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# DEVELOPING KNOWLEDGE BASED SYSTEM FOR COURT ADVISORY: IN CASES OF AMHARA REGION FAMILY LAW.

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**BAHIR DAR UNIVERSITY**

**BAHIR DAR INSTITUTE OF TECHNOLOGY**

**SCHOOL GRADUATE STUDIES**

**FACULTY OF COMPUTING**

# DEVELOPING KNOWLEDGE BASED SYSTEM FOR COURT ADVISORY: IN CASES OF AMHARA REGION FAMILY LAW.

**MSc. Thesis**

**By:-**

**Selamawit Mihret**

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# DEVELOPING KNOWLEDGE BASED SYSTEM FOR COURT ADVISORY: IN CASES OF AMHARA REGION FAMILY LAW.

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A thesis submitted to the school of Graduate Studies of Bahir Dar,
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of
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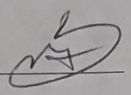
Advisor Name: Gebeyehu Belay (PHD)

Bahir Dar, Ethiopia
July 2022

# DECLARATION

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

Name of the student: Selamawit Mihret Signature 

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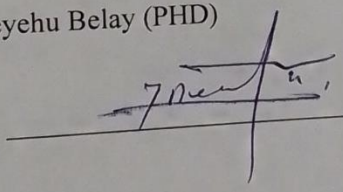
Advisor's Signature: 



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**Approval of thesis for defense result**

I hereby confirm that the changes required by the examiners have been carried out and incorporated in the final thesis.

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As members of the board of examiners, we examined this thesis entitled **DEVELOPING KNOWLEDGE BASED SYSTEM FOR XOURT ADVISORY: IN CASE OF AMHARA REGION FAMILY LAW** by **Selamawit** We hereby certify that the thesis is accepted for fulfilling the requirements for the award of the degree of Masters of science in "Information Technology".

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# DEDICATION

I would like to dedicate my thesis work to my beloved family.

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# Abstract

Modern information and communication technology is revolutionizing how courts function, reducing backlogs by speeding up case resolutions and improving citizen access to trial proceedings and disposition. Ethiopia's system of justice has suffered from long delays that undermined public confidence in the rule of law and imperiled rights granted under the Constitution. Family law, that governs the family related cases, is an area which can potentially benefit much from ICT. To address such problem, this study attempts to design and develop a knowledge-based Decision Support System that can provide advice to judge, lawyers and facilitate the judgment service within family law customers. To this end, knowledge is acquired using both structured and unstructured interviews from domain experts which are selected using purposive sampling technique from ANRS Supreme Court and Bahir Dar zuryia woreda court office. Relevant documents analysis method is also followed to capture explicit knowledge. Then, the acquired knowledge is modeled using decision tree that represent concepts and production rules are used to represent the domain knowledge and knowledge-based system is developed using SWI Prolog editor tool. Thus, the overall total performance of the prototype system is evaluated. The prototype system achieves 85% and it is a good performance and meets the objectives of the study. However, to make the system applicable in the domain area for court decision makings additional study is needed like updating the rules in the knowledge base of the system automatically and incorporating a well designed user interface.



**Keywords:** Knowledge-Based System, Decision Support system, family law, court advisory.

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## List of Abbreviations

**ML**: Machine Learning

**AI**: Artificial Intelligence

**ICT:** Information Communication Technology

**KBS:** knowledge-based system

**DSS:** Decision Support System

**CRR:** Case-based Reasoning

**RBR:** Rule-based Reasoning

**UML:** Unified Modeling Language

**JPL:** java prolog interface

**KBCADSS:** Knowledge Based Court Advisory Decision Support System

**ANRS:** Amhara National Regional State

**NN:** Neural Networks

**DB**: Data Base

**GUI:** Graphical User Interface

**FSCE:** Federal Supreme Court of Ethiopia

**LDSES:** Legal Decision Support Expert System

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# CHAPTER ONE
# INTRODUCTION

## 1.1. Background of the study

The concept of knowledge based systems is derived from the field of artificial intelligence (AI). AI intends understanding of human intelligence and building of computer programs that are capable of simulating or acting one or more of intelligent behaviors [41]

Knowledge based system is a software that uses artificial intelligence or expert system techniques in problem solving processes. It incorporates a store of expert knowledge with couplings and linkages designed to facilitate its retrieval in response to specific queries, or to transfer expertise from one domain of knowledge to another [43]

There are many definitions about knowledge-based systems given in the KBS works. According to O'Hara [15] defined a knowledge-based system as a computer system that attempts to store and organize a great deal of knowledge in a specific domain area to enable users solve problems and make logical inferences.

Contento et al [13] also defined a knowledge-based system as computer programs rich in facts, relations, and procedures and plans to support human decision-making. In these reviews and others describe a knowledge-based system as an interactive computer-based decision making tool that utilizes both factual and heuristic knowledge extracted from domain experts using various techniques for solving problems [23]. KBS is a computer program that reasons and uses a knowledgebase to solve complex problems. The term is broad and refers to many different kinds of systems. The one common theme that unites all knowledge based systems is an attempt to represent knowledge explicitly and a reasoning system that allows it to derive new knowledge.

KBS has come across a variety of approaches based on the knowledge-representation methods and the reasoning strategies applied during implementation. Rule-based reasoning (RBR) and case-based reasoning (CBR) are two popular approaches used in knowledge based systems [12]. Rules usually represent general knowledge, whereas cases encompass knowledge accumulated from specific (specialized) situations [10]. Their integration has shown significant improvement on a system than it would have been achieved from a system with a single reasoning technique. Examples of integrated systems in, [17] [18] [18] [20] testify that the two methods are complement of each other. Rules represent general knowledge of the domain, whereas cases specific knowledge. Rule based systems solve problems from scratch, while case based systems use pre-stored situations to deal with similar new instances. Each method serves to handle limitations of the other. Their integration increases the competence of the application in handling very complex and various problems and providing accurate solution. Therefore, the integration of both approaches is more power full than the single one.

As it is described in [46], law is the set of rules that guides our conduct in society and is enforceable through public agencies. Our relations with one another are governed by many rules of conduct-from important concepts of ethics and fair play to minor etiquette matters such as which fork to use and how to introduce strangers to one another. We obey these rules because we think they are right or simply because we desire the approval of others. Some rules of conduct, however, are considered so important that they are enforced through the government. Traditionally, the most serious breaches of the society's rules are labeled crimes, and people who commit crimes may be arrested, prosecuted, and punished by officials' aid by the government. Crimes are kinds of misconduct considered so harmful that the society employs public officers to try to prevent misconduct and to punish those who engage in it.

In general, law is a system of rules which are enforced through social institutions to govern behavior. Laws can be made by legislatures through legislation (resulting in statutes), the executive through decrees and regulations, or judges through binding precedents (normally in common law jurisdictions). Private individuals can create legally binding contracts, including (in some jurisdictions) arbitration agreements that exclude the normal court process.

The formation of laws themselves may be influenced by a constitution (written or unwritten) and the rights encoded therein. The law shapes politics, economics, and society in various ways and serves as a mediator of relations between people [11].

Family is the basic unit of a society. It has social as well as economic importance in any society. Naturally, persons bound by consanguinity and affinity are united to form the community. ‘With time, the growing family has a tendency to become a tribe.’ Family Law is the branch of law which sets the rules to govern the ongoing responsibilities of family members to each other; both at the time families are formed and after relationships dissolve. The application of the family law begins at the time of formation of family either through marriage or irregular union. Its application extends throughout the life time of the existence of the family relationship as well as at the time of its dissolution.

In general Family law is an area of the law that deals with family-related issues and domestic relations including, but not limited to marriage, civil unions, divorce, spousal abuse, child custody and visitation, property, alimony, and child support awards, as well as child abuse issues, and adoption.

Legal AI systems are categorized in legal retrieval and legal analysis systems. The legal analysis systems can be judgment machines or legal expert systems which are decision support systems. The judgment machines tend to replace judges. However, legal expert systems cannot and should not be used to replace human decision-makers. Any legal expert system, known as legal knowledge based systems (LKBS), must be capable of legal reasoning. Thus, the system must be based upon a model of legal reasoning by describing the norms that operate within the legal system. Legal reasoning, applied earlier in various approaches for decision making purposes, describes how legal expert system takes legal decisions with the help of rules. Accordingly, legal reasoning is considered as a rule-guided activity, where most part of it consists of applying legal rules to interpretations of cases [45].

This kind of reasoning is called rule-based reasoning performed by rule-based expert systems where the reasoning process is based on a set of if-then rule statements [44].A Legal knowledge-based system (LKBS) is a computer system which contains knowledge and implies the possible legal result of the application of law to certain cases and explains the reasoning process as well as the legal knowledge that is applied [47].

This study aims to design and develop knowledge based court advisory decision support model that will assist judges and lawyers in Amhara region to make correct and similar judgments for the same cases or give alike services in the field of family law.

## 1.2. Statement of the Problem

In Ethiopia, there are different studies that are conducted to investigate the applicability of knowledge based system in supporting court and other service but some of them uses a rule based reasoning techniques. For instance to family related cases , Beferdu Seifu investigated web-based legal decision support expert system: the case of Ethiopia he has tried To develop a web based legal decision support expert system that provides legal consultation and decision support service on A Case Study with Ethiopian family Law but he doesn't cover all family related cases.

As the number of cases to be handled by courts increases, the need for new mechanisms which can assist judges while giving decisions, and accordingly, to respond to the increasing needs of customers become more important. As we have to see records in Bahir Dar zuryia wereda court office from 2010 E.C to 2013 E.C the number of cases to be handled by the court was increase in number.

One of the problems which are faced by the legal system is delayed delivery of justice. The very core of a civil society and rule of law is the provision of justice, but the decision must be delivered within a reasonable time [68]. Delayed delivery of justice has a negative impact in the morale and economic status of the parties involved. Marshall,(2008) express how the trust of the people on the justice system can be threatened due to delayed justice in the following words: Justice, as delivered, is built little by little, piece by piece, detail by detail, each part affecting the whole.

For the parent anxiously awaiting a judgment on custody or child support, for the business that loses the use of funds while waiting for an award of monetary damages, or for the victim of crime who is denied some sense of closure because of endless continuances in a criminal trial, justice administratively delayed truly is justice denied. Public faith in our independent courts simply cannot be sustained if even the highest level of substantive justice is delivered in a manner that renders it practically useless.

Judgment disparity is also another problem which is being exhibited in the current legal system. Judgment disparity, as defined by Cheathouse (nd) is that the judge does not hand out the same judgment, or the terms of the judgment, when handling almost the same cases. Presence of discrepancies in similar rulings is one of the main reasons which threaten the trust of the people on courts in particular and the legal system in general.

The research issues are formulated as

- How to model and characterize the acquired knowledge for developing efficient and effective knowledge base advisory decision support models?
- What components are relevant to design knowledge-based decision support system that automatically updates its knowledge?
- Why the KBS advisory models make an accurate service and reduce the judgment error to the selected category (civil law in case of family law)?

## 1.3. Objectives of the study

### 1.3.1. General objective

The general objective of this research is design and develop knowledge based decision support model for the improvement of court services and performance.

### 1.3.2. Specific objectives

In order to accomplish the general objective, this study has carried out the following specific objectives:-

- To model and represent the domain knowledge using suitable knowledge representation techniques.
- Building a prototype knowledge-based system that assists lawyers and judges in their decision making process;
- To test and evaluate the performance of the prototype and report the findings.

## 1.4. Scope and limitation of the study

The main concern of this research is to develop a knowledge based court advisory decision support mode for the selected category of Ethiopian rule of law fields. The scope of the research is delimited to develop knowledge based model that provides decision support and advisory service on Family law for Ethiopia to Amhara regions only. But there are different categories of law like criminal law and civil law property law, labor law, contract law and etc.

## 1.5. Significance of the study

The Ethiopian legal system is predominantly Civil Law, in which the judges base their decisions on the written law. Therefore, judges are not obliged to be guided by past decisions. However, the planned legal knowledge-based system helps judges to consider the decisions of other courts on similar past cases and therefore allows them to pass similar decisions. This will have an effect of reducing discrepancies in similar rulings [28].

The following users of the system can get advantage from the proposed knowledge based decisions system:

- **Judges** can consult the knowledge based system about some cases according to the Ethiopian law before they are giving final decision, the system can support for judge used to make similar decisions for a like cases to all customers.
- **Lawyers** could sharpen their skills and develop better solutions for their cases
- **Law school students** can use this knowledge based system to study how cases can be seen in law by providing some cases and get the final advice.

## 1.6. Organization of the thesis

The main body of this thesis is organized in to five chapters. The first chapter introduces the background of the study and statement of the problem and its justification. It also presents objectives of the study, scope and limitations of the study, methodology of the study, and significance of the study.

The second chapter presents review of related literature. It provides an overview of knowledge based system, architecture of KBS, types of knowledge, knowledge acquisition, knowledge modeling, knowledge representation, knowledge verification, validation, usability and usefulness, tools used in KBS development, applications of knowledge-based system, and review of related works.

The third chapter discusses the acquisition of knowledge from different sources, and conceptual modeling of the acquired knowledge using decision tree. It also discusses the representation of the validated acquired knowledge using production rules for developing the prototype system.

The fourth chapter presents implementation of the knowledge-based system. It also presents the testing process and discusses the evaluation result on the performance of the prototype system. Besides, it shows analysis and interpretation as a basis for discussing the findings of the study.

At last, chapter five puts the major findings, based on which it provides concluding remarks and recommendations for further research in the domain area.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Overview of knowledge base system

In order to have a better understanding of knowledge base system, different books, journals articles, proclamation, statute, rule and researches have been carefully reviewed starting from the beginning of the study until its completion.

Computer systems that try to solve problems in a human expert of the area by using knowledge about the application domain and problem-solving techniques are known as Knowledge based system [32] and, Artificial Intelligence (AI) is one of the up-to-date sciences; the name artificial intelligence itself was coined in 1956. Majority definitions of artificial intelligence proffered over decades have relied on comparisons to human behavior. Thus according to Fogel in 2006 different authors define artificial intelligence in different ways such as: -the sciences of making machines do things that would require intelligence if done by men and suggested that some people define AI as the mechanization or duplication of the human thought process. Artificial intelligence is the study of mental process through the use of computational models, an intelligent program is one that exhibits behavior similar to that of a human when challenged with a similar problem. It is not necessary that the program solve or attempt to solve the problem in the same way that a human would [37].

Artificial Intelligence intends understanding of human intelligence and building of computer programs that are capable of simulating or acting one or more of intelligent behaviors. Intelligent behaviors include cognitive skills like thinking, problem solving, learning, understanding, emotions, consciousness, intuition and creativity, language capacity, etc. These days some of the behaviors such as problem solving, learning and understanding are handled by computer programs [34].

According to Sharma & Khandelwal [40] a knowledge base system has the following characteristics.

- It provides the high-quality performance which solves complex problems in a domain as good as or better than human experts.
- This System possesses vast quantities of domain specific knowledge to the minute details.
- Knowledge-based systems reduce the search area for a solution by applying heuristics to guide the reasoning.
- Explanation capability of such systems enables it to review its own reasoning and describe its assessments.
- This system can advise, modify, update, expand and deals with uncertain and irrelevant data.

### 2.1.1 Advantages of Knowledge-Based System

The main advantages of using a knowledge-based system are described as follows **[19]**:
**Permanent documentation of knowledge:** A knowledge engineer extracts knowledge from domain experts and relevant documents for a certain problem domain and represents it using one of the knowledge representation techniques and transfers it into the knowledge base. This helps end-users to use the knowledge stored for a long-term from the documented knowledge in the knowledge base at any time.

