Automatic Imagery Data Analysis for Proactive Computer-Based Workflow Management during Nuclear Power Plant Outages

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ABSTRACT:
The overall goal of this project is to test the hypothesis that real-time imagery-based object tracking and spatial analysis, as well as human behavior modeling of outage participants will significantly improve efficiency of outage control while lowering the rates of accidents and incidents. Automated imagery data analysis results will reveal design principles of an Advanced Outage Control Center (AOCC) defined in a recently published Idaho National Laboratory (INL) report. That report explains how communication and collaboration technologies can augment an Outage Control Center (OCC) outage coordination and problem resolution activities. A good design of AOCC should consider human factors and cooperative work behaviors in managing schedules and emergent issues during an outage. Finally, imageries capture rich spatial information and human behaviors associated with carrying out OCC functions, all of which are important for improved design of work environments, user interfaces, and workflow logic.

The project team plans to examine real-time and robust object tracking algorithms that use 2D/3D imagery data (e.g., 2D imageries generated by cameras, 3D imageries generated by Kinect depth sensors) to automatically derive the real-time status of outage workflows and interactions between OCC, satellite outage centers, Nuclear Power Plant (NPP) workers, and maintenance service providers (e.g., construction engineers). The goal is to assist automatic detection and diagnosis of inefficiencies and risks in outage control, using spatiotemporal analysis and by modeling human behaviors on site. According to another INL report, the Light Water Reactor Sustainability Program (LWRS) is initiating efforts on developing and testing Computer-Based Procedures (CBP) for supporting field activities. In the long run, feeding the detected risks and inefficiencies into scheduling tools used in CBP will not only improve outage coordination, but also streamline daily operations to ensure safe and efficient field works.

Specific objectives: 1) Establish real-time object tracking and spatiotemporal analysis methods for automatically assessing the productivity of field activities and detecting anomalous spatiotemporal relationship among activities that cause inefficiencies and risks; 2) Establish real-time human tracking and spatiotemporal analysis methods and relevant human factor modeling methods for automatically diagnosing ineffective human interactions and unexpected trajectories of workers that cause inefficient team collaborations between AOCC, satellite outage centers, NPP workers, and maintenance service providers; 3) Test the proposed automated object/human tracking and spatiotemporal analysis methods in outage control case studies in order to characterize the effectiveness of automated imagery-data-driven methods in proactively improving the efficiency and safety of workflows in outage coordination and risk management. Research activities related to these three objectives will collectively achieve effective integration of imaging and computer vision technologies, CBP, and real-time collaboration platform in order to support automated work status analysis and automatic pending support notifications in NPP operation and maintenance.