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# Rule-based expert system for disabled persons – The case of the nursing benefit<sup>1</sup>

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**ABSTRACT**

This paper presents and discusses the selected features of a simple legal expert system developed with the purpose of providing legal information on the frequent legal problems of disabled persons in Poland. We focus on the structure of the legal expert system and its limits of application. The nursing benefit, granted for those providing personal care to disabled persons, has been selected in the paper as the illustrative domain.

**KEYWORDS:**

legal expert system, legal problems of disabled persons, rule-based reasoning, nursing benefit

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“New applications in the judiciary against the exclusion of people with disabilities”<sup>1</sup> resulted in the development of a simple legal expert system (hereafter referred to as “INPRIS Legal Expert System” or simply “the System”) devoted to providing legal answers to selected legal problems of great social importance, including the law of housing, inheritance and social benefits. The legal problems in these areas are often particularly important for disabled persons, also because some of the analyzed benefit regulations are connected to the status of disability. Moreover, access to the well-structured online legal information is particularly important for people with limited movability. The System is not designed to provide fully-fledged legal advice and, therefore, its users should not make decisions or take steps basing only on its content or output. It performs educational functions and provides basic guidance for users who may thus increase their level of awareness with regard to their rights and legal procedures that secure these rights.<sup>2</sup>

The project was conducted by an interdisciplinary team composed of 7 people, among them lawyers, a doctor of arts, an expert on integration of

<sup>1</sup> Financed from the EEA Funds within the program and executed in the years 2015–2016 by INPRIS – Institute for Law and Society, a NGO concerned, *inter alia*, with legal policy, new technologies and access to justice (the website of the organization is accessible at <http://www.inpris.pl>).

<sup>2</sup> A relevant disclaimer may be found (only in Polish) on the INPRIS webpage: <http://www.inpris.pl/przedsiewziecia/infografiki-i-wzory-dla-osob-niepelnosprawnych>. It should be noted that the content of the system has not been updated since the conclusion of the project (2016) and the expert system does not include the function of self-updating, which results from the limitations of the Polish Journal of Laws in expressing dynamic references.

people with disabilities and a computer scientist. The output of the project encompasses not only the INPRIS Legal Expert system, but also visual information (infographics) and generic interactive document forms.

The logical features of the System as well as the methodology of its development have already been discussed thoroughly in our earlier paper (Araszkiewicz, Kłodawski 2018). For the sake of self-containment, the present paper repeats some content presented there, but the main focus of this paper is on the usability of selected features of the system as well as on its current limitations and possibilities of further development.

The authors of the present paper, being experts in law, were responsible for preparation of the legal content of the interactive documents, the infographics and for the content and the logical structure of the INPRIS Legal Expert System which was then implemented by the programmer. The order of investigations is as follows. In section 2 we discuss the characteristics of the developed System against the background of the state of the art. We also highlight Polish contributions to the advancements of the legal expert systems. Section 3 discusses the illustrative domain chosen for the aims of the present paper, i.e. the caregiver benefits derived from Polish law, but the System encompasses also other topics (such as eviction and succession law). Section 4 briefly discusses the methodology adopted in the process of the System development. Section 5 presents the application in action. Section 6 presents a discussion, emphasizing usability features of the system, and directions of further research.

### **The Idea of Legal Expert Systems**

The idea of legal expert systems consists in application of expert systems technology in the domain of law. Expert systems gained popularity in the 1970s as a reaction to the failure of the project of general artificial intelligence development, much anticipated in the 1950s and the 1960s. Unlike the projects aiming to create general artificial intelligence, expert systems were designed to perform reasoning in narrow, well-defined domains, thus simulating reasoning of human experts. The general principles of functioning of an expert system are as follows:

- the user enters information to the system by providing answers to questions asked by the system; the answers are not provided in natural language but, rather, by choosing one of the options suggested by the system,
- taking into account the elements of knowledge provided by the user and the elements of knowledge stored in the system's base, the system performs reasoning to infer an answer to a given problem,
- the knowledge is typically represented by a set of rules, i.e. conditional clauses of the form IF  $\alpha$  THEN  $\beta$ , where  $\alpha$  and  $\beta$  are formulas of the used language.

