Development of an expert system for generator operation training

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Outline

- Introduction
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  - Steps of expert system development
  - Software design of the generator training system
  - System explanation
- Experimental evaluation
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  - Experimental procedures
- Results and Discussion
- Conclusions

Introduction (1/2)

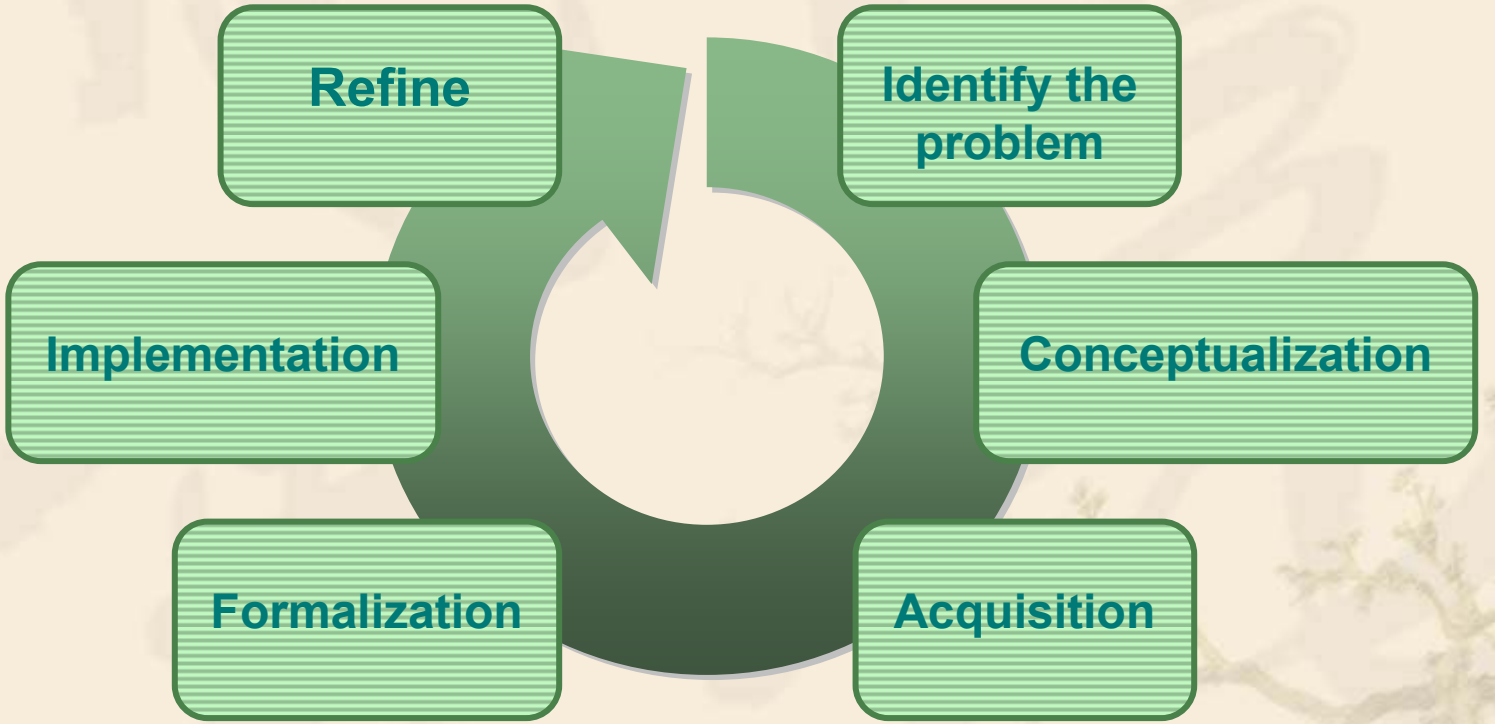
- The fastest development of semiconductor industry
- If the electric power stops suddenly
  - a big loss for more than NT$20,000,000
- All the electric power of the facilities relies on the generators
- The complicated and difficult in controlling of generators in a semiconductor plant

