The 11th COE Postdoctoral and Doctoral Researchers Technical Presentation

Evaluate User Panels for Plant Operations From the Perceptual Viewpoint

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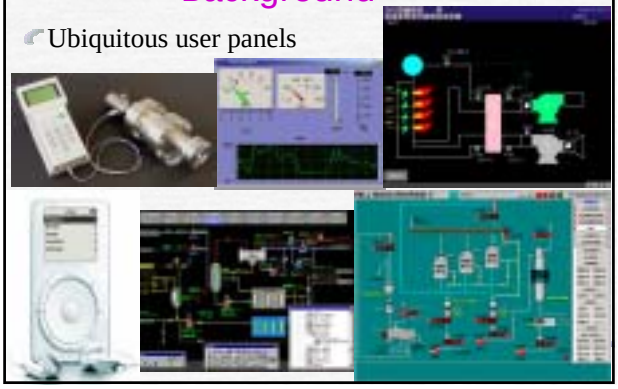
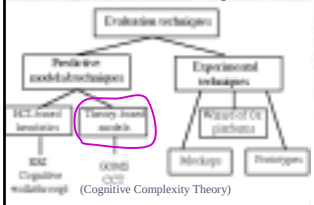
Background

- Ubiquitous user panels



Background (Cont'd)

- Life cycle of human-computer interface (HCI)
  - An iterative course including design, prototype, and evaluation
- Evaluation techniques



Classification of evaluation techniques
(Sandrine Balbo et. al, 1993)

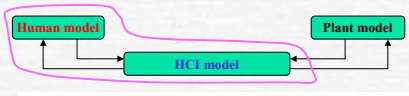
Life cycle of HCI

Objectives

- Evaluate the visual effect of user panels for plant operations by using human model.
- Improve the evaluation based on psychological experiments.

Our Evaluation Approach

- Human model based approach: user panel evaluation is based on human and HCI model.



General framework of HCI

Advantages:

- All parameters can be set freely for all kinds of cases.
- Evaluate without human subject.

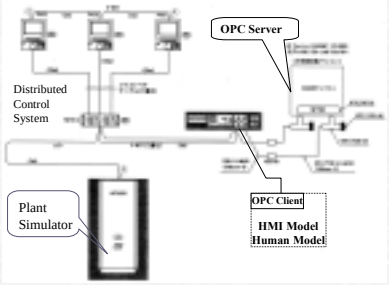
Disadvantages:

- Assumptions might be wrong.
- Build human, HCI, and plant models.

Our Evaluation Approach (Cont'd)

Experiment environment

- All real-time data in the plant simulator can be accessed to by using the object linking and embedding for process control (OPC) technology.



Hardware Configuration

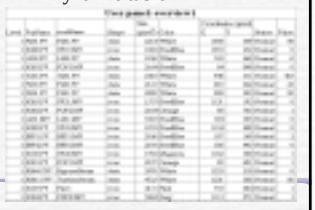
Our Evaluation Approach (Cont'd)

Model a user panel

- All of the iconic and digital information are extracted to a table that includes name, important level, shape, size, color, position, status, and value of every graphic item.

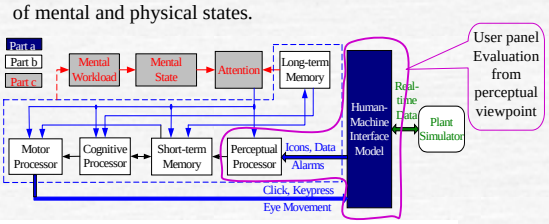
User panel

Dynamic table



Our Evaluation Approach (Cont'd)

The human model was built incorporating with the estimation of mental and physical states.

