THE TRADITION OF LEGAL EXPERT SYSTEMS – POSSIBILITIES, LIMITATIONS AND THE WAY FORWARD

Michał Araszkiewicz / Agata Łopatkiewicz / Tomasz Zurek

Adjunct Professor, Jagiellonian University, Faculty of Law and Administration, Department of Legal Theory
Bracka 12, 31-005 Kraków, PL
michal.araszkiewicz@uj.edu.pl

PhD Candidate, Jagiellonian University, Faculty of Philosophy, Department of Education
Stefana Batorego 12, 31-135 Kraków, PL
agata.lopatkiewicz@uj.edu.pl

Adjunct Professor, Maria Curie-Sklodowska University in Lublin, Institute of Computer Science
Akademicka 9, 20-033 Lublin, PL
zurek@kft.umcs.lublin.pl; www.informatyka.umcs.lublin.pl

Keywords: ***Legal education, legal expert systems, Machine Learning, rule-based reasoning, validity***

Abstract: *Legal expert systems, including rule-based ones (RBLES) have been around for four decades now. Their limitations are well-known and discussed in the literature. However, in our opinion, this technology has some underexplored potential and in this paper we highlight three such spheres: providing answers in restricted domains (in particular, in legal aid systems), enhancing information retrieval systems with respect to the notion of legal validity and performing important education functions. In the concluding part we also discuss the two spheres of possible future development of legal expert systems.*

1. Introduction[1]

This paper discusses the idea of legal expert systems, in particular Rule-Based Legal Expert Systems (RBLES) systematizes their well-known limitations and presents some new insights concerning usefulness of application of this classical technology. The 20th edition of the IRIS conference offers a good opportunity for creating a retrospective insight into the tradition of legal expert systems and to restate the basic question concerning legal expertise that may be embedded in knowledge-based systems.

2. Legal Expert Systems as a Scientific Project

Expert systems emerged in the domain of Artificial Intelligence in the 1960s. Unlike the systems developed to represent general intelligence, which failed as a scientific project in particular because of inability to represent common-sense reasoning, expert systems were developed to perform inferences from clearly defined domains of knowledge, such as chemistry (DENDRAL), medical diagnosis (MYCIN) and the like. The idea of legal expert systems, proposed in early 1970s, began to materialize in the second half of this decade (famous system TAXMAN developed by L. Thorne McCarty)[2] and was perhaps the most debated topic in AI and Law research in 1980s, resulting in many important projects (British Nationality Act as logic program,[3] Yoshino's

[1] The publication of this paper is supported by the research project NCN no 2012/07/B/HS4/02994 «Legal aid in Poland from the perspective of economic analysis of law. The current and the recommended state».

[2] McCarty, Reflections on «Taxman»: An Experiment in Artificial Intelligence and Legal Reasoning, Harvard Law Review Vol. 90, 1977, no. 5, pp. 837–893.

[3] Sergot et al., The British Nationality Act as a logic program, Comunications of the ACM Vol. 29, 1986, no. 5, pp. 370–386.

system LES,[4] case-based reasoning system HYPO[5] and many others[6]). Certain features of law as a domain of knowledge makes the idea of legal expert system very promising. Statutory law is (1) accessible in authoritative sources defined in the law itself (official journals of law); (2) structured in a manner which even in its raw form, expressed in natural language, resembles a knowledge base of a logic program (conditional and unconditional rules) and (3) in spite of many theoretical controversies, generally perceived to obey the rules of logic in the sense that lawyers may draw and actually do draw logical conclusions from statutory text (in this place we cannot enter in the broad discussion concerning the choice of logical calculus for representation of legal norm, the problem of monotonicity of this calculus and the like; for the recent elaboration of the state of the art see the recent volume «Logic in the Theory and Practice of Lawmaking»).[7] The abovementioned features are weaker as far as case-based reasoning systems are concerned (the databases of cases are not regulated to the extent characteristic for journals of laws; the cases are presented in less structured language than legislation; cases are used as premises of rather non-deductive arguments, based on the notion of similarity; however even in case-based reasoning the top level reasoning may be expressed as a logic program as in case of the IBP system[8]), but the essence of functioning of expert systems remains similar. In the following analysis we will focus on Rule-Based Legal Expert Systems (RBLES).

