DARPA ASKE GE Team M15 Report

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GE Research
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The latest version of this report is available at https://github.com/GEGlobalResearch/DARPA-ASKE-TA1/blob/master/StatusReports/Phase2/M15/GE_ASKE_M15_Report.pdf

and at

https://github.com/GEGlobalResearch/DARPA-ASKE-TA2/tree/master/Reports/GE_ASKE_M15_Report.pdf

Introduction

Milestone 15 consisted of a final, live system demo which took place on April 24, 2020. Part of the system's capabilities was presented to DARPA in a preliminary demo on April 10 and we include the content of that demo here as well. This report provides a record of the demo for documentation purposes.

Demo Content

The presentation and demo consisted of:

1. Introductory presentation providing an overview of the project concept of "Augmented Intelligence for Accelerating Engineering Design and Modeling".
2. Tabular description of the current state of the project and demo scope.
3. Capability demo 1: User interaction with queries leading to model composition, sensitivity analysis, and insights.
4. Capability demo 2: Mixed-initiative interaction to gracefully handle missing concepts and missing models by supplying additional text and SADL equations, followed by model composition, evaluations, and insights
5. Capability demo 3: Mixed-initiative interaction to gracefully handle missing models using extraction from free text.
6. Capability demo 4: User interaction with queries leading to model composition, sensitivity analysis, and insights for generalization use case from Wind Turbine modeling.
7. Capability demo 5: Automated human-readable ontology extraction from text and code from Wind Turbine modeling.
8. Discussion and feedback.

The following are the slides used in the April 10 demo and the slides from the April 24 demo.

The GE Team
DARPA ASKE

Team Members:

Andrew Crapo (PI TA1)
Alfredo Gabaldon (PI TA2)
Nurali Virani
Varish Mulwad
Narendra Joshi
Vijay Kumar
Jobin James
Sharad Dixit

DARPA ASKE – GE: Concept Overview

Augmented Intelligence for Accelerating Engineering Design and Modeling

EngineSim Java Codes from NASA Hypersonics Index

Extraction from Scientific Code

NASA Hypersonics Index Webpages, and Code Comments

Extraction of Concepts and Equations from Text

Contextual Extraction with Human-in-the-loop

Engine domain expert

Semantic alignment and joint extraction

External Knowledge Graphs (Wikidata, SWEET, …)

Automatic alignment with external KGs

Semantic Model of Knowledge

Just-in-time composition of fit-for-purpose models for user queries

Computational Graphs

Impact

- Accelerate model development for complex systems
- Reduce cycle time to update codes with new knowledge

Mixed-Initiative Interaction via Dialog Grammar

Insight generation

Human-readable output of inference

Interactive visualization and sensitivity analysis

Novice designer or mission planner

PM Feedback, Current State, and Demo Scope

Joshua's feedback and suggestions (Nov 22 and Dec PI meeting)	State	Current Demo Scope	Final Demo Scope
Be one integrated team within GE	✓	✓	✓
The Q&A should have under-the-hood simulation capability maybe where multiple scenarios and iterations are evaluated	✓	✓	✓
Get human-understandable explanation or insights not just that "I used this model tree with these weights/inputs".	✓	✓	✓
Improve usability and stability of the system	✓	✓	✓
Address what happens if user asks about a concept that is not known to the system	✓	✓	✓
Extraction seems to be highly manualized	✓	×	✓
Work with other teams to enhance overall capability	✓	×	✓
Show generalizability with diff use case and show how much effort is needed to instantiate and use models	✓	×	✓

Demonstrations of certain GE ASKE capabilities

Show: Input and output of knowledge extraction from NASA EngineSim code and associated text

