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Generation of Criticality Index For Functional Scenarios Related to the Driving Automation Testing

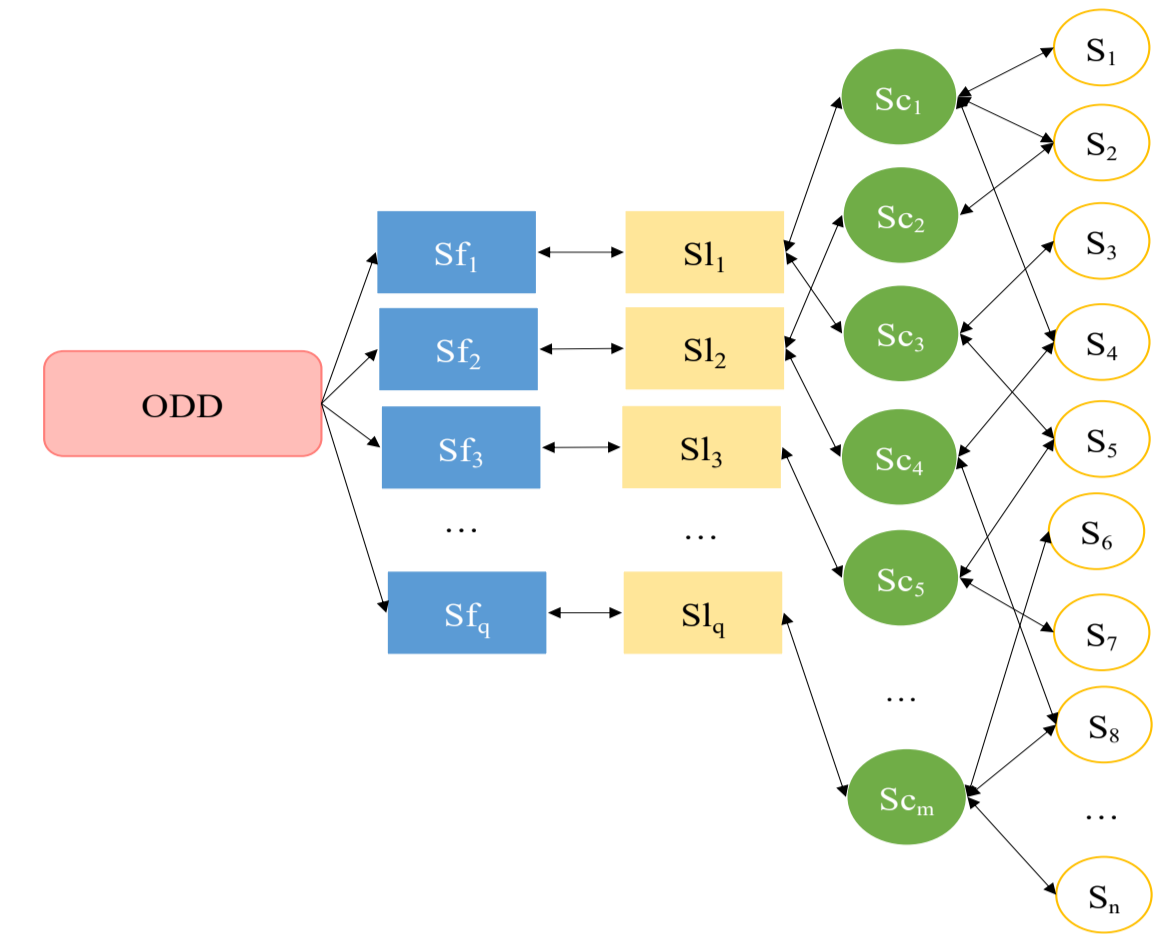
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Motivation

- Need to regularly test new functionalities on CAV and set up pre-certification processes, including test phases.
- Multiple test protocols exist in the literature [3]. We get interested in a **scenario-based** protocol [3], which are usually split into 3 steps:
 - Step 1:** Generation/Extraction of any feasible scenario
 - Step 2:** Application of a sampling process to select a set of concrete scenarios
 - Step 3:** Evaluation of CAV performance
- This paper proposes an extension of the protocol to include a prior assessment of scenario criticality with the purpose of guiding the sampling process of tested scenarios.

