



Human-centric algebraic machine learning

AML-DL Debugger - Final

Deliverable D3.11

WP3 - AML Description Language



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Consortium



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v0.1	2023-06	ALG	Nabil Abderrahaman-Elena	Draft
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v0.5	2023-07	ALG	Nabil Abderrahaman-Elena	Corrections
v0.6	2024-12	ALG	Nabil Abderrahaman-Elena	New UI
v0.7	2025-01	ALG	Nabil Abderrahaman-Elena	Editable embedding
v0.8	2025-02	ALG	Antonio Ricciardo	Review
v0.9	2025-02	ALG	Lars Wagoner	Review
v1.0	2025-02	ALG	Fernando Martin-Maroto	Final review

Executive summary

Algebraic Machine Learning (AML) is a novel machine learning technique based on algebraic representations of data. Unlike statistical learning, AML algorithms are robust regarding the statistical properties of the data and are parameter-free. AML systems can retain what they learn, including sociocultural ethical practices for human-artificial intelligence systems. The aim of the EU-funded ALMA project is to study the mathematical properties of AML and to leverage them to develop a new generation of interactive human-centric machine learning systems. These systems are intended to minimize bias in order to facilitate trust while better enabling distributed collaborative learning.

The AML-DL Debugger is a software tool to visually explore semantic embeddings built using AML-DL. Given a semantic embedding expressed using the AML Description Language, it can interpret the embedding, displaying its constants, as well as its positive and negative duples. It will also determine its consistency, and can be used to perform modifications and quickly rerun the whole analysis. The AML-DL Debugger has been built in a modular way, so it is simple to extend with new functionality.

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Acronyms

AI	Artificial Intelligence.
AML	Algebraic Machine Learning.
AML-DL	AML Description Language.
AML-DL Debugger	AML-DL Debugger.
ML	Machine Learning.
TUI	Text User Interface.

1 AML-DL Debugger

AML [1] is a new Artificial Intelligence (AI) paradigm that combines user-defined symbols with self-generated symbols. This permits AML to learn from the data and adapt to the world as neural networks do, combined with the power for explainability of Symbolic AI. AML is a purely symbolic approach and neither uses neurons nor is a neuro-symbolic method. AML does not use parameters and it does not rely on fitting, regression, backtracking, constraint satisfiability, logical rules, production rules, or error minimization.

The user should describe the Machine Learning (ML) problem at hand using a set of constants, that represent concepts, and a set of algebraic order equations and inequations, in the form of positive and negative duples, that represent relationships between subsets of concepts. These equations are referred to as the *embedding*, and the solutions of the embedding as the *model*. If the set of equations has at least one solution the embedding is said to be consistent. Inconsistent embeddings have no solutions, i.e. they have no representation as semilattice models. Further detail about semantic embeddings is provided in *Deliverable D3.7 - AML-DL Interpreter - Final* and in Semantic Embeddings into Semilattices [2].

The AML-DL Debugger is a software tool to visualize semantic embeddings and some of their properties. Currently the AML-DL Debugger can

- organize and display the embedding constants,
- display positive and negative duples using their given name,
- study and explore embedding consistency,
- modify, and reanalyse embeddings,
- be extended to implement new modules.

These properties allow for a quick feedback loop when developing or modifying semantic embedding using AML Description Language (AML-DL).

1.1 Components of the AML-DL Debugger

The AML-DL Debugger has been developed using modern web technologies, with the aim of being intuitive and simple to use. Its architecture allows for easy extendibility with modules. It combines:

- An AML-DL Interpreter module.
- An AML-DL Consistency Checker module.
- An editor module, for quickly update and reanalyse embeddings.

2 Demonstrator

This deliverable contains the AML-DL Debugger. Consistent, inconsistent, and incorrect semantic embeddings are also provided as examples.

2.1 Instructions

Instructions for installation and usage are included in the `README.md` file together with the program.

2.2 Examples

Consistent embeddings are provided for illustrative purposes: those provided in *Deliverable D3.4 - AML-DL Specification - Final* and *Deliverable D3.7 - AML-DL Interpreter - Final*. A longer, more complex, example is also included that corresponds to the algebraic semantic embedding of a cyclic group [2], and presets an inconsistency in region 9. Additionally an embedding with syntax errors is also provided.

3 Future work

3.1 Current state

The current AML-DL Debugger is fully functional and in use. It can help debugging hard and complex semantic embeddings such as the ones provided as examples.

In its last iteration, it has been fully revamped. The Text User Interface (TUI) and the module loader has been rebuilt to a full graphical interface (GUI) and the internal architecture has been refactored to simplify extendability. The new tools improves its user experience (UX), with special consideration for newcomers to this technology.

4 AML-DL Debugger walkthrough

In the README file you can find a link to a video showing the AML-DL Debugger in use.

References

- [1] Fernando Martin-Maroto and Gonzalo G. de Polavieja. “Algebraic Machine Learning”. In: *arXiv:1803.05252* (2018).
- [2] Fernando Martin-Maroto and Gonzalo G. de Polavieja. “Semantic Embeddings in Semilattices”. In: *arXiv:2205.12618* (2022).