Introduction (2/2)

- Way to result this problem
  - Expert systems (ES)
    - Suitable for the control of generators by providing searching function in the emergency situation
    - Serve as a training system to make training more efficiently
- Purpose
  - Improve training efficiency
  - Add search engine of generators for emergency situation

Development of the generator training system (1/8)

- Steps of Expert System development



Development of the generator training system (2/8)

- Step 1 Identify the problem
  - If the electric power from Taiwan power company service is interrupted suddenly, all the activities in the company will be shut down.
  - Three kinds of different generators in the X company
    - different characteristics and methods of control
  - Experts need to teach staffs repeatedly

Development of the generator training system (3/8)

- Step 2 Conceptualization
  - Two parts: one is for **training** and the other one is for **quick searching in the emergency situation**.
- Step 3 Acquisition
  - **Training document** collection, process observation, and **interview** with experienced staff

Development of the generator training system (4/8)

- Step 4 Formalization
  - The knowledge can be divided into procedural data and declarative data.

Procedural Knowledge	Declarative Knowledge
Emergency operation & Normal control method	Facility & Machine introduction

Development of the generator training system (5/8)

- Step 5 Implementation
  - Two systems: power system and load-shedding system
  - Two parts of training: routine check and emergency check.

Power System

The power system includes allocation of every facilities and circuit of electric power.

Load-shedding System

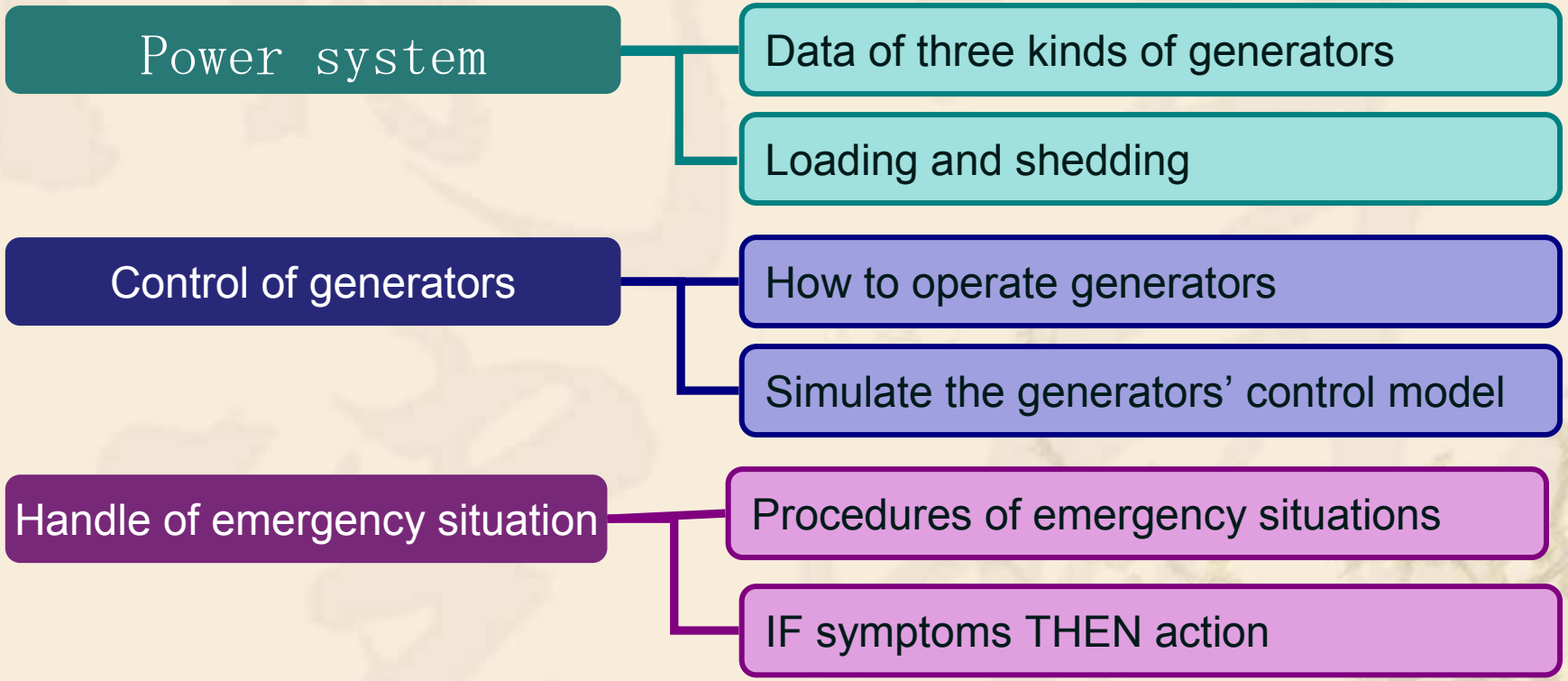
Load-shedding system includes the sequence of electric providing, and the method of loading and shedding with each kind of generator.

