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Case Based Reasoning: A Comparative Analysis of CBR Tools

Narina Thakur, Tushar Chhabra, Dharvi Verma, Divesh Kumar, Moulik Dayal

Associate Professor, Dept. of Computer Science Engineering, BVCOE, Affiliated to GGSIPU, New Delhi, India

B.Tech Student, Dept. of Computer Science Engineering, BVCOE, Affiliated to GGSIPU, New Delhi, India

B.Tech Student, Dept. of Computer Science Engineering, BVCOE, Affiliated to GGSIPU, New Delhi, India

B.Tech Student, Dept. of Computer Science Engineering, BVCOE, Affiliated to GGSIPU, New Delhi, India

B.Tech Student, Dept. of Computer Science Engineering, BVCOE, Affiliated to GGSIPU, New Delhi, India

ABSTRACT: With the rate of increase in the amount of information, the processing of information and derivation of relevant information to solve problems in the future has become a major concern. Case-based reasoning (CBR) is a problem solving approach that tries to solve new complications by re-using specific past experiences stored in cases. A case is the previous experience, keeping both the problem description and the solution applied in that context. All the cases are stored in the case base. CBR is based on the intuition that information gained from previous experiences (cases or illustrations) can be a significant tool to provide solutions for, and enhance processes related to, the problem at hand. Therefore, when the system is presented with a new case to solve, it searches for the most similar case(s) in the knowledge base and reuses an improved version of the repossessed solution to solve the new problem. However, enormous information can make it an intricate task to have useful vision from notable datasets.This paper gives contextual information about the software used to implement the methodology of CBR and it introduces the widely used CBR tools (CBR Shell, jCOLIBRI and myCBR). The paper then performs a comparative analysis based on some firm factors that mark the CBR software including noisy data or missing values in the cases.
The review conducts a study of CBR and its tools.

KEYWORDS: Artificial Intelligence, Case-based reasoning, CBR Tools

I. INTRODUCTION

These days, persons generally use experience that was successful in resolving previous, similar complications to solve problems in real world [1]. In CBR, experiences are modelled into a diverse form as concrete problems with their results (cases). Case-based reasoning (CBR) are used in many different fields to create plentiful applications in a wide range of areas comprising financial investigation, medical diagnosis, cataloguing of objects, help desk and decision support system.Case-based methods rely on rich feature-based illustrations and refined similarity metrics that make use of heterogeneous resemblance measures in order to deal with the several features that can create up a case [2]. The case-based reasoning system searches its memory of earlier cases (the case base) and tries to find a case that has the same problem description as the current case. If the reasoner cannot find an similar situation (case) in its case base, it will try to find the case or cases in the case base that utmost thoroughly match the present query case.
In the situation where a previous identical case is retrieved, presuming its result was successful, it can be returned as the current case solution. If the retrieved case is not identical to the present case, an adaptation phase occurs. In adaptation phase, the differences between the existing case and the recalled case must first be recognized and then the solution associated with the retrieved case modified taking into consideration these differences. The case base in the CBR system is the memory of all previous warehoused cases. There are three general zones that have to be considered when creating a case base [3].

- The structure and illustration of the cases themselves.
- The memory model used for establishing the entire case base.
- The selection of features which are used to identify each case.

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At the top level,a case-based reasoning (CBR) system can be thought of as a black box (Figure 1) that incorporates the reasoning mechanism and the external aspects [2, 3]:

- The input condition (or problem case).
- The output proposed solution.
- The memory of former cases that are referenced by the reasoning mechanism.

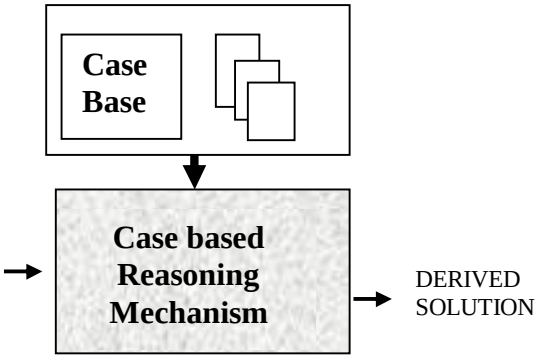

Fig 1. A CBR System

As of Now CBR fundamental principles have been recognized and numerous applications have confirmed that CBR is a useful technology, many investigators agree on the increasing necessity to formalize this kind of reasoning, Define application analysis approaches, and provide a design and implementation assistance with software Engineering tools. While the underlying tools of CBR can be applied consistently across application Domains, the specific implementation of the CBR approaches – in particular retrieval of case and similarity functions – is highly customized to the application at hand [4]. Two factors have become critical: the convenience of tools to form CBR systems, and the collected practical knowledge of applying CBR techniques to real-world cases.

