Applications of the Channel Theory

Commonsense Reasoning
Representations

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10.07.2003

Overview

- Repetition
- Commonsense Reasoning / Nonmonotonicity
- (Imperfect) Representations

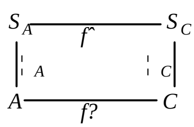
Repetition

Basics

- tokens (particulars, instances): things in the world (in time) - *a, b, c*
- types (in state spaces: states): *a*, *ß*, *?*, *s*
- classification: ***A,*** set of tokens (*A*) is classified in set of types
- if a is of type *a* we write: $a ¦_A a$ (with respect to *A*)

Constraints and Infomorphisms

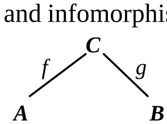
- *G*, *?* are sets of types, e.g. *G*={*a, ß*}, *?* = {*?*}
- ⟨*G*, *?*⟩ is a constraint, e.g. if *a* is of types *a, ß* then *a* has to be of type *?*
- ***A*⇆*C*** is an infomorphism between classifications



$f?(c) ¦_A a$
$\Leftrightarrow$
$c ¦_C f^(a)$

Information Channels and Local Logics

- C is an information channel, consists of core ***C*** and infomorphisms from parts to ***C***:



f: ***A*⇆*C***
g: ***B*⇆*C***

- L is a local logic, consists of ***A***, a set of constraints of ***A*** and a set of normal tokens
- normal tokens: satisfy all constraints in L

State Spaces

- ***S*** is a state space, consists of a set of tokens (S), a set of states (O_S) and a function mapping between them: $\boldsymbol{S} = \langle S, O_S, state\rangle$
- Evt(***S***) is the according classification
- Log(***S***) is the local logic on Evt(***S***)

Commonsense Reasoning

Overview

- Problem of Nonmonotonicity
- State Spaces, enhanced
- Background Conditions
- Relativising to a Background Condition

The Problem of Nonmonotonicity

Baseball:
(a_1) pitcher throws ball to batter
(ß) ball will arrive at batter
$\Rightarrow a_1 + ß$
monotonicity:
$a_1, a_2 + ß$
but:
(a_2) ball hits bird
$\Rightarrow a_1, a_2 + \neg ß$

Real valued State Spaces

- $\boldsymbol{S} = \langle S, O \subseteq R^n, state\rangle$
- each state is a vector s with dimension n
- s has input and output coordinates ($s = s_i \times s_o$) = observables
- outputs can be computed from inputs

Judith's heating system

- a state $s = (s_1, s_2, s_3, s_4, s_5, s_6, s_7)$

s_i:
- s_1: thermostat setting $55 = s_1 = 80$
- s_2: room temperature $20 = s_2 = 110$
- s_3: power on ($s_3 = 1$) or off ($s_3 = 0$)
- s_4: exhaust vents blocked (=0) or clear (=1)
- s_5: op. conditions cooling (=-1), off (=0) or heating (=1)

s_o:
- s_6: running yes (=1) or no (=0)
- s_7: output air temperature $20 = s_7 = 110$

Background Conditions

- B is a function from domain P to real numbers
- P in inputs of $\boldsymbol{S}$
  - is called set of parameters of B
- a state s satisfies B if the corresponding inputs of s have same value as given by B ($s_i = B(i)\ \forall i \in P$)
- $B_1 = B_2 \Leftrightarrow P_1 \subseteq P_2$

Silence

- a is silent on B, if it does not tell anything about the parameters of B:
  - $s =_B s'$ if $s_t = s_t'$ $\forall t \notin B$
  - $\forall s,s'$: if $s =_B s'$ and $s \in a$ then $s' \in a$

$\Rightarrow$ if we are reasoning about an observable t, then t must be either an explicit input or output of the system (and not a parameter)

Judith's heating system

(a_1) thermostat: $65 = s_1 = 70$

(a_2) room temperature: $s_2 = 58$

(a_3) power: $s_3 = 0$

(ß) hot air is coming out of the vents

a_1, a_2 + ß

a_1, a_2, a_3 + ¬ß

$\Rightarrow$ a_1, a_2, ß are silent about s_3, s_4, s_5 (which are supposed to be the parameters)

but:

a_3 is not silent about s_3

Weakening

- G is a set of types
- the weakening of B by G (B?G) is the greatest lower bound of all $B_0 = B$ such that every type $a \in G$ is silent on B_0

