

Implementations and Applications of DesignMap: Case Studies to Manage an Online Database of Visual Designs

Yoshihiro Kobayashi and Wael A. Abdelhameed



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This research introduces state-of-the-art techniques in the areas of online libraries, communities, and forums. The research endeavours to describe a computer system called DesignMap that could be categorized as a visual design forum. This system encourages networking and can also be applied as a visual design library. The DesignMap system, which manages and displays a massive number of visual designs in two and three dimensions, was presented and discussed in a previous research. This project, however, is concerned with the application of DesignMap as a tool to search, visualize, modify, and then add designs in a map; these designs are classified based on their formal properties of object relationships. DesignMap users have access to any part or category in the map. The resulting design series created by users of this system present a new and unique form of design collaboration. The research also investigates several applications of the DesignMap system.

I. INTRODUCTION

This paper describes our objectives in creating DesignMap, and presents state-of-the-art areas of related projects and research, introduces the framework of DesignMap, illustrates the concept and outcome of the program, proceeds to depict the main functions and main panel of the program, presents case studies, and finally concludes with the future implementations and potential applications of DesignMap.

DesignMap is a computational tool that not only enables form generation and manipulation through a modelling system, but also saves the created forms in series based on their formal properties. This computational tool acts as a network design environment, which is accessible by architects and urban planners through the Internet.

2. OBJECTIVES

The major objective of the research is to introduce an online interactive design library in order to have a database on the process and outcome in two and three dimensions. Architects and urban planners can use this library to search for a specific design in a certain form category, modify a design, and save the new one in a corresponding category of the map. The other research objectives concentrate on novel applications of the main objective as an innovative avenue to apply the visual design database.

3. RELATED RESEARCH WORK

Many researchers have presented different contributions to share various kinds of data via the Internet, through which users in different places would be able to communicate or to shape a forum with the same interest. In order to manifest the novelty of the research contribution, the following part of the research reports the main contributions made in the areas of networking and online communities and forums, respectively.

3.1. Networking

A project developed at Sasada Laboratory at the University of Osaka in Japan was one of the initial attempts in the area of networking. Sasada (1995) proposed even before employing the Internet within designing, that computer graphics, including computer generated animation, is a powerful communication medium and makes collaborative work easy. Sasada investigated and presented the demonstration of how these technologies, along with computer graphics through networking, can help solve problems of three dimensional designs in the architectural design process [1].

Fukuda, Nagahama, and Sasada (1997) developed Open Development Environment, an approach to allow various people separated by great distances to work together on a given project and to introduce computer simulation into the working environment [2].

Kepczynska-Walczak (2004) reported a discussion on sharing knowledge and experience in the field of digital preservation between universities which are members of the eCAADe organization, through investigated preservation metadata formats, and information management comprised of a proposed set of four inter-linked stages: creation, storage, dissemination and re-use [3].

In 2006 Matsumoto, Kiriki, Naka, and Yamaguchi proposed the collaborative design education program on the web based on “Plan-Do-See cycle” process model, and developed the special Design Pinup Board system for running it. The program focuses on a very limited environment including: distributed collaboration beginners, asynchronous, first meetings, and plural teams [4].

In the same year Rügemer reported considerable enhancements of the design development, construction document, and construction phase, by using digital media as a communication and information tool. The process demanded a highly articulated project description in text and images that were refined and exchanged daily; therefore, this helped to strengthen the cooperation between the design team and the project consultants toward a more team-related and democratic structure [5].

Additionally, Murakami, Morozumi, Homma, and Onishi described a new function for collaborative design teams, by developing an information exchange and sharing system, and making improvement on it through a collaborative design studio [6]. And Yamashita et al. developed a collaborative design environment which considers information and communication technology and architectural space. A computerized prototype environment for collaboration was proposed in an attempt to support synchronous design collaboration in a face-to-face meeting at a local site and also in a continuously connected project-room at distributed sites [7].

3.2. Online communities and forums

The initial contributions made in the area of online communities and forums were limited to the sharing of various kinds of data that are related to the design process or designs. Later on this use was developed further to include visual data such as different kinds of plans of a project or design.

