Designing Graphical Interfaces for Design Rationale Search & Retrieval

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Abstract
Design rationale (DR) explains why an artifact is designed the way it is, which is well recognized as critical information for designers in design reuse. The existing DR systems largely rely on human effort to capture DR which cannot discover DR from a large amount of archived design documents. Therefore those systems have limited features in helping designers to explore DR information from a holistic view. Our DR system focuses on discovering DR from archived documents (i.e. patent documents) and providing DR search and retrieval based on the proposed ISAL model. In this paper, we report our effort in designing graphical interfaces for our DR search and retrieval system, which provides interactive visualization of holistic view of DRs from a large amount of patents and it enables search & navigation of DR from multiple aspects.

Keywords
Design Rationale, Information Retrieval, User Interface, Visualization

ACM Classification Keywords
H.3.3 Information Search and Retrieval: *Retrieval models*.

General Terms
Design, Human Factors, Management.

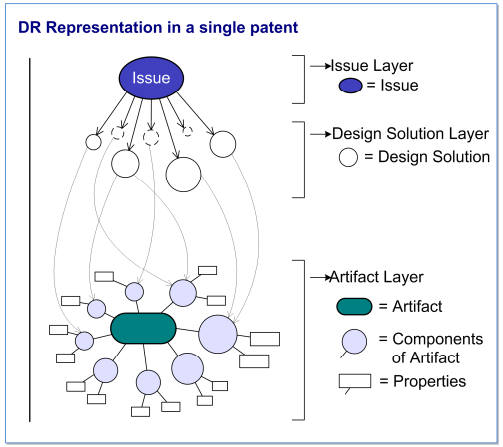

Figure 1. ISAL Model - DR representation in a single patent.

Introduction

In general, DR refers to the explanation of why an artifact is designed the way it is [1, 2]. It provides critical information to designers. Since 1970s, several DR systems have been introduced to capture DR in design disciplines, such as engineering design, human-computer interaction and software engineering [3]. Capturing DR is one of key initiatives that aim to achieve an effective management of design knowledge and to protect the company's investment in R&D. However, there are still few DR systems used in practice [3]. We observe that most of the DR systems are manual systems which can only handle a small scale of documentation and are unable to discover rationale from a large amount of archived design documents like patents. Consequently, helping designers to explore DR information is not well supported by those systems.

In this paper, we briefly present the proposed ISAL model in DR representation using patent documents and the framework of our DR search and retrieval system. Then we report our study in designing interactive graphical interfaces, which can visualize the holistic view of DRs and navigate DR search from multiple aspects, for helping designers in the exploration of DR information from patent documents.

Related Work

DR systems use different node types, such as issues, positions and arguments, and relationships between nodes to represent DR. Although many DR systems have been proposed [3], very few of them focus on DR search and retrieval.

One simple way of searching DR is the navigation approach which permits designers to explore DR by traversing one node to anther node via the relationship links [1], such as gIBIS [4] and SIBYL [5]. Similarly, the VIEWPOINTS system provides a look-up manual for finding answers and arguments to a specific problems [6]. However, the navigation process becomes severely inefficient when a larger number of answers and arguments are retrieved. Some other DR retrieval systems use a list of hyperlinks to illustrate the retrieved results. The Compendium tool supports simple keyword search and shows the relevant nodes in a list window [7]. Kim et al. established a predefined set of semantic relations for annotations between DR nodes [8]. From the previous literatures, we observe that most of DR systems rely on users to input DR information and cannot help to discover DR from a large amount of archived documents like patent documents which contain rich DR information. Consequently, those DR systems are weak in supporting designers to explore DR information from the archived documents and the graphical visualization of retrieved DR results is often limited.

ISAL Model & Framework of Design Rationale Search and Retrieval

Our ISAL model is a DR representation model which stresses discovering DR from the archived design documents like patents based on a triple-layer structure, i.e. issue layers, design solution layers and artifact layers, as shown in Figure 1. Issue layer describes motivations, shortcomings, limitations and challenges. We assume that each patent focuses on one single issue. Design solution layer describes how the issues can be solved and how the artifact can be created. This layer consists of design solution points which refer to the processes or methods that are designed to address the issue. Artifact layer explains design components, their features and properties as well as the component relations.

