

CAP Automation and Informed Inspection Preparation Project

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Agenda

- Introduction – Tim
 - Vision
 - Incentive
- Technical Approach - Jonathan
 - Challenges
 - Text Confidence Scores
 - Neural network architecture
 - Measuring success
- Broader Industry Potential - Ahmad
 - Integrating data from multiple plants
 - Data-driven keywords
- Future Work and Concluding Remarks – Tim



Vision

- Explore artificial intelligence and machine learning techniques to improve use of plant information
- Leverage rapidly advancing technologies/methods
- Opportunities to improve process (e.g., CAP)

Incentive for Change ... Why CAP?

- Cornerstone of Reactor Oversight Process (ROP)
- Streamline and improve corrective action program (CAP) and process
- Better inform the information provided for NRC inspection planning and support purposes

Challenges – Available Data

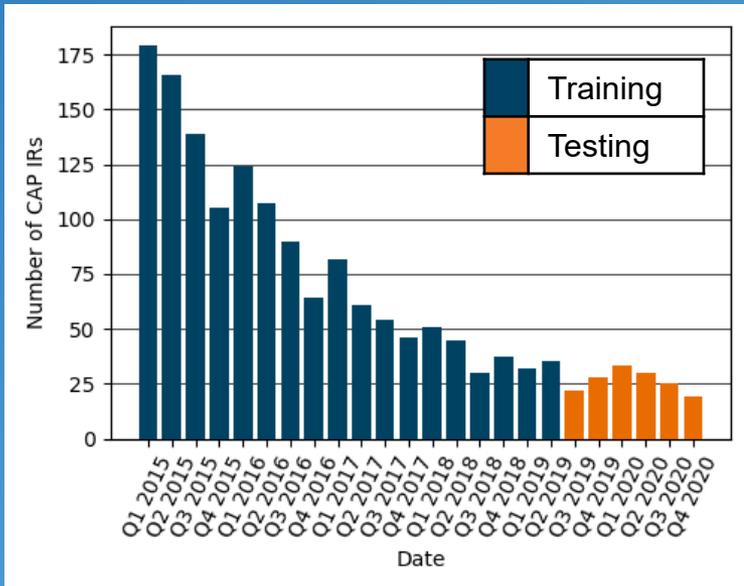
Category	Field	Description
Identifiers	FACILITY	Site affected by the incident
	IR_NUMBER	Numeric identifier
	ORINATION_DATE	Date the incident report was written
	SYSTEM_CODE	Which system was affected
	UNIT	Which unit was affected
Initial Text Description	IR_SUBJECT	Subject line describing the incident
	CONDITION_DESCRIPTION	Primary text field describing the incident.
	IMMEDIATE_ACTIONS_TAKEN	Describes immediate actions responding to the incident.
	RECOMMENDED_ACTIONS	Describes actions recommended by the reporter
Initial Screening Questions	HAS_EQUIPMENT	Was the incident associated with a specific piece of equipment?
	INITIAL_SCREENING_1	Is the equipment located in the Vital Area, Protected Area, or other owner controlled properties?
	INITIAL_SCREENING_2	Procedure or process issues with the potential to affect compliance with TS or license conditions?
	INITIAL_SCREENING_3	Potential reportability concerns?
	INITIAL_SCREENING_4	Analysis or setpoint deficiencies that impact onsite or offsite dose or dose rates?
	INITIAL_SCREENING_5	Nuclear safety issue?
	INITIAL_SCREENING_6	Significant Industrial Safety Issue (i.e.; excluding First Aids, non-work related issues, PPE Issues, etc?)
	INITIAL_SCREENING_7	Personnel injury requiring offsite medical attention?
Shift Review Questions	INITIAL_SCREENING_8	Tampering, vandalism or malicious mischief?
	EQUIPMENT_FUNCTIONAL	Binary field - Did the equipment lose functionality due to the event represented by IR?
	EQUIPMENT_OPERABLE	Binary field - Was the equipment operable at the time the incident occurred?
	EVENT_REPORTABLE	Binary field - Does the incident represent a reportable incident?
	FUNCTIONAL_BASIS	Text describing why the incident represents a loss of functionality.
	OPERABLE_BASIS	Text describing why the incident represents a loss of operability
	REPORTABILITY_BASIS	Text describing why the incident represents a reportable incident
Station Ownership Committee (SOC) Review	HAS_WORK_REQUEST	Is there a work request associated with the incident report?
	IR_PRIORITY	Investigation class of an event, based on risk impact and risk of recurrence.
	IR_SEVERITY	Significance level of an event, based on consequence of what happened and could have happened.
	MRFF	Does the event qualify as a maintenance rule functional failure.