**Cheaper solution and easy availability of knowledge:** It is assumed very huge, complicated and expensive to develop a KBS. Nevertheless, it costs once for building the knowledge base. After duplicating it into many copies, it is simple to use the knowledge in many places. This interrupts the dominations of domain experts and makes simple to acquire and utilize knowledge. On the contrary, educating new domain experts is inefficient and costly. Therefore, the aim of developing KBSs is to reduce cost, time, human expertise and medical error.

**Dual advantages of effectiveness and efficiency:** Since knowledge-based systems are computer-based systems, they have efficiency-directed factors such as speed, accuracy, control, and permanent content storage. It is possible to make the knowledge-based system effective by integrating the knowledge element. They are more efficient than domain experts and attempts to become equally effective like domain experts.

**Consistency and reliability:** Since the knowledge element is integrated into the KBS and the capability to perform effectively, the trustworthiness of the system rises. Besides, dupery and errors can be stopped. Information can be accessible rapidly for making decision with appropriate justification. As the level and amount of knowledge rises, making right decision will rise and thereby reduce the threat of wrong decision.

**Justification for better understanding:** The reliability of the domain experts relies on the capability to explain their decisions. This can be offered by using the reasoning and justification component of the KBS to the end-users. If there is a well understanding of the decisions made by end-users of the system, then it increases the quality and trustworthiness of the system.

**Self-learning and ease of updates:** With the assistance of the inference engine of the system, the knowledge base always updates its knowledge from experience. The knowledge-based system can update its knowledge either using automatic machine learning or manually by the knowledge engineer. Such self-learning advances the adaptability and tractability of the system.

### 2.1.2 Limitations of Knowledge-Based System

The following are some of the major drawbacks of using the KBS [19]: **Partial self-learning**: The knowledge-based systems can explain when they made a decision and learn from experience by updating its knowledge. However, the represented knowledge may not be completely known so that the knowledge-based system can learn partially from experience. Besides, domain experts can conform automatically to new conditions though KBSs should explicitly update their knowledge.

**Creativity and innovation**: It is not possible computer-machines to show a certain behavior as creative as humans do. Domain experts can answer back in a creative manner to new conditions though knowledge-based systems as a maximum can deal with the five basic senses. KBSs do not have any methodology to deal with invention, the ability to create and common sense. If we use AI methods in KBS, humanlike five basic senses can be partly applied. The vision, listening, smell, taste, and touch tasks are implemented so that they cannot totally assist activities associated to perception, emotion, and enjoyment. This is because knowledge-based systems are now reliant on symbolic input though human beings have a varied of sensory experience.

**Weak support of methods and heuristics**: Knowledge-based systems cannot operate with their full capacity if there is no response given or the problem is out of the system's knowledge. When the heuristics is applied to look for a solution from the search space, the success of the systems relies on the quality of the heuristics. Thus, the responsibility depends on the knowledge engineer to develop the heuristics.

**Development methodology**: System development is not only an art but also a science. For example, in the development of information systems there is no one common accepted methodology. There are common guidelines and lifecycle models that help to develop all types of computer-based information systems. However, there is no common development model that helps knowledge engineers to develop a KBS.

**Knowledge acquisition**: It is the transfer of knowledge from its source into an appropriate format that can be used by the knowledge-based system. Knowledge is basically personal in nature and is therefore very challenging to extract the embedded knowledge from human mind.

Development of testing and certifying strategies and standards for knowledge-based systems: A knowledge-based system operates in a specific problem domain. The absence of standardization is the main limitation of the existing state of acceptance of knowledge-based system. The acquired knowledge from its source should be tested before representing it into the knowledge base using one of the knowledge representation techniques. Likewise, the knowledge base should be tested even after the representation of the validated knowledge. Standards such as verification, validation and quality metrics are required for ensuring the quality of the KBS.

## 2.2 Architecture of Knowledge-Based System

According to Sajja and Akerkar [35], every KBS have at least five main components. These components are depicted schematically in figure 2.1 and are explained.

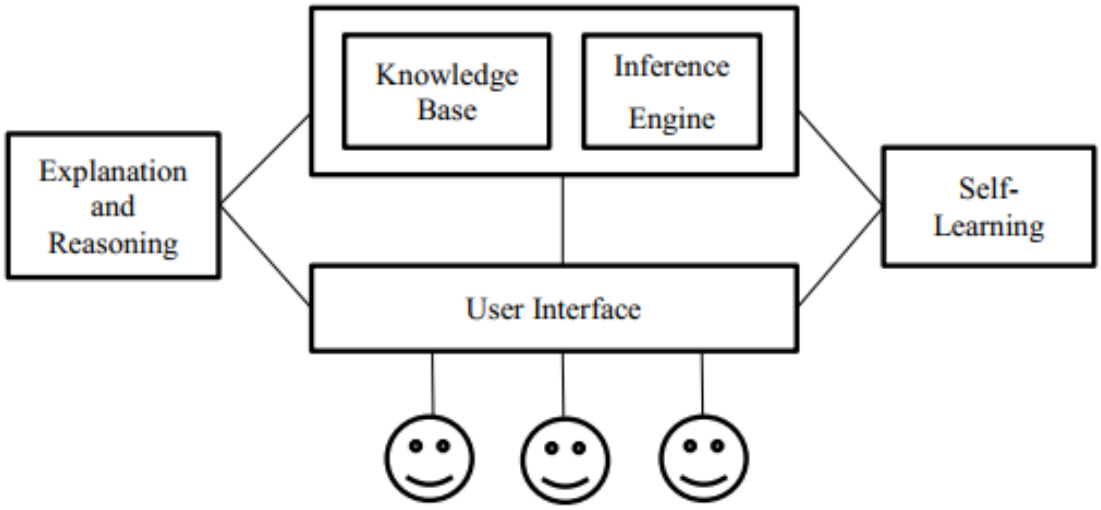


Figure 2.1. The Basic Structure of a Knowledge-Based System

### 2.2.1 Knowledge Base

The knowledge base comprises specific knowledge on a certain domain that makes human an accurate expert on the specific domain. This knowledge is extracted from human expert and encoded in the knowledge base using different knowledge representation techniques. In a knowledge-based system, one of the main techniques used for representing the knowledge is rule. A rule has an IF/THEN type structure which links a certain identified information in the IF part with the concluded information in the THEN part.

### 2.2.2 Inference Engine

According to the end-user input and the set of facts from the knowledge base and/or other sources, the inference engine infers facts or makes conclusions from the knowledge base. Three main techniques are known when deducing facts or drawing conclusions from the knowledge base [6], these are: forward chaining, backward chaining and hybrid chaining. Forward chaining technique is also called data-directed inference. It begins with some facts and rules in the knowledge base and attempts to find all possible conclusions from the data.

This technique is appropriate when a goal state is indeterminable. On the other hand, backward chaining which is also called goal-directed inference technique begins with possible conclusions or goals and functions towards the back to find supporting facts that verifies the goal. This technique often offers better explanation and reasoning for how were ached at a specific goal. When there exists a very complex problem domain, the above two techniques can be merged to produce an efficient program called hybrid chaining. Hence, in order to design the strategies used by the expert in the domain area, KBS must implement a complex inference engine that may involve both backward and forward chaining techniques.

### 2.2.3 Explanation/Reasoning Facility

In addition to delivering the end outcomes, domain experts together with KBSs can clarify „how‟ they reached at outcomes. This ability is usually essential since this kind of problems to which KBSs are carried out need an explanation of the outcome delivered to the end-users. KBSs also have the ability of justifying „why‟ a certain problem is being questioned **[25]**. For example, if an automated banking machine (ABM) comes to a decision to take-up the card of end-user, then the ABM can show an explanation message like:“Sorry, password still incorrect after three trials. We withheld your card, for your protection. Please contact your bank during regular office hours for help”.

According to Castillo et al. **[26]**, in several domains of problems explanations of the actions are essential because of the hazards related with the conclusions to be fired. For instance, in the medical diagnostic field, medical physicians are liable at the end of the day for the diagnoses made, irrespective of the help tools applied to make the actions. In these circumstances, in the absence of an explanation facility, medical physicians may not be capable to justify the reasons for diagnosis to their patients.

### 2.2.4 Self-Learning

Self-learning is one of the elements of KBS which tries to imitate the learning capability of human beings. It is possible to update the knowledge base of the KBS either manually or automatically using machine learning algorithms **[35]**. According to Akerkar and Sajja**[36]**, "Self-learning is a scientific task that enables the knowledge-based system to learn automatically from the inference process, cases executed, and environment. To carry out such tasks, one needs to have a control mechanism that discovers general conjectures and knowledge from specific data and experience, based on sound statistical and computational principles".
One of the key characteristics of KBS is the capability to learn. According to Castillo et al. **[26]**, there are three methods of learning. These are structural learning, parametric learning and learning by memorization.

**Structural learning** denotes to certain features associated to the structure of knowledge such as rules and probability distributions. For example, finding a new related symptom for a certain disease or incorporating a new rule in the knowledge base.
**Parametric learning** denotes to conjecturing the parameters required to build the knowledge base. For example, conjecture of probabilities associated with symptoms or diseases.
**Learning by memorization** denotes the capability of KBS to learn from experience based on the existing data. Using this method, KBS can carry out different activities such as storing or memorizing knowledge, and learning from the facts base

### 2.2.5 User Interface

As Castillo et al. [26] noted, user interface is a channel for communication between the KBS and the end-user. Therefore, in order for the KBS to be an interactive tool, it should include a means to show and retrieve information in a simple manner. Examples of information to be shown are the consequences made by the inference engine, the justifications for such consequences, and an explanation for the actions made by the KBS. Conversely, when no consequence can be arrived by the inference engine like because of the absence of information, the user interface offers a mechanism for attaining the desired information from the end-user. Therefore, an insufficient implementation of the user interface that does not assist this process would hinder the importance of the KBS by the end-users. Moreover, the reason for the significance of the user interface component is that end-users usually evaluate KBSs based on the quality of the user interface instead of the KBS itself.

## 2.3 Types of Knowledge

Knowledge is a set of facts designed for a special activity, procedures, and decision commonly articulated as rules [19]. As shown in table 2.1, types of knowledge can be used in AI. These types of knowledge may come from various sources like human mind, books, documents, sensors, computer files and so on.

Table 2. 1 Types of knowledge with example

| **Knowledge Type** | **Meaning** | **Example** |
|---|---|---|
| Permanent | Not changeable knowledge | Human beings are mortal, waterfalls down, etc |
| Static | Unchangeable knowledge for a certain period of time | Rules and principles |
| Dynamic | Endlessly changing knowledge | Prices of coffee |

### 2.3.1 Levels of Knowledge

It is possible to symbolize knowledge at various levels. The two common are shallow and deep knowledge **[28]**.

**Shallow Knowledge** is the representation of outermost level information that is used to address with very particular conditions. The shallow knowledge form represents the input and output relationship of a certain system. Intrinsically, it can be preferably represented in terms of IFTHEN rules. Shallow representation is narrow. A collection of rules by itself may have limited meaning for the end-user. This may restrict the ability of the system to offer suitable justifications to the end-user. Shallow knowledge may also be inadequate in describing complex circumstances.

**Deep Knowledge** is the interior and causal structure of a certain system and comprises the relations between the system's elements. It can be applied to various tasks and various circumstances. It is also hard to automate this kind of knowledge. The system developer should have a complete intellectual ability of the main components and their relations.

### 2.3.2 Categories of Knowledge

Knowledge can be classified as declarative, procedural, or meta-knowledge **[28]**. **Declarative knowledge** is a descriptive representation of knowledge. It expresses facts like what things are. It is expressed in an actual statement, for instance, there is a positive relationship between cigarette smoking and cancer. Experts of the domain tell us about facts and relationships. This kind of knowledge is regarded as shallow information that domain experts can articulate. It is mainly essential in the early phase of knowledge acquisition.

**Procedural knowledge** conceives the way in which things function under various collections of conditions. Hence, it comprises successions in a gradual manner and how-to kinds of instructions; it may also comprise justifications. It includes automatic replies to inputs. It associates to the procedures used in the problem-solving process. For example: information about defining the problem, gathering of data, process of the solution, and criteria of evaluation.

**Meta-knowledge** is knowledge about knowledge. In knowledge-based systems, meta-knowledge is knowledge about the operation of knowledge-based systems (i.e., about their reasoning capabilities).

## 2.4 Knowledge Acquisition

Knowledge can be gathered from different sources such as books, databases, images, maps, flow of diagrams, stories, sensors, and so on. According to Anand and Singh **[29]**, there are usually two types of knowledge sources. These are documented (tacit) knowledge and UN documented (explicit) knowledge.

Tacit knowledge is commonly deeply ingrained in human mind and organizations through experience. Explicit knowledge is relatively simple to express and capture in the form of books, tables, diagrams, and so on. Knowledge can be discovered and collected by using either the human senses or machines (e.g., scanners, cameras, pattern matchers, intelligent agents) **[28]**.

The extraction of appropriate knowledge from experts and other sources are the essential aspects in the knowledge-based system development process. In fact, knowledge acquisition is erformed during the whole knowledge-based system development process.

### 2.4.1 Methods of Acquiring Knowledge from Experts

Acquiring knowledge from experts is not a simple task. It involves knowledge identification, knowledge representation in an appropriate format, organizing the knowledge, and transferring the knowledge to a computer machine. Some of the reasons that increase to the difficulty of knowledge acquisition from experts and its transfer to a computer machine are stated below **[28]**

- Experts possibly will not recognize to express or state clearly their knowledge.
- Experts possibly have shortage of time to be able to work together with knowledge engineers.

- Examining and filtering knowledge is very difficult.
- Ways for knowledge elicitation possibly are ill-defined. It is hard to identify a particular knowledge when it is mingled with unrelated data and information.
- Knowledge engineers possibly will vary their behavior when they are conducting an interview, and bad communication factors that occur among people may affect the knowledge collection task.

The process of acquiring knowledge from experts could be significantly acted upon by the roles of the three main actors: the knowledge engineer, the expert, and the end-user. The best approach to the interrelationships of these actors is provided by Sandahl**[30]**. He suggested that experts must play a very significant role in the construction of a knowledge base.

The knowledge engineer must act as a trainer of knowledge structuring, a tool designer, and a catalyst at the interface between the expert and the end-users. The knowledge engineer should have the factual social skills. Some roles of the knowledge engineer are discussed below **[31]**:

**Good communication skills:** The process of knowledge elicitation demands a lot of time for discussion and debate. When results have been accorded with experts, it should be recorded. This needs an excellent use of the spoken and written word, diagrammatic representation, and clarification of body communication. Most of all there should be a good association between the knowledge engineer and expert. A person having a bad communication skill cannot be an effective knowledge engineer.

**Intelligence:** The knowledge engineer often updates his/her knowledge through learning. He/she wants to be capable to update a new knowledge domain, and know sufficient of the terminology and principles to be capable to argue it completely with a recognized expert. He/she should keep informed with developments in hardware and software. Moreover, he/she wants to have knowledge of disciplines such as formal logic, probability theory and psychology.

**Tact and diplomacy:** The attainment of the task possibly relies on the collaboration of little number of significant experts. An expert who has been estranged by self-seeking or undiplomatic handling will incline to drop off interest. Any idea that is suggested that a program can substitute or outdo the expert can be catastrophic. Thus, it is an indication that the expert is unable to offer the factual information in a suitable manner.

**Empathy and patience:** The knowledge engineer and expert should work in partnership with valuing one another as a team. This implies that the knowledge engineer should appreciate the problems faced by the expert.

