U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

NRC Perspective on Implementing Artificial Intelligence and Machine Learning in Nondestructive Examinations

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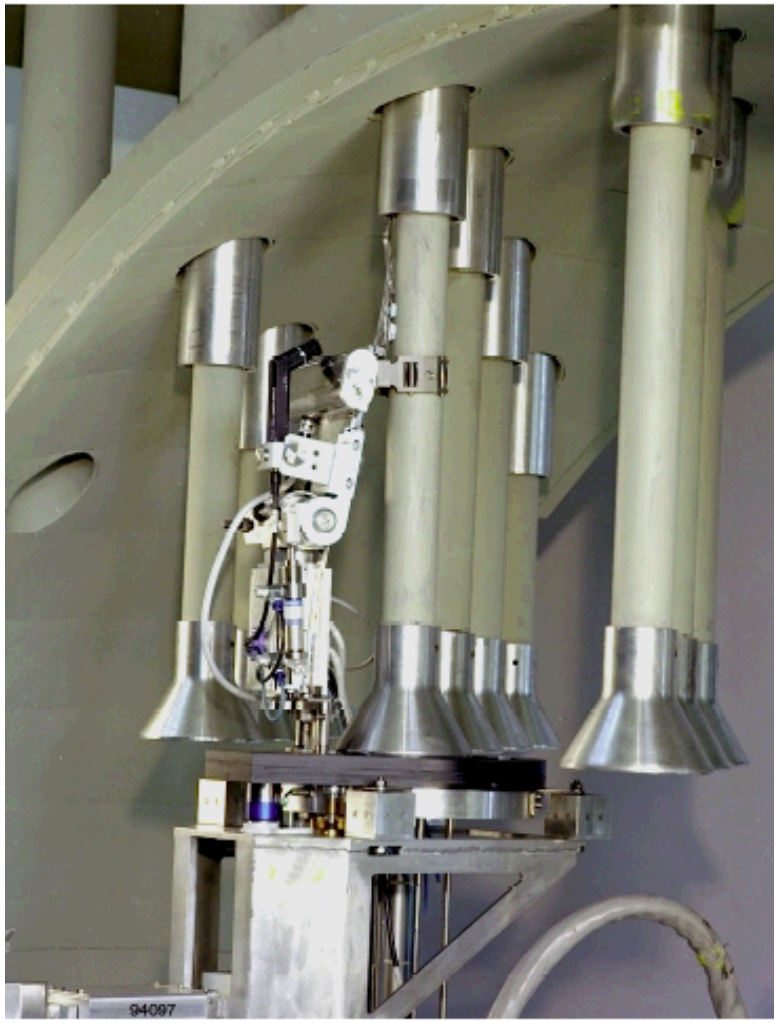
Drivers for Automated Data Analysis (ADA)

