

A Legal Expert System for Solving the Complexity of Inheritance Problems

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Abstract

The artificial intelligence is actually a method, providing the necessary infrastructure to perform intelligent operations by computer. The expert systems are considered as one of the general applications of the artificial intelligence. The legal expert systems examine the application of the expert systems in the field of law. The inheritance is considered as one of the most difficult and challenging issues in the field of law in Iran and its various aspects should be examined by legal expert. Given the complexities in the inheritance division and the existence of numerous laws and exceptions, the present study aimed to eliminate these complexities by developing a legal system to resolve the inheritance problems. The proposed system is based on the rule-based expert systems, using the if-then rules in their inference. The system interacts with the user and asks questions by the user interface designed separately for all three classes of the inheritance. The inheritance share of each heir is determined in the inference section and made available to the user by using these questions and information provided by the user to the system. The law experts were asked to design questions with high complexity to evaluate the performance of the proposed expert system. The recommendation of the proposed system was compared with the experts' response and the results indicated the system performs in dealing with the different conditions along with exceptions.

Keywords: Artificial intelligence, expert systems, inheritance problem, legal expert systems

1. Introduction

In recent decades, the information technology and artificial intelligence have been highly developed in various ways such as expert systems in the legal domain (Opijnen & Santos 2017 [1]). The Legal Expert System (LES) creates a link between the artificial intelligence and the law. The LESs make legal arguments and can reason and think like a lawyer. These systems may be designed for the public or individuals with expertise in the area of law to address complex legal problems (Cornelia et al. 2015 [2]). The systems designed for the use of experts in the field of law are used to speed up arguments and improve the accuracy of the legal investigations conducted to advise clients. Given that these systems are designed for experts, the questions asked from the user or the provided reports require information about laws. In other words, a LES which called "automatic legal service/advise system", "computerized legal advisor", "legal knowledge-based systems" or "automatic generator of legal documents" is a computer program that tend to replace judges and simulate the specific work of lawyer and judge (El Ghosh et al. 2017 [3]). The LESs known as legal decision support system would not only help the legal professionals (lawyers, judges, legislators) to draw specific conclusion and obtain information on what law to apply in a specific case in a timely and flexible manner, but

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would also reduce the internal cost of the legal research and reduce the cost of legal services and solve legal questions for clients (Di Giorgi et al. 1992 [4]; Bell et al. 2018 [5]; Dimyadi et al. 2019 [6]; Mohammadi Motalgh et al. 2018 [7]).

The inheritance problem and determining the share of each heirs from the decedent's property is one of the most complex, controversial and difficult problems in the Iranian judicial system. Because of the multitude of heirs, their varied relationships with the decedent and the complexity of the laws, it is difficult for many judges and lawyers to understand and determine the share of the deceased's property. An examination of a number of inheritance cases in the Iranian judiciary shows that the complexity of the inheritance problem is the main cause of the prolongation of proceedings. Despite the long history of the related judge, we sometimes encounter with the wrong votes at trial in specialized legal authorities such as the court due to the complexity of the issues and the mismatch of the case (project) with the "rules". On the other hand, the Judiciary of the Islamic Republic of Iran (JIRI) has been reported that ignorance, lack of knowledge and low legal literacy of the people is one of the sever problems in the Iran legal system. Accurate, rapid and timely advices and calculations in the inheritance problem can greatly alleviate the growing burden of Iranian judiciary and can increase public knowledge and awareness of the laws and transparency and trust in the judiciary and the court.

The use of computer is essential and inevitable for overcoming this problem due to its high accuracy and low error. Designing and building an efficient legal expert system could have a significant role for this purpose. Therefore, the present study aimed to develop a rule-based legal expert system for the inheritance problem in Iran. The laws related to the inheritance problem are studied and the appropriate knowledge base including the set of rules and mathematical formulas are extracted. A legal expert system with user-friendly interface is designed which can be used by judges, lawyers or law experts to assist in inheritance problem.

2. Literature Review

In this section, the LESs and their background are reviewed.

2.1. Expert Systems

The computer-based systems which are known as Expert Systems (ES) are used in solving problems that can usually be solved by an expert in a particular field such as law, industry, business, or commerce. They are part of the high-level software or high-level programming language which attempt to enhance the expert functionality by advising like an expert. To increase the applications of expert systems, researchers try to increase the capacity of expert systems to think and reason. In the other hand, some problems need to be solved is not only the algorithm but also the expert-field. The aim of ESs is not to replace humans, but to present human knowledge in form of a support system. Expert systems are made in the area of knowledge for a particular expertise approaching human capabilities in one specific field. Therefore, the ES is a software-based system that create or evaluate decisions based on rules defined in the software.

2.2. Artificial Intelligence and Law

Law known as a system of rules that is created and enforced through social or governmental institutions to regulate behavior. The law is one of the most complex disciplines (Dimyadi et al. 2019 [6]). To understand some areas of law such as tax or inheritance laws requires simultaneously different knowledge and skills such as process of lawmaking, interpretation of legal rules, accounting, mathematics, ability to process the large amount of data, etc. Judges, lawyers, and legal professionals may not have all of these skills and knowledge and hence make mistakes in their decisions. Therefore,

it seems that the use of computer science can reduce the complexity to some extent and assist them as a decision support system. Sourdin [2017,8] summarized the emerging and changing technology in justice system at three levels: (1) supportive technology: informing, supporting and advising systems, (2) replacement technologies: replacing technology with human activities, (3) disruptive technology: using artificial intelligence to change judicial processes.

Artificial Intelligence (AI) as a rapidly developing technology is a software system allows computers to think and act in an intelligent manner such as a human or imitate human ways of thinking (Cˇerka et al. 2017 [9]). Since the advent of artificial intelligence in the 1980s, the AI has been developed and used to solve problems in many disciplines such as mathematics, management, industry, healthcare legal, etc. (Russell and Norving, 2009 [10]; Greenleaf et al. 2018 [11]).

Using the capabilities of artificial intelligent technology in the law domain, known as legal artificial intelligence systems, not only would solve the complex problems in the law (Waterman et al. 1986 [12]) and assist the legal professionals in their decision making (Di Giorgi et al. 1992 [4]), but would also empower the system users to take advantage from the expertise and judgement of experts anytime anywhere and cost effectively (Dimyadi et al. 2019 [6]). The legal artificial intelligence systems, as a profitable domain for AI development, are divided into the main categories of the legal retrieval systems and legal analysis systems (Cornelia et al. 2015 [2]; El Ghosh et al. 2017 [3]; Tastle and Buscema, 2013 [13]). Fig. 1 indicates the general classification of the legal artificial intelligence systems.