II. RELATED WORK

Case based reasoning has gathered pace in the academia in the past few years to solve problems efficiently. Bradley P. Allen studied the business applications of CBR, described Compaq's SMART CBR customer service application, Cognitive Systems Inc's Prism telex classification system [5] and examined the CBRSystem development techniques.

In [6], authors David H. Jonassen and Julian Hernandez-Serranodescribed the use of stories to support problem solving by acting as instructional supports. The CBR methodology is being used in defining the means of solving problems by using stories as instructional support. In [7], A. Ram , J.C. Santamaría discuss the concept of Continuous Case based Reasoning, further extending the capabilities of case based reasoning to solve problems, especially when It comes to many real world problems. Case based reasoning is being studied extensively to solve problems in many real-world domains and is increasingly being found to be an effective problem solving methodology, especially because of its feature of revising the case base to find better solutions.

III.BACKGROUND STUDY

Cases in a case base can represent many different kinds of knowledge and store it in numerous different representational formats. The objective of a system will significantly impact what is stored. A CBR system may be aimed at the creation of a new design or plan, the conclusion of a new problem, or the argument of a point of view with instances.Solving a problem by CBR involves obtaining a problem explanation, measuring the similarity score of the current problem to previous problems stored in a case base (or memory) with their known answers, retrieving one or more like cases, and trying to reuse the solution of one of the retrieved cases, probably after adjusting it to account for variances in problem descriptions. The solution proposed by the system is then evaluated. Following revisionof the suggested solution if required in light of its evaluation, the problem description and its answer can then be retainedas a new case, and the system has learned to solve a new problem based on the memory.

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CBR Life Cycle: All the problem-solving systems using CBR for problem solving have in common the life cycle of CBR system consists of the following four phases (see Fig. 2):

- **Retrieving:** similar previously experienced cases (e.g., case- solution- conclusion triples) whose problem is refereed to be similar.
- **Reusing:** Reuse the solution of retrieved case for solving the current case.
- **Revising (adapting):** modifying the answer(s) retrieved in an attempt to solve the new case.
- **Retaining:** the new solution once it has been finalized or validated [8].

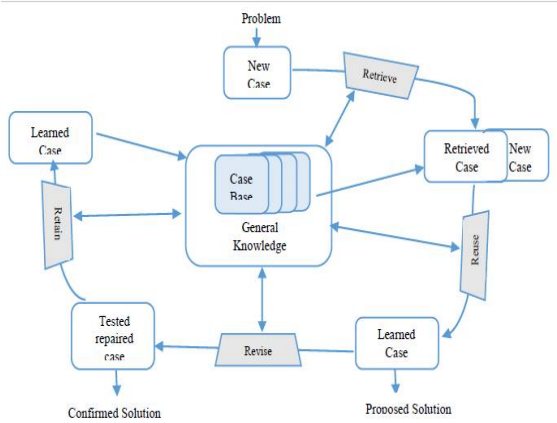

Fig 2. A CBR Cycle

Case-based reasoning is often confused as a technology. It is a methodology, not a technology. CBR, as a methodology, used a plethora of techniques prescribed by recommender systems in AI to solve problems. K-nearest neighbours (KNN), Information Retrieval, etc. are used in stages of the CBR cycle to solve problems, especially in the retrieve and reuse stages. As a concept, CBR has its roots in four different disciplines [9] namely-

1. Cognitive Science (Analogical Reasoning)
2. Machine Learning
3. Knowledge Representation and Reasoning
4. Mathematical Foundations

IV. APPLICATIONS OF CBR

Case-based reasoning is an excellent tool of machine learning, especially when we are dealing with problems for which we have available a vast amount of data derived from past cases. A repository of data which explains the previous cases can provide tremendous help in solving new problems which may contain some similarities. Systems which are known to contain a proper documentation and maintenance of past data are the systems which can employ CBR approach as a right fit to solve problems. Preservation of past data, assigning importance to past data and experience- these are some other features one can find in a system which can utilize the technique of CBR. Many a times, it is not easy to conclude generalizations in systems on the basis of some available data. This is when CBR comes to use- it enables the application of past experiences to solve novel problems. CBR finds great use in the fieldof design, especially architectural design. Industry has observed the application of CBR to help in design and assistance of automation systems. Academia has seen the development of case-based design systems such as JULIAbyHinrich and CYCLOPS by Navinchandra. CBR techniques have found their use in automation of the design process. Because the technique of case-based reasoning requires the retrieval of past data to solve novel problems, it finds application in the domains where the amount of data is plentiful but the presence of proper techniques, principles and theories is scarce. When it comes to Molecular Biology, CBR has been used in protein crystallization, in the determination of protein structure and in sequence analysis (DNA). Medical support systems are known to use case-based reasoning to make a system which can diagnose diseases more efficiently using past knowledge. CBR has also been applied in the field of robotics where, combined with some artificial intelligence techniques and fuzzy logic, CBR has been known to enhance the capabilities of robots.

