Utilization of Domain-Specific Knowledge for Quality Software Design

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Abstract

Suggests a practical method of extracting and describing
domain-specific knowledge
Feature1: Existing documents are used as a knowledge framework
Feature2: Knowledge is described in text and diagram
for anyone at anytime
Systematization and utilization of domain-specific knowledge increases
the organization's capability as well as the design quality

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Utilization of Domain-Specific Knowledge for Quality Software Design

Contents

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1. Introduction

1-1. Why Do We Need Domain-Specific Knowledge?

- Change of external factors
  - Short-term development
  - Requirement of safety
  - Advanced features of products

- Change of development environment
  - From a few select members to many diverse members
  - Necessity for an understanding of an unknown domain

Domain-specific knowledge means:
- Background knowledge, such as an operating environment, the purpose for which equipment is used
- Business knowledge, such as product strategy and relationships with peripheral equipment
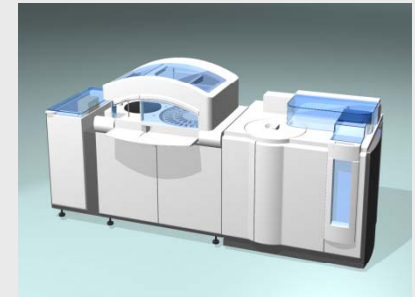
5

Two Main Pillars of Product Series

Electronic Device Systems

- **Semiconductor Manufacturing Equipment**
  CD-SEM / Wafer Defect Inspection System
  Etching System
- **Electron Microscope**

Life Sciences

- **Medical Analysis Equipment**
  Automatic Clinical Chemistry and Immunodiagnostic Analyzer
- **Biotech Equipment**
  DNA Sequencer
  Liquid Chromatograph

Typical Software Structure

User-operation software (GUI/image processing /DB/communication)	← **Measuring results** **Control command/parameter** → **LAN**	**Device control software** (control/ communication)
General purpose OS		**Real-time OS**

6
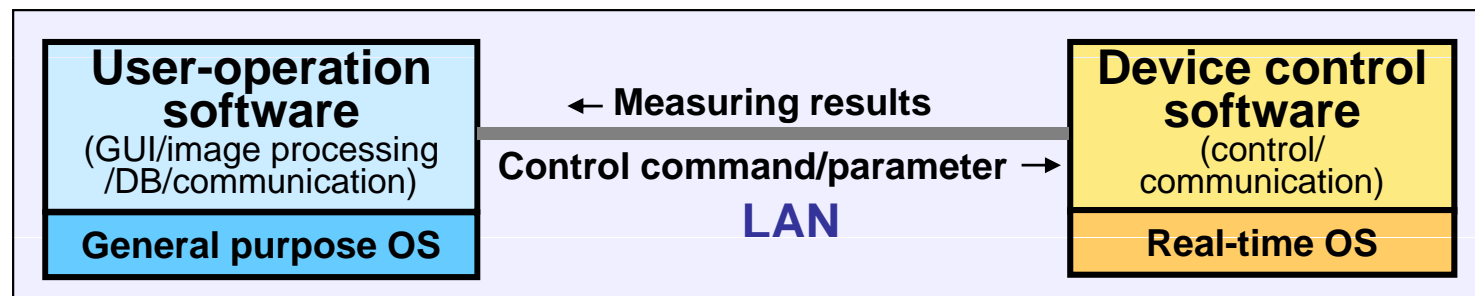
- **History of Quality Improvement**

  - ✓ Team review（Documents / Code）   （*since 1998*）

  - ✓ Software Reliability Improvements with Precise Software Development Process   *<The 31st Reliability and Maintainability Symposium (2001)>*

  - ✓ Simultaneous Design of Functional Specifications and Test Specifications Using Tool "F2T" *<3rd World Congress for Software Quality (2005)>*