Figure 2 shows our DR retrieval system framework using patent documents based on our ISAL model [9]. The framework can be divided into two stages, i.e. DR repository construction, and DR navigation and retrieval.

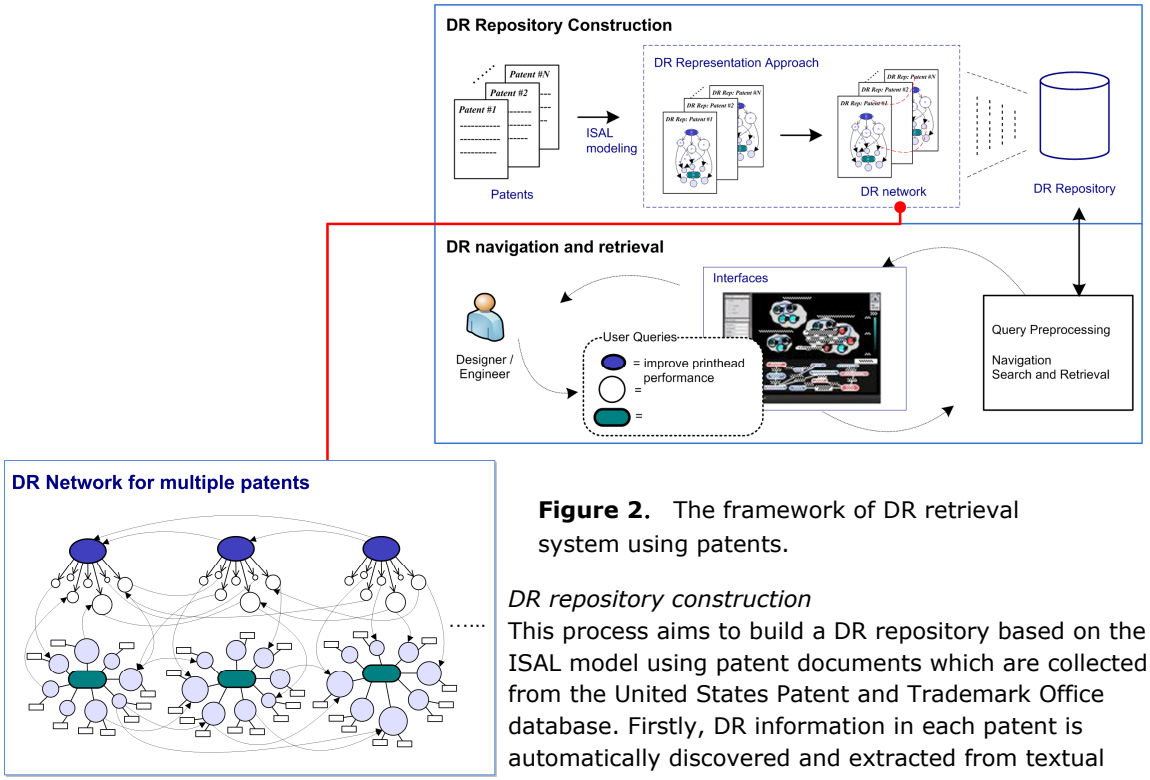

Figure 2. The framework of DR retrieval system using patents.

DR repository construction

This process aims to build a DR repository based on the ISAL model using patent documents which are collected from the United States Patent and Trademark Office database. Firstly, DR information in each patent is automatically discovered and extracted from textual patent and formed into the triple-layer structure. Then the discovered DRs of multiple patents are connected based on the weights to form a DR network. The weights represent relevance among DRs, which is calculated based on the citation information and the similarity between DRs. The DR network helps designers to understand design related information from a holistic view.

DR navigation and retrieval

Unlike typical DR retrieval systems which use query based search, our framework provides DR navigation through a holistic view and positional applications so that designers are visually guided in exploring DR information. For example, using the navigation based on the organizations, our system is able to provide DR statistics like the number of patents associated with a company in a particular domain. Besides providing overview information, the potential applications help designers to gain DR information from multiple aspects. For instance, if designers specify an artifact, i.e. "inkjet printhead" in artifact layer, the system can help designers to identify the major issues on this artifact. Also, based on similar issues, the key artifact components in the artifact layer are visualized.

