram construction method. Deposits that fall into the same cluster with the target object are considered to be analogues. The proposed methodology is implemented in a software product and tested on the fields of Rosneft-Krasnodarneftegaz Ltd. [2].

Glukhikh I. N. (2019) proposed a concept based on case based reasoning (CBR) to search for analogues of oil and gas fields. The author has developed a representation of the place of birth as a precedent, including a set of parameters that serve as classification features), geographical characteristics (belonging to the region, lateral distance between the objects), engineering properties (depth of occurrence, initial formation pressure and temperature, initial reserves, density of well grid, etc.), fluid properties (oil viscosity, presence of deep sampling, formation water mineralisation, etc.). The paper considers two options for finding candidate fields for analogues:
- ranking the base of precedents by qualitative characteristics followed by ranking of precedents by quantitative characteristics;
- creation of certain classes within the precedent base, selection of the precedent class using a decision tree and ranking of precedents within the selected class by quantitative characteristics.

The authors propose to apply the developed approach in the tasks of modelling and design of oil and gas field development. No information about software implementation and practical testing of the developed algorithm is given in the paper [3].

In [4] (2022) the problem of analogue selection was solved to find missing data for the case of oil and gas condensate deposits. The algorithm filters by qualitative similarity criteria (rock type, trap type, depositional environment, etc.). According to quantitative criteria, for
each candidate similarity measure is calculated as a weighted sum of differences between the criteria values of the candidate and the target object, and then the candidates are ranked according to the similarity measure value. The calculation of the similarity measure is automated using the RExLab programme supporting user scripts in Python. The developed software tool has been implemented in the RN KIN corporate software module (PJSC Rosneft Oil Company) [4].

A.V. Karsakov (2022) presents an algorithm for the selection of analogues in the problems of field development design. The algorithm is realised in two stages. At the first stage, the selection by qualitative geological parameters (type of rock, geological age, type of deposit, type of reservoir, type of object by phase state of fluid) is performed. The method of precedent extraction based on the decision tree is applied for selection. At the second stage, the measure of similarity of objects by quantitative parameters is calculated as a weighted sum of the moduli of the difference between the values of the target object and the candidate analogues. For each type of fluid, a number of quantitative geological-physical parameters of objects and physical-chemical parameters of fluid is made up, for example, for oil fifteen parameters are accepted. Weight coefficients for calculation of the similarity measure were determined on the basis of the Dupuis equation describing the fluid flow to the well. The algorithm is implemented in a software product and tested using data from more than fifty fields of JSC "TomskNIPIneft" [5].

The paper [6] (2022) presents an algorithm and software tool for the selection of analogues in solving a number of problems: drafting of design and technical document, selection of tertiary method of influence, optimisation of development system within the framework of pilot works, hydrodynamic modeling, preparation of investment memorandum. The algorithm supports consideration of more than 90 parameters, including geological and geophysical properties, development data, reserves estimation, well testing and technological characteristics. The set of used similarity criteria and weighting coefficients for each criterion are determined optionally depending on the problem to be solved. The search algorithm includes two stages. At the first stage, filtering by qualitative criteria (oil and gas bearing province, trap type, stratigraphic affiliation, etc.) is performed, and candidates for similarity with parameter values equal to the value of the target object parameters are selected. At the second stage the similarity function of the target object is calculated using fuzzy sets theory using quantitative parameters (porosity, permeability, formation partitioning, initial formation pressure, etc.). The development has been tested on the data of a number of fields of LLC "RN-Uvatneftegaz" [6].

The analysis does not cover all the works devoted to the search for analogues, but allows us to make some conclusions about the methods and software. The methods use the following groups of field parameters as similarity criteria: geographical location, structural and geological characteristics of objects, petrophysical properties of reservoir, fluid properties, reservoir system properties, development parameters. The sets of used criteria and the significance (weight) of criteria depend on the type of the task for which the search for analogues is performed and are selected optionally.

There are several stages in the search algorithms. At the first stage, the most significant criteria are used to select candidate objects as analogues with criterion values equal to those of the target object. Mainly qualitative criteria are used: geographical location, type of reservoir, type of fluid, type of trap, etc. At the next stage, the search is carried out among the selected candidate objects according to other, mainly quantitative, criteria. A similarity measure is calculated as a weighted sum of the criteria values or clustering is performed. At the last stage, the selected candidates are ranked and the most suitable analogue is selected.

Computer programmes for searching analogues are represented by developments integrated with corporate databases and not intended for replication, implementing individual search tasks according to specified criteria and algorithms. The available programmes as a
whole do not solve the problem of providing analysts with software tools. Expenses for programmers' work at such a low level of abstraction of created programmes may be inexpedient, especially for small companies.

In the absence of common methods, analysts need software tools that allow them to implement their own analogue search algorithms without involving programmers. In practice MS-Excel is widely used, but it has limited analysis functions and does not allow creating high-level user tools. An alternative to MS-Excel can be analytical platforms (STATISTICA, MatLab, Mathcad, etc.), which provide a greater number of analysis functions. But they are not often used in Russian companies because they are rather difficult to master and have high licence costs.

