Experience Based Nonmonotonic Reasoning

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Example

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Non-monotonic behavior!

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How to model?

- No prior logical knowledge
- Previous experiences

Decide what to expect based on *previous experiences in similar situations*

Approach

Formalize this situation using *formal concept analysis* (FCA)

Example

	sunny	sirens	tram on time
Day 1	×		×
Day 2			×
Day 3	×		×
Day 4	×	×	×
Day 5	×	×	
Day 6	×		×

Example

	sunny	sirens	tram on time
Day 1	×		×
Day 2			×
Day 3	×		×
Day 4	×	×	×
Day 5	×	×	
Day 6	×		×

Example

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	sunny	sirens	tram on time
Day 1	×		×
Day 2			×
Day 3	×		×
Day 4	×	×	×
Day 5	×	×	
Day 6	×		×

Example

On what days was it sunny and the tram was on time?

Example

	sunny	sirens	tram on time
Day 1	×		×
Day 2			×
Day 3	×		×
Day 4	×	×	×
Day 5	×	×	
Day 6	×		×

Example

On what days was it sunny and the tram was on time?

$$\{ \text{sunny}, \text{tram on time} \}'$$

Example

	sunny	sirens	tram on time
Day 1	×		×
Day 2			×
Day 3	×		×
Day 4	×	×	×
Day 5	×	×	
Day 6	×		×

Example

On what days was it sunny and the tram was on time?

$$\{ \text{sunny}, \text{tram on time} \}' = \{ \text{Day 1}, \text{Day 3}, \text{Day 4}, \text{Day 6} \}$$

Example

	sunny	sirens	tram on time
Day 1	×		×
Day 2			×
Day 3	×		×
Day 4	×	×	×
Day 5	×	×	
Day 6	×		×

Example

Example

	sunny	sirens	tram on time
Day 1	×		×
Day 2			×
Day 3	×		×
Day 4	×	×	×
Day 5	×	×	
Day 6	×		×

Example

What observations have Day 1 and Day 5 in common?

Example

	sunny	sirens	tram on time
Day 1	×		×
Day 2			×
Day 3	×		×
Day 4	×	×	×
Day 5	×	×	
Day 6	×		×

Example

What observations have Day 1 and Day 5 in common?

$$\{ \text{Day 1}, \text{Day 5} \}'$$

Example

	sunny	sirens	tram on time
Day 1	×		×
Day 2			×
Day 3	×		×
Day 4	×	×	×
Day 5	×	×	
Day 6	×		×

Example

What observations have Day 1 and Day 5 in common?

$$\{ \text{Day 1}, \text{Day 5} \}' = \{ \text{sunny} \}$$

Example

	sunny	sirens	tram on time
Day 1	×		×
Day 2			×
Day 3	×		×
Day 4	×	×	×
Day 5	×	×	
Day 6	×		×

Example

	sunny	sirens	tram on time
Day 1	×		×
Day 2			×
Day 3	×		×
Day 4	×	×	×
Day 5	×	×	
Day 6	×		×

Idea

If it is sunny, it *normally* follows that the tram is on time if this has happened *often enough* in similar situations.

Example

	sunny	sirens	tram on time
Day 1	×		×
Day 2			×
Day 3	×		×
Day 4	×	×	×
Day 5	×	×	
Day 6	×		×

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If it is sunny, it *normally* follows that the tram is on time if this has happened *often enough* in similar situations.

- True for Day 1, Day 3, Day 4, Day 6

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	sunny	sirens	tram on time
Day 1	×		×
Day 2			×
Day 3	×		×
Day 4	×	×	×
Day 5	×	×	
Day 6	×		×

Idea

If it is sunny, it *normally* follows that the tram is on time if this has happened *often enough* in similar situations.

- True for Day 1, Day 3, Day 4, Day 6
- Not true for Day 5

Example

	sunny	sirens	tram on time
Day 1	×		×
Day 2			×
Day 3	×		×
Day 4	×	×	×
Day 5	×	×	
Day 6	×		×

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	sunny	sirens	tram on time
Day 1	×		×
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Day 3	×		×
Day 4	×	×	×
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Day 6	×		×

Observation

If is sunny and there are sirens, it is not clear whether the tram will be on time

Example

	sunny	sirens	tram on time
Day 1	×		×
Day 2			×
Day 3	×		×
Day 4	×	×	×
Day 5	×	×	
Day 6	×		×

Observation

If is sunny and there are sirens, it is not clear whether the tram will be on time

- True on Day 4

Example

	sunny	sirens	tram on time
Day 1	×		×
Day 2			×
Day 3	×		×
Day 4	×	×	×
Day 5	×	×	
Day 6	×		×

Observation

If is sunny and there are sirens, it is not clear whether the tram will be on time

- True on Day 4
- Not true on Day 5

Example

	sunny	sirens	tram on time
Day 1	×		×
Day 2			×
Day 3	×		×
Day 4	×	×	×
Day 5	×	×	
Day 6	×		×

Observation

If is sunny and there are sirens, it is not clear whether the tram will be on time

- True on Day 4
- Not true on Day 5

Not enough evidence!

Goal

Formalize notion of “normally follows”

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Approach

Use notion of *confidence*:

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Formalize notion of “normally follows”

Approach

Use notion of *confidence*: define for X, Y sets of *attributes*

$$\operatorname{conf}(X \to Y) := \begin{cases} 1 & X' = \varnothing \\ \frac{|(X \cup Y)'|}{|X'|} & \text{otherwise} \end{cases}$$

as the *confidence* of $X \to Y$.

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$$\operatorname{conf}(\{\,\text{sunny}\,\} \to \{\,\text{tram on time}\,\}) = 4/5$$

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$$\operatorname{conf}(\{\,\text{sunny}\,\} \to \{\,\text{tram on time}\,\}) = 4/5$$
$$\operatorname{conf}(\{\,\text{sunny, sirens}\,\} \to \{\,\text{tram on time}\,\}) = 1/2$$

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Use notion of *confidence*: define for X, Y sets of *attributes*

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$$\operatorname{conf}(\{\,\text{sunny, sirens}\,\} \to \{\,\text{tram on time}\,\}) = 1/2$$

Approach

Consider implications with *high* confidence as “normally true”

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- Approach does not seem to be new

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- Approach may be used to *mine "non-monotonic rules"* from data

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- Shows connection between FCA and NMR
- FCA provides interfaces to Data Mining
- Approach may be used to *mine "non-monotonic rules"* from data
- Closer look on connections between this approach and existing ones

Thank You