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ChatGPT and EPICS: Pioneering LLM-Enhanced Control Systems for Synchrotron Beamlines

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The BAMline [1] at BESSY II represents a hard X-ray spectroscopy facility enabling non-destructive analysis across diverse research areas like materials science, chemistry, biology, and cultural heritage studies. As a multipurpose beamline serving users from various disciplines, it underscores the necessity of adaptable and efficient control systems to maximize beamline utilization and scientific output.
In this contribution, we detail the innovative integration of ChatGPT [2], OpenAI's state-of-the-art Large Language Model (LLM), with the Experimental Physics and Industrial Control System (EPICS) [3] which underpins the operational framework of the BAMline. This integration leverages the advanced natural language processing (NLP) capabilities of ChatGPT, presenting a revolutionary approach to beamline control that markedly simplifies user interaction. Through this, we facilitate a user-friendly pathway to executing complex experimental setups, eliminating the barrier imposed by conventional scripting languages and the often-challenging graphical user interfaces. This innovation promises to significantly streamline experimental workflows, thereby enhancing the efficiency of scientific research conducted at the beamline.
Further enhancing this user-centric approach, we introduce an advanced graphical user interface (GUI) application. This novel application seamlessly melds the LLM's NLP capabilities with EPICS, thereby enabling researchers to articulate experimental requirements through simple textual or voice commands. This interface interprets these commands to manipulate various beamline components, including but not limited to the Double Crystal Monochromator (DCM), Double Multilayer Monochromator (DMM), as well as various filters and slits. By parsing user input, extracting pertinent parameters, and generating a structured JSON object that reflects the desired device positions and experimental settings, the GUI application bridges the gap between complex control commands and intuitive user interactions. This advancement not only lowers the entry threshold for new users but also streamlines the operational workflow for experienced researchers.
Looking ahead, we aim to extend the system to cover the entire experimental cycle, from setup to data analysis. Using LLMs, one could translate plain-language experiment descriptions into precise operational commands, revolutionizing the research process and making advanced scientific exploration more accessible to a wider community.

[1] Buzanich, A. G., M. Radtke, K. V. Yusenko, T. M. Stawski, A. Kulow, C. T. Cakir, B. Röder, C. Naese, R. Britzke, M. Sintschuk and F. Emmerling (2023). "BAM
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[2] Achiam, J., S. Adler, S. Agarwal, L. Ahmad, I. Akkaya, F. L. Aleman, D. Almeida, J. Altenschmidt, S. Altman and S. Anadkat (2023). "Gpt-4 technical report." arXiv preprint arXiv:2303.08774.
[3] Thuot, M. E., M. Clausen, L. R. Dalesio, T. Katoh, M. E. Kraimer, R. Mueller, H. Shoaee and W. A. Watson (1996). "The success and the future of EPICS." Proceeedings of the Xviii International Linear Accelerator Conference, Vols 1 and 2 96(7): 611-615.

I plan to submit also conference proceedings

Yes

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