ADDIS ABEBA UNIVERISTY
SCHOOL OF GRADUATE STUDIES
FACULTY OF INFORMATICS
DEPARTMENT OF INFORMATION SCIENCE

APPLICATION OF CASE BASED REASONING IN LEGAL KNOWLEDGE BASED SYSTEM: A PROTOTYPE ON CHILDREN CRIMINAL CASES IN ETHIOPIA

A THESIS SUBMITTED IN PARTIAL FULIFEMENT OF THE REQUIREMENT FORTHE DEGREE OF MASTER OF SCIENCE IN INFORMATION SCIENCE

BY

YEMISRACH HAILEMARIAM

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SIGNATURE OF THE BOARD OF EXAMINERS FOR APPROVAL

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DECLARATION

This thesis is my original work and has not been submitted as a partial requirement for a degree in any university.

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YEMISRACH HAILEMARIAM GEBERTADIK

JANUARY, 2010

Dedication

This thesis is dedicated to

My Father, Hailemariam Gebretadik,

For his continuous support, tolerance and unselfish love,

And to all my parents,

For their patience, understanding and constant encouragement.

Acknowledgement

First and foremost, I would like to thank my advisor, Dr. Milion Meshesha, without whose support none of this work would have been possible. Also many thanks to all my fellow graduate students for all the ideas we shared over the years. Much appreciation to Mesert Ayano and Selamawit Kahasy for their great support. I want to thank my parents for their encouragement and patience with all my pursuits. Finally and most importantly my deepest gratitude and love goes out to my Glory of God, who ever my inspiration and companion throughout my entire journey.

Yemisrach Hailemariam

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List of Acronyms

AI	Artificial Intelligence
CBR	Case Based Reasoning
ES	Expert System
GUI	Graphical User Interface
KBS	Knowledge Based System
MBR	Model Based Reasoning
JCOLIBRI	Java Class Ontology Libraries Integration for Building Reasoning Infrastructure

Abstract

The target of Artificial Intelligence is to make computer behave intelligent. This is causing the development of many subfields; among which Case -Based Reasoning (CBR) is one of the hottest subfield of AI. Case-Based Reasoning (CBR) proposes the reuse of past experiences and cases to solve new problems. Law is an excellent domain for studying case-based reasoning that enables the reuse of the information contained in the cases to solve problems from diverse areas.

The goal of this thesis is to design prototype, case based reasoning in legal knowledge based system that advises in the investigation of children criminal cases. This paper describes Judicial Application, a case-based system that is able to adjust its retrieval and adaptation metrics, in addition to storing cases. Standard case representation to the original knowledge source (legal cases) has been used to store legal cases.

The prototype is developed using the Object-Oriented framework jCOLIBRI1.0. The CBR model has been effectively used to retrieve analogues previous cases in reaching a potential solution for decision making and also a means to adopt the current case of a problem for the future use. To enhance the effectiveness of the legal argument, local similarity matching and weight of the attributes are adopted to compare the equivalent values of a problem of a case and source cases. The performance of the system is evaluated using statistical analysis which results with average precision value 82.75% and user satisfaction which shows the suitability of CBR for designing legal knowledge based system. To improve the performance of the system the researcher mainly recommends the need for upgrading the capacity of the case using integrated domain knowledge to have a precise and up-to-date decision processing.

CHAPTER ONE

INTRODUCTION

1.1. Background

Computers have long been utilized in the sphere of law [1]. Basic applications such as word processors, spreadsheets and databases have all found their way into legal offices. Recently, more sophisticated tools such as computerized legal research systems, document drafting packages, and practice management systems have become increasingly common. Most exciting however, has been the prospect of using artificial intelligence (AI) techniques to create 'automated legal reasoning systems', computer systems that reason with and apply the law in an effort to resolve legal disputes. Examples of such systems include legal Knowledge-based systems.

Knowledge-based system can be seen in the perspective of human beings who have knowledge of the world, and able to interpret the knowledge to act upon the interpretation, as knowledge for 'understanding', 'reasoning', 'principles' and as data for reasoning on factual information [2]. Scholars classify the Knowledge-based system into three main groups: the rule based reasoning (RBR), case-based reasoning (CBR) and hybrid system that use mixture of RBR and CBR.

Building Intelligent Legal Knowledge-based Systems is a highly worthwhile application of artificial intelligence (AI) to the field of law. By providing lawyers with simple and accessible

explanations of AI, it should help dispel their fears about technology while the associated jurisprudential discussion should help dispel any myth in the wider audience [3].

Those researchers whose work constitutes the major theoretical ground, specializing in AI and law applications have, so far explored legal Knowledge-based systems designed to help decision making and provide advice as would a human expert. Legal Knowledge-based system is the nexus of artificial intelligence and the Law. It is capable of performing at a level expected of a Lawyer. Legal Knowledge-based systems designed for use by legally trained people aim to provide a method of speeding –up the provision, and improving the accuracy , of legal research undertaken with the aim of advising the client[4]. From the well known types of Knowledge-based system, case-based reasoning is more popular in legal firms.

Case-based reasoning is the process of predicting an outcome based upon a comparison between the present case and the cases in the case-base [4]. Case-based reason's store their knowledge of cases by some form of abstraction of the facts of the case, the result, and possibly the reasons for reaching that result.

1.1.1. Children and the Law system in Ethiopia

In the parlance of the law, the word 'child' may be understood in two different ways [5]. The first implies a relationship with respect to parentage and consanguinity, the natural relationship that derives form the community of blood. In its second meaning, 'child' denotes the status of a human being in its early years of life, and it is to this latter meaning that the convention under [6] refers. The first article of the convention defines a child as 'every human being below the age of eighteen years of life'. Under the Ethiopian legal framework, the law

provides that a child is a" person of either sex who has not attained the full age of eighteen years".

In the domain of the Ethiopian criminal law, acts committed against the child's inherent right to life and the security of person such as homicide, infancide, rape, child assault, child abduction and child prostitution are considered as serious offences that may entail severe penalties. Depending on the gravity of the crime, the punishment ranges from fine and simple imprisonment to life imprisonment and capital imprisonment. In its civil aspect, persons responsible for child abuse or child neglect may be held liable to make good whatever damage their actions or inactions have produced against the interest of the child.

Until very recently there was no special arrangement within the court system to deal with cases where children were victims of violence. However, presently, a child friendly system where a child victim need not personally appear before the formal settings of a courtroom is set up with the assistance of a Juvenile Justice Project of the Federal Supreme Court [7]. Thus, there is now one separate courtroom in Addis Ababa that is connected to a special room through a 'Close Circuit Television'. The child victim who will be sitting in the special room is assisted by an intermediary to answer all the questions forwarded from the courtroom.

This creates an opportunity for victim child to explain the cases without a stress. Due to explosive number of cases handled in court system, it is difficult to pass decision in short period of time. Being in this situation, no measure has been taken to enhance the performance of judges so as to help them to easily refer past cases and make timely decision. This research is a step forward in the area of case-based reasoning legal Knowledge-based system for child protection and promotion of the rights of children.

1.2. Statement of the Problem and its Justification

Children due to their age, gender, and level of maturity could be easily affected by adverse human made and natural disaster. Depending on to the damage, children may have long term effects on their growth and development. They need proper care and protection that requires the coordinated efforts of all actors to ensure national law, policies and practices confirm to the international standards. Among the most important challenges that faces children in our country are child labor, sexual exploitation of children and violence against children [8]. Sexual and physical abuse and violence against children is a serious offense for the psychological and emotional immaturity of the victims in these age category. Especially the ever increasing crime rate of rape even at a global level alarms that the future may not be a time to relax by whatever achievements made in preventing the commission of these offenses.

Further, a comprehensive understanding of the nature of the offenses, behavior of the offenders and the situation of victims needs the assessment of their socio-economic conditions and the consequential effects. Those of institutional setup like, court systems, prosecution also necessitate a close follow up of their operation, understanding and timely solution to the problems. The most faceable problems in court system of Ethiopia is, the way to handle and make use of the pervious cases for the current situation of court case. This inefficiency has resulted in court congestion and delays, and obstacles in the promotion and protection of the rights of children like disposition time and sentence disparity levied by judges [9]. The ***disposition time*** is a period within which the court decides a given case. According to [9], in criminal proceeding the faster the disposition time is the more the probability to hear evidences, the chance of hearing witness with fresh memory about the facts. Because of these advantages short proceedings better guarantee fair justice and successful prosecution.

NO.	FIRST INSTANCE COURTS	DISPOSITION TIME OF CASES SUBMITTED TO AND DECIDED BY THE COURT										NO. OF JUDGES
		2006/07					2007/08					
		A	B	C	D	E	A	B	C	D	E	
1	Lidata	2	3	16	4	15	8	6	10	15	27	3
2	Bole	-	-	2	17	23	1	7	10	23	31	2
3	Arada	5	7	3	2	16	1	12	15	16	60	2
4	Yeka	4	15	11	9	60	1	2	17	29	80	1
5	Keara	1	5	20	2	38	3	6	21	16	34	2
6	Akaki	1	5	16	11	42	-	4	11	14	40	1
	Total	19	35	68	45	194	14	37	84	113	272	10
	%	5.3%	9.7%	18.8 %	12.5 %	53.74 %	2.70 %	7.10%	16.30%	21.7 %	52%	

Table 1.1 Disposition times of cases on sexual abuse and violence against children in six Sub-cites of first Instance court in Addis Ababa. Key: A stands for 1 to 2months; B for 3 to 6 months; C for 6 to 12 months; D for 12 to 18 months; E for more than 18 months

Problems to produce short disposition time would result a number of congestion files in each year. As it is shown in the Table 1, of all of the time categories, the bulk of the cases (272), were taken a disposition time above 18 months. In 2006/07, only 5.3% of the cases were decided within 1to 2 month, however, in 2007/08 this percentage is down to 2.7%. This indicates that most of the cases were not decided within a short period of time.

In gross, the number of cases decided is 361in 2006/07 and 520 in 2007/08. This means the number of decided cases in 2007/08 has grown by 44% than 2006/07 and this total case load might have been caused additional burden for the court to decide within a relatively short period of time (1to 3 month). In addition in the court has less number of judges and it is logical to have a consequences of congesting of files. In such cases, unless there is a corresponding increase in the number of judges, technology assisted proceeding, and other remedial mechanism, disposition time will definitely be longer the average.

The other problem that the researcher observed is the ***sentence disparity*** which happens when different sentences are levied by judges who committed the same crime under relatively similar situations. According to the story gathered from prosecutor of the Lideta First Instance Court, case of public prosecution file No.85118/2007 and file No.70596/2006, the court has decided 25 years of imprisonment and life imprisonment respectively in the same criminal type with identical legal factor. On the other hand in the case of public prosecution file No 75575/2007 and prosecution No 75550/2007 the court has imposed a penalty of 8 and 3 months respectively. This comparison by itself is a conclusive evidence to show that penalty of offenses has been lead to sentence disparity in a court system.

To handle such problems, new technologies could be utilized to support the legal professionals and the judges in the court system to assist the daily activities of problem solving and decisions making of the cases. These require organizing knowledge of lawyers and documents, both tacit and explicit knowledge. Automating the adaptation of reasoning process from the vast years of experiences of legal experts reduces the time and cost of providing legal judgments.

There are strong reasons justifying the vigorous pursuit of CBR research and development in the field of AI and Law [9]. Case-based approaches can supplement rule-based expert systems, improving their abilities to reason about statutory predicates, solve problems efficiently, and explain their results. CBR can also contribute to the design of intelligent legal data retrieval systems, improve legal document assembly programs and contribute to Cognitive Science models of the use in various fields of case comparison methods to transform ill-structured problems into better structured ones.

It is therefore the aim of this study to exploit such knowledge through a case-based reasoning system that supports the judges to provide firmly legal and appropriate judgment to the children. The researcher preferred case-based reasoning rather than rule based legal decision support system is that, in CBR, as opposed to rule-base approaches, knowledge about the domain is acquired and maintained through similar cases and does not need a domain expert or knowledge about the problem domain as such.

Thus, in the present research an attempt is made to address the following research questions:-

- How crime cases on children such as sexual abuse can be represented in Knowledge-based system using case-based reasoning for future use in court system?
- Can a case-based reasoning legal Knowledge-based system helps to solve the current problem of legal judgments?
- How can case-based reasoning technique be formalized to determine whether a previously decided case can be used for present judgments?

1.3. Objective of the Research

The proposed research has the following general and specific objectives.

1.3.1 General Objective

The general objective of this research is to explore the possibility of designing a Knowledge-based System (KBS) using case-based reasoning that adapts to legal judgments practices in children criminal cases in Ethiopia.

1.3.2 Specific Objectives

In order to achieve the general objective, the research has the following specific objectives.

- To acquire domain knowledge using interview, observation and document analysis regarding decided crime case of children and the substantive law of the child in real life.
- To develop a case structure comprising of relevant attributes from pervious child sexual cases that have a direct impact on decision making.
- To construct a case-based comprising of various decided sexual abuse cases in order to implement the case-based reasoning model.
- To test and evaluate the case-based reasoning system to retrieve the most relevant cases and adopt a solution that can facilitate solving new problem of a case.
- To provide concluding remarks and propose future research directions in the area.

1.4. Scope and Limitation of the Research

As a general schema, CBR cycle in Knowledge-based system can be described in terms of four tasks (4 Rs)[10]: retrieve the most similar cases, reuse their knowledge to solve the problem, revise the proposed solution and retain the experience. Thus, the scope of this research is limited to the adaptation of cases after retrieving them from a case-based in case-based reasoning process cycling. It does not involve the other processing cycle of case-based reasoning (i.e. retaining, revising).

The prototype case-based legal Knowledge-based system handles only sexual abuse crimes on children, specifically on a girl victim with age of less than thirteen. This is due to the suddenly happening child crime cases in our country these days. Due to limitation of time and manual representation of legal text, the researcher has been referred only the three consecutive years (2006/07-20008/09) of the decided cases stored in the archive. This delimits the system to see other earlier types of cases with large case-based structure. In addition, explanation facility and knowledge-base editor are not integrated in our system since the main concern of the study is to explore the applicability of case-based reasoning for designing KBS that provides advice service in the area.

1.5. Research Methodology

In this research, different research methodologies are applied for adaptation of case-based reasoning in an attempt to come up with model that predicts appropriate solutions for current situations once a defendant is found guilty on children and juvenile as presented below.

1.5.1. Data collection

Various data sources are used to gather the required information. These sources can be classified into primary and secondary sources. In order to define cases on crime of sexual abuse on children, cases have been collected through structured interview with concerned judges in Federal First Instance court at Lideta sub-city of Addis Ababa. The researcher selected the above mentioned court, because there is a separate way of handling crime cases of children on sexual abuse harassment.

A secondary data source such as document analysis is another method issue to get further understanding about the legal system of children in Ethiopia. In addition, possible analysis of cases documents is made to obtain pertinent understanding and more evidential information related to the importance of the research. Relevant literature including journals, magazines, books and web documents are also reviewed to have a general understanding of the problem domain.

1.5.2. Prototyping

A prototyping approach has been used to design the Knowledge-based system so that the system would be tested first for its feasibility before taking on the complete task of designing and implementing the complete system. Thus, a much scaled down version of the case-based reasoning is going to be developed before proceeding to developing a system at the level set out to be designed in this study. For this prototyping, the researcher tried to attempt forty cases on children sex abuse.

1.5.3. Tools

For this research jCOLIBRI 1.0 in a nutshell is used as the framework that aims to formalize Case-based Reasoning that provides problem solving methods of CBR. The motivation for choosing this framework is based on a comparative analysis between jCOLIBRI framework and other frameworks, designed to facilitate the development of CBR applications. jCOLIBRI enhances the other CBR shells: CAT-CBR [11], CBR*Tools [12], IUCBRF [13] in several aspects: availability (open source framework), implementation (the Java implementation implies extended usability, extensibility and user acceptance), GUI (the provision of graphical tools facilitate the system design).

Developing CBR systems using jCOLIBRI Tools deals with the CBR methodology as follows:

- Retrieval: the main focus of methods in this category is to find similarity between cases. Similarity function can be parameterized through system configuration.
- Reuse: a complete design where case-based and slot-based adaptation can be hooked is provided.
- Retain: Process of updating the case-base is totally based on implementation of the case-base.

1.5.4. Evaluation Mechanism

The prototype CBR based legal argument system is evaluated with representative legal queries that has been taken from the previously decided cases which are not used as training examples from Lideta First Instances Court.

The performance of the system has been evaluated by comparing the decision suggested by the system against domain expert. In addition, the effectiveness of the retrieval is tested using recall and precision.

1.6. Application of the Research

Besides the academic exercise, the output of the study serves to inform all members of the professional community involved in child sexual abuse cases as well as nonprofessional citizens who serve as advocates for abused children of the status quo in hopes that future reform of the criminal justice system will better protect the rights and welfare of children. In addition to that, it will facilitate for less skilled judges to have quick reference for their case, to make the condition to actively decide the case particularly in children on sexual abuse.

1.7. Organization of the Thesis

The contents of the chapters in the thesis are summarized as follows.

The first chapter presents introductory part of the thesis including statements of the problem, objectives and the scope of the study, methodology used and application of the research work.

Second chapter reviews the Knowledge-based system i.e. a case-based reasoning. First, it describes general overview of case-based reasoning, CBR cycles and types of case-based reasoners. Then, it presents a case-based reasoning research area on retrieval and adaptation methods. It also includes case-based reasoning in law with examples of case-based reasoner.

Third chapter describes knowledge to identify case feature for modeling the concept in the punishable acts in child sexual abuse cases. Additional case acquisition analysis presents to convert legal texts into legal cases guided by domain experts.

The fourth chapter presents case representation mechanisms through case-based knowledge containers. A frame work for building the CBR prototype with jCOLIBI1.0 is described at the design concept layer. It includes how judicial application is configured and has been made to be executed.

The last chapter summarizes the main points presented in this thesis and provides future research lines and challenges to improve the approach proposed in this study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Artificial Intelligence

For thousands of years, it has been tried to understand how to think; that is, how a mere handful of stuff can perceive, understand, predict, and manipulate a world far larger and more complicated than itself. The field of artificial intelligence, (AI), goes further still attempting not just to understand but also to build intelligent entities [14].

Artificial Intelligence deals with various methods for processing information using prior stored knowledge, where the knowledge is represented by symbols along with heuristics or rules of thumb. By using heuristics one does not have to rethink completely what to do every time a similar problem is encountered. Moreover, many AI methods employ some kind of search mechanism. AI provides reasoning capability, which consists of inference from the facts and the rules using heuristics or other search approaches. The collection of knowledge related to a problem used in AI systems is organized, in a knowledge base. Knowledge-base focuses on some specific subject area or domain. With a Knowledge-base and ability to draw inferences from it, a computer can be used as a problem solver and decision maker [15].

AI currently encompasses a variety of subfields, ranging from general purpose areas, such as learning and perception to such specific tasks as playing chess, proving mathematical theorems, writing poetry, and diagnosing diseases [14].

This area of study is currently attracting considerable research interest and has generated knowledge-based systems (KBS) or Expert system (ESs) as one of the success stories of Artificial Intelligence (AI).

2.2 Knowledge-Based System

Scholars describe Knowledge-based System as a system that attempts to perform tasks that are usually undertaken by human experts in specialized areas of skill.

