Design_net: a online knowledge gateway for industrial design education and research activities

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Abstract

This paper presents Design_net, a knowledge-based system to the online digital display, retrieval and archiving of rich media resources for industrial design education and research. It addresses the needs of end-users (teachers, researchers and students) and content providers interacting with the School of Design of the Politecnico di Milano. The project moves from the assumption that traditional modalities of archiving and presentation currently adopted by the Politecnico and other academic institutions are not coherent with industrial design process and its need of project-support materials. The typical outputs of industrial design process are 3D models or 2D graphics, not just texts or simple images, the materials for which the usual method and technique of archiving and retrieval are conceived and developed. The challenges, philosophy and methodology in creating this evolving Web-based, cataloguing, multimedia knowledge-base to VR design resources are discussed. Finally, the related system and prototype are described.

1. Introduction

1.1 Design_net and industrial design education at the Politecnico di Milano

Design_net system originates within a wider program of the Politecnico di Milano, focused on developing digital tools to support the teaching and research activities of professors, researchers and students of the School of Design [1]. It aims to be a digital, multimedia design knowledge gateway [2], to satisfy the dynamic information needs of the academic community in the interdisciplinary industrial design field. At the same time, Design_net aims to nourish documentation and experience's exchange and creation. Its goals are to create tools to enabling the efficient management, retrieval and visualization of 3D and 2D resources within an open, integrated and collaborative structure.

Multiple levels of description, established criteria and standards are meant to guide the selection of resources for inclusion in the collection. Information Retrieval tools were selected to perform "creative" and personalized visualization, recombination and interaction with documents and with design community members.

This system is deeply connected to the dynamic structure and organization of teaching of the Industrial Design Degree: experimental research on new didactic methodologies and tools and a systematic weaving of relationships with professionals, companies, associations and design-related institutions. It's a novel inductive approach to the organic and integrated training for the design project, meant as an interdisciplinary "knowledge acquisition process built around a 'doing' methodology" [3], which parallels current transforma-

tion in the design productive system, such as digital prototyping processes, rendering techniques, digital mockup. Among characteristics of the project practice and teaching particular attention has been dedicated to the "meta-project" phase: collecting of necessary information, knowledge acquisition, and elaboration of conceptual and operative tools.

1.2 Project-related resources

To be effective, a gateway for the industrial design project must deal with specific typologies of heterogeneous resources used in design practice, such as multimedia files. For those resources is not possible to use traditional cataloguing standards and search engines, as their performances degrade with multimedia data, made of images, 3D models, 2D graphics and sounds instead of words. Project-related resources within the School of Design are specifically characterized by:

1. an exceptional richness and heterogeneity of typologies concerning products, processes and strategies: mostly multimedia documents (both 2D and 3D files) with a small percentage of textual materials (mainly grey literature, informally published material harder to identify and to obtain and difficult to organize), marketable goods, semi-manufactured products, material samples;
2. diversified typologies of content providers and of users: students, professors, researchers, design professionals, companies;
3. acquisition and conservation modalities with no standardized procedures, so that most of those materials often results "invisible" and hasn't got a defined and organized location through time.

Those complex features don't allow easy usability, transfer and visualization of design knowledge, which is mainly visual and manipulable (thus difficult to be formalized through procedures). Furthermore, design creativity is iconically manifested. Project-related resources in a networked and online environment require therefore different cataloguing, retrieval and visualization rules and tools from those elaborated for traditional documents. In the design field it's essential to perceive, compare, organize, link and interpret as many forms of knowledge expression as possible within a community, bringing people together around a pool of quality information. As the president of a knowledge management company states, "to leverage knowledge we need to enhance both thinking and information (…). The technical challenge is to design human and information systems that not only make information available, but help community members think together" [4].