Challenges – IR Statistics

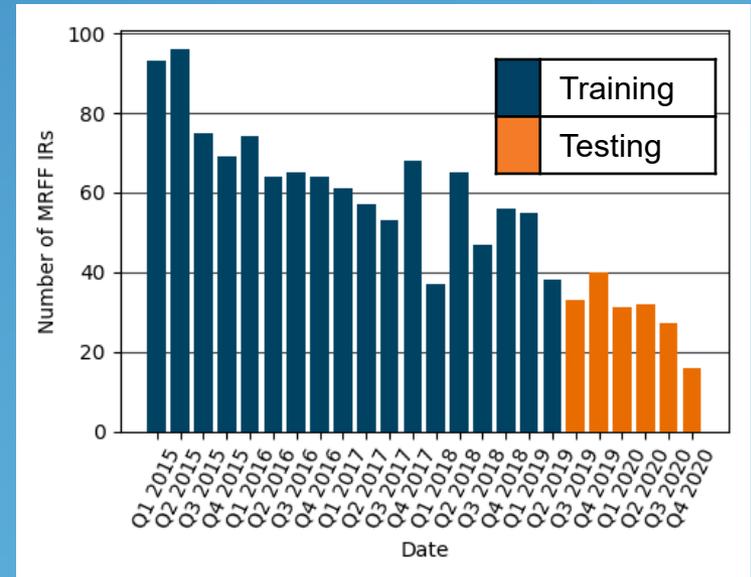
- Highly skewed datasets
- Adverse to Quality IRs ~0.1-0.2% of data