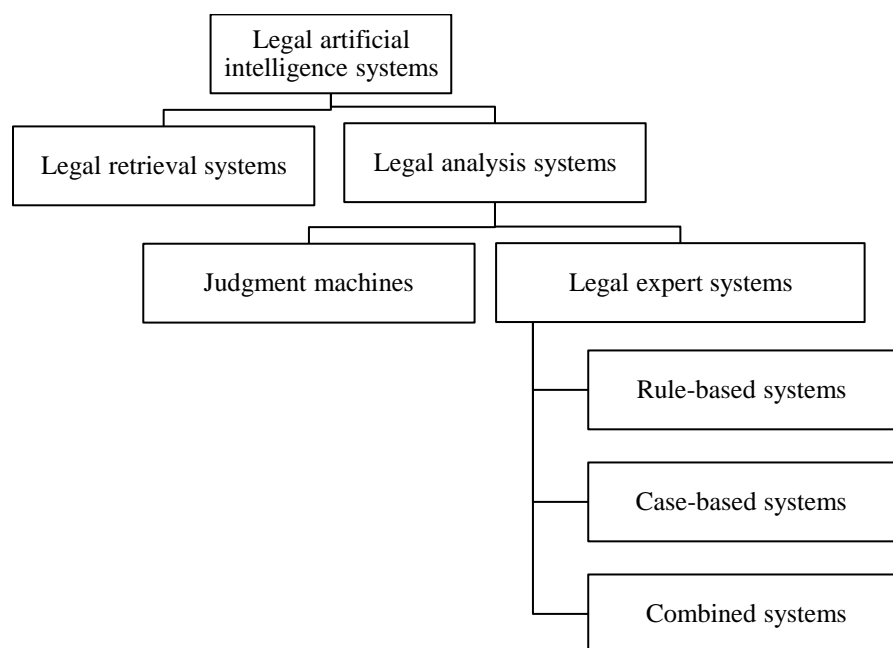


Fig 1. The classification of the legal artificial intelligence systems

The legal retrieval systems or legal information retrieval systems allow jurists to search within databases containing different details of the rules, which may be facilitated by the artificial intelligence techniques. In the other words, the legal retrieval systems are used to find and retrieve the relevant and best suitable documents and information objects in a database in order of their

significance to the relevant query (Zeleznikow, 2004 [14]; Opijnen and Santos, 2017, [1]). For example, searching for the keywords, which the user does not enter but they are related to the topic the user is looking for that results (Zeng et al. 2006 [15]; Verma et al. 2020 [16]). The legal analysis systems determine the information about a set of derived facts, which may be created within a specific area of law (Popple, 1990; 1996 [17, 18]). Further, the legal analysis system is divided into the areas of the judgment machines and legal expert systems.

The judgment machines are replaced by the human judges in some way. The first judgment machine was created in 1959. D'Amato (1977 [19]) suggested that a machine could be made and substituted for a judge. His proposed machine receives the relevant events as input and eventually, gives a number between -1 and +1, where a positive number indicates the success of the complainant. He believed that if there were many factors and events, the probability of achieving zero would be very low, and a nonzero number would always be obtained (Popple, 1996 [18]).

2.3. Legal expert systems

A legal expert system (LES) is a system, which has the capacity to "reason" and to "think" as a lawyer (Dimyadi et al. 2019 [6]) but cannot and should not replace human decision-makers (El Ghosh et al. 2017 [3]). The AI systems such as SHYSTER, solely assisting the lawyers in legal conclusions or preparing legal arguments, are not regarded in this category. A legal expert system should have a kind of legal expertise (Popple, 1996 [18]).

Since the LESs have been emerged in the mid 1980's, these systems have been extensively developed and used to solve legal issues. Harvey (2017, [20]) and Cornelia et al. (2015 [2]) categorized the application of (legal) expert systems into five areas: analysis and advice, intake and assessment, intelligent workflow, computer-added learning system, and document automation. Despite the development of the LES as a mature, pervasive and successful technology for solving the complicated problems in the law, due to their benefits there is enthusiasm for development of LES (Ashley 1992 [21]; Greenleaf et al. 2018 [10]; Wagner 2017 [22]). Improving the training and skill of lawyers, providing a more fair and efficient system of justice, reducing the high transaction cost of legal services, enhancing consistency in decision making, increasing people's awareness of the laws, saving cost and time in the courts, transparency, accuracy, efficiency, and etc. are some of the benefits of developing and using the LESs (Zeleznikow 2004 [13]; Stevenst et al. 2010 [23]; Dimyadi et al. 2019 [6]).

In addition, the legal expert systems are divided into the categories of rule-based systems, case-based systems, and combined systems. The rule-based systems use the if-then rules. The reasoning process of case-based systems is in such way that the intended case file is compared with the files existing in the database and an output is predicted. This system stores the knowledge about its cases by summarizing the facts of the case, result, and reasons for reaching the conclusion. The combination of these two systems are used in the combined systems. In the legal analysis system, developed by the human, the intended individual should be expert in the field of law. However, the legal retrieval systems are produced by individuals who do not have the knowledge about the law.

2.4. Background of LES

A large number of studies were conducted on the development of rule-based expert systems worldwide. Naik and Lokhanday (2012, [24]) developed a legal expert system to solve immovable property acquisition (IMP) problems like tangible assets such as land and home. The present study

aimed to develop a rule-based expert system for solving inheritance issues in Iran. The proposed system acts based on the rule-based expert systems, using the if-then rules in their inference.

Engin et al. (2014, [25]) developed the educational expert systems. They developed two rule-based expert systems to advise undergraduate students. The first expert system is a course counseling system to choose lessons. The second system advises undergraduate students based on their competency in obtaining scholarships. Both systems were successfully implemented and tested in Oracle Policy Automation software.

One of the most recent studies conducted on solving inheritance problems in the world is related to AbdAl-Retha and AL-Shahad (2015, [26]). They presented a legal expert system and used tables to solve inheritance problems in the law of Iraq. The proposed system is used by a judge or anyone who wants to know how a person's inheritance is divided among the heirs based on the law of Iraq. The proposed table includes first and second class of the inheritance, which is arranged in order to simplify the tables. These tables were regarded as the knowledge base of the expert system, later used as the expert system rules.

Elziny et al. (2016, [27]) developed a legal expert system for resolving the construction project disputes in Egypt. They identified the main sources of the disputes and suggested solutions by using a questionnaire and used them within the context of the inference system of the proposed expert system.

Further, Akkila and Naser (2016, [28]) presented a rule-based expert system for solving the inheritance problems in Islam by using CLIPS language to express the rules. They addressed the issue of “reduction of shares of heirs” and “system of agnatisation in inheritance by which the residue of the estate is passed to the male agnates” in Islamic inheritance.

In another study, El Ghosh et al. (2017, [3]) defined a unified strategy for modeling legal norms in the criminal field to support legal reasoning. They mainly aimed to present a rule-based system, called CORBS for the criminal field, which is based on the integration of the legal ontology and a set of rational rules.

Prakash et al. (2017, [29]) proposed a fuzzy rule-based legal expert system to solve the issues related to the women violence. The proposed system, called UMEED, uses a rule-based system and serves as a legal counsel for lawyers for reducing the time for legal decisions. The model was tested on the several historical cases of the women violence and the performance was compared to the actual legal decisions and was declared satisfactory.

3. Research Methodology

The research methodology is shown in the Figure 2. After defining the problem and identifying the dimensions and complexities of the problem, which were mentioned in the introduction section, the research steps are planned in two phases.