Development of the generator training system (6/8)

- Step 6 Refine the expert system
  - To collect the advice from tester and experts of the company

Development of the generator training system (7/8)

- Software design of the generator training system



Development of the generator training system (8/8)

- System explanation
  - The generator training system includes:
    - The introduction of the electric power system of company
    - The training of loading and shedding
    - Machine history of the generators
    - The ways to handle generator unworkable in emergency situation.

Introduces the goal of electric system

The introduction of the electric power system of company

電力系統介紹

系統目的

當台電供電異常停止時，緊急發電機自動啟動供應緊急電力給廠內中要設備用電，為了避免負載容量過大導致發電機當機，而利用緊急電力Load Shedding系統依據發電機運轉狀況而自動投入/切離高、低壓開關盤

適用範圍

力行廠區各變電站(CUB、FAB4、FAB5、TESTING、P/S等五個變電站)之高、低壓開關盤

適用時機

台電停止供應電力，發電機供應緊急電力給廠內重要設備用電時

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Information of CW170's generators

2. CW170

1. CW170可發電2600KW/台，屬於低發電量的機型
2. 屬於高轉速的發電型態
3. 電壓/頻率調整速率迅速，機器較易並聯上系統

Niigata

W200

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Information of the power supply

電量分配

種類分配

Niigata： Generator1, Generator2
CW170： Generator3, Generator4, Generator5, Generator6
W200 ： Generator7, Generator8, Generator9, Generator10

