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SAFEGUARDS APPLICATIONS OF PATTERN RECOGNITION AND NEURAL NETWORKS*

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Large quantities of safeguards data are automatically collected by continuous monitoring instruments used in chemical processing plants, nuclear material storage facilities, and nuclear reactors. With large quantities of complex and diverse data it is time consuming and difficult for safeguards inspectors to effectively examine all the data for consistency and to find subtle anomalies that could be caused by diversion. Software utilizing pattern recognition and neural nets can be an efficient aid to inspectors through analysis of all data for which interpretations, predictions of trends, and identification of anomalies can be automatically provided. Using new computing and analysis techniques, we can thoroughly analyze large volumes of data to provide inspectors with information that allows them to focus on primary areas of anomalies and data of interest for effective safeguards. Systems utilizing these techniques must be capable of classifying, clustering, and recognizing features within data; extrapolating features from the data to obtain new information; checking for proper operation of the systems; and detecting anomalies. The potential benefits of these software systems include

- correlating large quantities of diverse information;
- identifying abnormal information, such as diversion of material or faulty data from intermittent sensors;
- increasing inspector efficiency by providing routine analysis of all data and identifying specific information to be checked by an inspector; and
- providing oversight and verification of plant operation.

In this paper, we describe several pattern recognition and neural network software projects that have been developed to provide data interpretation and anomaly detection.

On-load Reactor Refueling Refueling of on-load reactors is performed without shutting down the reactor. Fresh fuel is pushed in one side of the core and spent fuel bundles are discharged on the other side. Effective safeguards requires constant monitoring of the refueling process to assure that spent fuel bundles are not diverted. Continuous, unattended monitoring of the refueling operation can be accomplished using a core discharge monitor (CDM) that collects radiation signals from multiple channels to detect when spent fuel bundles are discharged from the core.¹ Because the refueling is continuous and the data voluminous, the safeguards inspector would benefit from modern, high-performance computers and software tools that provide automated analysis and review of CDM data.

We have developed prototype automated analysis software to analyze the CDM data.² This program determines the number of spent fuel bundles discharged from the reactor and the time each discharge occurred. Additional information provided by the program is the reactor power level, the region of the core from which each fuel bundle is discharged, and a prediction of fuel bundle burnup.

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Process Material Transfers Material transfers in a chemical processing plant follow very specific patterns of activity as liquid is moved from one tank to another and valves are opened and closed. Transfers occur in a small number of patterns and leave the system in specific ways. A neural network model of normal plant operation was developed³ using simulated data that was based on chemical processing plant data. This model predicts the volume of liquid in chemical processing plant tanks, which is based on the history of liquid transfers and valve states. Based on this information, the model can identify loss of material. Studies of the simulated data resulted in correctly predicting changes in tank volumes and identifying known anomalies. With actual plant data, there were no known anomalies but a number of normal transactions, which were predicted by the model. This neural network analysis and prediction model can be adapted to provide continuous, unattended monitoring of material flow in a plant, to identify anomalous transfers, and to predict material loss.

Tracking Material Movement We have applied neural networks and pattern recognition to the analysis of combined, continuous radiation data from a number of detectors. The objective is to detect proscribed or abnormal movements of material. Analysis of experimental measurement data indicates that patterns within the data uniquely reflect the type of activity occurring. That is, normal movements generate patterns that can be identified as "normal," while abnormal activities generate distinctly different patterns that can be identified as "abnormal." Extensive field data exists from multiple, continuously operating nondestructive assay systems that have been installed in automated mixed-oxide fabrication facilities. Proscribed and abnormal material movements could be determined from analysis of this data.

Neural networks and pattern recognition provide significant capability to analyze data based on the ability to learn and to adapt to changing data. Results from current experience using these techniques will be presented in the full paper.

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