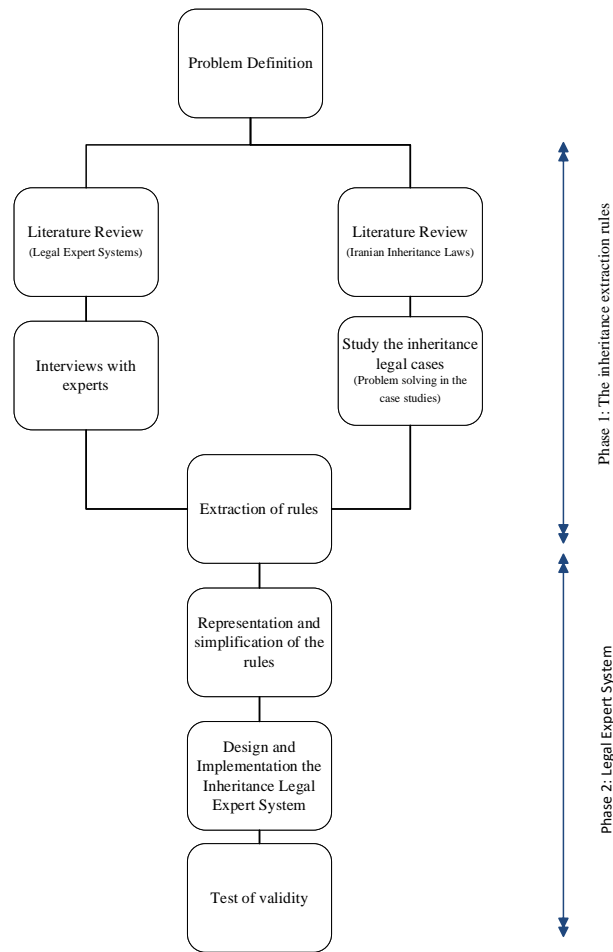


Fig 2. Research Methodology

Phase 1: The inheritance extraction rules (Knowledge base)

The knowledge base of the proposed expert system constitutes the main body, indicating the rules of inheritance. Given that there are three separate classes of inheritance, a separate knowledge base is provided for each inheritance class. The rules of the first class inheritance, related to the offspring and parents (Fig. 3) are situated at the first knowledge base, the second class inheritance rules, related to the brother and sister (father, mother, and parents) and ancestor و جد (father and mother) are situated at the second knowledge base, and finally, the rules of the third class inheritance, related to the uncle and aunt (father, mother, and parents) and uncles (father, mother, and parents), are placed in the third base. Further, it is assumed that the couple or wife receive their inheritance in all classes. As already mentioned, these rules are the if-then rules.

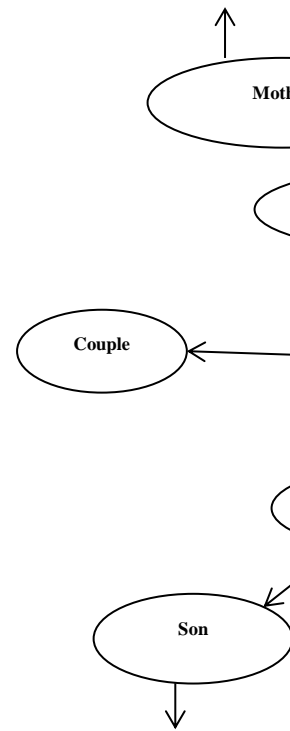


Fig 3. The inheritance tree network sample for the first class

In the present study, the knowledge in the forms of the rules is obtained through the interview techniques and legal texts and books. The extraction of rules is described in the section 4.

Phase 2: Designed Legal Expert System

As it shown in Figure 4, the proposed expert system consists of the following components:

- User: A person who interacts with the system and intends to solve the inheritance problem
- Expert: A person who is an expert in the specific field of the inheritance
- Knowledge engineer: A person who designs and makes an expert system
- Knowledge base: It includes knowledge and rules related to the inheritance
- Inference engine: It allows us to deduce from the knowledge base
- Knowledge acquisition: It is the process of extracting, designing and presenting knowledge.

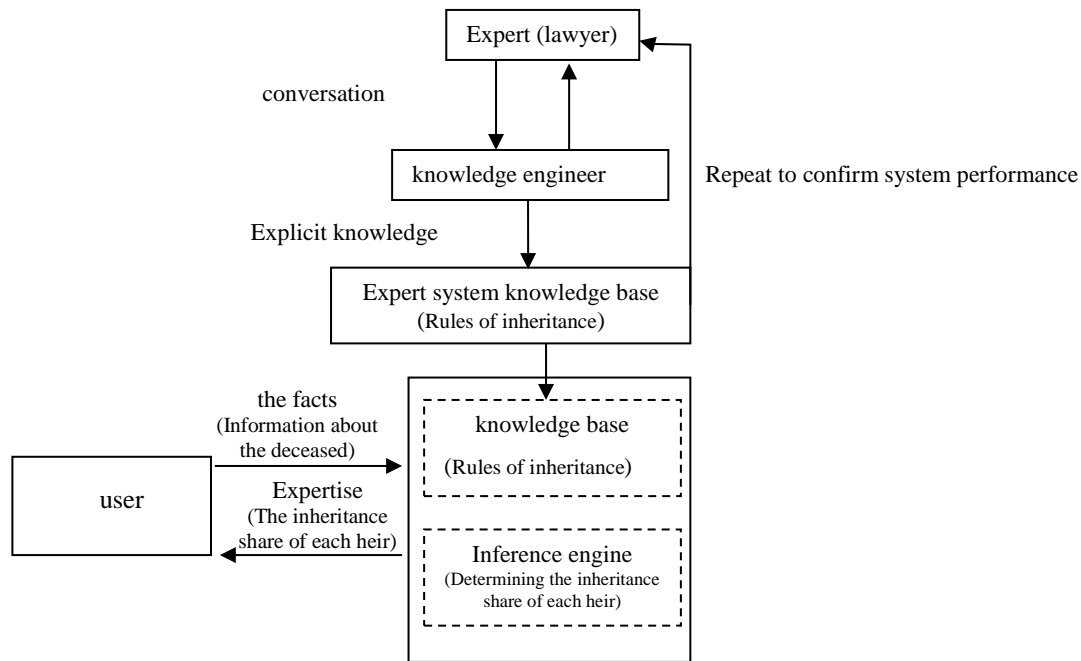


Fig 4. The framework of designing the proposed expert system

Three main components of designed LES is including Knowledge base, Inference engine and User interface. The details of knowledge base are described in the section 4. Two other components are as follow:

Inference engine

The inference engine is part of a system using rules to derive results. The inference engine uses the forward chaining, backward chaining, or their combination to deduce the data existing at any given moment. In the proposed system, the inference engine is at the heart of the knowledge base and uses the forward chaining to extract the results. As the inference engine finds rules fitting the input facts of the user and situates the facts in the desired rule and extracts the results. In the proposed system, the results are the same as the inheritance share, which should be specified. The results are made available to the user through the user interface. The proposed system is designed for individuals with little knowledge about the inheritance and legal terms.

User interface

One of the important parts of the expert system is the user interface through which the system asks questions from the user. Figure 4 demonstrates the interface user, which is specific to the first class of inheritance.

In the user interface, the system asks the user questions and then, specifies the shares of each heir in its inference section, and indicates the amount of shares in the section of the share of each person. The questions the system asks the individual are related to the number of heirs and whether he/she has chamberlain mother or not.

4. Knowledge base of the Inheritance Legal Expert System

In the present study, in order to establish and develop the proposed knowledge base of the proposed expert system, we first interviewed the expert (lawyer) to discover his knowledge of how to determine the inheritance share of the heir. In addition, the legal and civil law books were used to extract the

rules. The obtained knowledge was then entered into the knowledge base explicitly and in an understandable language to the machine. The expert evaluated the expert system and provided us with criticism and evaluation results. This process was repeated for several times until the knowledge base's performance was verified by the expert.

In order to better understand the rules of the data base, it is necessary to explain the basic concepts of inheritance.

4.1. Inheritance laws

Entitlement to property or rights due to the death of someone or what is due to death with special conditions and criteria is called inheritance. The mentioned definition is the definition of inheritance in the infinitive sense, its formal meaning is the property and rights that a person is entitled to by the death of another or what is a death sentence such as apostasy. The recipient of inheritance is called "heir", the person who leaves an inheritance is called "testator", and what remains of the deceased, whether property or transferable rights, such as the right of authority, the right of intercession, left properties and inheritance.