供電分配

工廠內所有的用電設備依照重要性分成17個GROUP，來決定停電時供電的優先順序，所有的GROUP都設為2500 KW，方便投載及卸載

容量設定

Niigata可負擔2個Group的電量，CW170和W200可負擔一個Group的電量

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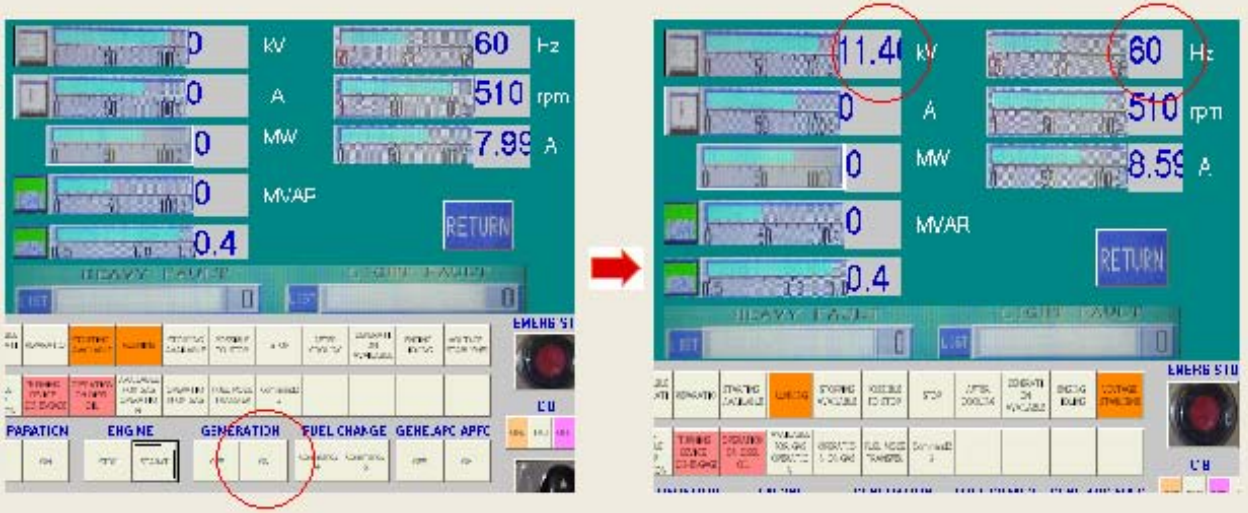
One step of the generator control

5. GENERATION(ON) →觀察MIMIC PANEL是否於11.4KV及60HZ



按下GENERATION至ON的位置，等待電壓至11.4KV及60Hz

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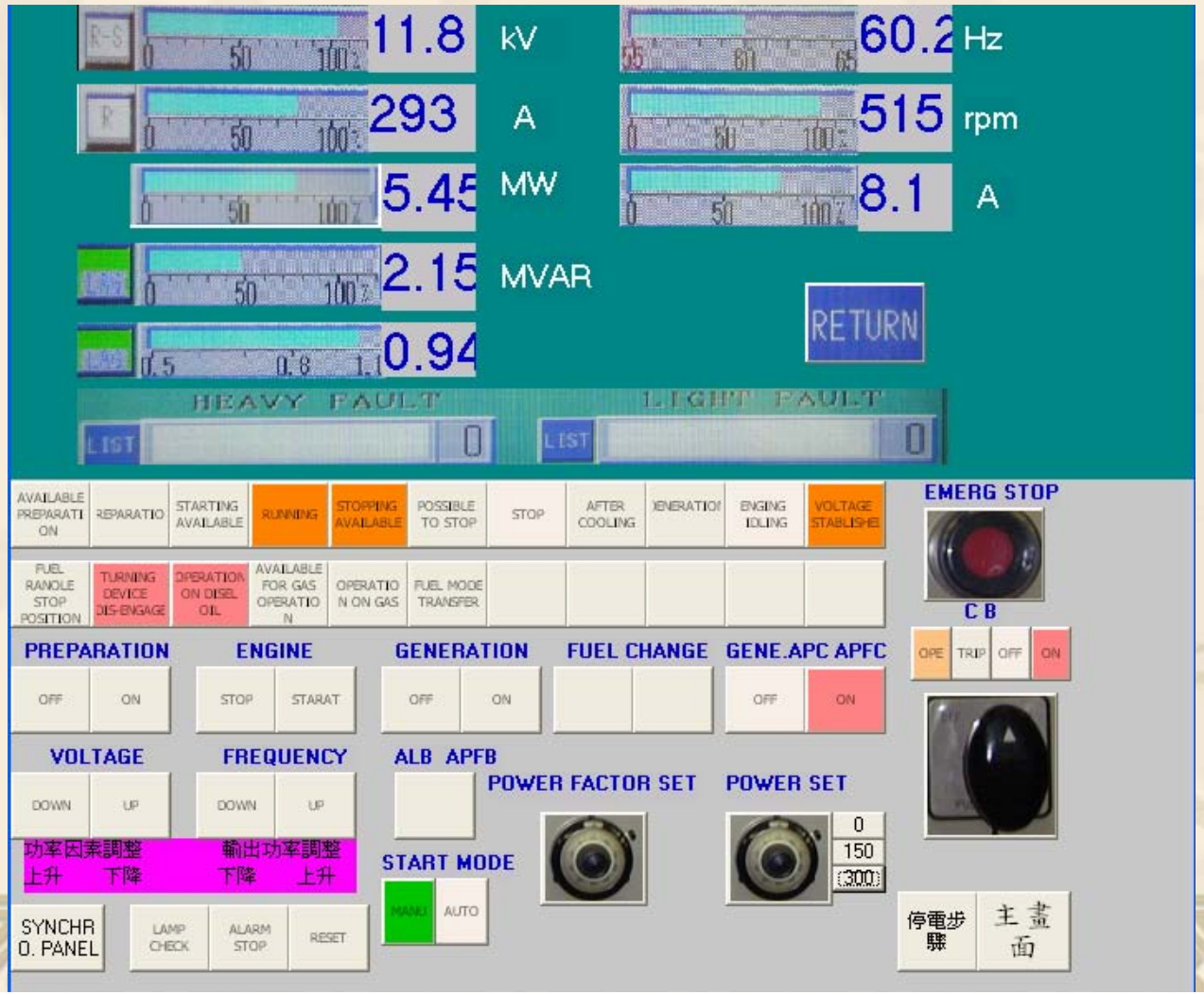
Control panel of Niigata's generator