**Persistence:** Outcomes may come gradually. So, to find the solution of the problems, the knowledge engineer should be persistent; he/she should keep his/her passion and trust in the task. Even though there are obstacles, he/she should be able to believe that achievement will come at the end.

**Logicality:** The knowledge engineer wants to be capable to contend rationally, knowing effective statements and offering substantial refutation by examples for potential mistakes. The comprehensiveness and consistency of the evolving model should also be evaluated. This necessitates a level of strong thought and logicality.

**Self-confidence:** The intermingling of these abilities should be synchronized by self- confidence. Even though the knowledge engineer is technically capable person, scared person would not be capable to regulate a task. Developing a knowledge-based system is a difficult task and the knowledge engineer should have sufficient self-confidence to keep up passion for the task.

**Domain knowledge:** It is better to discuss the knowledge engineer with the domain expert in the domain expert's terminology. Thus, it will be more useful for the knowledge engineer to have certain background knowledge of the domain.

**Programming knowledge:** The components of the knowledge-based system such as the knowledge base and inference mechanisms are implemented in a program. It is recommended but insignificant that the knowledge engineer may be able to understand programming and different knowledge representation techniques. However, an intellectual and versatile approach is the most significant thing during knowledge acquisition process.

### 2.4.2 Knowledge Acquisition Methods

Knowledge acquisition methods can be classified into manual and computer-based. Computer can support to acquire knowledge using semi-automatic or fully-automatic means .

#### 2.4.2.1 Manual Knowledge Acquisition Methods

The manual knowledge acquisition methods comprise **[32]**: Interview (structured and unstructured), tracking methods, and observation.

**Interviews:** The most frequently used form of knowledge acquisition is interviewing. This is an unambiguous technique that comes out in numerous inconsistencies. It encompasses a direct exchange of ideas between the human expert and the knowledge engineer.

Information is gathered with the help of instruments such as tape recorders, questionnaires, and so on and is consequently transliterated, analyzed, and coded. During the interview, the expert is presented with an imitated case or, preferably, with a real problem that the KBS will be anticipated to find the solution. The expert is inquired to talk the knowledge engineer via the solution of the problem.

One variant of the interview approach starts with no information at all being given to the expert. Whatever facts the expert needs should be inquired for openly. This variant makes the expert's path via the domain more manifest, mainly in terms of defining the input a KBS would expect. The interview process can be boring. It lays great demands on the domain expert. The expert should be able to exhibit expertise and express it. On the contrary, it needs little equipment and can generate a huge amount of information. There are two main types of interviews **[32]**: unstructured and structured interviews.

At the beginning of any study, numerous knowledge acquisition interview sessions are frequently conducted informally. Beginning informally avoids wastage of time and aids to proceed rapidly to the main structure of the domain. Normally, it is followed by a formal technique. Contrary to what numerous people think, unstructured interviews are not easy. Actually, they may present the knowledge engineer with a number of very problematic consequences.

Unstructured interviewing rarely offers comprehensive or well-ordered descriptions of cognitive processes. There are several reasons for this: the domains are complex; the experts frequently find it very hard to express some of the most significant elements of their knowledge; domain experts may interpret the lack of structure as implying that they need not prepare for the interview; data acquired from an unstructured interview are often unrelated, exist at varying levels of complexity, and are hard for the knowledge engineer to review, interpret, and integrate; and few knowledge engineers have the training and experience to efficiently conduct an unstructured interview. Hence, it should be supplemented by structured interviews.

Structured interview is a systematic and goal-driven process. It coerces organized communication between the knowledge engineer and the expert. The structure decreases the interpretation problems inbuilt in unstructured interviews and permits the knowledge engineer to avert the bias caused by the subjectivity of the domain expert. Structuring an interview needs care to many procedural issues, which are listed as follows **[28]**:

The knowledge engineer studies obtainable material on the domain to identify main demarcations of the relevant knowledge.
The knowledge engineer reviews the planned KBS capabilities. He/she identifies targets for the questions to be inquired during the knowledge acquisition session. Using a form, the knowledge engineer properly schedules and plans the structured interviews.

- The knowledge engineer may write sample questions, concentrating on question type, level, and questioning methods.
- The knowledge engineer makes sure that the domain expert understands the purpose and goals of the session and motivates the expert to prepare before the interview.

- During the interview, the knowledge engineer follows guidelines for conducting interviews.
- During the interview, the knowledge engineer uses directional control to keep the interview's structure.

**Tracking methods:** It is a collection of techniques that try to track the reasoning process of an expert. It is a widely held approach among cognitive psychologists who are interested in discovering the expert's train of thought in reaching a conclusion. The knowledge engineer can use the tracking process to find what information is being used and how it is being used. Tracking methods can be formal or informal **[28]**. The common formal method is protocol analysis.

Protocol analysis (also called verbal protocol analysis) is a method by which the knowledge engineer gets in depth knowledge from the expert. A protocol is a record or documentation of the expert's stepwise information-processing and decision-making behavior. In this method, the expert is inquired to accomplish an actual task and to articulate his/her thought processes. The expert is inquired to think loudly while carrying out the task or solving the problem under observation. Usually, a recording is made as the expert thinks loudly; it describes every aspect of the information processing and decision-making behavior. The recording becomes a record, or protocol, of the expert's currently happening behavior. Later on, the recording is transliterated for additional analysis and coded by the knowledge engineer.

The process of protocol analysis is listed as follows **[33]**:

- Offer the expert with a full range of information usually related with a task.
- Inquire the expert to articulate the task in the same manner as would be done normally while articulating his/her decision process and record the articulation on tape.
- Make statements by transliterating the verbal protocols.
- Collect the statements that look to have high information content.
- Simplify and rewrite the gathered statements and create a table of production rules from the gathered statements.
- Generate a sequence of models by using the production rules.

**Observations:** Occasionally, it is possible to observe an expert at work. In many ways, this is the most obvious and direct approach to knowledge acquisition. However, the difficulties involved should not be underestimated. For example, most experts advise several people and may work in several domains at the same time. In this case, the knowledge engineer's observations will also cover all the other activities. Therefore, large quantities of knowledge are being gathered, of which only a little is useful. In particular, if recordings or videotapes are made, the cost of transliterating large amounts of knowledge must be carefully considered.

As Mohammed et al.**[32]** noted, observations which can be seen as a special case of protocols are of two types: motor movements and eye movements. With observations of motor movements, the expert's physical performance of the task (e.g., walking, reaching, talking) is documented. With observations of eye movements, a record is made of where the expert fixes his/her stare. Observations are used mainly as a way of assisting verbal protocols. They are largely expensive and time-consuming.

#### 2.4.2.2 Computer-Based Knowledge Acquisition Methods

Acquiring knowledge from experts can be supported using computer-based tools. These tools offer surroundings for knowledge engineers to identify knowledge via an interactive process**[33]**. Besides, semiautomatic methods that use computer-based tools for helping the knowledge acquisition process are also possible to extract knowledge automatically from the set of data. The process of finding useful information and patterns from the set of data using computers is known as knowledge discovery. In early 1990s, the process was also known as machine learning. But, currently knowledge discovery and data mining are becoming widely used terms **[28]**.

## 2.5 Knowledge Modeling

Models are applied to express the important characteristics of real-time systems to understand in a simple way by dividing them into small parts. Models are more related with problem domain they represent **[34]**. Real-time systems are huge objects comprising of interconnected elements doing in complications as teamwork.

It assists individuals to weigh-up and know such complications by supporting them to explore every specific area of the system. Models are applied in the construction process of systems to draw the architecture of the system and to simplify the exchange of information between several individuals in the group at various levels of abstraction. Individuals have several understandings of the system and models can assist them to know these understandings in a coordinated way.

According to Schreiber et al. **[35],** the modeling process builds conceptual models of knowledge intensive activities. During the knowledge acquisition process, the knowledge engineer will attempt to understand both the tacit and explicit form of knowledge and then use visual tools to make an exchange of views between domain experts and end-users. This exchange of views produces concepts and understandings with regard to how the acquired knowledge is applied, how judgments are made, and so on. And the knowledge engineer should build the knowledge model from the acquired exchange of views with domain experts and end-users. This helps the knowledge engineer to transfer the knowledge model into functional computer-machine programs.

A paper by Wielinga et al. **[36]** argues knowledge models are very significant for knowing the operational means in the development process of a knowledge-based system. According to Schreiber et al. **[35],** knowledge modeling is a vital stage of the knowledge engineering process. It can provide a means to easily understand the source of knowledge, the inputs and outputs of knowledge, and the designation other parameters.

Different techniques can be used in modeling the domain knowledge, for example, decision trees can help steps (decisions) to find a solution for a certain problem domain. Decision trees play a crucial role in the knowledge modeling process. A decision tree is a graphical representation of the search space of a certain problem domain. It carries out classification by building a tree based on training instances with leaves having class labels. A node in the tree represents a decision rule on one or more attributes when solving the problem and the leaf nodes growing out from the node represents the predicted class labels of the decision **[37]**.

## 2.6 Knowledge Representation

A representation is a collection of agreements for describing the real world. It is the dedication to a vocabulary, data structures, and programs that let domain knowledge to be acquired and used. According to Buchanan and Duda**[38]**, there are three main requisites on a representation scheme of KBS. These are extendibility, simplicity and explicitness.

**Extendibility**: The data structures and access programs should be able to adjust readily to different conditions by permitting extensions to the knowledge base in the absence of coercing significant changes. A good method of constructing a knowledge base is through incremental improvement. Even though it is difficult for experts to define the whole knowledge for concerning problem areas at a time, they can define a subgroup and then improve it over a certain period of time by analyzing its effects.

**Simplicity**: The data structures were incomprehensible and unchangeable. When the syntax of the knowledge base is defined, at a large extent the access routines can be defined. But, novel reasons will come out for accessing the knowledge base just like clarifying of the contents of the knowledge base, analysis of the associations among items, display, or training. For these reasons, easy data structures give more advantages. From the developer's perspective, there are two ways of sustaining simplicity: continuing the form of knowledge as uniform as possible or writing unique access functions for inhomogeneous representations. Another way of sustaining simplicity is using the same terminology as the experts use.

**Explicitness**: Representing an abundant expert's knowledge is to offer a robust knowledge base of the system for solving problems with superior performance. But as a knowledge base should be constructed incrementally, it is essential to offer ways for examining and correcting it without difficulty. When items of knowledge are represented explicitly and using simple terms, the experts who are constructing knowledge bases can control which items are present and which are absent.

Knowledge representation is a means of encoding the domain expert's knowledge in a suitable medium. According to Kock**[6]**, the common techniques of knowledge representation are: logic, rules, semantic nets, frames, and cases. For the purpose of this research work rule based and case based reasoning approach are discusses as follows.

### *2.6.1* **Rule-Based Reasoning**

Rule based reasoning is a system whose knowledge representation in a set of rules and facts. Symbolic rules are one of the most popular knowledge representation and reasoning methods. This popularity is mainly due their naturalness, which facilitates comprehension of the represented knowledge. The basic forms of a rule, If<condition> then <conclusion> where <condition> represents premises and <conclusion> represents associated action for the premises. The condition of rules are connected between each other with logical connectives such as, AND, OR, NOT, etc., thus forming a logical function. When sufficient conditions of a rule are satisfied, then the conclusion is derived and the rule is said to be fired. Rules based reasoning was dominantly applied to represent general knowledge. Rule based expert systems have a significant role in many different domain areas such as medical diagnosis, electronic troubleshooting and data interpretations. A typical rule based system consists of a list of rules, a cluster of facts and an interpreter [1].

Rule

The term rules represent what to do or not to do while certain conditions are satisfied. Similarly, domain knowledge is represented by a set of rules[10]. The general form of rules based system can be illustrated as follows (Merritt, 2000).

IF

First premise, and

Second premise, and

...

THEN

Conclusion

The IF side of the rule is referred to as the left hand side (LHS) and the THEN side of the rules referred to as the right hand side (RHS). This is semantically the same as a Prolog rule: Conclusion:-
first _ premise
Second_ premise …

#### *2.6.1.1* **Rule based reasoning techniques**

There are two main inference methods in rule based reasoning mechanism. These are backward chaining and forward chaining. The former is guided by the goals (conclusions), whereas the latter one is guided by the given facts (Prentzas, 2007).

***I.*** **Forward chaining**

During forward chaining, the inference engines first predetermine the criterion and the next steps are to add the criterion one at a time, until the entire chain has been trained. With data driven control, facts in the system are represented in a working memory which is continually updated. Rules in the system represent possible actions to take when specified conditions hold items in the working memory. The conditions are usually patterns that must match with the items in the working memory. In forward chaining, actions are usually involves adding or deleting items from the working memory. Interpreter of the inference engine controls the application of the rules, given the working memory. The system first checks to find all the rules whose condition holds true (Shaffer, 1991).and (Freeman-Hargis, 2012).Both data driven and goal driven chaining method follows the same procedures. However, the difference lies on the inference process. The system keeps track of the current state of problem solution and looks for rules. This cycle will be repeated until no rules fire or the specified goal state is satisfied (Merritt, 2000).

## II. Backward chaining

This strategy focuses its effort by only considering rules that are applicable to the particular goal. It is similar with forward chaining the difference is it receives the problem description as a set of conclusions instead of conditions and tries to find the premises that cause the conclusion. Given a goal state and then the system try to prove if the goal matches with the initial facts. When a match is found goal is succeeded. But, if it doesn't then the inference engine start to check the next rules whose conclusions (previously referred to as actions) match with the given fact. Note that a backward chaining system does not need to update a working memory instead it keeps track of what goal is needed to prove its main hypothesis. Goal driven control is commonly known as top-down or backward chaining (Freeman-Hargis, 2012; Ghan, 2004).

## III. Forwards Vs. Backwards chaining

According to Freeman-Hargis (2012), both forward chaining and backward chaining have similar function. But, the difference occurs due to the data structure of knowledge based system. The following point give us a clear ideas how and when to apply each reasoning mechanisms.

- Whether you use forward or backwards reasoning to solve a problem, it depends on the properties of your rule set and initial facts.
- Sometimes, if you have particular goal (to test some hypothesis), then backward chaining is more efficient, as you avoid drawing a conclusions from irrelevant facts.
- Sometimes backward chaining can be very wasteful - there may be many possible ways of proving the hypothesis, and it may require checking almost all of the rules before you find one that works.
- When you have a small set of initial facts; and when there is lots of different rules which allow you to draw the same conclusion it is better to use forward chaining.
- Backward chaining may be better if you are trying to prove a single fact, given a large set of initial facts. Because if you used forward chaining lots of rules would be eligible to fire in any cycle.

#### *2.6.1.2* **Advantage of rule based reasoning**

Rule based reasoning approach have a numbers of good features. According to Jim Prentzas (2007) the major advantages of rule based reasoning in the development of knowledge based system are:

- Compact representation of general knowledge. Rules can easily represent general knowledge about a problem domain.
- Homogeneity. Rule based representation has uniform syntax. Hence, the meaning and interpretation of each rule can be easily analyzed.
- Independent. In rule based knowledge representation a new rule can be added without affecting the existing rules. Each rule is an independent piece of knowledge about the problem domain.
- Naturalness of representation. Rules are a very natural knowledge representation method with a high level of
- Comprehensibility. Rules can emulate the expert's way of thinking in natural expression.
- Modularity. Each rule is a discrete knowledge unit that can be inserted into or removed from the knowledge base without taking care of any other technical detail. This characteristic grants flexibility of rule-based reasoning. Because it enables incremental development of the knowledge base.
- Provision of explanations. The ability to provide explanations for the derived conclusions is a straightforward manner. This feature of symbolic rules is a direct consequence of their naturalness and modularity.