There was an expectation that legal expert systems, including rule-based expert systems, will act similarly to professional lawyers providing advice in concrete cases. The systems asked users questions in order to add factual information to the theory and then inferred logical conclusions from the knowledge base, encompassing both the law and the facts. The successful performance of the BNA project stemmed in particular from the fact that this program asked straightforward questions about date and place of birth and similar data. However, in case of other expert systems, providing answers to questions required a high degree of legal expertise (for instance, LES-2 asked a question whether a letter sent to the addressee contained an offer, the question which may be too difficult for a lay user). This feature of certain expressions of legal language was identified at the very beginning of legal expert systems (cf. the notion of deformation of prototype in TAXMAN) and is often discussed under the label of open texture; however, in fact, open texture as defined by Waismann[9] is only one among many reasons for difficulties in determination of the scope of statutory expressions.[10] In order to answer a question how human lawyers provide answers to questions concerning the cope of application of statutory rules we should first take a look at the process of legal training. Each lawyer possess a considerable degree of general knowledge (typically in the field of humanities) and during his or her professional training builds a system of legal knowledge not only from the statutes, but from textbooks, case law, monographs and papers written by legal scholars, etc. In addition to this, a vast degree of legal knowledge comes from experience and it is not stored in any publicly available source. Relatively complicated models of representation of legal knowledge – the development of which started in the 2000s (to mention the model developed by Bench-Capon and Sartor in 2003)[11] – have started to reveal the degree of complexity of actual legal reasoning and the theoretical elaboration of this process last to this day, recently focusing on the notion of statutory interpretation.

---

4 Yoshino et al., Legal expert system – LES-2, Lecture Notes in Computer Science Vol. 264, 1987, pp. 34-45.

5 Ashley, Modeling Legal Argument. Reasoning with Cases and Hypotheticals, MIT Press, Cambridge 1990.

6 Bench-Capon et al., A history of AI and Law in 50 papers: 25 years of the international conference on AI and Law, Artificial Intelligence and Law Vol. 20, 2012, Issue 3, pp. 215–319.

7 Araszkiewicz / Płeszka (eds.), Logic in the Theory and Practice of Lawmaking, Springer, Cham 2016.

8 Brüninghaus/Ashley, Predicting Outcomes of Case-Based Arguments, Proceedings of the Ninth International Conference on Artificial Intelligence and Law, ACM, pp. 233–242.

9 Waismann, Verifiability, Proceedings of the Aristotelian Society, Supplementary Volumes, Vol. 19, Analysis and Metaphysics, 1945, pp. 119–150.

10 Endicott, Vagueness in Law, Oxford University Press, Oxford 2001.

11 Bench-Capon/Sartor, A model of legal reasoning with cases incorporating theories and values, Artificial Intelligence Vol. 150, 2003, no. 1–2, pp. 97–143.

Therefore, it seems that the expectation concerning providing legal answers in concrete cases – in all classical domains of law including civil law – was definitely too high for legal expert system technology.

In our view, legal expert systems (using the classical rule-based knowledge bases and inference engines) may perform three important functions, to the benefit of the addressees of legal regulation: (1) providing answers in certain restricted domains, where questions and answers may be unequivocally understood by users of the system; (2) enhancing the existing legal information systems by modules providing answers on legal validity: the sets of rules, and versions thereof, applicable to states of affairs taking place on particular date and (3) educational function: enhancing the awareness of users of the system of issues to be decided in a case of particular type. The following sections of this paper are devoted to these problems respectively.

3. Providing Answers in Restricted Domains

Classical rule-based expert systems have succeeded only in some particular areas (medicine, credit granting decisions, etc.) where expert opinions require extensive but highly specialized and well-structured knowledge. What is more, the construction of such systems can only be purposeful if the expert opinions based on this knowledge are prepared often enough to make the construction of such a system worthwhile. Unfortunately, the majority of real problems faced by lawyers, even regarding a single legal act, necessitate very broad knowledge from various fields; quite frequently, for the proper consideration of a given case, commonsense specific knowledge relevant for the case is needed apart from the mastery of legal norms and rules. A realization of an expert system where every new case would entail the necessity of introducing big data resources of new knowledge can hardly be imagined.