In 2001 Kawasumi, Morozumi, Shounai, and Homma maintained that although web pages and simple script, such as the digital bulletin board, are generally used for network collaboration, these systems require extra work for a designer to present his or her proposal on the web. Consequently they proposed the Visual Pinup Board that allows handling the registered design proposal like an actual pinup board and also can be used with common web browser [8].

Chien and Shih developed a web environment to support the customization process of construction and enable efficient management and

synchronous exchanges of information. The environment provides three levels of design interaction to encourage user participation in a controlled customization process [9].

Elger and Russell present Net-Studio, a virtual design studio where the environment for presentation, criticism and communication is web based. This allows lessons learned from research into Computer Supported Cooperative Work to be adapted to the special conditions indigenous to the architectural design studio [10].

In 1999 Jung, Gross and Do introduced the 'Redliner' which lets design team members browse and leave text annotations on surfaces in three-dimensional models. They developed their research further in 2001 and 2002 introducing 'Space Pen', an annotation system with improved interaction capabilities that goes beyond simple posting. It allows users to draw on the virtual environment, and to post 3D web models [11].

Madrazo in 2000 investigated the use of the web as a medium in a pedagogic work concentrated on representation in architecture education. A web-based learning environment, 'Networking', was developed, which allows students to perform a variety of collaborative works: drawing visual and linguistic relationships, developing further the works of other students, and participating in collective processes of form generation and space perception. Madrazo proceeded to present a customized 'Networking' environment for each one of the six themes proposed in his course: text, shape, object, image, space and light [12].

In 2005 Heylighen, Casaer, and Neuckermans developed Dynamic Architectural Memory On-line, which can be described as an interactive platform to share ideas, knowledge and insights in the form of concrete building projects among designers in different contexts and at different levels of expertise. However, interaction with various user groups revealed that this platform suffers from few thresholds. They, therefore, proposed to conceive the platform as an associative network of projects, and developed ideas about how the relationships in this network can be determined and updated by exploiting the insights implicitly available in the project documentation and user interactions [13].

Subsequently, in 2006, Ise, Homma, and Iki introduced how to adopt the knowledge management in planning a city master plan and to develop a systematic tool for consensus decision-making in planning. For citizen participation, it is necessary to represent the process of an argument by arranging the information and ranking them. The tool presented by them supports a resident group for making a city master plan [14].

Also in 2006, Huang, Krawczyk, and Schipporeit proposed that a methodology could be developed by collecting and evaluating client's requirements with web technology. The proposed model presents a process of providing mass-customized prefabricated housing based on computer-aided design and a web-based product configuration system [15].

4. SUMMARY OF PREVIOUS RESEARCH

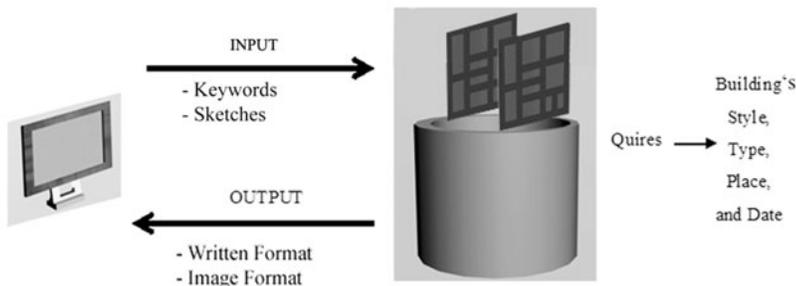
The areas of previous research can be implemented in various applications that share a major use/function described as online library, through introducing a wide stream of database from which architects or urban planners utilize what relates to the design. This function of an online library comes in two different types:

- (i) written format, obtaining the related information of a particular case of design through the exposure to knowledge from digital references provided; and
- (ii) image format, obtaining concepts or forms of design precedents, or even just viewing these precedents, through the exposure to drawings from digital references provided.

Although the two previous types of use are related and introduced together, the role of an online library is more comprehensive, prominent, and conspicuous in the second use.