4.2. Ways of entitlement to inheritance

There are three types of inheritance rights:

A: default contribution; Inheritance entitlement is sometimes "presumed" and "denomination"; It means that the share of the heir is specified in the Holy Qur'an.

B: relative contribution; Sometimes the right of inheritance is related to "kinship", such as the right of an uncle and aunt, who have not been assigned a share in the Qur'an (the holy book of Muslims) and are listed under the title of "first-born".

C: Restoration contribution; Sometimes it is interpreted as "restoration" for both reasons, i.e. inheriting the heir, adding to the obligation due to the relationship with the deceased, for example, if the heir is only a daughter, half of the estate is considered "assumption" and he inherits the other half to "kinship".

4.3. share of inheritance of relative and causal heirs

The causes of inheritance are parantage and cause, and causal relatives have classes and within each class they have different degrees, the first class includes father, mother, children and children's children. The second class includes ancestors, siblings, and children of siblings, and the third class includes uncles, aunts, uncles' children, and relatives.

The existence of any causal relative in each class prevents the inheritance of the relatives of the next class, and also any relative of the first degree within each class prevents the inheritance of the relative of the next degree, unless in the case of exceptions;

(1) The exception of inheritance based on the vicegerent which is related to the first and second class and in the relations between the two hereditary groups of these two classes, whose children share the inheritance with their parents in the first class, even though they are in the next degree and the parents are in the first degree, also each of the two groups of ancestors of the parents and the ancestors of the ancestors who are in the next degrees compared to the siblings will inherit with the siblings, as well as the children of the siblings who are in the degrees after the ancestors of the deceased. have, they share the inheritance with the deceased ancestors.

(2) The exception related to the third class, which is the precedence of an uncles cousin over an fathers cousin in the event that the relatives are exclusive to him, while the cousin is second in rank to the uncle.

Causative relatives are: Husband and wife in a permanent marriage, each of them will inherit from the relatives of all three classes, and the share of each of these two, if there are no children for the deceased, is at most two of the prescribed proportions, i.e. $1/2$ for the husband and $1/4$ for the wife, and If there are children, at least the two mentioned ratios are $1/4$ for the husband and $1/8$ for the wife.

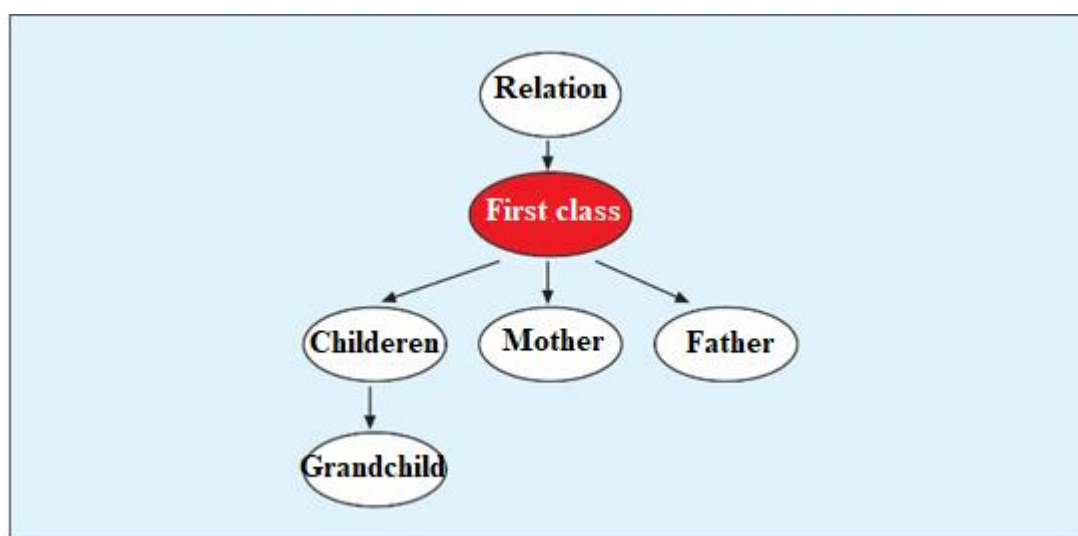
A point to consider is that according to the aforementioned cases, the manual calculation of the heir's contribution of the inheritance, especially when there are opposing heirs or where there is an obstacle, is very difficult, and it is the complexity of jurisprudence and law, which also becomes difficult in some cases and Sometimes it results in delaying the proceedings of the judicial authorities and consequently damages the rights of the plaintiffs or in some way the litigants. Therefore, in order to facilitate this matter by benefiting from the proposed expert systems, it aims to simplify the matter and further simplify and divide and categorize the heirs, inheritance, classes, etc., as well will check the performance of the proposed expert system based on the above rules.

In order to examine this performance, we first have to address the specific inheritance laws, the inheritance laws in Iran's legal system are determined in three classes, almost separately from each other, and we have also used the same method and division as the criterion for this investigation.

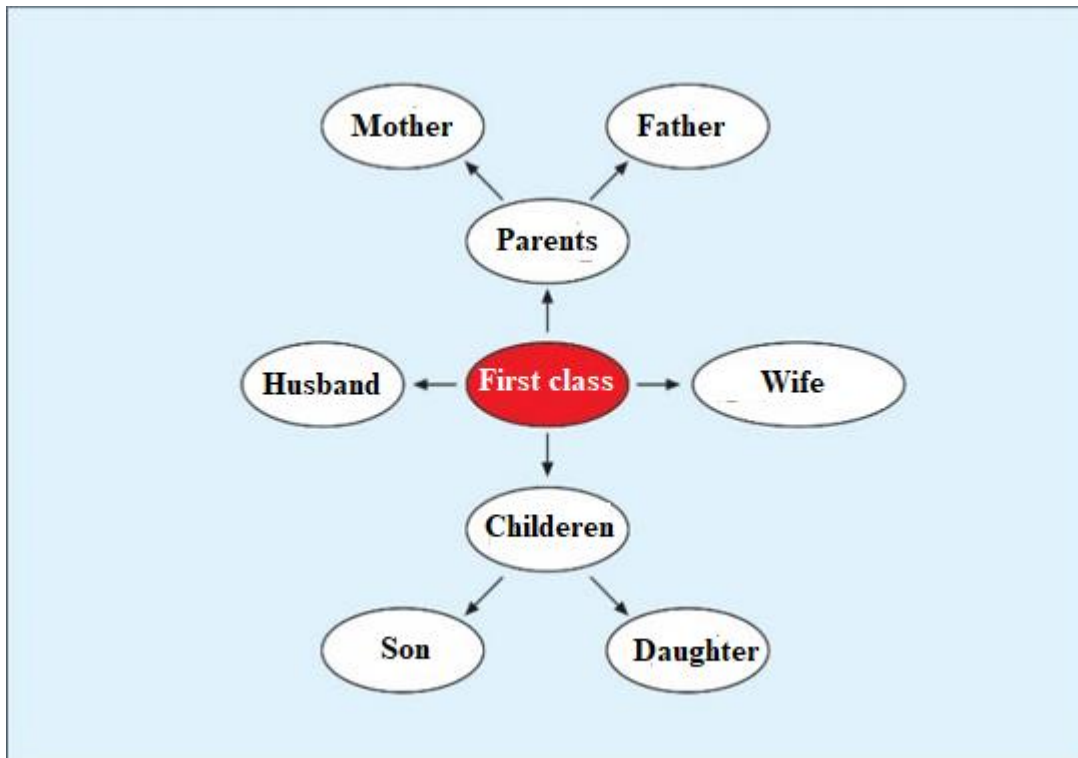
In each class, there are vertical and horizontal relatives to that class, to extract the inheritance rules, a series of simplifications will be done in the tree diagrams of each class. In the following, the

rules of inheritance related to each class will be explained. For each class, the method of simplifying and coding the rules of inheritance and the related user interface will be given.

