Application of a Case-Based Approach for Tasks of Industrial Safety Inspection

Aleksandr Yu. Yurin[1[0000-0001-9089-5730]], Aleksandr F. Berman[1[0000-0001-8339-7338]], Olga A. Nikolaychuk[1[0000-0002-5186-0073]], Kirill A. Kuznetsov[2]

[1] Matrosov Institute for System Dynamics and Control Theory, Siberian Branch of the Russian Academy of Sciences, 134, Lermontov st., Irkutsk, 664033, Russia
iskander@icc.ru

[2] Irkutsk Research and Design Institute of Chemical and Petrochemical Engineering, 3, Akademika Kurchatova st., Irkutsk, 664074, Russia

Abstract. A regular assessment of a technical state and calculation of a residual life are important measures for the safe operation of petrochemical facilities. These measures are parts of the industrial safety inspection (ISI) procedure. The efficiency of this procedure can be improved with the aid of decision support systems, which are process and reuse of accumulated information and experience on the basis of a case-based reasoning (CBR) approach. The formalization of the main ISI tasks is made in order to apply CBR. The case models developed for each ISI task. Testing models and approach was carried out in the special software in Irkutsk research and design institute of chemical and petroleum engineering.

Keywords: case-based reasoning, industrial safety inspection, case models

1 Introduction

A regular assessment of a technical state and calculation of a residual life are important measures for the safe operation of petrochemical facilities. These measures are parts of the industrial safety inspection (ISI) procedure that regulated by different normative documents and standards [1-6]. It is possible to improve the efficiency of ISI with the aid of decision support systems, which are process and reuse of accumulated information about earlier inspections presented in the form of cases.

In this paper we describe an example of the use of a case-based approach for decision support in the case of ISI of petrochemical facilities conducted by the Irkutsk research and design institute of chemical and petrochemical engineering (IrkutskNIIHimmash). In particular, the models of cases for ISI tasks are considered.

2 Background

2.1 Conceptualization and Formalization of a ISI Procedure

Most of normative documents and standards for ISI [4-6] define a composition and ISI stages in general without specifying their content. The specific content depends on the capabilities, experience and qualifications of the organization conducting the inspection [7]. In this study we use the experience of IrkutskNiiHimmash as an example.

IrkutskNiiHimmash carries out works in the field of a technical condition assessment since 1949, respectively, a large amount of information about the studies is accumulated during this period, and this information can be reused.

We define the following main ISI tasks (stages) as the results of analysis of ISI reports: 1) planning works for ISI; 2) analysis of a technical documentation; 3) forming a map of initial data; 4) development of an ISI program; 5) technical diagnostics; 6) analysis (including interpretation) of the diagnostics results; 7) calculation of a residual resource and durability; 8) making decisions for the repair; 9) forming a conclusion (report) for ISI. The information used in these tasks is sufficiently structured and formalized, so the methods for its automated processing and reuse can be applied.

The model of the subject domain is designed as the main result of ISI conceptualization and formalization. This model includes 170 entities and relationships between them [8]. The main information entities are the followings: "technical object", "work", "program", "conclusion" and "decisions". These entities are detailed and the relationships between them are defined. For example, elementary works are defined for the "work" entity, these elementary works are divided into classes: documents preparation works; technical diagnostic works; repair works and etc. Combination of elementary works forms the investigation program for each ISI. Examples of elementary works are: analysis of technical documentation; operational functional diagnostics; check of readiness for technical diagnostics; visual and measuring control; thickness measurement; flaw detection; study of metal properties; hydraulic tests, etc.

2.2 CBR in Petrochemistry

There are a lot of examples of the application of CBR in the field of maintenance and diagnosing, e.g., [9-10] etc. In this work we use our early achievements in the fields of identification of technical states of elements of petrochemical objects [11, 12], case adaptation [13] and material selection [14].

In particular, in [11] the application of CBR for identification of technical states of mechanical systems is considered; the main stages of the study with the reference to the stages of the CBR cycle, metrics used, formalization of structure and properties of mechanical systems, the structure is hierarchical composite indexes and a hierarchy of properties of the technical objects are defined. A method for case adaptation is described in [14]. This method is based on group decision-making methods and applied for justification of actions for prevention of repeated failures of the petrochemical equipment. Also we applied CBR [15] to select structural material for the design of petrochemical constructions and parts, during this process the model of the material of the technological object and its properties were specified.

In this work, mechanical systems and their properties are considered either as objects of a safety inspection, or as subsystems of more complex technological objects. For this reason we can use the previously obtained results in this study. In particular, we can consider the case as a structured representation of experience in the form of data and knowledge prepared for its subsequent automated processing with the aid of specialized software.

The decision-making is based on the CBR-cycle [11, 15] that includes the following main stages: retrieve, reuse and revise. The Zhuravlev metric [16] with normalization is used for case retrieval.

3 Models of Cases for ISI Tasks

A detailed analysis of ISI [7-8] showed the possibility to use CBR for following tasks (stages): "development of an ISI program"; "analysis (including interpretation) of the diagnostics results"; "making decisions for the repair" and "forming a conclusion (report) for ISI". The different models of cases were developed for each task; these models were based on the complete conceptual model [8]. Next, let's consider models obtained in detail.

