Distinguishing between Knowledge Visualization and Knowledge Representation in Legal Informatics

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Abstract: Knowledge visualization (KV) and knowledge representation (KR) are distinguished, though both are knowledge management processes. Knowledge visualization is subject to humans, whereas knowledge representation – to computers. In computing, knowledge representation leverages reasoning of software agents. Thus, KR is a branch of artificial intelligence. The subject matter of KR is representation methods. They are classified into (1) knowledge level and symbol level representations; (2) procedural and declarative representations; (3) logic-based, rule-based, frame- or object-based representations (supporting inference by inheritance); and (4) semantic networks. In legal informatics, methods of legal knowledge representation (LKR) are dealt with. An essential feature of LKR is the representation of deep knowledge, which is mainly tacit. It is easily understood by professional jurists and hardly by amateurs from outside law. This knowledge comprises the teleology of law and a whole implicit framework of legal system. The paper focuses on (1) identifying key features of KV and KR in the legal domain; and (2) distinguishing between visualization, symbolization, formalisation and mind mapping.

1. Introduction

The notions of knowledge visualization (KV) [Eppler, Burkhard 2006] and knowledge representation (KR) (see e.g. [Zarri 2006], [Brachman, Levesque 2004]) are distinguished, though both are knowledge management (KM) processes. The theses of the paper are:

1. The human is the subject of knowledge visualization, whereas the computer – that of knowledge representation. KV is viewed from social sciences perspective, whereas KR – from computing and artificial intelligence (AI).
2. Knowledge level representation of law is at the core of legal informatics.

When identifying differences between law and informatics, distinctions between legal logic and mathematical logic emerge. A norm in the law can be compared with a rule in AI production system. This is in principle true, but both have key differences, cf. [Hage 2005]. F. Lachmayer emphasises that “formalisation and symbolization have to be distinguished” [Lachmayer 2008], [Lachmayer 1977] p. 18-19. Symbolization means to be a symbol of something1. Formalisation, modeling and representation can be defined more formally. In informatics this is done in [Brinkkemper 1990] p. 21. The latter refers to Ogden and Richards2 and considers three types of systems (conceptual, concrete and symbolic). A formalisation is defined as a mapping onto a mathematical system of concepts with a corresponding representation. Here we note that the immediate subject of a formalisation is a human being. Further the formalisation serves as a representation in a computer.

We view mind mapping [Buzan, Buzan 2006] as a kind of knowledge visualization.

2. Knowledge Visualization

Studies in visual cognition lead to a conclusion that visualization dramatically increases our ability to think and communicate. [Eppler, Burkhard 2006] associate knowledge visualization with knowledge management and list numerous benefits of visual representations. Here J. Sparrow3 is referred to and a longstanding objective in knowledge management is

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2 Ogden, C. K., Richards, I. A. (1949), The meaning of meaning.
indicated: “making knowledge visible so that it can be better accessed, discussed, valued, or generally managed”. KV is defined as a field that “examines the use of visual representations to improve the creation and transfer of knowledge between at least two people. Knowledge visualization thus designates all graphic means that can be used to construct and convey complex insights” [Eppler, Burkhard 2006] p. 551. Hence the human is the subject of KV. KV is differentiated from other approaches, such as information visualization or visual communication:

Information visualization aims to explore large amounts of abstract (often numeric) data to derive new insights or simply make the stored data more accessible. Knowledge visualization, in contrast, facilitates the transfer and creation of knowledge among people by giving them richer means of expressing what they know [Eppler, Burkhard 2006], p. 551.

Information visualization typically helps in human-computer interaction while KV primarily is used in communication among individuals (ibid p. 552). KV aims at visual perception of the human. Graphic methods of representation are at the heart.

A KV framework comprised of three perspectives is considered (ibid p. 553). The perspectives answer three key questions with regard to visualizing knowledge:

1. Knowledge type (What? What type of knowledge is visualized (object)?)
2. Visualization goal (Why? Why should that knowledge be visualized (purpose)?)
3. Visualization format (How? How can the knowledge be represented (method)?)

The visualization format perspective structures the visualization formats into six main groups: (1) heuristic sketches, (2) conceptual diagrams, (3) visual metaphors, (4) knowledge animations, (5) knowledge maps, and (6) domain structures. The conceptual diagrams are important from the view of knowledge representation. Types of frequently used conceptual diagrams are: (1) pie chart, (2) Venn diagram, (3) pyramid, (4) circles, (5) bars, lines, (6) Gantt diagram, (7) coordinates, (8) sankey, (9) radar/kiviat, (10) tree, (11) mind map, (12) process, (13) cycle, (14) five forces, (15) Ishikawa diagram, (16) flowchart, (17) network, and (18) synergy [Eppler, Burkhard 2006] p. 554.