The awareness of these difficulties as well as limited possibilities of classical expert systems (regarding both the formal knowledge and reasoning representation methods and the scope of knowledge indispensable for reasoning) resulted in basically all attempts to practically implement legal expert systems ending up as related to a very narrow scope of some areas of administrative law.

It is worth to consider what characteristics a legal area must have in which a classical expert system could work. We believe that:

1. It should be possible to formalize relatively easily (which excludes the fragments of law allowing for large interpretation possibilities and narrows down the choice to the branches of law for which the primacy of linguistic interpretation is accepted).
2. It should constitute a wholeness which would not require the usage of other fragments of law, or require it to a very limited extent.
3. The expert opinions should be dependent as little as possible on the extrajudicial circumstances of the case.
4. The list of the possible circumstances of the case should be known and relatively small; also, every system user should be able to easily determine whether a given circumstance exists in a given case or not.

In particular, the last point made here leads to interesting investigation. What questions are (relatively) simple for the intended users? Obviously, an answer to this problem depends on two factors: the features of the question (in particular, the content of *datum questionis*) and the characteristics of the user. Obviously, different types of users possess different degrees of legal knowledge and therefore they may assess given questions differently with respect to the criterion of difficulty. However, the social group which would benefit to the greatest extent from the use of RBLES are lay users, people who have very limited knowledge about the law.

Expert opinions in this field should be usable, but not trivial (this is an economic condition, since coming up with an expert system for trivial problems is inefficient).

The above list clearly narrows the choice of the area in which such a system would operate to some areas of tax law (linguistic interpretation domination, strong determination of resolution by the legal text, prohibition of extensive interpretation, etc.), immigration law, and some fragments of inheritance law[12] (both these areas rely on unambiguous and easily described family relations), etc.

It is worth noticing that the abovementioned areas for which expert systems can be made have been known for many years (TAXMAN, British Nationality Act, etc.), and hence a question can be raised whether the current state of the art regarding AI and Law allows for extending this list.

The development of artificial intelligence tools which has occurred in the last years triggered the emergence of the possibilities which let us hope that the answer to this question is positive. We discuss them briefly in the last section of the paper. In the following section, however, we focus on a specific domain which may be fruitfully developed even if the classical method of RBLES development is preserved.

4. Enhancing Legal Information Systems with respect to Questions of Validity

The topic of validity is one of the most complicated issues in legal theory.[13] A fully-fledged discourse on legal validity is an extremely complex phenomenon[14] and thus it cannot be modelled in RBLES. However, there is an important part of this discourse, of utmost practical importance, which indeed can be captured in RBLES. This is the discourse of status of legal norms with respect to such predicates as «being in force» and «be applicable» to a range of states of affairs. This issue may be classified as relatively «easy» with respect to the criteria indicated in the previous section of this paper, and thus manageable for RBLES. This aspect of legal validity has been the subject of attention of classical legal expert systems.[15] However, it seems that this issue has not attracted sufficient attention in practical works on legal expert systems.

Contemporary commercial databases of legal knowledge offer the users access to updated and consolidated versions of legal acts, in particular, statutes. It is possible to display all versions of these normative acts, i.e. for each day in the calendar it is possible to display a version of legal act containing all provisions of this act which are in force (and these provisions only). From the computational point of view this result is not difficult, for any statutory provision has its fixed date of entering into force and of formal derogation or amendment (although the situation becomes more problematic if there is a mistake in a modifying or derogating provision). However, this result is not sufficient for practising lawyers as regards the choice of legal provisions applicable to given fact situations. Let us consider three following dates: X, Y and Z, where X is the date on which the state of affairs took place, Y is the date of initiation of legal proceedings in the case and Z is the date of judgement. Let us further assume that the legislator modified the applicable legislation L in such way that on the three abovementioned days, three different versions of this legislation (a, b and c) were in force. For any lawyer it is obvious that this does not automatically mean that the legislation being in force is applicable on the date in question. The typical situations are indicated in the following table:

Situation type	X	Y	Z
1.	a	a	a
2.	a	a	c
3.	a	b	b

[12] A good recent example from Poland, fit for application in legal aid systems: http://www.inpris.pl/przedsiewziecia/infografiki-i-wzory-dla-osob-niepelnosprawnych/ (last accessed on 31 January 2017). It should be stressed that the presence of any legal information in IT-enhanced legal aid systems, provided that it is unequivocal and accurate, can serve as a factor enhancing access to justice.