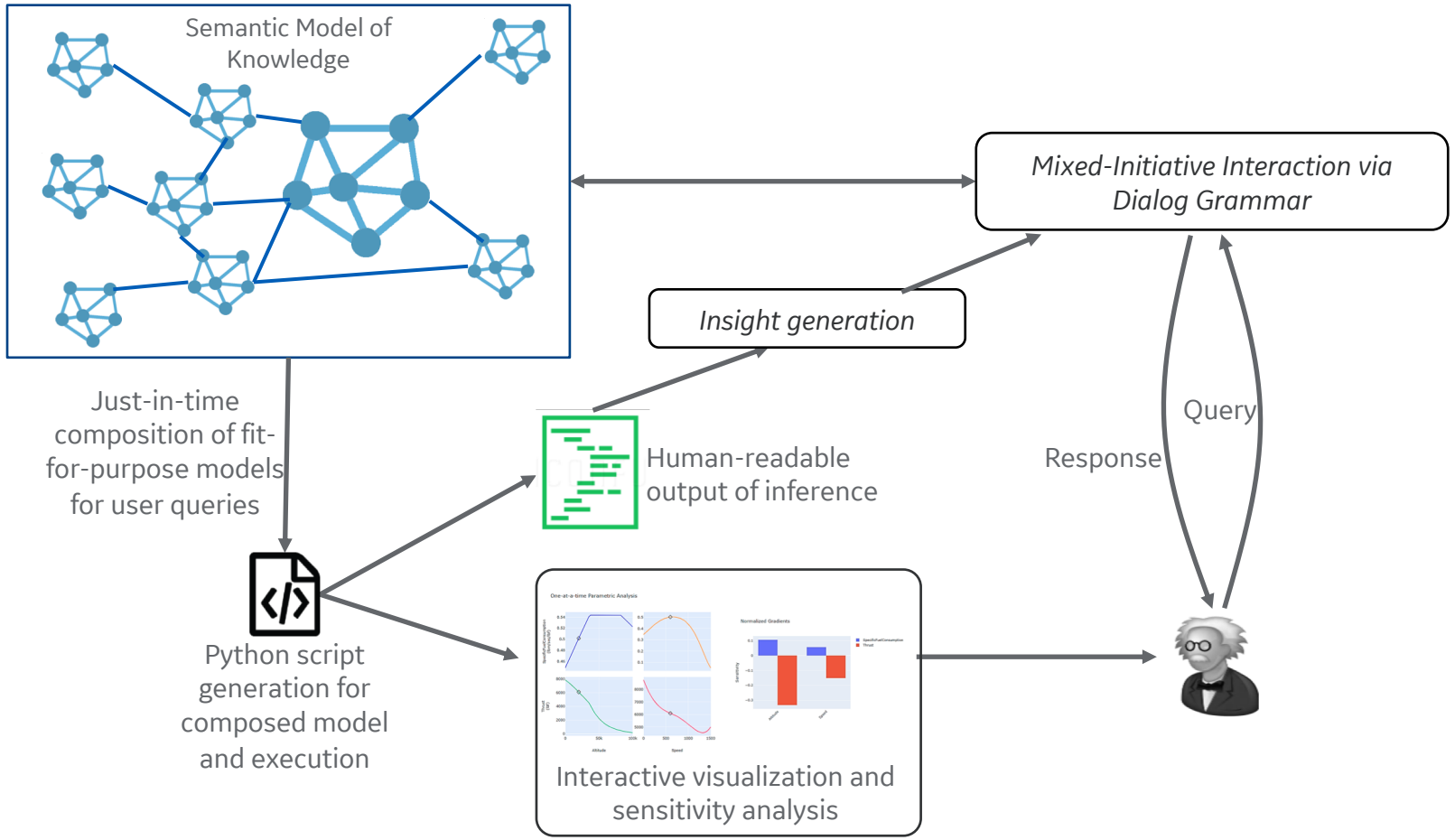
Demo 1: User interaction with queries leading to model composition, sensitivity analysis, and insights

Demo 2: Mixed-initiative interaction to gracefully handle missing concepts and missing models followed by model composition, evaluations, and insights

Demo 1: Model composition, sensitivity analysis, and insights

Key capabilities:

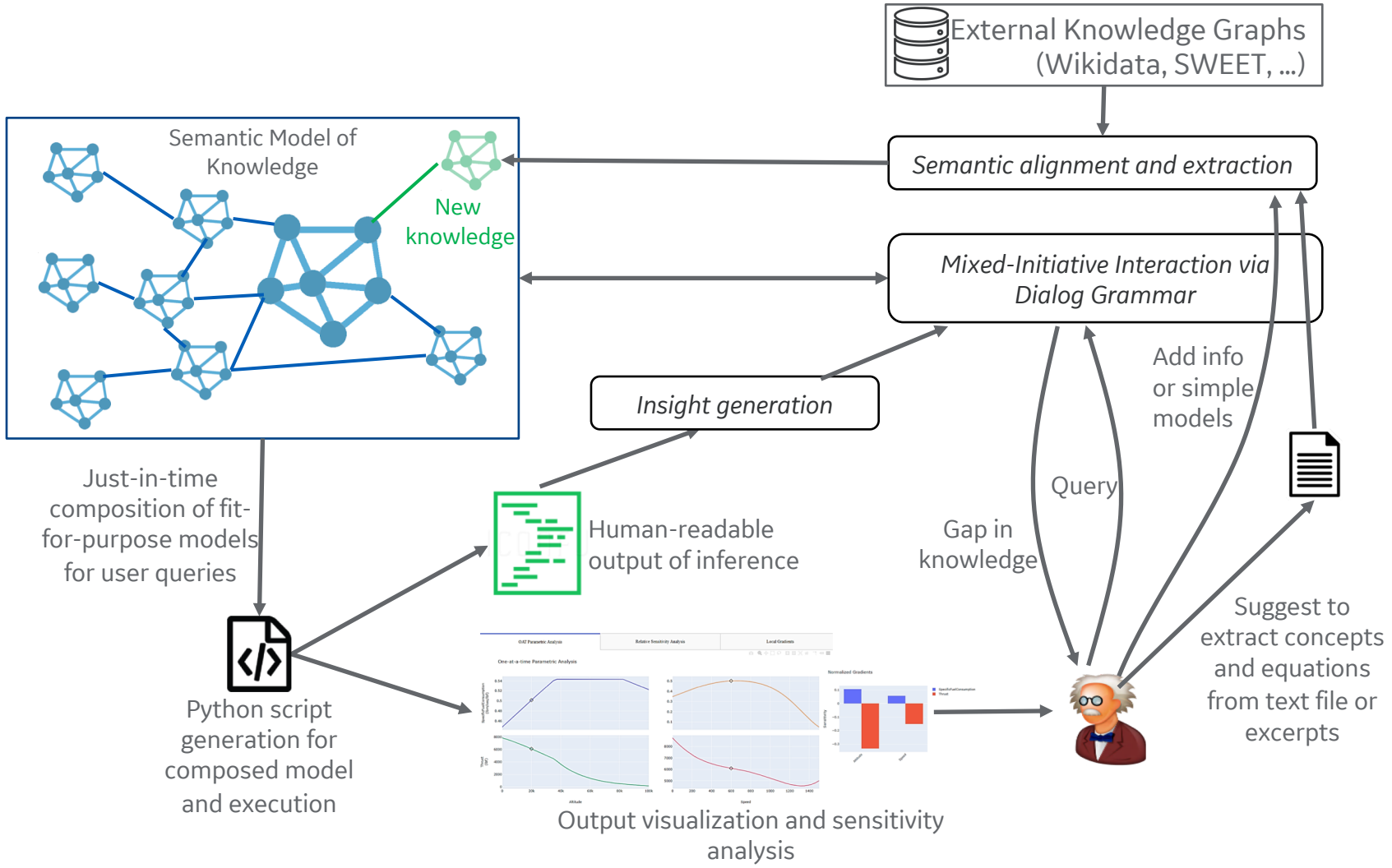
1. Scientific model knowledge representation
2. Dialog grammar for mixed initiative interaction
3. Semantic inference for fit-for-purpose model composition.
4. Python-NumPy script generation
5. Reasoning to extract insights
6. Procedural generation of interactive visualization
7. Automatic differentiation of python code



Demo 2: Mixed-initiative interaction to handle missing concepts and missing models

Key capabilities:

1. Semantic inference of knowledge gaps
2. Free interaction to add or edit information
3. Semantic inference of fit-for-purpose models
4. Knowledge graph evolution and new python model scripts