We hold that any conceptual diagram can be formalised as a graph \( G=(V,E) \) consisting of a diagram-specific set of vertices \( V \), a set of edges \( E \), and marking mappings of the vertices and the edges. However the strength of a conceptual graph is viewed from a different standpoint than a semantically strict knowledge representation. The latter is computer oriented. In contrast, the human is the subject of semi-formal visual formats. The strength of all visualization formats (including conceptual graphs) is informality (i.e. open semantics and lack of strict formalisation). The symbolization is human oriented.

Knowledge management concerns primarily an organization. The objective of KM is to increase its value. Here a conflict organization vs. individual can be observed. What contributes to the organization not necessarily contributes to the individual. Legal knowledge visualization primarily aims to increase the value of the individual. This is achieved when legal knowledge visualization contributes to human cognition.

[Brunschwig 2001] raises a question: What is legal visualization and what is not? The functions of legal visualization are identified in [Röhl, Ulbrich 2007]. A formalisation of legal concepts in the context of logic-based tools is investigated in [Daskalopulu 1999]. Two Hohfeldian squares of fundamental legal notions is an example of knowledge conceptualization. It contributes to the ontology of the legal domain.

3. Knowledge Representation

KR can be viewed from different perspectives – informatics and social sciences. The latter perspective can be compared with a view to law from social sciences. The fact that the sociology of law is a well established discipline\(^4\), supports the social perspective.

In informatics perspective, “knowledge representation developed as a branch of artificial intelligence – the science of designing computer systems to perform tasks that would normally require human intelligence” [Sowa 2000] p. XI.

The above view also accords with [Zarri 2006] where the roots of KR are examined. Zarri begins with the reference to [Newell 1982]. The proposal to distinguish between the “knowledge level” and “symbol level” representations thus also conceiving relationships between knowledge management and computer science sounds like this:

The knowledge level permits predicting and understanding behaviour without having an operational model of the processing that is actually being done by the agent [Newell, p. 108]. The knowledge level can be identified as a principle:

According to this principle, the knowledge level represents the highest level in the description of any structured system. (...) The knowledge level principle emphasises the why (i.e., the goals), and the what (i.e., the different tasks to be accomplished and the domain knowledge) more than why (i.e., the way of implementing these tasks and of putting this domain knowledge to use) [Zarri 2006] p. 467.

KR is treated as a branch of AI in [1998 ACM classification]. The branch “I.2.4 Knowledge Representation Formalisms and Methods” is included into “I.2 Artificial Intelligence”, and the latter is included into “I. Computing Methodologies”. The inclusions KR∈AI and AI⊂computing express a rough view. Fine grained views could maintain that KR is also a management activity. Knowledge management is a management process. Hence, knowledge representation intersects, but is not a proper subset of computing.

Computer is an immediate subject of AI and KR. But the computer is simply an intermediary in humans’ life. The human is a longstanding subject of AI and KR.

While reviewing the different solutions for representing knowledge, two main groups are isolated: the “symbolic” approach and the “soft programming” approach [Zarri 2006] p. 468. Further, in the symbolic paradigm, two basic forms of KR are ranged:

- Rule-based representations (inference by resolution).
- Frame- or object-based representations (inference by inheritance).

The soft programming paradigm is divided into three groups: (1) neural networks, (2) genetic algorithms, and (3) fuzzy knowledge representation techniques.

Slight classification differences rise through emphasis on specific methods. Branches of AI and KR can be classified according to different criteria. Logic can be placed in the first place, see e.g. [Brachman, Levesque 2004]. Then object oriented representation and structured descriptions come. Ontologies are emphasised in [Sowa 2000] and form a symbolic approach.

4. Legal Informatics

We claim that knowledge level representation of the legal domain is at the core of legal informatics. The reason is that teleology of law, the “why”, is mainly implicit, including the texts of legal sources. Representing such a deep knowledge is a challenge.

4.1 The Subject Matter of Legal Informatics

Interdisciplinarity is a key feature of legal informatics. A separate effort to the subject of legal informatics is devoted in [Schweighofer 1999]. Steinmüller and Garstka have to be quoted5:

After Steinmüller and Garstka [...] legal informatics is the 'Theorie über die Beziehungen Zwischen EDV und Recht sowie deren Voraussetzungen und Folgen'. ('Theory about the relationship between EDP and law as well as the associated assumptions and consequences'.) [Schweighofer 1999] p. 4.

4.2 Building a Bridge between Law and Informatics

Legal informatics is about building a bridge between law and informatics, see Fig. 1. This metaphor is supported by Lachmayer. The bridge’s metaphor is widely used in knowledge visualization, see [Eppler, Burkhard 2006].