#### *2.6.1.3* **Disadvantage of rule based reasoning**

As rule based reasoning of prototype knowledge based system has many advantages. But, it has the following limitations [10].

- Knowledge acquisition bottleneck- The standard way of acquiring knowledge through interviews with domain experts is bulky and time-consuming.
- Brittleness/fragility of rules- It is not possible to draw conclusions from rules when there are missing values in the input data.

- Inference efficiency problems- In certain cases the performance of the inference engine is not the desired one especially when the rules are too large.
- Difficulty in maintenance of large rules- The maintenance of rule bases is getting a difficult process as the size of the rules increases.
- Interpretation problems- The general nature of rules may create problems in the interpretation of their scope during reasoning process

### *2.6.2* **Case-Based Representation**

Case-based reasoning (CBR) means "adapting old solutions to meet new demands, using old cases to account for new situations, using old cases to evaluate new solutions, or reasoning from precedents to interpret a new situation" (Chen, 2007).CBR is more comfortable to make better decision in dynamically changing environment. People learn from their success and wrong activities to handle similar situations in the right manner and not to repeat their mistake of the past. CBR approach is more compatible to reuse previously solved problems and learning from experiences for future decision (Salem, 2007). Similarly, CBR is an approach to incremental learning. Once a problem has been solved, CBR approaches use the solution to solve for future problems (Plaza, 1994).

Cases

In CBR techniques cases are usually denotes a problem situation. A case can be defined as previously experienced situation which has been captured and learnt, is referred to as a past case, previous case, stored case or retained case. Note that the term problem solving is used with common practice in the area of knowledge-based systems. This means that problem solving is not necessarily the finding of a concrete solution to an application problem, it may be any problem put forth by the user (Plaza, 1994).

Therefore, and cases have three different aspects this can be described as follows.

- Situation/ problem description: describes specific circumstances, the state of a situation and state of the environment when this case is recorded.
- Solution: provide how the problem described was solved or treated in a particular instance.
- Outcome: describe the final result, consequence and feedback gained from the proposed solution.

According to Shu Huang Sun (2007) Case-based reasoning mechanism requires the following primary activities.

- Index assignment: Characterizes the given problem by assigning the appropriate attribute that describe the features of the case.
- Retrieval: Retrieves the relevant case from the case library.
- Explanation: Explains the deficiencies of the retrieved case by making a comparison of the differences between this case and the input problem. The explanation involves two aspects, i.e., which features are unsatisfactory and require modification and how to modify these features so as to satisfy new conditions.
- Modification: Modifies the retrieved case to conform to new situations according to the result of explanation.
- Store/adapt: Saves the modified case as a new case into the case library. The case libraries are incrementally expanded as the numbers of cases increase.

#### *2.6.2.1* **Case based reasoning life cycle**

Case based reasoning life cycle incorporate four major components that make the reasoning mechanism successful. These are retrieval, reuse, revise and retain. Retrieval is the task that involves retrieving a case from the collection of previously solved cases. The retrieved case is combined with the new case for later reuse into a solved case. Revise is a process that tests the success of a solution by applying into a real world environment, if repair is failed. When useful experience is retained the case is updated by a new learned case (Plaza, 1994).

Cased based reasoning process generally involves both determining the differences between the retrieved cases and the current query case. It also involves modifying the retrieved solution to appropriately reflect these differences (Shiu, 2004).

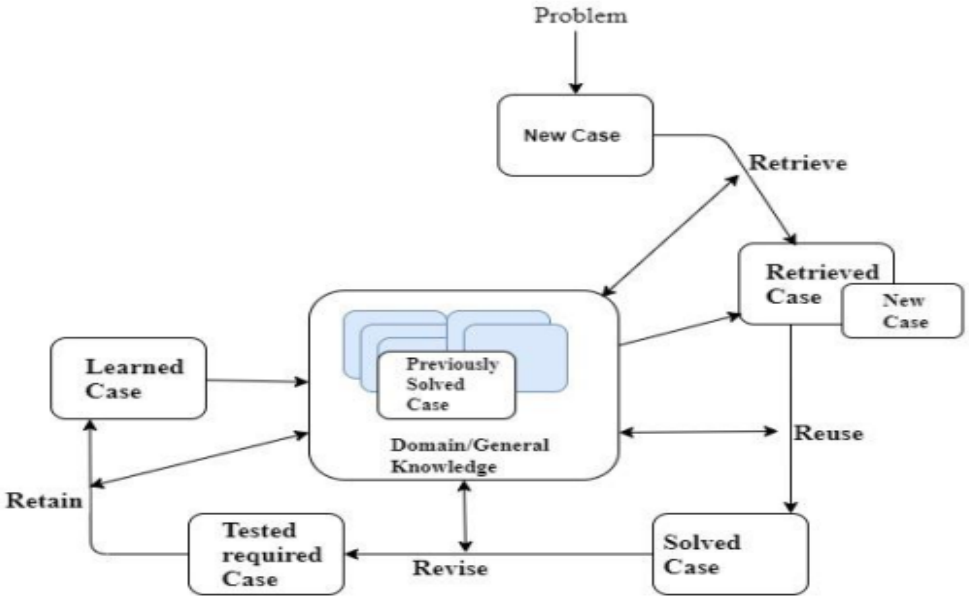


Figure 2.2 The Case Based Reasoning Cycle adopted from [53]

## A. Retrieve

In Case Based Reasoning, processes retrieving is the first step, it is also defined as the process of recalling the most similar cases from the case base by taking problem description as input and gives the most similar cases as an output(Richter & Weber, 2013). The complete CBR performance is determined by its retrieval performance since retrieval is the core process for the CBR cycles.

As Sqalli and Rissland [45] the process of case retrieval is subdivided in to three different subtasks:

- **Identify features**: this task identifies the most relevant descriptive feature in the problem to match it with saved cases.
- **Initially match**: involves the task of identifying old cases that matches with the current problem and retrieves the matched cases. Searching and similarity measurement are the two main tasks take place here to get similar case/cases.
- **Select:** finally, the best-matched case is selected and taken as the output of the retrieval process based on the result of similarity assessment.

The retrieval process has been also subdivided in to two tasks by [45] as;

- **Recall previous cases**: involves retrieving matched cases from the available past cases that helps to solve the new case.
- **Select the best subject:** involves the selection of the best case from the retrieved matched cases.

Searching algorithm, similarity assessment method and descriptive feature identification are the main critical factors affecting the retrieval process in CBR. Nearest Neighbor and Induction algorithms are the most well-known algorithms for case retrieval (Prasath, 2017; Recio-García, 2008). There is also a possibility of using these algorithms in combined as hybrid or alone for retrieval purpose.

## Nearest Neighbor Algorithm

This retrieval algorithm works by measuring the similarity of new case with the stored cases based on matching a weighed sum of features/attributes (CampilloGimenez, 2012; Gerhana, 2017).Nearest Neighbor algorithm returns nearest match from case-based reasoning library. This algorithm best fits when the new case doesn't exactly match with the old cases and when attributes have numeric (continuous) values (Bach, 2018). But as the cases in the case base increases the retrieval time in this s algorithm also increases.

The following is the algorithm for Nearest Neighbor (Bazmara&Jafari, 2013)

For each feature in the input case: Find the corresponding feature in the stored case, Compare the two values to each other and compute the degree of match, Multiply by a coefficient representing the importance of the feature to the match, Add the results to derive an average match score, This number represents the degree of match of the old case to the input.

Nearest Neighbor algorithm can be represented as in the following equation.

$$NN\ (I,R) = \frac{\sum_{i=I}^{n} Wi\ x\ sim(f^I, f^R)}{\sum_{I=1}^{n} Wi}$$

*Equation 2.1 nearest neighbor algorithm*

*Where:*

NN: nearest neighbor

w=weighting of a feature (or slot),

sim= similarity function for attributes i in cases fI and fR

fI = the values for feature i in the input cases.

fR= the values for feature i in the retrieved cases

n= number of attributes in each case

## B. **Reuse**

After selecting one or several similar cases, the reuse step tries to apply the contained solution information to solve the new problem. Often a direct reuse of a retrieved solution is impossible due to differences between the current and the old problem situation. Then the retrieved solutions have to be modified in order to fit the new situation. How this adaptation is performed strongly depends on the particular application scenario Stahl & Roth-Berghofer, 2008 [55]. In general, adaptation methods require additional general knowledge about the application domain. Because this leads to additional knowledge acquisition effort, many CBR systems used today do not perform case adaptation automatically, but leave this task to the user. Then, of course, the quality of the retrieval step influences the problem-solving capabilities of the entire CBR system primarily. Even if automatic adaptation is provided, the qualities of the retrieval result will strongly influence the efficiency of the system due to its impact on the required adaptation effort.

## C. **Revise**

Once the solution is designed for the new problem the correctness and how much it is good should be evaluated by different techniques such as by feedback from human experts of the domain area or by applying in actual tasks and see the result, by using simulators and other techniques. After the evaluation result is realized the system learns from the result and it needs to be repaired and corrected for the failures and errors occurred during revision to prevent it from having future such similar problems and failures[56].

### D. **Retain**

Retain is the final task of CBR approaches and takes place after the newly solved case passes all early cycles successfully. It retains tested case which represents new experience that might be used in the future to solve similar problems. Due to this the knowledge base of the case-based reasoning is upgraded by the new experience as well as problems are solved. The retain process selects useful and worth remembering new experiences and decides how to mix and integrate with existing knowledge. The new case is added to the case base and this type of learning is known as incremental learning because it always adds knowledge that is new and useful in addition to the existing knowledge [30]. Generally, the new experience gained may be either success or failure and if it is success, the retain process keeps how the problem is solved by modifying existing cases or by creating a new case if it has significant difference with the existing ones[57]. Keeping failure processes helps to prevent future similar problems from such similar failure including task failure and expectation failure.

#### *2.6.2.2* **Advantage of case based reasoning**

A case based reasoning approach has tremendous advantages in the development of knowledge based system. The following are main the advantages of case-based reasoning (Simon, 2004).

- Ability to express specialized knowledge.
- Naturalness of representation
- Modularity
- Easy to knowledge acquisition
- Self-updatability.
- Handling unexpected or missing values.
- Inference efficiency.

#### *2.6.2.3* **Disadvantage of case based reasoning**

Even though case based reasoning approaches have a numbers advantage. But, due to lack of sufficient cases, the construction and inference mechanism of a case-based system loss the required objective.

Some of the limitation issues in case-based reasoning are (Prentzas, 2007):

- Inability to express general knowledge
- Knowledge acquisition problems
- Inference efficiency problems and Provision of explanations

### *2.6.3* **Integrating Rule-based and Case-based Reasoning**

Cased based reasoning uses partial matching to draw a conclusion. If some of the given problem descriptions match with a given case, then the case is applicable to the proposed solution. It also tries to handle novel problems by referring previously solved cases. Rule based reasoning uses perfect matching to apply a rule for a given problem. It doesn't handle missing information and unexpected data values [10].

Rules are suitable to represent general knowledge, whereas cases are suitable for representing specific situations. Rules in a rule based system have the abilities to represent experiential knowledge acquired from experts in a direct fashion. Cases are capable of representing specific historical knowledge. The problem here is that it is difficult to acquire complete and perfect knowledge in a complex domain. Cases are natural and easy to obtain. They can be collected from the historical record, repair logs or other sources [12].

Therefore, the integrated reasoning approach makes use of both existing knowledge and the past experiences. This integrated approach eliminates the drawbacks of each method and provides a better way to handle problems, which combine both inductive and deductive approaches [14].

## *2.7* Testing & Evaluation Methods of Knowledge based system

Evaluation can be defined as an iterative process of systematic assessment of knowledge based system. The evaluation process carried out at different stage of system development life cycle. The performance of the system was assessed or measured through quantitative and qualitative techniques to achieve the expected objective.

We can evaluate the KB structure, inference engine, user interface, etc. For this reason, evaluation must follow an order, it has to be planned and it must be controlled to reduce the cost of the final system [53].

Knowledge based system evaluation process involves to determine the suitability and desirability of the prototype [54]. Effective knowledge based system evaluation process incorporates both technical and non-technical aspects. The technical aspects include exploring of the code, examining the correctness of reasoning techniques, checking the efficiency and performance of the system and debugging errors in the early age of a system development. The non-technical aspect includes system compatible with users' satisfaction, the easiness of the system, the quality of the user interface and the acceptability of the system in the real-world environments [50].

According to Juristo and Morant [55], there are four types of evaluations to be conducted on KBS. These are verification, validation, usability and usefulness.

**Verification** is the rightness of the developed KBS to be evaluated. It can be conducted entirely on the formal model or on the computable model whose syntax is clearly stated for their rightness to be evaluated. It assures whether the knowledge on the formal model or on the computable model does not comprise syntactical faults. This means it assures the coordination between several elements of the KBS. A verified KBS denotes the acquired knowledge from domain experts and secondary sources rightly.

**Validation** is checking the knowledge base of the KBS for semantic faults that may occur during the KBS development. A validated KBS comprises the correct knowledge to perform like the domain expert in the domain area. Thus, validation searches for faults in the KBS behavior when it attempts to find a solution for a certain domain problem.

**Usability** is an association between the KBS and the end-user. This means whether the end-user is satisfied when he/she interacts with the KBS. Therefore, it must be evaluated before installing the KBS to the end-user.

**Usefulness** refers the association among the new KBS, the end-users, and the company that owns the product. The usefulness view can be noticed when the new KBS accomplishes its job. It is not possible to evaluate the new KBS if it is not functional.

**Performance measures**: Precision, Recall, and Accuracy are the common parameters used for measuring the performance of a certain classifier [43]. These parameters are defined in terms of the instances that are relevant and the instances that are correctly classified (or retrieved). The following table 2.2 shows the confusion matrix which can be used to calculate P, R and Accuracy of the classifier.

Table 2. 2 Metrics for performance evaluation

| | **PREDICTED CLASS** | | |
|---|---|---|---|
| **ACTUAL CLASS** | | Class = YES | Class = NO |
| | Class = YES | TP | FP |
| | Class = NO | FN | TN |

- The precision (P) is the proportion of the classified information which is relevant, as calculated using the equation:

  P = TP/(TP +FP)
- The recall (R) is the proportion of the classified relevant information versus all relevant information, as calculated using the equation:

  R = TP/(TP +FN)
- The F-measure is the harmonic mean of precision and recall, as calculated using the equation:

  F = 2 * P * R/(P + R
  - The accuracy (AC) is the fraction of the total number of predictions that were correct, as calculated using the equation:

  AC = (TP +TN)/ (TP + FP + TN +FN) 10.

## *2.8* Tools Used in Knowledge-Based System Development

A KBS tool is a collection of software instructions and utilities taken to be a software package designed to support the development of knowledge-based systems. KBS can be built using programming languages namely LISP and Prolog. John McCarthy **[44]** published an outstanding paper showing a handful of simple operators and a notation for functions, one can develop a full programming language. He named this language LISP (List Processing) because one of his main personal views was to use a simple data structure called a list for both code and data. There are several versions of LISP, such as KLISP and C Language Integrated Production System (CLIPS).

Prolog is a logic programming general purpose fifth generation (AI) language **[45]**. It has a purely logical subset, called "pure Prolog", in addition to a number of extra logical features. Prolog has its roots in formal logic, and in contrast to numerous other programming languages, Prolog is declarative. The program logic is expressed in terms of relations, and execution is activated by running queries over these relations. The language was first believed by a group around Alain Colmerauer in Marseille in the early 1970s. According to Kowalski **[46]**, the first Prolog system was developed in 1972 by Alain Colmerauer and Phillipe Roussel. According to Robertson and Kingston **[47],** there are around 200 KBS tools and the products are grouped into three main categories based mainly on functionality which also occur to vary markedly in the platforms on which they are available. These groups are: Shells, Languages, and Toolkits.