Discussion & Feedback

The GE Team
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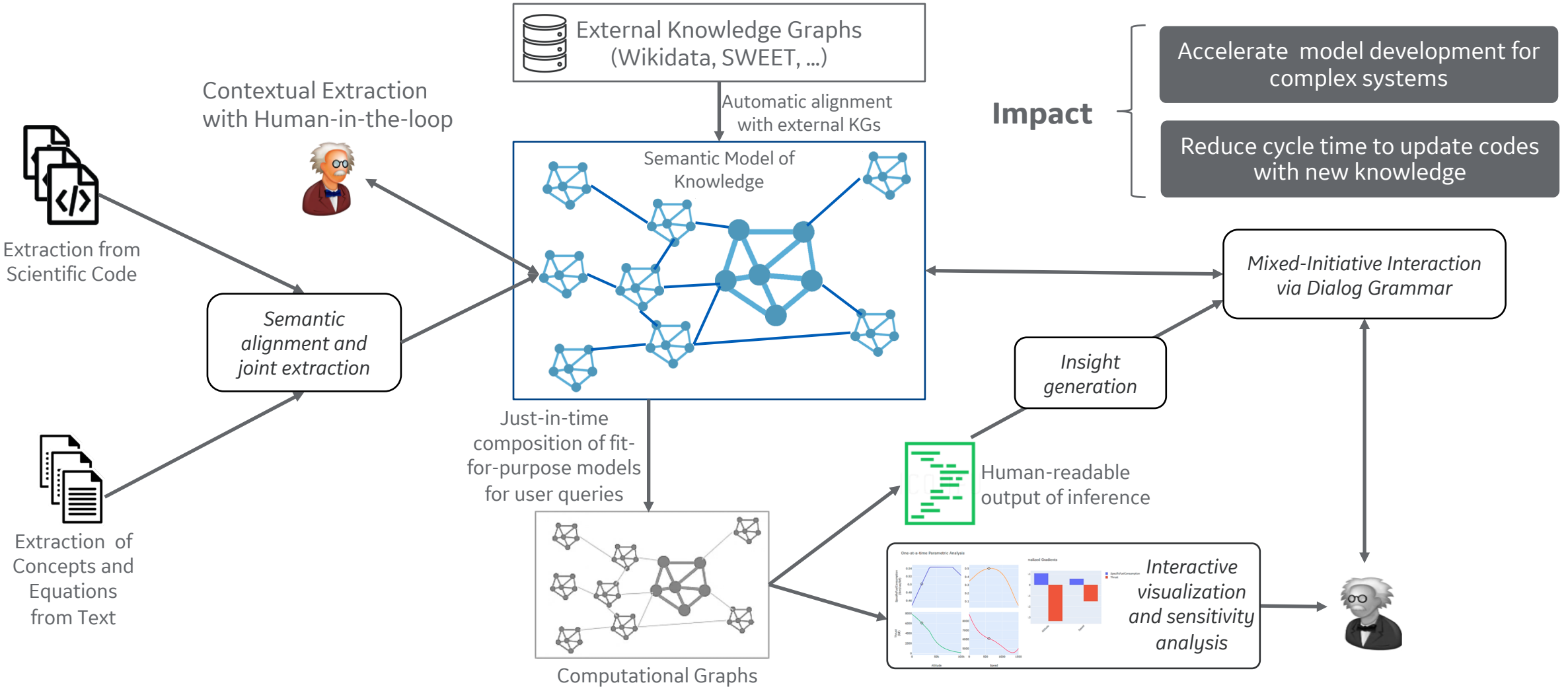
DARPA ASKE – GE: Concept Overview

Augmented Intelligence for Accelerating Engineering Design and Modeling



PM Feedback, Current State, and Demo Scope

Joshua's feedback and suggestions (Nov 22 and Dec PI meeting)	State	10th Apr Demo Scope	Final Demo Scope
Be one integrated team within GE	✓	✓	✓
The Q&A should have under-the-hood simulation capability maybe where multiple scenarios and iterations are evaluated	✓	✓	✓
Get human-understandable explanation or insights not just that "I used this model tree with these weights/inputs".	✓	✓	✓
Improve usability and stability of the system	✓	✓	✓
Address what happens if user asks about a concept that is not known to the system	✓	✓	✓
Extraction seems to be highly manualized, more automation in extraction	✓	×	✓
Work with other teams to enhance overall capability	✓	×	✓
Show generalizability with diff use case and show how much effort is needed to instantiate and use models	✓	×	✓

Demonstrations of certain GE ASKE capabilities

Demo 1: Mixed-initiative interaction to gracefully handle missing models using extraction from text.