Designing Graphical interfaces for DR Search and Retrieval

In this paper, we focus on designing user interface (UI) that is able to visualize the DR information from a holistic view and visually guide designers to navigate, search and retrieve DRs from multiple aspects.

Figure 3 shows the initial interface of our DR search and retrieval system. The functional bars are on left hand side. The search bar provides navigation functions based on some predefined categories, i.e. company and year, and search functions based on phrase-query by specifying either Issues, Solutions, Artifacts or patent number. The analysis bar provides several potential applications which help designers to explore DR from multiple aspects. For example, designers can input an

Issue query like "design high quality printhead", the relevant DRs results will be provided by the system and presented in groups based on default category, i.e. company. If the user chooses the category year, those DRs will be presented based on timeline. Also, the user can select the function like "key components identification" in the analysis bar, the key components related to those issues will be highlighted. We will show this in Figure 4. To get started, designers can use the navigation function by just zooming in and out, rotating, etc. Navigation in our interface design relies on the concepts of DR space. By default, the graphical representation on the right hand side demonstrates the number of patents according to organizations using the concept of galaxy. Patents filed by the same organization are visualized in the same galaxy. The colors of galaxies represent different organizations.

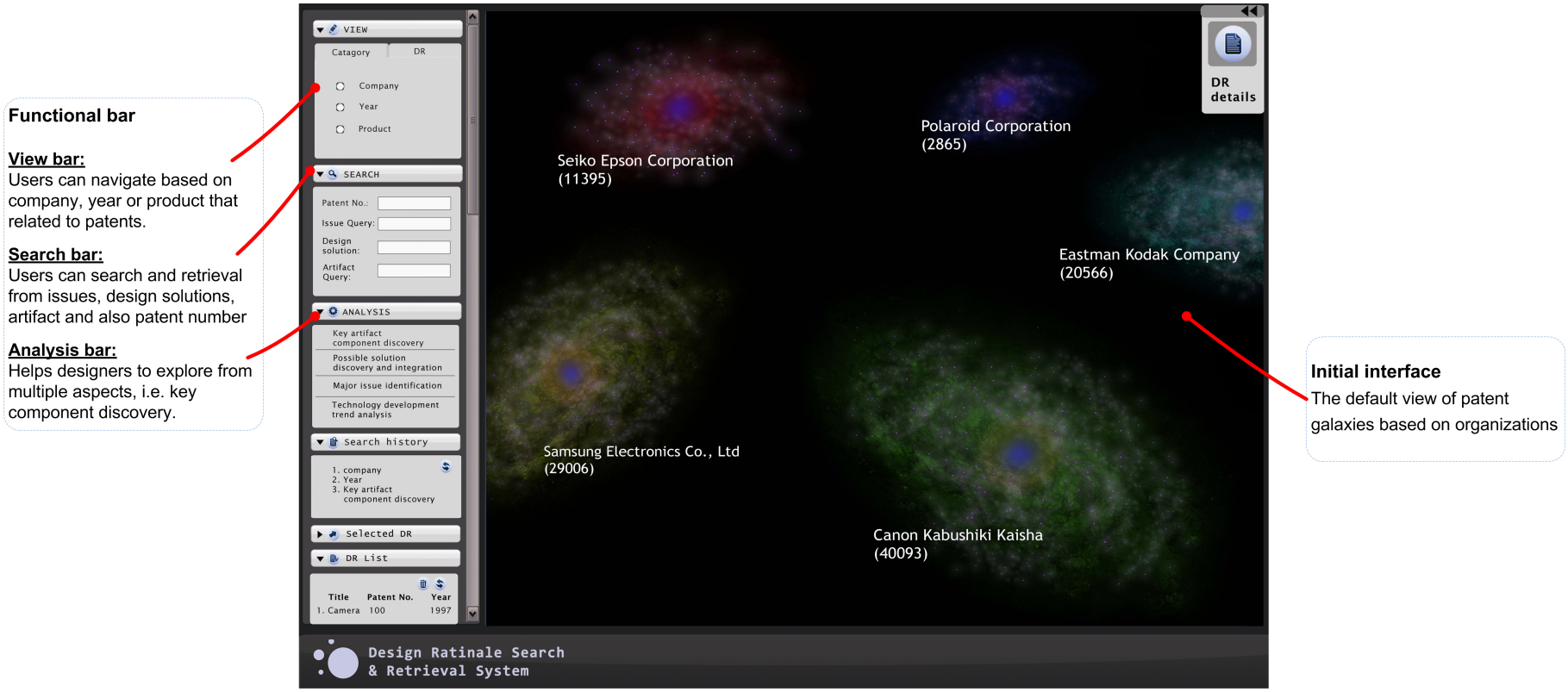

Figure 3. The initial interface of DR search and retrieval system using patent documents.

The density of the galaxy intuitively represents the number of patents. When users zoom in one of the galaxy e.g. Hewlett-Packard, using the mouse, it illustrates the sub-galaxy of patents based on three main types of patents, i.e. utility patents, design patents and plant patents (this figure is not shown). In this macroscopic manner, a designer can quickly understand the basic research and development strategies of his company and other organizations.

When continuing zoom into a sub-galaxy, the designers are guided to the DR space in which the DRs are grouped based on different products, such as printers, scanners and cameras (this figure is not shown). If users further zoom in one kind of product, their issue groups, which are formed based on the issue layer in our ISAL model, are presented (as show in Figure 4). For example, in Figure 4, three issue groups which are relevant to the printhead are shown in the upper window on the right.