The next step is to check the performance of the proposed expert system, for this purpose, it considers the different forms of inheritance in different classes of inheritance in the form of examples selected by experts as sample examples and the answer obtained from the proposed system and compare it with the answer calculated by experts and show the efficiency of the system, often, we have considered complex situations in order to check the efficiency of the system despite the complexity of these problems.



First diagram: Tree diagram of the first class heirs



Second diagram: Simplified tree diagram of the first class heirs

4.3.1. Inheritance contribution of first class relatives

The first class relatives are the closest relatives of the deceased, the relatives of this class include two groups; Parents (ascending vertical relatives), children and children's children as far down as they go (descending vertical relatives), among the heirs of this class, "mother" is always assumed, and son is always assumed to be consanguineous, and father and daughter and daughters are sometimes assumed, and sometimes they are inherited by kinship, at first the tree diagram of the heirs of this class can be shown in the form of a tree diagram (one) and then to extract the rules related to the diagram one, a series of simplifications must be done, figure 2, shows the basic diagram and the simplified diagram in the figures below, respectively. The inheritance of the relatives of this class is determined as follows.

(1) Mother always inherits by assumption, and her assumption is that if there are children for deceased, $\frac{1}{6}$ of the inheritance will be given, and if there are no children for deceased, $\frac{1}{3}$ of the inheritance will be given, unless the mother has humiliation, her contribution will be $\frac{1}{6}$.

(2) The son and the son's children always inherit by consanguinity, and the remainder of the inheritance is given to them after the dismissal of the hypothetical contribution.

(3) The father, daughter and daughters of the deceased inherit sometimes by assumption and sometimes by kinship, whose assumption is 1/6 of the inheritance, and if he has no children, the father inherits by kinship.

Table 1. The amount of inheritance of the first class

Heirs	Inheritance amount		
Parents or one of the children exclusively	inherits the entire inheritance		
Parents	If the mother has humiliation inherits 1/6		In any case, the rest to kinship belongs to the father
	If the mother doesn't have humiliation inherits 1/6		
Parents and one daughter	1/6 of father	1/6 of mother	3/6 of daughter If the mother has humiliation 1/6 of remaining will not return to her and if doesn't have will return
Father or mother and one of the daughters	1/6 of contribution of to father or mother	3/6 of contribution to daughter	2/6 returns to heirs
Parents and some of the daughters	1/6 to father	1/6 to mother	4/6 shares between daughters
Father or mother and some of the daughters	1/6 of contribution of to father or mother	4/6 to daughter	1/6 returns to heirs

Father or mother or one of them and daughter or son	1/6 to father	1/6 to mother	The rest is divided in proportion to the boy twice as much as the girl
Father or mother or one of them and one or some of sons	1/6 to father	1/6 to mother	The rest goes to the son or sons
Husband or wife with first class heirs	Husband or wife gets his contribution		The rest is shared between the heirs as described above
A couple with children is 1/4 and without children 1/2 of inheritances and a wife with children is 1/8 and without children is 1/4			
If there is a defect in the sum of the ratios in the first class and it is more than one, the defect is on the girl or girls			

If the deceased does not have a male child, daughter or daughters assume 1/2 and 2/3 of the inheritance respectively, and if the deceased has a male child, the daughters inherit according to their kinship. If there are no children, the children of the children will inherit the position of the successor of the children, and each generation will take the contribution of the person who passed on to the deceased through him.

Considering all the forms in this class, about 70 general rules were extracted and entered in the inference section of the first class of the proposed expert system.

4.3.2. Inheritance contribution of second class relatives

If the first class relatives doesn't exist, the Inheritance of the deceased goes to the second class relatives, the second class relatives are two groups: one group is the ascending vertical relatives, meaning the ancestors include the grandfather and grandmother of the deceased as far as they go, that is, the parents of the father and the father and the deceased's mother's mother, who are in the first degree of the second class, and then the father's grandfather and grandmother, and the mother's grandfather and grandmother, who are in the second degree, and in the same way, every generation that goes up, one degree is added to their degree of kinship with the deceased and according to the

rule of closer inheritance, each relative with a closer degree will deprive the relative of a more distant degree from inheriting, the other group of relatives are the relatives of the deceased, which include brothers and sisters of the deceased and their children, as far down as they go, in this group of brothers and the sister is in the first degree from the second degree and her children are in the second degree, and in the same way, one degree is added to the people of each generation, and each previous degree prevents the inheritance of the next degree, none of these two groups is opposed to the other group, although they are closer to the deceased in terms of the degree of kinship than the other group, therefore the last-ranked people from each of the two groups will share the inheritance with the first ranked people of the other group as the representative of the generation before them, and as previously stated participation of the last degree of each group is closer to the first degree in the other group, in the first class and the second class, one of the two exceptions to the principle of inheritance, which is based on inheriting as vicegerent. You will see the heirs of this class in chart 3.

Explaining that in the second class, there are three directions of kinship; In terms of paternal and maternal kinship, in this respect, ancestors are divided into two paternal ancestors categories: the father and mother of the deceased father as far as they go, and omi ancestors, i.e. the father and mother of the deceased mother, as far as they go, siblings and their children are divided into three categories: uncle brothers and their children, father brothers and their children, and mother brothers and their children as far as they go down.

To derive the rules related to the above diagram, a series of simplifications must be done, the simplified diagram is shown in Figure 6.

