

FEDERATED LEARNING AND ON-DEVICE PROMPT ENGINEERING: PERSONALIZING LOCAL INTELLIGENCE

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Анотація

У публікації досліджується інтеграція федеративного навчання (ФН) з інженерією підказок на пристрої для підвищення продуктивності децентралізованих мовних моделей. У ній розглядаються стратегії для локального налаштування моделей, де персональні дані залишаються на периферійному пристрої, забезпечуючи високий рівень конфіденційності та безпеки даних. Порівнюється ефективність різних методів «контекстно-залежних» підказок, щоб визначити, як спеціалізовані інструкції можуть компенсувати зменшену кількість параметрів квантованих моделей мобільного рівня. Крім того, у дослідженні підкреслюється вплив локальної поведінки користувачів та даних про навколишнє середовище на персоналізацію відповідей ШІ без необхідності централізованого збору даних.

Ключові слова: федеративне навчання, інженерія підказок, персоналізація, ШІ на пристрої, конфіденційність, децентралізований інтелект, локальна оптимізація.

Abstract

The publication investigates the integration of Federated Learning (FL) with on-device prompt engineering to enhance the performance of decentralized language models. It explores strategies for local model fine-tuning where personal data remains on the edge device, ensuring high levels of privacy and data security. The effectiveness of various "context-aware" prompting techniques is compared to determine how specialized instructions can compensate for the reduced parameter count of quantized, mobile-tier models. Furthermore, the study highlights the influence of local user behaviour and environmental data on the personalization of AI responses without the need for centralized data collection.

Keywords: federated learning, prompt engineering, personalization, on-device AI, privacy, decentralized intelligence, local optimization.

Introduction

As Large Language Models (LLMs) become central to daily digital interaction, the reliance on massive, centralized cloud infrastructures poses significant challenges regarding user privacy and data latency. Traditional AI personalization requires uploading sensitive user history to external servers, creating a "privacy bottleneck." To resolve this, Federated Learning has emerged as a decentralized alternative, allowing models to be fine-tuned locally. Coupled with On-Device Prompt Engineering, which optimizes how a user interacts with these smaller, local versions of AI, this framework enables a highly personalized experience that functions efficiently on consumer hardware like smartphones or IoT hubs.

Research results

The primary advantage of this integrated approach is the preservation of Data Sovereignty. In a federated system, personal conversations, habits, and preferences never leave the device. Instead, the local model learns from the user's specific context, and only the mathematical "gradients" (improvements) are sent to a global server to enhance the base model. This decentralized training significantly reduces the risk of large-scale data breaches associated with central repositories.

However, executing LLMs on edge devices introduces the "Efficiency-Accuracy Trade-off." Most consumer devices lack the VRAM required for full-scale models. To address this, research focuses on Model Quantization (e.g., converting 32-bit weights to 4-bit) and Prompt Compression. By using specialized "system instructions" that are computationally lightweight, On-Device Prompt Engineering allows a 7B-parameter model to achieve reasoning capabilities comparable to much larger cloud models within a specific local context.

Current applications show high success in Predictive Text and Virtual Assistants. By analysing local user behaviour – such as specific vocabulary or scheduling patterns – the AI can adjust its response temperature and style in real-time. This ensures that the assistant is not only faster due to zero-latency local processing but also more attuned to the individual user's linguistic nuances.

Conclusion

The synergy between Federated Learning and On-Device Prompt Engineering marks a transition toward Privacy-First Intelligence. By shifting the burden of personalization from the cloud to the edge, we address the inherent conflicts between AI utility and data security. While hardware limitations remain a challenge, the development of specialized neural processing units (NPUs) and refined prompt strategies suggests that the future of AI lies in decentralized, autonomous, and deeply personalized systems.

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