Design Automation: Term Definition and Methodical Analysis for Software Selection

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Introduction and Term Definition

Increasing demands on product properties, shorter product life cycles, and growing variant diversity place significant pressure on modern product development. At the same time, emerging technologies such as Additive Manufacturing (AM) enable the production of highly complex and customized parts but increase design complexity.

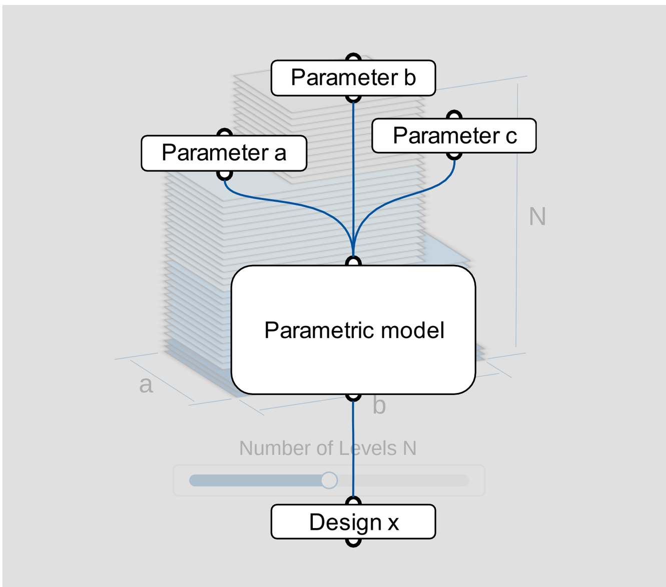
Design Automation (DA) offers a solution by automating repetitive and knowledge-intensive design tasks, accelerating development, and enhancing compatibility with advanced manufacturing processes. However, the diversity of available DA software solutions makes systematic selection increasingly important for users in engineering practice.

A clear understanding of key concepts such as **Parametric Design**, **Algorithmic Design**, and **Generative Design** is crucial for evaluating and clustering these software solutions. Yet, these terms are often inconsistently defined across disciplines like architecture, computational design, and mechanical engineering, complicating direct comparisons.

This work synthesizes existing definitions, refines them with a focus on mechanical engineering applications, and uses them as a conceptual foundation for the methodology and analysis. On the right side, the unified definitions are presented, offering a consistent terminology for the systematic evaluation and clustering of DA software.

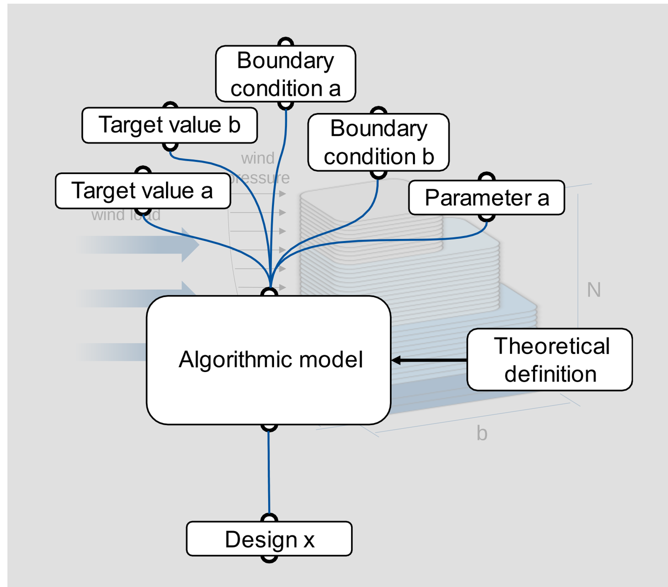
*In **design automation**, one or more of the methods parametric, algorithmic, and generative design are used to automate the steps conceptualizing, designing, and elaborating the product development process to create a 3D CAD model of a part. By applying these methods in combination with the suitable software, design configurators are set up.*

Parametric Design



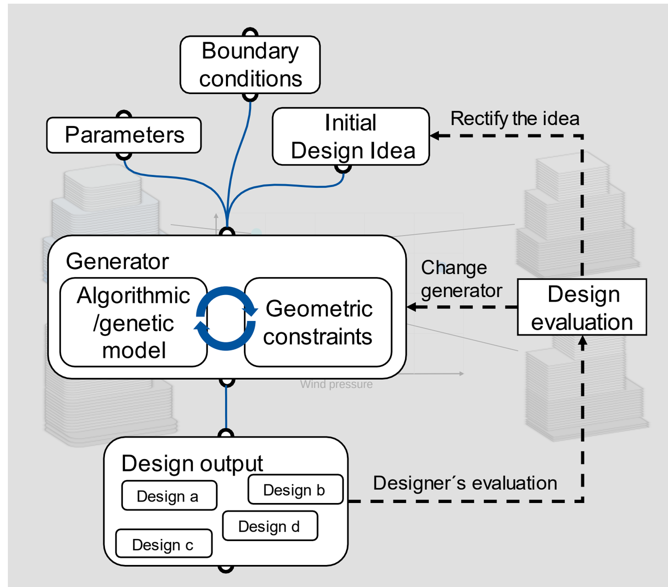
Method in which interdependent parameters are used to define the geometry of the design. By assigning discrete values to these parameters, the corresponding geometry is created.