Inference ART and KEE are among the first commercially effective toolkits to build KBS **[24]**. In addition to support towards knowledge acquisition and representational features, there are extra features like price, flexibility, ease of use, user friendliness and vendor availability and support, and documentation support from the tool need to be weighed before final selection

## *2.9* **Review of Related Works**

Ethiopia (2002) has investigated the application of CBR system in labor law domain. Ethiopia (2002) developed a prototype CBR system, Amharic legal precedent retrieval using CBR-Works tool. Ethiopia used 39 precedent cases to build and test the prototype. Using recall and precision performance measurements, she achieved 97.5% average recall and 47.8% average precision. She has tried to show retrieving similar cases for the current problems or queries. However, among of the four major applications of CBR: Retrieving, Reusing, Revising and Retaining, she was focusing on the Retrieving application mainly and due to the nature of the tool as seen earlier some ideas for Reusing and Revising.

Abebaw Alem (2013) conducted his thesis on application of case-based reasoning in legal case management: an experiment with Ethiopian labor law cases. He develop a prototype CBR system for legal case management that could help the domain experts (lawyers) in managing legal cases in terms of: retrieving similar cases to the query from the case base, adapting the retrieved case for use, revising the adapted solutions and retaining the modified cases in the domain of Ethiopian labor law .The researcher used 50 legal cases for developing and testing the prototype system and by using 6 sample test cases he achieved 71% average recall, 86% average precision and user acceptance 86%.

Yemisrach Hailemariam (2010) application of case based reasoning in legal knowledge based system: a prototype on children criminal cases in Ethiopia .the study 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. jCOLIBRI 1.0 in a nutshell was used as the framework that aims to formalize Case-based Reasoning that provides problem solving methods of CBR and she succeeded with the value of 82.75% precision.

Beferdu Seifu (2014) web-based legal decision support expert system: the case of Ethiopia. He has tried To develop a web based legal decision support expert system that provides legal consultation and decision support service on A Case Study with Ethiopian family Law. For developing *LDSE she* uses rule based reasoning techniques and by adopting the general architecture of Expert system, he modified it by adding another component called *LDSES_Preprocessor*, which can reduce the response time of LDSES. Because of this additional

component, the knowledge engineering process called data encoding becomes easier. He achieved 87.6% overall performance of the proposed LDSES and the proposed model of LDSES for making a legal decision is about 96% effective.

Yihenew Demelash (2010) conducted his thesis on knowledge-based systems for assisting the justice system**.** He investigates the potential application of a combination of rule-based and case-based knowledge-based system to the Ethiopian civil justice system, with particular emphasis to the Ethiopian Labor Law. Based on the investigation the prototype is developed by using SWI Prolog for rule base part and jcolibri for case based parts. And the researcher uses backward chaining mechanisms. He uses both case based and rule based reasoning's but those rule-based and case-based modules of the system exist independently (yihenew 2010).

Solomon Abebe (2010) has investigated knowledge-based system for settling tort claims under the Ethiopian law. He designed a legal knowledge-based system that assists in the legal decision making process. For designing those KBS he uses SWI Prolog, The performance of the prototype system is evaluated by taking thirteen previously decided sample cases by FSCE from a total of thirty-five cases.

To conclude, several studies have been developed in law fields. And we have seen RBR is better than CBR for our purpose. Because in RBR the knowledge base is composed of set of rules, while the knowledge base in CBR is composed of a set of precedents (prior cases). Since the Ethiopian legal system is not categorized as Common law legal system, there are no well organized precedents. Therefore, it will be difficult to use CBR as a methodology for developing knowledge based court advisory decision support system for the case of Ethiopia.

# CHAPTER THREE
# RESEARCH METHODOLOGY AND MODELING

## 3.1 Knowledge-Based System Development Methodologies

Similar to the development of any other software systems, a methodological approach is essential for KBS design and implementation [66]. During the past periods, the building of knowledge-based systems was mainly done by transferring the knowledge of one or more experts [67]. However, KBS development is currently becoming a modeling activity where many of its development methodologies emphasize the use of models [15]. According to Schreiber et al. **[35],** further strengthen this idea as a KBS involves methods and techniques for knowledge acquisition, modeling, representation and use of knowledge.KBS construction is mainly enabling knowledge to be re-used in different areas of one domain.

## 3.2 Knowledge acquisition

O'Hara (1994) defines knowledge acquisition as the act of getting information out of the expert and making it available in the machine. In order to obtain the knowledge required by the KBS, the knowledge acquisition phase is undertaken by following two steps: knowledge elicitation and knowledge structuring.

In the first step, the knowledge necessary for the construction of the KBS is elicited from domain experts including lawyers and judges through a series of semi-structured interviews, discussions, and observations while experts are solving a given problem. These knowledge gathering techniques help to collect the heuristic knowledge, which is the knowledge of good practice, good judgment, and plausible reasoning in the field of family law. A total of five experts such as judges and lawyers are interviewed. The experts were selected based on their educational qualifications, experience, and their immediate job positions in the domain area.

Table 3.1 presents the profile of domain experts. Moreover, statutes books (amhara region revised family code), case reports, and journal articles in the area of family related were consulted so as to gain the explicit knowledge, which is the knowledge that is documented and widely shared.

Table 3.1 The profile of domain experts

| **Expert category** | **Number** | **Sex** | | **Qualification** | **Experience** |
|---|---|---|---|---|---|
| Judges | 3 | Male | Female | | |
| | | 2 | 1 | 2Msc, 1Bsc | 12 year |
| Lawyers | 2 | 2 | | 1Bsc,1Msc | 10 year |

Knowledge structuring and the building of model are performed in the second step based on the concepts discovered in the knowledge elicitation step. The knowledge used for building the KBS in this research is organized into five modules. These are knowledge regarding marriage, property division, child nutrition, paternity proof and adoption.

## 3.3 Knowledge acquisition process

For the purpose of this research, the process of knowledge acquisition includes some basic activities such as interview of domain expert's and review of relevant documents. The objective of knowledge acquisition is to collecting the required knowledge, interpreting the acquired knowledge, analyzing and validating the knowledge content. Based on the acquired knowledge, the proposed knowledge based system is designed using decision tree model. Therefore, knowledge acquisition process of this thesis is based on domain expert interviewing of and reviewing of related documents. This section discusses the detail of knowledge acquisition techniques as follows.

Knowledge engineering is the process of gathering and codifying an expert system's knowledge in a form that is accessible to a non-expert through an expert system. Expertise necessary to solve the problem must exist.

In knowledge engineering, there are two most important steps are significant during the development of knowledge-based systems that every knowledge engineer should consider. The first one is acquiring the required knowledge from experts and relevant documents and the second one is representing the acquired knowledge with the appropriate knowledge representation method.

## 3.4 Methods of Knowledge Collection

To fulfill objective of the study both primary and secondary source of data are employed to collect the required domain knowledge. The data collection process incorporates typical fact finding methods like interviews, questionnaires, record reviews and observation to acquire factual and explicit knowledge and concept sorting, concept mapping, and protocol to extract tacit knowledge [48].

So an interview is one of the primary methods for obtaining knowledge from source, which we can gather the needed knowledge by using semi-structured and unstructured interview from knowledge experts such as judges and lawyers. Knowledge experts were selected by using purposive sampling techniques.

Purposive sampling is a probabilistic technique that does not need underlying theories or a set number of informants. In other words the researcher decides what needs to be known and sets out to find people who can and are willing to provide the information by virtue of knowledge or experience [49]. And the second category of primary source of information is Federal Negarit Gazetta Extra Ordinary Issue No. 1/2000 The Revised Family Code Proclamation No. 213/2000proclamation No.79/2003 the Amhara national regional state family code approval proclamation which is currently in effect to handle family related cases in Amhara regions. As secondary sources of information, statute, rule, various documents, books and journals which focus on the Ethiopian family Law were assessed.

### 3.4.1 Knowledge Collection

There are different types of data collection methods used for research studies. In this research interview and document analysis data collection method were applied.

**Interviews:**

According to Fontana and Frey (1998) interview is one of the most common and powerful ways used to understand the topic under investigation. The major role of research interview is to obtain relevant information from the perspective of the interviewee (Easterby-Smith et al). An interview is defined as a social encounter that involves the interaction of the researcher and respondent (Wilson, 1996). According to King (1995) an interview process involves four major steps: defining the research question; creating the interview guide; recruiting participants; carrying out the interview.

Interviews can range from structured to unstructured interviews, the semi-structured interviews being in the middle of the two. Structured interviews involve the use of a set of predetermined questions and the interviewer has to ask them in the exact form and order prescribed. With unstructured interviews, the interviewer has greater freedom in formulating and ordering the questions and even asking new questions. However, an interview guide with a number of salient questions and issues to be investigated guides a semi-structured interview. But the interviewer is given flexibility in wording and ordering the questions asked (Erlandson et at, 1993).

In this research personal or face-to-face semi-structured and unstructured interviews were selected and we have used A total of five experts are interviewed. The experts were selected based on their educational qualifications, experience, and their immediate job positions in the domain area, so two lawyer and three judges both in woreda and regional courts are purposively selected for the interview. From such interviews, it was able to understand how the statute in family codes of Ethiopia was used to reason out for certain claims.

The first strategy we have used for the knowledge engineering purpose was just fabricating a sample case that might be present in the Court. Second, we identify the possible methods that the judges in the court might have used in arriving at a final verdict, and then finally we draw the logic flow chart and write the equivalent rules which act as a rule.

According to the court staff, when a plaintiff comes to court to file a complaint, we find that they have difficulty writing in an organized manner. and also they do not have any system to help the trial process and they want to have a system that facilitates this process.

**Document Analysis:**

Document analysis is another method to get further understanding about the legal system of family law in Ethiopia. According to Erlandson et al, (1993) it describes this method as broad range of written records as well as any available material or data. Then we use Federal Negarit Gazetta Extra Oridnary Issue No. 1/2000 The Revised Family Code Proclamation No. 213/2000 proclamation No.79/2003 the Amhara National Regional State family code approval proclamation which is currently in effect to handle family related cases in Amhara regions and statute, rule, various documents, books and journals which focus on the Ethiopian family Law were assessed. We have also seen the records of court cases, but according to the data from 2010 to 2013, out of 5017 cases filed in the court, 1954 are family-related cases, but the number of cases seen in the court has increased and it's not proportional the judges and the cases to be handled.

## 3.5 Knowledge Modeling

After knowledge has been gathered from domain experts and different sources, a model for representing the knowledge is modeled using decision tree and represented using production rule which is one of the knowledge representation techniques. Production rules are easy for a human expert to read, understand and maintain. Decision trees models by constructing a tree based on training instances with leaves having class labels is used. These are easy to interpret. It can be represented as if–then-else rules.

Knowledge modeling involves organizing and structuring of the knowledge which is gathered during knowledge acquisition. Its packages are combinations of different knowledge or concepts into a reusable format for the purpose of preserving, improving, sharing, aggregating and processing knowledge to simulate intelligence. Here, the basic concepts that reveal the main activities and decisions that are made to solve cases in the domain are modeled.

There are many techniques used for knowledge modeling such as decision tree, semantic network, UML, and hierarchy of frames. For knowledge-based systems, decision trees have the advantage of being comprehensible by domain experts and of being directly convertible into production rules i.e. decision tree has the ability to represent the problem in natural and simple if-then [38].

According to Richard et al. **[39]**, Decision tree commonly acts a key role in a knowledge modeling process. Decision tree is used for the search space of a certain problem and presented by a graph. A node in the tree denotes a decision to be attained when finding a solution of a certain problem, and the branches extended from the node show the potential values of the decision. To find the solution of a certain problem, anyone then traces by way of its tree using data of a certain problem to select a branch at every node. Moreover, when used to handle a given case, a decision tree not only provides the solution for that case, but also states the reasons behind its choice. Thus, decision tree is used in this study to model the elicited domain knowledge and we used amhara revised family code to design the decision tree.

### 3.5.1 System Development and Implementation Tool

In this study, a knowledge engineer is involved throughout the development process of the knowledge-based system. Four major procedures or steps are followed in developing the KBS. These are:

a) **Knowledge acquisition**: The knowledge engineer interviewed four domain experts to extract the tacit knowledge. The knowledge engineer also acquires the explicit knowledge from relevant documents such as proclamation, statute and rule.

b) **Knowledge modeling**: The acquired knowledge is modeled using decision tree by constructing a tree based on training instances with leaves having class labels.

c) **Knowledge representation**: After modeling the acquired knowledge using decision tree, it is represented using production rule which is easy to understand and reasonably efficient in judge problems of the form: IF (condition), THEN (conclusion).

d) **Testing and evaluation**: Finally the prototype is built and extensively tested and evaluated to make sure whether the system is accepted by the end-users and the performance of the system is accurate.

Akerkar and Sajja**[40]** noted that the knowledge engineer should play a crucial role in knowledge elicitation, knowledge modeling, knowledge representation, implementation, testing and evaluation of the KBS.

To develop the proposed system, Prolog language is used to demonstrate the potential of knowledge-based systems in the area of Family Law. The programming language PROLOG (PROgramminginLOGic) is an implementation of predicate logic for computing and is therefore a natural environment for using predicate logic to represent knowledge in a domain; many successful applications have been developed in PROLOG (Bramer, 2005). Prolog language is chosen because of its built-in pattern matching, rule-based programming and backtracking execution.

### 3.5.2 Conceptual modeling of marriage issues

The Ethiopian constitution explicitly states that “marriage shall be entered into only with the free and full consent of the intending spouses” and the minimum legal age for marriage is 18 for both boys and girls, but these laws are not always enforced. The rate of child marriages has declined significantly over the past decades. However, according to UNICEF's 2017 estimate, 40% of girls are married before the age of 18.

To manage such types of problems in marriage there is the ethiopian constitutions so in this researche we are going to make or model desccision suport systems to support judjement processes. For example: someone asks the legal expert for advice about “is our marriage valid or not ” then the legal expert examines whether the person will satisfy all the essential condition of marriage by asking a series of questions. If the essential condition of marriage is satisfied, then the legal expert will respond the marriage will be valid. Otherwise, the marriage will be invalid by asserting the reason why it will be invalid.