Knowledge-based System allows a user to interact with a computer program in much the same way that the user would interact with a domain expert. The Expert System or Knowledge-based System (KBS) contains a well defined area of knowledge associated with a specific area of human expertise. The KBS also contains components that allow it to dialogue with the user to accept query and also to clarify a particular problem and then offer appropriate advice. KBSs can offer a very useful way to make scarce knowledge available to users (employees in the office, institution etc.) and also to put knowledge at the point of delivery. It can also help a company to protect some of its knowledge asset [16]. To perform its application, the KBS has structured components that interact with each other.

2.2.1 Architecture of Knowledge-based System

Fig 2.1 shows the architecture of a KBS with its components and the way the components interact with each other [17].

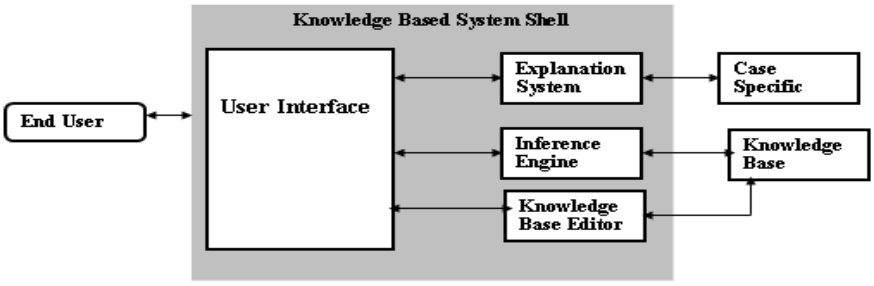


Fig 2.1 Architecture of Knowledge-based System [17]

As depicted in Fig 2.1, users interact with the system through user interface. The system also provides explanation facility to clarify its reasoning, recommendations or other actions (example asking a question).

Knowledge-base contains the domain-specific knowledge required to solve the problem. The Knowledge-base is created by the knowledge engineer, who conducts a series of interviews with the expert and organizes the knowledge in a form that can be directly used by the system. The process for seeking out the knowledge required by Knowledge-based system is referred to as knowledge acquisition [18]. There are two major steps in knowledge acquisition: *knowledge elicitation* and *knowledge structuring.*

Knowledge elicitation involves extracting knowledge from human experts, or written documents to build Knowledge-based system. On the other hand, knowledge structuring involves using concepts discovered during the knowledge elicitation session to build a model or representation of the experts. Knowledge structuring is a process where knowledge engineer uses concepts discovered during the knowledge elicitation phase to build a model of the domain using the hierarchical tree structure [19]. Inference engine is the other main component which provides methodology for reasoning about information in the Knowledge-base and for formulating conclusions.

The field of knowledge-based systems (KBS) has expanded enormously during the last years, and many important techniques and tools are available these days. Traditionally, reasoning in Knowledge-based system had been using model-based reasoning (MBR) for generating solutions. MBR systems are based on some general explicit model of knowledge of the domain in which they operate [20].Examples of such knowledge representations are production rules, frames, logic, and semantic networks and object oriented method. These representations are categorized under MBR because their methods of reasoning use general domain models to generate specific instances of concepts and their interrelationships [21].

Recently, researchers have begun utilizing an alternative reasoning paradigm and computational problem solving called case-based reasoning (CBR) [22]. CBR is a relatively new approach compared to MBR. CBR emphasizes on the use of a set of examples of prior events (case histories) in its problem solving. The focal part of its knowledge is contained in its instantiated cases instead of an explicit and complete domain model. The field of Case-based reasoning has blown a fresh wind and a well justified degree of optimism into AI in general and Knowledge-based decision support systems in particular. The growing amount of ongoing CBR research - within an AI community that has learned from its previous experiences - has the potential of leading to significant breakthroughs of AI methods and applications.

2.3 An Overview of CBR

In an effort to simulate human ability to solve problems, researchers realized that most people derive solutions based on previous experience(s) with similar situations [23]. It has been observed that people even discuss problems and solutions in terms of previous experiences. Thus, it appears obvious that, complete solutions derived solely from first principles are fairly rare. Instead, most problem solvers approach new problems and their associated solution(s) by relating both the problem and the solution to previous experiences. Thus, they build a new solution from information gained from previous experiences, coupled with some reasoning from first principles. Fig2.2 describes the simple structure of CBR adopted by [23].

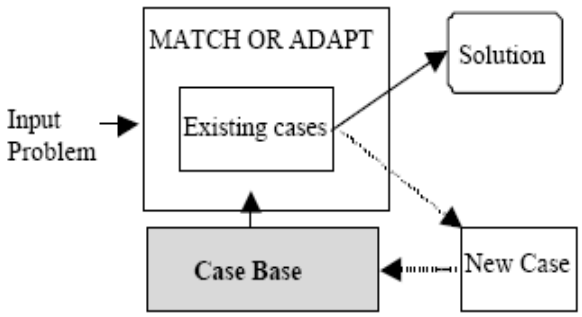


Fig 2.2 A simple structure of CBR adopted from [23]

2.3.1 What is CBR?

As the name implies; it is an approach for reasoning based on cases. According to [24]:

- Reasoning – is the process of inferences or conclusions through the use of facts or other intelligible information.
- Case - Similar set of related facts or information.

According to [23], in CBR terminology, a *case* usually denotes a *problem situation*. A previously experienced situation, which has been captured and learned in a way that it can be reused for solving future problems, is referred to as a past case, previous case, stored case, or retained case. Correspondingly, a new case or unsolved case is the description of a new problem to be solved. Case-based reasoning is - in effect - a cyclic and integrated process of solving a problem, i.e. learning from experience and reuses it for solving a new problem; etc. Successful solutions are tagged to the new case and are stored in the case-base. When a search fails to locate a similar case, the search itself becomes the basis for a new case, in effect "learning from experience". The result is a continuously expanding yet increasingly refined knowledge.

2.3.2 Types of Case-based Reasoning

In brief, CBR "remembers" previous problems and either adapts their solutions or uses their outcomes to evaluate new cases. Generally, there are two types of case-based reasoners: problem solvers and interpretive reasoners [25].

2.3.2.1 Problem Solver

Problem solver CBR derives solutions to new problems by adapting an old solution for the current situation. It modifies and adapts past solutions to new problems. This may lead to three different results [26]:

1. A full solution that is almost accurate or;
2. A previous case may address only part of the new problem and require further reasoning to solve the rest or;

3. The previous case may suggest an abstract solution that must be further refined.

2.3.2.2 Interpretive Reasoners

Interpretive reasoners, on the other hand, compares new situation to recalled experience. The interpretation is used when the problem is not well understood and when there is a need to criticize a solution. Cases are used to provide justification for solutions, evaluation of solutions when no clear-cut methods are available, and interpretation of situations when definitions of the situation's boundaries are not well defined.

As stated by [27], the main distinction between interpretative and problem solving case-based reasoning systems is that while the former group of systems does not use adaptation at all, the latter group relies heavily on adaptation.

2.3.3 Case-based Reasoning: CBR Cycle

The known pioneer researcher [23], classify the problem solving cycle of CBR into four major processes.

- Retrieve the most similar case or cases.
- Reuse the information and knowledge in that case to solve the problem.
- Revise the proposed solution.
- Retain the parts of this experience likely to be useful for future problem solving.

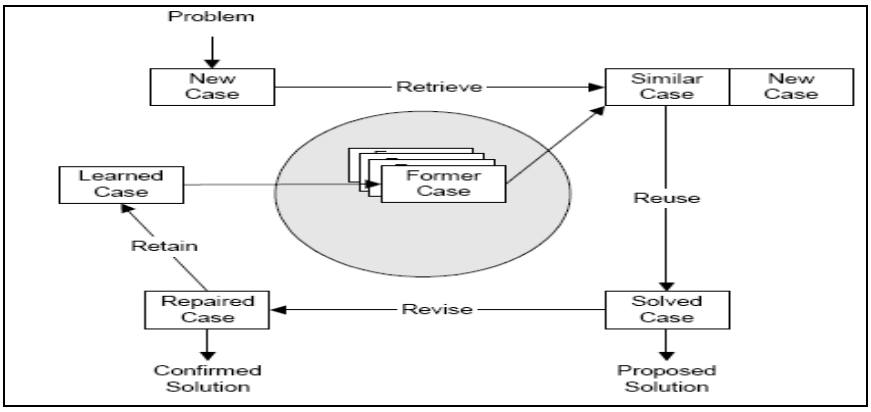


Fig 2.3 General model of Case-Based Reasoning Cycle adopted from [23].

As indicated in the Fig 2.3, the initial description of a problem defines a *new case.* This new case is used to RETRIEVE a case from the collection of *previous cases*. The *retrieved case* is combined with the new case - through REUSE - into a *solved case*, i.e. a proposed solution to the initial problem. Through the REVISE process this solution is tested for success. During RETAIN, useful experience is retained for future reuse, and the case-base is updated by a new *learned case*, or by modification of some existing cases.

2.3.4 Case-based Reasoning Research Area

The challenges in CBR are to come up with methods that are suited for problem solving and learning in particular subject domains and for particular application environments. In line with the task model just shown, core problems addressed by CBR research can be grouped into five areas [28].

- Knowledge (case) representation and indexing
- Retrieval methods
- Reuse methods

- Retain methods
- Revision methods

2.3.4.1 Case Representation and Indexing

A case is "a contextualized piece of knowledge representing an experience that teaches a lesson fundamental to archiving the goal of the reasoner" [29]. Typically, according to Watson [29] there are three major parts of a case:

- Problem description: the state of the world while the case is happening and what problem needed solving at the time
- Solution: the stated or derived solution to the problem
- Outcome: the resulting state of the world after the case occurred.

Another way to describe case presentations is to visualize the structure in terms of the problem space and the solution space [30]. Fig 2.4 illustrates the problem and solution space structure. According to this structure, the description of a problem resides in the problem space. The retrieval process identifies the features of the case with the most similar problem. When the best matching is found, the system uses similarity metrics to find the best matching case. In those processes, the solution of a case with the most similar problem may have to be adapted to solve the new problem.

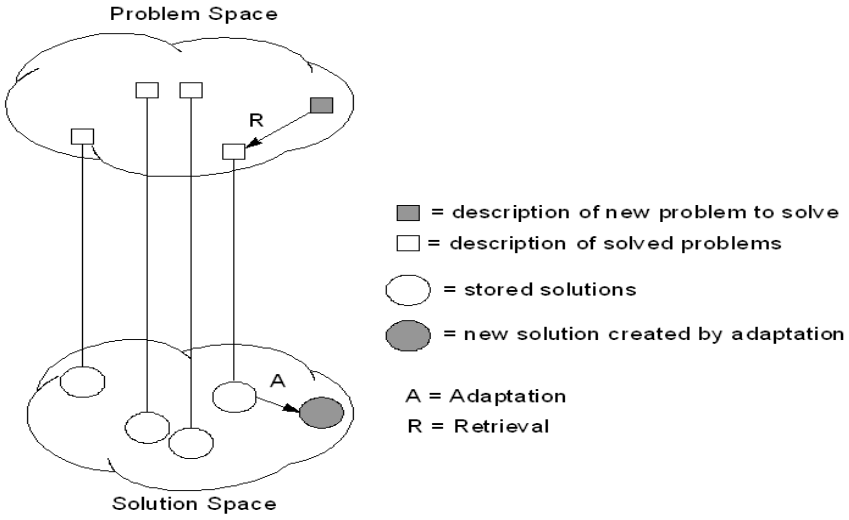


Fig 2.4 Problem and solution spaces adopted from [30]

Once the case is represented, there is a need to apply case indexing techniques [31]. An index is a computational data structure that can be stored in memory and searched quickly. Case indexing involves assigning indexes to cases to facilitate their retrieval .The CBR community proposed several guidelines on indexing:

1. Indexes should be predictive.
2. Predictions that can be made should be useful ones, that is, they should address the purposes the case will be used for.
3. Indexes should be abstract enough to make a case useful for future cases.
4. Indexes should be concrete enough to be recognized in the future.

Methodologies for choosing indexing include manual and automated methods. In some systems, cases are indexed by hand. When the cases are complex and the knowledge needed to understand cases well enough to choose indexes accurately is not concretely available, hand

indexing is needed [29]. On the other hand, if problem solving and understanding are already automated, it is advantageous to use automated indexing methods.

2.3.4.2 Retrieval Methods

The ability of CBR system to retrieve relevant cases quickly and accurately from its case-based is its main power. It builds a structure that will return the most appropriate case(s) at high speed. Case-based indexing minimizes the number of cases that have to be evaluated at run time and is required for a large set of cases long retrieval time proportional to the number of cases considered. In general, two retrieval techniques are used by the major CBR applications: nearest neighbor retrieval algorithm and inductive retrieval algorithm [32].

Nearest Neighbor Retrieval: This technique measures similarity between source case and new case which need searching [33]. If case is not matched with CBR library. Then, CBR system will return nearest match. Fig 2.5 displays a simple scheme for nearest-neighbor matching. In this 2-dimensional space, case3 is selected as the nearest neighbor because similarity (NC, case3)> similarity (NC, case1) and similarity (NC, case3)> similarity (NC, case2).

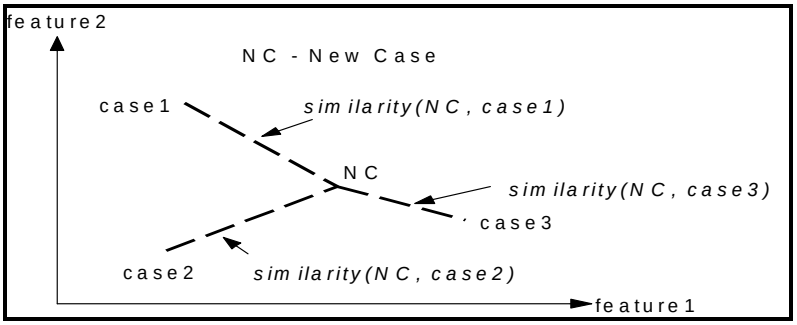


Fig.2.5 How to find the nearest neighbor of the new case (NC) [32]

Inductive Retrieval: This algorithm determines which features do the best job in discriminating cases and generates a decision tree type structure to organize the cases in memory [34]. This approach is very useful when a single case feature is required as a solution, and when that case feature is dependent upon others. The choice between nearest-neighbor retrieval and inductive retrieval in CBR applications requires experience and experimentation. Usually, it is a good choice using nearest-neighbor retrieval without any pre-indexing and simple to apply. If retrieval time becomes an important issue, inductive retrieval is preferable.

Retrieval knowledge may be needed to identify which features should be considered when determining relevance, what relative importance among features should be used when determining similarity. Furthermore, retrieval may not be sufficient, and the retrieved solution may need to be revised to reflect differences between the new and retrieved problems. Adaptation knowledge is required to capture the adaptations that should be applied and the circumstances in which they are needed [35].

2.3.4.3 Case Adaptation /Reuse Methods

Once a matching case is retrieved a CBR system should adapt the solution stored in the retrieved case to the needs of the current case. Adaptation looks for prominent differences between the retrieved case and the current case and then applies formulae or rules that take those differences into account when suggesting a solution [36]. As stated by [34], a CBR system retrieves cases corresponding to similar problems from its case-based. The adaptation step must recognize differences between the new and retrieved problems, and refine the retrieved solution to reflect these differences, as appropriate. According to Watson [29], there are three types of case adaptation:

- Substitution replaces values in the retrieved solution with new values appropriate for the new problem;
- Transformation alters the retrieved solution by adding, deleting or replacing parts of the retrieved solution to suit the new problem (e.g. altering steps in a plan); and
- Special methods apply specialized heuristic knowledge to repair the retrieved solution, or replay the method used to derive the retrieved solution for the new problem.

According to [34], the adaptation task is to recognize the difference between the retrieved cases and the case form a case-base. Because the new and retrieved problems are sufficiently different in some relevant way, adaptation performs some change(s) to the retrieved solution. An adaptation can be considered as a situation-action pair. The situation contains the differences between the new and retrieved problems. The action captures the update for the retrieved solution: new values for the reused solution (substitution).

Fig.2.6 shows the case-based adaptation in action. Each adaptation captures the adaptation situation that the extracted problem and the retrieved case demonstrate and the adaptation action that should be applied. The adaptation situation consists of the attribute values in the problem part of the extracted case, the differences (dissimilarities) between the extracted and retrieved cases for each of these problem part attributes, and the retrieved solution. The adaptation action captures the update that is necessary to change the retrieved solution into the solution of the extracted case.

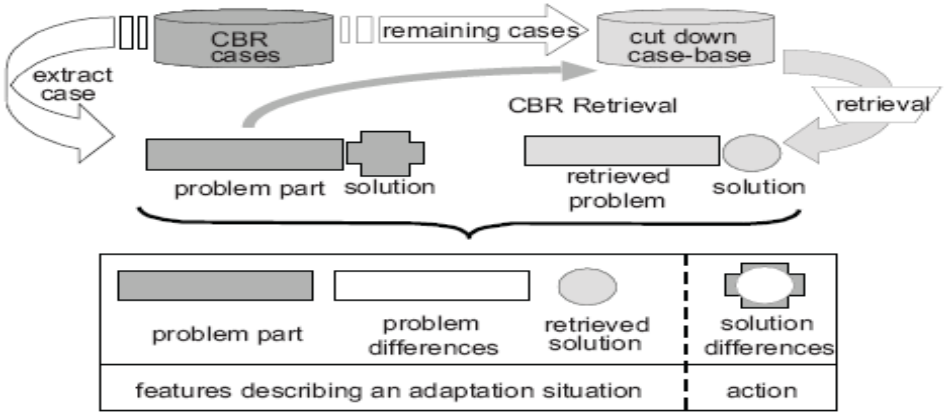


Fig 2.6 Case-based adaptation Actions adopted from [34]

Techniques of Case Adaptation in CBR

A case in a given CBR application encodes a problem-solving episode that is represented by a problem statement (*pb*) and an associated solution (*Sol (pb)*). The case is denoted by the pair (pb, Sol (pb)) in the following. Let Problems and Solutions be the set of problems and the set of solutions of the application domain, and "is a solution of" be a binary relation on Problems × Solutions. In general, this relation is not known in the whole but at least a finite number of its instances (pb, Sol(pb)) is known and constitutes the case-based (CB).

An element of CB is called a *source case* and is denoted by *srce-case = (srce, Sol (srce))*, where *srce* is a *source problem*. In a particular CBR session, the problem to be solved is called *target problem*, denoted by *tgt*.

A case-based inference associates to *tgt* a solution *Sol(tgt)*, with respect to the case-based CB and to additional knowledge bases, in particular *O*, the *domain ontology* (also known as domain theory or domain knowledge) that usually introduces the concepts and terms used to represent the cases.

2.3.4.4 Revising

Once an appropriate solution has been generated and returned, there is some expectation that the solution will be tested in reality [36]. To test a solution, it has to be considered both the way it may be tested and how the outcome of the test will be classified as success of failure. This means that some criteria need to be defined for the performance rating of a proposed solution. Using this real-world assessment, a Case-based Reasoning system can be updated to take into account any new information uncovered in the processing of the new solution. This information can be added to a system for two purposes: fist, the more information that is stored in a case-based, the closer the match found in the case-based is likely to be; second, adding information to the case-based generally improves the solution that the system is able to create.

