A Case Study of Design Knowledge Acquisition Using Workflow System

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Outline

- Background
- Purpose
- Software
- Knowledge Acquisition Method
- Case Study
- Discussion
- Conclusion
Background

- Manufacturing industry in Japan is rapidly aging
  - Knowledge of elder Experts must be acquired in formal manner
  - Knowledge of elder Experts must be transferred to young engineers
Purpose

- Propose a method to support knowledge transfer from elder experts to young engineers by information technology
  - How we acquire and represent knowledge of experts?
  - How we evaluate knowledge acquired through this method?
Software
UT-ESS

(University of Tokyo Educational Software for Shipbuilding)

- UT-ESS is a document management system based on workflow
- UT-ESS is developed for Knowledge Acquisition and Representation
- Originally UT-ESS is developed for student education and is customized for experimental use in shipyards
- Association between design documents and workflow is described by metadata based on semantic web
UT-ESS is client/server system

There are two client software component

- Workflow Editor
  - Create and edit workflow
  - Upload created workflow to server

- Tree Explorer
  - Associate documents with tasks in workflow
  - Browse workflow and documents associated with workflow
UT-ESS System

Workflow Editor

Write Workflow

Workflows and documents are stored in server

Tree Explorer
Associate and Upload Documents

(Tree Explorer)

(Metadata based on Semantic Web)

Server

(workflow)

(meta data)

(meta data)

(meta data)

(meta data)

(meta data)

(meta data)

(workflow)

(meta data)

(meta data)

(meta data)

(meta data)

(meta data)

(meta data)
Document Retrieval using Metadata

Document associate with Task A?
Documents Created by Engineer A?

Return Metadata Search Results.

- Creator
- Date
- Keyword
- Associated Task
- etc

meta data

• HTML
• Word, Excel
• Documents
• Calculation sheets
• etc

Doc

meta data

workflow
Semantic Web

- Describe documents

  Metadata Model

  DocumentA
  - dc:subject: Basic Design
  - dc:creator: Kazuo Hiekata

  DocumentB
  - dc:subject: Lines
  - dc:creator: Kazuo Hiekata

- Look for a Document

  ?x
  - dc:subject: Basic Design

  Look for specified pattern in Metadata Model
Demonstration #1

- Create and Upload Workflow
Demonstration #2

- Associate Documents with Workflow
  Drag and Drop Document file into Task in Workflow
  Document File is uploaded to server
Demonstration #3

- Browse Workflow and Retrieve Documents

Search Documents are associated with a Task

Click Task in Workflow

New window opens with list of associated documents
Knowledge Acquisition Method
Knowledge Acquisition Method

UT-ESS

1. Write workflow for some design process
2. Associate design documents with tasks in workflow
3. Interview design engineers to get detailed information about workflow

This method covers knowledge acquired in this simple three steps
Design Knowledge Representation

- Design process is written in Workflow in UT-ESS
- Design documents explain details of design work

Design Knowledge is represented by Workflow and Associated Documents

Association is described by semantic web metadata
Interview with Workflow

- Gather information using workflow

Gather information about all tasks in workflow

Structured and informal interview is applied to all the tasks

Diagram:

- Task 1
- Task 2
- Task 3
- Check 1

Questions
Case Study
Case Study in a Shipyard

- Machinery Arrangement
  - Design process to determine the capacity of electric generators, boilers, and other equipments

- Case Study Steps
  - Design engineer organizes design process on paper (2 hours)
  - Input design process into UT-ESS as workflow (3 hours)
  - Associate design documents to workflow (10 minutes)
  - Structured and informal interview (1.5 hour)
Actually torsional vibration of the shaft is investigated before deciding the radius of main shaft.

Torsional vibration is investigated by manufacturer of the main engine.
Capacities of equipments about cooling system are determined through these tasks.
Steam system are here. These tasks include equipments such as boiler and exhaust gas economizer.
Interview for Engineers

- Four questions for each task (See Figure 6)
- General questions about each tasks

Q1 Who is the person in charge?
Q2 Level of Importance
Q3 Level of Difficulty to complete this task
Q4 Level of Difficulty to transfer knowledge about this task

Ask the engineer about each tasks

Q1: Who is the person in charge?
A: The engineer does this task.
B: The engineer does this task with team member.
C: The engineer (and/or the team) does this task with other team or section.
D: Other team or section does this task.
E: Not applicable.

Q2: Level of Importance
A: A mistake in this task will cause critical impact to whole project.
B: A mistake in this task will cause impact to the department.
C: A mistake in this task will cause impact to the engineer.
D: Not Applicable.

Q3: Level of Difficulty to complete this task
A: This task requires expertise.
B: This task requires a certain level of expertise.
C: This task can be learned by a few experiences.
D: Not Applicable.