Faults related to implementation   21

18   **Faults related to domain-specific knowledge**

Fig 1. Classification of past faults
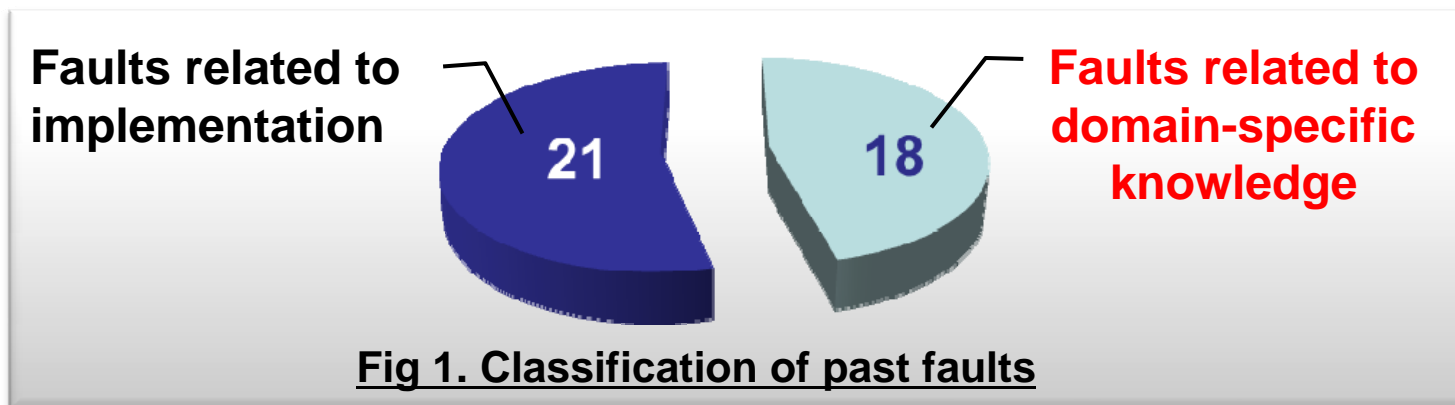
We must focus on acquiring Domain-Specific Knowledge!!

7

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2. Difficulties in utilizing Domain-Specific Knowledge

- Domain-specific knowledge is accumulated within individuals through experience

    - ✓ People who need domain-specific knowledge cannot show what is necessary

    - ✓ People who need domain-specific knowledge cannot provide the scope

Difficult to show what they need

- Domain-specific knowledge is accumulated within individuals through experience
    - ✓ It cannot be seen from outside
    - ✓ It does not have an organized form
    - ✓ The significance changes by people who possess Domain-specific knowledge

Difficult to output domain-specific knowledge
by specialists themselves

- For understanding domain
  - The user's business
  - The purpose of installing the equipment
  - The user's operation flow
  - Social motivations such as laws and regulations

- For quality software design
  - The historical reasons for changes of requirements or demands
  - Background of the hardware technology
  - Background of the software technology

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3. Method for Extracting and Describing Domain-Specific Knowledge

Extracting

- Designed to be conducted by software engineers

    (a) Formation of a team

    (b) Knowledge framework based on the existing documents

    (c) Extraction using interview questionnaire

Describing

- Explain domain-specific knowledge in text and diagram for anyone at anytime

    (a) General information manual (Text)

    (b) Domain-specific model (Diagram)

(a) Formation of a team

  ➢ One or more engineers (as a writer)

  ➢ One or more specialists (as a reviewer)

(b) Creation knowledge framework using existing documents

  ➢ Source of domain-specific knowledge

    – Operation manuals

    – User requirements

    – Design specifications

Key point! Use two or more product's documents

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(c) Extraction steps

Step 1: Knowledge determination

- Determine the scope of search knowledge

- Decide the references from selected documents

- Make a knowledge frame

Step 2: Information collection

- Look for descriptions corresponding to the domain-specific knowledge

- Copy and paste relevant parts from existing documents

Key point! Make knowledge framework using existing documents

3-3. (Cont)

(c) Extraction steps(Cont)

Step 3: Information arrangement and question compilation

Generate topic lists with questions

-> Enable remove bias from writers and specialists

Step 4: Knowledge extraction from specialists using questionnaire

Extract knowledge using the list of questions

-> Enable lessen the specialists workload

Key point! Set a common goal and go there
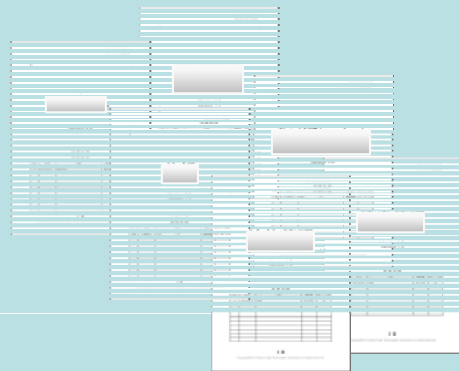
Common goal

Step 5: Knowledge description(to be shown next)