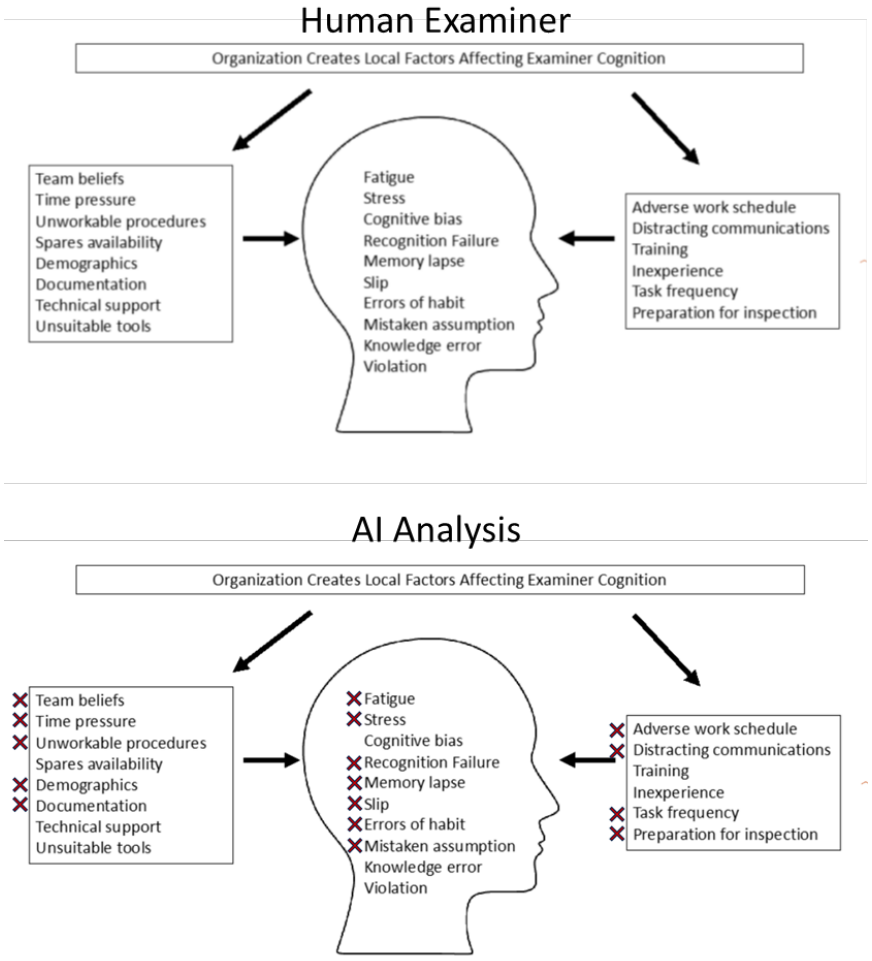


- Industry is projecting a potential shortage in NDE technicians with proper skillsets to conduct NDE to meet future fleet needs (ML24026A087)
- Some UT inspections such as upper head exams yield large quantities of data that must be reviewed by multiple qualified inspectors during the outage period. (EPRI 3002023718)
  - High level of focus required for long periods of time
  - Human factors related to fatigue and momentary loss of focus can challenge reliability of results

Automated Data Analysis – Possible Benefits

ADA has the potential to improve detection of flaws and improve the human factors of an examination.

- In-service flaws are rare in the nuclear industry. Computers can maintain vigilance in cases where humans can be challenged.
- Humans and computers make different types of mistakes, and a qualified analyst paired with an analysis run by ML gives the best of both worlds.
- Reduced dose to inspectors if ML used to support manual UT examinations.



Graphic adapted from NUREG/CR-7295

Automated Data Analysis – Possible Hazards

- Licensees may not understand the capabilities and limitations of ADA, which could lead to improper use of ADA
- ADA assistance may allow people to pass Appendix VIII qualification testing without the skills to recognize unknown degradation in the field
- ML algorithms can be challenging to train and retrain, possibly making the ML algorithms unreliable
- ML algorithms require a new class of experts to support UT examinations

Barriers to AI/ML Implementation

- Some high-value examinations (many dissimilar metal welds) may not have a sufficient set of service-induced or realistic flaws to train models
- The complexity of using the AI/ML systems may result in many false or missed calls

How to Get Enough Flaws for Training?

- Sources of Flaws and Flaw Signals
  - Use service-induced flaws
  - Build mockups with implanted flaws
  - Virtual and/or Synthetic modified or simulated flaws
- Each of these methods have advantages and disadvantages

Service-Induced Flaws

- Advantages
  - Actual flaws, will produce the most realistic flaw responses
- Disadvantages
  - Not enough of them for most examinations
  - May be the result of unusual circumstances
  - May not be representative of novel degradation

Mockups with Implanted Flaws

- Advantages
  - Provide actual flaw responses for transducers
- Disadvantages
  - Expensive
  - Time consuming
  - Requires a large facility
  - May not be representative of novel degradation

Virtual and/or Synthetic Flaws

- Advantages
  - Individual simulations are much less expensive than a physical examination of mockups
  - Can produce a large number of flaw signals
- Disadvantages
  - Process is still under development
  - Least realistic flaw responses
  - Every transducer would likely need to be simulated for every examination procedure

What are the Tolerances?

- What are the essential variables for the virtual and simulated flaws?
- What are the essential variables for the AI/ML training?
- Does the transducer need to exactly match?
- Can the V/S flaws or ML training for one transducer be used effectively for a slightly different transducer?

Approaches to Training

- The most defensible method would be to build a variety of realistic mockups and removed-from service flaws
- A hybrid approach between mockups and modified flaws where the modified signals come from the same transducers as in the procedure is second
- Work to determine the sensitivity of the flaws and ML models could be used to justify other methods

Added Complexity

- Complicated and sensitive systems are a bad pairing with the hectic outage schedules at plants
- Small changes to AI/ML systems and how the data is handled can have significant effects
- How can a regional inspector determine if the AL/ML system is being used properly?

How to Reduce Complexity?

- The use of the AI/ML system needs to be relatively simple and require as few inputs as possible in the field
- It needs to be relatively simple to verify that the AI/ML system is being used correctly
- A lot of work will likely have to go into the user interface to prevent errors

Path Forward

- The NRC will continue to work with EPRI to monitor developments in the use of AI/ML for NDE data analysis
- We will pay extra attention to the training methods and deployment of AI/ML systems