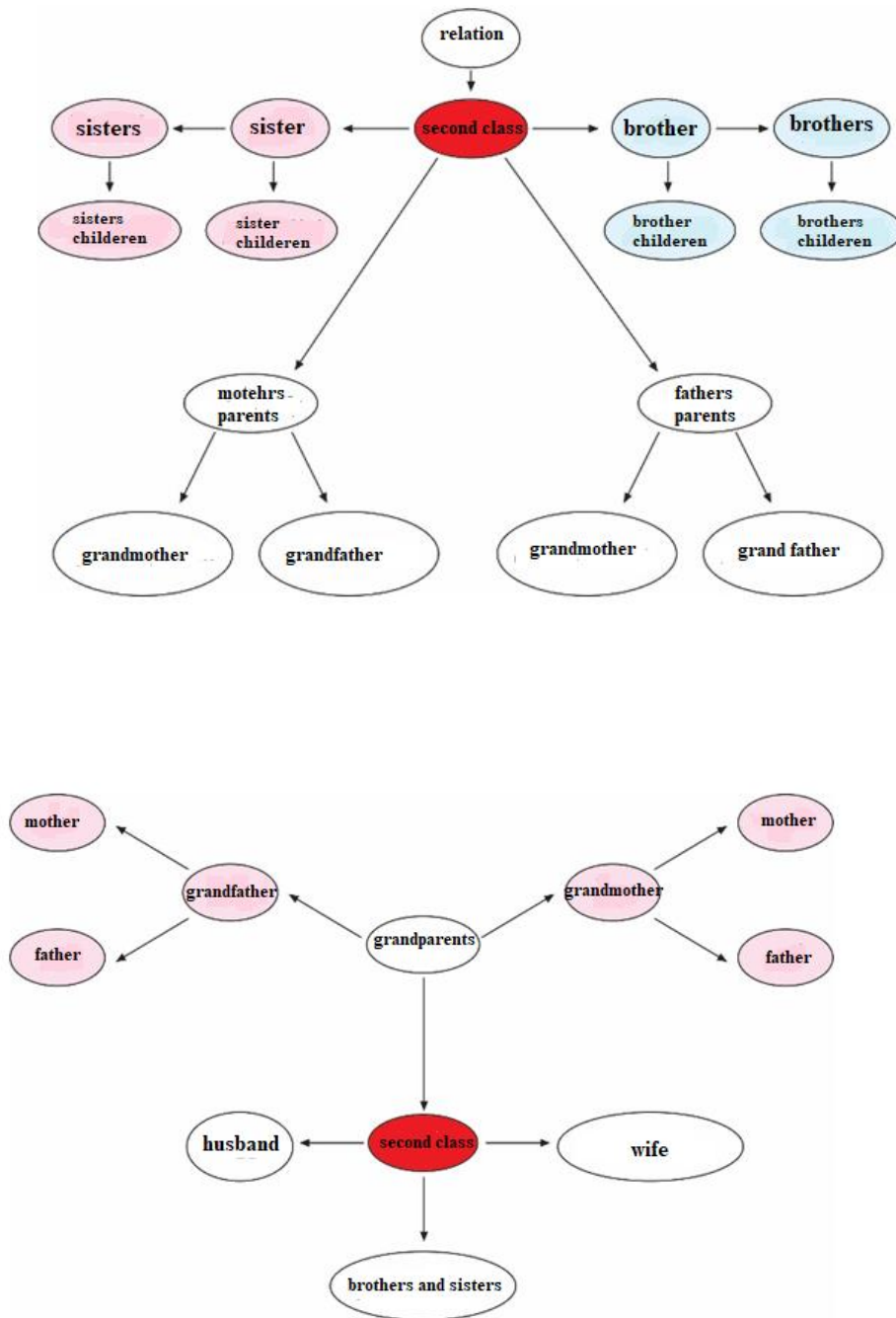


Figure6. First diagram: Tree diagram of the second class heirs

Second diagram: Simplified tree diagram of the second class

motheral relative means mother ancestors and mother siblings and their children are always assumed, and mother grandfather and grandmother's assumption is always 1/3 in the case of

individuals and multiples, and mother siblings assumption is $1/6$ in the case of individuals, and $1/2$ in the case of multiples, and the assumption of siblings It is also $1/2$ inheritance with mother ancestors.

Parental and paternal relatives also inherit by Kinship, except in the case of their exclusiveness to one or more parental and paternal sisters, in which case it will be assumed, and the assumption of one parental and paternal sister is half, and the assumption of multiple parental and father sisters, which $2/3$ is left.

According to Article 918 of the civil code of Iran, even if there is an elder brother, the elder brother will be deprived of inheritance, and in the absence of an elder brother, the half brother will take the share of the elder brother, but the half brother will be with the elder brother, and in the absence of the elder brother or the elder brother, according to the rule males Males inherit twice as much as females and between male relatives according to the rule of males equal to females, so the paternal grandfather inherits twice as much as the paternal grandmother and equal to the brother of the father or the father and twice as much as the sister of the father or the father inherits. It means that the share of my grandfather is equal to the share of my grandfather and equal to the share of my brother and sister. If there are no ancestors of the first degree, the ancestors of the next degree, and if there are no brothers, the children of the brothers, and if there are no children of the brothers, the grandchildren of the brothers, and in the same way and according to article 925, each generation has a contribution that takes someone who reaches the deceased through him.

Each of the husband or wife inherits from the relatives of the second class, and their inheritance reaches the maximum due to the absence of children of the deceased, which is $1/2$ of the Inheritance for the husband and $1/4$ for the wife, the excess and deficiency of the total amount of the inheritance. relative to the unit, in the second class, sometimes all the heirs are assumed exclusively, in this situation, as in the first class, the sum of the assumptions may be equal to, more than, or less than the unit of the inheritance, in this case, the defect of the inheritance is on one or more sisters, parental or paternal is entered.,The inheritance contribution of the second degree is shown in table 2.

Table 2. The amount of inheritance of the second class

Heirs	Inheritance amount	
One of grandparents or one of siblings (exclusively)	inherits the entire inheritance	
Grandfather or grandmother of father	Grandfather inherits twice of grandmother	
Grandfather or grandmother of mother	Grandfather and grandmother inherit the same	
Grandfather or grand mother of mother and grandfather or grandmother of mother	2/3 to fathers parents in ratio of 1/2	1/3 to mothers parents in same ratio
Parental sisters or brothers	Heirs inherit in same ratio	
Parental sisters and brothers	Inherits in ratio of 1/2 between heirs	
Motheral sisters and brothers	Heirs inherit in same ratio	
Parental or fatheral sisters and brothers and motheral sisters and brothers	1/3 of contribution to brother and sister in same ratio	The rest goes to parental or fatheral brother and sister in ratio of 1/2
Parental or fatheral sisters and brothers or motheral sister or brother	1/3 of contribution to brother or sister	The rest goes to parental or fatheral brother and sister in ratio of 1/2
Brothers or sisters grandparents	1/3 of contribution to motheral grandparents brother and sister in same ratio	If they are fatheral grandparents brother and sister or one of the motheral brothers and sisters heirs 1/6 of contribution
	2/3 of contribution to fatheral grandparents brother and sister in ratio of 1/2	
Husband or wife with second class heirs	Husband or wife in assumption of return	Then motheral relatives don't heir ond the rest goes to fatheral relatives

About 100 rules have been extracted for this table.

6-1-1- The contribution of the inheritance of the third class relatives, if the deceased has no first and second class relatives, his inheritance goes to his third class relatives, that is, his maternal uncles and aunts and in the absence of maternal uncles and aunts, the children of the uncles and aunts, as far as they go down, and in the absence of them, it goes to uncles and aunts of the deceased parents, and in the absence of them, to their descendants, and then to the uncles, children, of the uncles, and the children of the previous generations, the deceased will get closer by observing the principle of inheritance.

In this way, the third class relatives third class are one group, all of them are relatives in the surrounding line, the said relatives have different ranks, and within them there are also different ranks, in such a way that the first rank are uncles and aunts. The deceased goes as low as possible, and the second rank includes uncles and aunts of parents and their children, who go as low as possible, and in the same way, the next ranks include uncles, relatives, and their children in relation to the upper generations, observing the principle inheritance will be closer. In order to extract the fifth rule, we have to simplify it, which you will show in diagram 6.