1.3 Needs and solutions

Among tools supporting design didactics and research, hypertext tools are currently preferred, despite having significant limits. Hypertext-related documents are typically written texts, with currently no possibility of creating semantically autonomous paths through heterogeneous documents, differing in format and in media type. A hypertext system is not equal to a hypermedial system, which allows autonomous navigation, creation of personalized learning paths, and interrelation of documents based both on description and content. This clearly constitutes a limit, since interdisciplinarity is a distinguishing mark of design teaching, along with teaching how to interrelate different disciplinary areas and their referring documents. Another limit of both current hypertext and hypermedia systems is the absence of ad-hoc interfaces, enabling the user to exploit the potential of multimedia to originate synesthetic, explorative and immersive experiences, necessary to the development of novel relations among heterogeneous digital knowledge bases.

To avoid those problems we chosen to create a rich media database using a metadata repository stimulated by current experiences from other digital library projects.

After analysis of a variety of schemas, we selected DublinCore Metadata Schema [5], a recognized standard allowing simplicity, flexibility, interoperability and modularity. Dublin Core was specifically created to provide a metadata vocabulary of "core" properties. It's semantic model allows to offer basic descriptive information about any kind of resource, independently from the media format, area of specialization or origin. Distributed resource description with Dublin Core is feasible and practical, content providers and staff can readily use it.

A Web client/server architecture was preferred as it enables remote access to resource in ways not easily possible with conventional applications. Changes in server based information can be made immediately and collectively available. Simultaneous collaborative sessions are possible. Access control provides a mechanism for creating multiple user classes having different access rights to the information. Web servers were chosen to serve content over the Internet using XML. The XML documents are used for specifying queries and visualizing text, images, movies such as information supported by Web browser. The Web server accepts requests from browsers like Netscape and Internet Explorer and then returns the appropriate XML documents [6].

The main advantage of the adoption of those solutions is that it provides meaningful access to valuable and validated resources. As a metadata repository, the system shows what kind of resources we have, what is their meaning within the context of industrial design, where they are located, how they were acquired and which retrieval modalities are necessary to access them in a distributed and integrated environment. Those documents are finally made "visible" and accessible through a combination of a more industrial designer-friendly interface and cataloguing and retrieval tools shaped for industrial design issues. In this way the Design_net framework can represent a powerful aid within the training of the industrial design project, and in the design process.

2. The system

2.1 Using subject gateways and digital libraries

A wide variety of methodologies, languages and technologies available in digital libraries and other resource repositories are often commonly used in design teaching and in project development. Design_net gateway has been conceived as integrated database to bring together collections, services and people in support of creation, dissemination and use of industrial design knowledge. It features a searchable, browsable digital library of high quality resource collections and services, specific interface modalities and recognized standards that allow interoperability with other collections, to provide different types of users and content providers (departmental and interdepartmental laboratories and archives, museums and companies) access or add contents in a user friendly manner.

2.2 Working collaboratively

In the creation and maintenance phase of the project, a collaboration mechanism among content providers and content engineers (IT specialists) has been established. We use two distinct communication areas:

- periodical face-to-face meetings and online chat rooms for the Design_net project team, content providers and content engineers;
- online white-boards for message exchange and e-bulletins for user feedbacks.

Technical and theoretical documentation of the system are available online. Access modalities are diversified for project team members, content engineers, content providers and users. A dedicated unit collaborates with content provider in the thesaurus development and in the identification of new resources to be included in the gateway, according to predefined selection criteria. Cataloguing records are partially automatically completed in the case of digital objects. The unit validates the proposals and verifies online the accompanying records, which are then included in the gateway database.

2.3 Metadata schema and protocol

At the School of Design there was evident need for access to materials typically not considered by traditional bibliographic metadata, as they were designed for analogical and static resources. As already mentioned, the application profile schema used in the project is based on Dublin Core Qualified Schema, implemented for the use of XML and adopted worldwide. The standard schema is composed of 15 elements (remained unchanged) and a subset of qualifiers, which we modified and integrated according to our needs, upon the examples of other Dublin Core projects. For instance in the "Type" element a "Audiovisual Resource" qualifiers was added to integrate the existing "Interactive Resource"; in the "Creator" element we added "Personal Address", "Personal Role", "Corporate Address", "Corporate Role" qualifiers; in the "Description" element "Sample Material", "Environmental Requisites", "Manufacturing Technologies" qualifiers and so forth. OAI Protocol for Metadata Harvesting is being implemented for interoperability. This allows to share our resources via the Web with other communities, using commonly understood semantics and choosing the richness of description, and to provide unified access to databases within different underlying schemas.