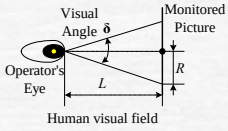


Model structure of a human-machine system for plant operations

Part a: HMI model
Part b: human model
Part c: estimation model of human mental state and attention level

Perceptual Processor Model

- **Visual field**
- Eye movement
- Perceptual performance



Human visual field

Human visual field is a circle around a fixed point

$$R = L\tan(Ap \times \frac{\delta}{2})$$

L : length
R : visual field radius
Ap: perceptual attention level
δ : visual angle

The default value of ***L*** is 75cm.
Ap is set to 0.8, 0.6, and 0.4 according to former research (Kurooka et al., 2001).
δ is set to 10° based on EPIC cognitive architecture (Kieras et al., 1997).

Perceptual Processor Model (Cont'd)

- Visual field
- **Eye movement**
- Perceptual performance

- **Shift trajectory**
- Overlay level
- Fixation and saccade intervals

Eye movement in simulation run

Perceptual Processor Model (Cont'd)

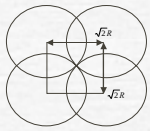
- Eye movement
  - Shift trajectory
  - **Overlay level**
  - **Fixation and saccade intervals**

Shift span of saccade :

- Centric distance of two consecutive saccades
- Scanning can cover all elements in a panel, only when it is smaller than $\sqrt{2}R$

$$D = \frac{\sqrt{2}R}{\alpha}$$

D: shift span
α: overlay level



Shift span of saccade

- The total duration of fixation and saccade is 70~700 millisecond (Card, et al., 1983)

Perceptual Processor Model (Cont'd)

- Visual field
- Eye movement
- **Perceptual performance**

Visual strength of a graphic element within a visual field

(Weber-Fechner's law)

$$V = f(x, y, z, Ap)$$

V: visual strength of the element
x: color difference
y: size
z: position
A_p: perceptual attention level

$V < \theta_P$ (Perceptual threshold) → The element might not be captured and sent to the short-term memory.

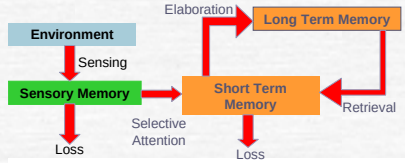
Perceptual Processor Model (Cont'd)

- Visual field
- Eye movement
- **Perceptual performance**

	Types	Capacity	Duration
Sensory memory	Iconic memory	[7~17] letter	[70-1000] ms
	Echoic memory	[4.4~6.2] letter	[900-3500] ms

(Card, et al., 1983)

If the number of graphic items is more than 17, some items with low visual strength might be lost.

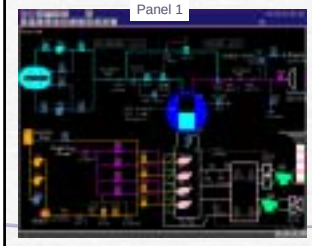


Atkinson-Shiffrin Model

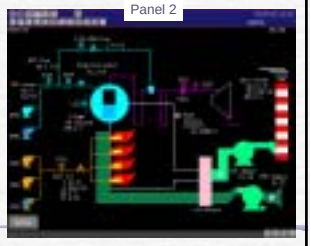
Evaluation Experiments

- Target user panels
  - We evaluated 6 user panels, and show two of them as examples.

High density with 75 items



Low density with 33 items



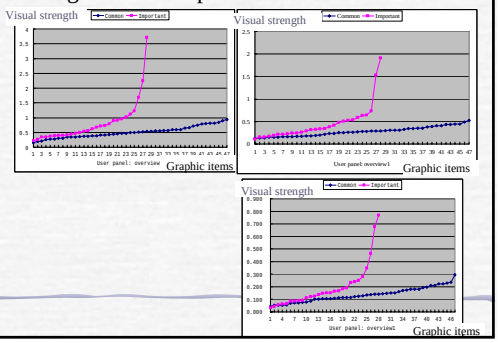
Evaluation Experiments (Cont'd)

- Evaluation scenarios
  - Build HCI model for an objective graphic panel, and divide the graphic items into two groups—common and important process variables.
  - Scan throughout the panel with different perceptual attention level and record the visual strength of every graphic item.
  - Integrate the above evaluation results and find the weak points of the graphic panels and their causes.