[13] Araszkiewicz/Casanovas, On Legal Validity, in: Bex/Villata (eds.), Legal Knowledge and Information Systems – JURIX 2016: The Twenty-Ninth Annual Conference, IOS Press, Amsterdam 2016, pp. 125–130.

[14] Grabowski, Juristic Concept of the Validity of Statutory Law, Springer-Verlag, Berlin Heidelberg 2013.

[15] Yoshino, The systematization of law in terms of validity, Proceedings of the 13th International Conference on Artificial Intelligence and Law, ACM, New York 2011, pp. 121–125.

4.	a	b	c
5.	b	b	b
6.	b	b	c
7.	c	c	c

Table 1. 7 typical variants of applicability of different versions of legislation to: the date of state of affairs, the date of initiation of proceedings and the date of issuing of judgement

The table presented above shows only 7 out of 27 logically possible variants, because the remaining 20 are not very likely to happen in actual legislative practice. The table shows that regulation may be applicable to present situations even if they are formally repealed (as in situations 1-3) as well as they may be applied retroactively (situations 5-7). In particular the situation 3 is typical with respect to procedural provisions (legal rules in force on the date of initiation of proceedings are applicable to the issued judgement). Unless the intertemporal regulations are manually checked (for instance, by a paralegal) a lawyer cannot be sure whether rules in force on certain date are actually applicable to the state of affairs taking place on this date.

Due to the fact that intertemporal provisions typically use simple information (indication of temporal range of applicability of certain regulations, dates of formal repeal and entering into force) they are in principle manageable for RBLES. From a formal point of view, such RBLES should model the following valuation function. Let S_t be the set of all legal relevant states of affairs, where subscript «t» indicates the date on which this state of affairs took place. Let PROV(L) be the set of all (versions of) provisions of a given legislative act L. The valuation function «is applicable to» is a function which adopts an element prov $\in$ PROV(L), s $\in S_t>$ as its domain elements and values 1 (is applicable) and 0 (is not applicable) as elements of its counter domain. Let us note that calculation of this function might give interesting additional information for the user: as set of all states of affairs (types and dates) to which a given provision is applicable and, conversely, a set of all provisions which are applicable to a given state of affairs.

5. Performing Educational Functions

As Bench-Capon rightly points out, one certain benefit of using RBLES is that they give the user a set of questions or issues to be considered in a given legal problem, albeit seldom enabling the user to obtain the relevant answers.[16] One might state that even an information on the relevant issues and the ordering of their consideration is already a valuable, although seriously incomplete, legal information. However, RBLES contribute to the task of legal education to a much higher extent. The degree of this contribution is relative to the nature of the knowledge base of an expert system and the intended context of its application.

For instance, the prototype Parenting Plan Support System (PPSS) is a hybrid system which helps the users (parents) to draft an agreement on exercise of parental custody after the divorce or in case the couple is not married and they do not intend to live together; in such situations the issues of parental custody have to be either authorized or resolved by the court.[17] The court can accept the agreement between the parents (that is, the parenting plan) only if the latter is in accordance with the well-being of the child. The latter concept is of course open-textured and context-sensitive. The PPSS contains a rich database of cases, factors, pedagogical knowledge rules and common-sense rules which enable the system to present suggestions on the content of the parenting plan. The system was partially implemented in Prolog language.[18] Thus the information stored

[16] Bench-Capon, What Makes a System a Legal Expert?, in: Schafer (ed.), Legal Knowledge and Information Systems – JURIX 2012: The Twenty-Fifth Annual Conference, IOS Press, Amsterdam 2012, pp. 11–20.

[17] Araszkiewicz/Łopatkiewicz/Zienkiewicz/Zurek, Framing a Knowledge Base for a Legal Expert System Dealing with Indeterminate Concepts, The Scientific World Journal 2015 Article ID 985425, 14 pages, doi:10.1155/2015/98542.

