Some Insights for Assessing Diagnosis Error Probabilities of Operators in Advanced MCRs

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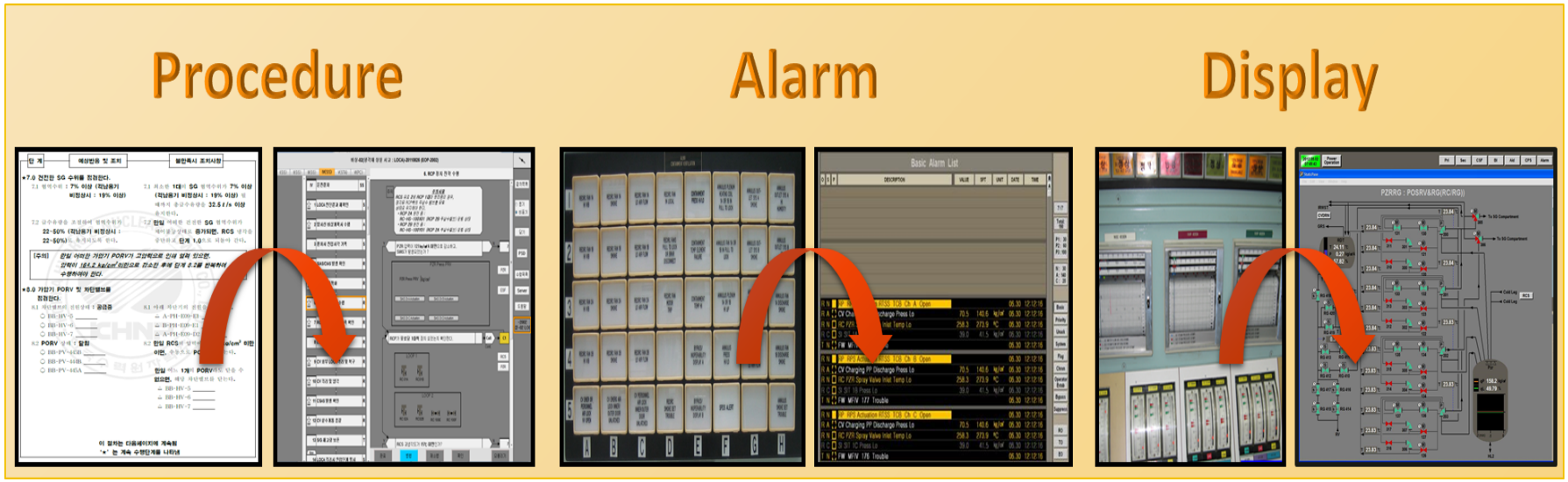
Contents