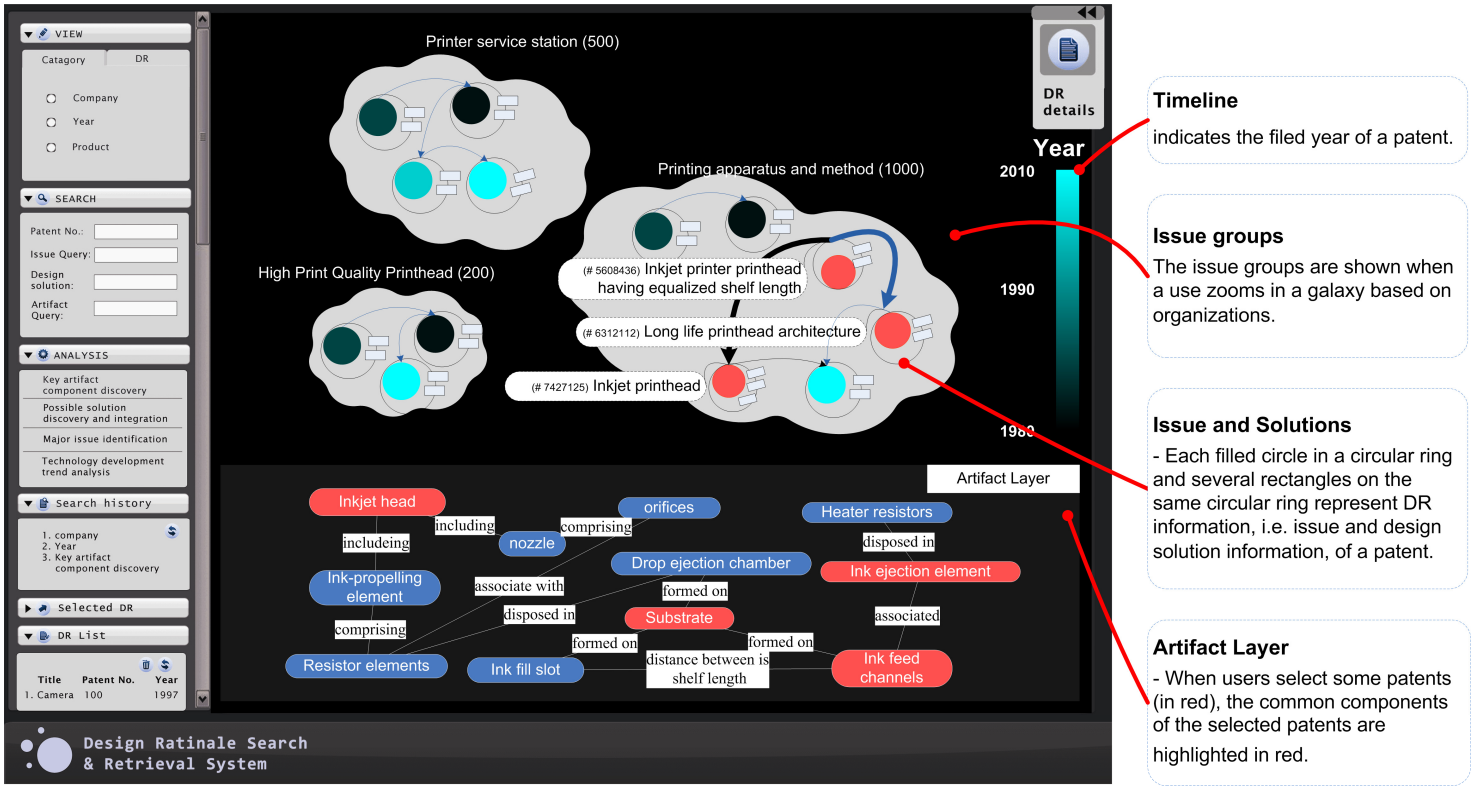

Figure 4. The DR information and their relations.

Based on the size of each issue group, designers can quickly understand which issues have been received much attention in the previous designs. In each group, the filled circle in a circular ring and the rectangles on the same circular ring jointly represent DR information, i.e. issue and design solution information, of a patent based on our ISAL model. The filled circle represents the issue and the rectangles denote the solution. The color of each circle presents filed year of each patent according timeline bar on the right. The links between DRs show their relevance, the thicker the link the higher the relevance. Meanwhile, the arrow points from the old patents to the new ones. The window on the bottom shows the overall artifact structure in the artifact layer. When users select some patents, their relevant DRs, or their issues and solutions in the groups, their relevant components in the artifact layer will be highlighted, say in red color with a 3D effect. In this way, designers can quickly gain insights of the hardware structure in different DRs.

Conclusion and Future Work

In this paper, we have presented our work on graphical interface design for DR exploration from a large amount of archival documents. The visualization of DR is able to show the holistic view of DR information and relations between them. Through the visual navigation, it helps users to find DR information, e.g. issue groups and key artifact component suggestion, conveniently. We are currently researching the visualization of other DR analysis components, e.g. major issue identification and technology development trend analysis.