1) The case model for the "development of an ISI program" task. This model provides a link between the "inspection" and "program" concepts, which are included in the descriptive part (problem) and the training part (decision) of a case, respectively (Fig.1).

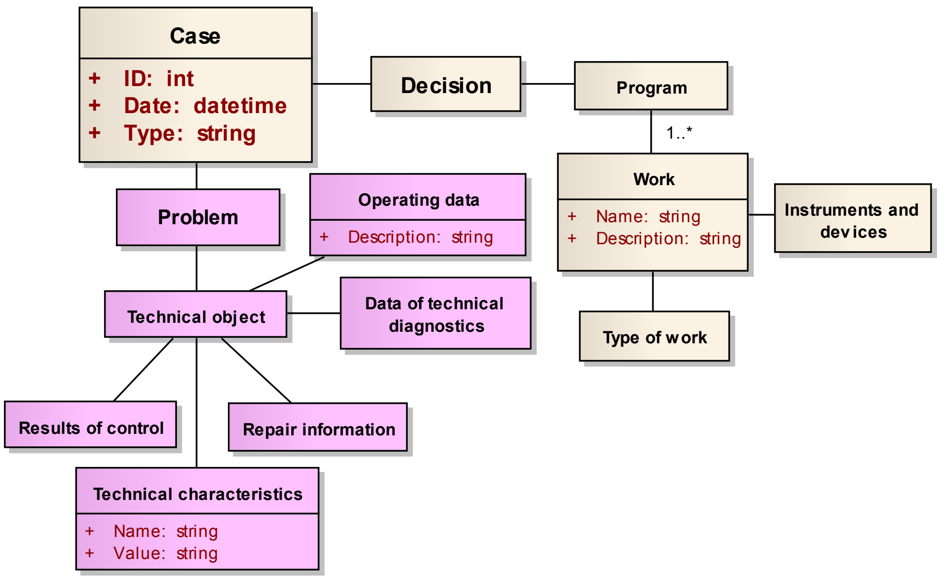

Fig. 1. A fragment of the case model for task 1

The main result of case retrieval for this task is a set of similar objects and their programs selected on the basis of information about the technical characteristics and data on the operation. On the basis of the set obtained the program for the current ISI is formed.

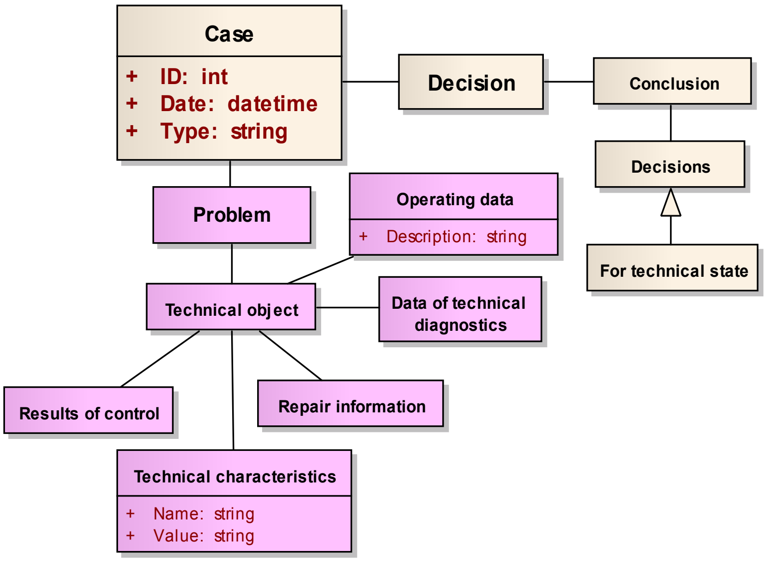

Fig. 2. A fragment of the case model for task 2

2) The case model for the "analysis (including interpretation) of the diagnostics results" task. This model provides a link between the concepts of "inspection" and "decision for technical state" concepts (Fig.2).

The main result of case retrieval for this task is a set of similar objects and results of technical diagnosis. On the basis of the set obtained the conclusion about the causes of the current technical state of the ISI object is formed.

3) The case model for the "making decisions for the repair" task. This model provides a link between the concepts of "inspection" and "decision for repair" concepts (Fig.3). The main result of this task is a set of similar objects and results of repair.

4) The case model for the "making decisions for the repair" task. This model provides a link between the concepts of "inspection" and "conclusion" concepts (Fig.3).

Aggregated conclusions of similar ISIs are used as templates for the formation of the conclusion for the current ISI. If retrieved no similar cases then selected conclusion the object which belongs to similar kind of objects, e.g., container, vessel, etc.