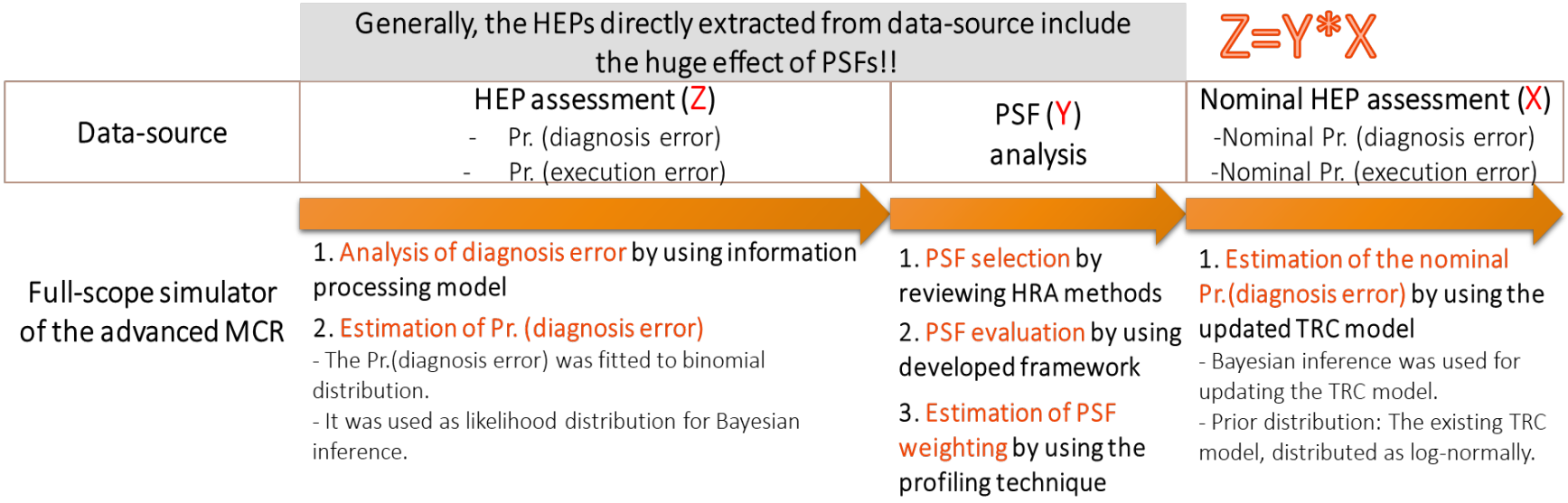
Introduction

- **As the advanced MCR (Main Control Room) is being adopted in NPPs (Nuclear Power Plants), the operators may obtain the plant data via computer-based system.**



Introduction

- **A new framework to assess diagnosis error probabilities in advanced MCR has been suggested.**



Purpose :
To provide the insights in the process of developing a framework to assess the proba bility of diagnosis error in the advanced MCR

Brief Introduction of the Framework to assess di agnosis error probabilities

- **Overview of the framework**

Analysis of diagnosis error

Audio-visual recording dat a

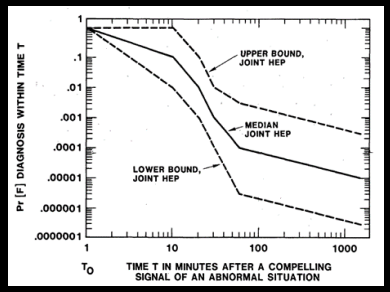
Diagnosis error analysis using ATHEA NA's information process model

Monitoring /detection	Situation A ssessment	Response Planning

For that, speech act coding sch me was used.

Announcement	Command
Inquiry	Call
Judgment	Reply
Suggestion	Etc.

calculation of diagnosis er ror probabilities



To update TRC (Time Reliability Curve) with diagnosis error prob abilities, observed probabilities s assumed to be distributed as b nomially.

$$f(n;m,p) = \frac{m!}{n!\,(m-n)!}p^n(1-p)^{m-n}$$

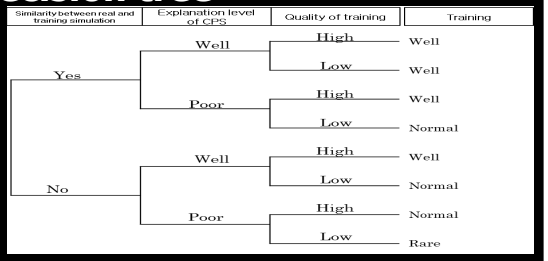
$$p = \frac{n}{m}$$

p=Probability that when a given task performed
m=Task opportunity, n=Number of errors

Analysis of PSFs

PSFs considered in this study :
Stress level, Action type, Experie nce, Time constraints, Places wh ere operator's action taken, Proc edures, Training, HSI, Teamwork

Decision tree



PSF profiling

X2

	HEP	PSFs		
		Procedure	Training	HSI
Task A	0.002	Good	Poor	Good
Task B	0.001	Good	Good	Good

Brief Introduction of the Framework to assess di agnosis error probabilities

- **Overview of the framework**

Update of TRC model

Bayesian inference was applied.

