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Expert System for Simulation of Litigation Outcome in Breaching the Administrative Construction Contracts

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Abstract

Because of the nature of the Egyptian public sector construction projects, disputes of breaching administrative construction contracts are subject to the supervision of the administrative judiciary. According to the special nature of these contracts, and resolving these disputes through litigation there was a great need to use the artificial intelligence application to simulate the induction litigation outcome to back up the decision of litigation. The purpose of this paper is to present a rule-based litigation expert system (RB-LES) for simulating the induction of the litigation outcome process using knowledge derived from - 1) four hundred and three lawsuits stored in the archive of the Supreme Administrative Court. 2) Articles stipulated in the Egyptian Tenders and Auctions Law no. 89 of 1998 and the Contracts Made by the Public Authority’s Law no. 182 of 2018. 3) The legal principles approved by the Technical Office of the Fatwa and Legislation Department of the Egyptian Council of State. The (RB- LES) architectural and elements (knowledge base, inference engine, and database) are presenting, as well as their functions. The applicability of the (RB-LES) has been demonstrating in five real lawsuits.

Keywords: Administrative Construction Contracts, Law of Contracts made by the Public Authorities No. 182 of 2018, Legal Rule-Based System, Litigation, Tenders, and Auctions Law No. 89 of 1998.

I. INTRODUCTION

Construction contracts that are subject to administrative laws and the control of the Egyptian council of state's judiciary, which govern the contractual relationship between the state represented by any of its institutions (administrative authorities (the "employer") and their contractors, are characterized by a special nature. Impose penalties are the most important authority enjoyed by the employer in confronting the contractor, in case the employer identifies that there is a breach of the construction contract. In construction, the obligations of the parties in their deals with each other are governing by a contract. one another in a construction project, but some of the contract's terms aren't sufficiently defined to allow for straightforward application [1]. Claims and disputes are causing by design changes, defect in implementation, and other uncertainty conditions [2].

The paper scope was limited to disputes arising from imposing the employer on the contractor one of the financial or coercive penalties or both. Throughout this paper, other limitations also stood. These limitations follow disputes arising from financial compensation because of floatation, inflation, and financial rebalancing of the Contract, changing contract quantities by more than 25%, and methods of calculating the newly.

Disputes often arise because of conflict between the contract parties. To settle the conflicts, the contractor would have to spend extra money and time [3]. Construction litigation cases were difficult to analyze because they required both engineering and legal expertise. Ashley created the legal expert system [4] by storing a vast amount of historical data on computers and analyzing it using data mining algorithms to discover the rules and solve the problem of making legal claims. To foresee the outcome of a building lawsuit, David Arditi proposed a 44-feature model based on CBR [5]. By combining CBR and fuzzy-set theory in dispute resolution, Min-Yuan Cheng was active in finding related cases as references. [6]. to generate change conflict warnings CBR and Artificial Neural Networks (ANN), Jieh Haur Chen developed a hybrid Artificial Intelligence (AI) model [7]. As a result, automated systems that use the facts and results of prior dispute cases would be highly helpful to the construction industry. Yusi Cheng developed a model for forecasting court decisions in design change cases.

The result of the case was decided using a rule-based expert method in this article (RB-LES). The following is how the majority of the paper is organized: Context information of rule-based expert systems was adopting in Section II. Section III's development strategy is described (RB-LES).

Since building statements are complex and reliant on several interrelated variables, induction of the litigation outcome of a dispute would be extremely useful to the parties involved. According to the literature, construction litigation costs increased by 425 percent from 1979 to 1990, while construction dispute settlement costing increased by 309 percent during the same period [4]. Not only had that but also as Galadari and Al Hammadi [5] point out, litigation had an impact on potential future projects between the parties involved.

As a result, litigation is more expensive and has detrimental long-term implications. This burden motivates specialists and professionals in the field to develop methods for predicting the outcome of construction litigation before it starts. Arditi and Pulket ([6] and [7]), and Chau ([8], [9], and [10]), Arditi et al. [4], researched several techniques for predicting litigation outcome by designing a specific learning algorithm and feeding it with training cases via its input cells, a perceptron. Predicting the outcome of a construction lawsuit begins with a comparison of the current case to a previous case with similar characteristics. A case with similar characteristics and proceedings held under a similar statute in a similar jurisdiction would be searching out by the researcher. A building project is, by definition, a one-of-a-kind undertaking; as a result, identifying historical parallels to predict a specific current case is nearly impossible.