A modern approach to software development to search for analogues in the concept of "no-code" (without programming) seems reasonable.

3 No-code software development concept

The term "no-code" was introduced by Forrester Research in 2014 [7]. The term covers software development areas that minimise manual programming. The technological basis of "low code" development is the model-driven development (MDD) approach, which means that business logic is taken out of the software code into high-level specifications (metadata, control and application models) and the methods of their transformation into supported programming technologies are specified. "No-code" platforms allow to build thematic applications with the specified functionality but with arbitrary information content without programming with the help of visual constructors [8].

During the development of "no-code" the required functionality and architecture of a software product are declaratively described in models. Creation and improvement of models is available to an analyst without involving a programmer, which allows testing several algorithms for searching analogues, choosing the best one for a certain type of search tasks. After selecting the best variant, the programme can be developed with the involvement of programmers. In this case it is possible to provide variability of search conditions, which will allow to increase the level of abstraction of development and the possibility of its replication.

4 Development of a software tool for the initial stage of analogue search based on the Loginom platform

The authors used the Russian analytical platform Loginom [9] to solve the problem of analogue search. Loginom has a wide range of data analysis functions, including Data Mining, is intuitive to use, and provides the ability to combine individual functions into problem-solving models in a graphical interface. Thus, analysts without programming can create their own variable software tools for searching analogues.

The task of express data analysis at the initial stage of analogue search was solved. The initial data for the analysis were the forms of statistical reporting 6-gr in MS-Excel table format [10]. Data on more than 33000 objects were taken for the analysis (Fig. 1). The similarity attributes of the objects were adopted:
- qualitative: proximity of geographical location (subject of federation), reservoir type (terrigenous, carbonate), fluid type (oil), reservoir name;
- quantitative: porosity, permeability, oil saturation, oil density and viscosity, total and effective oil saturated thickness.
The following search algorithm was implemented: 1) filtering by qualitative attributes, 2) clustering by quantitative attributes, 3) calculation of the similarity measure with the target object by quantitative attributes for candidate analogues, 4) ranking of candidate analogues by the similarity measure value. The stages of the algorithm implementation in the Loginom platform are demonstrated below:

1. Filtering by qualitative attributes: selection of objects with attribute values equal to those of the target field (Fig. 2).

2. Clustering by quantitative features; g-means algorithms, Kohonen networks (Fig. 3).

3. Selection of objects-analogues, which fell into the cluster with the target one, calculation of the similarity measure, ranking by the similarity measure value. The similarity measure was calculated by seven quantitative attributes using the

**Fig. 1.** Table with data for analysis

<table>
<thead>
<tr>
<th>no.</th>
<th>Federal District</th>
<th>Federal Subject</th>
<th>Deposit</th>
<th>Strata</th>
<th>Collector</th>
</tr>
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<td>North-West</td>
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<td>Peschanoezerskoe - OGC</td>
<td>T1cb Characologian, strata of Fleringenius</td>
<td></td>
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<tr>
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<td>Peschanoezerskoe - OGC</td>
<td>T1cb Characologian, strata of Fleringenius</td>
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<td>16</td>
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**Fig. 2.** Filtering by qualitative attributes

**Fig. 3.** Setting up clustering by quantitative attributes
Euclidean distance metric. Closer analogues are recognised as objects with the lowest similarity measure value.

The listed analysis operations are combined in a single script with the block of loading the initial data and the block of saving the analysis results (Fig. 4). Thus, by means of visual design a user software tool for express search of analogues in the tables of the statistical reporting form 6-gr. The use of the tool requires the participation of a specialist in three operations (in the figure highlighted in yellow): 1) in the loading block, specify the name and storage folder of the table with the source data; 2) in the filtering block, enter the target field data by subject of the federation, reservoir type, fluid type, reservoir name; 3) in the unloading block, specify the file name and folder for storing the results. Other operations with data are performed in the developed software tool without the involvement of a specialist.

Fig. 4. Scenario of analogue search in Loginom

The developed software tool was used to search for analogues for fifteen target objects. The results obtained were compared with the results of semi-automated search conducted by experts using MS-Excel. The similarity of the results is more than 80%. The time of analogues search using the developed tool was about a minute, including the time of interaction between the expert and the programme, which is significantly faster than the search using MS-Excel.

5 Conclusion

The current trend in "no-code" software development allows us to form a new approach to creating, testing and updating methods and computer programmes for selecting analogues of oil and gas fields. The use of analytical platforms gives specialists an opportunity to apply modern methods of data analysis, including data mining, and visual design of programmes allows one to create and test their own search tools without involving programmers. In the absence of generalised analogue search techniques, "no-code" development on the basis of analytical platforms is a more effective alternative for analogue search software than the currently accepted use of MS-Excel or writing software code.

References


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