[18] Araszkiewicz/Łopatkiewicz/Zienkiewicz/Zurek, Representation of an actual divorce dispute in the parenting plan support system, Proceedings of the 15th International Conference on Artificial Intelligence and Law, ACM, New York 2015, S. 166–170.

in the system is a closed environment and in certain fact situations it may appear insufficient to capture the circumstances of the case in adequate manner. The reasoning performed by the system may be useful and informative for different types of actors nevertheless.

As far as the principal users (parents) are concerned, the system informs them, first, about the content of applicable legal rules and about the consequences of refraining from parental plan drafting. Second, the system provides an information that the well-being of the child is the paramount criterion as far as legal assessment of the parenting plan draft is concerned, thus imposing constraints on the scope and content on the developed agreement. In particular, the PPSS rejects certain options as inacceptable with respect to the mentioned criterion. Third, the program suggests the user how an agreement should be systematized and what types of information should be contained therein, in order for the plan to be relatively complete, and thus decreasing the likeliness of its rejection by the court. In this respect, the system also instructs the users as regards the possible options of agreement provisions. The program increases the awareness of parents as for the content of the legal concept of well-being of the child, as it is understood and developed by the judiciary.

The PPSS may also be useful for judges, deciding on acceptability of the parenting plan draft, submitted by the parents, with regard to the notion of well-being of the child. The PPSS can be used as a comparative background for any concrete agreement draft and be used to test the consistency and completeness of the submitted parenting plan. Informed by the content of the system's knowledge base, the court may intervene in the exchange of opinions between the parents, possibly mitigating the escalation of the conflict.

The PPSS is also potentially beneficial for professional counsels, representing the interests of parties to the dispute. Like judges, attorneys are trained to act as professional lawyers and they may lack professional knowledge with respect to the issues of children psychology and related issues. Reference to the knowledge base of the PPSS and inferences it may perform relieves attorneys from performing reasoning beyond the scope of their professional expertise. More generally, even though RBLES may not be sufficient to suggest an attorney the best possible argument, they may at least suggest a few reasonable options or at least exclude the inacceptable ones.

Finally, legal expert systems may play much more important role than they do at present moment in the field of legal education and legal research. The results of experiments made by Ashley and Aleven with the CATO system in 1990s are promising.[19] Yet it seems that the generally conservative attitude of legal doctrine does not foster a broader application of legal expert systems in this field. In our opinion a broader application of RBLES in the process of legal education is desirable, even if their purpose would be to model the repetitive and schematic elements of legal reasoning. In this context legal expert systems could enhance the awareness of automatic and creative domains of legal inference. However, the discussed example of the PPSS suggest that the educational features of RBLES may be much more extensive.

6. Discussion and Conclusions

In general, we see two directions which can provide (separately or together) an interesting and novel space for the development of legal expert systems.

The first direction relates to the rapid development of a variety of artificial autonomous agents operating in the legal or quasi-legal environment. The most extreme and advanced kind of such an appliance being self-driving cars, there are a number of much simpler environments where increasingly more autonomous agents function (e.g., more and more autonomous elements of the Internet of Things). The devices' self-sufficiency entails quasi-legal regulations of their operation; most basically, the «conduct» of such devices can be regulated by a collection of rules based on deontic logic and a reasoning mechanism working in real time. The more freedom

[19] Aleven/Ashley, Doing Things with Factors, Proceedings of the Fifth International Conference on Artificial Intelligence and Law, ACM, New York 1995, pp. 31–41.

of action the devices have and the less deterministic their working environment is, the more refined methods of knowledge representation ad reasoning will have to be implemented in them. The issue of employing reasoning and argumentation in agents' activities in multi-agent systems does not seem new[20] and constitutes a prospective field of legal expert systems implementation. For example, the authors of Vasconcelos 2012 present a multi-agent system representing a supply-chain scenario in which companies and individuals come together in an (electronic) marketplace to conduct business. The system distinguishes two kinds of norms: the first type is embedded in constitutive and procedural norms that are regimented and outside the control of participating agents. The second type corresponds to non-regimented functional norms.

Moreover, quasi-legal and rule-based reasoning can be utilized in a security management of mobile devices. For example, the authors of one of the papers published in the field[21] introduce a system in which a set of rules and an inference engine control the behavior of the device in order to preserve its security.