Advances in artificial inelegance, programmers to train on particular patterns, assess the relationship between input and output sets, and forecast new systems based on data from previous systems, on the other hand.

II. RULE-BASED EXPERT SYSTEMS (RBES) IN APPLICATION

RBES is a device that solves real-world problems in a particular domain using expert human intelligence. [15]. The information acquisition engineer produces domain-specific knowledge in collaboration with a domain expert, and then saved as rules in a knowledge base Expert knowledge is communicated by laws, which are if-then statements. In the same way as a domain expert looks for patterns in input data that match patterns in the rule set to infer answers, make predictions, and make recommendations, an inference engine in expert systems looks for patterns in input data that match patterns in the rule set. The "if" means that a corresponding action should be taking when "the condition" is true. As a result, RBES necessitates a broad understanding of the domain as well as techniques for applying that understanding to problem-solving and inference generation. A typical RBES is making up of three main components.

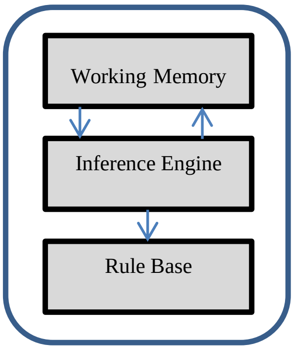

Fig1. Rule-based System element

A. *Working memory*

This is often using to save data input or details about a specific problem or scenario. Working memory aids the system in problem solving by serving as a method for collecting knowledge in a rule-based framework [15].

B. *Inference engine*

The role of the inference engine is to obtain information or produce logic from a given situation by applying rules from the knowledge base. The inference engine would find and correctly assemble all of the necessary data, interpretations, and laws. Forward chaining (data-conclude, antecedent-conclude) and backward chaining are the two main methods for processing rules. [15]. All facts are fed into the systems in forwarding chaining, In the case of the rules in the rule set, the scheme allows a propositional inference. Backward chaining is a system that examines facts in the rule base to see whether clauses are true in a consistent manner.

C. *Rule base*

The knowledge base (rule base) is made up of a set of rules that make up the domain's knowledge [8]. Expert knowledge has been depicted as "if antecedents were then because of this." Based on the input data, the rule base was used to derive conclusions from a series of patterns. The basic sense of law is as follows: If Conditions 1 and 2 are true, then Actions 1, 2, and 3 are also true. As antecedents, the conditions (1-n) have been discovered. When all elements (Condition 1-n) are met and the effects (Action 1-n) are carried out, a rule is activated. In complex circumstances, however, some RBES make the use of disjunctions like "or" in the antecedents before the Action (1-n) is performed. [15].

III. DEVELOPMENT OF A LITIGATION EXPERT SYSTEM BASED ON RULES (RB-LES)

A rule-based expert framework was using to draw conclusions (s) from user inputs [16]. The system is making up of a database that stores the domain for collecting information, rules for inferring new evidence, and a process control engine (rule interpreter). A law is making up of two parts: a premise and an action. Due to the vast majority of domain experts, communicate their knowledge as rules. As a result, rules are the most common way for expert systems to represent knowledge. As a result, the expert system's goal is to formalize domain experts' knowledge for implicit reasoning to replicate their expertise and reasoning skills. This is done by ensuring that all relevant knowledge has been explicitly formulating and that any derivation of that knowledge had been subjecting to explicit rules. This section outlines the (RB-LES) growth strategy. The growth framework is depicting in Figure 1. The development of expert systems is dividing into four phases. Phase 1 of the knowledge engineering process includes knowledge acquisition, knowledge categorization, and knowledge representation. The system's architecture is the focus of phase two. The design and construction of the system is the third phase. The system's operation and validation are depicting in the fourth phase. The

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stages are outlined [15] as follows:

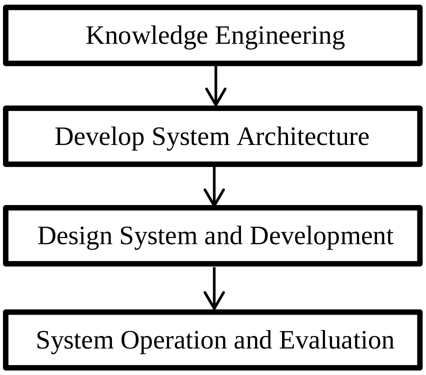

Fig2. (RB-LES) System development methodology

A. *Knowledge engineering*

This phase of the system development covers the knowledge engineering elements. Knowledge from a domain specialist, knowledge categorization, and knowledge representation in the form of rules make up this system [17]. Figure 3 illustrates and describes each process in detail.

