Inference from paraconsistent legal knowledge

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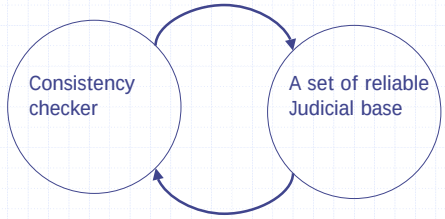
For safe e-society



Inconsistency checker

- Influence on code change, revision, or update

↓

- Necessity of logical consistency

Legal reasoning, thus far

- Expert system based on First-order logic
- Rule-based reasoning
- Case-based reasoning
- Defeasible reasoning by multi-agents
- Similarity
- Event and temporal reasoning
- …

Ex1: negative connective (¬)

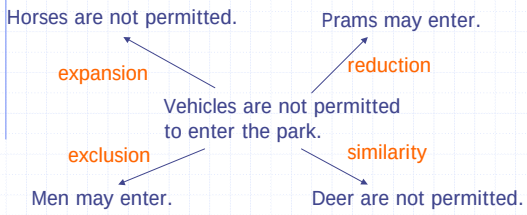
- `Self-defence is tolerable.'

$$\forall x[act(x) \wedge selfdefence(x) \rightarrow tolerable(x)]$$

- `Self-defence would not be punished.'

$$\forall x[act(x) \wedge selfdefence(x) \rightarrow \neg crime(x)]$$

Ex2: revision



Nonmonotonic reasoning

- Belief revision
  - expansion
  - revision
  - contraction
- Default logic
- Circumscription

Belief revision

$\{\alpha, \alpha \rightarrow \beta, \beta \rightarrow \gamma\} \dot{+} \neg\gamma$

$\{\alpha, \alpha \rightarrow \beta, \neg\gamma\}$, or
$\{\alpha, \beta \rightarrow \gamma, \neg\gamma\}$, or
$\{\alpha \rightarrow \beta, \beta \rightarrow \gamma, \neg\gamma\}$

Circumscription

$\{r(a), p(x) \rightarrow r(x), q(x) \rightarrow r(x)\}$

Predicate completion

$r(x) \rightarrow p(x) \vee q(x) \vee (x = a)$

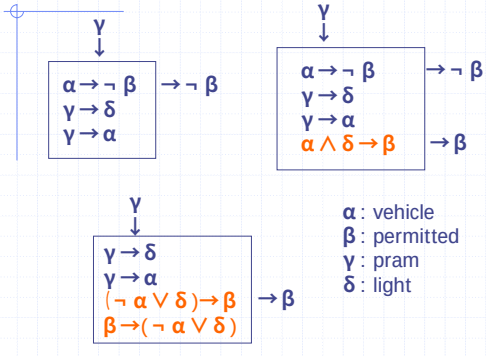
`Vehicles are not permitted, exclusive of small and ones.'

$vehicle(x) \rightarrow \neg permitted(x).$

$vehicle(x) \wedge light(x) \rightarrow permitted(x).$

↓ circumscription

$permitted(x) \rightarrow \neg vehicle(x) \vee (vehicle(x) \wedge light(x))$



Logic with paraconsistency

- Multiple concepts of negation
  ↓
- Reasoning from an inconsistent knowledge
  ↓
- Prover with paraconsistent logic

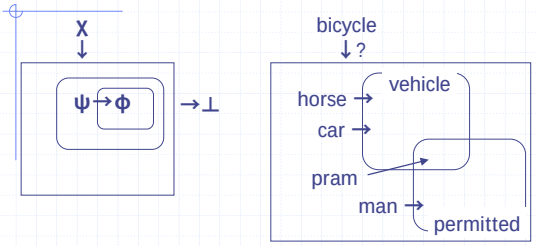
Minimal negation

Graded negation

$\Delta \vdash \neg_{\varphi}\psi$ iff $\Delta \vdash \varphi$ and $\varphi \wedge \psi \vdash \bot$

Minimal negation $\Delta \vdash \ominus_{\varphi}\chi$

$\Delta \vdash \neg_{\varphi}\chi$, and for any **ψ**, if $\Delta \vdash \neg_{\psi}\chi$ and $\vdash \varphi \rightarrow \psi$ then $\psi \rightarrow \varphi$



Maximal toleration

$\Delta \vdash \circ_{\varphi}\psi$ iff $\Delta \vdash \varphi$ and $\varphi \wedge \psi \nvdash \bot$.

Maximal toleration $\Delta \vdash \oplus_{\varphi}\chi$

$\Delta \vdash \circ_{\varphi}\chi$, and for all **ψ**, if $\Delta \vdash \circ_{\psi}\chi$ and $\vdash \psi \rightarrow \varphi$ then $\varphi \rightarrow \psi$

In multiple MC(**Δ**),

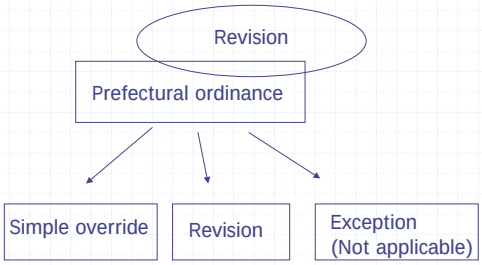
Absolute reject: for all,

$$\Delta^* \in MC(\Delta),\ \Delta^* \cup \{\chi\} \vdash \bot,$$

Possibly reject: there exists

$$\Delta^* \in MC(\Delta) \text{ that } \Delta^* \cup \{\chi\} \nvdash \bot.$$

Ex3. Code revision



Summary

We admit:

- Multiple negations, and
- Knowledge-base may be inconsistent

But,

- Minimal negation,
- Maximal toleration, and
- Prover.