2.4 Indexing and retrieval: the Industrial Design Thesaurus

The development of a visual retrieval system for 2D and 3D in Design_net is ongoing, but it is also essential to have a textual retrieval system in order to provide a unified integrated access to data. Unlike current automatic thesauri, manual thesauri improve the precision for descriptions and subject access to resources, enabling more exhaustivity, specificity and flexibility than classification and subject headings. Their creation is easy for traditional textual material, while is complex for 3D Virtual World and 2D animated graphics, which hasn't been created to be catalogued and in which textual data are implicitly contained but not explicitly declared [7].

Design_net project team is working on the development of a term-based approach. There are practically no thesauri in Italian specifically created for the field of industrial design. It was decided to develop an in-house Italian Industrial Design Thesaurus for our needs, selecting and organizing terms according to the main issues in the project creation. We referred to ANSI/NISO standard and manuals [8], to pre-existing thesauri and to the direct experiences of the School of Design Community members. Parallel to the Industrial Design Thesaurus is the elaboration of authority files of companies, institutions and relevant people of the industrial design world, with particular attention to Italian industrial design districts.

2.5 Management and visualization of multimedia and heterogeneous resources

A crucial problem of heterogeneous resource collections in Web-based applications, often preserved in different repositories which have adopted different standards and formats, is their management and visualization with a homogeneous interface. In Design_net,

metadata are associated to resources inside a RDBMS with a Web interface appositely created. This allows effective and proven methods for information retrieval and manipulation through exploitation of Java e eXtensible Markup Language (XML), access to metadata but also to the very same resources (using a clear codification of archival standards for digital resources). Visualization is supported by previous selection of current available standards (PDF, JPEG, VRLM, MP3, Real, QuickTime), to assure portability on different platforms.

Traditional data visualization focuses on descriptive textual approach of query results. Design_net's aim was to render data accurately while highlighting important patterns, introducing coherently codified graphical elements. This "semantic visualization" approach [9] introduces assessments of the meaning and relevance of the data into the visualization evocative process. We do no think in pure abstractions, rather, our thinking is metaphoric. In the design field, in particular, the rich visual data articulation requires a kind of visualization presenting a similar degree of iconicity and similarity.

A number of information needs manifested by the School of Design community were also investigated: the possibility of finding resources (especially visual ones) that other subject specialists in the community have rated highly, having search results filtered or ranked according to rules based on a quality-related property of the resources listed, knowing other users' exploitation of specific resources, tracking emergent trends and evolving patterns.

3. The prototype's implementation

3.1 System architecture

The heart of multilayered structure Design_net Metadata Management System (fig. 1) is Design_net framework, based on a J2EE platform and on a Dublin Core data structure. The framework is a set of tools which enables to create, catalogue and search every metadata recorded within the database. It's possible to import metadata from other archives using different metadata schemas, such as UNIMARC or VRA (efforts concerning the use of MPEG-7 are undergoing). The system operates over a remote connection to a server or a standalone application.

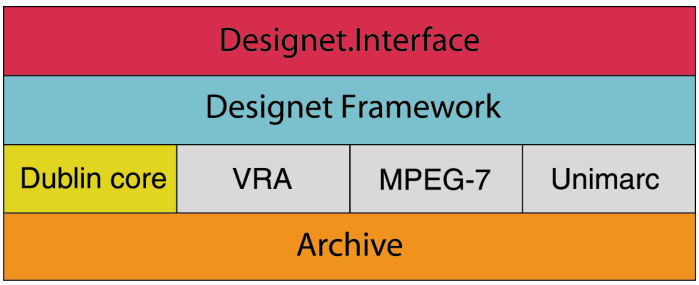

Figure 1 Schema of Design_net Metadata Management System

Content is collected, selected and processed with metadata creation and validation (fig. 2). Typical user of the system is people looking for or interested in making available specific, reliable and updated resources to be employed in a industrial design project, either for educational or professional purposes. The Industrial Design Thesaurus is an information storage and retrieval tool: it's used both by indexers (as a listing of words and phrases authorized for use in an indexing system, together with relationships, variants and synonyms) and searchers (as aids to navigation and retrieval, sitting behind a search interface