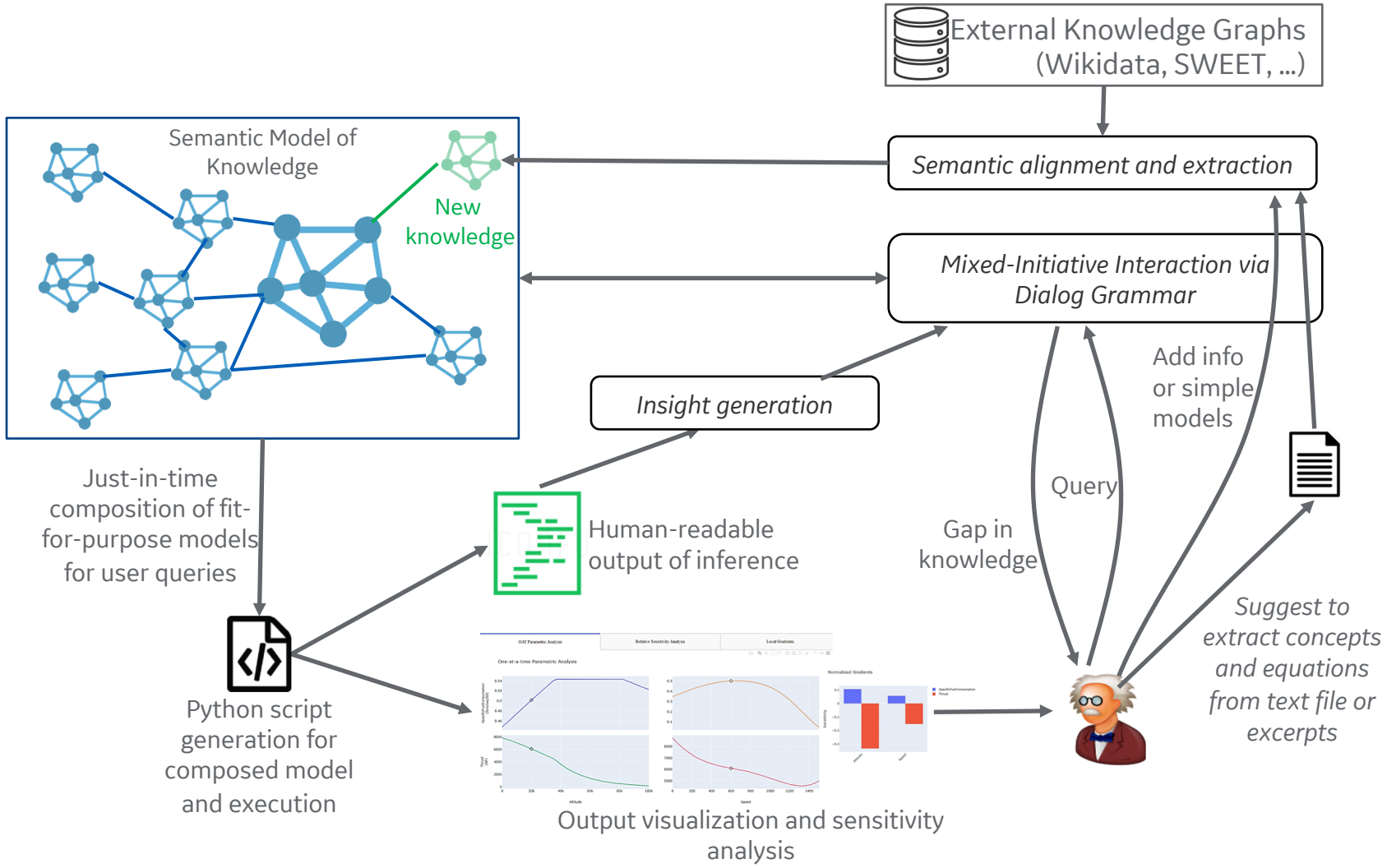
Demo 2: User interaction with queries leading to model composition, sensitivity analysis, and insights for generalization use case from Wind Turbine modeling.

