An Expert System for Danish Traffic Law Cases (Student Abstract)

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Abstract

We present FÆRDXEL, an expert system for providing answers and explanations to legal questions (queries) regarding Danish traffic law cases. It utilizes a Datalog encoding of Danish traffic laws and uses SLD-resolution to answer queries. The SLD-resolution's trace of operations can be converted into a legal explanation for the query. A user interface allows legal professionals to input case facts, ask questions, and explore explanations. Feedback from legal experts identified usability challenges and potential end-users, including traffic police and judges. Future steps include empirical evaluation of soundness, integrating punishment reasoning, and enhancing usability through natural language processing.

Introduction

The release of ChatGPT in late 2022 sparked a global desire to integrate machine learning based AI into as many domains as possible. However, some domains seem resistant to integrating machine learning AI into their workflow. For some domains, machine learning AI may not be suitable, and for others, there is aversion to the technology.

The domain of law exhibits both types of resistance. Firstly, in many legal systems, there is a requirement for an explanation of judgments (Bibal et al. 2020), and it is not clear from precedent whether the explanation has to be the specific reason for the judgments or just a possible reason behind the judgment. It can be argued that machine learning AI, in the current form of generative and deep neural networks, can only to provide the latter. Secondly, legal experts have a tradition of discussion and argumentation, which clashes with AI that provides answers without argumentation.

To overcome this resistance it may be necessary to employ more traditional AI in the form of expert systems. Expert system provide symbolic reasoning using some inference algorithm and a knowledge base. The knowledge base must be tailored for the specific application such that it is able to reason within that application similar to how an expert might reason. The main drawbacks are that constructing a knowledge base is very time-consuming, and the application is often only usable by other experts. The main advantage is the ability to trace its inference and therefore trace the expert system's reasoning behind its answers.

Related Work

Research into expert systems flourished in the 1980s, and applications within the legal domain soon followed, but the research seems to have slowed down in the 2000s and by 2010, to the best of our knowledge, almost no research within the domain has been published (Farajollahi and Baradaran 2024). In the last 10 years there have been nearly no papers nor articles working on legal expert systems. The only one we found is a 2016 paper on an expert system for Islam inheritance law (Akkila and Naser 2016).

Research on expert system applications in other domains has also been lacking in the last decade, with the notable exception of the medical diagnostic domain, where research into expert system applications has seen a low but steady output (Hossain et al. 2016; Jain et al. 2023).

Contribution

Our contribution is FÆRDXEL,[1] an expert system for answering legal questions about Danish traffic law cases. It contains a modifiable implementation of Datalog that uses SLD-resolution as its inference system. This allows FÆRDXEL to answer questions by creating SLD-refutations, which it uses to provide a tree-like structure of possible explanations for each answer.

FÆRDXEL's knowledge base consists of rules (clauses) representing a surface-level understanding of every paragraph of the Danish traffic law and a couple of relevant cases. This surface-level understanding is derived by hand from *Færdselsloven med Kommentarer*, which is a book covering the in praxis interpretation of the Danish traffic law.

The encoding itself is based on a general principal of reification. The general idea is that objects include not only physical items but also concepts, like driving a car or crossing the street. This allows for a smaller and simpler set of predicates, as a single predicate, such as 'reckless', can be used to describe both reckless driving and reckless street crossing.

To allow for an encoding that is closer to the natural language of the law, the tool allows syntactic sugar in the form

