5th International Workshop on Independent Verification and Validation of Software

SEMANTIC-BASED KNOWLEDGE REPRESENTATION

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Semantic-Based Knowledge Representation

- Introduction – What is Semantics?
- How does Semantics relate to knowledge representation?
- How would Semantics be used in the context of IV&V?
  - Tracking and mining of findings/issues/risks
  - Tracking and mining of IV&V evidence
  - Assurance statement development
- What are other uses of Semantic-Based Knowledge Representation?
- What’s next for IV&V?
Introduction – What is Semantics?

- (as the lawyers say) *It Depends*
  - The literal meaning of the Greek word σημαντικός – signifiers – signs or symbols
  - If you’re a philosopher
    - The study of meanings – context
  - If you’re a Linguist
    - Linguistic semantics is the study of meaning that is used for understanding human expression through language
  - If you’re a computer scientist
    - The processes a computer follows when executing a program – the model of computation in a particular programming language
  - If you’re an IV&V analyst (a little of all of these)
    - Finding the meaning of evidence in its context
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Semantics and Knowledge Representation

- Used when knowledge best understood as a set of concepts that are related to one another
- Context is everything
- **NOT** a new concept
- Extended Ontological/Taxonomic structure makes it derivable, searchable and mineable
- Stored relationships provide the data needed to automatically generate visual network diagrams and to later mine for significances of subtle relationships
Semantics and Knowledge Representation

A Simplistic Semantic Network Model
Semantic-Based Knowledge Representation

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Reported anomalies (findings/issues/risks) are inherently contextual (e.g., a software error which would cause a hypergolic propellant valve to open when it is not supposed to):

- Catastrophic when the vehicle is being fueled (loss of life and mission assets)
- Merely an annoyance when the vehicle is unfueled and being processed

A semantic–based knowledge system can suggest appropriate scoring of anomalous findings based on context and a pre–determined “bar”
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What are other uses of Semantic–Based Knowledge Representation?

What’s next for IV&V?
A semantic–based knowledge system can describe evidence element relationships and derive their significance

A semantic–based knowledge system can suggest additional evidence that must be acquired in order to complete an analysis

A knowledge–based system always generates a decision path which can be evaluated and learned from
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A semantic–based knowledge system can suggest assurances that can be made for captured assurance element relationships.

A semantic–based knowledge system can suggest caveats that must be attached to assurances that are desired to be made, based on missing assurance element relationships.

A knowledge–based system always generates a decision path which can be evaluated and learned from.
Assurance Statement Development

A Simplistic Semantic Network Model of an IV&V Assurance Case

Assurance Case 1

- Assumption
- Test Results Analysis

Assurance Case 2

- is evidence for
- is partial evidence for

Assurance Case 3

- is assumed by
- is evidence for

Assurance Case 4

- is evidence for
- is partial evidence for
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What are other uses of Semantic-Based Knowledge Representation?

- IBM’s Watson computer system
  - Showcased on the Jeopardy network television program
  - Used as an open-domain question answering system using natural language input
  - An example of a semantic-based knowledge representation and retrieval system
  - Competitors – two other semantic-based knowledge representation and retrieval systems: *two well-read humans*
What are other uses of Semantic-Based Knowledge Representation?

Question

Answer Sources

Evidence Sources

Primary Search

Candidate Answer Generation

Supporting Evidence Retrieval

Deep Evidence Scoring

Hypothesis Generation

Soft Filtering

Hypothesis and Evidence Scoring

Synthesis

Final Merging and Scoring

Trained Models

Answer/Confidence

Simplified Context Diagram

Watson Open Domain Question Answering Engine
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Conclusions

- Several semantic-based knowledge systems show promise for documenting and mining aspects of the Independent Verification and Validation of software.

- Semantic-based knowledge systems show promise for documenting and mining aspects of other areas outside of the Independent Verification and Validation of software.
Suggestions for the future of IV&V

- Development of a self-populating database tool for entering entities and relationships in multiple functionalities/domains (e.g., requirements quality in a spacecraft guidance, navigation and control [GN&C] domain)
- Development of a self-populating database tool for entering ISO/IEC 15026–2 assurance elements and their relationships
- Development of a customizable common notation for ISO/IEC 15026–2 (for display)
- Development of display, report generation, analysis and mining tools to make the databases useful
- Using the tools to analyze patterns and trends to improve the IV&V process
Questions?