

Optimizing Instructions and Demonstrations for Multi-Stage Language Model Programs

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Abstract

Language Model Programs, i.e. sophisticated pipelines of modular language model (LM) calls, are increasingly advancing NLP tasks. However, building these pipelines requires crafting prompts that are jointly effective for all modules. We study prompt optimization for LM programs, i.e. how to update these prompts to maximize a downstream metric without access to module-level labels or gradients. To make this tractable, we factorize our problem into optimizing the free-form instructions and few-shot demonstrations of every module and introduce several strategies to craft task-grounded instructions and navigate credit assignment across modules. Our strategies include (i) program-and-data-aware techniques for proposing effective instructions, (ii) a stochastic mini-batch evaluation function for learning a surrogate model of our objective, and (iii) a meta-optimization procedure in which we refine how LMs construct proposals over time. Using these insights we develop MIPRO, a novel optimizer that outperforms baselines on five of seven diverse LM programs using a best-in-class open-source model (Llama3-8B), by as much as 13% accuracy. We have released our new optimizers and benchmark in DSPy at <http://dspy.ai>.

1 Introduction

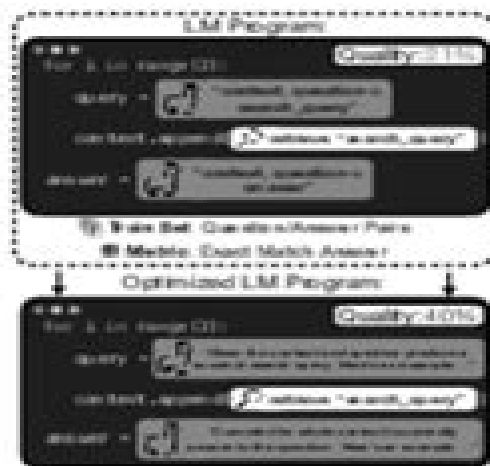


Figure 1: An example of the optimization problem we explore, shown for a multi-hop retrieval LM program. Given some question-answer pairs and a metric, the optimizer proposes new instructions and bootstraps new demonstrations (not pictured) for each stage.

and Shanahan, 2022; Pan et al., 2024) and tool use (Qin et al., 2023). However, LM programs today are commonly designed via “prompt engineering”: crafting prompts via manual trial and error to coerce a specific LM to operate each step in a specific pipeline. Recent work such as APE (Zhou et al., 2023), OPRO (Yang et al., 2024), and EvoPrompt (Guo et al., 2024) presents *prompt op-*

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