The other direction of development of rule-based legal expert systems is connected with the limitations resulting from the knowledge acquisition bottleneck problem. From among the limitations of the existing systems, one of the most essential problems is the representation and collection of commonsense knowledge. The major issue here is not only the formal instrument of knowledge representation, but also, or perhaps above all, its hardly predictable extent (as it has already been noticed, one could hardly imagine an expert system requiring the input of new knowledge for each new case) and its source or rather, the lack of it: the models of commonsense reasoning which have worked out in projects like CYC [www.cyc.com] are still not expressive enough to be used for modeling complex real-life legal reasoning and put into legal expert systems.

The only potential source of commonsense knowledge for computer systems seems the Internet. The rapid development of machine learning techniques, deep learning, NLP (IBM Watson, IBM Debater) does, however, give hope to use these mechanisms are the prospective source of commonsense knowledge. This source appears very promising, but one should also take into consideration its serious limitations. Firstly, the source is severely cluttered (errors, lies, illogical and incoherent content, etc.) and the verification of the knowledge obtained from it seems a very serious though not yet fully specified problem (it is worth noticing that the IBM Debater is based on Wikipedia, which is verified). Another difficulty is linked with the specificity of legal reasoning where the justification of the judgment is frequently no less important than the judgment itself. The machine learning techniques, in particular neural network-based deep learning, are not able to justify their conclusions (a neural network can learn to recognize patterns, but it cannot indicate how they are recognized) – in the case of legal expert opinions, it is a serious flaw, since an expert opinion lacking a justification is practically useless. For example, IBM Debater can justify some claims, but the problem lies in the strength, reliability, and consistency of the knowledge gained from the ML mechanisms. The difficulties result from the constraints of the source of knowledge. Sophisticated ML mechanisms can relatively easily find the most popular justification of a claim, but it is much more difficult to recognize its strength: the most popular arguments do not have to be the best ones. The statistical popularity of some arguments does not necessarily have much in common with their real power.

Needless to say, the utilization of NLP and ML seems a highly promising direction of development of RBLES. However, the research results obtained so far, promising as they are, do not yet provide instruments effective enough to evaluate their prospective usage options. However, we are of the opinion that the classic technology, which obviously enables the user not only to obtain certain answers to legal questions (even if in the most basic ones) together with solid justification, may still play a much more important role than it actually does

[20] Vasconcelos et al., Distributed norm management for multi-agent systems, Expert Systems with Applications, Volume 39, 2012, Issue 5, pp. 5990–5999; Antoniou/Dimaresis/Governatori, A modal and deontic defeasible reasoning system for modelling policies and multi-agent systems, Expert Systems with Applications, Volume 36, 2009, Issue 2, Part 2, pp. 4125–4134.

[21] Zurek/Mokkas/Ksiezopolski, On the Modelling of Context-Aware Security for Mobile Devices, Mobile Information Systems, vol. 2016, Article ID 8743504, 16 pages, 2016. doi:10.1155/2016/8743504.

nowadays. We have indicated three such fields of further exploration: (1) providing answers in restricted domains (with socially beneficial application possibilities in legal aid systems, (2) enhancing information retrieval systems with reasoning on validity and (3) utilization in different spheres of legal education.

7. References

Aleven, Vincent/Ashley, Kevin, Doing Things with Factors, Proceedings of the Fifth International Conference on Artificial Intelligence and Law, ACM, New York 1995, pp. 31–41.

Antoniou, Grigoris/Dimaresis, Nikos/Governatori, Guido, A modal and deontic defeasible reasoning system for modelling policies and multi-agent systems, Expert Systems with Applications, Volume 36, 2009, Issue 2, Part 2, pp. 4125–4134.

Araszkiewicz, Michał/Łopatkiewicz, Agata/Zienkiewicz, Adam/Zurek, Tomasz, Representation of an actual divorce dispute in the parenting plan support system, Proceedings of the 15th International Conference on Artificial Intelligence and Law, ACM, New York 2015, pp. 166–170.

Araszkiewicz, Michał/Łopatkiewicz, Agata/Zienkiewicz, Adam/Zurek, Tomasz, Framing a Knowledge Base for a Legal Expert System Dealing with Indeterminate Concepts, The Scientific World Journal 2015, Article ID 985425, 14 pages, doi:10.1155/2015/98542.