Often, expert systems are based on the negation-as-failure understanding of negation: if there is no evidence for the fact that  $p$ , then it is assumed that

*not-p* holds. This assumption is important in particular when the user is not able to provide the systems with some necessary information, although many systems require the user to provide a definite yes/no answer to a question. Probably the most discussed and influential expert system in history is the medical diagnostical system MYCIN (Buchanan, Shortliffe 1984). The research on expert systems has led to the development on many sub-types as well their application in different areas (Liebovitz 1998). One of the most important directions of research, already present in the MYCIN project, is the incorporation of elements enabling the expert systems do reason with imprecise, fuzzy or otherwise indeterminate information (Siler, Buckley 2005). However, the application of such elements is limited in domains where qualitative reasoning is required (as in law) and quantitative information is difficult to incorporate in the structure of the knowledge base and reasoning patterns.

The idea of legal expert systems has been initiated by Buchanan and Headrick (1970) and developed, *inter alia*, by McCarty (1978), Waterman and Peterson (1981), Sergot *et al.* (1986) and Susskind (1986). The work on legal expert systems has been recently summarized and commented on by Bench-Capon (2012), Araszkiewicz, Łopatkiewicz and Żurek (2017) and Ashley (2017). Some Polish scholars have conducted fruitful research in the field of legal experts systems. Antoni Niederliński had identified methodological obstacles and had proposed some serious ideas of rule-based legal expert systems, which presented not only basic assumptions of the Rule-Model Expert System (Niederliński 2005), but also a detailed set of rules, formulas and their adoption for solving practical problems in the domain of law, for example calculating cost of employing the employee, including basic salary, employment taxes and benefits (Niederliński 2015). However, the practical application of legal expert systems in Poland still remains rather limited and generally uncommon, hence the INPRIS project aims to fill this important gap, at least partially.

The main advantage of rule-based expert systems is that they are capable of drawing conclusions from the information stored in the knowledge base and to support these conclusions by explicit, symbolic reasoning. A rule-based expert system infers conclusions that are justified relatively to the given set of rules and facts, where the set of facts is typically generated on the basis of answers provided by the user. The expert system approach is useful in particular where the set of relevant rules is large enough to prevent a human being from perform the reasoning easily, and where potential answers may be counterintuitive. The usefulness of expert system increases in well-defined domains, where it is relatively easy for the user to provide answers to questions asked by the system.

There are, however, also numerous disadvantages of this approach. First, expert systems require the users to provide definitive answers to questions that may be difficult for them, in particular because they may involve a degree of

interpretive reasoning or legal knowledge. Second, expert systems are not able to process natural language information, requiring the user to choose one of the predefined answers. Third, consequently, they are not useful in processing vague, open-textured concepts: the user is often asked to decide whether a given condition is satisfied in his or her situation, where this very issue may be the most contestable one in given case. The application of such methods as fuzzy sets or rough sets to embrace vagueness is not directly applicable to the domain of legal reasoning. Fourth, not all legal knowledge is easily expressible in terms of rules – therefore other approaches were developed to include other structures of knowledge such as cases, which was done in the hybrid systems that combined rule-based and case-based reasoning (Skalak, Rissland 1992). Fifth, the classical approach of expert systems consisting in providing answer to questions was abandoned in favor of accounting for the argumentative character of legal reasoning (and thus providing arguments pro and contra a given solution rather than definitive answers) already in the 1980s with the rise of Case-Based Reasoning systems (Ashley 1991). Sixth, at certain point of time, validation of the legal expert systems knowledge base has to be performed which is a demanding task in itself, and the subsequent updating of its contents is a complicated task which requires due heed for the complexities of inter-temporal issues in law.