Demo 3: Automated human-readable ontology extraction from text and code from Wind Turbine modeling.

Demo 1: Mixed-initiative interaction to handle missing models using extraction from text

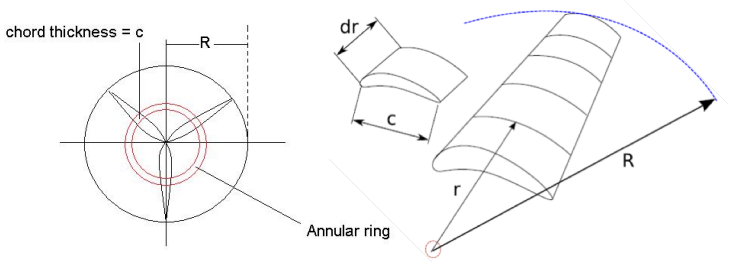
Key capabilities:

1. Semantic inference of knowledge gaps
2. Free interaction to add or edit information
3. Extraction from text
4. Semantic inference of fit-for-purpose models
5. Knowledge graph evolution and new python model scripts



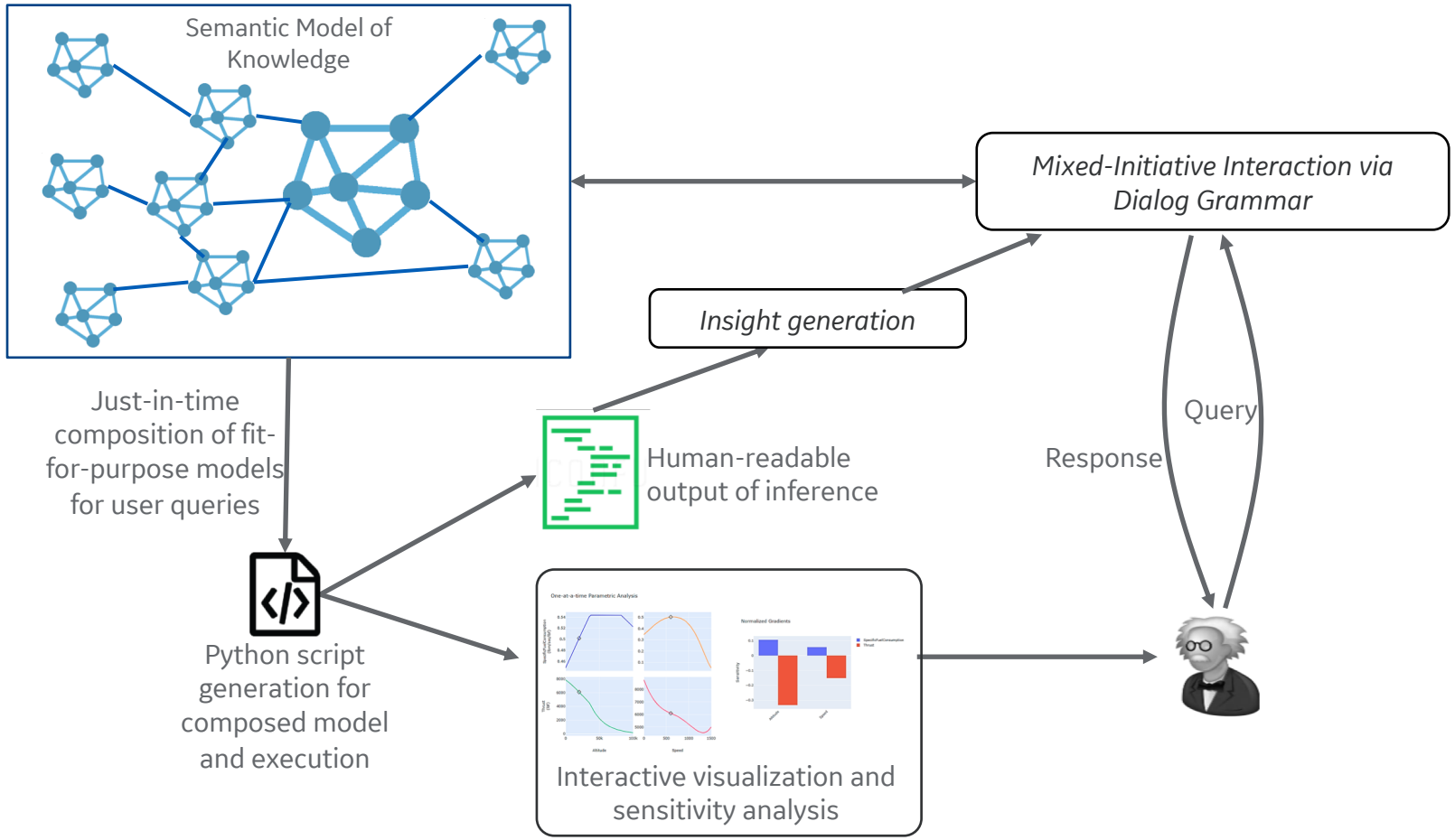
Demo 2: Query-driven Model composition, sensitivity analysis, and insights (Generalization Demo)