1) *Knowledge acquisition*

The most difficult and time-consuming phase of expert system development is knowledge acquisition (KA) [18]. Regardless, it is the first step toward developing any knowledge-based system. The method of collecting and transmitting information from an information provider (domain expert) to a human expert knowledge engineering (expert system builder) knows as Knowledge acquisition (KA) [17].

(KA) a process carried out through two phases, the first phase conducted is determination the characteristics of data collection was for litigation lawsuit stored in the archives of the third circuit of the Supreme Administrative Court. The first phase has three parts; the first part is the extraction of the legal articles governing disputes that arise from breach the administrative construction contracts that in paper scope from Egyptian Tenders and Auctions Law no. 89 of 1998 and Contracts Concluded by Public Authority's no. 182 of 2018. Also, extraction the legal principles approved by the Technical Office of the Fatwa and Legislation Department of the Egyptian Council of State. The second part is conducting an investigation study on the litigation files stored in the archives of the Supreme Administrative Court. The third part demonstrates the practicality, sufficiency, and effectiveness of the priority data collected from the previous two parts, it conducting by formulating priority data in documents to conduct 65 personal interviews including 25 personal interviews with the supreme administrative court and 40 interviews with engineering experts at the Egyptian Ministry of Justice. The completed list of factors affecting the disputes in breach of the administrative construction contracts included in the expert system has shown in table I.

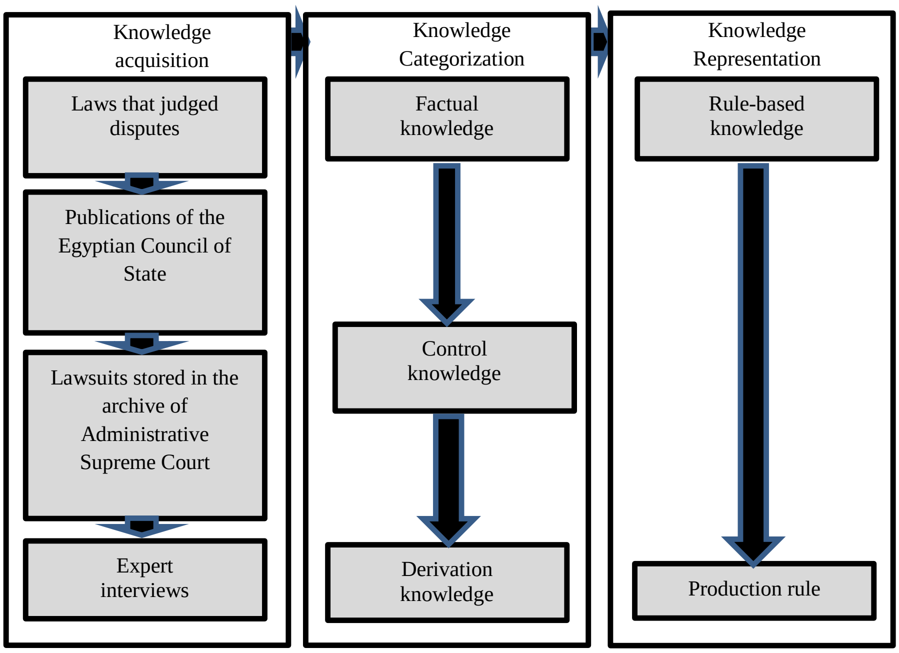

Fig3. The flowchart of the knowledge engineering phase

Table I. Factors affecting the disputes in breach of the administrative construction contracts included in the expert system