The training of loading and shedding



Machine history of generator 1 and generator 2

Machine history of the generators

機歷表

Adodc1

識別碼	設備名稱	日期	保養OR意外	內容
1	G1緊急發電機	88 / 12 / 01	定期維修保養,零配件	年度定期保養
2	G1緊急發電機	91 / 01 / 03	定期維修保養,零配件	年度定期保養
3	G1緊急發電機	91 / 12 / 18	定期維修保養,零配件	年度定期保養
4	G1緊急發電機	92 / 03 / 07	定期維修保養,零配件	冷卻水塔季定期保養及
5	G1緊急發電機	92 / 06 / 18	定期維修保養,零配件	冷卻水塔季定期保養
6	G1緊急發電機	92 / 09 / 16	定期維修保養,零配件	冷卻水塔季定期保養及
7	G1緊急發電機	92 / 11 / 07	定期維修保養,零配件	冷卻水塔季定期保養
8	G1緊急發電機	93 / 01 / 09	定期維修保養,零配件	年度定期保養
9	G1緊急發電機	93 / 03 / 12	定期維修保養,零配件	冷卻水塔季定期保養及
10	G1緊急發電機	93 / 06 / 10	定期維修保養,零配件	冷卻水塔季定期保養
11	G1緊急發電機	93 / 09 / 16	定期維修保養,零配件	冷卻水塔季定期保養及
12	G1緊急發電機	93 / 12 / 08	定期維修保養,零配件	冷卻水塔季定期保養
13	G1緊急發電機	94 / 02 / 21	定期維修保養,零配件	年度定期保養

Adodc2

識別碼	設備名稱	日期	保養OR意外	內容
1	G2緊急發電機	88 / 12 / 10	定期維修保養	年度定期保養
2	G2緊急發電機	91 / 01 / 07	定期維修保養	年度定期保養
3	G2緊急發電機	91 / 12 / 18	定期維修保養	年度定期保養
4	G2緊急發電機	92 / 03 / 07	定期維修保養	冷卻水塔季定期保養及
5	G2緊急發電機	92 / 06 / 18	定期維修保養	冷卻水塔季定期保養
6	G2緊急發電機	92 / 09 / 16	定期維修保養	冷卻水塔季定期保養及
7	G2緊急發電機	92 / 11 / 07	定期維修保養	冷卻水塔季定期保養
8	G2緊急發電機	93 / 01 / 09	定期維修保養	年度定期保養
9	G2緊急發電機	93 / 03 / 12	定期維修保養	冷卻水塔季定期保養及
10	G2緊急發電機	93 / 06 / 10	定期維修保養	冷卻水塔季定期保養
11	G2緊急發電機	93 / 09 / 16	定期維修保養	冷卻水塔季定期保養及
12	G2緊急發電機	93 / 12 / 08	定期維修保養	冷卻水塔季定期保養
13	G2緊急發電機	94 / 02 / 24	定期維修保養	年度定期保養