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Customer Service systems also apply CBR to enhance the quality of their service. When it comes to the realm of finance, CBR is known to have been used in tasks pertaining to assessment when values of variables have to be compared to variables with similar values in old data. Enterprise systems also use the technique of CBR.

V. CBR TOOLS- PROBLEM AREAS

CBR is relatively a new part of the domain of CBR as the concept of CBR originated in early 1980s. It is a knowledge-based problem solving approach [10]. Despite its success as an effective methodology for solving problems based on past knowledge, there still exists a dearth of efficacious tools which can implement CBR to solve real-world problems. There are some software tools which implement CBR which will be discussed in the next section, but there still is a scarcity when it comes to their number. The implementation of CBR can be done on various platforms but a tool which can implement its complete development process, is easy to manage and use, can solve problems with minimal hassles is the ideal solution to use CBR to solve new problems. CBR provides a facility to revise the solution in order to obtain the best possible solution which has adapted to changes in the problem domain. This necessitates the need of software tools which provide an easy-to-use graphical user interface, are extensible in nature and implement the case representations properly.

VI.SOFTWARE TOOLS FOR CBR

CBR Shell, myCBR, Jcolibri are some of the tools used in the implementation of CBR. This section gives an overview of the tools used.

A. CBR Shell

The AIAI CBR [11] Shell is a generic tool for case-based reasoning. The tool performs classification based on comparison of cases. The parameters of the algorithm can be varied: the number of nearest neighbors considered can be specified, the weights can be fixed either manually, or optimized by genetic algorithm. The accuracy of the algorithm is measured by a leave-one-out evaluation. The data must be in CSV format, where a newline delimits a case. The first line of the case base must have the name of the key file, the second states the goal field. The key file expresses the type of matching that is done to each field in each case.

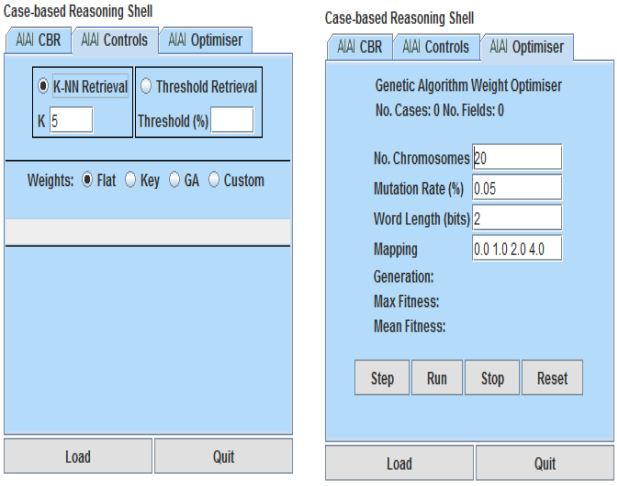

Fig 3. CBR Shell GUI Interface

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B. Jcolibri

jCOLIBRI is just a white-box tool that licenses programmer users to have total control of the internal details of the software. jCOLIBRI symbolizes a case in a very general way.jCOLIBRI [12] is a framework for developing various CBR applications. It is Java-based and uses JavaBeans technology for representation of case and automatic generation of user interfaces. jCOLIBRI supports full CBR cycle. A CBR application can be built by instantiating the framework, or through the GUI-based configuration tools, which allow one to form the application without writing a line of code. Nevertheless, if we want to build a very intricate CBR system or we need problem-solving methods that are not available in the framework, then, we could program new ways (methods) and include them into the framework, contributing them to other CBR system designers to use. At Retrieve stage, the N nearest cases are retrieved and there are five retrieval strategies, seven selection methods and over 30 kinds of text similarity functions and ontology. At the Refusal stage, several adaptation methods are offered (direct proportion) and also in ontology. At Revise stage, methods for revision of cases as well new indexes (IDs) generation methods and methods for decision making (preference elicitation). At Retain stage, there are query retaining methods as a new case. jCOLIBRI allows retrieval form clustered and indexed case bases and program interfaces (connectors) are used to access text and XML format files, as well standard and data bases that are descriptive logics. These interfaces can be used for access of diagnostic systems databases. A graphically representation can be used to show CBR cases.

