Tutorial – Automated Deduction with Legal Texts

Introduction to a normative logic

Tomer Libal

Logical reasoning

- Scenario
  - We have a problem
    - Some facts
    - context
- We consult the right legislation
- How do we reach conclusions?

Logical reasoning

- Scenario
  - We have a problem
    - Some facts
    - context
- We consult the right legislation
- How do we reach conclusions?
- Can a computer do that for us?

Computer reasoning

- Given a legal text
  - Persons who are doctors and lawyers qualify
  - Andrew is a doctor
- how can a computer decide if Andrew qualifies?

partially based on an example from Allen, Layman E., and C. Rudy Engholm. "Normalized legal drafting and the query method." J. Legal Educ. 29 (1977): 380.

Some approaches

- Machine learning
  - Show the computer examples of people who are and are not qualified
- Logic based
  - Our approach

Challenges

- Text can be ambiguous, imprecise, requires context, spread over different pages/documents
- Example
  - Persons who are doctors and lawyers qualify
  - Option 1: Persons who are lawyers [qualify] and [persons who are] doctors qualify.
  - Option 2: Persons who are [both doctors and lawyers] qualify

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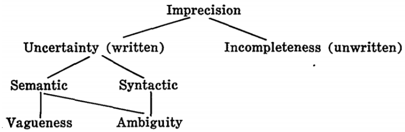

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English as a legal language

- Is English precise?
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English as a legal language

- Is English precise?
  - Persons who are doctors and lawyers qualify
  - Persons who are lawyers [qualify] and [persons who are] doctors qualify
  - Persons who are [both doctors and lawyers] qualify
- English is too imprecise. How can we provide a precise interpretation to a sentence?

Formal languages

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    - ... **AND** ...
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  - Propositional symbols - `p1 p2` ...
    - Each can mean anything
  - The phrase templates (from now on called connectives)
    - ... **AND** ...
    - **IF** ... **THEN** ...
- Which of the sentences can be written in this language?
  - Persons who are doctors and lawyers qualify
  - Persons who are lawyers [qualify] and [persons who are] doctors qualify
  - Persons who are [both doctors and lawyers] qualify

Formalization and meanings

- Since we have propositional symbols, we can write all sentences
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  OR

  - **IF p1 THEN p3 AND IF p2 THEN p3**
    - **p1** means "The persons are lawyers"
    - **p2** means "The persons are doctors"
    - **p3** means "The persons qualify"

Symbolic reasoning

- Can we infer if Andrew, who is a doctor, qualify?
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- More or less since **p1** does not exactly mean "Andrew, who is a doctor"
  - We will consider this problem later

Logic

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  - **IF p1 THEN p3 AND IF p2 THEN p3**
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- and deduce
  - **p3**
  - Andrew is qualified

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- More about that in Alex's talk

Formal interpretations

- We have translated a sentence from English into another language
- We can express the intended interpretation of a natural language sentence in a non-ambiguous way
  - We call it **formal interpretation** or **formalization**
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    - NLP will be integrated later in order to assist

Automation

- Once we have a formalization, we can use the computer to
  - Confirm or refute queries
    - "Is Andrew qualified?"
  - Check if the formalization makes sense
    - Consistency
  - Check if the formalization contains redundancy
    - Independency
  - Explain why something is not correct
    - Model checking, abductive reasoning
  - Paint graphs and other visualization

Consistency

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  - **NOT** ...

Consistency

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- Assume we have the sentences
  - "Driving under the affect of drugs is a crime"
  - "Driving during the night is not a crime"
- One possible formalization is
  - **IF p1 THEN p2**
    - **p1** means driving under the affect of drugs
    - **p2** means crime
  - **IF p3 THEN NOT p2**
    - **p3** means driving during the night
- What is the problem?

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- What is the problem?
- What happens if we drive under the affect of drugs during the night? Are we committing a crime?

Redundancy

- A set of natural language sentences might contain some redundancy
  - “Driving under the affect of drugs during the night is a crime”
  - “One cannot drive during the night”
- One might be redundant in a certain formalization

Automated reasoning

- So far, we have said that the computer can answer certain questions
- In fact, there are specific software which can do that
- Automated theorem provers
  - Can answer questions for a specific logic
  - Our focus

Formalization power

- We have considered two languages
  - English
  - A language containing
    - **AND**
    - **NOT**
    - **IF THEN**
- What are the limits of each of these languages?