Q4: Level of Difficulty to transfer knowledge about this task
A: Existing documents are enough to learn this task.
B: Documents are enough to learn this task, but documents don’t exist.
C: Documents and limited experience are enough to learn this task.
D: Many years of experience is required to learn this task.
Interview Result

Result Table
(See Table 1)

Classify tasks by following rules to evaluate the difficulty for transferring knowledge about task

Group A: (difficult to transfer knowledge)
Q4 == D

Group B: (important and critical task)
(Q2 == A) && (not Group A)

Group C: (difficulty to complete this task)
(Q1 != D) && (not Group A) && (not Group B)

Group D: (other team’s task)
Q1 == D

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Determine Main Engine (Planning Group)</td>
<td>C</td>
<td>A</td>
<td>A</td>
<td>D</td>
</tr>
<tr>
<td>Calculate Electric Power</td>
<td>C</td>
<td>B</td>
<td>A</td>
<td>D</td>
</tr>
<tr>
<td>Group B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculate Gas Mileage</td>
<td>A</td>
<td>A</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>Group C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assume Capacity of Electric Generator</td>
<td>A</td>
<td>B</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Determine Harbour Speed</td>
<td>A</td>
<td>B</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Determine Capacity of Atmospheric Condenser</td>
<td>A</td>
<td>C</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Assume Capacity of Boiler</td>
<td>A</td>
<td>C</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Calculate Capacities of Tanks in Engine Room</td>
<td>A</td>
<td>C</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Calculate Capacity of Lubricating Oil Pump</td>
<td>A</td>
<td>C</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Determine Capacity of Water Pump</td>
<td>A</td>
<td>C</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Calculate Cooling Water Heat Balance</td>
<td>A</td>
<td>C</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Determine Cooling System</td>
<td>A</td>
<td>C</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Calculate Capacity of Deep Tank</td>
<td>A</td>
<td>C</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Determine Capacity of Exhaust Gas Economizer</td>
<td>A</td>
<td>C</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Calculate Capacities of Air Tank and Compressor</td>
<td>A</td>
<td>C</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>Calculate Steam Heat Consumption of Fuel Oil Settling and Service Tank</td>
<td>A</td>
<td>C</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>Calculate Capacity of Fuel Pump</td>
<td>A</td>
<td>C</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>Calculate Capacity of Lubricating Oil Purifier</td>
<td>A</td>
<td>C</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>Determine Capacity of Distilling Plant</td>
<td>A</td>
<td>C</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>Calculate Radius of Main Shaft</td>
<td>A</td>
<td>C</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>Calculate Capacity of Package Air Conditioner</td>
<td>A</td>
<td>C</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>Calculate Capacity of Air Machine</td>
<td>A</td>
<td>C</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>Calculate Capacity of Package Air Conditioner</td>
<td>A</td>
<td>C</td>
<td>C</td>
<td>A</td>
</tr>
</tbody>
</table>

(See Table 1)
Interview Result

Group A
(To transfer knowledge about these tasks is difficult)

Group B
(An engineer can do this task by himself/herself)

Group C
(These tasks are done by the engineer. Classified not Group A nor Group B)

Group D
(This task is carried out by other team)
Discussion - Software

- Create and Edit Workflow
  - Writing workflow by reminding tasks of regular design process is not so difficult (one day is enough for creating this workflow)

- Associate Documents to Workflow
  - Associating existing design documents with workflow by drag and drop is easy work and not a burden for design engineers
  - Simple operation of client software supports engineers to input their knowledge into system
Discussion – Knowledge Acquisition

- **Group A**
  - Through structured and informal interview, it turns out that tasks in Group A contains negotiation work. And this negotiation work makes it difficult to transfer knowledge about tasks.

- **Group B**
  - In this workflow, “Calculate Gas Mileage” is the only task classified Group B. Failure in this tasks will affect whole project because this is an important design constraint, but it is not a difficult task.

- **Group C**
  - Most of tasks in this workflow are classified in Group C
  - These tasks can be learned from existing design documents and limited experience

- **Group D**
  - Tasks in Group D are done by other team or department.
Discussion – Knowledge Acquisition

- To transfer design knowledge about the workflow efficiently.
  - Training such as on-the-job training should focus on tasks classified Group A
  - Group B and Group C should be learned from existing documents. UT-ESS provides efficient retrieval of documents.
  - From a knowledge transfer point of view, tasks in Group D can be skipped.
Conclusion

- Knowledge acquisition method using UT-ESS can be applied to design process of machinery arrangement and represent the design process
- Knowledge acquired by this method is valuable for knowledge transfer
  - Direction of knowledge transfer is shown by analyzing interview results
Future Work

- This method analyze current design process only for knowledge transfer. The results should be helpful to make the design process better.
Thank you