Total IRs

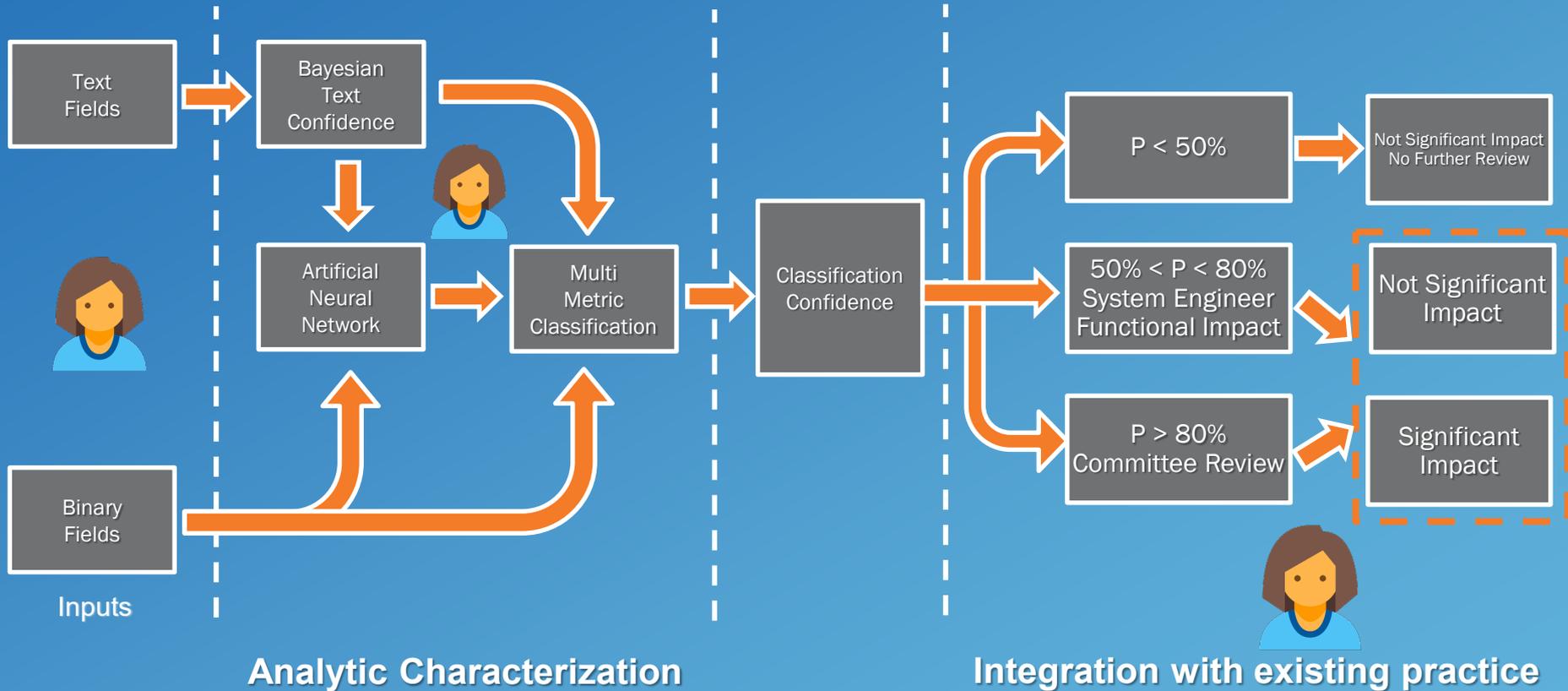


CAP IRs



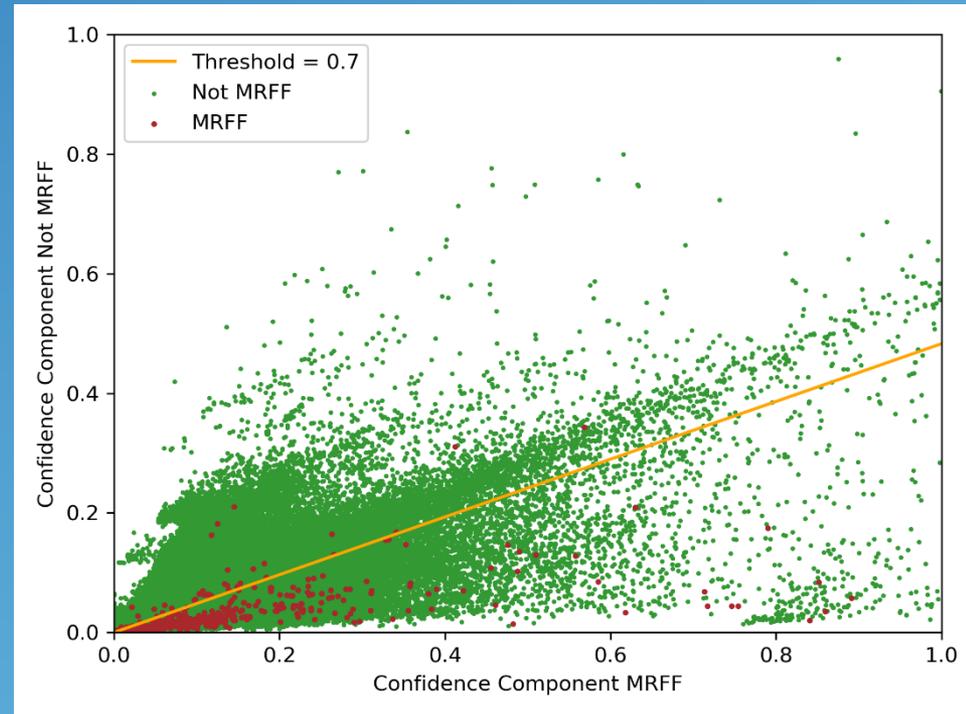
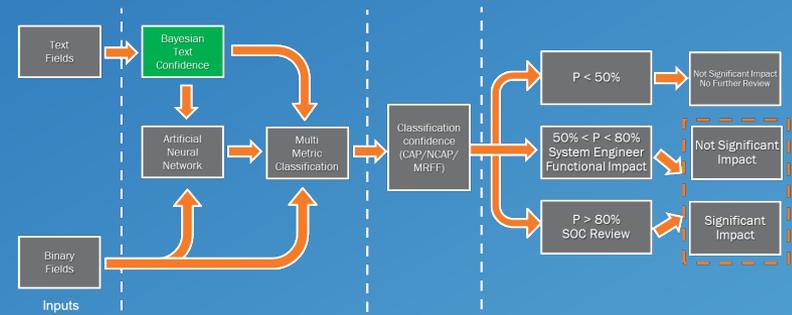