Algorithmic Design



Method based on manually implemented rules or algorithms, creating a direct and traceable causation between the algorithm and the design elements. This method allows algorithmic design to be used independently of other methods like generative design, offering a tool for generating, optimizing, and refining designs.

Generative Design



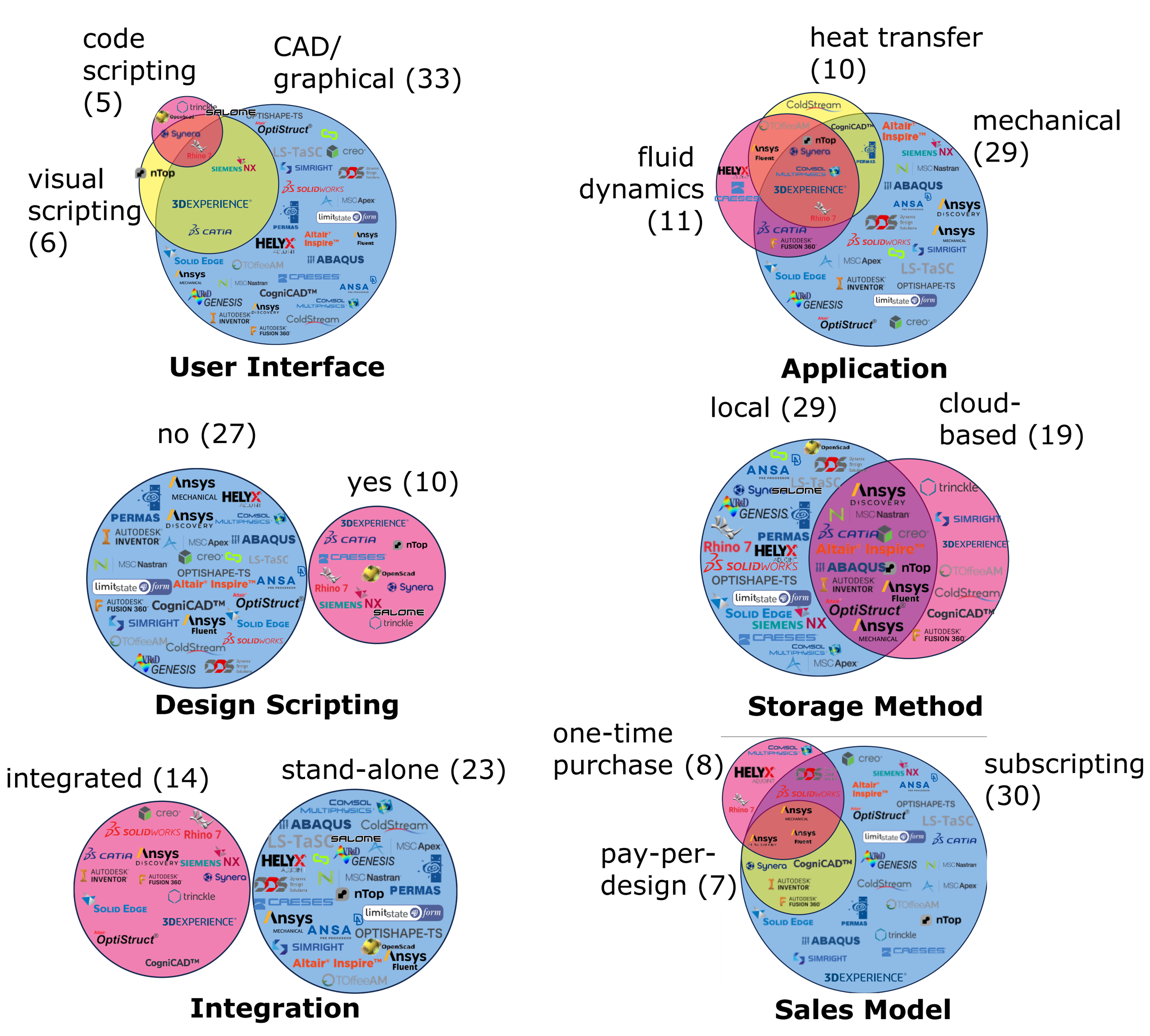
Method that autonomously generates multiple geometric variants using techniques like evolutionary algorithms, optimization algorithms, and artificial intelligence.

Overview of the Software Clustering Results

To support the selection of suitable design automation (DA) software, the available solutions were systematically clustered based on **key characteristics: user interface, application domain, design scripting capabilities, storage method, integration level, and sales model**.

The results are presented in Venn diagrams, showing overlaps between different software functionalities, and a portfolio matrix, helping to position software options according to variant diversity and part complexity.

The Venn diagrams illustrate which DA software solutions fulfill specific criteria. Overlapping areas represent software offering multiple functionalities. This visualization supports quick identification of tools matching individual requirements..