Taking into account these and other limitations, we are of the opinion that legal expert systems technology is appropriate for the purpose of providing basic legal information in the domains that are easily representable in the form of rules, and where the rules conditions often operate with such types of information as numbers, degrees of kinship, formal statuses and other types of information which enable relatively easy provision of answers from the user of the system. It is worthwhile at this point to explicitly state what limitations have been adopted in the development of the System:

- the System is purely a rule-based one. It contains no Case-Based Reasoning, probabilistic or argumentative components;
- the System is designed to deal with factual situations that occurred not later than on March the 1st, 2016, and are close to this date. The system models concrete (static) versions of normative acts;
- the functioning of the System is typical for classical legal expert systems: first defining the issue to be decided and then determining an answer to the issue by providing answers by the user to the questions asked by the system;
- the questions asked by the System are either “yes or no” questions (where an answer is dictated by application of a well-defined concept), or a question about quantities of certain objects;
- the System assumes negation as failure.

Although the INPRIS Legal Expert Systems has been developed on the basis of the limiting assumptions described above, it basically fulfills its purposes

in the sense that it provides the users with clear answers, guiding them through a set of properly ordered questions. The INPRIS legal expert system lightens the burden of interpretation on the user's side. The user is simply guided along in a step-by-step manner, which is not typical to any interpretative activity in the domain of law, even in the domains intended by the legislature for readers without legal qualifications. The main advantage of the System is to give relatively simple and clear answer to issues of importance, especially for the disabled persons' point of view. The System divides the problem into multiple questions with predefined simplified possible answers. The user is then asked to choose one of them, with no need of recourse to other legal sources. The final answer is complete, definitive and, thus, ready for application. It therefore offers an occasion to reflect on the usability of simple expert systems technology.

### **Description of the Domain**

Although the INPRIS Legal Expert System consists of 6 components (applications), here, due to limitations of space, we choose the domain of caregiver benefits as illustrative material, therefore limiting our examples to the functioning of one application: Nursing Benefit, under Polish law.

In Polish law, statutory provisions related to caregiver benefits are gathered mostly in the Family Benefits Statute<sup>3</sup> (hereinafter "FBS"), enacted in 2003. Within the framework of the FBS various types of benefits are provided (e.g. family benefits, additions to the family benefits, grants financed by municipal agents, parental benefits, birth benefits), and caregiver benefits are a separate group of them. Apart from the Nursing Benefit, the legislature has also provided for granting caregiver allowance and special attendance allowance.

The Nursing Benefit is regulated in Art. 17 of FBS, which contains references to Art. 10 of FBS and to the Minimum Salary Statute. The latter reference may engender interpretative confusion in terms of the amount of Nursing Benefit, which depends on the minimum salary (subject to adjustment). It may also be noticed that Art. 17 of FBS is divided into many paragraphs, subparagraphs and items, which increases complexity of the text – certainly from the Nursing Benefit addressees' point of view. Therefore, even if it is not particularly intricate as statutes go, the Nursing Benefit's regulation is not fully adequate to the needs of lay people who are their most probable recipients.

The Nursing Benefit is paid to four groups of entitled persons: a child's mother, father or the registered guardian or to another person who has custody (i.e. the obligation to support the child or other relatives). Initial criteria are comprised in situations when a person in need of care becomes disabled before reaching 18 years

<sup>3</sup> Journal of Laws from 2018, item 2220, with further amendments (<http://dziennikustaw.gov.pl/DU/2018/2220/1>).

of age or while in schooling or in upper education (but not older than 25 years of age). There are also further requirements (of which one must be fulfilled): (1) to hold a ruling on disability indicating the need for permanent or long-term care or assistance from another person or (2) to hold a ruling on the degree of the disability. The Nursing Benefit is granted for an indefinite time (albeit it is predicated upon validity of the disability ruling or assessment on the degree of disability), but while she or he collects the benefit the caregiver may not have other sources of income. There are also other limitations, e.g. marital status of the person under care.

The number of questions within the algorithm is connected with circumstances concerning both the caregiver and the person under her/his care. This observation becomes important when we take into consideration that it is the caregiver who is most likely to be the legal expert system's user, compelling her/him to answer detailed questions concerning not only her/himself.