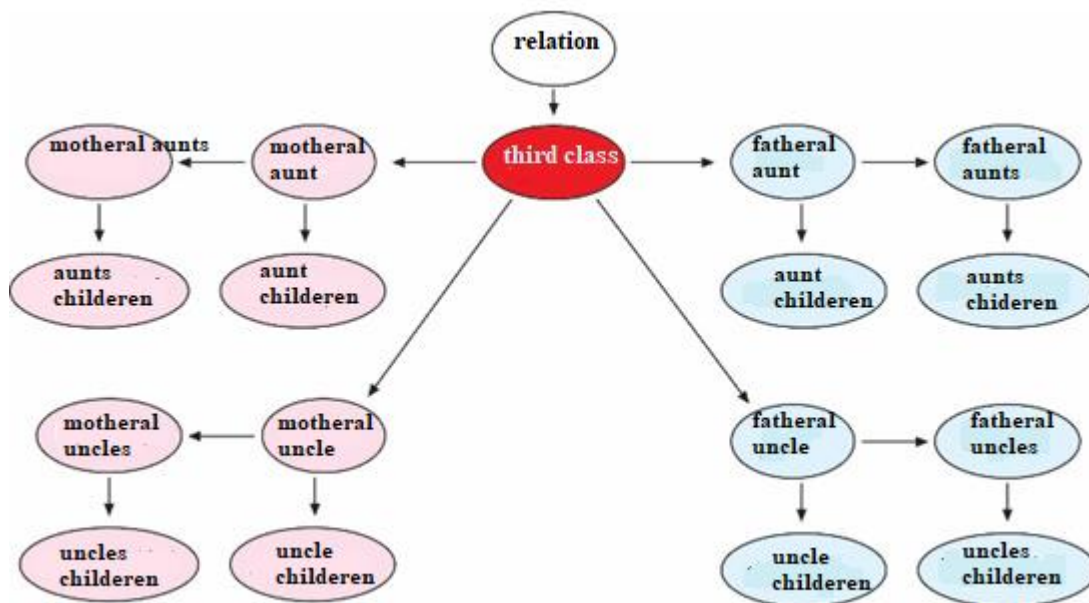


Figure 7. Simplified tree diagram of the third class

In the third class relatives, there are two main directions, which are the direction of the paternal kinship that exists in uncles and the direction of the maternal kinship that exists in the aunts, in the diagram above you can see the tree diagram of the third class.

In the relatives of each of the mentioned directions, there are also three sub-kinship directions, which consist of paternal, maternal, paternal relatives, so a total of six kinship directions can be imagined in the third class, as follows: Uncles and aunts who are brothers and sisters of the deceased father, if they share the same parentage with the deceased father, then the maternal uncle and aunt, if they share the same father, the paternal uncle and aunt, and if they share only the same mother, the deceased maternal uncle and aunt. are. Also, uncles and aunts who are brothers and sisters of the deceased, if they are the same father and mother as the deceased mother, and maternal uncles and aunts, if they are the same father. paternal uncle and aunt, if they are only from the same mother, they are maternal uncle and aunt, in the sense of both paternal uncles with the presence of paternal uncles and paternal uncles with the presence of paternal uncles, they do not inherit, and if there are no paternal uncles, paternal uncles will inherit, and in case and if there are no maternal uncles maternal aunts will inherit. (Article 932 and 934 of the civil code of Iran)

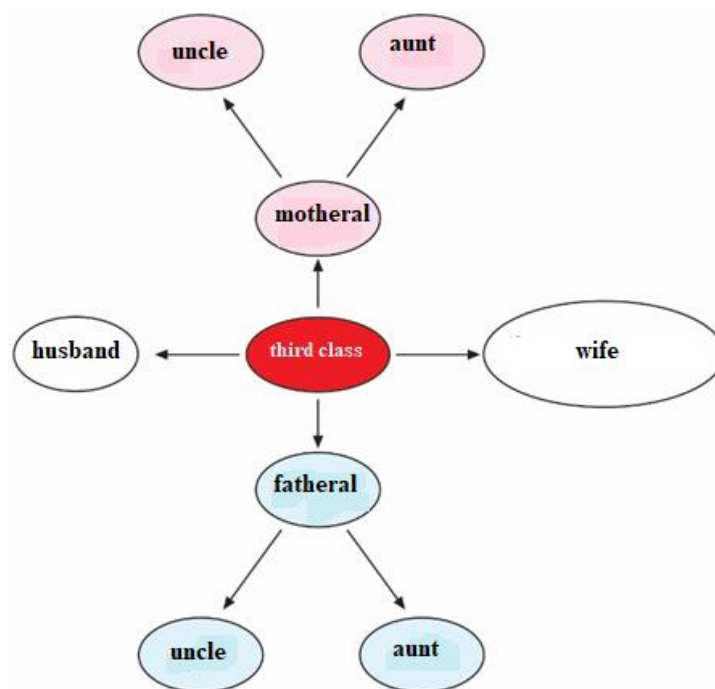


Figure 8. Tree diagram of the third class heirs

Maternal uncles always inherit with parental or paternal uncles and maternal uncles with parental or paternal uncles (Articles 932 and 934 of the Iranian civil code)

Therefore, parental uncles do not deprive paternal relatives from inheritance, and paternal relatives do not oppose parental uncles.

According to article 935 of the civil code of Iran, maternal relatives, always inherit by presumption, and their presumption is always $\frac{1}{3}$ of the estate in the case of individuals and multiples, and the rest of the estate belongs to the paternal relatives, if there is one person among the relatives, $\frac{1}{6}$ of the contribution of maternal relatives, and if there are many, $\frac{1}{2}$ of the share of maternal relatives is given to them.

(Article 935 of the civil code of Iran) If there is one person among the father brothers, $\frac{1}{6}$ of the father brothers contribution goes to him, and if there are several imams, $\frac{1}{2}$ of the father brothers contribution is given to them. It is divided (Article 935 of the civil code of Iran), therefore, in the third class, the sum of presumptions will never exceed one, because uncles do not inherit by presumption under any circumstances, and presumptions are exclusive to husbands and wives and relatives. The sum of suppositions reaches its maximum in a inheritance where there are odd and odd numbers, and the sum of suppositions reaches its maximum in a state where even and odd numbers are together, in which case the sum of suppositions becomes $\frac{5}{6}$; And the remaining $\frac{1}{6}$ goes to the uncles.

Also, due to the absence of children, the husband and wife take their maximum contribution for the deceased, which is $\frac{1}{2}$ for the husband and $\frac{1}{4}$ for the wife (Article 938 of the Iranian civil code), if there are no uncles and aunts, the inheritance will be given to the uncles' children and inheritance is closer by observing the rule of inheritance (Al-Aqrab Falaqarb) and each generation takes the share of the person who is connected to the deceased through him. In the table below, we can see the share of the third class inheritance.

Table 3. The amount of inheritance of the third class

Heirs	Inheritance amount
One of maternal uncles or one paternal uncles (exclusively)	inherits the entire inheritance
Some maternal or paternal or parental uncles or aunts	Heirs inherit in same ratio

Some fatheral or parental uncles and aunts		Inherits in ratio of 1/2 between heirs	
Some motheral or parental uncles and aunts		Heirs inherit in same ratio	
Some fatheral or parental uncles and aunts and Some motheral or parental uncles and aunts		1/3 of contribution to motheral uncles or aunts	
Some fatheral or parental uncles and aunts and one motheral or parental uncles and aunts		1/6 of contribution to motheral uncles or aunts	
Motheral or fatheral or parental uncles and aunts		Heirs inherit in same ratio	
Motheral or fatheral or parental uncles and one aunt		Heirs inherit in same ratio	
Fatheral or parental uncles and one aunt and motheral uncles and one aunt		1/3 of contribution to motheral uncles or aunts in same ratio	
Fatheral or parental uncles and one aunt and one motheral uncle and aunt		1/6 of contribution to motheral uncle or aunt	
Some fatheral uncles and aunts and Some motheral uncles and aunts		1/3 of contribution to motheral uncles or aunts in same ratio	
Husband or wife with third class heirs	Husband or wife inherit with supposition	1/3 of contribution motheral uncles and aunts	The remaining contribution to fatheral uncles and aunts

5. Evaluating the performance of the proposed expert system

The various forms of the inheritance in the classes were selected by the experts as sample examples and the answer obtained from the proposed system was compared with the answer calculated by the experts to evaluate the performance of the proposed expert system. The complex cases with different exceptions were often considered to evaluate the system performance. Some of the selected problems are presented in the following.

