Likelihood of Concern Satisfaction

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Physical CPS System

Definition

A physical CPS system S is a tuple (C, A, F, R) where:

- C is a set of physical components.
- A is a finite set of actions that can be execute over CPS system.
- F is a finite set of fluent literals.
- R is a set of relations that map each physical component $c \in C$ with a set of physical component properties that are defined in CPS Ontology. For any $r \in R$, $r : C \longrightarrow 2^P$. P is set of all properties that are defined in CPS ontology. The predicate `relation(c,p)` $\in R$ denotes that component $c \in C$ is related with property $p \in P$ in system S.

Idea: Likelihood of Concerns Satisfaction

- A component was added to calculate the likelihood that concerns are satisfied. This was computed by:
  - Percentage of properties/requirements with positive impact that are satisfied the concerns vs the total number of properties/requirements with positive impact, and
  - Recursively aggregating the likelihood that its subconcerns are satisfied.

Representation the knowledge from Ontology

- **Step 1:** Representation of concerns, properties and their relations from CPS Ontology by predicates `concern/1`, `property/1`, `subconcern/2`, `addressedBy/2`, `addressesConcern/2`, etc.
- **Step 2:** Representation the *polarity* impacts of properties/requirements R from CPS Ontology by predicates `addressesPolarity(R,P)`. In which, `P=pos/neg` denotes that properties/requirements R impacts positively/negatively respectively.
- **Step 3:** Representation the satisfaction of properties/requirements R from CPS Ontology by predicates `body_satisfied(R,S)` denotes that properties/requirements R is satisfied at step S of evolution.

Reasoning degree of satisfaction of the concern

- **Step 4:** Compute the degree of satisfaction of positively-impacting properties/requirements. $degree\_impacted\_pos(c, S)$ denotes the degree of satisfaction of concern c based on its positively-impacting properties/requirements at step S.
  - N_1 is the number of properties/requirements which *(positively-impacting)* $\wedge$ *(address the considered concern)* $\wedge$ (*are satisfied*)
  - N_2 is the number of properties/requirements which *(positively-impacting)* $\wedge$ *(address the considered concern)*
  - $$degree\_impacted\_pos(c, S) = \begin{cases} \frac{N_1}{N_2} * 100, & \text{if } N_2 \neq 0 \\ 100, & \text{if } N_2 = 0 \end{cases}$$

Reasoning Likelihood of concern satisfaction

- **Step 5:** Compute Likelihood of considered concern satisfaction: Recursively aggregating the likelihood of a concern based on the likelihoods of its satisfied subconcerns.
  - Predicate `lh_sat(c,S)` is the likelihood value of the satisfaction of concern c at step S of evolution.
  - Predicate `lh_sat_sub(c,S)` is the likelihood value of the satisfaction of subconcern(s) of concern c at step S.
  - $lh\_sat(c, S) = \frac{lh\_sat\_sub(c, S) * degree\_impacted\_pos(c, S)}{100}$

Reasoning Likelihood of concern satisfaction

- **Step 6:** Recursively compute likelihood of subconcerns satisfaction.

$$lh\_sat\_sub(c, S) = \begin{cases} lh\_sat\_sub\_aux(c, S), & \text{if } c \text{ has sub-concerns} \\ 100, & \text{if } c \text{ has no any sub-concerns} \end{cases}$$

  In which, $lh\_sat\_sub\_aux(c, S)$ is the likelihood of satisfaction of biggest sibling concern among the subconcerns of concern c.

- **Step 7:** Compute $lh\_sat\_sub\_aux(c, S)$

$$lh\_sat\_sub\_aux(c, S) = \begin{cases} lh\_sat\_sub\_aux(c, S), & \text{if } c \text{ has sub-concerns} \\ 100, & \text{if } c \text{ has no any sub-concerns} \end{cases}$$