Bachelor's Thesis / Semester Thesis

Technical University of Munich

TUM School of Engineering and Design
Institute of Aircraft Design

Recovery and Machine-Readable Modeling of the UNICADO Software Architecture

Field of Activity:

Software architecture recovery and documentation for a multidisciplinary aircraft design framework, including the development of machine-readable architectural representations to support future ML- or AI-assisted maintenance and evolution.

Task description:

The UNICADO (UNIversity Conceptual Aircraft Design and Optimization) project aims to establish a common, long-term, university-based aircraft conceptual design environment by bundling the expertise of German aviation universities. Further information on UNICADO is available on the project website.

Due to its extensive functionality and long-term evolution, the software architecture of UNICADO has grown organically over time and is only partially documented. Architectural knowledge is distributed across the source code, developer experience, and informal documentation. This situation leads to several challenges, including:

- Difficulties in long-term software maintenance
- A steep learning curve for new developers
- Risky and error-prone system evolution due to limited traceability of architectural decisions

As a result, understanding, maintaining, and systematically evolving the system has become increasingly challenging.

Methodology and Scope of Work

To systematically recover and document UNICADO's architecture, the work is organized into four steps, each with defined objectives and work packages (WP).

Step 1: System Scoping and Initial Analysis

Objective:
Become familiar with the existing UNICADO codebase. Understand what architectural knowledge exists, where it is located, how reliable it is, and identify gaps in documentation or understanding.

WP1:

- ✓ Systematically locate, collect, and record all existing documentation related to the software
- ✓ Identify missing information and assess the current state of the codebase to create a baseline checklist for tracking progress and measuring completion

Step 2: Selection of Documentation Format

Objective:
Determine the most appropriate format for representing UNICADO's architecture, ensuring it is visual where possible, using diagrams or graphical views for easier understanding.

WP2:

- ✓ Evaluate and select suitable documentation formats (e.g., diagrams, structured models, or metadata-based representations)
- ✓ Define standards for both human-readable and machine-readable documentation

Step 3: Architecture Knowledge Extraction

Objective:
Extract architectural information from the codebase and existing documentation using a combination of manual, semi-automated, and automated methods.

WP3:

- ✓ Identify software components, interfaces, dependencies, and architectural patterns
- ✓ Model the architecture using established architectural views (e.g., diagrams, component maps)
- ✓ Produce documentation in both human-readable and machine-readable formats

Step 4: Validation and Consistency Analysis

Objective:
Ensure the recovered architecture accurately represents the implemented system and is consistent with existing knowledge.

WP4:

- ✓ Validate the derived architecture via code walkthroughs or semi-automated verification
- ✓ Compare extracted architecture with existing documentation and developer knowledge
- ✓ Identify inconsistencies, dependency cycles, and signs of architectural erosion

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Required Skills:

- Programming skills in C++ and/or Python
- Basic understanding of software architecture concepts (e.g., components, dependencies, interfaces)
- Interest in or basic knowledge of software analysis and architecture documentation
- Interest in ML- or AI-assisted software engineering and automated documentation approaches
- Structured thinking, attention to detail, and problem-solving skills

Time Period:

- Immediate start possible, 6 months

Basic Literature and Online Resources:

- Schültke, F., and Stumpf, E., "UNICADO - Devel- opment and Establishment of a University Con- ceptual Aircraft Design Environment: Presenta- tion,", 2020.
- UNICADO website

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