and facilitating searches without requiring users to interact with it as a separate operation). A metadata editor designed by the Designet project team provide a template for creating records, a RDMBS repository stores the records and a application provides a searchable and browsable interface.

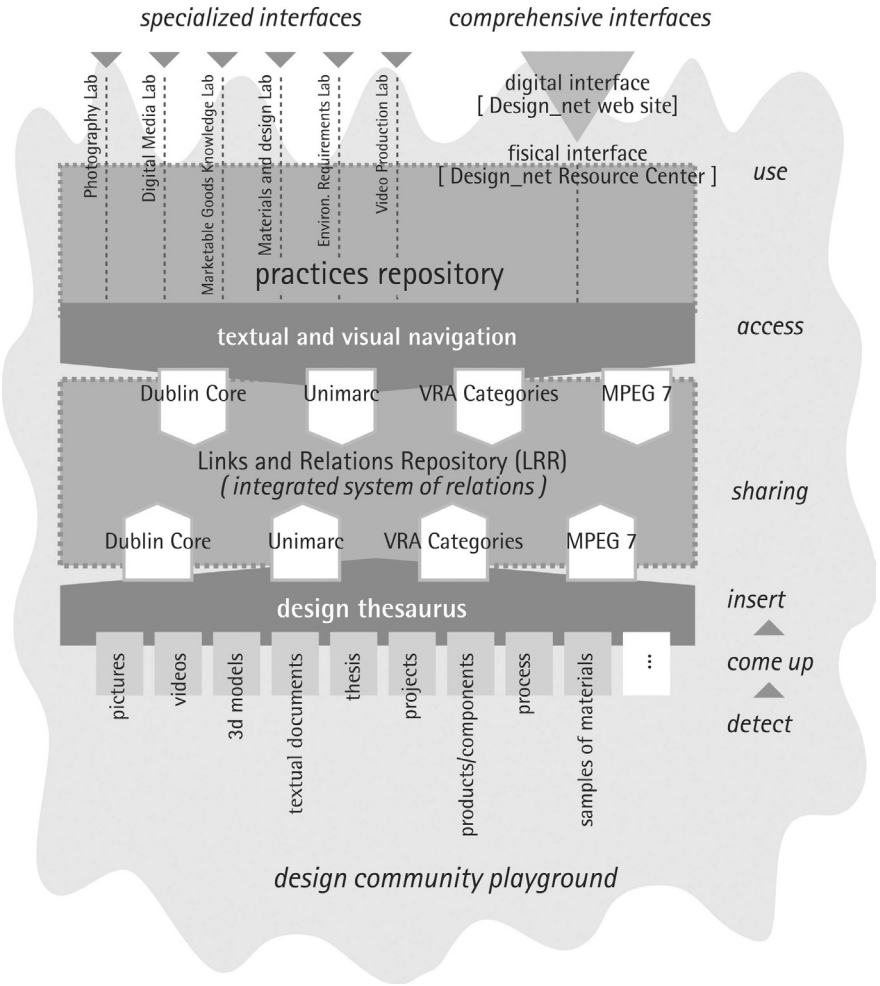

Figure 2 Workflow of Design_net system

In order to represent semantic values while searching documents, dynamically build schemas are provided to help users in the retrieval and to evoke the context of the searched resources, in terms of quantity and typology. The system supports different methods of search and shows users their search path to build a major consciousness of the researching context and methodology. The user can play with many different parameters, starting with the keywords. In the main search page we can filter results by keyword or document type, change values, see the table listing, ask for the metadata of a resource. To trace our activity we can use tags to insert an object into advanced bookmarks listed by category or related to a real active or past project. Users can see this tag and be able to ask the system such information.

