
O&Mgpt: Context-Aware Natural Language Processing for Improving Operations and Maintenance Planning in Nuclear Power Plants

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ABSTRACT:

The goal of the proposed work is to develop O&Mgpt, a *context-aware* artificial intelligence (AI)-natural language processing (NLP) approach-powered decision support tool, to *assist* human experts in the time-consuming task of prioritizing work orders (WOs) in existing nuclear power plants (NPPs) to improve the efficiency of operations and maintenance (O&M) planning. More specifically, O&Mgpt will leverage the current advances in large language models (LLMs) *and* incorporate *plant's context*, especially probabilistic risk assessment (PRA) models and plant/component information contained in Maximo, to categorize WO into (granular) priority bins to facilitate O&M planning. Additionally, it will provide justification/explanation to ensure human expert engagement and confidence. We will investigate the transferability of O&Mgpt (e.g., from one unit to another nominally similar unit, across plants, and considering pressurized water reactors (PWRs) and boiling water reactor (BWRs)) to provide insights into the best approaches to implement O&Mgpt in practice.

The proposed research supports the U.S. Department of Energy Office of Nuclear Energy (DOE-NE) priority in enhancing the long-term viability and competitiveness of the existing U.S. reactor fleet. Existing and past DOE-NE and National Institute of Standards and Technology (NIST) efforts clearly highlight the need for developing NLP models to automatically classify WOs. However, this problem is far from trivial and many gaps and challenges remain, which this proposal aims to address.

Although there has been much research activity around the use of foundational models such as LLMs, there are still open research questions that remain, especially as they relate to NPPs. In many applications, it is adequate to only use the unstructured data directly to learn, train, and create models that can accomplish a task (e.g., in sentiment analysis). However, in the context of NPPs, the additional layer of “*plant context*” is extremely important to consider as it enables the model to account for probabilistic risks, potential component failure dependencies, and any component information that may be relevant to the task of WO prioritization. The widespread use of acronyms, initialisms, abbreviations, and terminology that have *certain contextual associations and meanings* further complicates learning, but also provides an opportunity for developing models that can leverage these data to create more robust predictions. Finally, in NPPs, it is important that human experts remain in control and receive adequate information from decision support tools. Therefore, it is imperative that justification/explanation about their reasoning is provided. Hence, O&Mgpt, which builds upon state-of-the-art AI/NLP to *learn from both unstructured and structured data* to recommend WO prioritizations and provide reasoning significantly contributes to the scientific literature and stands to improve O&M planning in practice.

O&Mgpt will be built and tested in a series of steps as follows: Task 1: Acquiring past WOs and the corresponding prioritization for a sub-system of interest; Task 2: Pre-processing the data and developing the NLP pipeline; Task 3: Applying NLP to learn from unstructured data in historical WOs; Task 4: Developing AI/ML models to predict WO priorities; Task 5: Incorporating NPP context into risk prioritization using other existing data and providing explanations; and Task 6: Investigate the transferability of O&Mgpt. This project will result in the major deliverable of the fine-tuned, holistic O&Mgpt tool that provides reasoning to ensure the buy-in and confidence of the subject matter experts.