2.3.4.5 Retaining

This is the process of incorporating what is useful to retain from the new problem solving episode into the existing knowledge [23]. The learning from success or failure of the proposed solution is triggered by the outcome of the evaluation and possible repair. It involves selecting which information from the case to retain, in what form to retain it, how to index the case for later retrieval from similar problems, and how to integrate the new case in the memory structure.

At present, CBR is a mature and established technology that became a critical [37]: the availability of tools to build CBR systems, and the accumulated practical experience of applying CBR techniques to real-world problems. Many researchers in the field agree on the increasing need to formalize this kind of reasoning, define application analysis methodologies, and provide design and implementation assistance with software engineering tools.

2.4 Case-based Reasoner: jCOLIBRI 1.0

In order to create a CBR framework that can cover different approaches that are reviewed in the last sections, the selected CBR tool are defined and extracted some axes of variability in its architecture.

Fig 2.7 depicts the architecture of jCOLIBRI Framework. It stands for Java Cases and Ontology Libraries Integration for Building Reasoning Infrastructures. jCOLIBRI comprises four main modules: Case-based (In-memory Organization of Cases), Task and Method Ontology and jCOLIBRI Core. It also shows the four different data sources types (Persistence Layer), which are connected with the other framework components via objects, referred to as Connectors.

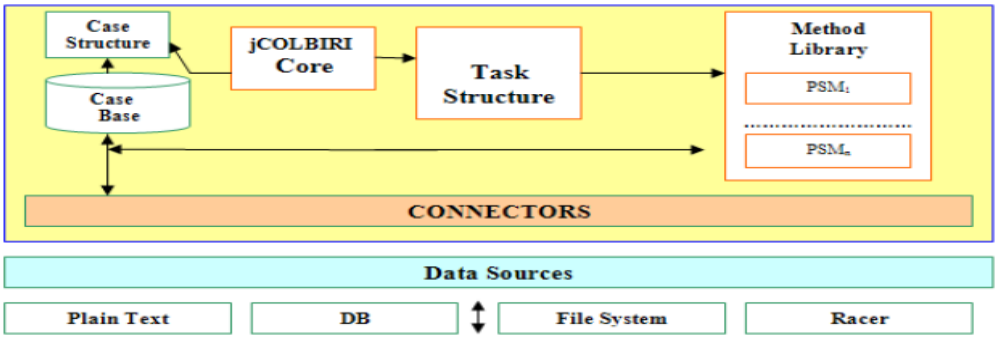


Fig 2.7 jCOLIBRI Architecture adopted from [38]

2.4.1 Case Structure

jCOLIBRI represents a case in a very general the framework that support several case structures, from plain attribute value records to hierarchical trees with composed attributes.

A case is composed of Description (describes the problem by means of several attributes), Solution (contains the description of the solution of the case) and Result (represents the result of applying the case to a real situation). Description and Solution are sets of Attributes, and there are two types of attributes: simple and compound. Simple Attributes are described by Name, Type, Weight and Local Similarity Function. Compound Attributes collect other simple attributes, allowing complex case structure. When two cases are compared, the local similarity functions are used to compare simple attribute values. Global similarity functions are linked to compound attributes and are used to gather similarities of the collected attributes in a unique similarity value. At last the similarity value of two cases is computed as the similarity of their Description concepts.

2.4.2 Case-based and Connectors

jCOLIBRI splits the problem of Case-based Management into two separate although related concerns: persistency mechanism and in-memory organization [39]. Persistence layer is composed by several connectors that allow developers to change the data storage sources very easily. Connectors are objects that know how to access and retrieve cases from the medium and return those cases to the CBR system in a uniform way.

jCOLIBRI implements Plain Text Connector, JDBC Connector, File System Connector and Racer Connector. The second layer of Case-based Management is the Case-Base (data structure) used to organize the cases once read and loaded by the connector into memory.

2.4.3 Tasks /Methods

The most well known knowledge level analysis applied to CBR systems describes the general CBR cycle in terms of four tasks at the highest level of generality: Retrieve the most similar case/s, reuse its/their knowledge to solve the problem, Revise the proposed Solution and Retain the experience [40]. Each one of the CBR tasks involves a number of more specific subtasks. jCOLIBRI includes additional methods to solve the Preparation and Maintenance Tasks, named Pre-Cycle (loads the cases from data sources) and Post-Cycle (stores the learned cases in the persistence layer). As the major aim of this research is exploring the adaptation mechanism in CBR, the study further explores how jCOLIBRI adaptation method works.

2.4.3.1 Case Adaptation in jCOLIBRI 1.0

Case adaptation is a knowledge-intensive task and most CBR systems have traditionally relied on an enormous amount of built-in adaptation knowledge in the form of adaptation rules [35].

The adaptation rules in JCOLIBRI1.0 allows developers to create rules for adapting solutions and store them in textual files that would be loaded and interpreted by the generic adaptation method. These rules are composed by three parts. The first one identifies the instance (*I*) to adapt following a <concept, relation> chain. Then the rule has a condition that will be evaluated for deciding if the adaptation of (*I*) should be performed. The last part defines the adaptation process. By now the method supports the following adaptations:

- Substitution *I* of by another instance specified by the developer. It is also possible to indicate conditions that the substitute instance must obey.

- Direct substitution of an instance that is related with I using a property of the ontology. Note that this related instance should define a characteristic of I. This option allows indicating directly the substitute instance.
- Substitution of a related instance indicating conditions for the substitute instance.

These rules can also follow dependencies (i.e. properties) that relate instances to perform the adaptation process recursively. Fig.2.8 and Fig.2.9 show adaptation rules syntax and their meaning, respectively, in JCOLIBRI1.0.

```
IDONTO:= /(Concept/Relation)* /Concept
IDPROPERTY:= (Relation/Concept)*
IDCASE:= "CASE."(attribute[.])*
RULE:= IDONTO,@,CONDITION,@,ADAPTATION
CONDITION:= (IDPROPERTY (=|!=) IDCASE) | (IDCASE (=|!=) String)
            | [not] (IDPROPERTY instanceOf Concept)
ADAPTATION:= SUBSTITUTION | MODIFY [FOLLOWDEPENDENCIES Relation]
SUBSTITUTION:= "SUBSTITUTE" [#CONDITION#]
MODIFY:= DIRECTMODIFICATION | ANYOTHERINSTANCEMODIFICATION
DIRECTMODIFICATION:= "DIRECT":IDPROPERTY:instance
ANYOTHERINSTANCEMODIFICATION:= "ANYOTHERINSTANCEOF":IDPROPERTY:concept
                               [#CONDITION#]
```

Fig 2.8 Textual form of Adaptation rules syntax

IDONTO identifies the path to the instance to adapt.
IDPROPERTY identifies a property of a concept.
IDCASE identifies an attribute of the case
SUBSTITUTION substitutes the instance by another one chosen randomly. Accepts can include a condition that the substitute instance must obey.
DIRECTMODIFICATION substitutes an attribute of the instance with the instance indicated by the developer.
ANYOTHERINSTANCEMODIFICATION substitutes an attribute of the instance by another instance of a concept. Accepts a condition for the substitute instance.
FOLLOWDEPENDENCIES applies the rule recursively to the instances related with the specified relation.

Fig 2.9 Definition of syntax in adaptation rules

2.4.4 jCOLIBRI Core

The Core is the most important component of the framework. It is in charge of maintaining the CBR configuration and executing the application [41]. When a user generates a CBR application template, it generates the Java code that configures the Core components with the appropriate tasks, methods, data types and case structures. The Core is composed of CBR-State (maintains the tasks and method configuration, CBR-Context (contains the Case-based and working cases), Packages (manage the remaining components, such as similarity functions, case structure.

Case-based reasoning (CBR) is now a mature subfield of Knowledge-based system [42]. The fundamental principles of case-based reasoning have been established, and numerous applications have demonstrated its role as a useful technology. Application with Reasoning is an important in legal practice of all kinds, and legal practice involves a wide variety of case-based tasks and methods. The paradigms' respective benefits and costs suggest different approaches for different legal tasks.

2.5 Case-based Reasoning in Law

Research in case-based legal reasoning has a more restricted meaning: formal judicial decisions (that is, legal cases) play the role of remembered experiences, and the problem-solving goal is the application of a prior case to answer legal questions about a new case. In legal CBR models, a set of domain-dependent, legally-relevant features is defined, and a prior case is considered more or less *on point* depending on the degree of match between the features of the prior case and those of the new case.

Case-based legal Knowledge-base system takes one or more examples or cases instead of rules in the system. The system, when presented with a new legal case, tries to match the closest similar case in its Knowledge-base and adopt the solution to the legal case at hand or instant case. Patterns of reasoning typically found in case-based reasoning are 'analogizing' and 'distinguishing' [43]. The former involves pointing out similarities between a decided case and the case at hand, while in the latter the relevant differences between the cases are stressed. Various essences of case-based reasoning and studies that have been done both internationally and locally dwell to establish an overview of the works that have been done so far.

2.5.1 Case-based Model on Criminal Sentencing

JUDGE system [44], strictly rule-based system, adopts an approach which is similar to that of a case-based system. It analyses the similarities and differences between cases to give advice about sentencing for certain crimes including murder, assault and murder. JUDGE starts with a rule about a crime (provided by the user) and an appropriate sentence taken from a case. When a new case is added, JUDGE finds similar crimes and generates a rule about the new case on the basis of the similarities and differences between the new case and those similar crimes.

2.5.2 Case-based reasoning in Patent Law

HYPO [45] does case-based legal reasoning in the area of patent law. Centered on cases claiming violation of a patent, such as the release of a trade secret, HYPO uses its case-base of precedents to generate plausible arguments for the prosecution and the defense. The basic similarity measure of HYPO is the degree of overlap of dimensions shared by the instant case and a given case, relative to that of other cases. The magnitude of shared dimensions, and a

case's potential relevance as a near miss(i.e. when a small hypothetical change would make that near miss case more on point).

2.5.3 Hybrid Case-based Reasoning in Texas' law

GREBE (Generator of Recursive Exemplar-Based Explanation) [46] uses knowledge in the form of generalizations and category exemplars to determine the classification of new cases. GREBE's knowledge-base contains rules and a small collection of exemplar cases concerned with Texas' laws for injuries to workers traveling outside of the work place. GREBE uses a semantic network representation for cases and uses generalization and exemplar-based explanation. GREBE represents an advance over previous exemplar-based systems in that it accepts detailed semantic network representations of cases, retains and reuses the explanations of category exemplars and use exemplar based reasoning recursively to assess similarity.

2.5.4 Case-based Reasoning with Building Regulation

KICS [47] is being implemented in the domain of building regulations. This system accumulates case histories of interpretation of regulations used to establish precedents. These precedents can be used when revising statutory regulation and enrich the resulting new versions of regulations. They also provide relevant information for the experts to interpret and make decisions about cases coming to appeal.

2.5.5 Case-based Legal Precedent Retrieval System [48]

This is a case-based legal precedent retrieval system specifically for the labor law of Ethiopia. The research work was concerned with the development of case-based reasoning to build the

Knowledge-base in which complete decided cases could be entered and then recalled when similar cases arose again using the nearest neighbor similarity measure.

But the research was limited to the retrieval of the similar cases comparing the case at hand to the library of past decided cases, using the CBR works framework methodology. The researcher did not involve construction of adaptation mechanism for precedent based a legal argument that helps to reuse the current problem of a case for the future use. In addition it did not definitely decide a final sentencing for a given problem of a case.

Subsequently, increasing numbers of research paper and applications were published, and CBR has grown into a field of widespread interest. To enhance and upgrade the case-based reasoning for legal arguments, implementation of each individual task of case-based reasoning has been explored for more effective knowledge representation and problem solving. AI research and Knowledge-based systems development should incorporate CBR techniques because human experts in diverse fields reason with cases in performing a wide variety of tasks. The tasks are not rare or exotic. They represent a significant core of human expert advice-giving in many domains. Since, for each task, legal applications come readily to mind, designers of Knowledge-based systems will also need to take cases into account. This is the original motivation for this study; to construct precedent based legal arguments by adapting previous cases on case-based reasoning through investigating how the adaptation mechanism assisted in case-based problem solving.

2.6 Summary

The main objective behind this chapter has been to provide a detailed background of case-based reasoning and techniques in the field of Law importantly relevant for the present thesis. The type of the case-based reasoning used in this research is a problem solving approach in which the CBR compares new situation to recalled experience. In addition the CBR framework i.e. jCOLIBRI1.0 is discussed with common components that are included in the framework.

Based on the literature review and as the research knowledge, the present work is a new research that applies precedent legal arguments that adapts a new case from pervious cases for future use in children sexual abuse cases. To study the domain knowledge that are implemented in the framework, preliminary investigation i.e. discussion with legal professionals and review the past decided cases on crimes of child sexual abuse for decision making are required. The next chapter presents the knowledge acquired for designing a case-based reasoning in legal knowledge-based system.

CHAPTER THREE

KNOWLEDGE ACQUISITION

3.1 Initial Knowledge Acquisition to Identify Case Feature

Legal experts make a decision after consulting all information relevant to a given case. In addition to statute and case histories relevant to the given case, the experts should refer to all information available to provide justification for their decision. The problem is therefore to support the consultation of these loosely expressed legal requirements without being forced to make explicit all the information needed to arrive at a decision.

Further more, discussions conducted with domain experts revealed the fact that the cases the court handles tend to be similar and increase in number very rapidly. Consequently, provision of a system to adapt the domain could have a paramount role in assisting legal professionals. The process for seeking out the knowledge required by knowledge-based system is referred as knowledge acquisition with major steps such as *knowledge elicitation* and *knowledge structuring;* as discussed in chapter two.

3.2 Acquisition of Domain Knowledge

3.2.1 Sexual Abuse and Violence Against Children

Child sexual abuse has gained public attention in the past few decades and has become one of the most high-profile crimes. Since the sexual abuse of children and child molestation has

increasingly been recognized as deeply damaging to children and thus unacceptable for society as a whole.

While sexual use of children by adults has been present throughout history, it has only become the object of significant public attention in recent times [49]. In the domain of the Ethiopian criminal law, acts committed against right to life such as sexual abuse are considered as serious offences that entail severe penalties. Depending on the gravity of the crime, the punishment ranges from fine and simple imprisonment to life imprisonment.

3.2.2 Modeling the Concept in the Punishable Acts for Child Sexual Abuse

Concepts used in the judgment of sexual violence in children are presented in table 3.1. These concepts are acquired by interviewing legal experts/judges. The interpretation of these concepts helps to model the framework required for determining the ranges of years for a given case.

Input parameters	**Out put parameters**	**Years of imprisonment**
Rape on a ***girl*** child of age<13	Art623(2)(a)	<=20 years
Sexual intercourse with a ***girl*** of 13-18	Art (629(1))	15 years
Sexual offence on a ***female child*** of age< 13	Art (630(1))	15 to 25 years
Sexual act on a ***male child of age*****<** 13	Art (630(3))	6 months to 7 years
Any sexual act on a ***male child*** below the age of 13 by a person of the same sex	Art (634)	3 months to 5 years
Sexual act on a ***female*** or ***male child*** of age 13-18 by a person of the same sex	Art(633(2)(c)	3 to 15 years

Table 3.1: Input and Output Parameters of Sexual abuse of children judgment.

As discussed in chapter two, one of the most widely used knowledge structuring, in Knowledge-based system development, is the hierarchical tree structure. This model puts a goal at the highest level of the hierarchy and factors leading to that decision are represented down the hierarchy, with primary parameters nearer to the top.

3.2.2.1 Sexual Abuse Cases

The legal experts explained the criminal and civil offenses in which an adult engages in sexual activity with a minor or exploits a minor for the purpose of sexual gratification.

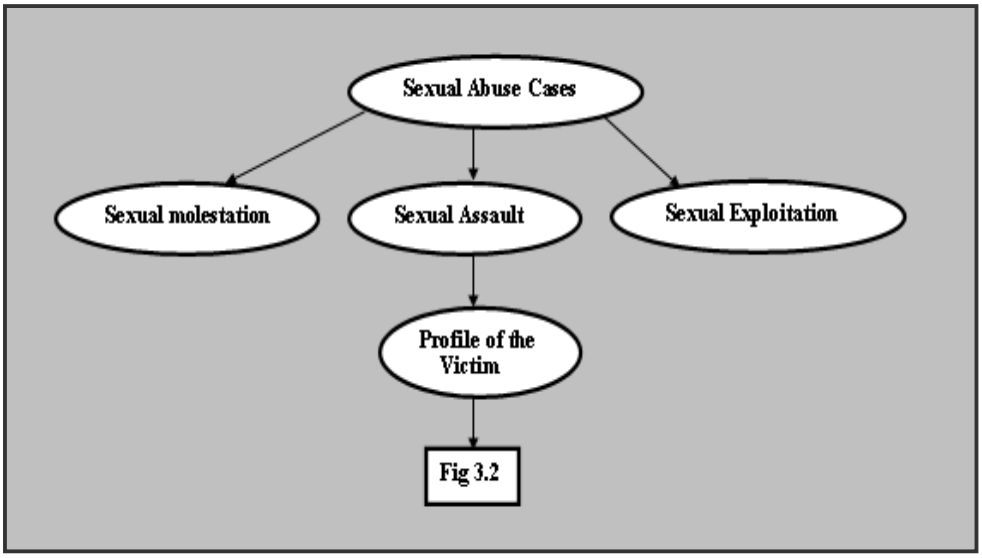


Fig 3.1 Case Concept for Sexual Abuse Cases

In Fig 3.1, presents a variety of sexual abuse cases: sexual molestation, sexual exploitation and sexual assault.

- ***Sexual molestation*** defines offenses in which an adult engages in non-penetrative activity with a minor for the purpose of sexual gratification; for example, exposing a minor to pornography or to the sexual acts of others.
- ***Sexual exploitation on the other,*** defines offenses in which an adult victimizes a minor for advancement, sexual gratification, or profit; for example, prostituting a child, and creating or trafficking in child pornography.
- Finally, ***sexual assault*** defines offenses in which an adult touches a minor for the purpose of sexual gratification; for example, rape, sexual penetration with an object, etc. After determining a type of the sexual offenses, the next point to identify is that a profile of the victims.

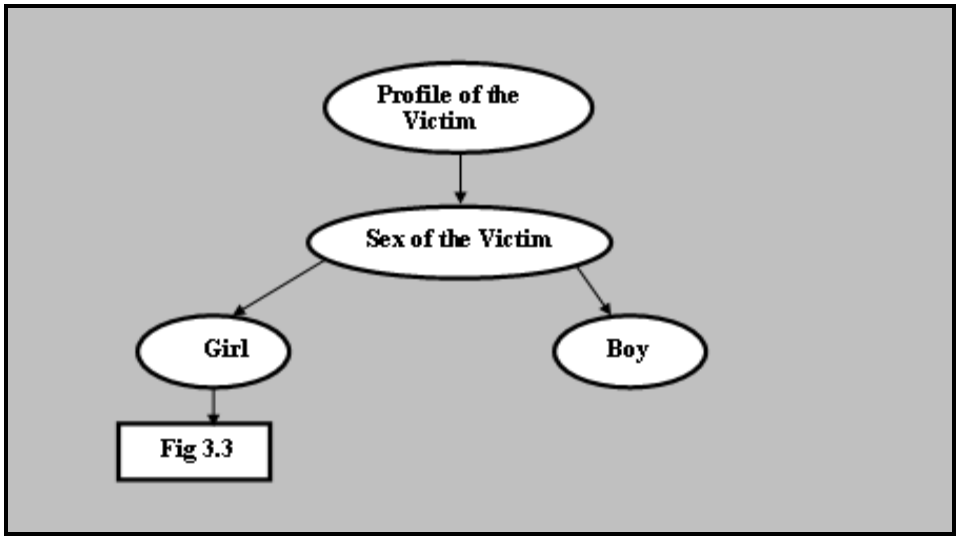


Fig 3.2 Case Concept for Victims Profile

3.2.2.2 Profile of victims

From the profile of the victim in Fig 3.2, ***sex*** of the victim needs to be considered in modeling the concept in the punishable acts of sexual abuse. The interviewed legal judges explained that, sex of the victim is an important issue in the understanding and analysis of any form of

violence. Most of the times, cases on female victims exceeding the number of male victims. So that the researcher modeled knowledge needed for decision given for victim girl. Besides the sex of the victim, the age of the victim is the other issue to be considered.