3.2 Components

Design_net system includes components that reside both on the server and client sides. On the server side a Web server serves client requests for static and dynamic content. The visualization and query architecture is a typical client/server architecture based on four main components:

- open relational database management system (RDBMS)
- Web server
- Web browser
- server side Web-oriented language and communication software to dynamically retrieve the contents.

In the overall, we employed: server-side technologies to increase the power of the server beyond its ability to deliver XML pages, a RDBMS with compatible driver JDBC 2.0, an application server WebObjects™ compatible and a Apache 1.3.9 Web server or Microsoft IIS 5.0.

The client-server process is the following: the client sends a request for information to the http server using the XML browser; the Web server processes the request and returns the data statically or dynamically to the client station. According to the request and the type of the data received, four fundamental phases can be distinguished: identification, query, visualization and navigation, manipulation. The requested information, in form of XML document, e.g. a table with text data or a 3D model, is visualized in XML at the client station.

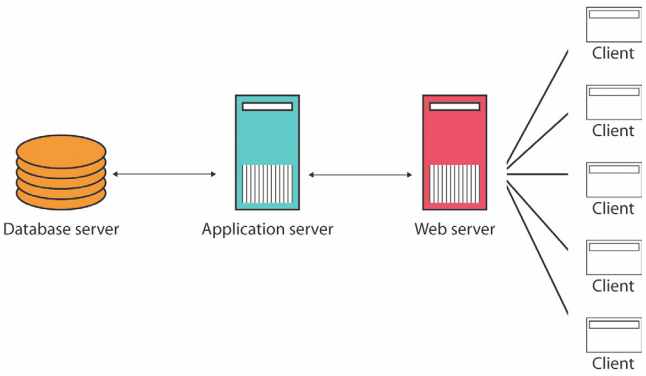

Figure 3 Simplified schema of core elements of the system

3.3 Features

The system features a single point of entry for the user to cross-database resources, provided knowledge-based retrieval with dynamic visualization; advanced search and browse functionalities; sections with on-going projects, latest resources added, documentation for Design_net Team members and users (with glossary, resource selection criteria, metadata manual, progress report, publications); conference and events notice board to promote Italian design knowledge; electronic forum; updated lists of industrial design companies, associations, people; possibility of sharing files with others on the Internet through upload and download; online white-boards for message exchange and e-bulletins for user feedbacks.

3.4 Graphics User Interface (GUI)

Graphic elements collect search results as homogeneous sets, according to the keywords adopted in the search. The keyword-based search can be compared to drawing a line on a blank sheet, an *incipit* to enclosure a field of interest. The system then builds a map to let us find resources "near of". Beside the map there's a traditional listing of the best results, the way a search engine usually creates, but the added value is the academic accreditation. The map let us combine many parameters included in the metadata fields. With a dynamic visualization we can "play" with parameters, keywords and filters to adjust the "target" of our search (figg. 4-7). Search refining is made on a single dynamic

page, but the system logs all our activities and saves our path of search, to be eventually shown later. Each object is placed into a context inside the target, but the type of relationship shown by the target can change. For example, we can select a group of objects and switch the visualization from keyword-ranking to users-ranking and see how users employed the selected resources. With this method we can ask the system to show what 3D model or 2D graphic files were used by somebody else while searching on a particular topic and learn how others used resources. The user profile too can be used in the retrieval.