## Method

Development of any and all components of the System consisted in the following steps, as presented in Araszkiewicz, Kłodawski 2018:

1. Definition of the legal issue to be decided by the system and its sub-issues.
2. Identification of statutory provisions relevant for the modelling.
3. Initial transformation of the statutory provisions into rules expressed in any language rich enough to express natural numbers, separately for each of the sub-issues.
4. Determination of a list of sufficient conditions for the negative answer to the legal issue in question.
5. Determination of a list of the remaining legal issues to be taken into account to provide a final answer to the legal issue in question.
6. Development of an exhaustive list of "yes or no" or quantitative questions such that:
  - (a) Providing answers to all questions from the list yields an unequivocal and legally adequate answer to the legal issue in question;
  - (b) It is determined first whether any of the sufficient conditions for the negative answer hold;
  - (c) The sequence of questions is the shortest one possible;
  - (d) One question asks for one piece of information (understood as a simple proposition with no connectives), unless it is possible to ask a complex question without significant risk of its misinterpretation by the user.
7. Development of a list of rules dictating to the system what it should do in reaction to a given answer to a particular question, where the options are as follows:
  - (a) Present the information "please use the algorithm X" if, according to the initial information given by the user, he should not use the present application, but another one;

- (b) Present the information “explanation” if the question concerns a legal term or a complex factual issue and it is assumed that the user will handle the question after acquiring and understanding the explanation;
- (c) Present the information “please consult a lawyer” if the question uses an open-textured term or if the degree of complexity of the legal issue initially described by the user is too high (this option does not appear in the Nursing Benefit algorithm);
- (d) Present the screen “Nursing Benefit will not be granted” if any of the sufficient conditions for such a conclusion is satisfied;
- (e) Go to the next question in the sequence;
- (f) Provide a final answer to a legal issue in question, as a simple confirmation or negation, if no calculations are necessary.

We now propose to demonstrate how this method was employed with regard to the legal issue of the Nursing Benefit.

The legal issue is defined as follows: (1) is the user of the system sufficiently related to the person receiving care and (2) depending on the answer to question (1), a different path within the algorithm begins. Let us note that, due to the fact of existence of different groups of caregivers under Polish law - and likewise of nursing benefits other than the Nursing Benefit, this legal issue is divided into questions concerning both the caregiver and the person receiving care. Here, we distinguished 12 questions (6 concerning the caregiver’s situation, and 6 concerning the person under her/his care), which are result of interpretation of pertinent provisions.

The set of statutory provisions for the modelling was chosen on the basis of internal systematization of the FBS, where provisions ranging from Art. 17 to the Art. 17b together form Chapter 3 of FBS, entitled “Care Benefits” and concerning strictly the Nursing Benefit. Those statutory provisions expressed in natural language were transformed into rules expressed in a simplified first-order language.

The sequence of questions, with rules determining the reactions of the system to the answers given by the user, is mostly linear, with some ramifications. It should be noted that within the entire application (which was developed in Java) the representation of the sequence of questions encompasses both substantial rules (on the merits of law) and procedural steps.

### **INPRIS Legal Expert System in Action**

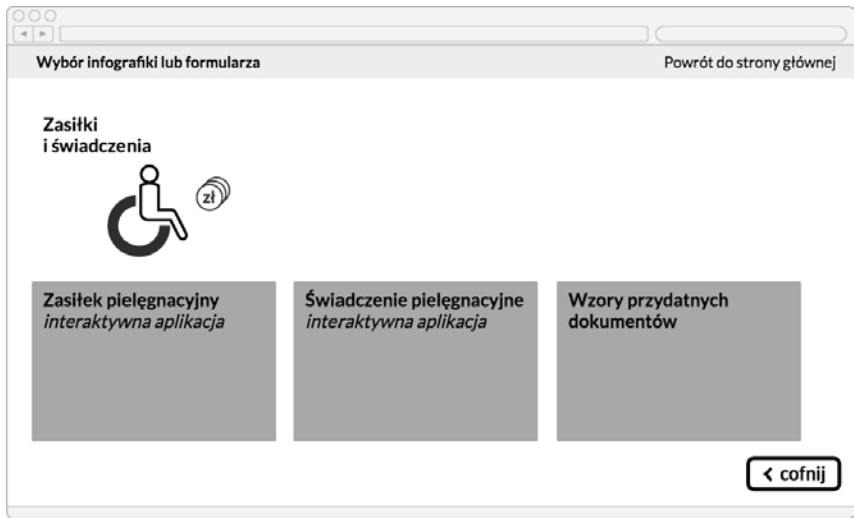
In this section, we present selected screens captured from the JavaScript interactive application available at <http://www.inpris.pl/infografika/2016/index.php> and concerning the Nursing Benefit component. The entire application is accessible only in a Polish language version, so we shortly summarize the content of each screen. All graphics used in the application were designed by prof. Justyna Lauer of Academy of Fine Arts in Katowice (Akademia Sztuk