Definition



- Functional scenarios (Sf)** include operating scenarios on a semantic level. [1]
- Logical scenarios (Sl)** include operating scenarios on a state space level. [1]
- Concrete scenarios (Sc)** distinctly depict operating scenarios on a state space level. [1]

Methodology

- The prior criticality assessment process is split into 4 steps.
- Step 1 : Generation of Functional Scenarios (Sf)** from an ontology based on 5 layers.
 - Main specificity:** Introduction of stochasticity in the ontology: the trajectories of the obstacle-vehicles in the surrounding of the EGO vehicle (under test) are not exhaustively described, but formulated according to macroscopic traffic indicators (e.g. traffic demand) with random seeds.
 - Any Functional Scenario ($S_{f_i}^{ontology}$) is featured by a set of words (β_{w_n})

$$\forall i \in [1, q] S_{f_i}^{ontology} = (\beta_{w_1} \beta_{w_2} \dots \beta_{w_n}) \quad \forall j \in [1, n] \beta_{w_n} \in \{0,1\}$$
- Step 2 : Estimation of criticality indicators from field test observations**
 - Assigning the appropriate set of words (*i.e.* ontology's attributes) defining a functional scenario to any concrete scenario instantiated on the field and resulting in data collection (use of LevelxData).
 - Computing the frequency distribution over a criticality indicator (here, Time To Collision – TTC) for any available functional scenario with field observations.

- Step 4 : Generation of a priori criticality indicator** for any Functional Scenario, defined by a set of words / ontology's attributes. Thanks to the least mean square method, the process is adjusting a combination of the words generating the K latent topics with the ones associated to the Functional Scenario.

$$\forall i \in [1, q] S_{f_i}^{new} = \sum_{k=1}^K topic^k * \alpha_k \Leftrightarrow \begin{pmatrix} \beta_{w_1}^i \\ \beta_{w_2}^i \\ \vdots \\ \beta_{w_n}^i \end{pmatrix} = \begin{pmatrix} p_{w_1}^1 & \dots & p_{w_1}^K \\ \vdots & \ddots & \vdots \\ p_{w_n}^1 & \dots & p_{w_n}^K \end{pmatrix} * \begin{pmatrix} \alpha_1 \\ \alpha_2 \\ \vdots \\ \alpha_K \end{pmatrix}$$

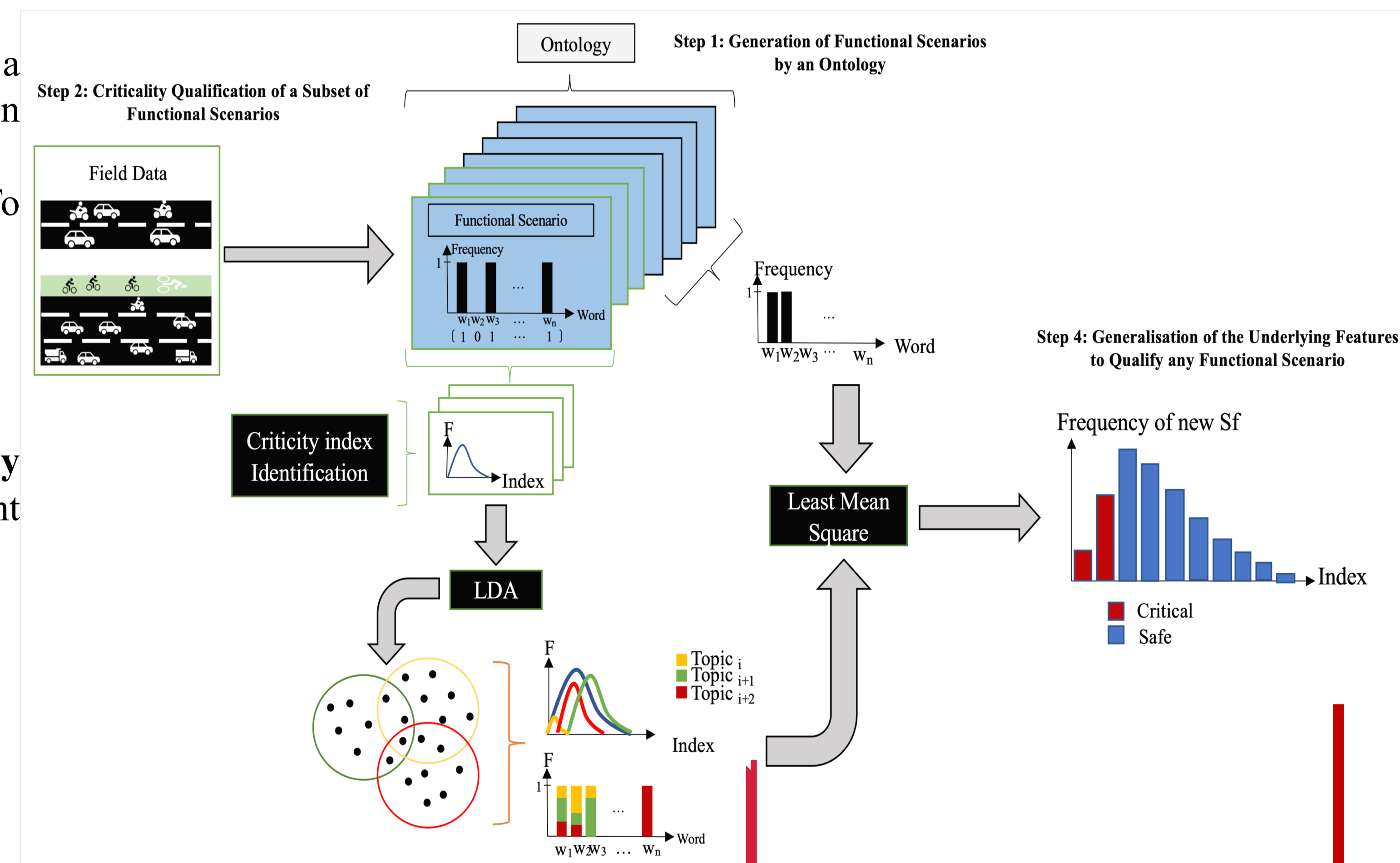
$$\beta = P * \alpha \Leftrightarrow \| P * \alpha - \beta \|^2 = 0$$