Age of the victims is a determining factor in understanding ones cases, assessment of a risk and the ability to properly react to a given situation. Victims' age basically indicates the level of his/her psychological and physical vulnerability to a given risk. As shown in Fig 3.3, the punishable criminal code of Articles determined on age of the victim.

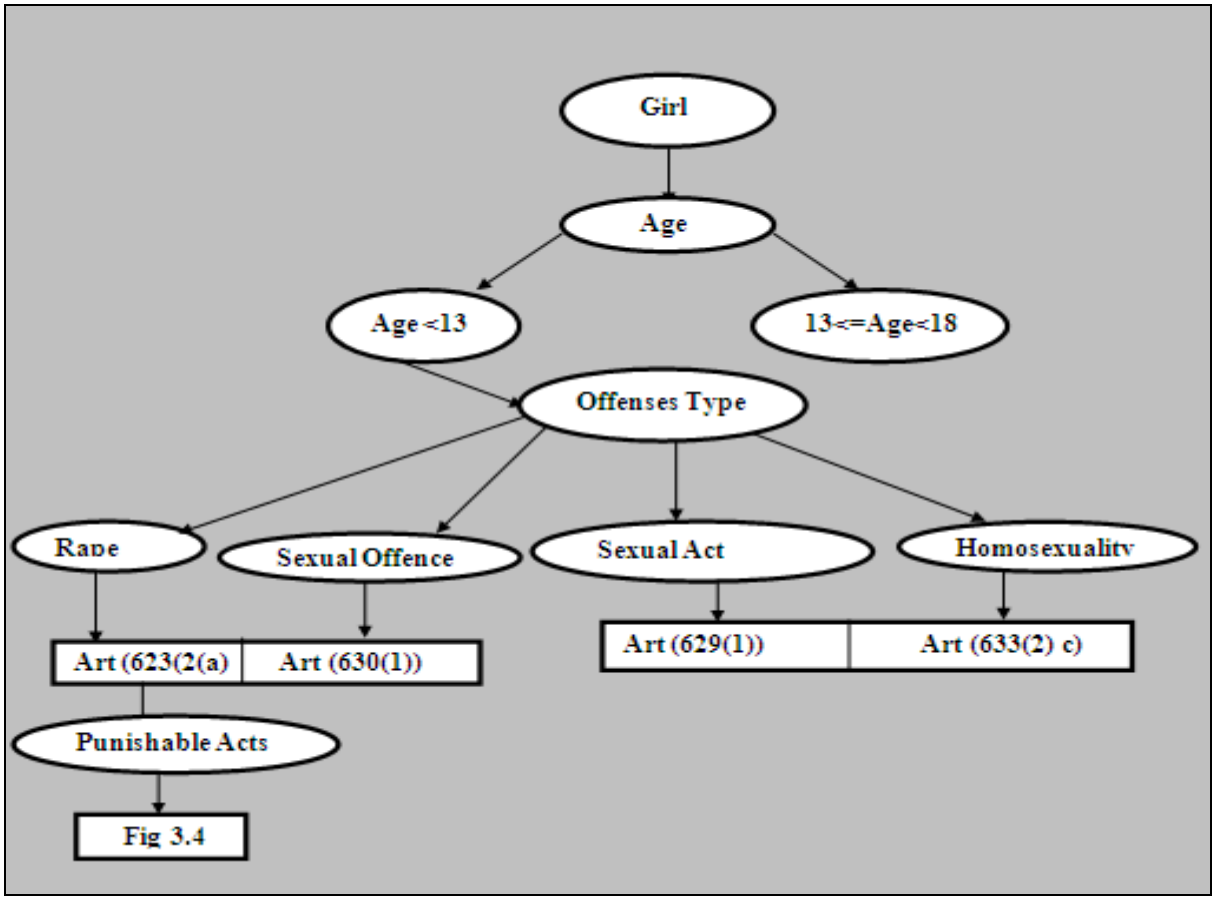


Fig 3.3: Case Concept for Punishable Acts for Girl Victim.

3.2.2.3 Types of Committed Offenses

Before dealing on punishable acts, the types of offenses selected for the purpose of this research are four, namely; *Rape, Sexual Offense, Sexual act and homosexuality* (see Fig 3.3). This doesn't mean that these offenses are the only offenses committed against children's and youths. Under the Ethiopian Penal Code (2006), Article548 any offenses against the person or health of the child are punishable acts.

3.2.2.4 Punishable Acts

The Ethiopian penal code defines different punishment based on the age and sex of the victim referring to a definite criminal code of Article

- ***Rape on a girl*** child of less than the age of 13 by a person of the opposite sex will result in an aggravated case punishable according to Article 623 (2) (a) with rigorous imprisonment up to 20 years.
- ***Sexual intercourse with a girl*** of 13-18 years by a person of the opposite sex will be punishable with a maximum rigorous sentence of 15 years regardless of the girl's consent for the act with reference to Article (629(1)). The punishment will be aggravated to 20 years in the cases where the victim is the pupil, apprentice or servant of the offender, or is in any other way directly dependent upon or subordinate to the offender.
- ***Sexual offence on a female child*** below the age of 13 is punishable according to Article630 (1) with rigorous imprisonment of 15 to 25 years.
- Any sexual act on a ***female*** or ***male child*** of age 13-18 by a person of the same sex be punishable with a rigorous imprisonment of 3 to 15 years, as stated in Article (633(2) (c)).

To resolve the ranges of years of punishment, the researcher further studies the tacit knowledge of the legal experts, the way how to decide specific year's of imprisonment depending on the gravity of crime, and other non legal factors such as the age of the offenders, situation of the victim and other additional factors that aggravate the penalty.

3.2.2.5 Factors Relevant for Sentencing

The judge decides on a sentence after a plea hearing. At the plea hearing the perpetrator's lawyer asks for major facts to be taken into account when the judge makes a sentence. For example, how judges physiologically and socially defines the article in criminal code. The factors are so tacit in ones legal expert mind and difficult to present and may appear different perspective in ones cases for making definite sentencing. Most of the times, the judges determines the cases with due consideration of the offender side and the victim side to give reasonable verdict. The details are presented in Fig 3.5 and Fig 3.6.

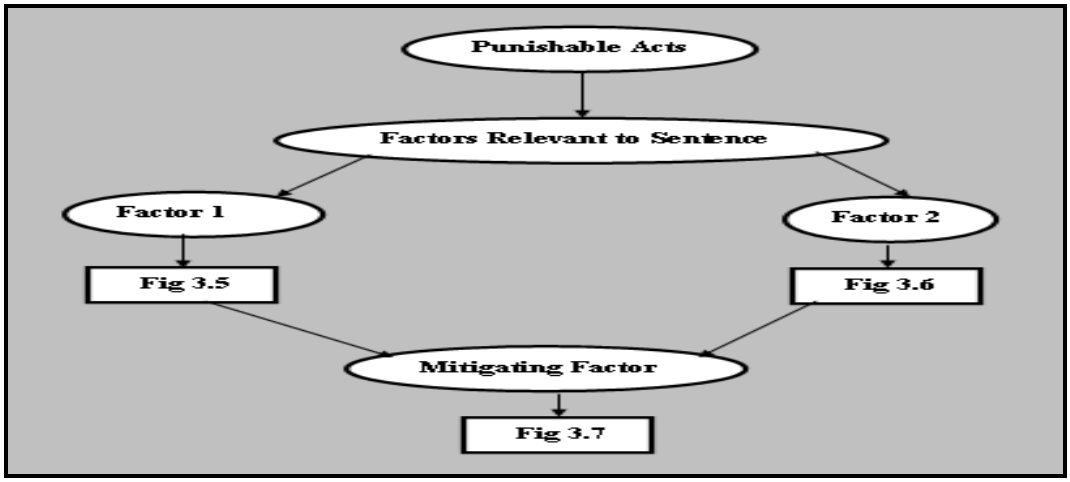


Fig 3.4 Concepts on Factors Relevant for Sentencing

Once the offenders and victim profiles are analyzed, the judge further considers mitigating factors, as presented in Fig 3.7

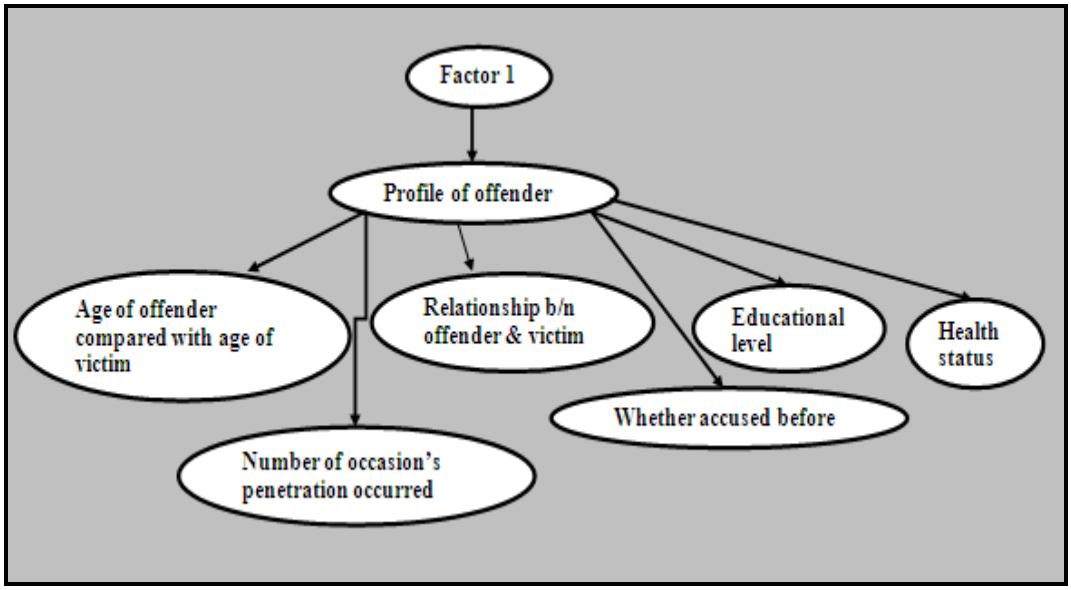


Fig 3.5 factor for giving relevant sentencing 1

Factor one: Profile of Offender

Educational level of offenders: One of the uncontested merits of education is its impact on positive behavioral change through inducing sense of responsibility for ones act, respect for the rights and interest of others. The judges considers the educational level of the offenders as illiterate, lower educational level (1-6) and higher than the lower category. The lower educational level of the offender are assumed as being unaware of the consequence of their acts and lower moral standing that makes the rigorous sentence less severe (lower penalty period). As the educational level of the offender increase, it is expected that the sentence of the penalty is more severe (the final ranges of penalty) than lower level of education.

Age of offender: The verdict to be pronounced and the punishment to be imposed on offender depend on the age of the offenders. Offenders under nine years of age are placed in the category of irresponsible persons and are fully exonerated form criminal prosecutions. Young offenders between the ages nine and eighteen years are responsible for their criminal acts but they are not subject to the same penalties and measure applicable for adults. In the third category fall offenders greater than eighteen years are considered fully responsible for purposes of criminal law.

Health status:- One of the focal point for giving a judgment is determining whether the offender is mentally ill or not. If the offender mentally ill, the punishment acts on the offender is less than that of offenders with health status in normal condition.

Relationship between offender and victim:- the interviewed judges explained that those who have close relationship with the victim child like the victim family member, victim teacher at school, and medical doctor treating the victim will make the sentencing more severe than those offenders having less relation with the victim child.

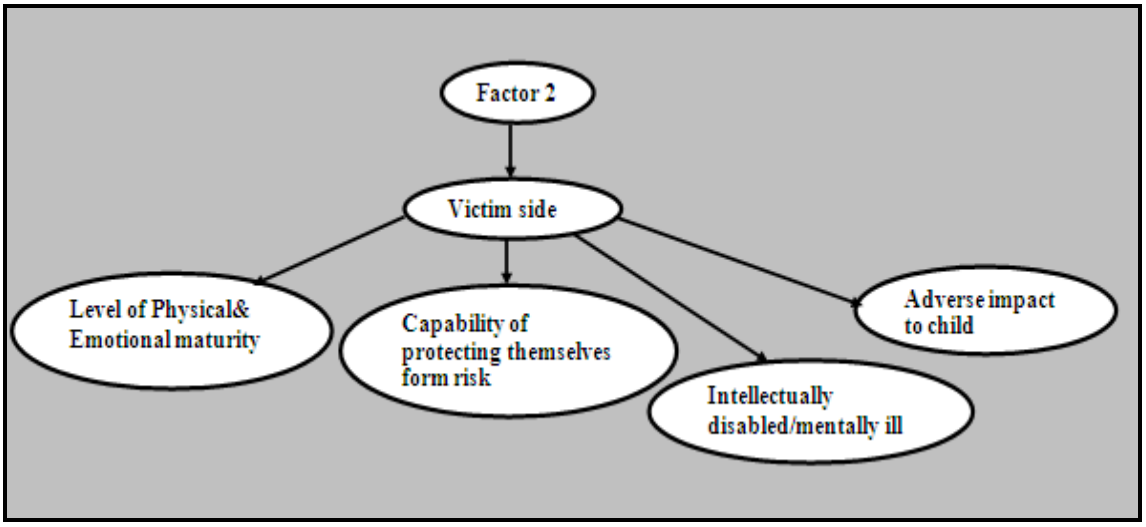


Fig 3.6 Factor for giving relevant sentencing 2

Factor Two: Profile of the Victim

The other factors that are taken as guidelines for giving appropriate sentencing for offender are the profile of the victim, as shown in Fig 3.6.

Level of emotional maturity: Emotional maturity in terms of physical and psychological readiness for sexual acts is also a natural fact that is manifested in age category of 13-18. The judges also consider specific age of the victim kind of situation and give appropriate penalty to Offenders.

Capability of protecting themselves from the risk: A more vulnerability situation of 1-5 age groups of children, who are absolutely incapable of protecting themselves from possible risk that may victimize them. This situation may increase the probability to take the maximum penalty of the criminal code.

Intellectually disable/mentally ill:-if the victim child proven to be that with mentally disable indicate a sentence of 20 years.

Adverse impact of the victim: - Depending on the age and size of the child, and the degree of force used, child sexual abuse may cause infections, sexually transmitted diseases, or internal lacerations. In severe cases, damage to internal organs may occur, which, in some cases, may cause death. This indicates a sentence of life imprisonment which is the maximum sentence for sexual intercourse with a girl child. In addition to the above factors, before the final penalty is decided mitigation factor are considered by the judge.

3.2.2.6 Mitigation Factor for Final Penalty of Imprisonment

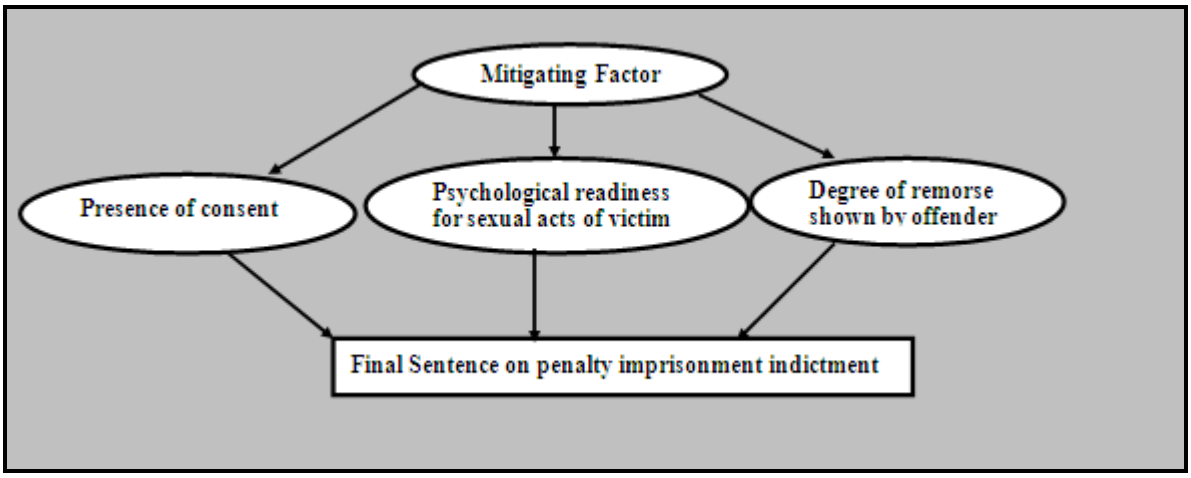


Fig 3.7 A case concept in mitigation factor

Mitigating is a term used in legal institutions for making the penalty of the offenders less severe (i.e. in order to make a crime appear less serious). Fig 3.7 shows that consideration of well being psychological readiness for sexual acts, the degree of remorse shown by the offender will have a great impact on final sentence of penalty given by the judge.

The most widely used method for knowledge acquisition has been the interview with domain engineer that helps the researcher to model the knowledge required for appropriate judgment. The normal approach is to record the entire conversation, transcribe the interview, and model the relevant items of knowledge. However, the modeled knowledge provides no guarantees about the completeness of knowledge acquired. Alternative methods for obtaining full knowledge, such as performing careful analysis of case history especially in legal sector, have been developed to provide complete coverage of knowledge. Hence the researcher has extracted the knowledge needed for adaptation on decided child sexual abuse cases.

3.3 Legal Cases Acquisition

The knowledge acquisition in a CBR system is the main issue to be resolved. The cases that comprise the case memory describe legal texts. These texts are converted into cases through the definition of attribute-value pairs that describe and index the cases [50]. The type of texts from where the cases are converted is analyzed by the help of domain experts. The goal is to define the symbolic structure of the texts and identify the parts in which the meaning of expressions is present. The researcher has performed sample tests to ensure that each substructure is actually present in every legal text or not. The detailed symbolic structure of the legal texts is described in Fig 3.8-3.10.