![Fig. 1: Legal informatics is visualized as a bridge between law and informatics](image)

The bridge has to be built in a balanced way. It can collapse in case informatics scholars lack legal knowledge when they build computational models of legal tasks, see Fig. 2.

![Fig. 2: The bridge has to be balanced. If informatics scholars lack legal knowledge when building computational models of legal tasks, the bridge can collapse](image)

Similarly, in case informatics scholars expect too much computing knowledge from legal scholars, the latter give up, and the bridge can collapse, too.

A formalism of informatics is involved when modeling legal activities such as legal reasoning, process flow, etc. Informatics is rich of formalisms, notations and models, e.g. mathematical logic, state transition diagrams, workflow diagrams, Universal Modeling Language UML, etc. Formal methods constitute a well established branch of informatics.

Let $f_1$ denote legal reasoning. Thus the latter is treated as a mapping from premises to a conclusion. Let $f_2$ denote the formalisation of the legal domain. Thus $f_2$ is treated as a mapping from the legal domain to the formalism of informatics, e.g. predicate logic. Let $f_3$ denote inference in predicate logic. The inference is a sequence of certain inference rules, e.g. *modus ponens*, replacing a variable with a constant (Socrates), etc. These mappings form a diagram shown in Fig. 3. If legal reasoning and formal reasoning have “good” properties, the diagram commutes, $f_1 = f_4 \circ f_3 \circ f_2$, i.e. $f_1(x) = f_4(f_3(f_2(x)))$, where $x$ denotes the premises.
Law (as a domain) Argumentation in law \( \xrightarrow{f_2} \) Argumentation in informatics Informatics

\[
\begin{align*}
\text{legal reasoning} & \quad \text{(e.g. legal logic)} \\
\xrightarrow{f_1} & \quad \xrightarrow{f_3} \\
\text{Conclusion in law} & \quad \xrightarrow{f_4} \quad \text{Conclusion in informatics}
\end{align*}
\]

\[
\text{formalisation} \quad \sim \quad \text{reasoning in informatics} \quad (\text{e.g. mathematical logic})
\]

\[
f_1 \quad \xrightarrow{f_2} \quad f_4 \circ f_3 \circ f_2
\]

Fig. 3: Formalising legal reasoning. The diagram commutes: \( f_1 = f_4 \circ f_3 \circ f_2 \)

Formalisation of the premises in the legal domain is not a trivial task. In our example the premises are formalised as a list of two statements. Fig. 4 depicts inference of “Socrates is mortal” from the premises which consist of two statements: (1) “Socrates is a human” and (2) “All humans are mortal”. Fig. 4 also shows that the diagram commutes.

Law

Premises:
1) “Socrates is a human”
2) “All humans are mortal”

\[
\xrightarrow{f_1} \\
\xrightarrow{f_2}
\]

Conclusion in law:
“Socrates is mortal”

Informatics

Premises:
1) human(Socrates)
2) \( \forall x \ (\text{human}(x) \rightarrow \text{mortal}(x)) \)

\[
\xrightarrow{f_3} \\
\xrightarrow{f_4}
\]

Conclusion in informatics:
mortal(Socrates)

\[
f_1(x) = f_4(f_3(f_2(x)))
\]

Fig. 4: Inference of “Socrates is mortal” from “Socrates is a human” and “All humans are mortal”. The diagram commutes.

5. Distinguishing Approaches in Legal Informatics

In legal informatics we distinguish between the approaches of “informatics in law” and “information and communication technologies in law” (ICT in law).

Human is the final interpreter of legal knowledge. In “ICT in law” approach, legal knowledge is transferred from a human to a human. In the transfer, the knowledge must be recreated in the mind of the receiver [Zarri 2006] p. 552. The computer does not interpret the knowledge and thus serves as an intermediary. The subjects are chained human-computer-human.

Knowledge level representation is a challenge. In “informatics in law” approach, the purpose of the final interpreter is to understand the deep legal knowledge. For this purpose the legal knowledge needs not to be represented in the computer. Visualization on the paper may suffice. However, in case the legal knowledge is represented in intelligent computer that “understands” it, the knowledge engineer is satisfied to serve the jurist. The engineer is an intermediary who serves the jurist to interpret the knowledge. The subjects are chained: the human - a method of informatics in law - the human, shortly, human-informatics-human.
6. Conclusions
The human is the direct subject of legal knowledge visualization. The computer is that of legal knowledge representation. However, thinking teleologically, the final subject of LKR is the human, too. Knowledge level representation is a challenge to legal informatics. In “informatics in law” approach the subjects are chained human-informatics-human, whereas in “ICT in law” – human-computer-human.

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8. References