[1] 'Færdsel' is the Danish word for traffic

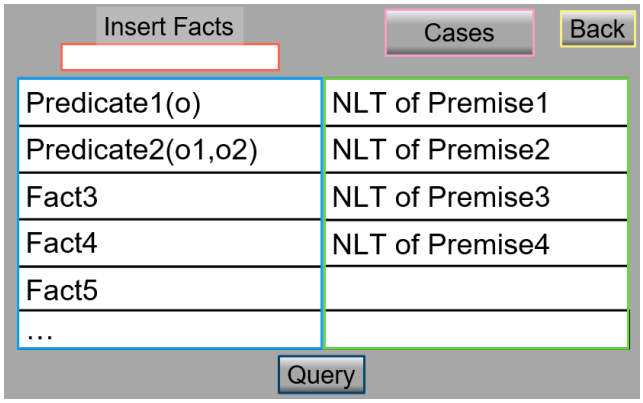

Figure 1: Redrawing of interface for FÆRDXEL (original is in Danish). Top left (red) shows a box for inserting facts about a traffic law case. Middle left (blue) shows a list of facts inputted. Right shows an explanations of an answer. Top right shows two buttons: one for cases and laws covering rule used for current explanation (pink), and one for going back in an explanation (yellow). Middle right (green) shows a list of premises for current explanation

of arbitrary use of disjunction and conjunction in the body of the rules. This is to more easily model laws specifying the same rules for multiple situations. E.g. you are not allowed to drive drunk in a car and you are not allowed to drive drunk on a motorcycle. Such of rules are then transformed into a set of clauses using standard Conjunctive Normal Form (CNF) conversion. The formulation resulted in 2579 clauses.

Part of the contribution is to prove the usability of expert systems, and to this end, a simple interface has been developed. The left side of the program accepts facts about the traffic case given in Datalog using predefined predicates, while the right side provides answers to queries and explanations for selected answers. To enhance usability, every predicate has a natural language translation (NLT), which is shown instead of the standard Datalog notation. Selecting on an answer gives its top-level explanation, i.e., the instance of the rule that unifies with the query. A selected rule will contain a list of premises for that rule that each can be clicked to get the instance of the rule that unify with that premise. This can be continued until the selected rule is a facts, i.e., a rule with no premise. If at any point there are multiple explanations, the user can select any one of them.

To further ensure that FÆRDXEL is usable, the program has been shown to a group of legal experts. They provided feedback on the problems with usability, mainly that inputting facts in Datalog would be too difficult. They also identified four possible end-users who would benefit from FÆRDXEL:

Traffic police could benefit from having potential lawbreaking drivers and illegal cars identified; everyday citizen seeking legal advice could benefit from having legal questions answered without consulting expensive lawyers; prosecutors could benefit from getting legal argumentation about a case potentially helping decide whether to press chargers; and judges could benefit from another perspective in the form of arguments and counter-arguments before making a judgment.

In addition, the legal experts pointed out necessary requirements for each of the four types of end-users: Traffic police would need the tool to be fast and mostly automatic as to not impair their work; everyday citizen require that the tool is able to explain its reasoning to a non-expert; prosecutors need the inputting of cases to be fast as to not slow down their work; and judges need the tool to be able to reason about punishment.

As an early proof of concept, FÆRDXEL has been used in a court case, with consultancy from the sitting judge, where it reached the same conclusions as the judge about what laws the defendant had broken. However, it was unable to provide a suitable punishment range as this part of the knowledge base was not encoded at the time of the court case.

Next Steps

The entire Danish traffic law has since been encoded, and the next step of the project is an empirical evaluation of the soundness of FÆRDXEL's answers by applying the program on ongoing court cases and evaluating whether the tool and the judges reach the same verdicts.

Simultaneously, it is being explored how to improve the ability of the tool to argue punishment. Danish traffic law only states a range of punishment for a given crime and provides conditions for when the punishment should be 'Harsh' and 'Soft', with most cases fulfilling multiple conditions for both a 'Harsh' and a 'Soft' punishment. To solve this problem, we are exploring applying Fuzzy Logic, viewing 'Harsh' and 'Soft' as Fuzzy terms in the domain of possible punishments. A similar approach, from which we draw inspiration, has been applied to Polish punishment law (Lower and Lower 2019).

Lastly, to improve the usability of FÆRDXEL we are exploring using Large Language Models to convert natural written language about a case into the Datalog format that the tool requires as input.

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