$$p(\theta|y)=\frac{p(y|\theta)\pi(\theta)}{\int p(y|\theta)\pi(\theta)d\theta}$$

$\pi(\theta)$: prior distribution
$p(y|\theta)$: likelihood distribution
$p(\theta|y)$: posterior distribution
y : a data point
θ : parameter of data points' distribution

TRC model:

$$\pi(\theta) = \frac{1}{\sqrt{2\pi\sigma^2}}\exp\left[-\frac{(\ln\theta-\mu)^2}{2\sigma^2}\right]$$

Observed data:

$$p(y|\theta) = \frac{n!}{y!\,(n-y)!}\theta^y(1-\theta)^{n-y}$$

Data-source

1. Domestic full-scope simulator of the advanced MCR

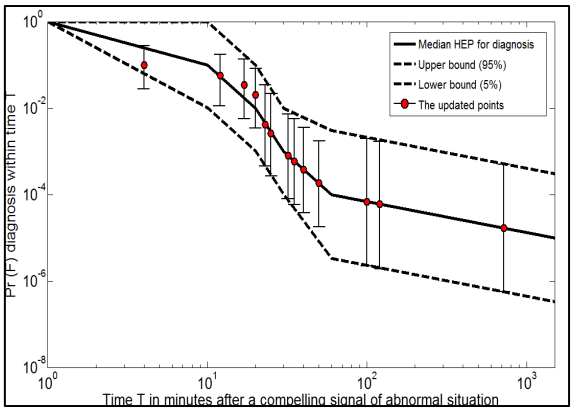
Duration: 2009 –2014
Scenario: LOCA, SGTR, and SBO
The number of the crews: 9 crews
The number of tasks corresponding to HFEs: 7 tasks

2. HAMMLAB (HAlden huMan-Machine LABoratory)

Duration: 2007 – 2010
Scenario: SGTR (base and complex scenarios), and LOFW (base and complex scenarios)
The number of the crews: 14 crews
The number of tasks corresponding to HFEs : 11 tasks

Result

PSFs	Multiplier
Teamwork	11.00
Both time constraint and **Training**	5.72
HSI	1.03
Procedure	2.50
Stress level	2.15
Experience	1.39
Time constraint	3.00



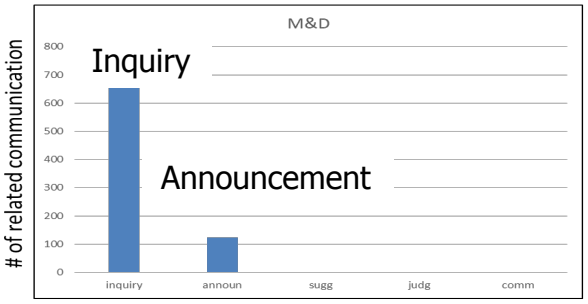
Insights derived from the Suggested Framework

- **Insights from analyzing diagnosis errors**

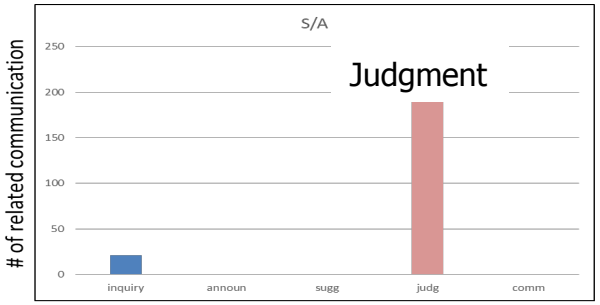
1) Significant relationship between the cognitive activities and speech act coding scheme

- **In this study, diagnosis error were analyzed by using ATHEANA's information processing model.**
- **In order to properly distinguish the nature of verbal protocol data, speech act coding scheme was used.**