The extracted domain-specific knowledge is used to complement the engineers' limited knowledge.
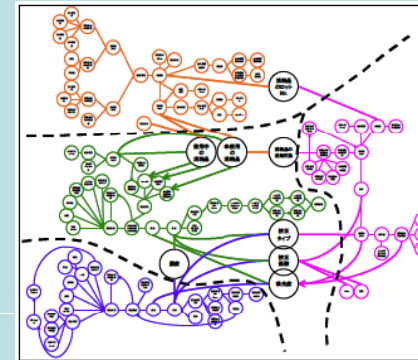
Requirements

➢ Enable the study of domain-specific knowledge at any time by a newly arrived engineer

➢ Enable the overview and the relation between sub-domains
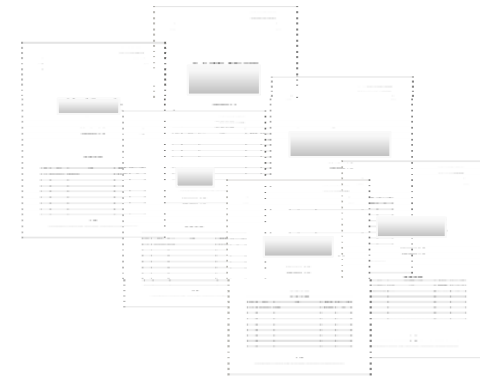
(a) General information manual   (b) Domain-specific knowledge model

Features

➢ Explain from user view

 No : What can the system do?

  Yes: Why is it necessary?

Attentions!

➢ Explain the software's purpose

➢ Describe the environment relevant to a rationale

➢ Review the followings

  ✓ Is it arranged in order from the introduction to detailed arguments?

  ✓ Is the need for the function and the premise described?

  ✓ Is common knowledge described for series products?

  ✓ Are terms defined and used consistently?

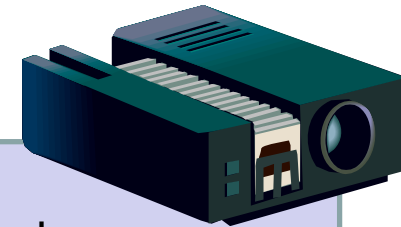 ✓ Are terms used with awareness of the appropriate subject, information, or role?

Features

➢Show overview of domain-specific knowledge

➢Show relation between sub-domains
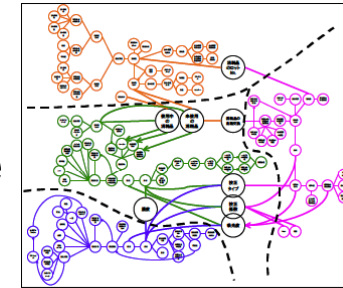
Example

Projector:
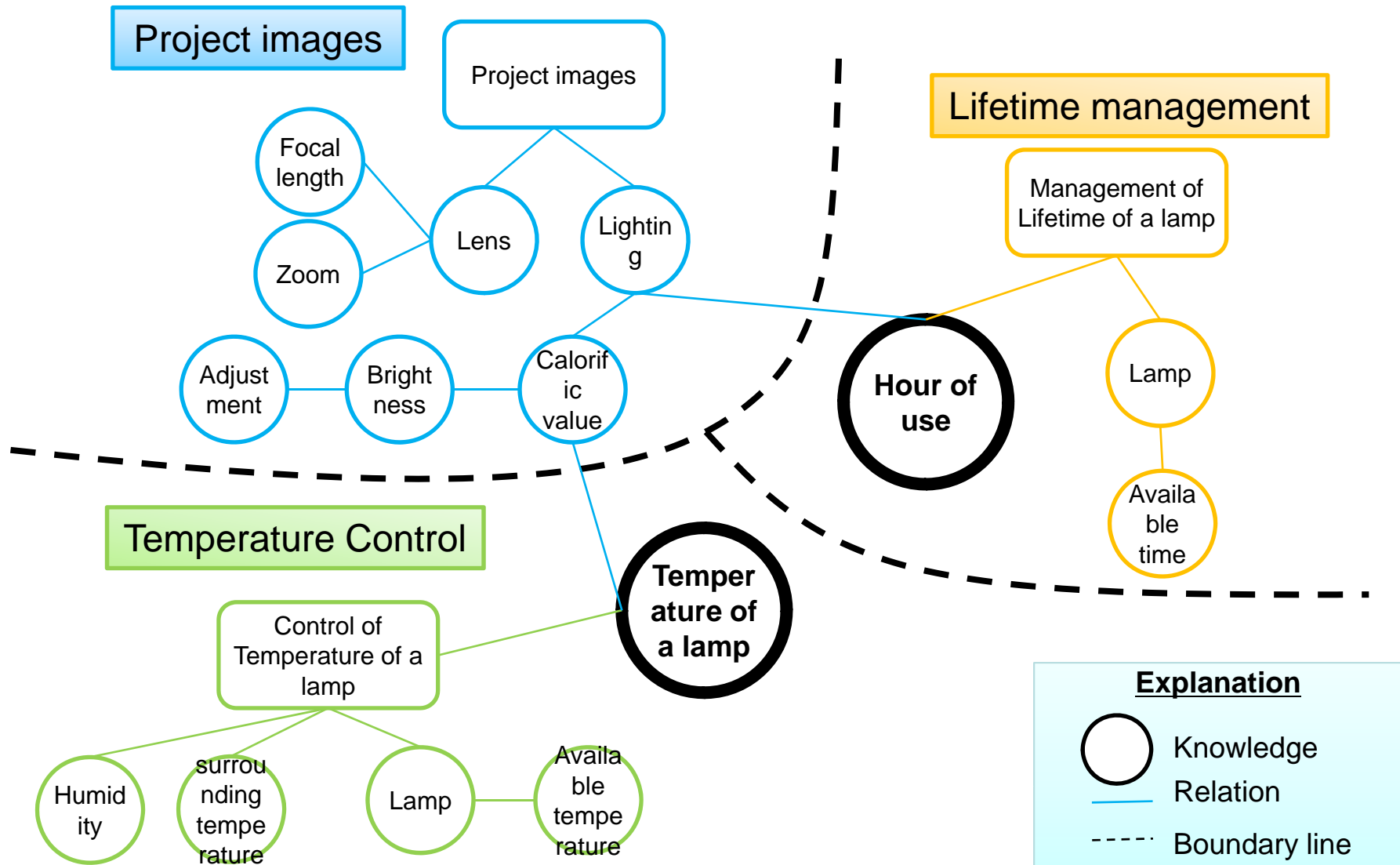 Equipment which projects an image on a large-sized screen