Pięknych w Katowicach). The graphics combine text and pictures and aim to enhance understanding of the presented content. The language used in the application is a simplified version of statutory language.



**Figure 1.** Initial screen of the interactive application (from the left, upper row: “Debts, Litigation and its costs”, “Inheritance and Estates”, “Accommodation”; from the left, lower row: “Consumer Rights”, “Social Benefits”, “Employment”)



**Figure 2.** Sub-menu “Social Benefits”. “Caregiving Allowance” (left) and “Nursing Benefit” (center) algorithms are separated. Also presented (right) are “Templates of Useful Documents”

Świadczenie pielęgnacyjne Powrót do strony głównej

**Sprawdź, czy osoba która chciałaby uzyskać świadczenie pielęgnacyjne jest jedną z poniżej wymienionych. Odpowiedzi na dalsze pytania pozwolą jednoznacznie określić, czy świadczenie pielęgnacyjne będzie należne.**

- matka albo ojciec
- opiekun faktyczny dziecka informacje
- osoba będąca rodziną zastępczą spokrewnioną informacje
- inna osoba informacje

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**Figure 3.** Step 3. (question: “Who is the caregiver?”, possible answers “mother or father” or “the actual guardian of the child” or “a person from foster family of the person under care, being also relative of the person under care” or “another person who has custody”) of the Nursing Benefit’s algorithm. The blue buttons lead to “Information” explaining the relationship of the caregiver to the person under care. This is the first step at which the user has to answer differently than “yes” or “no”

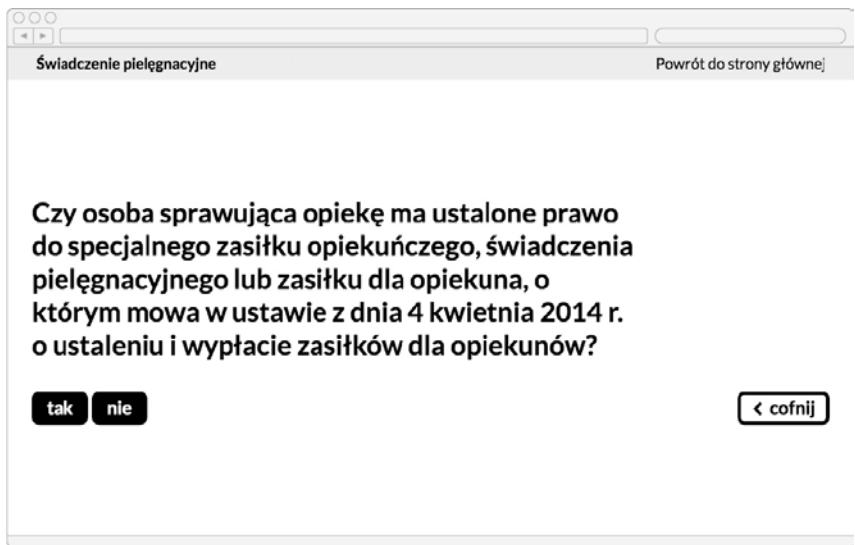
Świadczenie pielęgnacyjne Powrót do strony głównej

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Diagram illustrating the concept of a foster family relative (Rodziną zastępczą spokrewnioną). It shows two adult figures at the top, connected by a dotted line. Below them, a child figure in a wheelchair is connected to an adult figure by a DNA helix symbol.

„Rodziną zastępczą spokrewnioną” tworzą małżonkowie lub osoba niepozostająca w związku małżeńskim, będący wstępnymi lub rodzeństwem dziecka.