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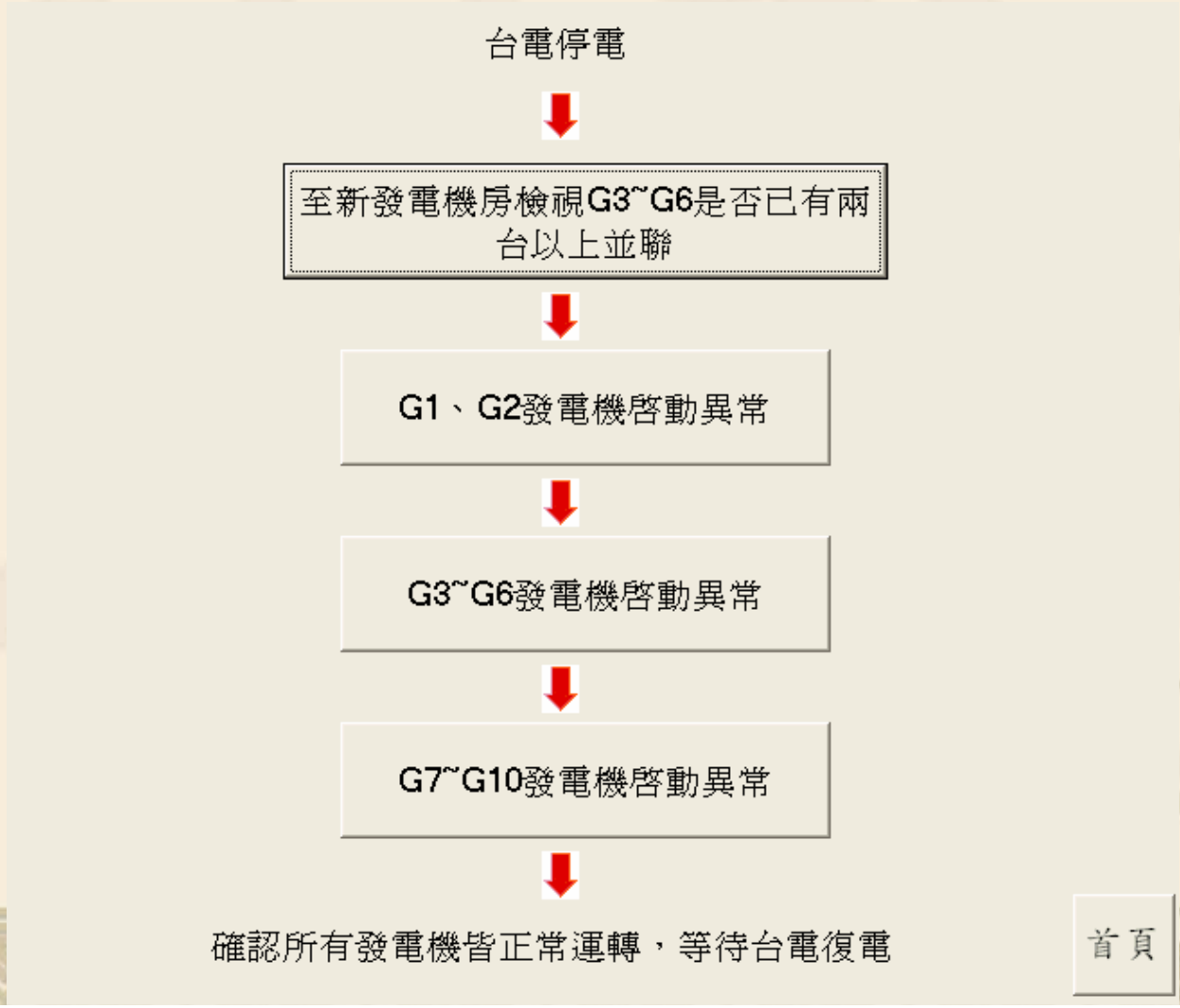
Process of a power failure