No.	Factor name	Measure
1	The existence of an explicit provision in the contract states how to impose a penalty of damages compensation.	Yes/No
2	The incident leading to force majeure was predictable.	Yes/No
3	The incident leading to force majeure could be repaid or reducing.	Yes/No
4	The execution of the contract continued even if force majeure occurred.	Yes/No
5	The force major was occurring due to the fault of the contractor or the employer or both.	Yes/No
6	The beginning of force majeure was before the date of contracting and actual execution of works.	Yes/No
7	The term between notifies the contractor to accept his bid and his payment of the final insurance value exceeded ten working days.	Yes/No
8	Existence an explicit item in the contract that states how the amount of the delay fine is calculated.	Yes/No
9	Existence of declarations or correspondences or evidence from the employer, expressly or impliedly that it was not keen on implement the contract.	Yes/No
10	Force majeure was existence.	Yes/No
11	The contract was signed before 3/10/2018	Yes/No
12	The existence of a breach by the employer of any item of the contract led to a delay.	Yes/No
14	Existence explicit of items in the contract related to the entitlement of the employer to impose any financial penalties other than the delay fine and confiscation of insurance.	Yes/No
15	Existence of technical errors on how to calculate the penalty value as stated in the contract provision.	Yes/No
16	The employer informed the Public Prosecution against you after it decided to remove you from the register of contractors.	Yes/No
17	The delay works were subtracting by one of the contracting methods with the same terms and specifications according, contracting with the original contractor except for the price.	Yes/No
18	In the case of withdrawal of the work, the employer did not take procedures contracting with others and took an assignment to the next bid.	Yes/No
19	In the case of withdrawal of the work, the employer imposes a delay fine on you before the date of issuance of the work withdrawal decision.	Yes/No
20	The rationale for the decision to remove you from the contractors' register relates to the contractor's use of fraud, deception, manipulation, bad intentions, roguery, corruption, or monopoly.	Yes/No
21	The date for imposing the delay fine is later or earlier than the date of initial delivery of the works.	later /earlier
22	Amount of work performed by another contractor after the withdrawal of work from the original contractor.	…L.E
23	The original contract amount is…	…L.E
24	The amount of administrative expenses because of the re-subtraction of the delay work is…	…L.E
25	The amount of the delay fine is providing for in the contract.	…L.E
26	The amount of the delay work is…	…L.E
27	The amount of the delay fine penalty under the law applied or contracted.	…L.E
28	The amount of delay fine penalty signed by the employer is…	…L.E
29	The amount of the primary insurance according to the contract, is…	…L.E
30	The amount of the final insurance according to the applicable Law contracting, is…	…L.E
31	The amount of final payment is….	…L.E
31	The amount received by the original contractor from the extracts before the issuance of the work withdrawal decision.	…L.E
32	The amounts deducted from the contractor other than the amount of delay fine and damages	…L.E

No.	Factor name	Measure
	compensation penalties, for example (quality control, defective specifications, maintenance work ... etc.	
33	The executive period stipulated in the contract.	…Day
34	The actual period of the work carried out.	…Day
35	The period added to the period of implementation stipulated in the contract.	…Day
36	The period of the work performed by the original contractor according to the schedule stipulated in the contract from the beginning of the contract until the date of placing of the employer on the contracting.	…Day
37	The period of the incident leading to force majeure is...	…Day
38	The period of delayed works according to the schedule is…	…Day
39	The period of the delay work by the original contractor according to the schedule stipulated in the contract from the beginning of the contract until the date of placing the employer on the contracting.	…Day
40	The contract period stipulated in the delay work -contracting contract.	…Day

The second phase of (KA) process is data collection from litigation files. All investigated litigation files were in the scope of disputes that arises from breaching administrative construction contracts. Over 9000 files were investigating. Four hundred and three files approximately 4.5% of 9000 files were adopting and considering.

2) Knowledge Categorization

Differentiations have been made in categorizing domain specialist information according to its users depending on the knowledge source.. Control knowledge and factual knowledge, and derivation knowledge have been classified as three kinds of knowledge related to administrative construction contract breaches [18]. The laws of (RB-LES) are obtaining from the wisdom of derivation. Physical observation identified derivation knowledge, which was discovered by a domain expert. Failure to consider the formal aspects of filing a lawsuit, for example, results in the lawsuit has been rejected without examination of the technical aspects of the dispute.

Control knowledge refers to the meta-laws that govern the deductive rules derived from derivation knowledge. Experience and decision-making differentiate factual knowledge, such as the experience gained from applying rules (derivation knowledge) to make decisions.