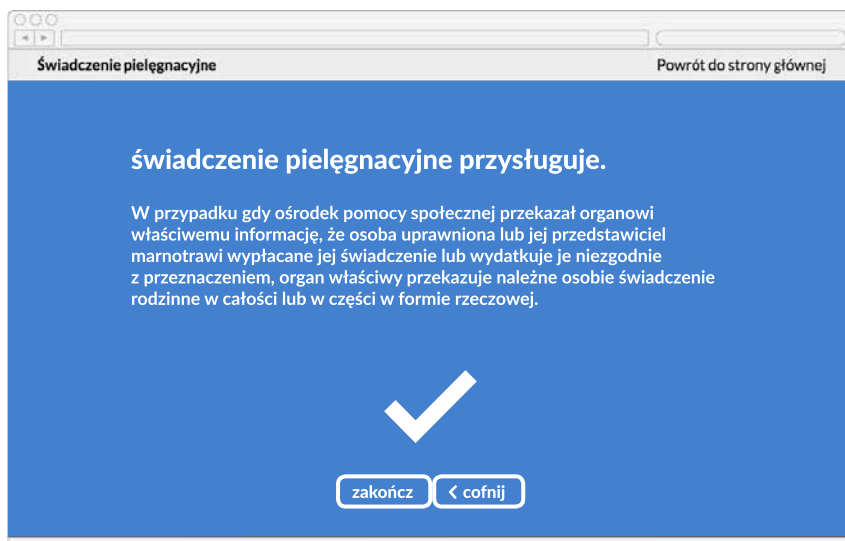
**Figure 4.** Explanation available after clicking on the second blue button presented in Figure 3. This screen explains who might be deemed to be a person from foster family of the person under care, being also relative of the person under care. The blue button “Close” (upper right) returns the user to the previous screen (step 3.)



**Figure 5.** Step 6. of the path of the person from foster family of the person under care, being also relative of the person under care. This step was preceded by a question about the period in which the person in need of care had become disabled – before reaching 18 years of age, but not later than before 25 years of age in certain circumstances (step 4., answer “yes”) and questions about, inter alia, entitlement to old-age pension of the caregiver (step 5., answer “no”). The question presented in step 6. concerns, *inter alia*, the right to special caregiving allowance of the caregiver



**Figure 6.** One of two possible variants of step 7. in the same path as in Figure 5. Up-on choosing “yes” in aforementioned step 6., the user receives information that the Nursing Benefit is not available in the case described by data input by the user



**Figure 7.** Step 13. Final result of the path chosen in step 3., presenting a positive answer to the primary question in the Nursing Benefit algorithm, i.e. “The Nursing Benefit should be granted”

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The described project is a classical rule-based expert systems devised to enhance access to justice by providing legal information for people who have limited possibilities to make use of legal services and are interested in learning about the scope of rights that are due to them in their current situation.

Seeing as the theoretical discussion of the project may be found in our earlier paper (Araszkiewicz, Kłodawski 2018), here we would like to focus on the summary concerning usability of the System. In our opinion, the imperfect quality of Polish legislation and the relatively low degree of its comprehensibility is one of the main factors that may impair the System’s usability. Even though the selected domain is one where interpretive problems are not numerous, the questions posed by the System still have to be based on the text of legislation, which often formulates the conditions of rule application very extensively. Extensive character of these conditions follows, in turn, from the complexity of the Polish regulations on social benefits and the variety of types thereof.

Another source of complexity appearing in the questions are as follows:

- 1) nested, explicit exceptions to rules, and
- 2) multi-level referring provisions, often not referring to determined acts of law.

As the two abovementioned phenomena may be results of violations of the Principles of Legislative Technique in the process of legislative drafting, likely following from a series of *ad hoc* or hasty amendments of the regulations,

the development of expert systems similar to the one discussed may lead also to some conclusions concerning the potential amendments of the analyzed regulation.