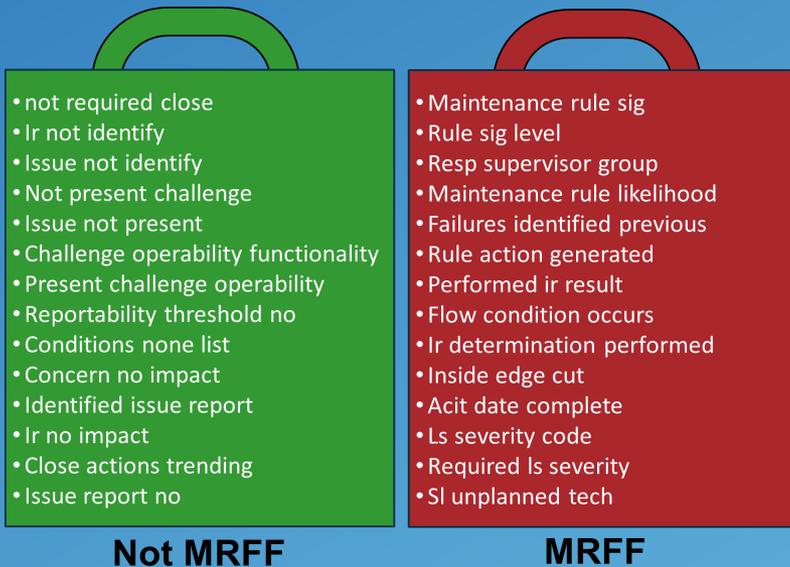
MRFF IRs
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The Approach