Aerodynamic Efficiency Calculations for Wind Turbines using Blade Element Momentum Theory (BEMT)



Key capabilities:

1. Scientific model knowledge representation
2. Dialog grammar for mixed initiative interaction
3. Semantic inference for fit-for-purpose model composition.
4. Python-NumPy script generation
5. Reasoning to extract insights
6. Procedural generation of interactive visualization
7. Automatic differentiation of python code



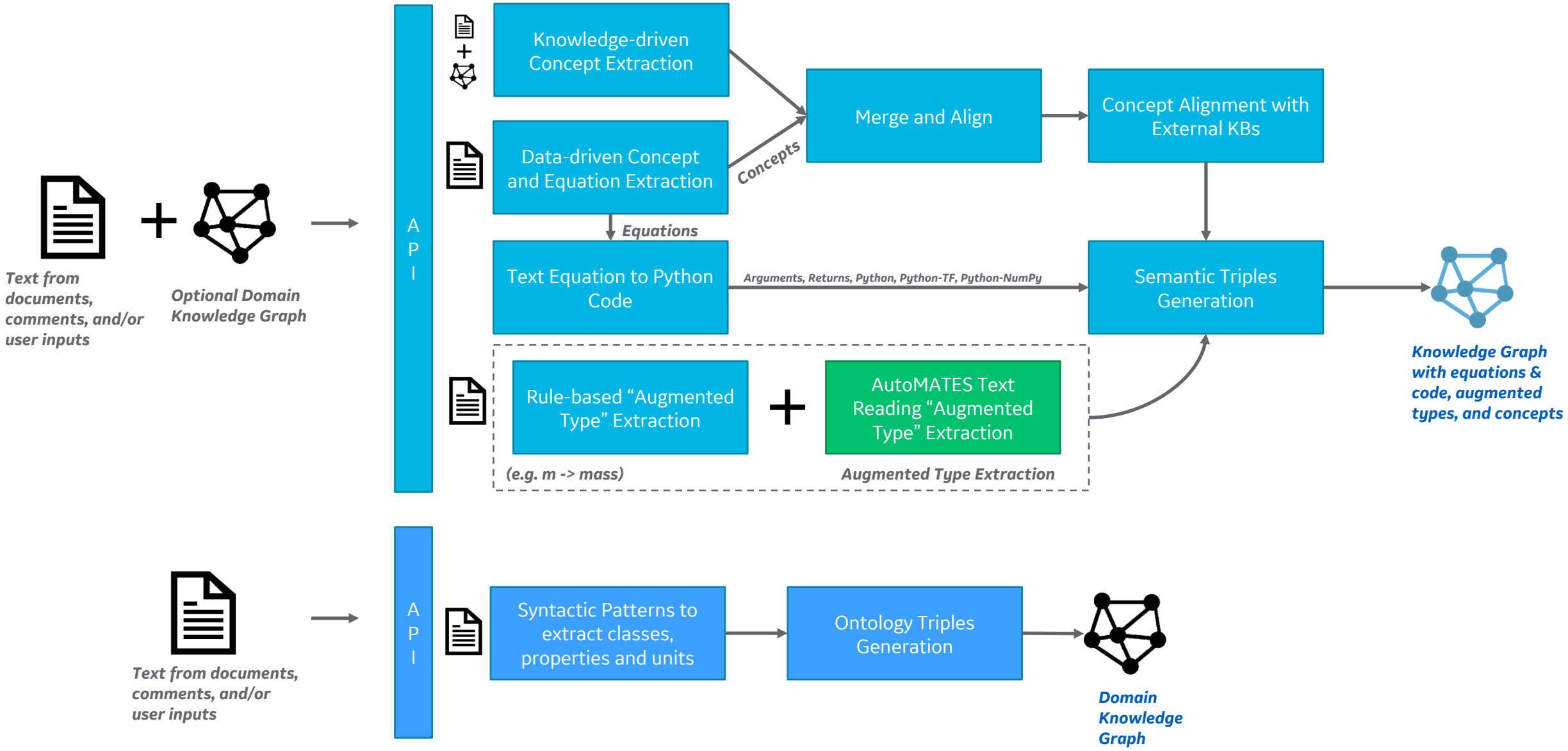
Demo 3: Automated human-readable knowledge graph extraction (from code and code comments)