Evaluation Experiments (Cont'd)

- Visual strength curves of panel 1

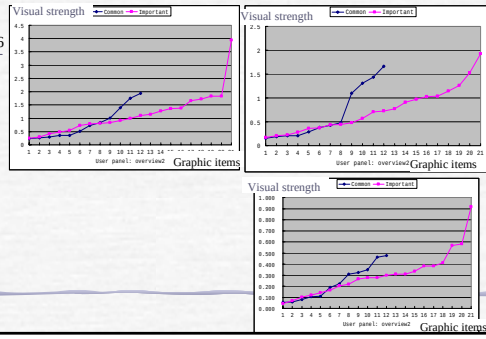
Ap=0.8 | Ap=0.6 | Ap=0.4



Evaluation Experiments (Cont'd)

- Visual strength curves of panel 2

Ap=0.8 | Ap=0.6 | Ap=0.4

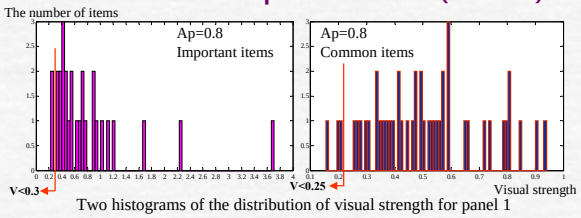


Evaluation Experiments (Cont'd)

- Evaluation points
  - Density check
  - Visual strength curves
  - Visual strength of every item
  - Average visual strength

- Weak point 1: The number of items within every visual field exceeds 17.
- Weak point 2: The visual strength curve of Important items is lower than that of common ones

Evaluation Experiments (Cont'd)



Two histograms of the distribution of visual strength for panel 1

- Weak point 3

Condition	Ap=0.8	Ap=0.6	Ap=0.4
Important item	**V<0.3**	V<0.2	V<0.1
Common item	**V<0.25**	V<0.15	V<0.05

V: Visual strength

- Weak point 4

Condition	Ap=0.8	Ap=0.6	Ap=0.4
Process overview	Vt<0.6	Vt<0.3	Vt<0.15
Operational panel	Vt<0.8	Vt<0.4	Vt<0.2

Vt: Average visual strength

Evaluation Experiments (Cont'd)

- Evaluation results:
  - Density is proper—no visual field can hold more than 17 items.
  - The important items in panel 2 are not given suitable emphasis.
  - There are 20 and 3 weak items in panel 1 and 2 respectively.
  - The average visual strengths of both panel 1 and 2 are proper.

Summary

- We proposed a human model to user panel evaluation from the viewpoint of perception.
- The perceptual processor model is introduced.
- Through simulation runs, we showed the weak points of user panels.

Future Work

- Based on eye mark recorder, we improve the simulation fidelity by
  - obtaining the trajectory of eye movement
  - modifying the algorithm of visual strength
  - validating the simulation

Future Work (Cont'd)

A psychological experiment to obtain eye movement trajectory of a human subject

Experiment environment: ask the subject to scan throughout the user panel 1, and try to relaxedly cover all graphic items.
Experiment results: extract the coordinates of fixation points and fixation and saccade intervals.

Future Work (Cont'd)

- The characteristics of human eye movement.
  - Try to focus on graphic items.
  - Fixation point is moved based on the understanding of user panel.
  - Fixation time is decided by the complexity of graphic items within a visual field.

A problem of the former simulation:

The actual trajectory is not a zigzag line as the assumption in the former simulation run. Accordingly, the fixation points in simulation are different to the real case. Such difference affects the position factor in the calculation of visual strength.

Future Work (Cont'd)

Simulation program based on the human subject's eye movement

Thank you very much for your attention!