Graphical representation of the software classification results using Venn diagrams (absolute numbers in brackets)

Design scripting is emerging as a key innovation in DA software, enabling advanced applications across mechanical, fluid dynamics, and thermal fields. Despite the dominance of major CAD companies like Autodesk, Dassault Systèmes, Siemens, Hexagon, and PTC, smaller companies have distinguished themselves by adopting design scripting, supported by only 9 of 35 analyzed solutions. Early adopters like Synera, nTop, and Trinckle introduced design scripting between 2012 and 2018, while larger companies only integrated it recently. The delayed adoption is likely due to higher entry barriers, including the need for specialized scripting interfaces and additional training. Driven more by technology push than market demand, design scripting continues to evolve as a differentiating factor and innovation catalyst in the DA software landscape.

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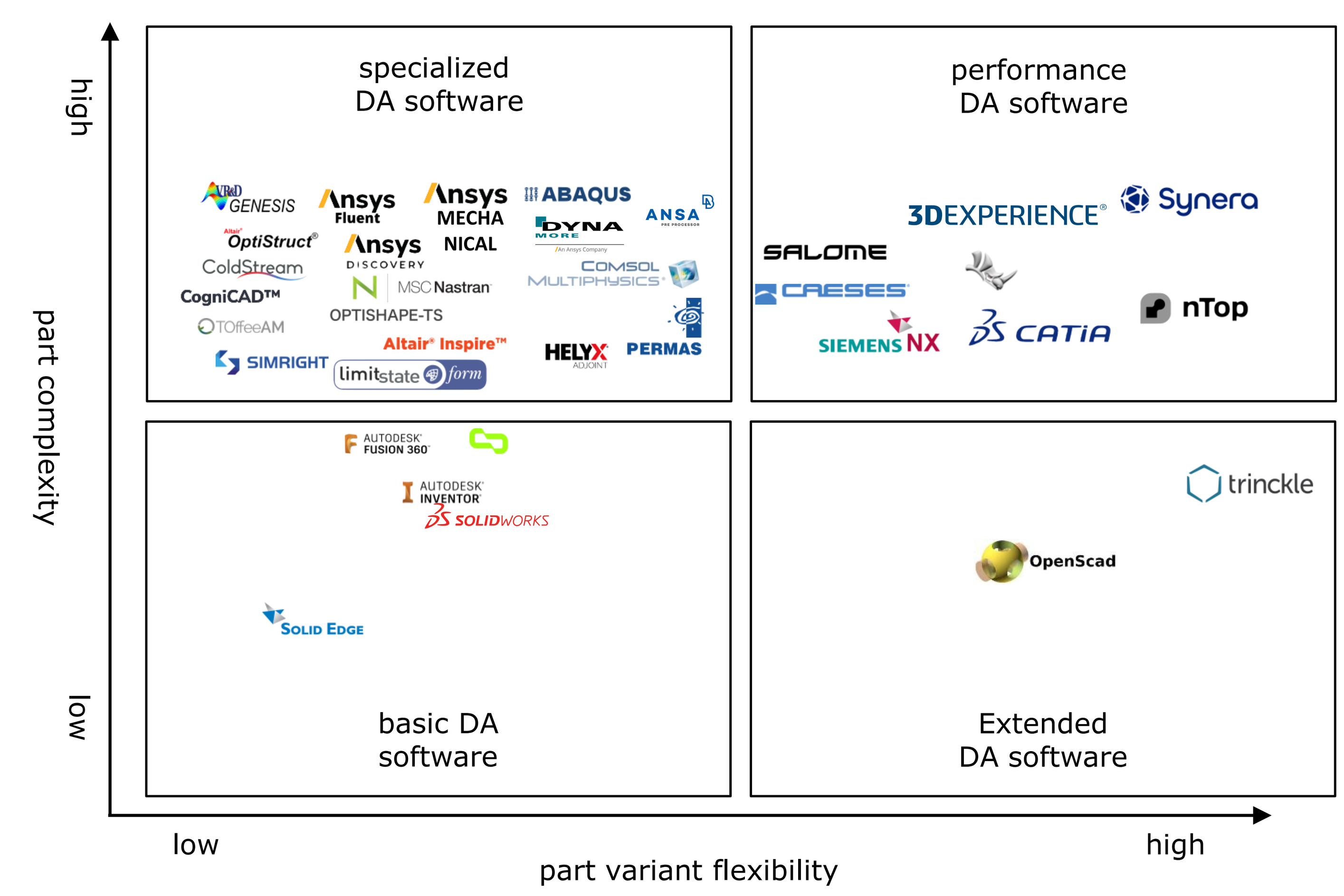

Portfolio matrix for DA software selection

The portfolio matrix positions DA software along two strategic dimensions: variant diversity and application complexity. It defines four categories:

Basic DA software for simple products with few variations,

Specialized DA software for highly complex but low-variation designs,

Extended DA software for a wide range of variants with moderate complexity, and

Performance DA software for managing both high variant diversity and high part complexity with advanced tools like topology optimization and simulation integration.

To ensure the continued relevance of this study, the clustering table is maintained and regularly updated online at dap-aachen.de (Link s. QR-Code left), allowing users to access the latest software landscape and submit suggestions for modifications or additions directly to the author.

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