1. Extraction of Ontology from all comment text (tags excluded)

```java
package windTurbine;

/**
 * This class is meant for creating {@code WindTurbine} objects, effectively modeling a wind turbine
 * with a given radius, number of blades and tip speed ratio.<br><br>
 * This class also provides the necessary methods to
 * compute the efficiency of a HAWT wind turbine iteratively in terms of power coefficient, C<sub>p</sub>,
 * using blade element momentum theory.
 *
 * @author Mitchell Keeley, Chaitanya Varier
 * @version 05/19/2016
 */

public class WindTurbine {

    // Class variables
    private static final double PI = Math.PI;
    private static final double e = Math.E;
    private static final double DIFF_THRESHOLD = 1e-15;
    public static final double dr = 0.05;   // Radius increment in m

    // Instance variables
    private int B = 3;
    private double R = 3.0;
    private double lambda_R = 6.0;
    private double dlambda_r;
    private double Omega; // Blade rotational speed in rad/s, giving lambda at blade tip (max lambda)

    /**
     * Constructor for instantiating {@code WindTurbine} objects, which model wind turbines
     * with a given radius, number of blades and tip speed ratio.
     *
     * @param radius            The radius of the turbine in m.
     * @param numBlades         The number of blades of the turbine.
     * @param tipSpeedRatio     The tip speed ratio of the turbine at the blade tip.
     */

    public WindTurbine(double radius, int numBlades, double tipSpeedRatio) {
        R = radius;
```

2. Extraction of augmented types from Line Comments
3. Extraction of augmented types from Javadoc @param and @return content

GE ASKE Knowledge Extraction from Text Pipeline



Discussion & Feedback

Key GE ASKE Capabilities:

1. Scientific model knowledge representation
2. Code extraction and reasoning over code elements
3. Extraction of equations from text and text-to-code service
4. KG-driven, data-driven, and rule-based concept extraction
5. Concept alignment with external knowledge bases
6. Automated human-readable knowledge graph construction
7. Knowledge graph evolution and new python model scripts

Key GE ASKE Capabilities:

8. Dialog grammar for mixed initiative interaction
9. Semantic inference for just-in-time model composition
10. Semantic inference of knowledge gaps
11. Python-NumPy script generation from DAG models
12. Reasoning to extract human-readable insights
13. Procedural generation of interactive visualization
14. Automatic differentiation of code for local sensitivity