Also, from the legislative point of view there arises the remark that the chosen illustrative domain is rather complex in terms of naming and similarity of the content expressed by the (*prima facie*) synonymous names. Polish law distinguishes many care services with names resembling each other. Additionally, those services are not arranged in or expressed in a single statute. This results in necessity of interpretative proficiency as well as of access to professional legal search engines capable of presenting the possible forms of financial support for disabled persons in all their variety. However, legal expert systems, if validatable, must be based on the actual content of the represented legal system, imperfect as the latter may be. Therefore, taking into account the factors that decrease comprehensibility of the text of the normative act, the following choices were made in hopes of enhancing the usability of access to legal information through the INPRIS Legal Expert System. First, the proper ordering of questions enabled the user to not consider additional, irrelevant information of the sufficient conditions for either positive or negative decision to be verified. Second, the intellectual process entailed in assembling all elements of the legal system relevant to inferring an answer to a given legal issue has been done in the process of legal knowledge engineering. Third, the questions drafting was generally based in accordance with the premise “one question, one issue”, unless this would lead to an unduly extensive set of questions (accordingly, in this particular area, the development of the System required certain tradeoffs). Fourth, where vague or otherwise imprecise character of a given legal term led to increased difficulty for the user, additional natural language commentary is inserted, and in selected cases where such explanation would still be too complex, the user is asked to consult a lawyer.

In the future, we intend to confront the multiplicity of care services offered in, and expressed by, Polish law. As we assume, the user of the System should be able to obtain a comprehensive solution of his issue in conditions of the current state of the Polish legal system, which would not be set manually within the System. Therefore, the questions must allow the System to catch all the legislative details (*inter alia* amendments, referring provisions, abbreviations, intertemporal issues) needed to fully formulate the final answer from the legal point of view. The System should encompass a set of rules derived from all relevant statutes and other normative acts concerning the care services and should be equipped with possibility of linking the static data originating from outside the legal system, although indicated by certain provisions (e.g. index used in adjusting the minimum salary). Such functionalities seems necessary to provide enhanced insight into actual and valid prerequisites of

granting the care services which will provide legal aid suited for the individual given user.

The subsequent step along the way should also foresee extension of the System by implementing solving mechanisms for other legal issues important for disabled persons. Polish law retains a vast area of services intended for ordinary citizens (also disabled ones) which are not anywhere as simple as their common character would indicate. For example, statutory provisions in the area of pension and retirement benefits are decried by legal experts, e.g. attorneys at law, as unintelligible and convoluted, even from the perspective of experienced legal practitioners.<sup>4</sup> To state the obvious, one day everyone will need to know what is the most favorable retirement option and how (or when) to apply for it. As matters stand, the variety of pension and retirement provisions in Polish law and their mutual interrelations depart beyond the realm of understanding of ordinary citizens, and a properly developed expert system may provide important insights in this area, thus increasing access to legal information and to justice.

<sup>4</sup> Such opinion may be found, for instance, in the following document: <http://orka.sejm.gov.pl/wydbas.nsf/0/F95B769D3BF2A010C1257424002E780F/%24File/system%20emerytalny.pdf> [accessed: 25 June 2019].