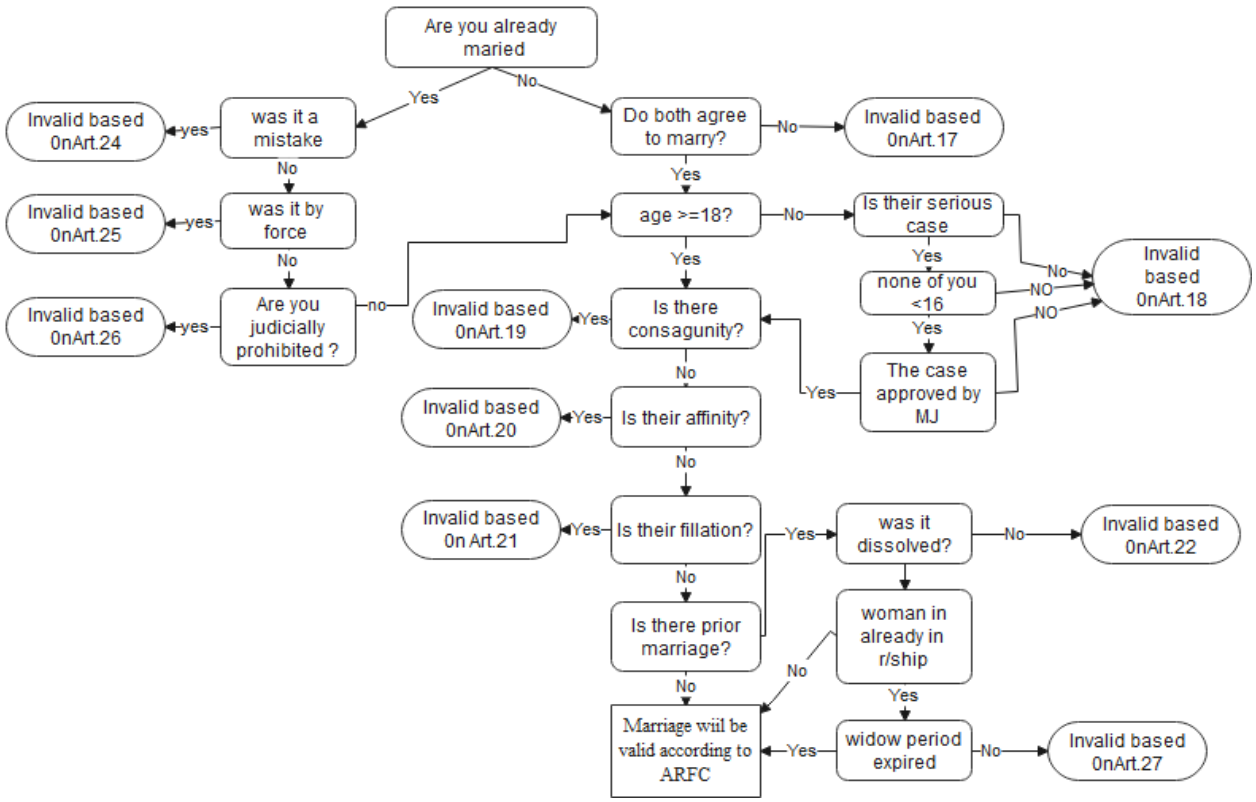


Figure 3.1 Decision tree for check the marriage will be valid or not according to ANRSRFC

### 3.5.3 Conceptual modeling of minors

Amhara family law covers thirteen chapters and there is one chapter dealing with minors. Minors is a person of either sex who has not attained the full age of eighteen years, and a person under the age of full legal responsibility. The chapter divided in to five sections those are **,**General Provisions, Organs of Protection of Minors, Powers of the Guardian and of the Tutor, Sanction of the Rules for the protection of the Minor and Cessation of the Disability of the Minor. In between those sections there are subsections listed under Care of the Person of the Minor, Administration of the Property of the Minor, Acts of the Minor, Acts of the tutor, Liabilities Which May be Inclined, Emancipation and Rendering of Accounts of Tutorship.

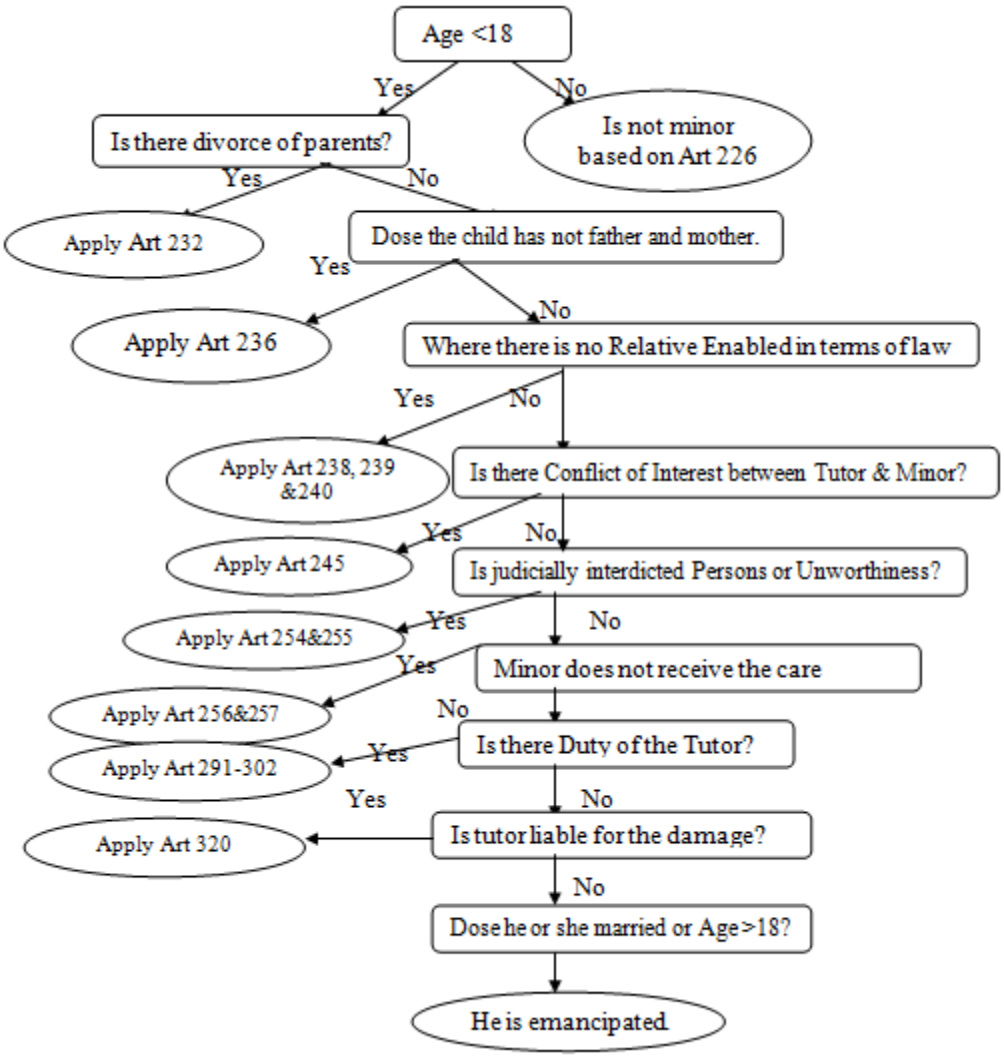


Figure 3.2 Decision tree for minors

### 3.5.4 Conceptual modeling of obligation to supply maintenance

In the obligation to supply maintenance, the person bound to supply maintenance under Article 209 of this Code shall supply to his creditor the means to feed, lodge, clothe, and to care for his health and education, as the case may be, in a decent manner having regard to social conditions and local custom. Without prejudice to the provisions of Article 60 (1), an obligation to supply maintenance exists between ascendants and descendants, and between persons related by affinity in the direct line. And also an obligation to supply maintenance likewise exists between brothers and sisters. The amount of such allowance shall be fixed by taking into consideration the needs of the person claiming it and the means of the person liable there to.

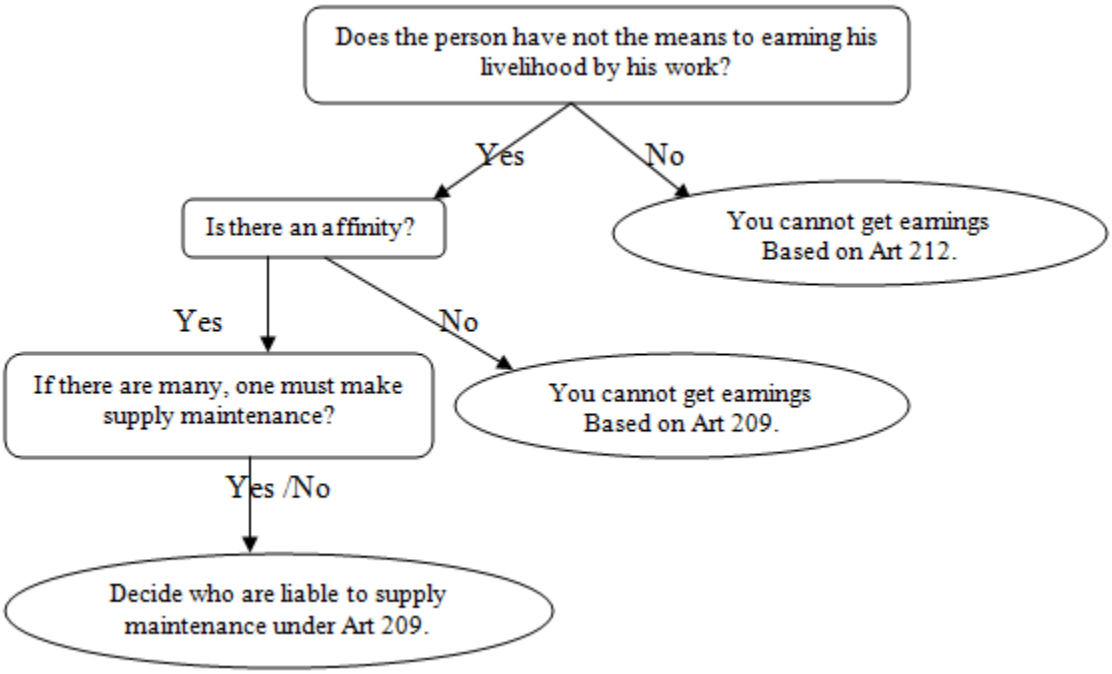


Figure 3.3 Decision tree for obligation to supply maintenance

### 3.5.5 Conceptual modeling of Filiations

The revised family codes in the filiation's chapters said that unless the law expressly authorizes, the legal rules concerning the ascertainment of paternity and maternity shall not be derogated by agreement.

Maternal Filiation:-it is ascertained from the sole fact that the woman has given birth to the child. Paternal Filiation. Paternal filiations results from the maternal filiation when a relation provided for by the law has existed between the mother and a certain man at the time of the conception or the birth of the child, it may result from an acknowledgement of paternity made by the father of the child. And it may also result from a judicial declaration.

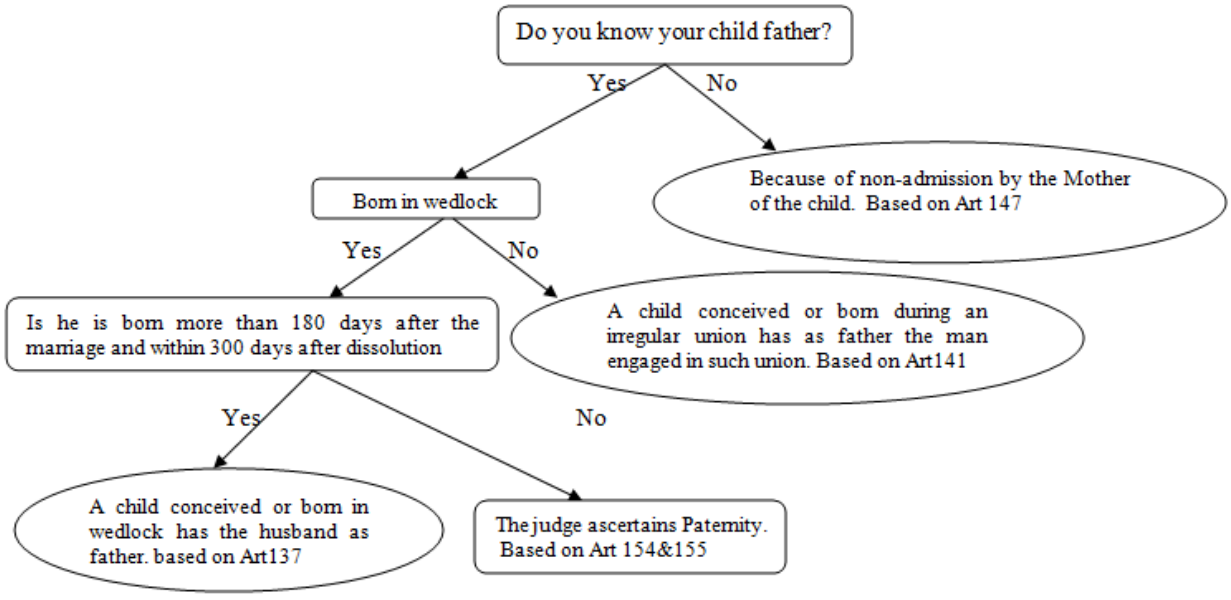


Figure 3. 4 Decision tree for filiations

### 3.5.6 Conceptual modeling of adoption

Adoption is one of the chapters included in the family law and tells us about the rights and obligations of adoptees. In this chapter there are seventeen articles .According to the Ethiopian Family Law the adopter must attain the age of 25 years to adopt a child. Age of the adoptee, any child whose age is less than 18 years and under guardianship may be adopted.

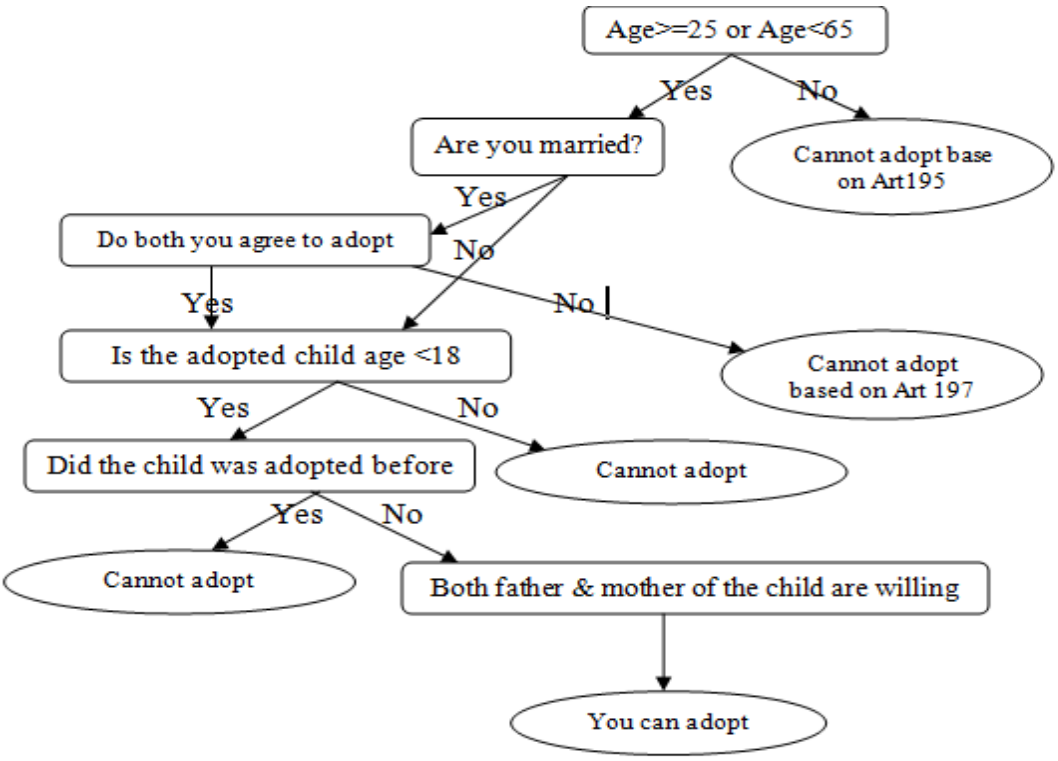


Figure 3.5 Decision tree for adoption cases.

The entire discussions made in this chapter revolve around capturing the essential knowledge for handling family related case from domain experts, statute books, and journal articles followed by the modeling of the elicited concepts which serve as a blueprint for the representation of the Knowledge inside the machine.