3) Knowledge Representation

This phase aims to coding specialized knowledge (formal and technicalities factors) affecting the outcome of litigation for disputes raised from breach administrative construction contracts, This is done by transforming the facts (laws and judicial decisions that govern these disputes) and the relationships that make up specialized knowledge into a machine-readable format. Information representation methodologies include ontology, semantic networks, rational wording, casual networks, and laws [19]. Due to its impressive deductive inference performance using only a few rules, For expert systems, rule-based software has become very popular. [20]. (RB-LES) the database contains fourteen cycles which are (Formalities, general procedures, damages compensation, delay fine, confiscation of Insurance, withdrawal of work and execution on account, removing contractor from the contractors' records, Termination of Contract, ...). Each cycle coded with a different code, and the litigation results had shown for each part separately in the form of a tree of decisions for each branch as a result (rule). Table II has shown (RB-LES) Cycles and their Rules.

Table II (RB-LES) Cycles and its Rules

NO	Code	Cycle	Rule
1	A	Formalities	5
2	B	General procedures	4
3	C	Damages compensation	4
4	D	Confiscation of Insurance	14
5	E	Delay fine	12
6	F	Damages compensation & confiscation of Insurance	2
7	G	Damages compensation & delay fine	12
8	H	Confiscation of Insurance & delay fine	16
9	I	Damages compensation & confiscation of Insurance & delay fine	16
10	J	Withdrawal of work and execution on account	12
11	K	Termination of contract	12
12	L	Withdrawal of work and execution on account & removing contractor from the contractors' records	12
13	M	Termination of contract & removing contractor from the contractors' records	12
14	N	Removing contractor from the contractors' records	8
SUM			141

For example, figure four shown a decision tree for the withdrawal part and execution on the accounting cycle.

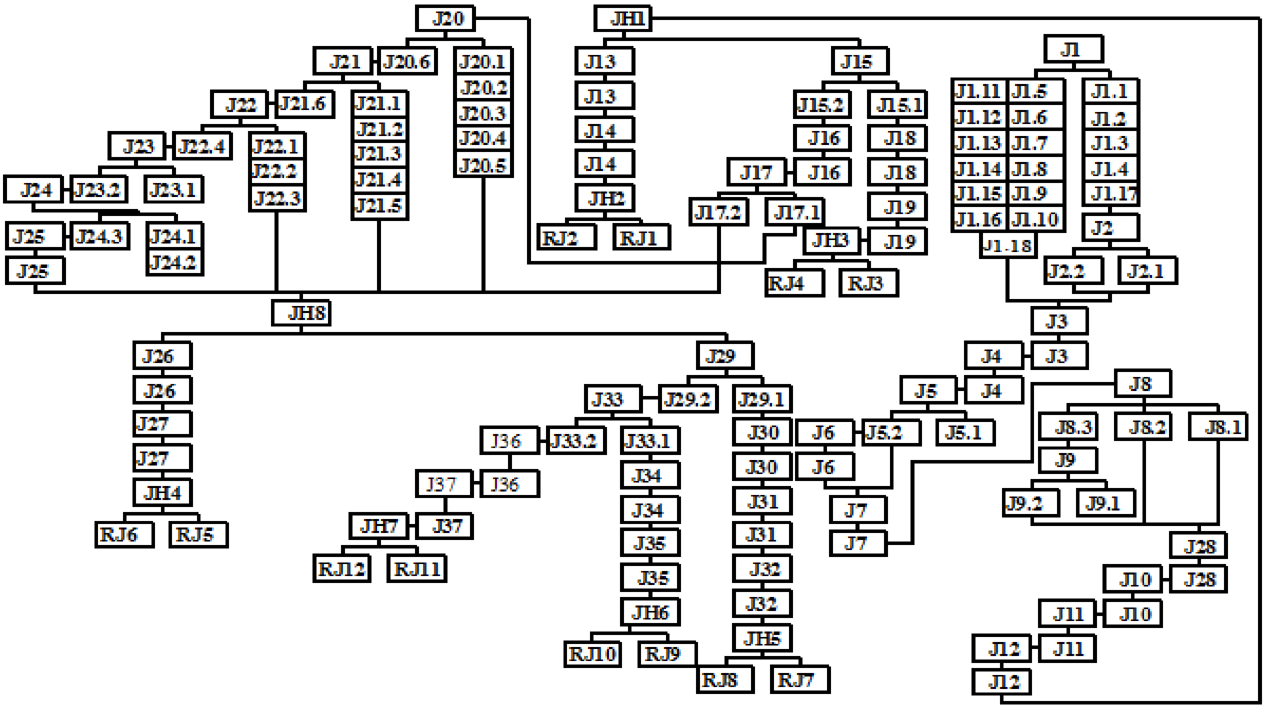

Fig4. Decision tree for the withdrawal part and execution on the accounting cycle