Some organizational outlines described in Figure 1, which were used and applied in the online library of previous research, can be extracted and summarized, as follows:

- The indexing of databases allows using query according to some characteristics of the indexed items, e.g. in databases of building drawings the query are based on buildings' style, type, place, and date.
- The input of databases is either keywords or sketches.
- The output of databases is in either written format (information) or visual format (images).



◀ Figure 1: characteristics of the databases of previous research.

5. APPLICATIONS OF PREVIOUS RESEARCH

Accounts of creative architectural design often mention natural and artificial objects as sources of architectural form. Studies of design methods and processes often identify visual analogy, metaphor, and visual reference as important activities in creative designing [16]. Therefore, the databases of

previous research have been employed in different applications. The next sections present the main areas of such applications.

5.1. Architectural education

Databases are used in architectural education through keywords in queries via hard coded links, e.g. classifying a building with others by the same architect, or a plan of a building with photographs and other drawings. This enables architects and urban planners to search using queries formed by keyword contents (Figure 1).

Prominent uses of online library that have been developed in this area of architectural education are:

- ArchWAIS, a Multimedia Based Architectural Information System for Teaching and Learning History and Theory, by Choi, J.W.;
- Architectural Courseware, a Network Based Multimedia System for Design Education, by Tector, J. and Thornhill, C.;
- DOORS, Design Oriented On-line Resource System, by Sklar, H.;
- SPIRO, Slide Library Image Database at UC Berkeley, <http://www.mip.berkeley.edu>;
- A more comprehensive use with a possible application in architectural education has been presented through free websites for various buildings collections, for example <http://www.greatbuildings.com/>.

5.2. Various applications

Although research work has proceeded further beyond the stage of hard coded links in indexing and searching previously offered through online libraries, these progressive studies have not been applied into the Internet. These further stages have prominent applications, such as: (1) Drawing Analogies technique by Do and Gross [17], where they reported that the queries can be posed including a sketch or diagram instead of keywords; and (2) DesignRep by Ozel [18], in which she introduced a computer assisted learning system model which uses abstraction and analogies to analyze a design precedent. The aim was to build a database of a problem or sub-problem hierarchy of this precedent's problem solving stages, to be used in a similar design-problem. This is done by identifying goals, constraints and solutions for each level of precedent hierarchy.

6. DESIGNMAP

To give a sense of how the users will benefit from and succeed by using the presented map, and to frame our description of the program, we begin by briefly describing the applications, from concept through execution and documentation.

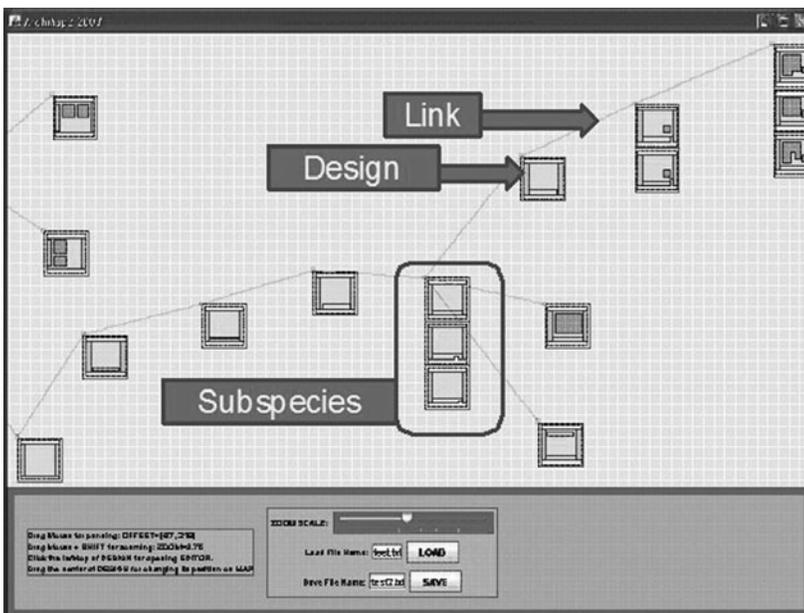
6.1. Concepts

The main concepts of DesignMap entail:

1. Creating a network application to share designs without any words for users all over the world. The database of DesignMap depends on two and three dimensional drawings easily created and comprehended by users.
2. A global community of users that search, modify, add, and categorize, without words but with 2D/3D forms (a set of spaces).
3. Generating a huge number of designs of any particular function by anonymous online users. For example, residential houses including driveway, back and front yard, garage, house, etc.