#### REFERENCES

- Aleven, Vincent. 1997. *Teaching Case-Based Argumentation Through a Model and Examples* [PhD diss., University of Pittsburgh Graduate Program in Intelligent Systems].
- Araszkiewicz, Michał. 2013. *Towards Systematic Research on Statutory Interpretation in AI and Law*, [in:] Kevin Ashley (ed.), *JURIX 2013: The Twenty-Sixth Annual Conference*. Amsterdam: IOS Press.
- Araszkiewicz, Michał, Kłodawski, Maciej. 2018. *Developing Rule-Based Expert System for People with Disabilities – The Case of Succession Law*, [in:] Ugo Pagallo et al. (eds.), *AI Approaches to the Complexity of Legal Systems. AICOL 2015, AICOL 2016, AICOL 2016, AICOL 2017, AICOL 2017. Lecture Notes in Computer Science*, vol. 10791. Cham: Springer.
- Araszkiewicz, Michał, Łopatkiewicz, Agata, Żurek, Tomasz. 2017. *The tradition of legal expert systems - Possibilities, limitations and the way forward*, [in:] Erich Schweighofer, Franz Kummer, Walter Hötendorfer, Christoph Sorge (eds.), *Trends and communities of legal informatics: Proceedings of the 20th International Legal Informatics Symposium (IRIS 2017)*. Wien: Österreichische Computer Gesellschaft.
- Ashley, Kevin. 1990. *Modeling Legal Argument. Reasoning with Cases and Hypotheticals*, Cambridge, MA: MIT Press.
- Ashley, Kevin. 2017. *Artificial Intelligence and Legal Analytics: New Tools for Law Practice in the Digital Age*, Cambridge: Cambridge University Press.
- Bench-Capon, Trevor. 2012. *What Makes a System a Legal Expert?* [in:] Burkhard Schäfer (ed.), *Legal Knowledge and Information Systems, JURIX 2012: The Twenty-Fifth Annual Conference*. Amsterdam: IOS Press.
- Buchanan, Bruce G., Headrick, Thomas E. 1970. Some speculation about artificial intelligence and legal reasoning. *Stanford Law Review*, 23(1): 40–62.
- Buchanan, Bruce G., Shortliffe, Edward H. 1984. *Rule-based Expert Systems*. Reading, MA, Menlo Park, CA, London, Amsterdam, Don Mills, Ontario, Sydney: Addison-Wesley Publishing Company.

- Gardner, Anne von der Lieth. 1987. *An Artificial Intelligence Approach to Legal Reasoning*, Cambridge, MA: MIT Press.
- Liebowitz, Jay. 1998. *The Handbook of Applied Expert Systems*, Boca Raton: CRC Press.
- Macagno, Fabrizio, Sartor, Giovanni, Walton, Douglas. 2012. *Argumentation Schemes for Statutory Interpretation*, [in:] Michał Araszkiewicz et al. (eds.), *ARGUMENTATION 2012: International Conference on Alternative Methods of Argumentation in Law*. Brno: Masaryk University Press.
- McCarty, Thorne L. 1977. Reflections on “Taxman”: An Experiment in Artificial Intelligence and Legal Reasoning. *Harvard Law Review*, 90(5): 837–893.
- Sartor, Giovanni, Walton, Douglas, Macagno, Fabrizio, Rotolo, Antonino. 2014. *Argumentation Schemes for Statutory Interpretation: A Logical Analysis*, [in:] Rinke Hoekstra (ed.), *JURIX 2014: The Twenty-Seventh Annual Conference*. Amsterdam: IOS Press.
- Schäfer, Burkhard. 2017. Formal models of statutory interpretation in multilingual legal systems. *Statute Law Review*, 38(3): 310–328.
- Sergot, Marek, Sadri, Fariba, Kowalski, Robert, Kriwaczek, Frank, Hammond, Peter, Cory, H.T. 1986. The British Nationality Act as a Logic Program. *Communications ACM*, 29: 370–386.
- Siler, William, Buckley, James J. 2005. *Fuzzy Expert Systems and Fuzzy Reasoning*, Hoboken–New Jersey: Wiley-Interscience – Hohn Wiley & Sons, In.
- Skalak, David, Rissland, Edwina. 1992. Arguments and Cases: An Inevitable Intertwining. *Artificial Intelligence and Law*, 1: 3–44.
- Susskind, Richard. 2011. Expert Systems in Law: A Jurisprudential Approach to Artificial Intelligence and Legal Reasoning. *The Modern Law Review*, 49(2): 168–194.
- Walton, Douglas, Sartor, Giovanni, Macagno, Fabrizio. 2016. Contested Cases of Statutory Interpretation. *Artificial Intelligence and Law*, 24: 51–91.
- Waterman, Donald A., Peterson, Mark A. 1981. *Models of Legal Decision Making: Research Design and Methods*. Rand Corporation, The Institute for Civil Justice.
- Żurek, Tomasz, Araszkiewicz, Michał. 2013. *Modelling teleological interpretation*, [in:] Bart Verheij et al. (eds.), *ICAIL 2013: Proceedings of the Fourteenth Conference on Artificial Intelligence and Law*. New York: ACM.