Araszkiewicz, Michał/Casanovas, Pompeu, On Legal Validity, in: Bex Floris/Villata, Serena (eds.), Legal Knowledge and Information Systems – JURIX 2016: The Twenty-Ninth Annual Conference, IOS Press, Amsterdam 2016, pp. 125–130.

Araszkiewicz, Michał / Płeszka, Krzysztof (eds.), Logic in the Theory and Practice of Lawmaking, Springer, Cham 2016.

Ashley, Kevin, Modeling Legal Argument. Reasoning with Cases and Hypotheticals. MIT Press, Cambridge 1990.

Bench-Capon, Trevor, What Makes a System a Legal Expert?, in: Schafer Burkhard (ed.), Legal Knowledge and Information Systems – JURIX 2012: The Twenty-Fifth Annual Conference, IOS Press, Amsterdam 2012, pp. 11–20.

Bench-Capon, Trevor/Sartor, Giovanni, A model of legal reasoning with cases incorporating theories and values, Artificial Intelligence Vol. 150, 2003, no. 1–2, pp. 97–143.

Bench-Capon, Trevor/Araszkiewicz, Michał/Ashley, Kevin/Atkinson, Katie/Bex, Floris/Borges, Filipe/Bourcier, Daniele/Bourgine, Paul/Conrad, Jack G./Francesconi, Enrico/Gordon, Thomas F./Governatori, Guido/Leidner, Jochen L./Lewis, David D./Loui, Ronald P./McCarty, L. Thorne/Prakken, Henry/Schilder, Frank/Schweighofer, Erich/Thompson, Paul/Tyrrell, Alex/Verheij, Bart/Walton, Douglas N./Wyner, Adam Z., A history of AI and Law in 50 papers: 25 years of the international conference on AI and Law, Artificial Intelligence and Law Vol. 20, 2012, Issue 3, pp. 215–319.

Brüninghaus, Stefanie/Ashley, Kevin, Predicting Outcomes of Case-Based Arguments, Proceedings of the Ninth International Conference on Artificial Intelligence and Law, ACM, New York 2003, pp. 233–242.

Endicott, Timothy, Vagueness in Law, Oxford University Press, Oxford 2001.

Grabowski, Andrzej, Juristic Concept of the Validity of Statutory Law, Springer-Verlag, Berlin Heidelberg 2013.

McCarty, L. Thorne, Reflections on «Taxman»: An Experiment in Artificial Intelligence and Legal Reasoning, Harvard Law Review Vol. 90, 1977, no. 5, pp. 837–893.

Sergot, Marek J./Sadri, Fariba/Kowalski, Robert A./Kriwaczek, Frank/Hammond, Peter/Cory, H. Therese, The British Nationality Act as a logic program, Communications of the ACM Vol. 29, 1986, no. 5, pp. 370-386.

Waismann, Friedrich, Verifiability, Proceedings of the Aristotelian Society, Supplementary Volumes, Vol. 19, Analysis and Metaphysics, 1945, pp. 119–150.

Vasconcelos, Wamberto/García-Caminob, Andrés/Gaertnerc, Dorian/Rodríguez-Aguilarb, Juan A./Noriegab, Pablo, Distributed norm management for multi-agent systems, Expert Systems with Applications, Volume 39, 2012, Issue 5, pp. 5990–5999.

Yoshino, Hajime, The systematization of law in terms of validity, Proceedings of the 13th International Conference on Artificial Intelligence and Law, ACM, New York 2011, pp. 121–125.

Yoshino, Hajime/Kagayama, Sigeru/Ohta, S./Kitahara, M./Kondoh, H./Nakakawaji, M./Ishimaru, K./Takao, S., Legal expert system – LES-2, Lecture Notes in Computer Science Vol. 264, 1987, pp. 34–45.

Zurek, Tomasz/Mokkas, Michail/Ksiezopolski, Bogdan, On the Modelling of Context-Aware Security for Mobile Devices, Mobile Information Systems, vol. 2016, Article ID 8743504, 16 pages, 2016. doi:10.1155/2016/8743504.