- Step 3 : Extraction of Underlying and Latent Relationship between ontology attributes and Criticality Index of Functional Scenario** thanks to the Latent Dirichlet Allocation (LDA) [2] clustering method.

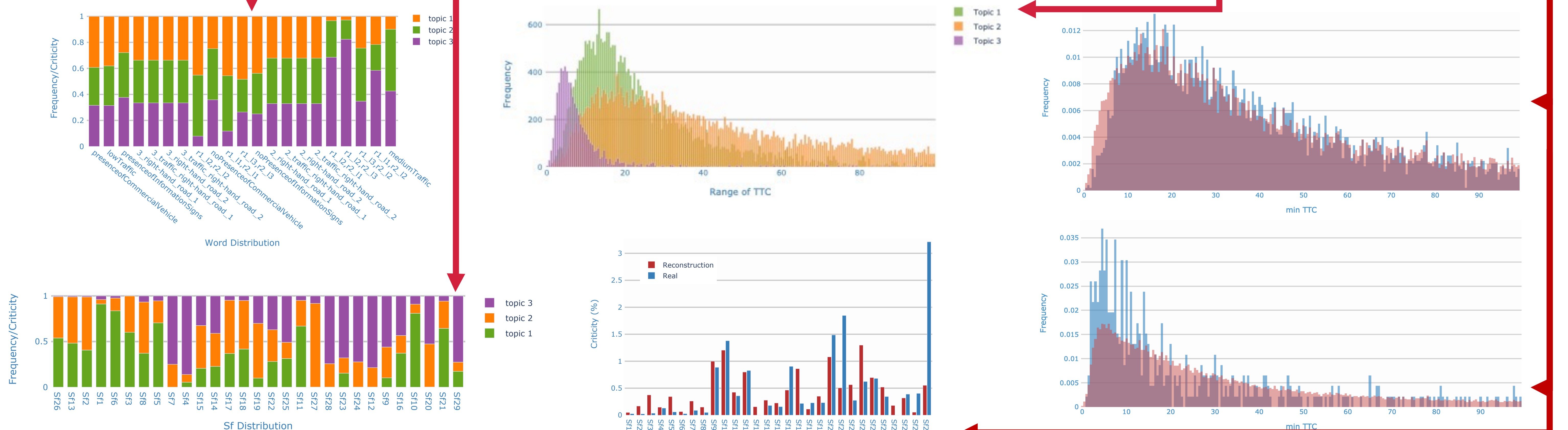
$$\forall k \in [1, K] topic_k^{ontology} = (p_{w_1}^k, p_{w_2}^k, \dots, p_{w_n}^k)$$

$$p_{w_j}^k \in [0, 1] \quad p_{w_j}^k = \sum_{i \in [1, q]} \theta_k^{(i)} * \frac{\beta_{w_j}^{(i)}}{\sum_{s \in [1, q]} \beta_{w_j}^{(s)}}$$

Each latent topic resulting from the LDA is featured by a frequency distribution over the words / ontology's attributes and is supposed to be a generator for any S_f .



Results



Conclusion

- Difficulty in accurately reconstructing profiles since raw profiles are noisy, while typical profiles are smooth. It strongly affects the Key Performance Indicators under consideration.
- Opportunity operate with new databases to extend the set of Sf and ontology's attributes covered..

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