Typical functions (Excerpt)
  ✓Project images clearly
  ✓Distortion compensation
  ✓Keep a lamp condition
    --- Temperature control of a lamp
          --- Monitoring of the temperature of a lamp
          --- Cooling of a lamp
    --- Lifetime management of a lamp
          --- Alarm display
          --- Measurement of a hour of use

19

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Project images

Project images

Focal length

Zoom

Lens

Lighting

Adjustment

Brightness

Calorific value

Lifetime management

Management of Lifetime of a lamp

Hour of use

Lamp

Available time

Temperature Control

Control of Temperature of a lamp

Temperature of a lamp

Humidity

surrounding temperature

Lamp

Available temperature

Explanation

◯ Knowledge

─── Relation

----- Boundary line

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4. Application Results

Applied in five teams consisting of engineers engaged in software development for a series of products

(Automatic clinical chemistry analyzer)
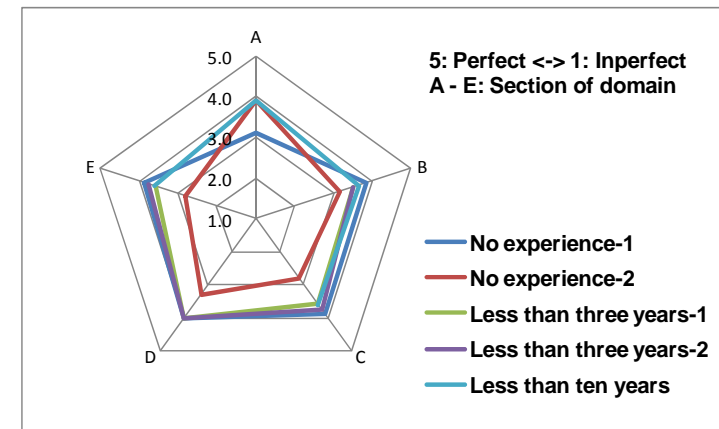
Steps of implementation

1. Explain the meaning of domain-specific knowledge extraction (manager)
2. Indicate the working hours available (manager)
3. Organize teams and determine team leaders (extraction team)
4. Explain domain-specific knowledge extraction process (support team)
5. Devise a domain-specific knowledge extraction schedule (extraction team)
6. Conduct domain-specific knowledge extraction (extraction team, support team)

SECTION (TEAM)	NUMBER OF TEAM MEMBERS	NUMBER OF MEETINGS	NUMBER OF PRODUCTS REFERRED TO	TOTAL PAGES OF SOURCE DOCUMENTS	TOTAL PAGES OF OUTPUT
A	8	13	5	1123	32
B	13	14	4	616	51
C	7	17	4	493	31
D	5	15	4	154	36
E	6	12	4	1617	33