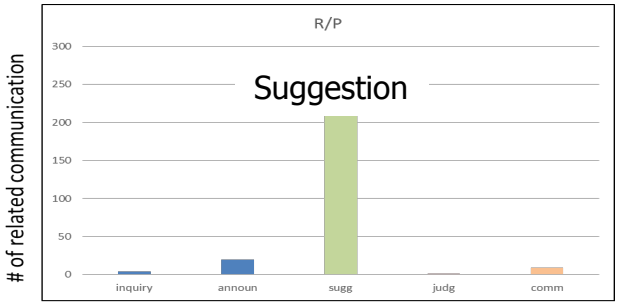
Cognitive step in ATEANA model	Speech act coding scheme	Definition
Monitoring /detection	Announcement	A statement to the public which gives information
	Inquiry	A statement for asking the status of information
Situation assessment	Judgement	A statement identification based on observation and inquiry
Response planning	Suggestion	A statement of recommendation for specific action or an introduction of an idea



<Relationship between 'M&D' and coding scheme>



<Relationship between 'S/A' and coding scheme>



<Relationship between 'R/P' and coding scheme>

Insights derived from the Suggested Framework

- **Insights from analyzing diagnosis errors**

2) Patterns of cognitive activities

- **Most crews performed a part of cognitive activities (monitoring/detection and response planning).**

  - Since they performed their tasks using the given procedures, most crews did not perform situation assessment.

- **Most crews performed monitoring/detection again since they checked the result of their diagnosis.**

Insights derived from the Suggested Framework

- **Insights from calculating diagnosis error probabilities**

1) Factors to increase the probabilities of diagnosis errors

- **For two tasks, all crews failed to diagnose the situation**

I. **Tasks under insufficient procedure**

When the given procedure was insufficient, all crews failed to diagnose the situation. In the situation under that indicators or components were not addressed in the given procedures, all crews were difficult to correct diagnose the situation.

II. **Tasks under broken indicators**

When the crucial indicator malfunctioned, all crews failed to diagnose the situation. In this situation, operators could not obtain the cue from the related indicators, then all crews were not able to correct diagnose the situation correctly.

Insights derived from the Suggested Framework

- **Insights from analyzing PSFs**

1) Most influential PSF -> 'teamwork'

- When 'teamwork' PSF was 'poor', most crews failed to correctly diagnose the necessary actions.
  - Even the RO recognized the required cue, the SS neglected RO's opinion and they eventually failed to diagnose the given task.
  - When communication and coordination between the crew members were inappropriate, they eventually failed to diagnose the given task.

2) 'Procedure' and 'time constraints' are also highly influential PSFs

- When operators perform the diagnostic activities, those two were the crucial PSFs as addressed in many papers.

3) Multipliers of 'Experience' and 'Stress level' PSFs are different to those in THERP

- It seems that because the advanced MCR is designed to enhance human performance, the effects of those PSFs to the diagnosis error probabilities might be reduced.

Insights derived from the Suggested Framework

- **Insights from updating TRC model by Bayesian inference**

1) **Because of the limited available data, it is necessary to collect more diagnosis error data from the full-scope simulator of the advanced MCR.**
   - **Until now, it is difficult to provide the updated TRC model with accurate values.**

2) **Nonetheless, this is a good starting point to suggest the framework to estimate diagnosis error probability in the advanced MCR.**

Summary

- **In this study, the insights were derived from the new framework to assess the probabilities of diagnosis error in the advanced MCR.**
  - **Insights from analyzing diagnosis errors**
    - **Significant relationship between the cognitive activities and speech act coding scheme**
    - **Patterns of cognitive activities**
  - **Insights from calculating diagnosis error probabilities**
    - **Factors to increase the probabilities of diagnosis errors were scrutinized.**
  - **Insights from analyzing PSFs**
    - **'Teamwork', 'Procedure', and 'Time constraint' are most influential PSFs.**
  - **Insights from updating TRC model by Bayesian inference**
    - **More accurate and reliable framework will be suggested when sufficient data are accumulated.**

THANK YOU

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