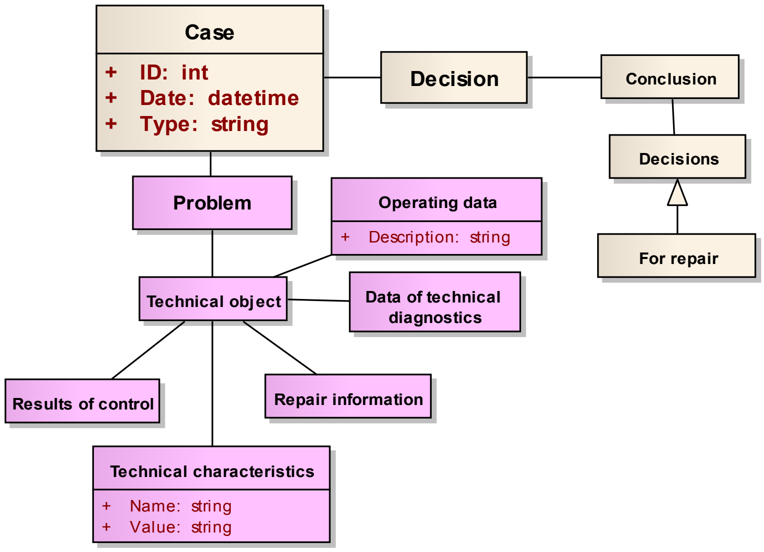

Fig. 3. A fragment of the case model for task 3

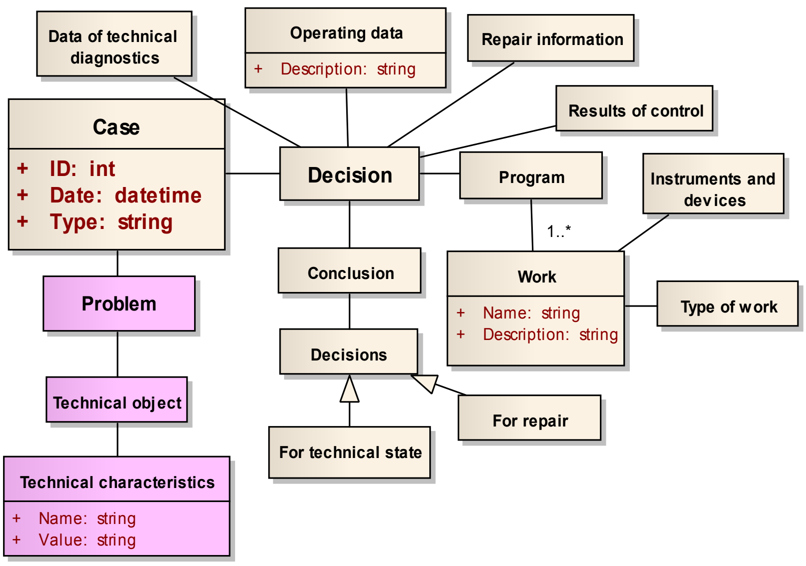

Fig. 4. A fragment of the case model for task 4

4 Conclusion

One of the ways to improve the reliability and safety of technical systems in chemical, petrochemistry and oil refining industries is to improve ISI on the basis of decision support systems. Such systems provide interpretation of operation data, planning of diagnostic works and forecasting of technical conditions.

In this paper we propose to apply a CBR approach for support decision-making at the formation of the ISI program, conducting technical diagnostics, forecasting the technical conditions; making decisions on repair and formation of the ISI conclusion. It should be noted that the proposed approach can be used for solving another tasks, in particular, automatic filling of sections of the ISI report and the formation of relevant documents (for example, within the "analysis of a technical documentation" task).

Algorithms and models presented were used for implementation of specialized software [7] (Fig.5). The main effect of its application is achieved both in research to identify laws of change in the technical conditions of the objects under consideration, and in the organization and conduct of ISI.

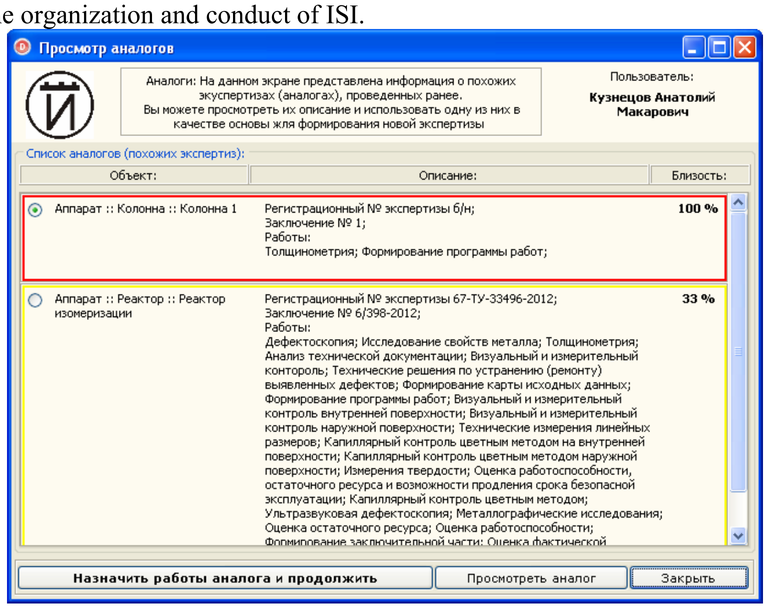

Fig. 5. An example of a GUI form of software with the results of case retrieval

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