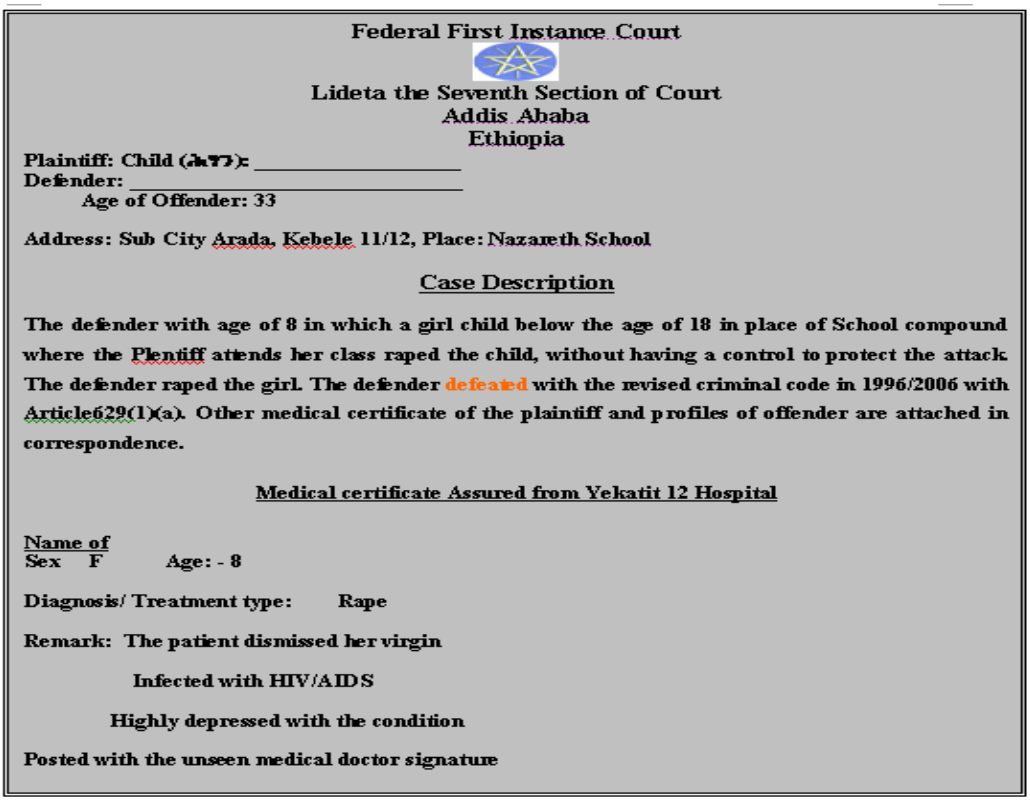
Identification: surface features such as date, address, age of the offender, and victim type.

Case description: which presents how and where the offender processed the activity, the remark from medical report and the profile of the offender

Decision: in its conclusion it is usually the court decision and its foundations. Upper paragraphs describe details of the situation, indicating the laws that categorize the subject, and points to foundations.

Closing: The last paragraphs describe the mitigating factors followed by final sentence of penalty, date, place and names of participating attorneys.

To acquire cases, the researcher designed a study involving 40 decided criminal cases on child sexual abuse. It is taken from the seven section of the court stage of the Federal First Instance Court in Lideta settled only on child sexual abuse cases.



Federal First Instance Court

Lideta the Seventh Section of Court
Addis Ababa
Ethiopia

Plaintiff: Child (ሕጻን): _____
Defender: _____
Age of Offender: 33

Address: Sub City Arada, Kebele 11/12, Place: Nazareth School

Case Description

The defender with age of 8 in which a girl child below the age of 18 in place of School compound where the Plentiff attends her class raped the child, without having a control to protect the attack. The defender raped the girl. The defender defeated with the revised criminal code in 1996/2006 with Article629(1)(a). Other medical certificate of the plaintiff and profiles of offender are attached in correspondence.

Medical certificate Assured from Yekatit 12 Hospital

Name of
Sex F Age: - 8

Diagnosis/ Treatment type: Rape

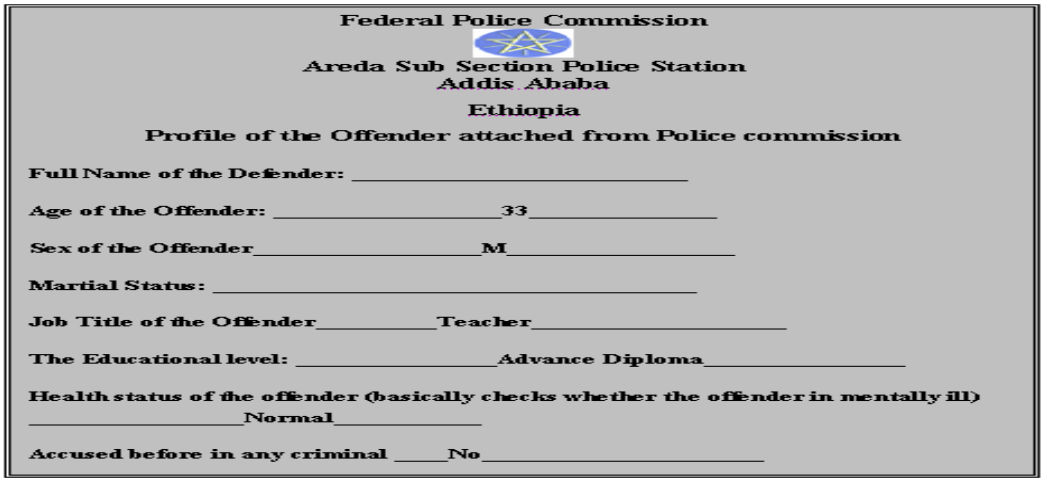
Remark: The patient dismissed her virgin

Infected with HIV/AIDS

Highly depressed with the condition

Posted with the unseen medical doctor signature

Fig 3.8 Symbolic Structure and legal texts containing identification, case description



Federal Police Commission

Areda Sub Section Police Station
Addis Ababa
Ethiopia

Profile of the Offender attached from Police commission

Full Name of the Defender: _____

Age of the Offender: _____33_____

Sex of the Offender_____M_____

Martial Status: _____

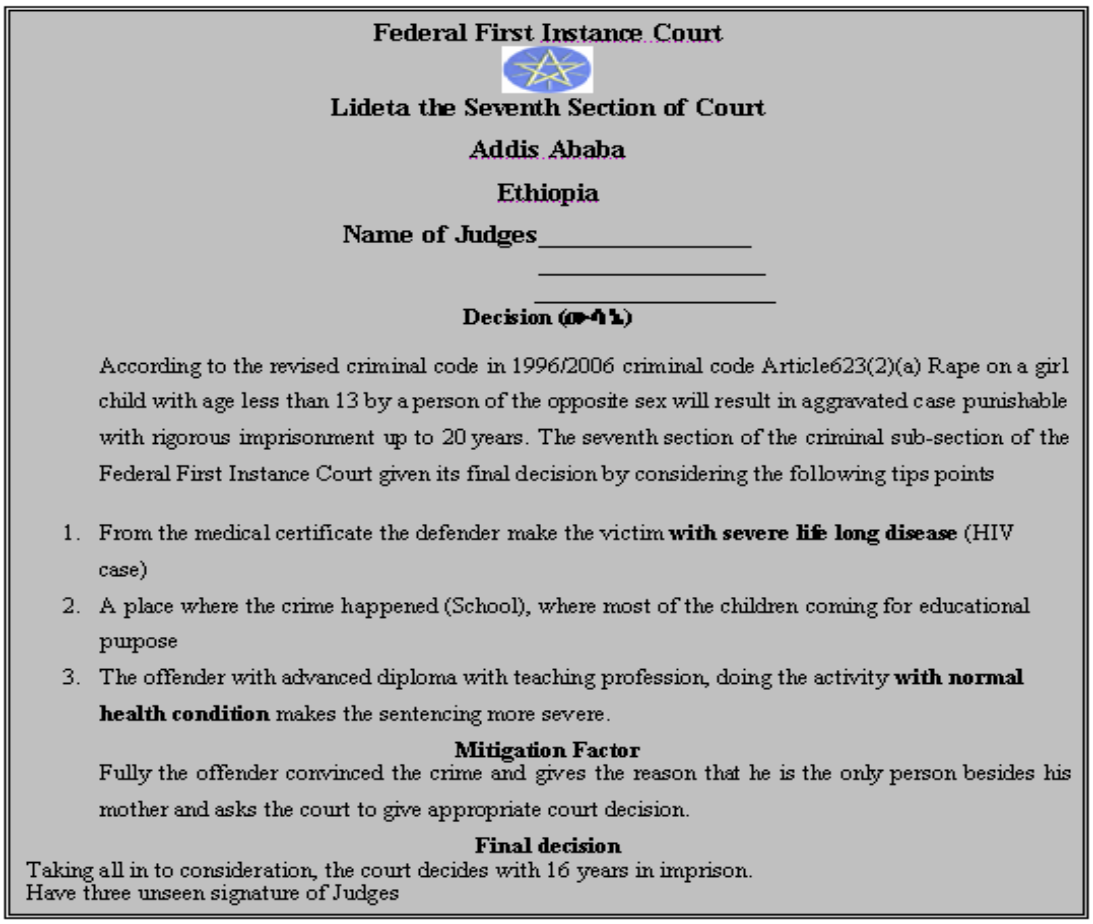
Job Title of the Offender_____Teacher_____

The Educational level: _____Advance Diploma_____

Health status of the offender (basically checks whether the offender in mentally ill)
_____Normal_____

Accused before in any criminal _____No_____

Fig 3.9 Sample Legal text containing profile of offender



Federal First Instance Court

Lideta the Seventh Section of Court

Addis Ababa

Ethiopia

Name of Judges_____

_____

_____

Decision (ውሳኔ)

According to the revised criminal code in 1996/2006 criminal code Article623(2)(a) Rape on a girl child with age less than 13 by a person of the opposite sex will result in aggravated case punishable with rigorous imprisonment up to 20 years. The seventh section of the criminal sub-section of the Federal First Instance Court given its final decision by considering the following tips points

1. From the medical certificate the defender make the victim **with severe life long disease** (HIV case)
2. A place where the crime happened (School), where most of the children coming for educational purpose
3. The offender with advanced diploma with teaching profession, doing the activity **with normal health condition** makes the sentencing more severe.

Mitigation Factor

Fully the offender convinced the crime and gives the reason that he is the only person besides his mother and asks the court to give appropriate court decision.

Final decision

Taking all in to consideration, the court decides with 16 years in imprison.
Have three unseen signature of Judges

Fig 3.10 A sample of Legal text containing final decision

From the sample decided case, attributes shown in Table 3.2 are identified as the main descriptors of the legal texts during decision making. These attributes are selected with help of legal experts.

Surface structure /attributes	Substructure
Age of victim	Identification
Sex of victim	Identification
Offenses Type	Case Description
Medical report remark	Case Description
Disability of victim	Case description
Age of offender	Identification
Sex of offender	Identification
Educational level of offender	Case Description
Health status of offender	Case Description
Relation with victim	Case Description
Accused before	Case Description
Article of a penalty	Decision
Years of imprison	Closing

Table 3.2 Features and dimensions Surface representing a case.

As the main aim of this study is to explicitly extract the knowledge inside the previously decided cases and to make use of in a case-based legal reasoning. The new feature of this research work is extracting knowledge to specifically decide a new problem of a case-based on both legal factor (punishable acts) and non legal factors (identified attributes form case sub structure) to get how much an offender takes its final penalty inducement.

In this chapter, a brief discussion is held to merge the tacit and explicit knowledge needed to analyze a single crime case on child sexual abuse. Fig 3.11 shows a structure model with a flow of knowledge used for representation in the preceding chapter. The shaded part of the box i.e. tacit knowledge needed for decision making is implicitly inside ones in the legal expert. The researcher has extracted the implicit knowledge needed for decision, encoded in side the case in which the legal experts defines the punishable acts of the criminal code, in accordance of determining specific penalty of imprisonment for an offender.

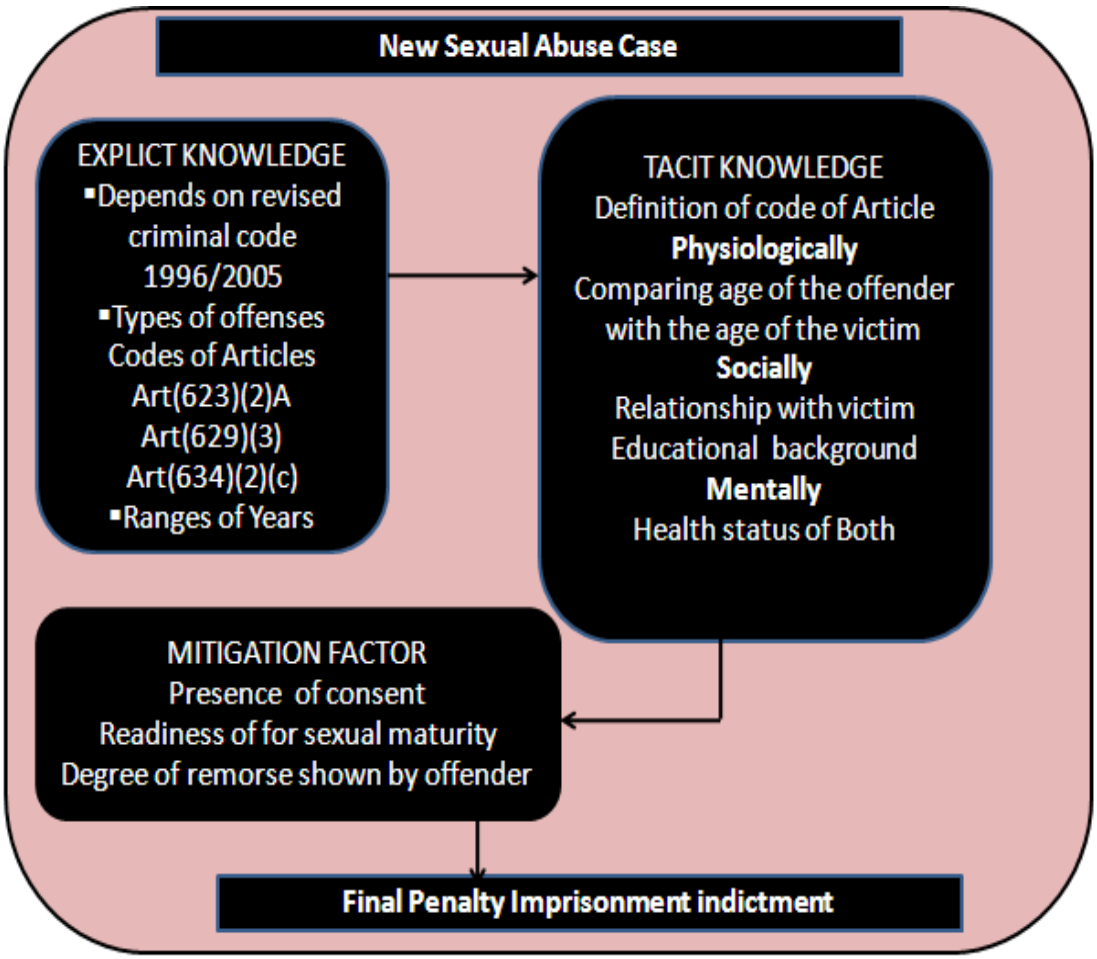


Fig 3.11: Summarized Knowledge model for Decision Making.

CHAPTER FOUR

IMPLEMENTAION AND EVALUATION

After case acquisition and its transformation into useful knowledge, the next phase is to codify the knowledge using suitable representational model for case-based reasoning. In this research the case structure supported by jCOLIBRI are formulated and stored as XML file. Before dealing about the implementation issues, explanation is given on system framework designed in this research.

4.1 Designing CBR in Legal Knowledge-based System

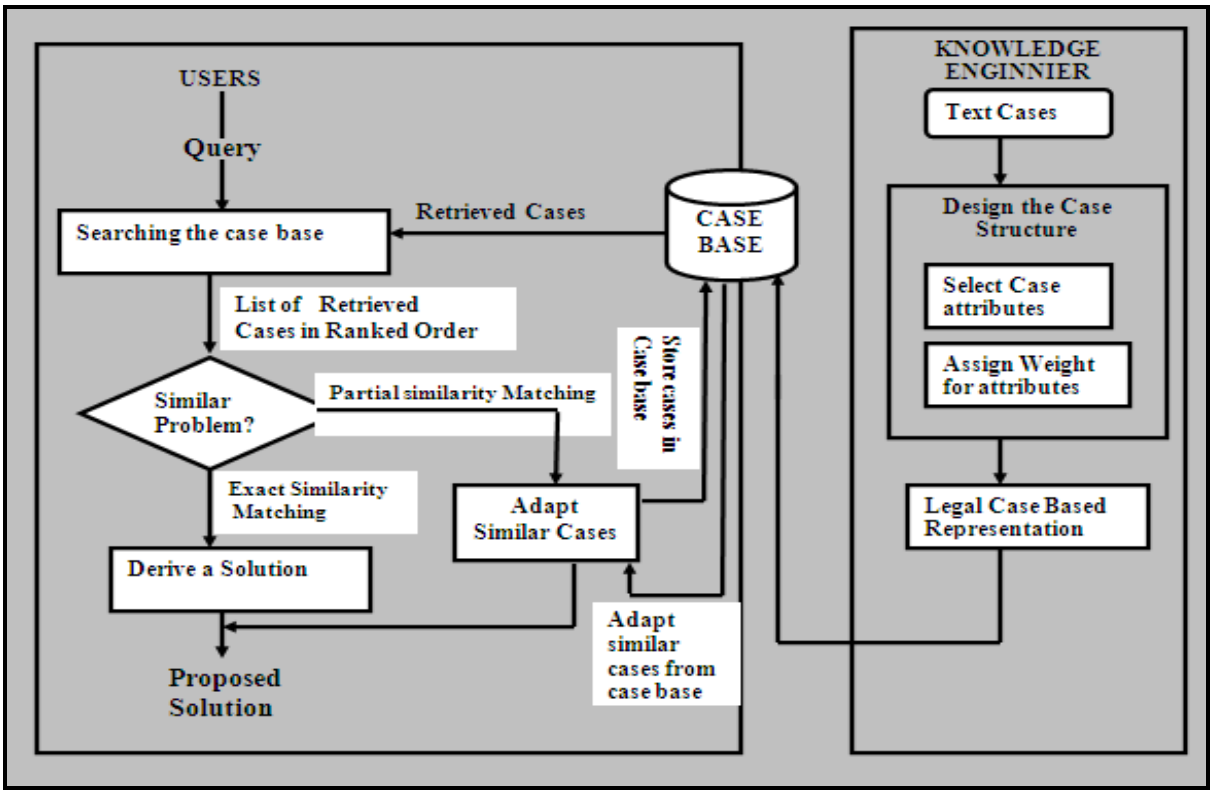


Fig 4.1 Architecture of Case-based Reasoning in Legal KBS for Children Criminal Cases

In Fig 4.1, a framework that has been used for legal case-based reasoning in children criminal cases is presented. As the new requested parameters of a new case entered by the user, the prototyped system searches a similar problem in the case-based and listed out the retrieved cases with order of ranking. If the exact matching similarity occurred, the suggested solution has been derived and the system displays a final proposed solution. The partial matching similarity of a case from the reduced case-base, the problem and similar cases are analyzed to construct an adaptation case that can be used to adapt the *proposed solution* from the similar case into the correct *known solution* for the problem case.

From the knowledge engineer side preparing the heart of a CBR-System i.e., the case-based containing the knowledge of the domain has been constructed. Accordingly, the first step in the construction of case-based is to collect legal texts of cases with the homogenous set of relevant decided court cases. The collected legal texts further processed to extract a set of attributes that has a direct impact for decision making.

The case-based in this research are represented in a form of Plaintext as shown in Appendix B, which is presented in N columns representing case attributes ($\{A_1, A_2, A_3, \ldots, A_N\}$), and M rows representing individual cases ($\{C_1, C_2, C_3, \ldots, C_M\}$). Consequently, each attribute has a sequence of possible values associated with it: $A = \{V_1, V_2, V_3, \ldots, V_K\}$.