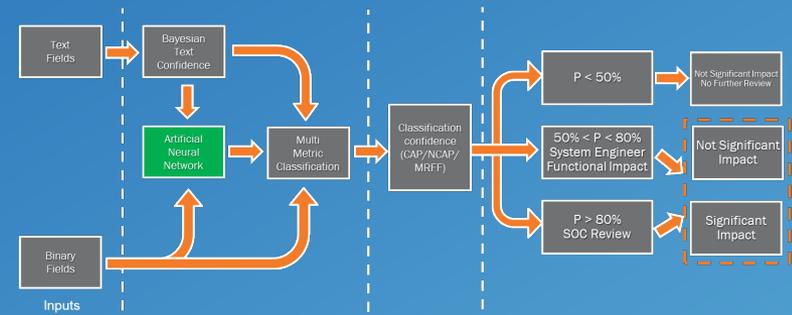


Text Confidence Scores

- Bag of words approach to Natural Language Processing (NLP)
- Split each text field into 1-word, 2-word, and 3-word phrases
- Bayesian inference uses conditional probability of class 1 versus class 2

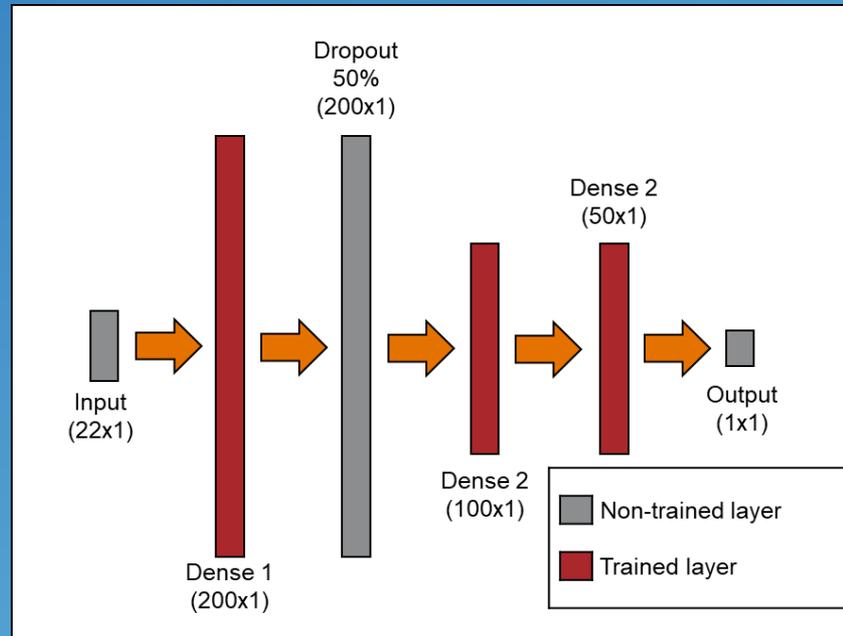


Artificial Neural Network



- SUBJECT-CONFIDENCE
 - CONDITION_DESCRIPTION-CONFIDENCE
 - IMMEDIATE_ACTIONS_TAKEN-CONFIDENCE
 - RECOMMENDED_ACTIONS-CONFIDENCE
 - OPERABLE_BASIS-CONFIDENCE
 - REPORTABLE_BASIS-CONFIDENCE
 - FUNCTIONAL_BASIS-CONFIDENCE
 - SOC_COMMENTS-CONFIDENCE
 - EQUIPMENT_OPERABLE
 - EQUIPMENT_FUNCTIONAL
 - EVENT_REPORTABLE
 - UNIT
 - INITIAL_SCREENING_1
 - INITIAL_SCREENING_2
 - INITIAL_SCREENING_3
 - INITIAL_SCREENING_4
 - INITIAL_SCREENING_5
 - INITIAL_SCREENING_6
 - INITIAL_SCREENING_7
 - INITIAL_SCREENING_8
 - HAS_EQUIPMENT
 - HAS_WORK_REQUEST_NUMBER
- Text Confidence
Numeric/Binary Data

Inputs



Network Architecture



Neural
Network
Confidence

Output

Measuring Success

Misses: Potential regulatory impacts
 False Positives: Process efficiency impacts
 System Bias: False Positives > Misses

- Accuracy
 - Bad metric for skewed data
 - 99.8% accurate by predicting NO system issues

$$Accuracy = \frac{(TP+TN)}{(TP+FP+TN+FN)}$$

- False Negative Rate (FNR)
 - Fraction of real issues which may have regulatory implications depending on the significance

$$FNR = \frac{FN}{(TP+FN)}$$

- False Discovery Rate (FDR)
 - Fraction which will need to be evaluated by plant personnel due to false alarms

$$FDR = \frac{FP}{(TP+FP)}$$

	Ground Truth	
Model	Issue	Not Issue
Issue	True Positive (TP)	False Positive (FP)
Not Issue	False Negative (FN)	True Negative (TN)

Dataset	Training		Testing	
Metric	FDR	FNR	FDR	FNR
ANN Alone	2%	0%	3%	6%
Multi Metric Class.	15%	0%	20%	2%

Broader Industry Potential

- Integrate data from multiple plants to improve AI/ML model performance
- Create industry scalable model for CR data-mining
- Validate plant AI/ML models via benchmarking