The first example of the first class of the inheritance: in this example, the wand is 12 units and the heirs are father or mother and a daughter. This example is solved as follows:

Mother or father share of the assumption: $12 * \frac{1}{6} = 2$; daughter share of the assumption: $12 * \frac{1}{2} = 6$; the sum of two assumptions: $6 + 2 = 8$, the rest of the wand of mother / father and daughter is rejected: $12 - 8 = 4$; mother / father share of rejection: $4 * \frac{1}{4} = 1$; the sum of mother / father share of assumption and rejection : $2 + 1 = 3$; daughter share of rejections: $4 * \frac{3}{4} = 3$; total daughter share of

assumptions and rejections: $6 + 3 = 9$. The wand is generally divided into four parts and one part is given to the father or mother and three parts to the daughter. The system recommendation for this problem was consistent with the expert recommendation.

Gender of decedent Heritage Father Mother Mother has chamberlain?

First class inheritance Couple or number of wives Number of sons Number of daughters

Number of grandsons Number of granddaughter Number of grandsons Number of granddaughter

Problem solving software of the first class of inheritance

Each person's share

Relationship Father's share Mother's share Couple's share Share of each spouse

Share of each son Share of each daughter Share of each grandson

Share of each granddaughter Share of each grandson Share of each granddaughter The mother in the following cases has a chamberlain mother:

She has at least two brothers. She has at least two brothers and two sisters.

She has at least four sisters.

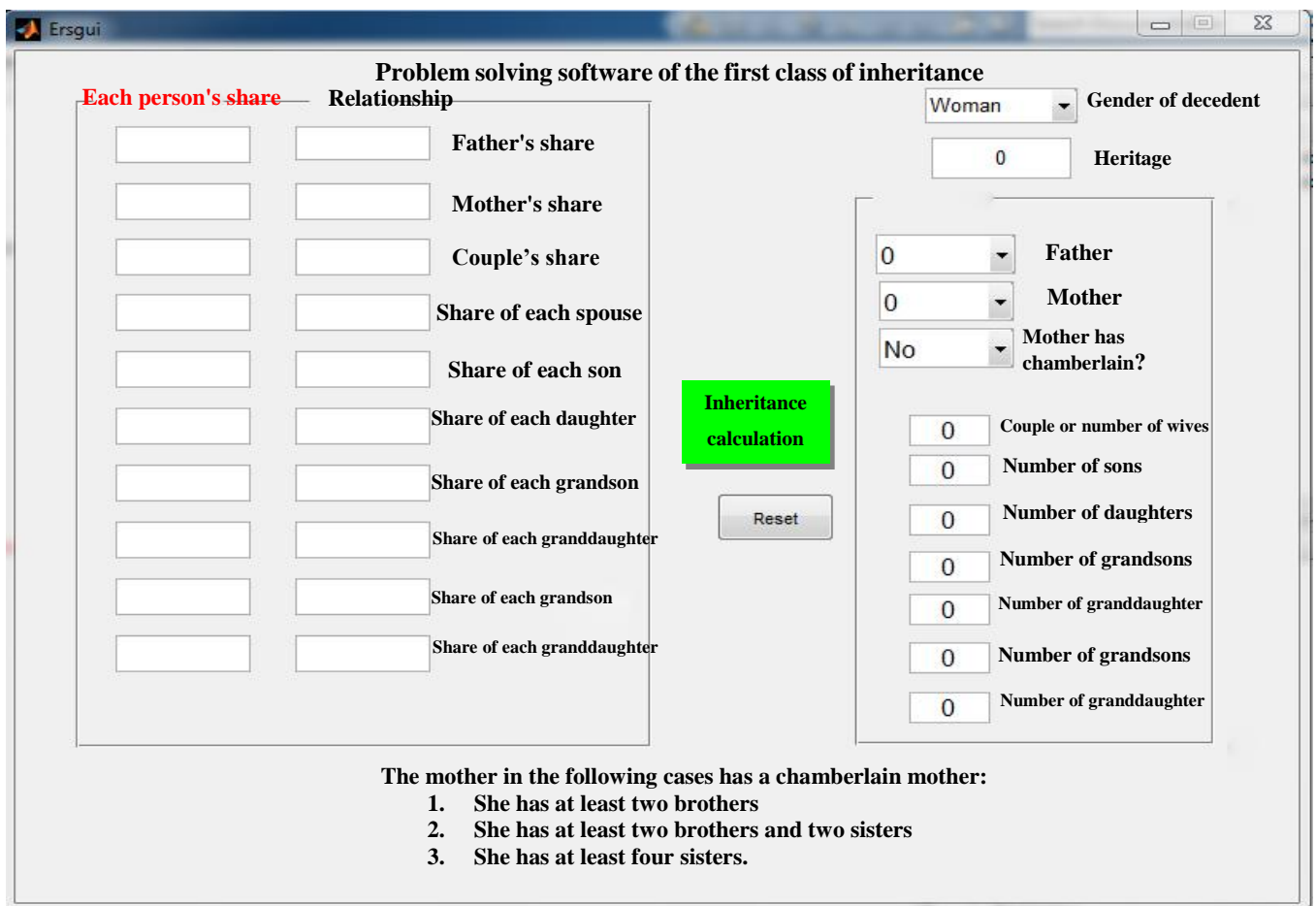


Fig 9. The user interface of the proposed expert system for the first class inheritance

The second example of the first class of inheritance: If the wand is 72 units, the heirs are allocated to the wife and four grandchildren, one male and one female from a son and one male and one female from a daughter, the inheritance shares are as follows:

The inheritance share of the wife; rest of the wand after the assumed exclusion of the wife ; share of the daughter of the decedent divided among her children ; share of the granddaughter ; share of the grandson ; share of the son of the decedent divided among his children ; share of the granddaughter ; share of the grandson ; The recommendation of the proposed system was in line with the expert's recommendation.

The third example of the second class of the inheritance: We consider a case in which the sum of the assumptions is greater than the unit. In this case, the defect of the wand is attributable to the share of one or more of the parental or parent sisters, and the other owners of the assumption receive their share completely. We consider a case in which the heritage is 30 units and the decedent had couple and many maternal brother and two father sisters. In this case, the wand is given to the couple () and different maternal collateral , which is equally divided among them and the rest of the wand, which is less than the assumption of two sisters, is given to two sisters. Since the sum of the assumptions is more than one and the sisters receive the wand instead of. By solving this example by the proposed expert system, we find that the recommendation of the proposed system is consistent with the expert's recommendation and the inheritance share is correctly calculated by the system.

The fourth example of the third class of the inheritance: We consider the case in which the heir of the decedent is **a'mâme abwini**, **a'mâme abbi**, and, **a'mâme ami** . In this case, **a'mâme abbi** is deprived of inheritance and wand is given to the , **a'mâme ami** in case of solitude and multiplicity. The wand is equally divided among them in the case of multiplicity and the rest of the wand is divided between the **a'mâme abwini** in the male rule twice male (Articles 322 and 930 by observing the Article 898 Gh. M). The system recommendation was correct in both cases.

6. Conclusion

The present study aimed to evaluate the use of expert systems in one of the most important parts of law, namely inheritance. Given the complexity of inheritance in Iran and the existence of numerous exceptions and rules, the use of computers in this field is crucial for minimizing error and speeding up inheritance computation. Therefore, the present study sought to combine IT and law to integrate these two fields. The proposed system acts based on the rule-based expert systems. Inheritance rules were defined as if-then rules and placed in the inference section of the system. The system interacted with the user and asked questions through the user interface, designed separately for all three classes of inheritance. The inheritance share of each heir was determined in the inference section and made available to the user by using these questions and the information provided by the user to the system. Finally, the performance of the proposed system was evaluated by using the opinion of the legal experts.

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