4.2 Implementation of an Application with jCOLIBRI

The researcher has represented a real life judicial decision given for child sexual abuses of cases with jCOLIBRI. This application is used for getting similarity of cases and adapting the solution by matching pervious cases. It takes new cases from the user and matched with pervious cases to find the best solution of a problem. The best selected matched case are

retrieved and presented back to the user. If any new case does not have any matched solution then it would be retained.

4.2.1 Classification using jCOLIBRI 1.0

Development of CBR Judicial application with jCOLIBRI has been done using three processes:

1. Managing/Defining the Case structure

2. Managing Connectors and

3. Managing Task/Managing Method

These processes are dependent on each other. For instance connecters depend on case structure of application. Each task or process are classified and configured properly. These classified tasks in judicial application are represented in Fig 4.2:

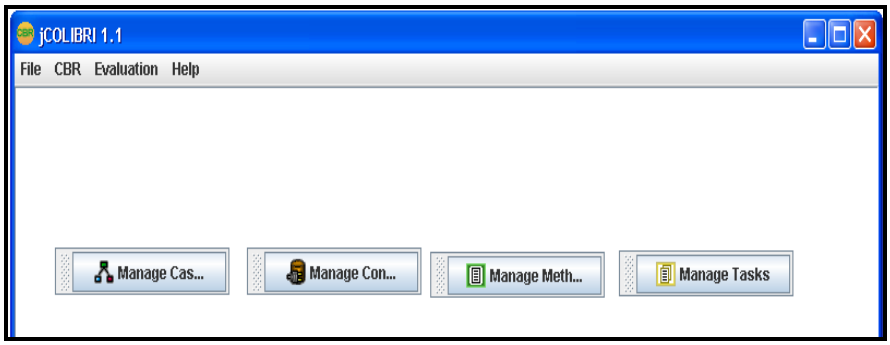


Fig 4.2 Classification Task of jCOLIBRI

4.2.2 Managing/Defining the Case Structure in jCOLIBRI

Defining case structure in jCOLIBRI is done by using case structure window. Attributes are added in description of case structure and set properties of attributes. The tool has generated codes automatically and saved in xml file. Significant attributes are settled by the researcher to assign higher weight. Significant attributes have higher weight as compared to other attributes. In the present research, age_victim, sex_victim, age_offender,Health_statusof_victim/offender are significant attributes with higher weight as compared to other attributes in the case structure.

4.2.2.1 Similarity Types of Case Attributes

As discussed in section 3.3, one case of the judicial application has eleven description attributes and two solution attributes. The detail is presented in Table 4.1 with each along name, data type weight, local similarity (for problem type) and global similarity (for solution part). Solution attribute is used for storing solution used for finding the best selected cases.

The similarity among case attributes of cases is defined using local similarity and global similarity. Local Similarity is used to compare simple attribute values. When there is an exact match between input value and value of case-based, equal local similarities are used. In the experiment attributes such as attributes Sex_of_Victim/Offender and Offenses_Type have equal local similarity. For integers, the similarity is computed based on the interval value like attributes Age_Of_Victim/Offender attributes. The other similarity among case attributes, is global similarity linked with compound attributes used to get similarity of collected attributes, i.e. a solution attributes composed of (Article_Of_Penalty, String) and (Years _Of _Imprisonment, Integer).

Problem part of attributes			
Name	Data Type	Weight	Local Similarity
Age_of_victim	Integer	1.0	Interval
Sex_of_victim	String	1.0	EqualStringingnrecase
Offenses Type	String	0.9	EqualStringingnrecase
Impact_Of_offenses	String	0.7	EqualStringingnrecase
Medical _Report_Remark	String	0.8	EqualStringingnrecase
Disability _Of_Victim	String	0.8	EqualStringingnrecase
Age_of_offeneder	Integer	0.9	Interval
Sex_of_offender	String	0.9	EqualStringingnrecase
Educational_level_Offender	String	0.9	EqualStringingnrecase
Health _Status_Offender	String	0.9	EqualStringingnrecase
Relation_with_victim	String	0.8	EqualStringingnrecase
Accused_before	String	1.0	EqualStringingnrecase
Solution attributes			**Global Similarity**
Article_of_penalty	String	1.0	EqualStringingnrecase
Years _of _ Imprisonment	Integer	1.0	Interval

Table: 4.1 Description of case attributes

As shown in Table 4.1, in a problem part of attributes such as Age_of_the_victim, sex_of_the_victim and accused_before and in solution attributes such as Article_of_the_penalty and Years_of_imprison have highest weight value 1.0. Impact of offenses attribute has less weight of 0.7. Other attributes have 0.8 to 0.9 weights. Here the weight of the attributes shows that how much each individual attributes has been accredited in giving judgment.

4.2.2.2 Case Similarity, Matching and Ranking

Selecting the best similar case(s) is usually performed in most Case-based reasoning systems by means of some evaluation heuristic functions or distances, which are possibly domain dependent. Accordingly, the similarity between two cases is calculated pair-wise, between pairs of fields. The similarity between a query (Input problem) and a case from the case-based is computed as shown in Fig.4.3. For each attribute, a local similarity measure (the similarity metric) determines the similarity between two attribute values and for each object (the case and the query) based on the local similarities of the belonging attributes. The selected CBR-tool in this research (jCOLIBRI1.0) used Nearest Neighbor Similarity for case matching. To get the nearest neighbors of the input problem as shown in Fig 4.3, the similarity is calculated for each case in the case-based which is ranked by their similarity.

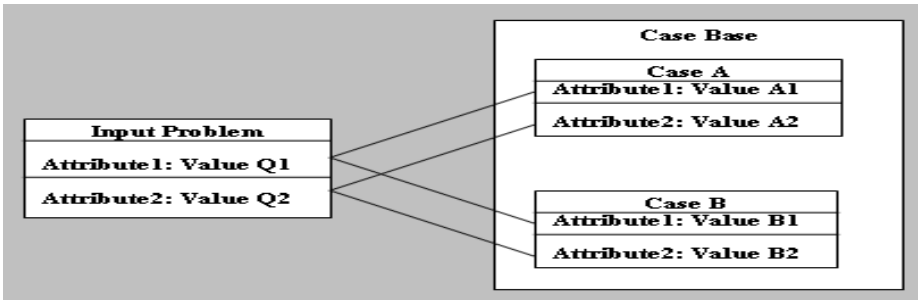


Fig 4.3: Nearest Neighbor Similarity Matching Algorithm

The Nearest Neighbor Similarity Matching algorithm is expressed as [51]:

$$\text{Similarity}(T, S) = \sum_{i=1}^{n} f(Tj, Si) \times Wi$$

Where, T represents target case, *S* =source case, *n* = number of attributes in each case, ***I*** = individual attribute from 1 to n, *f* = similarity function for attributes I in cases T and S and ***w***= importance weighting of attribute. The similarity of a case from the case-base (source case) and the problem case (Target case), is calculated by adding up all weighted attribute similarities.

It can be noticed that, the research presented in this paper is based on the assumption that a classical decomposition of CBR relies on the steps of retrieval and adaptation.

To create the case structure the researcher used the graphical tools, provided by jCOLIBRI (Fig .4.4). The left panel displays the structure of the cases as a tree, and the right panel shows the property values of the selected attribute. Once, the case structure is defined it is stored in XML File.

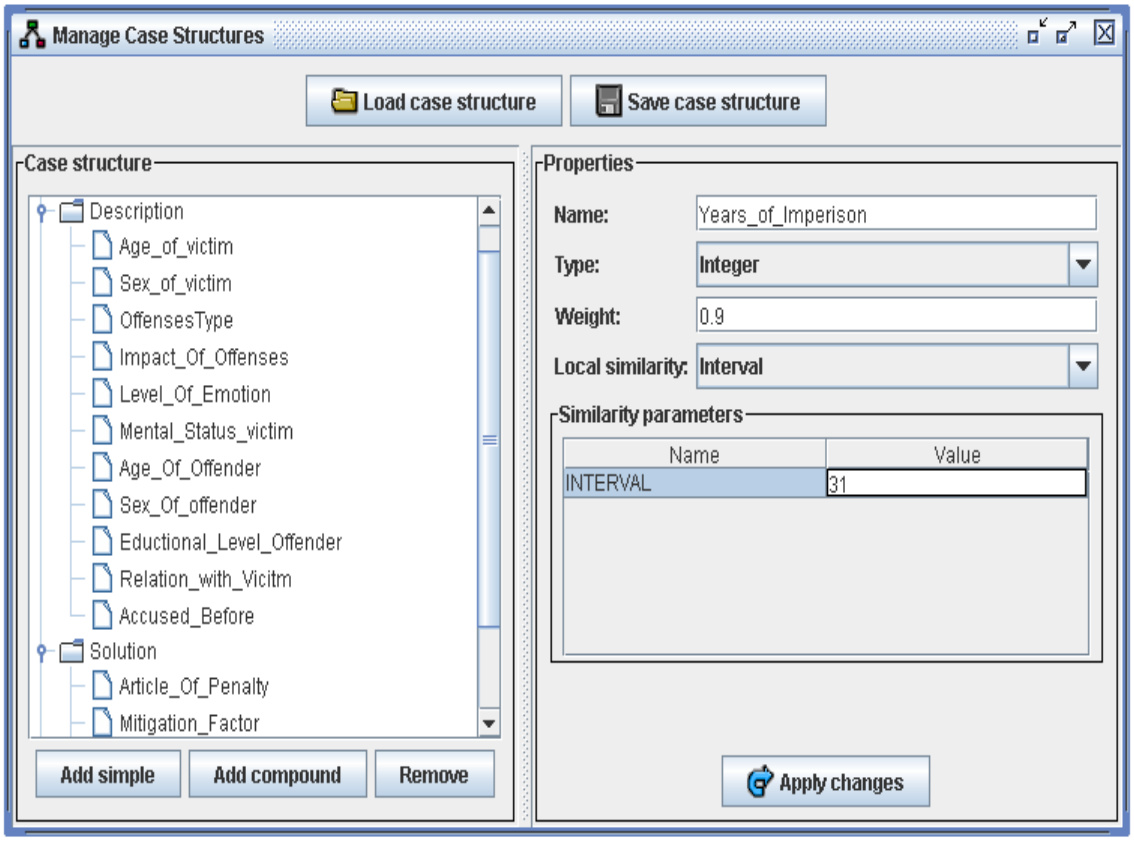


Fig 4.4 Defining the Case Structure

4.2.3 Managing Connectors

For this application, the researcher has configured a Plaintext Connector to work with cases stored in JudicalApplication Plaintext Case-Base. The graphical interface (Fig 4.5) helps mapping the case structure with the columns from the Plaintext file (Appendix D), storing the JudicalApplication Case-based. Like the case structure the connector configuration is saved in a XML file, generated by jCOLIBRI tools. Case-based (Plaintext File) is a section, which contains the descriptions of the previously decided cases on child sexual crimes, is given in Appendix D.

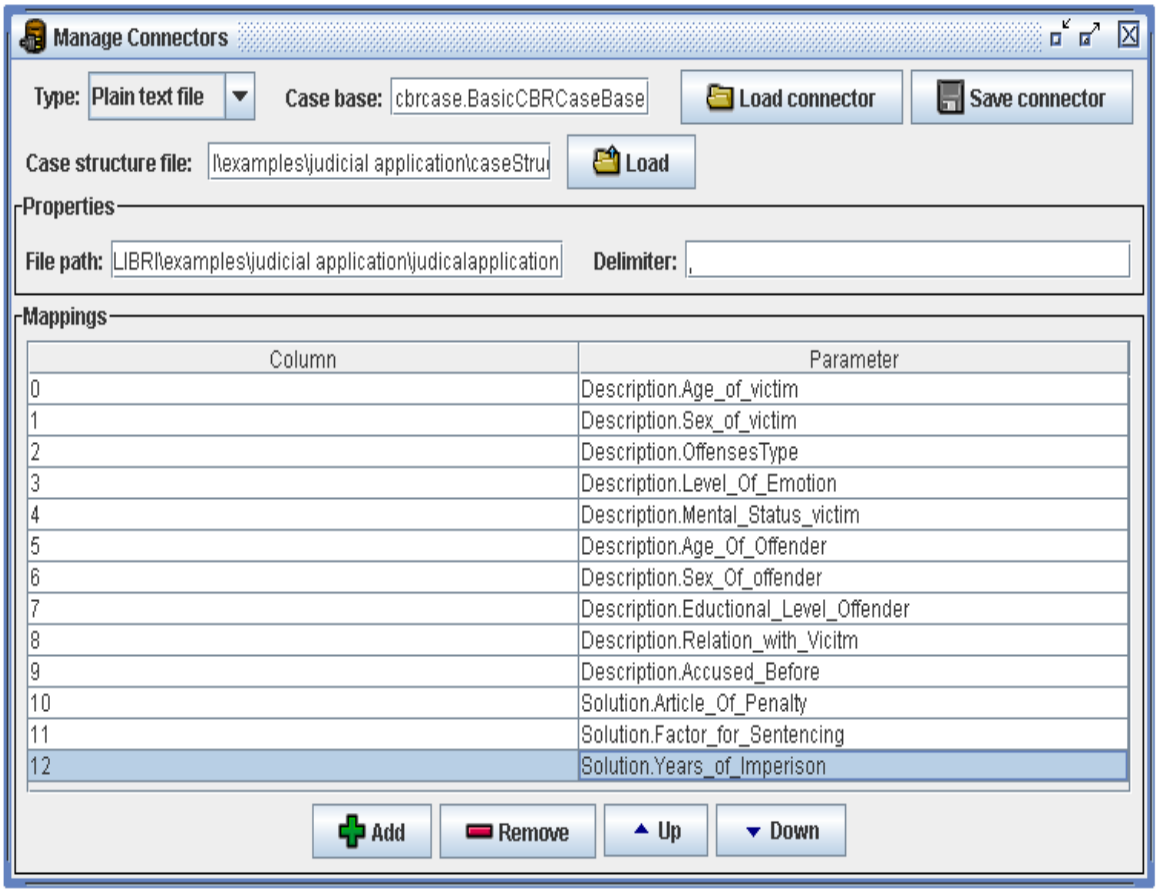


Fig 4.5 Judicial Application for Child sexual crimes Case-based

4.2.4 Managing Task/ Methods

After defining the case structure and configuring the connectors to store the Case-based of the application, it is needed to select the tasks and methods of the application.

Since the Judicial Application aims in adaptation process, the researcher associated a method of retrieving the most similar cases, with reusing method, leaving other tasks(revising or retaining) unsolved using the user interface depicted in Fig.4.6.

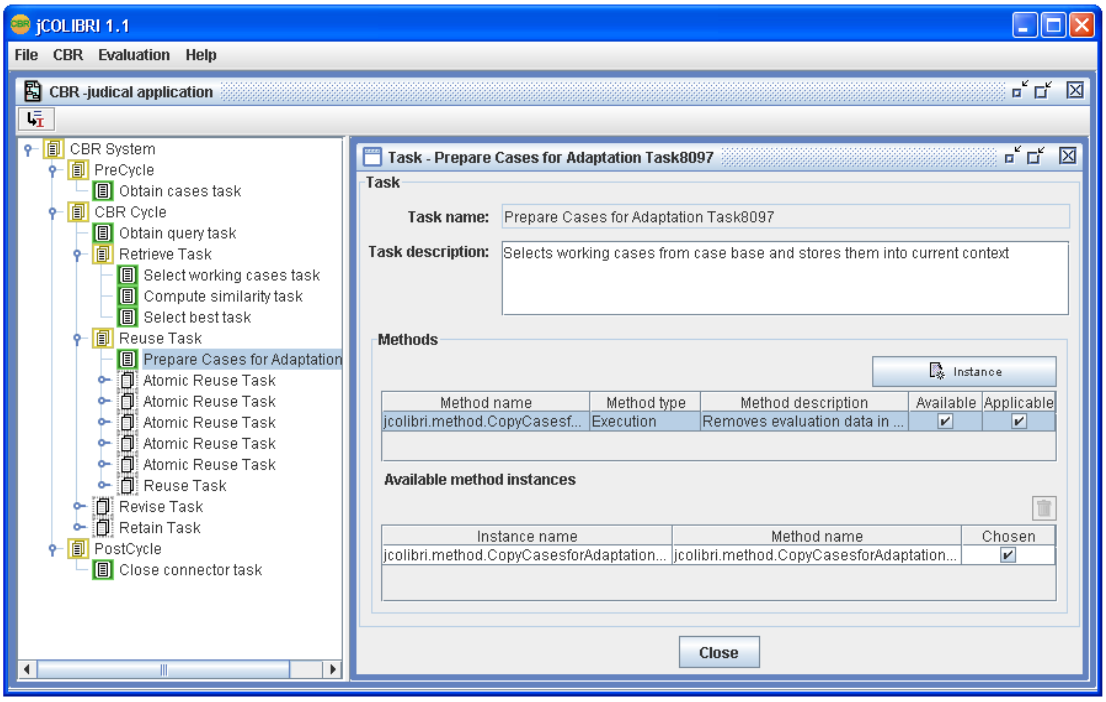


Fig 4.6 Managing Tasks/method

Adaptation scheme

In this section, the researcher proposed an adaptation scheme based on substitutions on the adaptation rule syntax method that are described in chapter two in section 2.4.3.1.To implement this functionality in an extensible way, it has been defined an adaptation language. This language allows creating rules for adapting solutions and storing them in textual files that would be loaded and interpreted by generic adaptation method in JCOLIBRI1.0. In Fig.4.7, the judicial adaptation rule has been used to recommend years of imprison to query given from the users. The query contains information about the behavior of the child victim and offenders, with types of the offenses and the case-based contains several cases with its solution. The concept referenced by the solution is the “FinalDecison” which is composed by: “Article of the crime” and “Specific Years Of imprison”. Each of this part contains a property that corresponds to each individual offenses type. In the scenario where a user with offenses type

“Rape”, the system returns a solution that contains the criminal code of Article with specific Years of Imprisons. The following rule would adapt the retrieved solution changing the inappropriate solution.

```
IDONTO:=
/FinalDecsion/hasFinalPenaltyInduicemnet/YearsOfImperison*
IDPROPERTY:=(FinalPenaltyInduicement/YearsOfImperison)*
IDCASE:= "CASE."(attribute[Rape])*
RULE:=IDONTO,@CONDTION,@ADAPTATION
CONDTION:=(IDPROPERTY(=|!= IDCASE)
||(IDCASE(=||!=)String))||[Not](IDPROPERTY InstanceOfConcept)
ADAPTATION: =SUBSTITUTION | MODIFY [FOLLOWDEPENDENCIES
Relation]
SUBSTITUTION: =”SUBSTITUTE” [# CONDITION]
MODIFY: =DIRECT MODIFICATION | ANYOTHERINSTACEMODIFICATION
DIRECTMODFICATION: =”DIRECT”: IDPROPERTY: INSTANCE
ANYOTHERINSTANCEMODIFICATION: = “ANYOTHERINSTANCEOF”:
IDPROPERTY: CONCEPT [# CONDTION#]
```

Fig 4.7 Judicial Adaptation Rule syntax1

Having configured the CBR application, the first task is obtain query task, which obtains the query that is going to be used to retrieve the most similar cases (Fig.4.8).