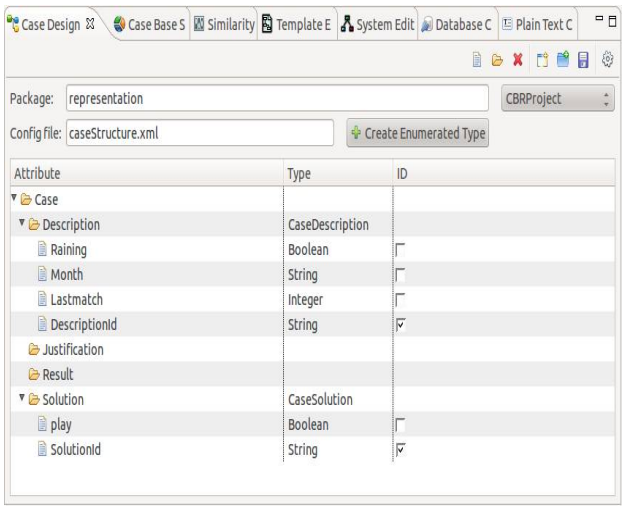

Fig 4.Jcolibri case designer tool

C. myCBR

MyCBR [13] is an open-source similarity-based retrieval tool and software development kit (SDK). The framework my CBR supports description of cases with various attributes: numeric, character and string, logical, class type, etc. The cases templates are generated as classes or subclasses with a number of attributes, called slots.The CBR Cases are class objects described by its attributes. Each attribute can participate in the class with its value and weight that determine the significance of the attribute in relation to others. Attributes having zero weights are not considered when penetrating the case-base. In myCBR the case and their attributes can be generated either manually or automatically. The automatic generation of attributes (slots) is done through the import process of the Comma Separated Value (CSV) file.

VI. COMPARATIVE ANALYSIS

This section introduces a comparative study after testing and comparing the CBR applications. Table 1 shows the normal comparison of whether these CBR tools are open source or not, language in which they are developed, etc.

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	Jcolibri	myCBR	CBR Shell
Developed by	GAIA - Group for Artificial Intelligence Applications	Joint effort of the Competence Centre CBR at DFKI, Germany, and the School of Computing and Technology at UWL, UK	AIAI-Artificial Intelligence Applications Institute, University of Edinburgh
Language	Java	Java	Java
Open Source	Yes	Yes	Yes
Paid	No	No	No

Table 1. CBR Tools

After applying the same query to all CBR software, the following observations are made:

CBR Shell has very simple interface. Here, the retrieval can use KNN or Threshold, and weights can be identified manually. It uses genetic algorithm for optimization. No case is revised and cases are stored in the form of custom text files. Also, case indexing is not done in CBR Shell.
jColibri has a very powerful and influential GUI, it represents cases in a very simple manner. jColibri allows cases to retrieve using a SQL query and then it organizes cases after they load into memory; thus the case can be graphically accessible. There are a lot of case retrieval algorithms applicable in case based reasoning. These algorithms are based on the similarity metric that allows likeness between cases stored in case base. The nearest neighbor retrieval algorithm & induction retrieval algorithms are two principal algorithms used in this process.
myCBR does not work with external databases. It stores the cases in text or XML file format. That's way it cannot provide the case indexing and categorization. The case cannot be presented graphically in the GUI, but it is possible to present the value distribution of a selected attribute for all cases in the database. On the 'Retain' phase, myCBR allows the user to save the query as a new case, and an old case is used as a foundation for the new query.

CBR TOOL	Cases structure	selection strategies	Case retrieval	Case revised	Case storage	Case indexed	Graphical User Interface(GUI)	Dealing with uncertain data
CBR Shell	Textual	distance method	Two methods KNN Threshold	Manual	Text	No	Very simple GUI	Can't handle
jCOLIBRI	Xml /text	similarity functions	Followingmethods -k-NN -Threshold -Ontology -Textual OpenNLP and GATE Recommenders	Automatic	CSV/XML	Yes	Simple and powerful Use wizard to simplify	Handle as null
myCBR	Object	similarity functions	Query model	Manual	CSV /XML	No	User can customize GUI and handle most things	Handle as unknown or undefined_

Table 2. Comparison of CBR Tools

VII. RESULTS AND CONCLUSION

Fig 1. shows the CBR System where Fig 2. shows the CBR cycle. Fig 3. and Fig. 4 show the CBR Shell GUI interface and the jColibri case designer tool respectively. Table 1. lists the CBR tools and Table 2. Compares the CBR tools. Our purpose in this paper has been to provide a concise overview of the cognitive science foundations of CBR and of the four main tasks involved in the CBR cycle, namely -retrieval, reuse, revision, and retention. The paper performs a

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review on CBR and charts its development. It enlists its applications and the desirable features a tool implementing CBR should possess. It discusses some of the tools used to implement CBR in research, industry, teaching, finance, medicine, etc. A comparative analysis on the software tools is also performed to help users decide which tool to adopt based on their problem statements and its nature. CBR emphasizes problem solving and learning as two sides of the same coin: problem solving uses the solution of past learning events while problem solving provides the backbone of the experience from which learning advances. Originated in the US, this methodology is now being widely used for research and practical purposes in other countries and its usage is predicted to grow.

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