DOE-ID NEPA CX DETERMINATION
Idaho National Laboratory

CX Posting No.: DOE-ID-INL-20-069

SECTION A. Project Title: Automated Logging of Analog Control Rooms

SECTION B. Project Description and Purpose:

TCF funding (under TCF award number TCF-20-21458) was recently awarded to Idaho National Laboratory (INL) with WSC, Inc. (WSC) as collaborative partners, to develop automated logging of analog control rooms.

INL is the leading laboratory for nuclear energy research and development (R&D). INL has extensive image processing, simulator development, and operations experience that will be leveraged for this work. EBR-II at INL control room is currently used for the sole purpose of training, since the reactor is decommissioned. The control room contains multiple gauges that could be utilized for the initial testing of this project before testing the method in an actual simulator in collaboration with WSC.

WSC, located in Frederick, Maryland, provides innovative, state-of-the-art simulation technology products and services that add value in the design, commissioning, and safe and reliable operation of customer power generating or process plant assets. WSC's 3KEYSOFTWARE technology has its roots in the nuclear and thermal power plant Operator Training Simulators. WSC leads the industry with web-based training simulators accessible at any time or place.

Because most United States (U.S.) nuclear power plants (NPPs) were built between 1960 and 1990, most control rooms are based on panels with analog instruments. Therefore, the instruments values or states are not captured in a digital form and operators must manually monitor and log the data from the panels on periodic bases (at least once a shift). The modernization of control rooms to a digital form is a lengthy, complex, and expensive process that has been only pursued by few NPPs. A typical analog control room contains hundreds or thousands (for multiple units) of instruments to log. The logging process is time consuming, prone to human error due to the amount of logging performed, and results in sparse data in time (i.e., often one measurement per instrument per shift).

INL recognized that most instruments in an NPP are gauges and developed a technology to read gauges at oblique angles. This overcomes the limitation of current gauge digitization technologies that require direct and perpendicular view of a gauge, and results in several new applications that could increase NPP operation's efficiency. In this effort, the control room logging process is automated using the developed technology with a single or multiple 360-degree camera, installed in optimal locations in the control room. Each camera captures hundreds of panels' readings in a single 360-degree image. The technology can identify gauges in the image, acquire each, normalize deformed gauges (due to the oblique angle view), determine each's type, capture its reading, and store the reading in a digital form. Multiple image processing methods are applied to each of these steps.

Automating the control room data logging process: (1) replaces the need for operators logging data periodically and enable them to focus on plant operations; (2) provide a continuous stream of data which is needed to enable the plants to move to an automated diagnostics and prognostics model of operations and maintenance (these two benefits result in direct and indirect cost-savings to the plant); and (3) create a plant historian that can be leveraged for training scenarios. This benefit has a significant safety improvement impact that is associated with using simulators. NPP simulators are a key requirement for training and licensing NPP operators. These simulators can be a physical replica (i.e., the panels are extract physical copy of the control room) or digital (i.e., the panels look the same as the control room panels but are based on large interactive touch screens). The later approach has been the dominant approach provided by NPP simulators because it provides flexibility in customizing the panels, automated data and time logging, and the ability to inject the simulator with failures that represent events in which the operators need to be trained. One of the key features of an NPP simulator is its ability to playback events that are designed by the trainer. Current training simulators cannot replay actual control room scenarios (i.e., only trainer designed scenarios). This effort enables the replication of control room events in a training simulator, a feature that does not exist with current simulators. An event can be replicated almost immediately after it occurred in the control room. This improves the training process of reactor operators, and consequently enhances the safety of NPP operations.

Overview

The application targeted by this collaboration is to use the technology to bridge a gap that exists between simulators and actual NPP control rooms data, which is to stream the data from the control room to the simulator for rapid simulation and replay of events that occur in the plant. The direct cost savings will result in significant reduction of trainers' hours in scenario configuration. The indirect cost savings is improved operator's readiness, fewer number of outages, and improved plants capacity. The technology introduces the ability to bridge the actual plant performance with the simulator. This feature is missing in current analog based NPP control rooms (which represent the vast majority of NPP control rooms in the U.S.). Additionally, this feature will generate a new stream of data for operators that could replace the need for control room operators to manually log the data and automates calibration of control room gauges. The commercialization of the bridging of the simulator with the plant control room is dependent on the ability of the solution to provide accurate gauge measurements, and therefore dependent on the outcome of this effort.

From the application perspective, both the replication of control room events in a training simulator, and the non-invasive logging of control room data for various applications are features that do not exist in current simulators. The ability to read control room gauges has not been pursued before because the technology to read gauges at oblique angles did not exist and because only recently that 360-degrees camera matured to an extend that enabled commercial use of this technology. From the technology perspective, none of the methods found in literature or in form of products can identify all gauges in the image, acquire each, normalize deformed gauges (due to the oblique angle view), determine each type, captures its reading, and store the reading in a digital form. The novelty of the developed technology is in the image processing algorithms developed to meet every step function of the gauge reading algorithm.