The next chapter presents the representation of the acquired knowledge, the testing of the knowledge base for accuracy and completeness, and the performance evaluation aspects at length.

# CHAPTER FOUR

## IMPLEMENTATION AND PERFORMANCE EVALUATION

In the following sections, the implementation includes the construction of the prototype knowledge based system to make court advisory decision support using rule based reasoning approach. After the necessary knowledge is acquired and modeled using decision tree, the next step is represented using a production rule and coding the represented knowledge using Prolog programming language into a suitable format that is understandable by the inference engine of rule base reasoning. To this end, the researcher first attempt to design the knowledge based system architecture as presented here under

### 4.1 Architecture of the System

The KBS development follows two phases, the first one, the knowledge engineer collects both tacit and explicit knowledge. The tacit knowledge is the important knowledge for designing the KBS that serves in family related cases, is acquired from domain experts. In addition, the codified knowledge is gathered from manuals and law documents. Then, the knowledge is modeled and represented using rule-based knowledge representation technique, which is stored in the knowledge base.

The other one is, users (domain experts) are requesting the system for advisory services. Through the user interface, users provide their queries and then the inference engine, which is implemented using backward chaining, is initiated to search for rules in the knowledge base that are matching with the user's query. Accordingly, the solution is communicated back to the user through the user inference.

The architectural design of the KBS serves as a blueprint for the implementation of the system. And architecture is an outline showing how the components of the prototype knowledge based system interacts and interrelates. This system was designed with the sequence of conceptual design that refined the systems architecture.

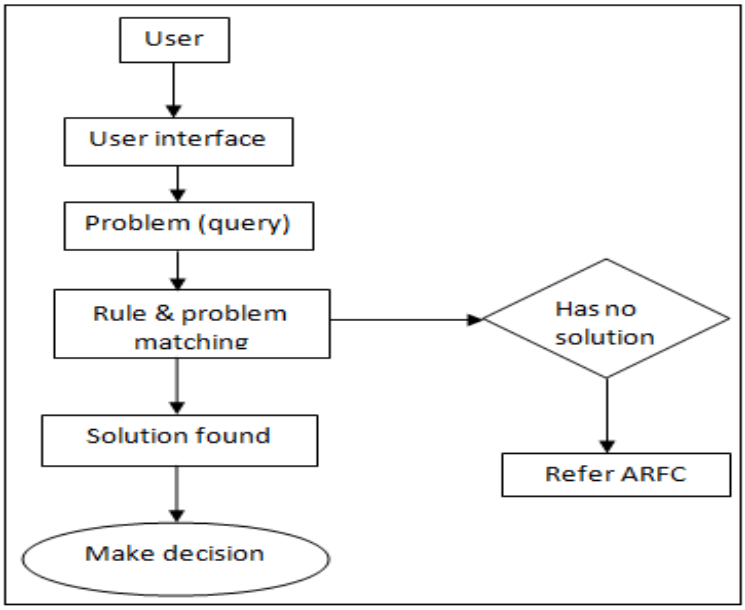


Figure 4.1 Architecture of the prototype knowledge-based system

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**User**: Its judges.

**User interface**: Bridge through which the user interacts and communicates easily with the system prototype.

**Problem (query**): A written accusation file.

**Rule and problem matching**: It's the rule of Amhara region revised family codes and this is the stage at which the verdict is considered by inserting the written case file into the model.

**Make decision**: It means that dose it matches the problem with stored in prolog rulings and will get decisions.

The implementation of the system is done into two phases: writing codes using the PROLOG programming language and performance evaluation. The purpose of implementation is to show how the knowledge is codified internally and then to test the system is built right. Extracted knowledge from document and experts are used for designing rule-based reasoning system. In addition, researcher tried to see precedent cases, both the ANRS supreme court and Bahir Dar zuryia woreda court office are willing to study file but they are not give copy of files because, saying that it contradicted the secrecy of private information of the case owner. So we were fabricated a sample case that might be present in the Court.

## 4.2 Knowledge Representation

Prior to the discussion of the internal representation of the knowledge for use by the KBS, it is better to give a general idea on how the knowledge is going to be encoded using the rule-based approach.

### 4.2.1 Knowledge Coding

The prototype KBS comprises of five modules: marriage, minors, obligation of supply maintenance, filiations and adoption. The marriage module deals about marriage. The minors and child nutrition module, if a couple divorce, those two modules will determine the distribution of property and child support. The other module is adoptions; it is the action or fact of legally taking another's child and bringing it up as one's own, or the fact of being adopted. Adoption module will make a decision how to adopt legally the child.

The knowledge concerning about marriage consists the following:

- Make sure the marriage is in the interest of both parties.
- The marriage must be in accordance with the Amhara revised family codes.

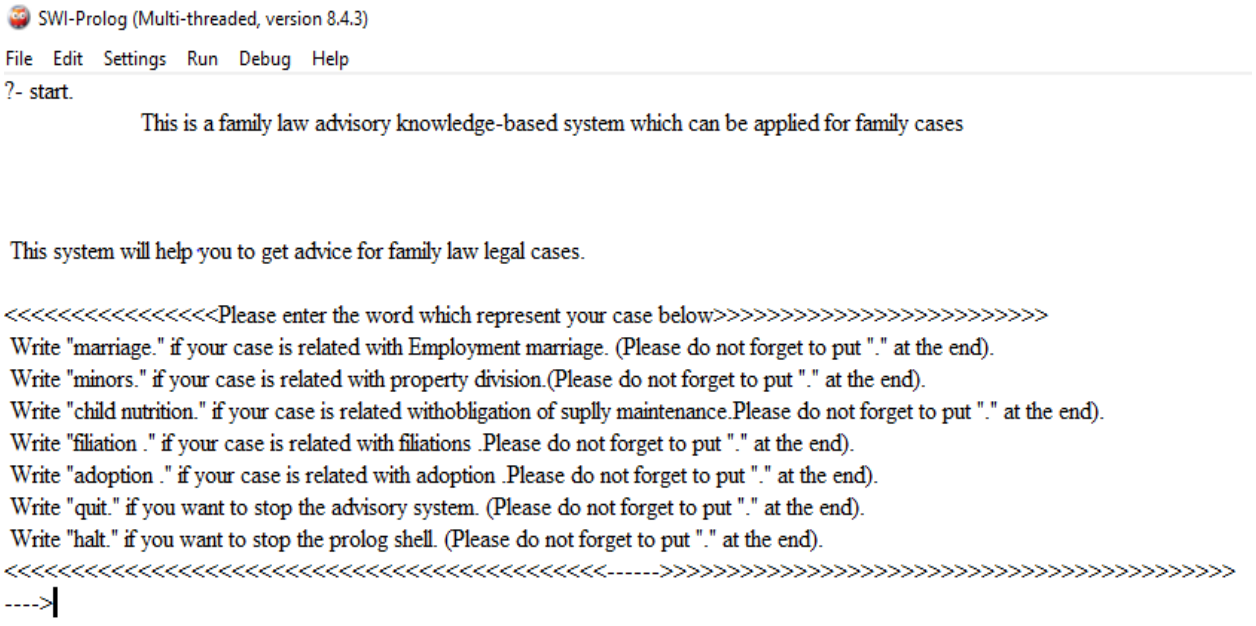



Figure 4.2.The first page of KBCADSS

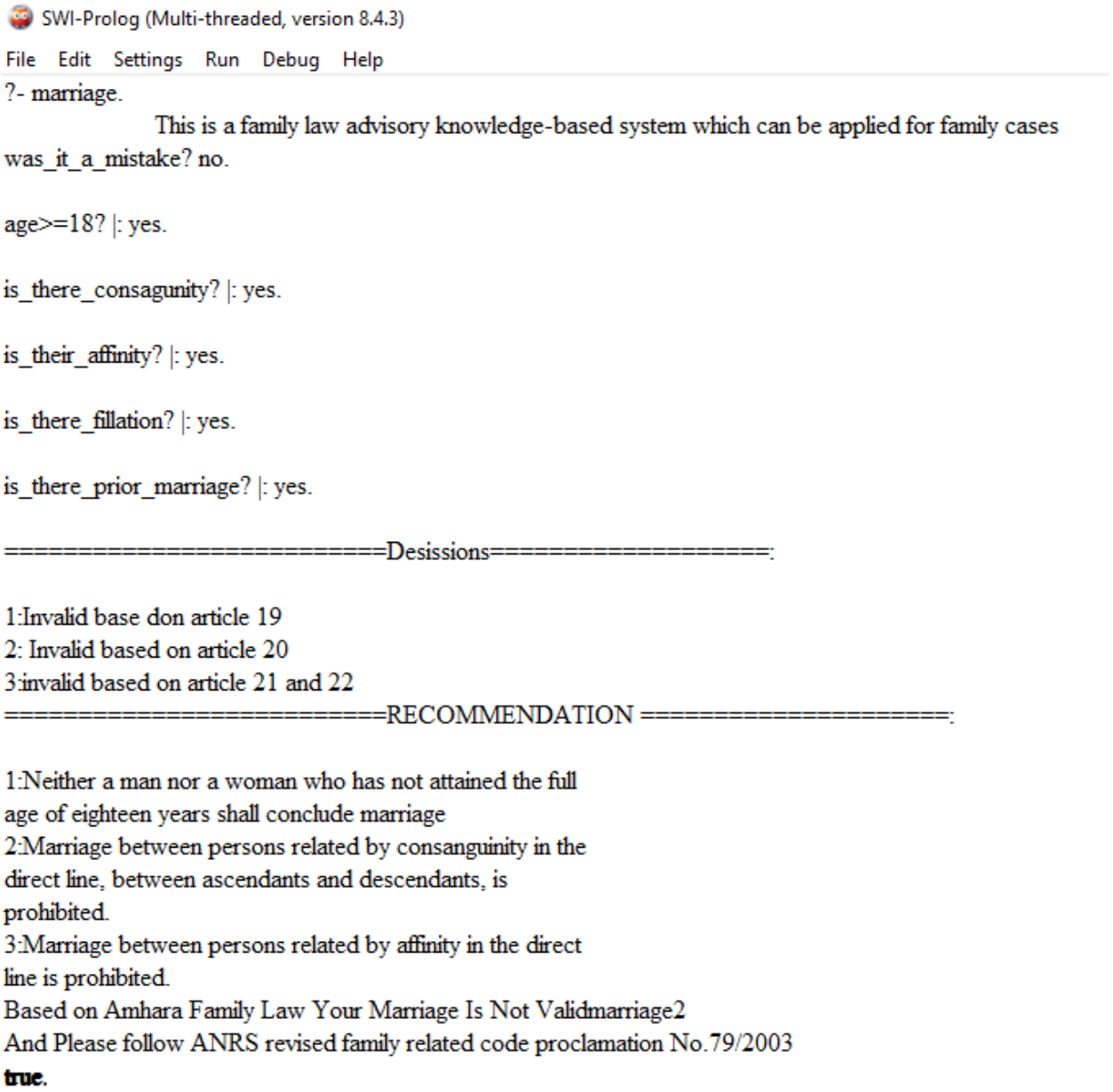
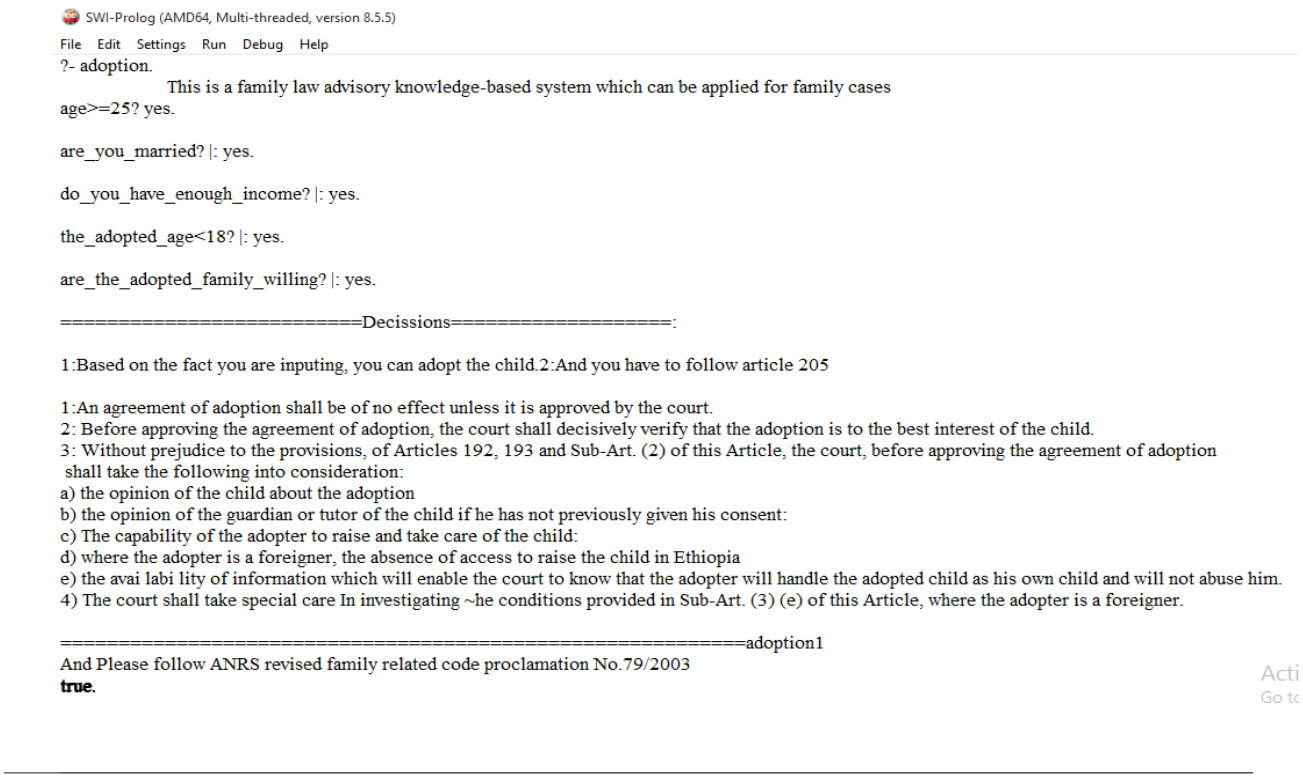



Figure 4.3 sample dialogs that decide about marriage.