Formalization power

- We have considered two languages
  - English
  - A language containing
    - **AND**
    - **NOT**
    - **IF THEN**
- What are the limits of each of these languages?
  - English is too expressive and can denote imprecise/ambiguous sentences
  - The second is too weak

Weak languages

- The United Nations Convention on Contracts for the International Sale of Goods - part of Article 31

"If the seller is not bound to deliver the goods at any other particular place, his obligation to deliver consists:

(a) if the contract of sale involves carriage of the goods - in handing the goods over to the first carrier for transmission to the buyer;

(b) in other cases – in placing the goods at the buyer's disposal at the place where the seller had his place of business at the time of the conclusion of the contract."

- How can we formalize it in our weak language?

Possible formalization

- We need two more connectives
  - **EITHER ... OR ...**
  - **IF ... THE OBLIGATION IS**

Possible formalization

- We need two more connectives
  - **EITHER . . . OR . . .**
  - **IF . . . THE OBLIGATION IS**

IF NOT p1 THEN EITHER IF p2 THEN THE OBLIGATION IS p3 OR IF NOT p2 THEN THE OBLIGATION IS p4

- Where
  - **p1** is "the seller is bound to deliver the goods at any other particular place"
  - **p2** is "the contract of sale involves carriage of the goods"
  - **p3** is "handing the goods over to the first carrier for transmission to the buyer"
  - **p4** is "placing the goods at the buyer's disposal at the place where the seller had his place of business at the time of the conclusion of the contract."

Reasoning example

- Assuming
  - **NOT p1** - “the seller is not bound to deliver the goods at any other particular place”
  - **p2** - " the contract of sale involves carriage of the goods"
- The theorem prover can conclude
  - **THE OBLIGATION IS p4** - “There is an obligation for the seller to hand the goods over to the first carrier for transmission to the buyer”

Strengthening the language

- We can continue to strengthen the language to be able to express all legal nuances
- Fundamental Requirements
  1. It should be formal (precise and non-ambiguous)
  2. A logic needs to be strong enough to capture interesting legal nuances
  3. It should be weak enough to be implemented in an efficient theorem prover

Formal languages for legal reasoning

- There are many
  - Standard deontic logic (SDL)
    - too weak
  - Dyadic deontic logics
  - Input/output logic

Formal languages for legal reasoning

- There are many
  - Standard deontic logic (SDL)
    - too weak
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  - Input/output logic
- Efficient theorem provers exist only for SDL (among those in the list)

Balancing between the requirements

- Find a logic which is
  - expressive enough to capture some (not all) legal nuances
  - has an efficient theorem prover
- Our choice
  - DL*
  - MleanCoP
    - An efficient normal multi-modal first-order theorem prover (J. Otten)

What can be captured by DL*?

- Contrary-to-duty scnearios (CTD) and the distinction between ideal and actual obligations
- Chisholm's paradox
  (1) it ought to be that Jane helps her neighbors;
  (2) it ought to be that if Jane helps her neighbors, she tells them that she is coming;
  (3) if Jane does not help her neighbors, then she ought not to tell them that she is coming;
  (4) Jane does not help her neighbors.

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  (4) Jane does not help her neighbors.
- The theorem prover can infer
  - Ideally Jane ought to help and to tell her neighbors
  - Currently, she ought not to tell them
  - Jane has violated an ideal obligation

DL* language (syntax)

- Non-normative connectives: **NOT . . . , . . . AND . . . , . . . OR . . . , IF . . . THEN . . . , IFF . . . THEN . . .**

DL* language (syntax)

- Non-normative connectives: **NOT . . .**, **. . . AND . . .** , **. . . OR . . .**, **IF . . . THEN . . .**, **IFF . . . THEN . . .**
- Normative unary connectives: **OBLIGED . . .** , **PERMITTED . . .** , **FORBIDDEN . . .** , **IDEALLY . . .**

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- Normative unary connectives: **OBLIGED . . .** , **PERMITTED . . .** , **FORBIDDEN . . .** , **IDEALLY . . .**
- Normative binary operators: **IF . . . THEN THE OBLIGATION IS . . .**, etc.