Solving process of Niigata breakdown

Niigata簡易故障排除

排除步驟：

1. 判讀GCP盤警告訊息:針對警報訊息，予以排除
2. 檢查空壓桶（原因：空氣壓力不足）
3. 檢查空氣管路開關（原因：空氣壓力不足）
4. 檢查空壓機（原因：空氣壓力不足）
5. 檢查燃油管路開關（原因：燃油系統異常）
6. 重新調整引擎燃油桿
7. GCP控制
8. 輔機盤開關未定位
9. GCP盤Reset後再啟動

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Experimental evaluation (1/4)

- Experimental variables
  - Independent variables
    - Conventional training system:
      - Participants take manual to learn about the knowledge and procedure of generator handling.
    - Expert training system:
      - Participants use generator training system.

Experimental evaluation (2/4)

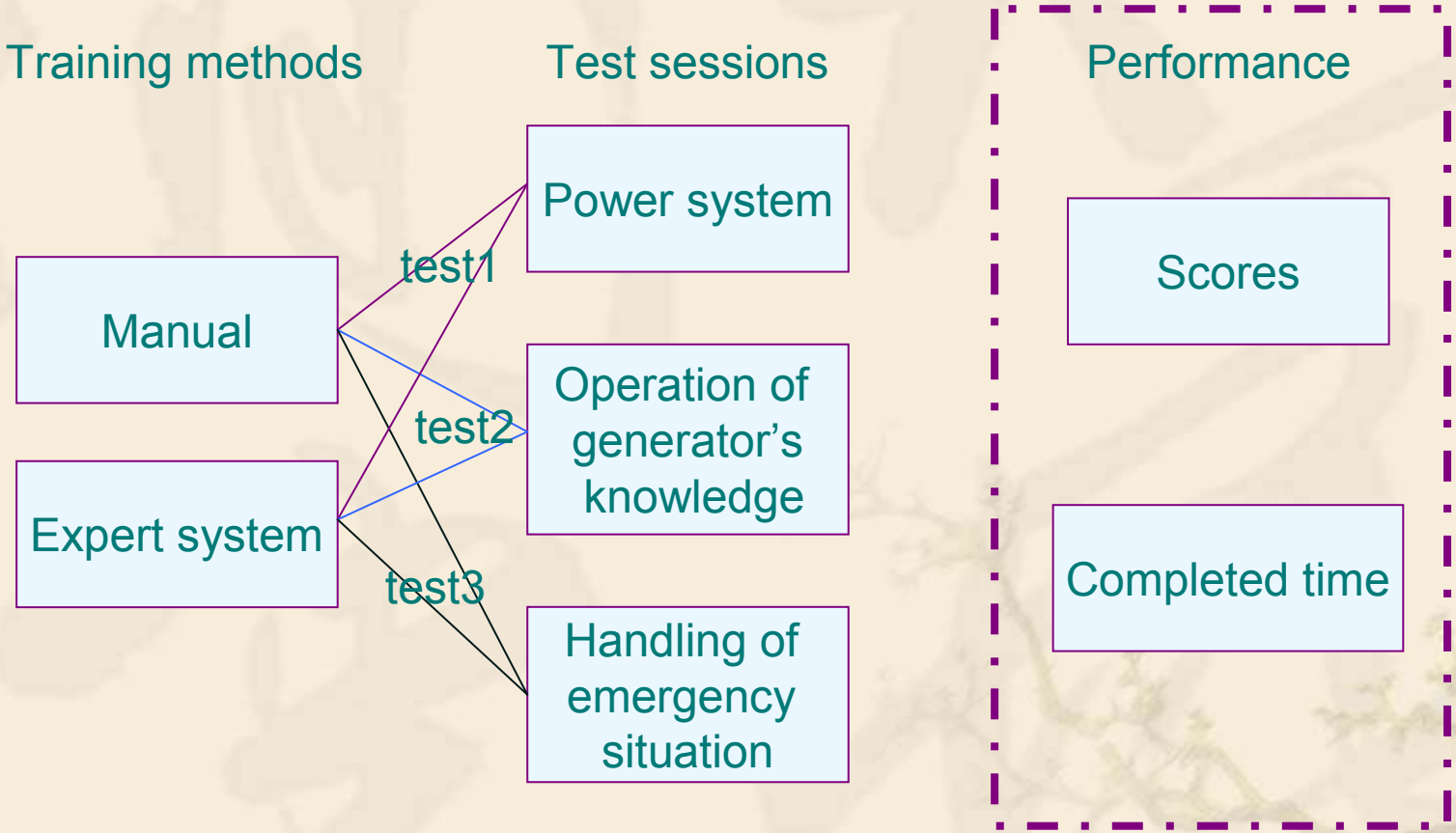
- Dependent variables
  - Accuracy:
    - The accuracy of the decision making of the participant. The participant will receive two tests, one is for **declarative knowledge memory** and the other one is for **procedural knowledge memory**.
  - Training time:
    - The time indicates efficiency of learning.