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References and Citations

[1] W.C. Regli, X. Hu, M. Atwood and W. Sun, 2000, A Survey of Design Rationale Systems: Approaches, Representation, Capture and Retrieval, *Engineering with Computers*, 16 (3): 209-235

[2] J.T. Lee, 1997, Design, Rationale Systems: Understanding the Issues, *IEEE Expert-Intelligent Systems & Their Applications*, 12 (3): 78-85

[3] J.E. Burge and R. Bracewell, 2008, Special issue: Design rationale, *Ai Edam-Artificial Intelligence for Engineering Design Analysis and Manufacturing*, 22 (4): 309-310

[4] J. Conklin and M.L. Begeman, 1988, gIBIS: a hypertext tool for exploratory policy discussion, *ACM Trans. Inf. Syst.*, 6 (4): 303-331

[5] J. Lee, 1990, SIBYL: A qualitative decision management system, in *Artificial intelligence at MIT expanding frontiers*, MIT Press, 104-133

[6] F. Gerhard, C.L. Andreas, M. Raymond and I.M. Anders, 1991, Making argumentation serve design, *Hum.-Comput. Interact.*, 6 (3): 393-419

[7] S. Shum, A. Selvin, M. Sierhuis, J. Conklin, C. Haley and B. Nuseibeh, 2006, Hypermedia Support for Argumentation-Based Rationale, *Rationale Management in Software Engineering*, 111-132

[8] S. Kim, R.H. Bracewell and K.M. Wallace, 2005, A Framework for Design Ratioanle Retrieval, in *International conference on engineering design*

[9] Y. Liang, Y. Liu, C.K. Kwong and W.B. Lee, 2009, A Design Rationale Representation Model Using Patent Documents, in *The 2nd ACM workshop on Patent information retrieval*