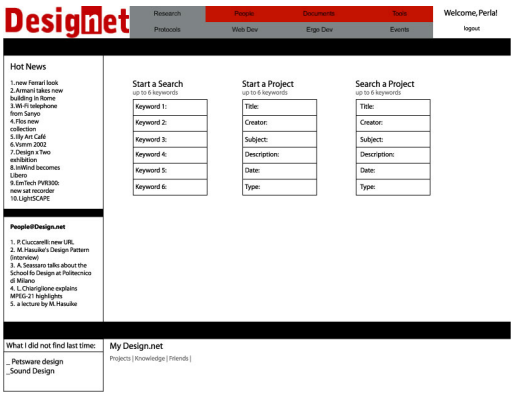

Figure 4 Design_net website homepage

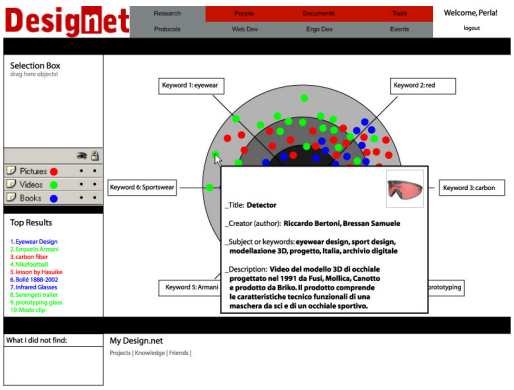

Figure 6 Pop-up windows with one of the searched records

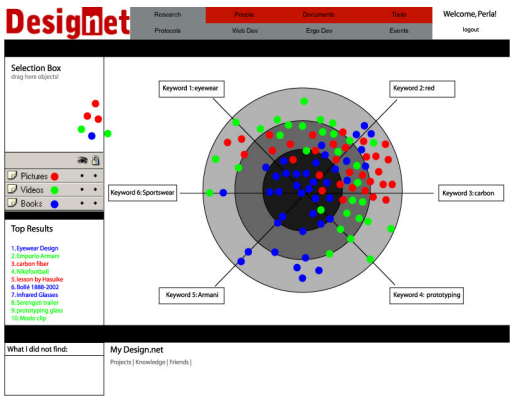

Figure 5 Design_net interface showing query results

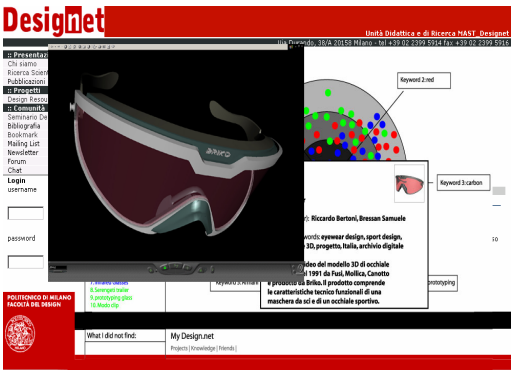

Figure 7 Visualization of a VRML model of the selected record

3.5. First results and problems encountered

The complexity of such a system implies several problems during the implementation phase. The latest version of the prototype showed bugs concerning mainly the import modules of metadata coming from other schemas. Metadata mapping is not a mere automatic operation, as every metadata schema derives from a particular cultural and operative background. For instance, MARC schema (used worldwide for cataloguing books and periodicals) has more than 800 fields and presents many local "dialects" (UNIMARC, USMARC etc.). At the same time, importing data from other archives using Dublin Core has highlighted different interpretations of elements and qualifiers. Additional qualifiers to further refine the meaning of a resource allow the application to increase the specificity of the metadata. Unfortunately, they often introduce additional complexity that can make

metadata less interoperable. This problem should be solved with the implementation of a module that will signal to the operator discrepancies in the imported data.

Another crucial issue is the GUI implementation. As Design_net system is constantly evolving, the interface changed over time during the course of the project and will change again in the near future. More investigations and experiments are needed to develop GUIs allowing both content providers, project-team members and end-users to effectively use the system. The current interface is quite simple but allowed us to focus and solve issues concerning the entire Design_net framework.

4. Conclusions and future works

The gateway is being continuously monitored and tailored on user's demands. As the system evolves, efforts will entail:

- further investigation on visual retrieval techniques and personalized retrieval
- implementation of GUI and personalized information environment
- implementation of thesaurus and of multilingual access tools
- investigation on access with palm and UMTS technology
- targeted services such as a live discussion series on current issues, online exhibitions and events, newsletter, video interviews, scholarly publications.

In a longer-term perspective, Design_net will provide new challenges for design education, research and professional activities, as a effective system of transferring, integrating and stimulating design knowledge sharing and creation.

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