Identifying Concerns When Specifying Machine Learning-Enabled Systems: A Perspective-Based Approach

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Abstract. *Engineering machine learning (ML)-enabled systems poses various challenges from both a theoretical and a practical side. This thesis presents PerSpecML, a perspective-based approach for specifying ML-enabled systems that helps practitioners identify which attributes are important to contribute to the overall system's quality. We evaluated PerSpecML in three different contexts: (i) in academia, (ii) with industry representatives, and (iii) in two real industrial case studies. The results particularly revealed key components that would have been otherwise missed without using PerSpecML.*

Resumo. *Desenvolver sistemas habilitados por aprendizado de máquina apresenta vários desafios tanto do ponto de vista teórico quanto prático. Esta tese apresenta a PerSpecML, uma abordagem baseada em perspectivas para especificar sistemas habilitados por aprendizado de máquina que ajuda os profissionais a identificar quais atributos são importantes para contribuir para a qualidade geral do sistema. Avaliamos a PerSpecML em três contextos diferentes: (i) na academia, (ii) com representantes da indústria, e (iii) em dois estudos de caso reais. Os resultados revelaram, em particular, componentes essenciais que teriam sido ignorados sem o uso da PerSpecML.*

1. Background and Motivation

ML has rapidly gained prominence and are increasingly integrated into various software projects due to its ability to extract valuable insights from vast datasets, automate complex tasks, and enhance decision-making processes. The process flow for an ML project differs significantly from that of traditional software systems, for example, (i) involving a high degree of experimentation with data and models, (ii) incorporating multidisciplinary teams such as data scientists into larger development teams, and (iii) executing Proof-of-Concept (PoC) efforts that eventually make it into production.

In recent years, multiple ML projects have failed, leading to severe repercussions for the organizations involved and to the society at large. The reason is often the same: systems that incorporate ML components tend to put stakeholder needs in the background, and to oversimplify important scenarios and trade-offs. This leads to a problem that can be tackled by the requirements engineering (RE) discipline.

2. Methodology

We followed the technology transfer model introduced by [Gorschek et al. 2006] to design and evaluate *PerSpecML*. We used this model since our research method involved

formative evaluations in both academia and industry with the aim of scaling the proposal up to practice, for which this model is recommended. This involved participating in real R&D ML projects [Kalinowski et al. 2020], conducting a literature review on RE for ML [Villamizar et al. 2021]. A catalog of concerns was created [Villamizar et al. 2022] and a candidate solution was proposed [Víllamizar et al. 2022], which was iteratively evaluated and improved through three case studies, leading to the creation of *PerSpecML* [Villamizar et al. 2024].

We provided an opportunity to gather user feedback and incorporate it into the solution design. By involving stakeholders and practitioners in the evaluation process, we gathered valuable insights about their experience, needs, and preferences. This feedback informed iterations and refinements of the solution, making it more user-centric and aligned with actual user requirements.

3. Results and Concluding Remarks

Throughout the evaluations, we corroborated the potential of *PerSpecML* as a comprehensive tool for guiding practitioners in collaboratively designing ML-enabled systems, enhancing their clarity, exploring trade-offs between conflicting requirements, uncovering overlooked requirements, and improving decision-making. We make available to the community a catalog of concerns and tasks together with its descriptions, a conceptual model, a specification template, and the replication package, allowing *PerSpecML* to be applied in real industrial contexts.

Referências

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