Diagnosis (03)

Incremental Diagnosis and De Kleer Theory

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Incremental Diagnosis

De Kleer Theory

Other problems

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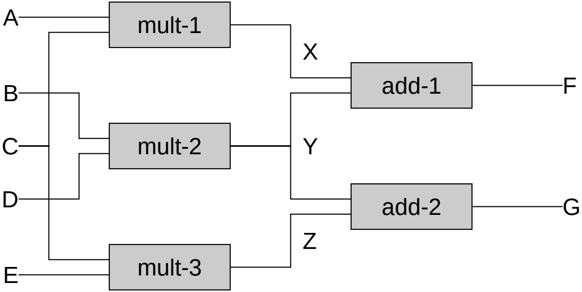
Davis Circuit



Why an incremental computation?

- Some observations are not known at first. Solutions:
  1. Wait until all the observations are present
  2. Compute a diagnosis, and re-compute it when new observations are given
  3. Compute a diagnosis, and incrementally refine it
- A cost is associated with some observations, we prefer not to use it if we do not need
  1. First perform a diagnosis with some observations, and incrementally add new observations if we need

Prediction

- Definition

  A Reiter Diagnosis Δ *predicts* O iff

  $$SD \cup OBS \cup \{\neg Ab(c) \mid c \in COMP \setminus \Delta\} \cup \{Ab(c) \mid c \in \Delta\} \models O$$

- Example: Davis Circuit
  - $\Delta_1 = \{m_1\}$ predicts $Out(m_2) = 6$
  - $\Delta_2 = \{m_2, m_3\}$ predicts $Out(m_2) = 4$ and $Out(m_3) = 6$

Confirmation and invalidation

- Confirmation
  - A Reiter Diagnosis Δ for $(SD, COMP, OBS)$ that predicts O is a Reiter Diagnosis for $(SD, COMP, OBS \cup \{O\})$
- Invalidation
  - A Reiter Diagnosis Δ for $(SD, COMP, OBS)$ that predicts $\neg O$ is not a Reiter Diagnosis for $(SD, COMP, OBS \cup \{O\})$

Incremental diagnosis

Let Δ be a Reiter Diagnosis for $(SD, COMP, OBS)$, let O be a new observation

- If Δ predicts O, then Δ is confirmed
- If Δ predicts $\neg O$, then look at supersets of Δ

- Let O be an observation that confirms the Reiter Diagnosis Δ_1 and invalidates Δ_2 for $(SD, COMP, OBS)$. We say that O discriminates Δ_1 and Δ_2

Diagnosability

- A system $(SD, COMP)$ is diagnosable if for any set of posible measurements (any complete set of observations) we have a unique diagnosis

- Example (Davis Circuit):
  - If we can observe A, B, C, D, E, F, G, then the system is not diagnosable
  - If we can observe A, B, C, D, E, F, G, X, Y, Z then the system is diagnosable

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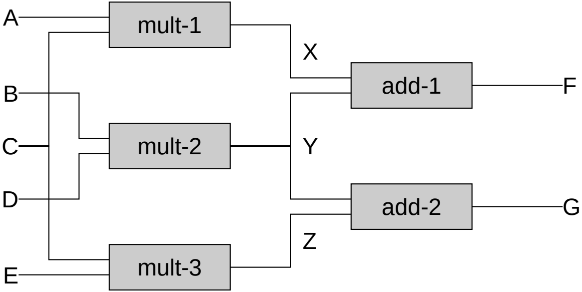
Problem of Reiter Theory



New piece of information on the system (failure knowledge):

$$Ab(m_1) \Rightarrow Out(a_1, 0)$$

A super set of a Reiter Diagnosis is not always a diagnosis

Cover

- Definition

  Let C and D be a conjunction of litterals
  - C covers D iff any litteral of C is a litteral of D

- Example
  - $C = Ab(c_1) \wedge \neg Ab(c_2)$ covers $D = Ab(c_1) \wedge \neg Ab(c_2) \wedge Ab(c_3)$
  - $C = Ab(c_1) \wedge \neg Ab(c_2)$ does not cover $D = Ab(c_1) \wedge Ab(c_2) \wedge Ab(c_3)$

How to represent the diagnoses?

- Problem

  n components $\Rightarrow 2^n$ states

- Intuition

  $Ab(c_1) \wedge \neg Ab(c_2) \wedge Ab(c_3)$
  $Ab(c_1) \wedge \neg Ab(c_2) \wedge \neg Ab(c_3)$
  Partial diagnosis = $Ab(c_1) \wedge \neg Ab(c_2)$

- Definition

  A partial diagnosis is an Ab-clause Φ such that any state e covered by Φ is a diagnosis

Kernel diagnosis

- Definition
  - A kernel diagnosis is a partial diagnosis that is not covered by any partial diagnosis
- Example
  - State Diagnoses
    - $Ab(c_1) \wedge Ab(c_2) \wedge Ab(c_3)$
    - $Ab(c_1) \wedge Ab(c_2) \wedge \neg Ab(c_3)$
    - $Ab(c_1) \wedge \neg Ab(c_2) \wedge Ab(c_3)$
    - $Ab(c_1) \wedge \neg Ab(c_2) \wedge \neg Ab(c_3)$
    - $\neg Ab(c_1) \wedge Ab(c_2) \wedge Ab(c_3)$
  - Partial diagnoses that are not states
    - $Ab(c_1) \wedge Ab(c_2)$
    - $Ab(c_1) \wedge Ab(c_3)$
    - $Ab(c_1) \wedge \neg Ab(c_2)$
    - $Ab(c_1) \wedge \neg Ab(c_3)$
    - $Ab(c_1)$

Conflict

- A conflict is an Ab-clause that is a deduction of $SD \cup OBS$
- A conflict is minimal if no sub clause is a conflict
- A positiv conflict is such that all the literals are positiv

Link between minimal diagnoses and kernel diagnoses

- Theorem

all the minimal conflicts are positiv

$$\Leftrightarrow$$

any kernel diagnosis (De Kleer) is a minimal diagnosis (Reiter)

Which diagnosis to choose?

- The kernel diagnosis that contains the fewest faulty components
- Explanatory diagnoses

Explanatory diagnosis

- A diagnosis Δ for $(SD, COMP, OBS)$ explains an observation o iff $SD \cup OBS \models o$

- Example (Davis Circuit)
  - $Ab(a_1) \wedge \neg Ab(a_2) \wedge \neg Ab(m_1) \wedge \neg Ab(m_2) \wedge \neg Ab(m_3) \models Out(a_2, 12)$
  - $\neg Ab(a_1) \wedge Ab(a_2) \wedge \neg Ab(m_1) \wedge Ab(m_2) \wedge \neg Ab(m_3) \not\models Out(a_2, 12)$

- Which observations to explain?
  - All the observations?
  - The biggest number of observations of *OBS*?
  - The normal observations?

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Other problems

Other problems

- Non monotonicity
  - Monotonicity: if $KB \models \alpha$, then $KB \wedge \beta \models \alpha$
  - Problem: exceptions (example, all the bird flies, so the emu does!)
  - Non monotonic logics
- Uncertainty
  - We considered the knowledge is complete
  - How to express and make reasonning about ignorance, uncertainty, incompleteness?
  - Probability theory: Bayesian Networks, Markov Decision Process, Fuzzy logic