A Conceptual Model for Integrative Monitoring of Nuclear Power Plants Operational Activities Based on Historical Nuclear Incidents and Accidents

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ABSTRACT

A conceptual model for improvement in nuclear power plant operational safety and monitoring is presented. The innovation of this model is based on a calibrated software that utilizes an interactive component, thereby, eliminating a Corrective Action Management Plan’s sole dependence on informational databases. Artificial intelligence tools are used to build this model and, subsequently, support the monitoring and decision-making process software. Furthermore, the model integrates past historical knowledge of accidents and incidents occurring within the nuclear industry. Overall, intelligent analytic methods coupled with encoded accidents and incidents experiences synergize an inference system for nuclear operations monitoring and corrective action management. The proposed concept is challenged on two examples specific to nuclear power plants' operation.

Keywords: Corrective Action Management Plan (CAMP), Integrative Monitoring, Nuclear Accidents, Nuclear Power Plants, Nuclear Safety

INTRODUCTION

There are few industries that command the safety and security bandwidth like that of the nuclear industry. And the parties tasked with promoting its allocation have a certain responsibility, a responsibility that has powerful consequences. Therefore, nuclear safety and security must be on the forefront of every nuclear engineering decision. With every mistaken step taken during a past nuclear process, a valuable monitoring and safety program step was taken as well. An abundance of these steps can always be found within the formation of any well-established...
process. While typically only a fraction of these recorded incidents are utilized to the benefit of the before-mentioned processes’ safety and security. This means that the current methods employed for the safety and monitoring of nuclear processes are not as comprehensive as they could be.

The current methods utilized for the safety and monitoring of nuclear processes are reliant upon databases with limited depth. The length of time and type of information that they store limits the depth of knowledge available to them. By broadening the range of civilian nuclear accident data available to the databases of safety and monitoring software, its pattern-identifying process will have access to more intelligence. And with this increased access to a deeper pool of knowledge, the software’s algorithms will be allowed to make more intelligent and complex analysis.

The software’s databases supply the inputs to parameters for the process monitoring and safety of the nuclear system. The user’s Corrective Action Management Plan (CAMP) defines the type and style of software, but the underlying mechanism to its safety and monitoring abilities relies upon its given databases whether local or remote (Hirschberg, Burgherr, Spiekerman, & Dones, 2004), and therefore, the complexities of its inputs are dependent on the complexity of its databases. This places a limitation on the ability of the safety and monitoring software to analyze increasingly complex conditions.

The complexity of the decision-making process, especially with regards to the human/machine interface, is currently on the forefront of systems integration research. Therefore, to ensure that nuclear process safety and monitoring is as advanced as innovation will allow, it must be integrated with an analytical complexity beyond its current capabilities (Alamaniotis, Ikonomopoulos, & Tsoukalas, 2012; Uhrig & Tsoukalas, 2003). The best method for future innovation often lies with integrating lessons of the past with objectives for the future. This integration is the driving motivation of this artificially intelligent conceptual model, and it can be accomplished with the formation of an algorithm calibrated from historical evidentiary patterns and embedded within the current nuclear monitoring and safety standard for process protection (Uhrig, Tsoukalas, & Gao, 2008).

CURRENT METHODS

Currently, utilizers of nuclear technology use Correction Action Management Programs (CAMPs) to monitor the safety and reliability of the given processes that they employ. Typically, CAMPs rely on a software suite. The individual applications employed within this software suite monitor the core functions of the nuclear system (Hashemian, 2011). These applications employ an initialization phase and an evolution phase to provide customized monitoring and safety protection. The application’s initialization phase is determined based on user request, and the information volume currently available to the software vendor. The application’s evolution phase is continual through its life cycle and can be derived from administrator inputs or daily network data feeds.

The initialization phase of a nuclear system’s safety and monitoring management plan is typically dependent on operational experience (IAEA, 2005). This operational experience is composed of industry experiences, good practices, self-assessment, and internal events of the operational system (IAEA, 2005). Due to the uniqueness of each system’s external and internal influences, the operational experience of each nuclear system is unique unto itself (IAEA, 2005). And this type of system-dependent experience is beneficial to the focused monitoring of system specific processes. But in order to encompass total nuclear system safety and monitoring protection, the system must have the capability of awareness to non-specific and unexpected events.

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