Research Plan

The specific application targeted by this effort is to stream the data from the control room to the simulator for rapid simulation and replay of events that occur in the plant. The current limitations of the developed technology are the type of gauges that can be read (i.e., currently only measures round gauges), the optical requirements, and the lack of product deployment strategy to achieve accurate readings. All these challenges will be addressed as part of this effort. Once the technology limitations are overcome, the gauge readings need to be translated into meaningful simulator data that can be used to replay the control room events. This is another task that will be addressed by this effort.

This project will advance the technology use from simulated testing environment at the Human System Simulation Laboratory (HSSL) to an actual commercial feature on a simulator. The aim is for the collaborating simulator vendor to introduce the feature in an evaluation form for NPPs to evaluate. In addition to the direct benefit, this enables the INL team to receive feedback from actual users and expand the technology applications to new areas that are not currently identified.

Tasks

The project objective of incorporating the technology to a simulator will be achieved using the following tasks.

Task 1 (14 months): Develop gauge detection for rectangular shaped gauges (bar indicators). The same methods developed as part of this effort will be leveraged to achieve this task. This effort will be led by INL.

Task 2 (6 months): Develop a strategy for placement of cameras and minimum optical requirements needed to deploy the technology in a control room environment. This includes researching optimal placement of cameras in a control room for accurate measurement of gauges data. This effort will be performed by INL.

Task 3 (12 months): Integrate the developed methods with the simulator platform. This involves migrating the codes from the platform used for the methods development to the platform used by WSC. An automated method will be created to couple these gauges locations with the simulator database to allow system modularity and usability. This effort will be performed by WSC based on input provided by INL for gage naming conventions and locations.

Task 4 (6 months): Perform pilot evaluations of the technology as part of an NPP simulator that exists at WSC facilities or in a plant and perform validation and verification. This pilot will introduce the feature to one or more NPPs and function as a feedback mechanism to the technology performance in addition to formulating a deployment strategy that will be pursued by the simulator vendor outside the scope of this work. This effort will be performed by INL and WSC. WSC will seek approval from an existing plant for this test and verification on a simulator that uses the WSC simulation technology.

The work for this project will be performed at INL's HSSL and WSC facilities. The team plans to perform the pilot in EBR-II, a training center of a nuclear power plant, or in a remote or emulated control-room simulator room. Equipment purchases include cameras, tablets and laptop computers.

SECTION C. Environmental Aspects or Potential Sources of Impact:

Air Emissions

N/A

Discharging to Surface-, Storm-, or Ground Water

N/A

Disturbing Cultural or Biological Resources

EBR-II is a building that is over 50 years old. No structural or aesthetic changes will be made to the building.

Generating and Managing Waste

Some industrial waste will be generated in the form of paper, cardboard, wire, etc.

Releasing Contaminants

When chemicals are used during the project there is the potential for spills that could impact the environment (air, water, soil).

Using, Reusing, and Conserving Natural Resources

All materials will be reused and recycled where economically practicable. All applicable waste will be diverted from disposal in the landfill where conditions allow.

SECTION D. Determine Recommended Level of Environmental Review, Identify Reference(s), and State Justification:

Identify the applicable categorical exclusion from 10 Code of Federal Regulation (CFR) 1021, Appendix B, give the appropriate justification, and the approval date.

For Categorical Exclusions (CXs), the proposed action must not: (1) threaten a violation of applicable statutory, regulatory, or permit requirements for environmental, safety, and health, or similar requirements of Department of Energy (DOE) or Executive Orders; (2) require siting and construction or major expansion of waste storage, disposal, recovery, or treatment or facilities; (3) disturb hazardous substances, pollutants, contaminants, or Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-excluded petroleum and natural gas products that pre-exist in the environment such that there would be uncontrolled or unpermitted releases; (4) have the potential to cause significant impacts on environmentally sensitive resources (see 10 CFR 1021). In addition, no extraordinary circumstances related to the proposal exist that would affect the significance of the action. In addition, the action is not "connected" to other action actions (40 CFR 1508.25(a)(1) and is not related to other actions with individually insignificant but cumulatively significant impacts (40 CFR 1608.27(b)(7)).

References: 10 CFR 1021, Appendix B, B3.6, "Small-scale research and development, laboratory operations, and pilot projects"
Justification: The proposed R&D activities are consistent with CX B3.6 "Siting, construction, modification, operation, and decommissioning of facilities for small-scale research and development projects; conventional laboratory operations (such as preparation of chemical standards and sample analysis); small-scale pilot projects (generally less than 2 years) frequently conducted to verify a concept before demonstration actions, provided that construction or modification would be within or contiguous to a previously disturbed area (where active utilities and currently used roads are readily accessible). Not included in this category are demonstration actions, meaning actions that are undertaken at a scale to show whether a technology would be viable on a larger scale and suitable for commercial deployment;"

Is the project funded by the American Recovery and Reinvestment Act of 2009 (Recovery Act) ☐ Yes ☒ No

Approved by Jason Sturm, DOE-ID NEPA Compliance Officer on: 9/10/2020