**Bridging MDE and AI: a systematic review of domain-specific languages and model-driven practices in AI software systems engineering**

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**Background**

Modern software systems have risen in complexity due to components, functionality, and the various disciplines, making it difficult to deal with the traditional document-driven development style. Model-driven engineering (MDE) improves development efficiency by using models as core artefacts, combined with automated tools. Meanwhile, artificial intelligence has shown potential in data mining, but its application faces challenges such as high algorithmic complexity and difficulties in interdisciplinary collaboration. The aim of this study is to investigate the current state of the art in the application of DSL-dependent MDE methods in AI software systems engineering, to clarify the state of the art and to propose future research directions through a systematic literature review (SLR). This study hopes to reduce the complexity of AI development and improve the efficiency of interdisciplinary collaboration by combining DSL and MDE methods.

**Methodology**

A total of 1335 candidate papers were obtained from five mainstream databases, and 18 core papers were retained by filtering three groups of elements: title/keywords, abstract and the full text. The snowball method was also used to analyze. Six research questions called RQ1 to RQ6 were inspired by the six stages of CRISP-DM which are: business understanding, data understanding, data preparation, modeling, evaluation and deployment. The different RQs are:

- RQ1: Status of MDE technology application in AI development.

- RQ2: MDE coverage of stages in the AI development process (CRISP-DM).

- RQ3: Main application areas of MDE4AI.

- RQ4: Methods and tools to support MDE4AI.

- RQ5: MDE approaches to promoting interdisciplinary collaboration in AI development.

- RQ6: Open challenges and future directions facing MDE4AI.

**Results**

**For the RQ1**, existing research is highly dependent on language workbenches such as EMF and WebGME, but the tools are fragmented and lack unified standards. Text grammars such as Xtext are dominant, graphical grammars such as SysML are less used, and model verification such as OCL constraints and runtime dynamic support are weak, and only a few studies have attempted to solve this problem. **For the RQ2**, there is a significant unbalance in the support of MDE technology for the AI ​​development process: the model training stage (14/18 articles) receives the most attention, while business understanding (5 articles) and deployment monitoring (5 articles) are seriously insufficient, resulting in a disconnect between AI development and business goals and a lack of an end-to-end tool chain covering the entire process. **For the RQ3**, most studies (8/18 articles) focus on general areas and provide cross-scenario AI development support. In vertical fields, IoT/CPS (5 articles) is the main direction (such as sensor data analysis), while key areas such as image processing (1 article) and others like medical and finance have not been deeply explored. **For the RQ4**, existing methods focus on code generation (11/18 articles), generating Python/Java and other codes through model conversion, but lack semantic analysis and reverse engineering support. The tool chain is highly fragmented (such as EMF and WebGME are used independently), with poor interoperability and difficulty in collaboration across the different stages. **For the RQ5**, MDE has limited effect in promoting collaboration between AI experts and domain experts: only 5 studies integrated business requirements modeling (such as GSN/SysML), and the degree of data understanding was insufficient, resulting in manual communication and low efficiency. **For the RQ6**, the core challenges include tool chain fragmentation, lack of business value modeling and insufficient practical research. In the future, it will be necessary to develop an end-to-end framework covering all stages of CRISP-DM, promote standardized tool interfaces, strengthen domain-customized DSL and interdisciplinary collaboration methodology.

**Discussion**

This study reveals the potential and challenges of collaboration between MDE and AI. Model-driven approaches such as DSLs and meta-models can abstract the AI development process, improving accessibility and collaboration efficiency. The problem is more one of industrialization, which still faces issues such as fragmented tools, uneven coverage of stages, and a lack of business value modeling. Existing research has focused more on technical implementation such as model training, while neglecting business requirements and deployment support, resulting in AI development that is disconnected from business goals. In the future, it is necessary to combine low-code platforms with MLOps to build a full life cycle tool chain, develop domain-specific DSLs, and adapt to the compliance and interpretability requirements of specific industry scenarios. In addition, it is necessary to improve research on interdisciplinary collaboration methods and connect AI experts, domain experts, and developers through standardized meta-models and unified interfaces. Despite the limitations of the literature coverage (e.g., lack of non-English studies) and the lack of depth in practice, this paper provides a good technical and theoretical roadmap for future MDE4AI research.

**Conclusion**

This study analyzes the current state of MDE's application in AI system development. The core conclusion shows that although MDE4AI shows great potential, it is still in the beginning. The current fragmentation of the tool chain and the imbalance of stage support severely restrict the industrialization process. The key challenges are the lack of business value modeling, the lack of standardized interfaces in the tool chain and insufficient practical research in vertical fields. In the future, progress will be achieved through covering the full cycle of CRISP-DM, developing domain-specific DSLs, and innovating mechanisms of interdisciplinary collaboration. The contribution of this paper is to map the research landscape of the intersection of MDE and AI for the first time, indicating to academia the direction of tool chain standardization and business-technology alignment modeling, and providing industry with practical paths such as low-code/MLOps integration.