Experimental evaluation (3/4)

- Subjects
  - 22 students in industrial engineering at NTHU
    - None of the students had experiences about generators before.
  - These subjects were randomly assigned to one of the training conditions.
    - One group used generator training system.
    - The other group received manual training system.

Experimental evaluation (4/4)

- Experimental procedures
  - Memorization and training session
    - All subjects should understand the procedure and recognize which action should be taken in a certain situation.
  - Test session
    - Power system knowledge memory
    - The operation of generator's knowledge memory
    - Handling of emergency situation. The accuracy and the training times would be measured at this session.


Training methods
Test sessions
Performance
Power system
Manual
test1
Operation of generator's knowledge
test2
Expert system
test3
Handling of emergency situation
Scores
Completed time

Result and Discussion (1/3)

- Result
  - Normal Probability Test was applied on the total scores of knowledge of **manual** and knowledge of **generator training system**.
    - The total scores were all fit normal distributions.
  - Two different training methods combined with three test sessions analyzed by t-test
    - The effect of training method on test1, test2, test3, time1, time2 and total time was not significant ($p > 0.05$).
    - time3, score1, score2, score3 and total score were significant ($p < 0.05$).
  - The effects of generator training system may be better than conventional training.

Result and Discussion (2/3)

- Discussion
  - The computer aided tutorial system are significant in scores, but not in times.
    - The reason may be due to that there are too difficult to remember in a short time.
    - It needs training to obtain the knowledge of the generators in long time. It may be taken one or two months in training.

Result and Discussion (3/3)

- In manual training method, all knowledge is separated in many documents, and the user needs to read a lot of texts with neither systematical nor hierarchical arrangements.
  - One can see that ES can improve the performance in complex tasks training.
  - From the score, we can find the score of expert training system is higher than conventional (manual) training.
  - The result shows that the generator training system is better, so we can use it to train novices.

Conclusions

- The contributions of the research
  - The system can help trainees learn complex knowledge efficiently.
  - The generator training system can simulate the machine controlling, and let users feel truly.
  - The Expert System in this study is not only helpful in training but also a decision support system.
  - The generator training system allows the trainees to use computers to study knowledge repeatedly and to make learning more flexible.

Further study

- Apply the Expert System to nuclear power plant, aviation industry, and others.

Thanks for your attention

Q & A