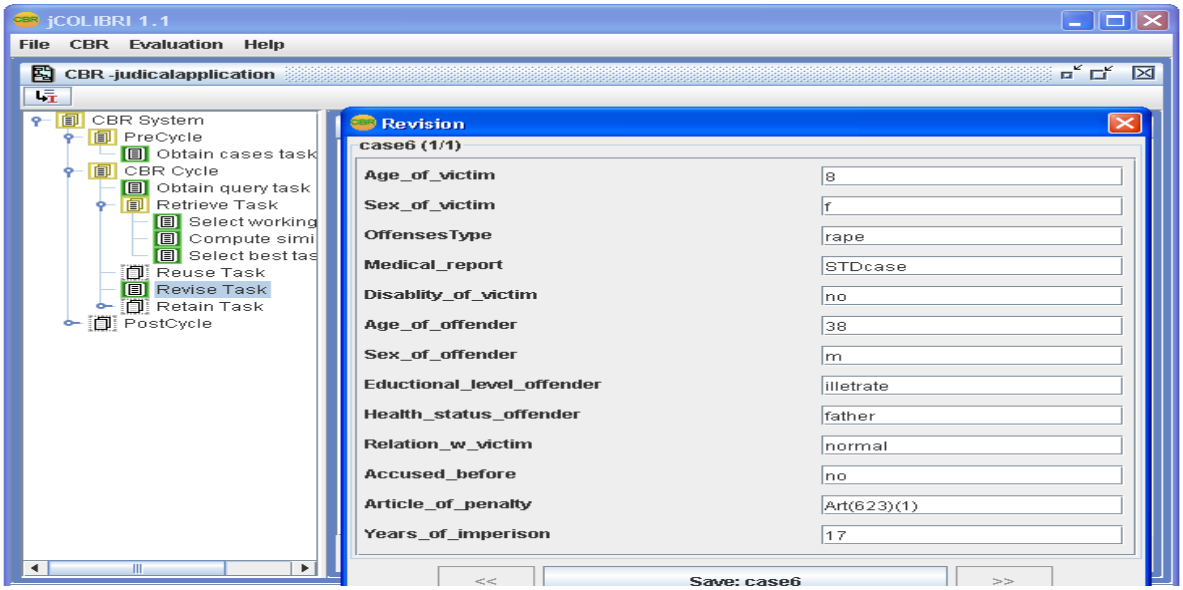


Fig 4.8 Query Form for Judicial application

4.3 Testing and Evaluation

4.3.1 Testing the prototype

In order to test the performance of the system separate cases on which judges already pronounced a decision are presented to the prototype by the researcher. A description of one of the case is as follows.

The story gathered from the public Prosecutor's charge shows that Mr.X (the name kept anonymous for privacy reasons) with age of 8 years old victim on the specified date in the premises of Nazareth school raped her without having a control to protect the attack. Witnesses on the defendant's side contended upon the hearing of the case that it is true that the accused and the victim have relation of a teacher and a student. The medical certificate from the hospital confirmed that with a result in HIV case. From the police commission attached about the offender side with 39 years old with normal health condition having advanced in Mathematics and has no charge in any crime before.

From the above case description the following facts are extracted manually and fed as the judicial application Query.

- The victim with age of 8, and gender female.
- Evidence of rape act was presented with HIV case from medical report.
- The relation of the victim with the defender is that of a teacher and a student.
- The offender with age 39, normal health condition, and grouped under literate.

Based on the above fact the judicial application decided that the defender is a guilty of raped under the Article (623) (1) of revised criminal code of Ethiopia. The case is fed to jCOLIBRI1.0 as described in Fig 4.8.

The value of age of victim was 8 (less than 13)

The value of sex of victim Female

The value of the offenses type Rape

The value of the medical report evidence of rape act with HIV positive case

The value of the disability of the victim no disability problem

The value of age of the offender with 39 years of old

The value of sex of the offender male

The value of educational status of the offender literate

The value of health status of the offender normal condition

The value of whether accused before no

Fig 4.9 Input values of the requested parameters in jCOLIBRI1.0

The judicial application designed in jCOLIBRI1.0 has used to insert the above requested parameters using the obtain query task form. The result of the requested parameters is presented in the appendix E.

The application selects from the working cases tasks and computes the similarity task and selects the best task and prepares the given solution for reusing for future use. The system displays its result giving the type of Article issued i.e. Article 623 (1) and suggest a penalty of 17 years in imprison.

4.3.1.1 Case Similarity Test

The purpose of this test case is to test the system in selecting the appropriate cases from the case-based. Each new case should be presented to the system individually, and the set of selected cases should be evaluated against the expected selection. For testing purpose, the researcher has taken three experimental groups with 10 individual cases. The first group, representing the same cases with previous case-based and the other groups representing a modification in one or more of the cases so as to observe the effect on system performance. Table 4.2 shows how the similarity measures behaved for the given set of problems.

Case Id	Description	Problem
CaseId 1	With offenses type "Rape" + "Age of child =3 "+ "medical Report= HIV case" + "Accused before=No"	QID5,QID6,QID9
CaseId 2	With offenses type "Rape" + "Age of child =14 "+ "medical Report= STD case" + "Accused before=No"	QID3,QID5,QID9
CaseId3	With offenses type "Rape" + "Age of child =5 "+ "medical Report= Bleeding" + "Accused before=No"	QID6,QID3,QID9
CaseId4	With offenses type "sexual act" + "Age of child =15 "+ "medical Report= "Pregnancy " + "Accused before=No"	QID8,QID10

Table 4.2 Test Case Similarity Evaluation

Problem 1: *The person (requester) wants to know the judgment with a case offenses type rape, age of the child 3 years old with medical report HIV case, and the offender didn't participated in any crime before.*

Answered Queries	Cases	Similarity [0,1]
QID5	CaseId1	1.0
QID6	CaseId3	0.875
QID8	CaseId4	0.8

Table 4.3 Test case similarity 1

As shown in Table 4.3 the nearest neighbor similarity algorithm correctly identifies CaseID1, which matched perfectly with the requester's query. CaseId3 is less accurate than CaseId1 since its problem definition contains QId3 as well and this is not part of the requester's query.

Problem 2: *The person (requester) wants to know the decision on a crime case done by three people on sexual act on a child age of 5, with a medical report death, and the offenders were participated in other crimes before.*

Answered Queries	Cases	Similarity [0,1]
QID4	NULL	NULL

Table 4.4 Test case similarity2

Table 4.4 presents the retriever does not find any suitable cases or any other questions to present to the requester for the next cycle. This is because most of the answered questions, though present in the Judicial Application they are not present in any of the cases.

Discussion on similarity Test

From the test case similarity measure, one can understand that when the new case has attribute values the same as those stored cases in case-based, the retrieved case exactly match with the current case with similarity 1.0. Otherwise, the result of the similarity matching degrades to 0.875 or 0.8 depending on the input values of the new case. One of the challenges that the researcher has faced in this process is missing attributes in the case structure that has a significant factor on decision making for examples number of offender in a given crime and make the victim unconscious with alcohol. The other constraint in this system is that, limited organization of cases in the case-based. Better result will be achieved if more cases are represented in the case-based.

4.3.1.2 Test Case Adaptation

The purpose of this test case is to test the system's ability to adapt cases from its case-based. Assuming the system performed as expected in the previous test case, the outcome of adaptation as presented in the Appendix F.

From appendix F the test case adaptation, no adaptation process has made on remarks of successfully match (with similarity computation 1.0) and fewer matches (with similarity computation values less than 0.2). In contrast, the system successfully adopts the given requested query to the case-based for future use with values of similarity computation in between 1.0 and 0.2.

The reliability of the adaptation process depends on two major factors. One is a dissimilarity of the values of attributes. As the dissimilarity between the *src* (source) and *tgt* (target) is smaller the adaptation of cases is performed successful. Where as, the dissimilarity values

increases per attributes it may or may not to adapt a *tgt* (target) case with the *src* (source) case. As new *tgt* value case completely dissimilar with the existing case-based (as the similarity computation values approaches to zero), no adaptation process can be handled. The other factor that affects the adaptation process is the adaptation rule embedded in the system. If there are limited on no rules exist in the system the adaptation process would degrades its performance.

4.3.2 Evaluating the performance of the system

The purpose of an evaluation process is to assess the performance of the system, with reference to some selected baseline, and identify a problem area that needs further improvements. In this study, two evaluation methods are used. First, the performance of the prototype system is evaluated in proposing optimal solution to the case at hand. In another scenario, the retrieval performance of the system's is evaluated using the statistical analysis (precision and Recall).

In order to evaluate the performance of the system, the domain experts working in child justice from Federal First Instance Court Lideta sub section (participated during knowledge acquisition) and new domain experts(not participated in the system) from Federal Supreme Court has been selected with four members in each individual group.

4.3.2.1 Evaluation by Domain Expert

For evaluation purpose ten distinct queries are given as requested queries for the system. The ranked search results with its final argument of solution are given for the respective domain experts. The domain experts then evaluate the performance of the system from the point of its

relevance in generating the appropriate solution, the significance of the attributes used for defining the case text and the ease of use of the system. The domain experts assigned values (excellent, very good, good, fair and poor). Table 4.6 shows summary of the evaluation result of domain experts.

Parameters	Domain Expert I					Domain Expert II				
	poor	Fair	Good	Very good	Excellent	poor	Fair	Good	Very good	Excellent
Does the method account for more situations					√				√	
Is the method more efficient in time or space?					√					√
Does the method model human behavior in a more useful way/detail?				√				√		
Ease of use (to enter the requested query, to access the description of the retrieved case from case base with its solution, to adapt the new case in case base,)					√				√	
Weight of Attributes used for defining the case text				√				√		
Fitness of the final solution to the case at hand				√				√		

Table 4.5 Evaluation of the system by domain expert

From Table 4.5, those of domain experts participating in knowledge acquisition (Domain Experts I) has a better understanding on attributes used for expressing the legal texts and the fitness of the final solution given from the system than the domain experts (Domain Experts II) that have used the system for the first time. This is because the selected CBR tool does not support the explanation facility for the experts to communicate with the system when they need explanation on 'how' and 'why'. But, both of the domain experts have assigned more than the average value for all parameters, which shows that an encouraging result is obtained in this research.

4.3.2.2 Evaluation using the Statistical Analysis

In order to perform statistical analysis of the results, the recall and precision has been calculated in order to quantify the performance of the CBR system. Recall measures the proportion of the number of relevant cases identified from the case-based (i.e. percentage of cases which are identified as correct judgment) and precision measures the proportion of the retrieved cases that are actually relevant for the case at hand.

$$recall = \frac{Number\ of\ relevant\ cases\ retrieved}{Total\ number\ of\ relevant\ cases}$$

$$precision = \frac{Number\ of\ relevant\ cases\ retrieved}{Total\ number\ of\ cases\ retrieved}$$

Both the domain expert (I and II) selected for evaluating the user satisfaction, are participated in labeling the relevant cases for each of the three new queries from the case-based that are used in the system. Summary of the relevance judgment is depicted in Fig.4.10.

Query one
Relevant documents: CaseId3, CaseId7, CaseId11, CaseId15
Query Two
Relevant documents: CaseId1, CaseId5, CaseId8, CaseId9 CaseId18, CaseId20, CaseId21
Query 3
Relevant documents: CaseId3, CaseId5, CaseId14, CaseId15 CaseId16, CaseId22. CaseId9. CaseId10

Fig 4.10 Relevance judgments given by domain expert

Based on the above relevance judgments provided by the domain expert, the system is evaluated using single value summaries (Recall-Precision average). The result is shown in Table 4.6.

Query	Performance Measure		Similarity Rank Threshold
	Precision	Recall	At 0.1 decrements
Query one	87.5%	41.01%	Similarity [1,0.8)
	62.5%	55.50%	Similarity [0.8,0.5)
	46.1%	71.2%	Similarity [0.5, 0]

Table 4.6 Recall /precision result of queries

When more than 0.8 similarity threshold value is used, the result of precision is becoming 87.5% with 41.01% of recall. As the similarity rank threshold is reduced to in between 0.8 and 0.5, the result of average precision is 62.5% with 55.50% of average recall. At less than 0.67 similarity threshold value 46.1% and 71.2% precision and recall is registered, respectively. This evaluation shows that as the threshold value increase the precision increase though the recall result decreases and vice versa. Since in CBR system; the main objective is retrieving the most similar cases, highest precision is obtained at similarity value greater than 0.8 and hence this similarity threshold value is selected for further experiment.

Query	Precision	Recall
Query Two	85.75 %	41.65%
Query Three	75%	40%

Table 4.7 Performance of the system

The performance of the system is decreased because of high variability in the cases presented by different victims. So the system is attempting to find the best match for the given problem.

The use of nearest neighbor retrieval system influences the accuracy since it gives more score for those exactly matching and tremendously reduces the score by assigning high penalty as the two words vary in their similarity.

Discussion on Evaluation Result

Evaluation of the CBR system is held from two dimensions. The first dimension is from the user satisfaction side in which the system is evaluated whether it helps the user to understand the system better. Accordingly efforts are exerted to include important attributes that are needed by new domain expert in the decision making process, for example, the number of offender participated in crime and to use other mechanisms to make the child unconscious. The other side investigates the effects of different similarity threshold value and weight on the performance of the system. Thus, the system has a better performance when the similarity rank thresholds assigned values greater than 0.8. In addition, the flexibility of CBR system shows that it has assigns important attributes to have high weight of similarity that helps to retrieve relevant cases form the case-based.

CHAPTER FIVE

Conclusion and Recommendations

5.1 Conclusion

Research in case-based legal reasoning has led to significant advances in modeling the way lawyers use previously decided cases. Case-based reasoning has blown a fresh wind and a well justified degree of optimism into AI in general and Knowledge-based decision support systems in particular. The growing amount of ongoing CBR research within an AI community that has learned from its previous experiences has the potential of leading to significant breakthroughs of AI methods and applications.

The major and most important contribution of this research is, an application of case-based reasoning in the field of child sexual abuse cases for the development of a new CBR system that can provide advice for consistent decision making by judges and lawyers.

To this end, domain knowledge has been acquired using interview, observation and document analysis regarding decided crime case of child and the substantive law of the child in real life. During the knowledge acquisition process both the tacit and explicit knowledge are collected and a case structure has been constructed. A set of significant relevant attributes are selected with the help of domain experts from previous child sexual abuse cases that have a direct impact on decision making.

In this research a case-base has been built which comprised of forty (40) cases. It has been defined a retrieval method to construct CBR system. jCOLIBRI1.0 has been used for devising

the retrieval method using nearest neighbor and reuse the retrieved cases to adopt a new problem of a case using the adaptation rule syntax developed by developer. The selected tool has been employed as a user-defined, explicit parameter to carry out particular retrieval requests and the most appropriate case has been chosen with its solution (final inducement years of imprisonment).

Performance analyses using the numeric similarity comparison method show that the similarity function value has been 1.0 when all values of requested parameters of attributes are the same with the stored case-based. The similarity of computation decreases as the values of attributes varies from the stored case-based. The test case adaptation after retrieving the requested parameters has also been verified. The legal case-based reasoning developed in this thesis should be evaluated for performance issues arising from giving appropriate solution for a requested query. The knowledge integrated in the system and performance of relevant solution has been evaluated.

To effectively evaluate the performance of system, user satisfaction, precision and recall have been used. The result of these tests has been considered satisfactory with value of 82.75% of precision. But, this is a need to test such systems on a large set of cases which requires building a large case corpus.

Through the tests that have been shown the design of the case-base, the retrieval process and the adaptation method affects the performance of the system to some extent, and this also further depend on the similarity measure function. After considering the attained results, the following conclusions are drawn.

- For the reason that, the knowledge needed for the legal precedent domain is extremely incomplete and context dependent, it is difficult to formalize general rules to help lawyers solve problems. In contrast, by using CBR techniques, a set of legal precedents can be stored in a case library to guide the lawyer during argument writing.
- The prototype system developed as part of this work can be used as a base for future works of CBR systems, which can be expanded to other knowledge domains by adding domain knowledge.
- As the system helps in the retrieval and adaptation of previously stored legal decisions, legal professionals can gather elements to guide their actions; judges can make consistent rulings, and lawyers can seek arguments that favor their case.

5.2 Recommendations

In general, the functionality that has been offered by the legal case-based reasoning developed in this study allows to: suggest a decision to solve the problem described in query task; check the suitability of a solution by adapting cases from previously stored cases. However, there are issues that need further investigation and the researcher recommends them as future research directions.

- Case-based reasoning requires preparing the case structure and storing the case in the case-base. In this research, texts are converted into cases and analyzed manually with a guide by domain expert. A possible future work in this area would apply natural language processing (NLP) techniques to automatically convert legal texts into legal cases suitable for CBR knowledge-based system.

- The potential benefits of attribute selection may include: enhancement of CBR performance, facilitation in data visualization and data understanding; reduction in storage requirements and improvement of prediction performance. A further research is needed to include machine learning algorithms such as decision tree that can help in the selection of optimal attributes.
- The retrieval algorithm that retrieves the most similar cases in this research is nearest neighbor retrieval system. This algorithm influences the accuracy and retards speed of retrieval as number of cases increase in the case-based. In future, there is a need to consider inductive retrieval system that generates a decision tree type structure to organize the cases in memory.
- In the design of a legal Knowledge-based system, there is always the issue of explanation facility that explains its reasoning to the user. Thus additional finding should be made to have the explanation facility with the case-based reasoning system
- Promising new direction for research include hybrid case-based reasoning that employ two or more representations (such as rule based and case-based) of expertise to emulate reasoning in some domain. Typically, the existing case-based reasoning is highly complementary if other types of reasoning models (neural network, fuzzy logic, model based reasoning) are compensated.
- Most of the existing legal and other domains are suitable for applying case-based reasoning to come up with an optimal solution. It is therefore necessary to extend the use of CBR in other domains.

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APPENDIXES

Appendix A: Interview

1. What are the important factors that judges take into account when making a sentencing decision on an offender already convicted child sexual abuse?
2. How much useful be experienced in sentencing a pervious decision cases which is similar to the current new court case situations?
3. Do you try to use judgments through retrieving the past decided cases that will help for current new court case for judgments?
4. What are the most frequently situation on sexual abuse and violence case on children?

Appendix B: jcolibri 1.0

jCOLIBRI1 is a Java framework that helps designing Case Based Reasoning systems. It provides graphical tools to facilitate the CBR systems design. In fig A.1, shows the main window of jCOLIBRI with upper toolbar which shows 3 menu lists; file, CBR and Help. New application can be develop step by step through this GUI.