Equivalent (more concise) notation

- **(∼ . . .), (. . . , . . .), (. . . ; . . .)**
- **(. . . => . . .), (. . . <=> . . .)**
- **(Ob . . .), (Pm . . .), (Fb . . .), (Id . . .)**
- **(. . . O> . . .), (. . . P> . . .), (. . . F> . . .)**

NAI

- Theoretically, we have a relatively expressive language which has automation
- We provide NAI - Normative AI tool
  - tools for making formalizations
    - Focus of Tereza's talk
  - tools for reasoning over the formalization
    - Focus of Alex's talk
- In the rest of my talk
  - First-order DL*
    - Note that fully understanding the logic is not necessary for using the tool
    - But it can help improving and understanding the formalizations

Generalization

- Before we have considered
  - "Persons who are doctors and lawyers qualify"
  - "Is Andrew, who is a doctor, qualified?"
- We formalized it as
  - **IF p1 THEN p3 AND IF p2 THEN p3**
  - **p1**
- Where
  - **p1** means "The persons are lawyers"
  - **p2** means "The persons are doctors"
  - **p3** means "The persons qualify"
- What is the problem?

Need for generalization - problems

- Andrew is just one of the persons who are doctors
  - Incorrect interpretation

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- We cannot make a distinction between the people
  - Assume Jack is an engineer - **p4**
  - If we know that Andrew is a doctor and Jack is an engineer, who is qualified?
  - **IF p1 THEN p3 AND IF p2 THEN p3**
  - **p1**
  - **p4**

Need for generalization - problems

- Andrew is just one of the persons who are doctors
  - Incorrect interpretation
- We cannot make a distinction between the people
  - Assume Jack is an engineer - **p4**
  - If we know that Andrew is a doctor and Jack is an engineer, who is qualified?
  - **IF p1 THEN p3 AND IF p2 THEN p3**
  - **p1**
  - **p4**
- The prover answers **p3**.

Generalization

- Solution
  - **FOR ANY Person IF doctor(Person) THEN qualified(Person)**
- Where
  - **doctor** means that Person is a doctor
  - **qualified** means that Person is qualified

New formalization

1. **FOR ANY Person IF doctor(Person) THEN qualified(Person) AND IF lawyer(Person) THEN qualified(Person)**
2. **doctor(andrew)**
3. **engineer(jack)**

- Deduce automatically: **qualified(andrew)**

New formalization

1. **FOR ANY Person IF doctor(Person) THEN qualified(Person) AND IF lawyer(Person) THEN qualified(Person)**
2. **doctor(andrew)**
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- Deduce automatically: **qualified(andrew)**

- concise syntax

1. **((doctor(Person) => qualified(Person)), (lawyer(Person) => qualified(Person)))**
2. **doctor(andrew)**
3. **engineer(jack)**

Syntactical conventions

1. **((doctor(Person) => qualified(Person)),**
   (lawyer(Person) => qualified(Person)))
2. **doctor(andrew)**
3. **engineer(jack)**

- If a word starts with an Upper case letter, it refers to ANY

Some consequences

- Problems with propositions only are decidable
- Problems with variables are only semi-decidable
  - We are ensured of an answer only if the answer is true
  - If it is not, the prover may never terminate
- This has implications on the automated process as we will see in Alex's talk

About us

Team

- Tereza - Legal expertise
- Alex - Implementation of the frontend
- Matteo - Theory and research
- Tomer - Implementation of the backend, theory and research

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- We welcome help!

How can lawyers help

- Use the tool and send us feedback
  - Slack
  - https://github.com/normativeai/frontend/issues
- Help build a benchmark
- Help define the requirements and future of the tool

How can researchers help

- Some possible topics
  - New logical capabilities (abduction, model finding, etc.)
  - Explainable proofs
  - Implications of FOL on DL*
  - Extend the legal language (mainly to include powers)
  - Integration of defeasibility
- We will be happy to collaborate on these and other topics

How can software engineers help

- Help improve the tool
  - Open source, just fix bugs and implement features and send us a pull request on github
- Join our team and discussions

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- Long and intelligble for most people
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- Once the document is formalized in NAI
  - Graphs and visualization
  - Automatic FAQ
  - Automatic generation of comics
  - ...
- http://lawforme.in/

Next part

- Tereza will show how to use the NAI tool in order to formalize legislation and queries
- Slack
  - Will be used in the interactive session
  - Asking questions, giving feedback, suggesting improvements
  - `https://tinyurl.com/y2jzlhyr`