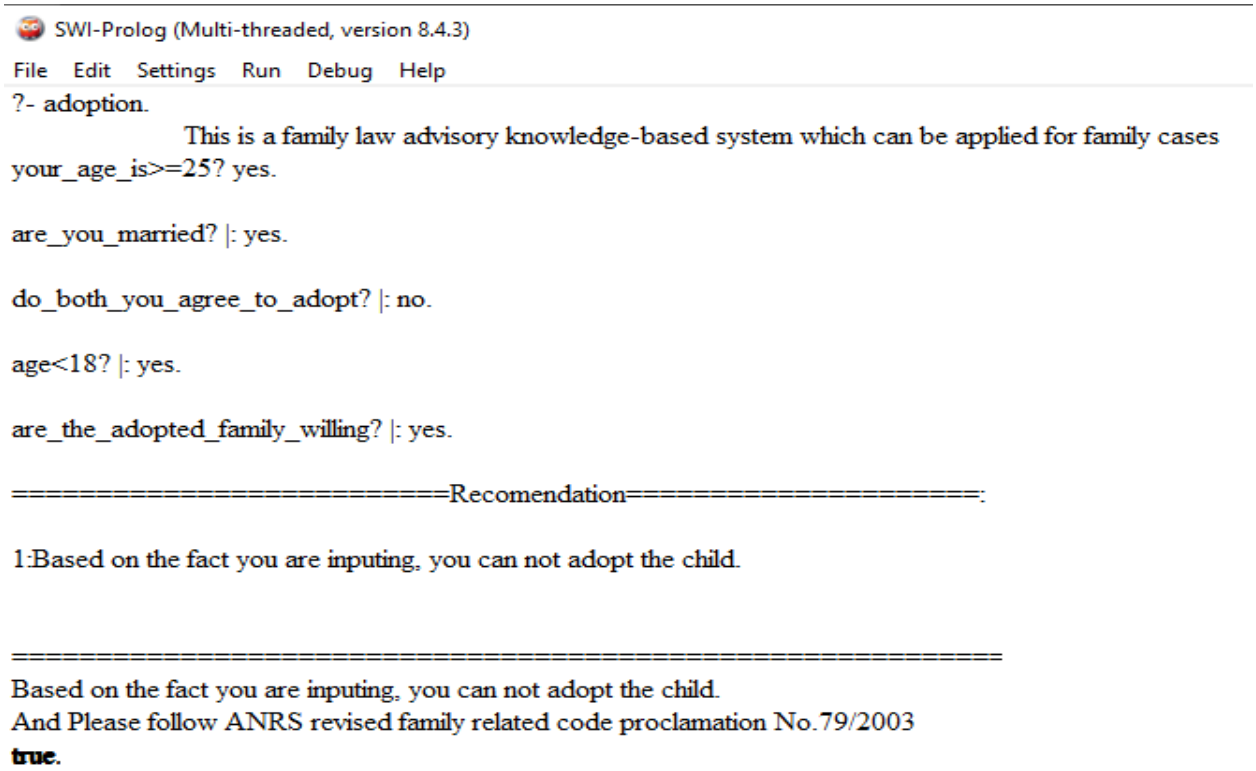




Figure 4.4 sample dialogs that decide about adoption.

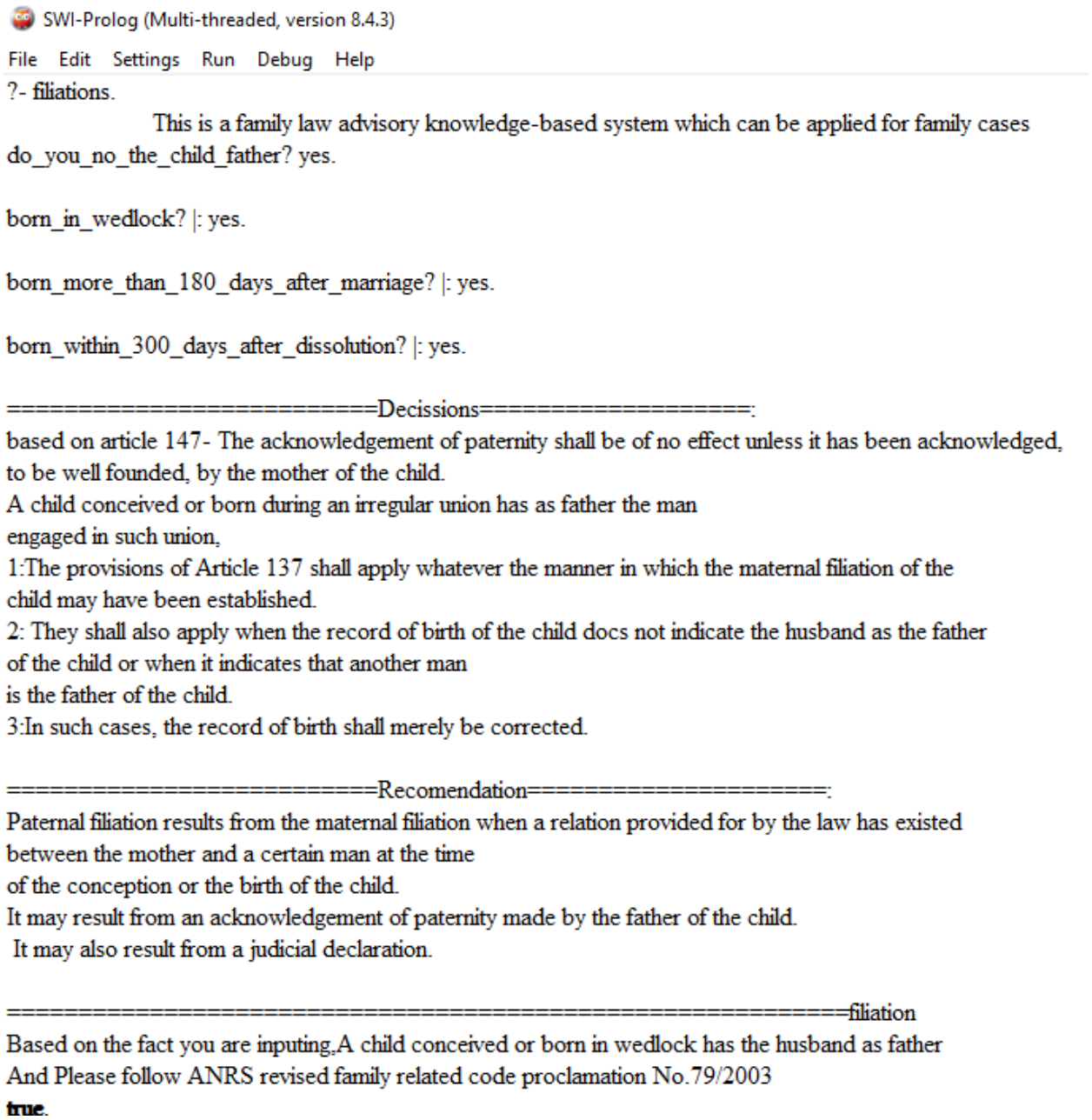



Figure 4.5 sample dialogs that decide about filiations.

### 4.2.2 System Testing

After the prototype knowledge-based system for court decision making is implemented in ProLog (**Pro**gramming in **Log**ic) using SWI-Prolog editor tool, ultimately every knowledge-based system must be tested and evaluated to ensure that whether the performance of the system is accurate and the system is usable by the end-users.

For evaluating the performance of the system by taking previously decided sample cases, non live test data were used in non-live environment for the purpose of system testing. Both the data and situations are artificially developed or fabricated which are similar to what users would encounter in the real life situation. The checking of the proper manipulation of the knowledge base by the inference engine and the checking of the responses obtained from the different inputs were done by the researcher as well as by the intended users who were not participating in the knowledge acquisition phase (one lawyer and one judge).

The scope of testing and evaluation that is accomplished and the significance involved to it rely on the size, complexity, and other features of the knowledge-based system. As the aim of testing and evaluation of the knowledge-based system is to assure that the prototype system does what it is required to do, we can test and evaluate a knowledge-based system as long as we already understand what to expect. Therefore, in this the system is tested by users (judges).

## 4.3 Performance Evaluation

After Designing and implementing knowledge-based system the next step is testing the performance of the system whether is achieve the objective or not. Performance evaluation is performed to ensure whether the prototype system works properly or not, and to ascertain what the system knows, what it incorrectly knows, and what it doesn’t know. To do this, four experts from legal domain (two judges and two lawyers) who were not participating in the knowledge acquisition stage are made to use the system and evaluate it.

At the end of their evaluation, they were asked to assign values (Poor, Fair, Good, Very good, and Excellent) based on the evaluation criteria set as ease of the user interface, appropriateness of queries/questions for making decision, adequacy and clarity of decision made, and the KBS doesn't take forever (loops) to make its inferences. The questionnaires used to test the performance of the prototype system by domain experts is found in appendix I

The researcher fixed values for each attributes of the questionnaire for the purpose of evaluating the performance of the prototype system on the side of the end-users. The values for all attributes are fixed as: Excellent = 5, Very good = 4, Good = 3, Fair = 2 and Poor = 1. This allows the domain experts to put their values for each criteria of evaluation. The following table 4.3 illustrates the outcomes achieved after evaluation by domain experts.

Table: 4.1 the Performance Evaluation of the System by Domain Experts

| **No** | **Criteria of evaluation** | **Poor** | **Fair** | **Good** | **Very good** | **Excellent** | **Average** |
|---|---|---|---|---|---|---|---|
| 1 | Simplicity of use and interact with the prototype system, | 1 | 0 | 1 | 2 | 0 | **3** |
| 2 | Efficiency in time, | 0 | 0 | 0 | 1 | 3 | **4.75** |
| 3 | The ability of the prototype system in making the right decision and recommendations, | 0 | 0 | 0 | 2 | 2 | **4.50** |
| 4 | The importance of the prototype system in the domain area. | 0 | 0 | 0 | 1 | 3 | **4.75** |
| | | Total average | | | | | **4.25** |

As shown in the above table, 50% of the evaluators scored the simplicity to use and interact with the prototype system criteria of evaluation as very good, 25% as good, and 25% as poor. The second evaluation criteria in the efficiency of the prototype system with respect to time criteria of evaluation, 75% of the evaluators scored as excellent, 25% as very good. The ability of the prototype system in making right conclusions and recommendations criteria was scored by half of the evaluators as excellent and half of the evaluators scored as very

good. The importance of the prototype system in the domain area criteria, 75% of the evaluators gave the prototype system excellent while 25% rated the prototype system as very good. Finally, the average performance of the prototype system according to the evaluation results filled by the domain experts is 85% which is above very good.

## 4.4 Discussion

As the system evaluator's response indicated, the proposed knowledge based system is promising and applicable in the domain area. The feedback and suggestion of domain expert reveals that the proposed knowledge based system satisfactorily gain user acceptance.
The table below shows the summary of system performance evaluation result obtained from close ended questions.

Table: 4.2 summaries of system evaluators Result on Close Ended Questions

| **Respondent who respond as** | **Poor(1)** | **Fair(2)** | **Good(3)** | **Very good(4)** | **Excellent(5)** | **Avg Perf.** |
|---|---|---|---|---|---|---|
| **Total number** | 1 | 0 | 1 | 6 | 8 | 4.25 |
| **avge out of 100%** | 6.25 | 0 | 6.25 | 37.5 | 50 | 85% |

As shown the table 4.2 above indicates based on system performance gained from user's visual interaction using the closed ended questions. There is no evaluators respond as fair, evaluators reply poor only one times (6.25%), good one times (6.25 %), very good six times (37.5%) and excellent eight times (50%). The total average user acceptance evaluation result of knowledge based system is 85%.

Generally, the performance of the knowledge based system has got good user acceptance by the system evaluators. As a result, the knowledge based system would assist human expert to provide a better judgment service.

# CHAPTER FIVE
# CONCLUSION AND RECOMMENDATION

## 5.1 Conclusion

The earlier chapters have brought to light some significance issues in developing knowledge based model to optimize court decision making process. In this part, the researcher concludes the study work and gives recommendation for future investigation in the law fields. In the world of scarce resources, law plays a vital role in resolving conflicts by protecting one goal set over another.

Family law is a legal domain which focuses on issues involving family relationships such as marriage, adoption, divorce, and child custody, among others. In developing the prototype system, knowledge is acquired using both structured and unstructured interviews with domain experts and from relevant documents by using documents analysis method to find the solution of the problem. The acquired knowledge is modeled using decision tree that represents concepts and procedures involved in court decision making process. Then, the validated knowledge is represented using rule-based representation technique and codified using SWI-Prolog editor tool for building the knowledge-based system to provide advice for family related cases.

The performance of the prototype system is evaluated by taking ten fabricated sample cases in order to test the accuracy of the prototype system. The correct and incorrect results are identified by comparing decisions made by the domain experts on the family cases and with the conclusions of the prototype system. And also the process of ensuring that the prototype system satisfies the requirements of its end-users is performed. This permits end-users to test the prototype system by actually using it and evaluating the benefits received from its use. As the testing result show, the overall performance of the prototype system registers 85%.

In general the prototype system enables lawyers and judges to have access to a good deal of knowledge and assists them in making appropriate decision by reducing the time required in consulting the large volumes of statute books and in analyzing the complex family related claims.

Finally, the prototype system achieved a good performance and meets the objectives of the study. However, in order to make the system applicable in the domain area for court decision making process, some adjustments like automatically updating the rules in the knowledge base of the system, incorporating a well designed user interface and a mechanism of NLP facilities are needed.

## 5.2 Contribution of this work

The major contribution of this work was design and develop knowledge based decision support model in cases of Amhara region family law. And we showed that using a system as it is possible to provide legal supports for judges.

To develop the proposed Knowledge Based Court Advisory Decision Support System, we did the following:-

- We studied about the domain knowledge, in detail.
- We reviewed the related work for developing expert system in the areas of legal matters especially family law.
- We developed a decision tree, which makes designing and testing Knowledge Base
- Finally, we develop and validate the KBCADSS model.

## 5.3 Recommendations

The study achieves its objective by demonstrating rule based reasoning approach in designing knowledge based system for court advisory in cases of Amhara region family law. However, there are problem areas that need further investigation and the researcher recommends the following issues as a future research direction based on this study.

- A method must be investigated on how to integrate the prototype system with the existing court case management system. This would lead to the development of standards applicable to all, enabling suitable information exchange and planning for additional improvement of functionality.
- A smart phone is one of the main ways of making work efficient and convenient. Hence, further research is recommended to explore on how to integrate the KBS'S to phone.
- To enhance the performance of the knowledge based system the hybrid strategy approaches should be investigated which combines case based reasoning. The inclusion of case based reasoning helps the system to learn from documented experiences.
- Further study is needed to enhance user interface of the prototype system by adding local language.

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# APPENDICES I

1. What is family law?
2. How many family cases are handled by the court every year?
3. Judges and lawyers in the court are proportional to the cases that come?
4. How soon will he give judgment for the cases that come?
5. Is there a system that helps the judgment process?
6. If not, are you interested in providing a system-assisted trial?
7. Do you believe that doing work with the help of the system will save us a lot of time?

# APPENDICES II

The importance of this evaluation form is to evaluate to what extent the prototype system is usable by the end-users in the domain area. I would like to thank for your cooperation and valuable information.

The values for all attributes in the following table are fixed as: Excellent = 5, Very good = 4, Good = 3, Fair = 2 and Poor = 1.

| **No** | **Criteria of evaluation** | **poor** | **Fair** | **Good** | **Very good** | **Excellent** | **Average** |
|---|---|---|---|---|---|---|---|
| 1 | Simplicity of use and interact with the prototype system, | | | | | | |
| 2 | Efficiency in time, | | | | | | |
| 3 | The ability of the prototype system in making the right decision and recommendations, | | | | | | |
| 4 | The importance of the prototype system in the domain area. | | | | | | |
| | | Total average | | | | | |

**N.B:** Put „X" symbol on the available place for the corresponding attribute values for each criteria of evaluation.

# APPENDICES III

Sample Test Cases

1. In a charge sheet dated 12-3-2010, a thirteen-year-old fifth grade student was forced by her parents to marry a forty-year-old adult and drop out of school. Therefore, I request the honorable court to stop this marriage because it is an invalid marriage. It can be confirmed from her own words that the marriage was against her will and the court can verify her ages from education certificate.

**Fact**.

- The fact that the marriage was against the consent of the girl.
- The fact that she is not old enough to marry.

**Evidence.**

- The fact is supported by evidence.

**Rules Applied:** Articles 18.

**Decision By the court.**

According to Article 18, the court annulled the marriage because it was an early marriage.

**Decision By the prototype**

After asking different questions, the system decided the case as:

The system decides the marriage is invalid marriage based on article 18.

- Neither a man nor a woman who has not attained the full age of eighteen years shall conclude marriage.

**Discussion**

Similar decision forwarded by the court and the system that the marriage is not valid.