Fig B.1 The main window of the jCOLIBRI

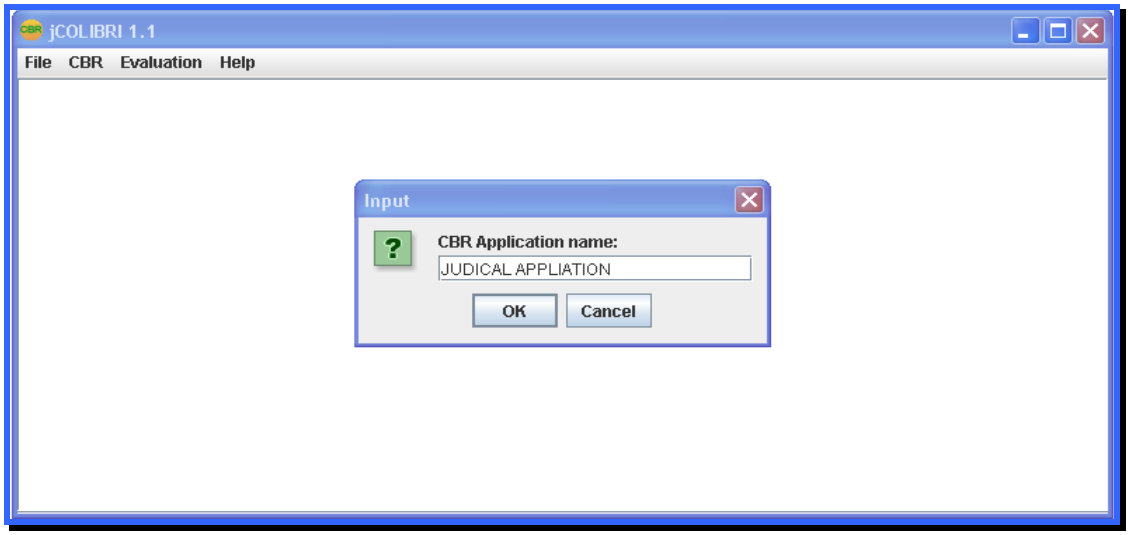

Fig B.2 Window for Creating a new application

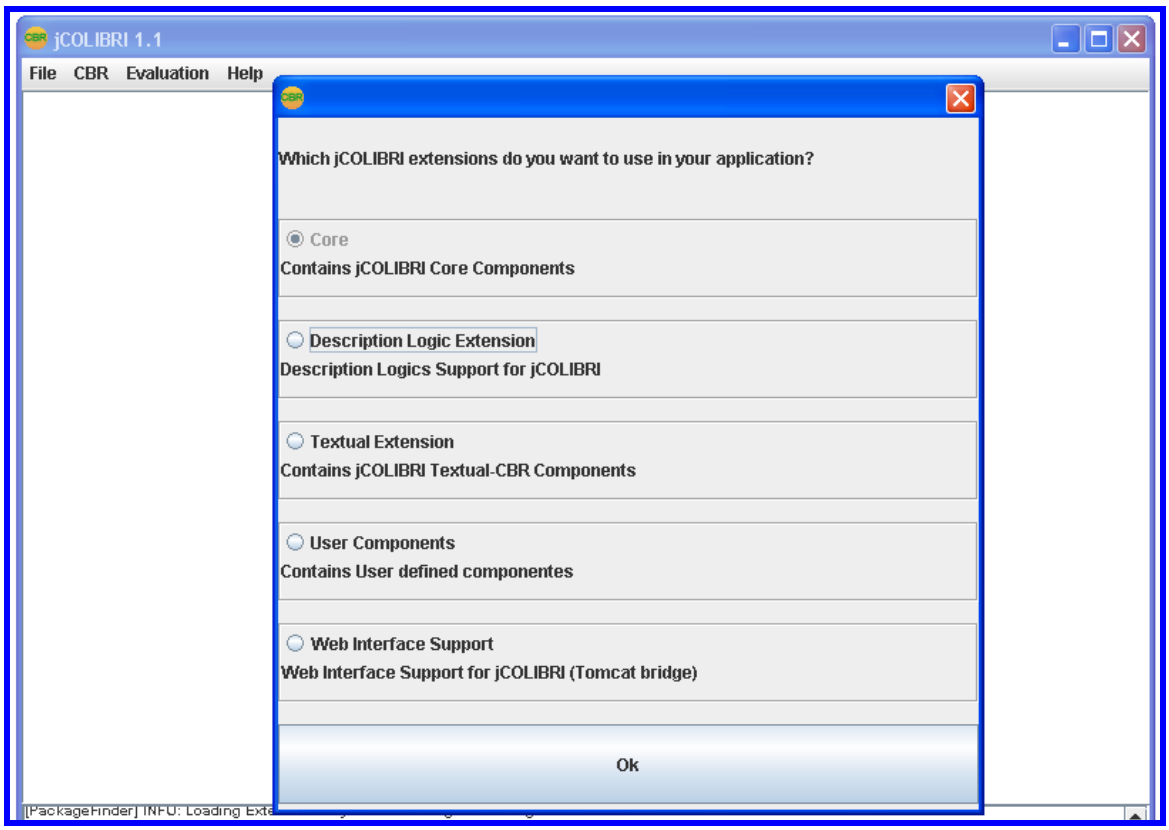

Fig B.3 Window for logic extension supported in jCOLIBRI

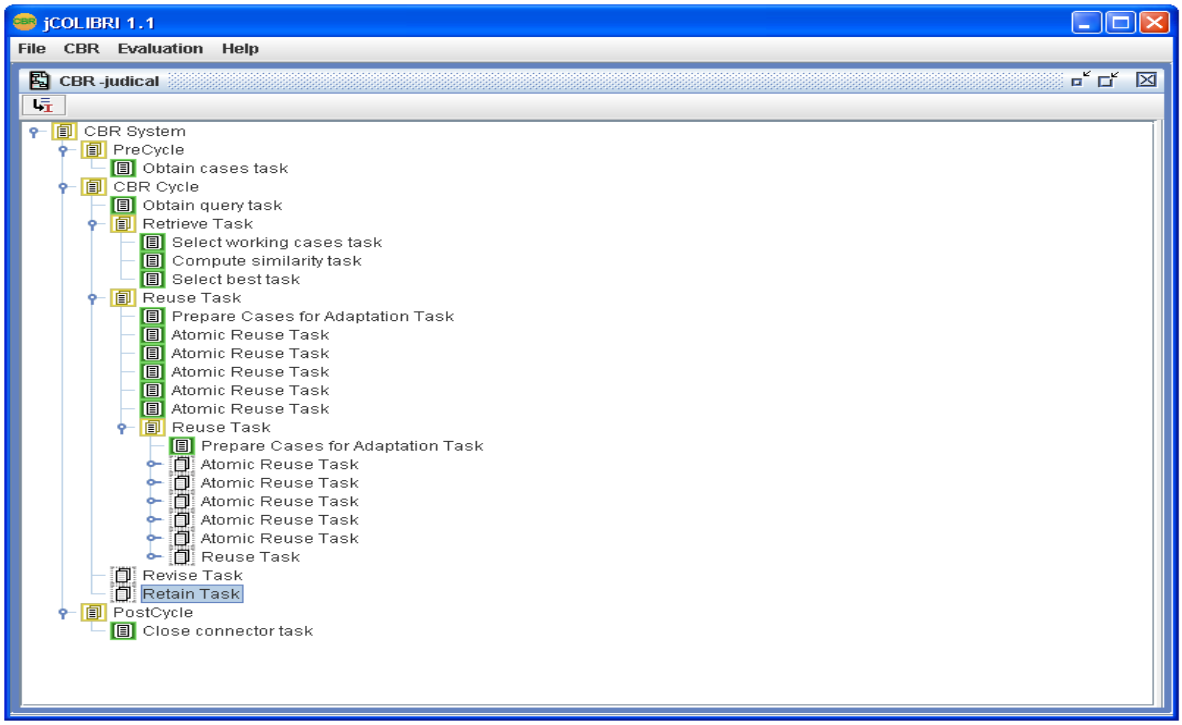

Fig B.4 The four cycle of CBR

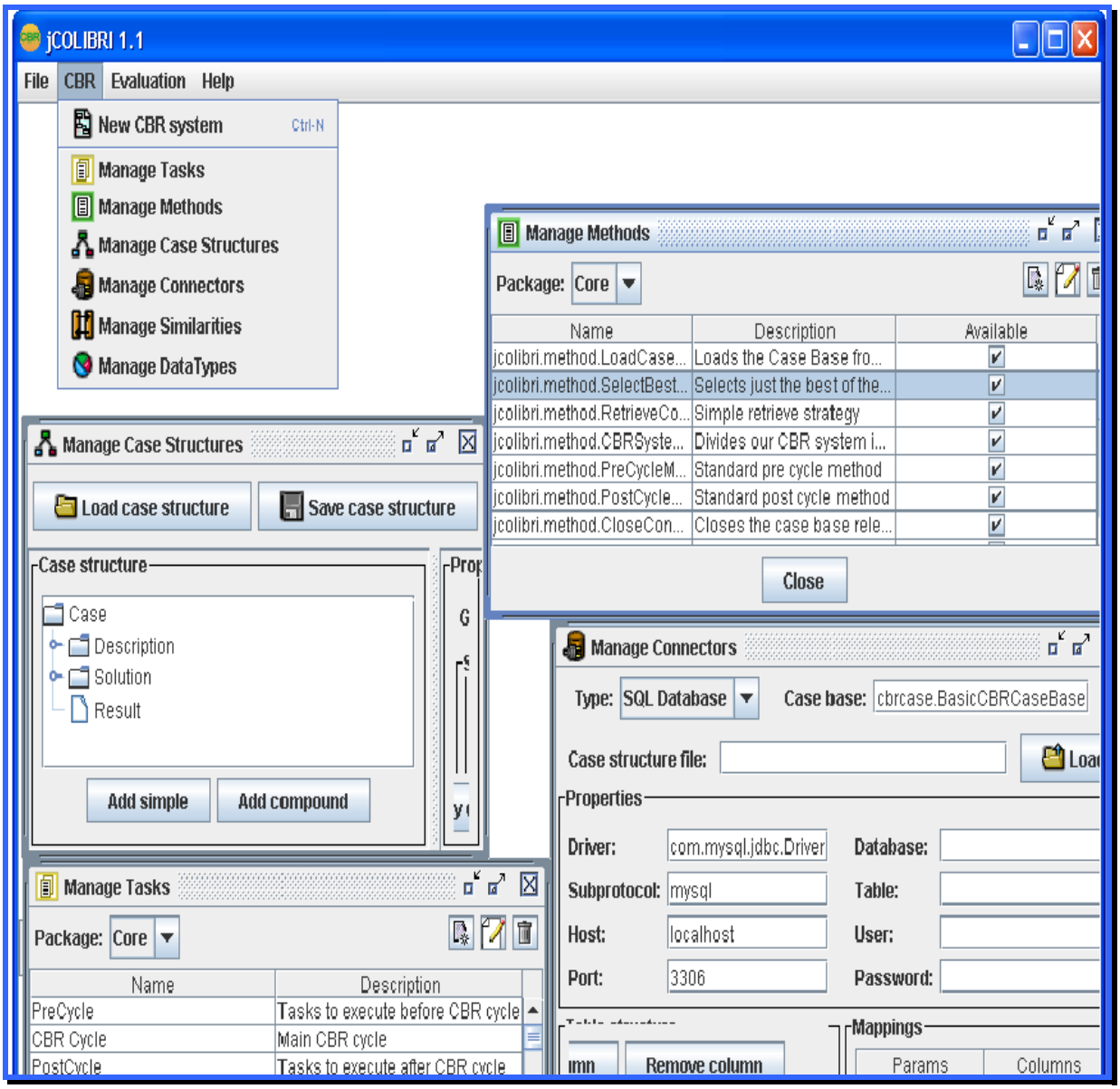

Fig B.4 Task / Method configuration panel

Appendix C: Definition Of The Selected Attributes Used

Attributes Used	Definition of Terms
Profile of Victim	
Age_Of_Victim	Identify age of victim
Sex_of_victim	Identifies the sex of the victim
OffensesType	Defines a type of committed offenses
Medical_result	Defines medical result of the victim
Disability_of_victim	Identifies whether the victim is disable or not
Profile of Offender	
Age_of_offender	Identifies information about age situation of offender
Sex_of_offender	Identifies sex of the offender
Educational_level_offender	Identifies the educational level of offender
Health_status_offender	identifies whether the accused mentally ill or not
Relation_w_victim	Defines the type of relationship between the offender and the victim(family member, schoolmate, staff in school, etc)
Accused before	Identifies whether the accused had been earlier convicted in guilty of crime or not
Final decision levied by the Judges	
Article_of_penalty	The Penal code of the crime
Years_of_impersion	Identifies years of imprison from the case base

Table C.1 definitions of the Selected Attributes

Appendix D: A Plaintext Case Base

This appendix contains the working **Case Base.** A Case Base (Plain Text File), which contains the descriptions of eleven attribute value, is given in Fig D.1.

```
#JudicialApplication PlainText CaseBase
#columnsare:caseId,Age_of_victim,Sex_of_victim,OffensesType,Medical_result,disablity_of_victim,A
ge_of_offender,Sex_of_offender,Educational_level_offender,health_status_offender,Relation_w_vict
im,Accused_before,Article_of_penalty,Years_of_impersion
case1,13,m,homosexuality,no,no,40,m,illietrate,normal,neighbors,no,Art(633)(2)(c),2
case2,3,f,sexualact,no,no,16,m,literate,neighbor,abnormal,no,Art(634),3
case3,7,f,rape,HIVcase,no,25,m,illetrate,stepfather,normal,no,Art(623),18
case4,5,f,rape,bleeding,no,23,m,literate,neighbors,normal,no,Art(623),14
case5,12,f,sexualact,no,yes,44,m,illetrate,stepfather,normal,no,Art(630)(1),13
case6,8,f,rape,STDcase,no,38,m,illetrate,father,normal,no,Art(623)(1),17
case7,16,f,rape,pergancy,no,40,m,literate,houseguard,normal,no,Art(623)(1),10
case8,7,f,sexualact,nopro,yes,19,m,literate,brother,normal,yes,Art(630)(1),17
case9,1,f,sexualact,death,yes,24,m,illeterate,neighbor,normal,no,Art(630)(1),25
case10,10,f,sexualact,nopro,yes,24,m,illeterate,stepfather,normal,no,Art(630)(1),14
case11,15,f,rape,bleeding,no,23,m,literate,neighbors,normal,no,Art(623),9
case12,7,f,rape,bleeding,no,16,m,literate,neighbors,normal,no,Art(623),3
case13,5,f,rape,bleeding,no,23,m,literate,neighbors,normal,no,Art(623),14
case14,13,f,rape,bleeding,no,33,m,ilterate,neighbors,normal,no,Art(623),7
case15,7,m,homosexuality,no,no,17,m,illietrate,normal,neighbors,no,Art(633)(2)(c),1
case16,7,m,homosexuality,no,no,40,m,illietrate,normal,guard,no,Art(633)(2)(c),2
case17,9,f,rape,STDcase,no,46,m,illetrate,father,normal,no,Art(623)(1),14
case18,13,f,rape,STDcase,abnormal,48,m,illetrate,stepfather,normal,no,Art(623)(1),16
case19,7,M,Sexualact,Noprob,No,26,F,lliterate,Neighbors,abnormal,no,Art(630)(1),1
case20,10,f,rape,bleeding,no,43,m,literate,neighbors,normal,no,Art(623),9
case21,15,f,rape,bleeding,no,23,m,literate,neighbors,normal,no,Art(623),9
case22,5,f,rape,STDcase,no,23,m,literate,neighbors,normal,no,Art(623),15
```

Fig D.4 A Plaintext case base used in judicial application

Appendix E: The case base of the jCOLIBRI1.0 with their solution

```
WORKING CASES:
case1
has-Result: Result
has-Solution: Solution
has-Solution.Years_of_imperison: 2
has-Solution.Article_of_penalty: Art(633)(2)(c)
has-Description: Description
has-Description.Eductional_level_offender: illietrate
has-Description.OffensesType: homosexuality
has-Description.Relation_w_victim: neighbors
has-Description.Sex_of_offender: m
has-Description.Age_of_victim: 13
has-Description.Health_status_offender: normal
has-Description.Medical_report: no
has-Description.Age_of_offender: 40
has-Description.Accused_before: no
has-Description.Disablity_of_victim: no
has-Description.Sex_of_victim: m
```

```
case2
has-Result: Result
has-Solution: Solution
has-Solution.Years_of_imperison: 3
has-Solution.Article_of_penalty: Art(634)
has-Description: Description
has-Description.Eductional_level_offender: literate
has-Description.OffensesType: sexualact
has-Description.Relation_w_victim: abnormal
has-Description.Sex_of_offender: m
has-Description.Age_of_victim: 3
has-Description.Health_status_offender: neighbor
has-Description.Medical_report: no
has-Description.Age_of_offender: 16
has-Description.Accused_before: no
has-Description.Disablity_of_victim: no
has-Description.Sex_of_victim: f
```

case3
has-Result: Result
has-Solution: Solution
has-Solution.Years_of_imperison: 18
has-Solution.Article_of_penalty: Art(623)
has-Description: Description
has-Description.Eductional_level_offender: illetrate
has-Description.OffensesType: rape
has-Description.Relation_w_victim: normal
has-Description.Sex_of_offender: m
has-Description.Age_of_victim: 7
has-Description.Health_status_offender: stepfather
has-Description.Medical_report: HIVcase
has-Description.Age_of_offender: 25
has-Description.Accused_before: no
has-Description.Disablity_of_victim: no
has-Description.Sex_of_victim: f

case4
has-Result: Result
has-Solution: Solution
has-Solution.Years_of_imperison: 14
has-Solution.Article_of_penalty: Art(623)
has-Description: Description
has-Description.Eductional_level_offender: literate
has-Description.OffensesType: rape
has-Description.Relation_w_victim: normal
has-Description.Sex_of_offender: m
has-Description.Age_of_victim: 5
has-Description.Health_status_offender: neighbors
has-Description.Medical_report: bleeding
has-Description.Age_of_offender: 23
has-Description.Accused_before: no
has-Description.Disablity_of_victim: no
has-Description.Sex_of_victim: f

case5
has-Result: Result
has-Solution: Solution
has-Solution.Years_of_imperison: 13
has-Solution.Article_of_penalty: Art(630)(1)
has-Description: Description
has-Description.Eductional_level_offender: illetrate
has-Description.OffensesType: sexualact
has-Description.Relation_w_victim: normal
has-Description.Sex_of_offender: m
has-Description.Age_of_victim: 12
has-Description.Health_status_offender: stepfather
has-Description.Medical_report: no
has-Description.Age_of_offender: 44
has-Description.Accused_before: no
has-Description.Disablity_of_victim: yes
has-Description.Sex_of_victim: f

```
case6
has-Result: Result
has-Solution: Solution
has-Solution.Years_of_imperison: 17
has-Solution.Article_of_penalty: Art(623)(1)
has-Description: Description
has-Description.Eductional_level_offender: illetrate
has-Description.OffensesType: rape
has-Description.Relation_w_victim: normal
has-Description.Sex_of_offender: m
has-Description.Age_of_victim: 8
has-Description.Health_status_offender: father
has-Description.Medical_report: STDcase
has-Description.Age_of_offender: 38
has-Description.Accused_before: no
has-Description.Disablity_of_victim: no
has-Description.Sex_of_victim: f
```

```
case7
has-Result: Result
has-Solution: Solution
has-Solution.Years_of_imperison: 10
has-Solution.Article_of_penalty: Art(623)(1)
has-Description: Description
has-Description.Eductional_level_offender: literate
has-Description.OffensesType: rape
has-Description.Relation_w_victim: normal
has-Description.Sex_of_offender: m
has-Description.Age_of_victim: 16
has-Description.Health_status_offender: houseguard
has-Description.Medical_report: pergancy
has-Description.Age_of_offender: 40
has-Description.Accused_before: no
has-Description.Disablity_of_victim: no
has-Description.Sex_of_victim: f
```

Fig E.4 A Plaintext case base used in judicial application