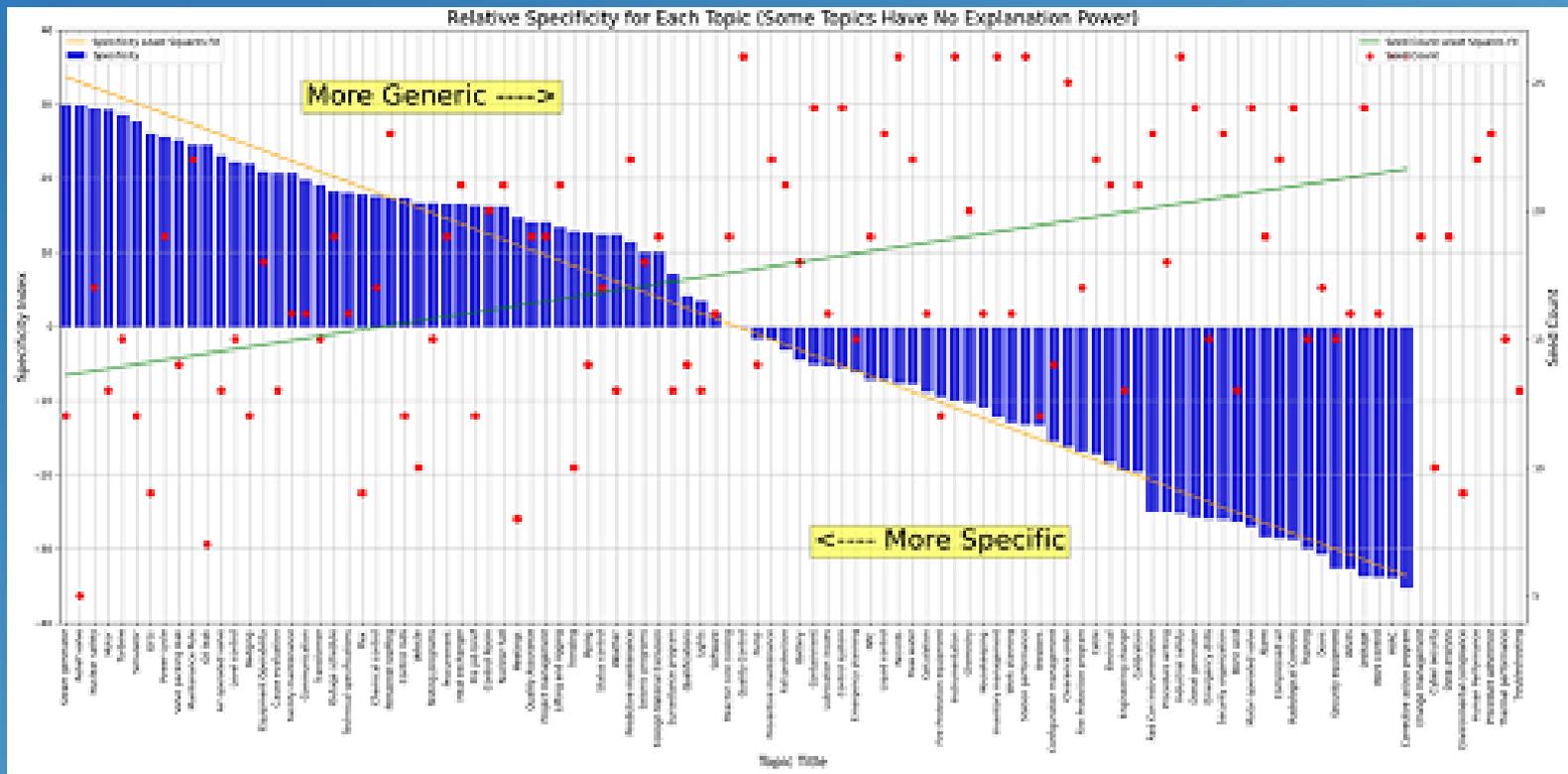
How can data from the broader industry be used to improve model results?

MIRACLE
(Machine Intelligence for Review and Analysis of Condition Logs and Entries)

	Utility 1 Model	Utility 2 Model	Combined Model <i>using fewer fields</i>
Utility 1 Data (large dataset)	84%	75%	>85%
Utility 2 Data (medium dataset)	77%	90%	>90%

Broader Industry Potential

Create data-driven keywords using industry data to standardize usage for industry-wide trending



Future Work

- Validate plant models independently via benchmarking
- Enhance assessments and inform inspections
 - Streamline information sharing through an inspection data portal
 - Develop data-driven metrics to support inspection outcomes
 - Inform these processes through automation
- Develop tools to automate and identify risk contributors
 - Components and/or operator actions
 - Programmatic and predictive trends
- Deploy open-source tools for broad industry use

Concluding Remarks

- AI/ML will strengthen Corrective Action Program
- Improve Exelon's internal governance and oversight
- Technologies and methods are improving rapidly
- Integration of similar applications with NRC (e.g., pilot project) presents the opportunity for a powerful outcome

Questions?



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