$\Rightarrow$ B?a is restriction of B to the set of inputs $i \in P$ such that a is silent on i

Judith's heating system

(a_1) thermostat: $65 = s_1 = 70$

(a_2) room temperature: $s_2 = 58$

(a_3) power: $s_3 = 0$

(ß) hot air is coming out of the vents

$B = \{s_3 = s_4 = s_5 = 1\}$

$\Rightarrow$ B?$a_3 = \{s_4 = s_5 = 1\}$

Relativising to a Background Condition

- $\boldsymbol{S}_B$ is relativisation of $\boldsymbol{S}$ to B
  - subspace of $\boldsymbol{S}$
  - only states that satisfy B
- Log($\boldsymbol{S}_B$) is the local logic on Evt($\boldsymbol{S}$) supported by B
  - consistent states are those satisfying B
  - entailment only over states satisfying B
    - $G +_B$? $\Leftrightarrow$ $\forall s$ sat. B (if $s \in p\ \forall p \in G$ then $s \in q$ *for some* $q \in$?)
  - normal tokens are those satisfying B

Judith's heating system

(a_1) thermostat: 65 = s_1 = 70
(a_2) room temperature: s_2 = 58
(a_3) power: s_3 = 0
(ß) hot air is coming out of the vents

- *a1, a2* + ß holds in Log($\boldsymbol{S}_B$)
- because a_3 not silent about s_3: switch to $B?a_3$

⇒ *a1, a2* + ß does not hold in Log($\boldsymbol{S}_{B?a3}$) (is no constraint there)

⇒ *a1, a2* , *a3* + ¬ß is constraint in Log($\boldsymbol{S}_{B?a3}$)

Strict Entailment

- $G \Rightarrow_B$?: *G* strictly entails ? relative to B
  - $G+_{Log(S_B)}$?
  - all types in $G \cup$? are silent on *B*
- then (conclusions):
  - $G \Rightarrow_B$? is a better model of human reasoning than $G+_B$?
  - $G \Rightarrow_B$? is monotonic in *G* and ? (only with weakening)
  - if you have a type *a* not silent on *B* it is natural to weaken *B*: *B*?*a*
  - $G \Rightarrow_B$? does not entail: *G, a* $\Rightarrow_{B?a}$? or $G \Rightarrow_{B?a}$?, *a*

Representations

Overview

- The Problem of Imperfect Representations
- Representation Systems
- Explaining Imperfect Representations

The bridge

The Map

The bridge

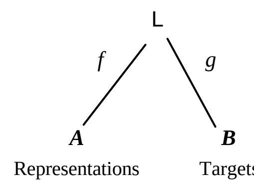
The bridge

The Map

correct?

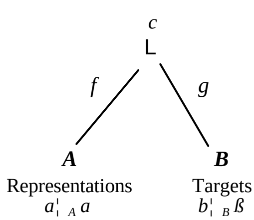
Representation Systems

- R = ⟨C,L⟩ is a representation system
  - C = {*f*: ***A*⇆*C***, *g*: ***B*⇆*C***} is a binary channel
  - L is the local logic on the core ***C***



Representations

- *a* is a representation of *b*, if *a*,*b* are connected by some $c \in \boldsymbol{C}$
  - *a* is accurate representation of *b*, if *c* is normal token ($c \in N_L$)
- content of *a*: *a*¦ $_A$ *G* *f*[*G*]+$_L$ *g*(?)
- *a* represents *b* as being of type *ß*, if *ß* in content of *a*



if *a* is accurate representation of *b* and *a* represents *b* as being of type *ß*, then *b*¦ $_B$ *ß*

Explaining Imperfect Representations

- tokens in target classification (***B***) are really regions at times
- if b_0 changes to b_1 this gives rise to a new connection c_1 between *a* and b_1

⇒ *a* represents both: b_0 and b_1

⇒ but c_1 supports not all of the constraints of R

b_0

b_1

References

- Jon Barwise and Jerry Seligman, *Information Flow, The Logic of Distributed Systems*, Cambridge University Press, 1997