(1) Lecture system

Initial training for software engineers

- Five candidates:
- Two with no experience in software development
- Two with less than three years of experience

- One with more than three years but less than ten years of experience
- Team leaders were assigned to lecturers
- Two hours for reading and two hours for lecture
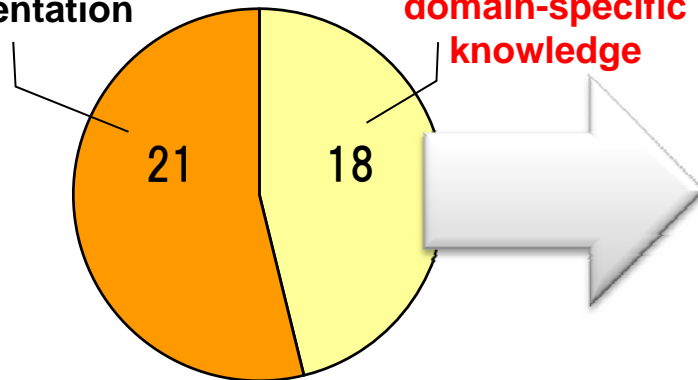
(2) Self-education system

Easy to access

People in other products departments also refer!!

Causal analysis of previous faults:

How many faults would have been eliminated?

Details of 18 faults

Faults related to implementation

Faults related to domain-specific knowledge

21

18

No description in both

2

Knowledge in domain-specific knowledge model

5

11

Knowledge in general information manual

These could have been prevented
(5+11) / 39*100 = 41%
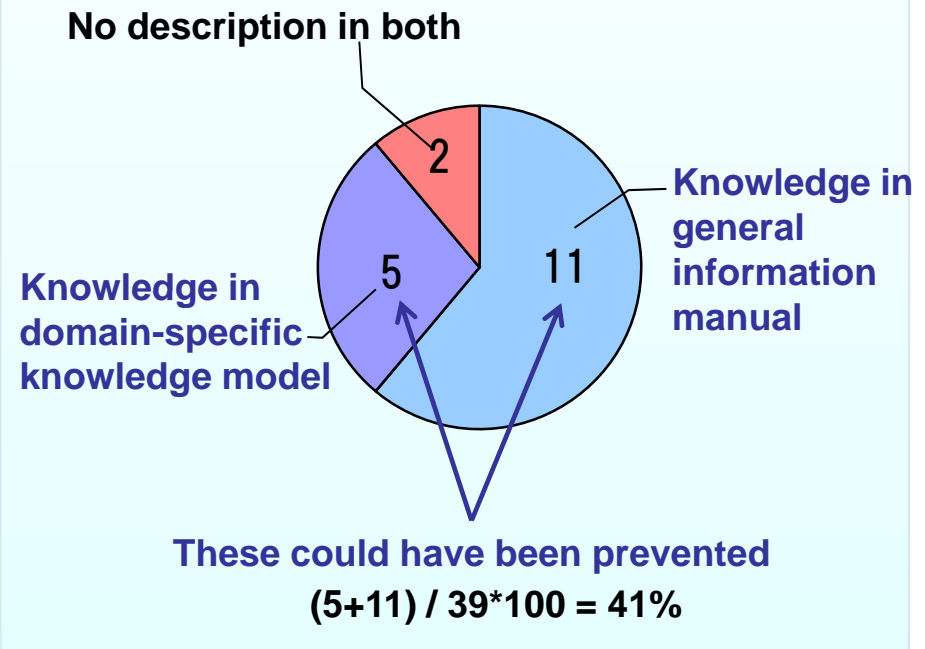
(1) Availability of the suggested method

- ✓ Little understanding of software development practice leads misinterpret
- ✓ The result in a team reinforces a specialist's confidence

(2) Evaluation of this attempt

- ✓ The output by this approach is authorized.
- ✓ A periodic review is necessary for maintain the contents

(3) Utilization of tacit knowledge

- ✓ Results has been used widely since the aim and the purpose are agreed

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5. Conclusions

5-1. Concrusions

Suggested a practical method for extracting and describing domain-specific knowledge.

<u>Extracting method</u>

Using existing documents as a knowledge framework

Using questionnaire as the basis of knowledge extraction

->Completeness and efficiency

<u>Describing method</u>

The general information manual: Guide to rationale

The domain-specific knowledge model: Overview of knowledge

-> Self-education at any time

The essential aim is to make every engineer notice the scope of his or her understanding of each domain!

Ending

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Bringing the frontier to the forefront.