Probabilistic Mitigation Strategies

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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 set of tuples $(a_i, prob_{a_i})$, where a_i is an action which can be executed on the CPS, and $prob_{a_i}$ is the probability of success of the action a_i. $(0 \leq prob_{a_i} \leq 100)$ or $prob_{a_i} =$ None if the probability is unknown. A successful action modifies the current state, an unsuccessful action has no affect.
- 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.

Representation the System

- **Step 1**: Represent the probability of success of action. The fluent `prob_success(`a_i`,`$prob_{a_i}$`)` denotes that an action a_i has probability $prob_{a_i}$ $(0 \leq prob_{a_i} \leq 100)$.
- **Step 2**: The fluent `prob_of_state(`$prob_s$`)` models the propagation by the model to the successor state. The statement `holds(prob_of_state(`$prob_s$`),S)` means that at step S of the CPS evolution, the probability of the current state described by this fluent is $prob_s$ $(0 \leq prob_s \leq 100)$. The initial value at time step 0 is `holds(prob_of_state(100),0)` or `prob_of_state(0)` $= 100$.
- **Step 3**: Assuming that at step S of evolution, an action a_i can be executed. The predicate `do(`a_i`,S)` denotes that action a_i is executed at step S.

Compute the Probability of success of mitigation strategies

- **Step 4**: (1) Given the probability of success of mitigation strategies in CPS System at step S : `prob_of_state(S)`. (2) At step S, an action a_i is executed (`do(`a_i`,S)` holds) and the probability of success of a_i is `prob_success(`a_i`)`. So the probability of success of CPS system at step $S+1$ is:

$$prob\_of\_state(S+1) = \begin{cases} \dfrac{prob\_of\_state(S) * prob\_success(a_i)}{100}, \\ \text{ if } prob\_success(a_i) \neq None \\ prob\_of\_state(S), \text{ if } prob\_success(a_i) = None \end{cases}$$

- **Step 5**: Finally, assume that S_{last} is the last step of system evolution, the value of `prob_of_state(`S_{last}`)` represents the probability of success of mitigation strategy $\alpha = a_0 ... a_{S_{last}}$