B. Components and architecture of (RB-LES)

The system architecture is a road map that outlines the system's functionalities and gives a high-level overview of the development process. (a) A user interface, (b) a database, (c) an inference engine, (d) a knowledge base, and (e) a knowledge base have all been developing as part of the LES architecture. Below is a diagram of Figure 5's basic architecture (RB-LES).

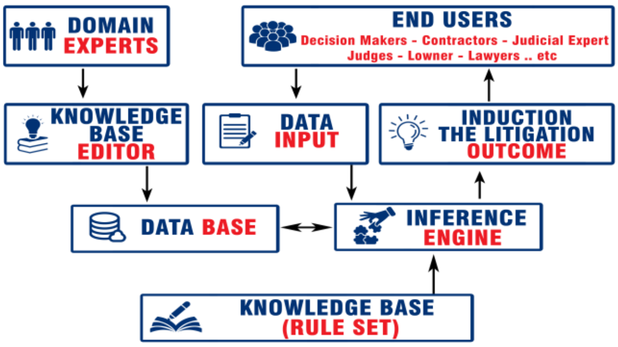

Fig5. The structure of (RB-LES)

1) Graphical User Interface (GUI)

Domain experts would find it easy to use the interactive (GUI) , end-users (decision-makers, contractors, judicial experts, judges, employers, and others) to communicate with each other in (RB-LES). The system is simple to use when interacting with a domain specialist who is responsible for creating or editing the knowledge base, as well as the knowledge base's end-users (RB-LES). Various interfaces for the knowledge base editor are being developed.

2) Database

The (RB-LES) database component stores indigenous knowledge on disputes resulting from administrative construction contract breaches on a relational database server is referring to as a SQL server. Truth, data for the knowledge base and possible litigation results come after the deductive inference. relevant have all been stored in the database. The system developer extracted domain-specific knowledge from 403 lawsuits in the Administrative Supreme Court's archive and transformed it into SQL data...

3) Inference Engine

The forward-chaining technique is used by the inference engine to perform rule-based reasoning. Forward chaining is useful because it can solve problems quickly, it can use for tracking and rule-based expert systems [20]. The forward chaining method's search techniques begin with facts that match the premise in the hypothesis.

If the premise of an IF-THEN rule matches the facts, the rule is applied [21, 22]. The forward chaining method [20, 20] has three fundamental steps: -

- To determine whether a rule is applicable, the premises or conditions of all rules must match/satisfy content from databases. If all of the rules are following, a contradictory set will emerge.

- Choose - from the conflict set, choose one or more rules to execute.
- The conclusion is activating by the chosen rule from the conflict set that has been executing.

Users may select the rule of conflicts set in the second stage using a variety of methods, including priority values and first-come-first-served priority values met the criteria [23]. Each rule has a priority value, and if there is more than one rule that matches the facts in the conflict set, the rule with the highest priority value is choosing for execution [23].

This part contains the software code that, in a given situation, applies the rules based on facts provided by a domain expert. It provides administrative construction contracts advisory knowledge information through the GUI and predicts the likely outcome of litigation using the knowledge base's decision rules-tree. (RB-LES) uses SQL Server Management Studio (SSMS).

4) Knowledge base

Previously, the knowledge base was using to store domain knowledge in the form of rules that were required for a successful litigation outcome. Questions and answers are repeating through a decision tree in local indigenous expertise on conflicts arising from administrative construction contract breaches. Because the nature of a judicial decision in a lawsuit is analogous to the approach (if ..., etc., then ...). Due to the astounding deductive inference performance of combining rules, Expert systems have benefited from the use of rule-based programming. There are approximately 141 rules in the (RB-LES) rule base.

C. (RB-LES) Design and Development

This system n has been designing to use by those interested in the field of disputes that rose from breaching administrative construction contracts (decision-makers, contractors, judicial experts, judges, and employers. The litigation expert systems (RB- LES) will be programming using SQL Server Management Studio (SSMS). RB-LES is compatible with SSMS and runs on the Microsoft Windows platform.

The relational database contains extensive indigenous information expertise on litigation outcomes of disputes arising from breaches of administrative construction contracts, the knowledge base, on the other hand, includes rules for dealing with domain-specific issues. Before settling on SSMS, a thorough analysis of the available tools for building an expert system shell had been conducting.

SSMS is intelligent expert system that can be built using a rule-based tool. SSMS is a centralized management environment for SQL systems, including SQL Server and Azure SQL Database are two different databases. The SQL Server Management Studio is a platform for handling SQL Server databases (SSMS) is a collection of tools for configuring, monitoring, and administering SQL Server and database instances.

D. Validation and operation of the RB-LES

Every deductive session begins with the user selecting a function from the GUI to determine the necessary interface from the three options – knowledge base editing, data input, and data output – while running on a Windows PC/SSMS. The graphical user interface is how the user interacts with the device (GUI), which includes pushbuttons, radio buttons, drop-down lists, text fields, and other methods for entering data. Using the domain specialist can add, update, and delete rules and other contents in the KB and database using the knowledge base editor interface. Based on the knowledge base's rules, the decision was made by the inference engine. After each inference, the deductive feasibility decision of litigation produced an indication of a financial claim. The inferred knowledge is showing via the output interface after the deductive inference from the users' input. The database's Methodology for preparing claims is also displaying depending on the content of the conflicts, to the end-user. End-users may benefit from this additional information in accepting the deductive litigation result.

The method of determining the consistency of an expert system's inferences knows as expert system evaluation [17]. Verification and validation, according to the procedures, the verification process ensures that the system's expertise is accurate and that it properly implements its specifications, the validation process ensures that a device performs to a sufficient degree of accuracy after it has been implementing. requirements (display the litigation feasibility). Five real litigation lawsuits stored in the archive of the Supreme Administrative Court that had previously adjudicated related to disputes raised from breaches of administrative construction contracts have been using to illustrate the expert system's practicality.

The five cases were analyzing and inputted into the system using the variables and characteristics described in Table I. (RB-LES). The result of the cases is deduced from the decision trees in RB-LES once all of the variables have been obtained. The Expert System's outputs showed whether to proceed with the litigation process, the amount of money owed to the Contractor in the event of positive feasibility, and the applicable legal grounds. Table III shows a comparison of RB-LES output and the judgments issued in the five lawsuits mentioned above.

Table III. Comparing between RB-LES output and the judgments issued in the aforementioned five lawsuits

Case	Disputes in case rise from…	Feasibility of proceeding into litigation, funds owed to the Contractor according to	
		judgments issued	RB-LES OUTPUT
1	Withdrawal of work and execution on account & removing contractor from the contractors' records	No	No

2	Delay fine	Yes (149621 L.E)	Yes (149621 L.E)
3	Withdrawal of work and execution on account & removing contractor from the contractors' records	No	No
4	Delay fine	Yes (13672 L.E)	Yes (13672 L.E)
5	Delay fine	Yes (6823.3 L.E)	Yes (6823.3 L.E)

IV. CONCLUSION AND FUTURE WORK

By integrating local indigenous knowledge, the RB-LES is a useful tool for improving the induction of litigation outcomes. A rule-based approach is using by the system. The need to combine local indigenous knowledge with cutting-edge artificial intelligence (AI) methods prompted the current research. As a result, the designs and implementation of rule-based, administrative construction disputes expert systems are discussing in this research. As a foundation for the achievement of induction litigation outcome expert systems based on local indigenous knowledge. This method made it easier to generate inferences with improved intelligence from domain experts' expertise. By matching user input with facts, it can imitate native domain expert forecasting procedures (laws and judgment). The output of the RB-LES allows those interested in the field of administrative construction contract disputes (decision-makers, Judges, lawyers, experts, contractors, and employer) as follows:-

- Initial induction based on the outcome of the lawsuit
- Assisting with claim preparation

It should note, however, that the court cases represent Egyptian construction litigation and may not apply to other countries. A few projects could pursue. As a result, the following are the upcoming projects:

- Improving the RB-LES process by use an adjacency matrix and integrating inferences from heterogeneous information bases, and even an ontological-based logic strategy.
- RB-LES is a stand-alone application that runs on a PC/Server in its current form. In the future, it will be as an application expert system running with a quality assurance system assessment.

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