6.2. Methodology

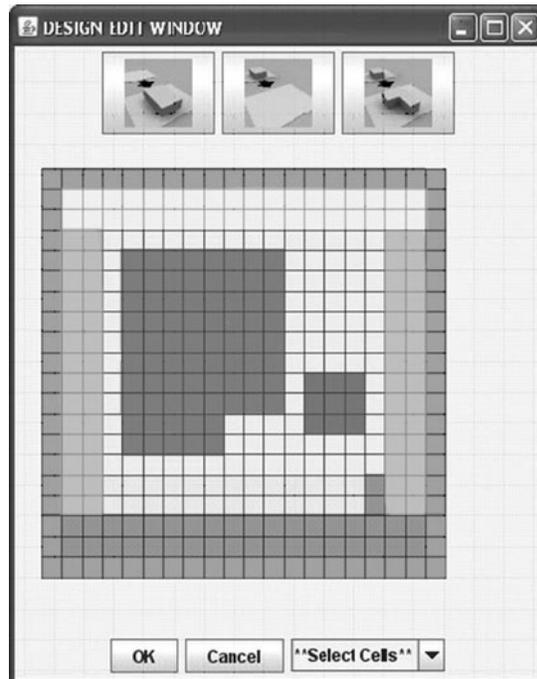
DesignMap presents a comprehensive approach to support navigation in the map of proposed generative design. This approach contains a general model of design space, basic navigation operations, and principles for designing support. The basic operations facilitate navigation activities in the introduced design map, Figure 2.



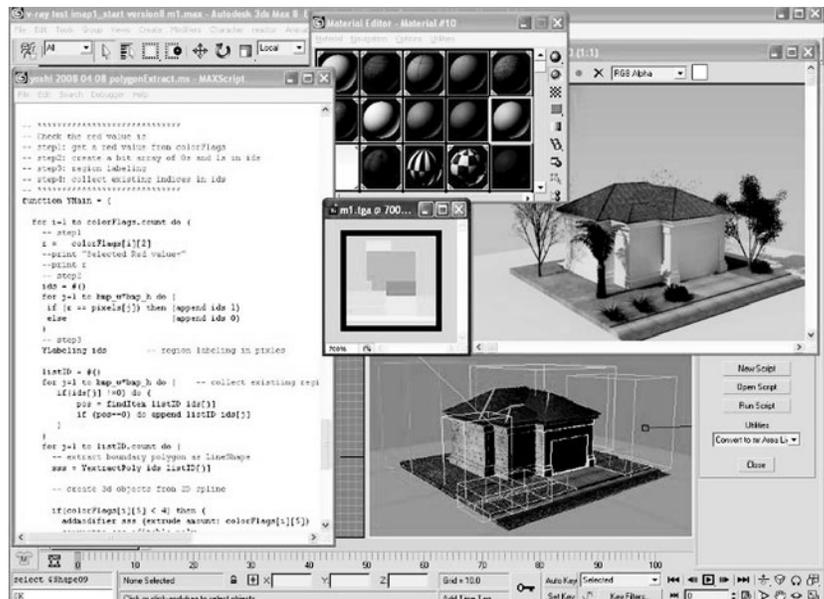
◀ Figure 2: DesignMap interface.

The DesignMap program is written in Java language. There are two methods which online users can use to create their own designs in the map: (1) using the editing window of DesignMap to create a design, Figure 3; and (2) uploading their own scripted algorithms (3DMax scripting language), Figure 4.

► Figure 3: The Design Map's editing window with a 20 x 20 grid to create or modify a design.



► Figure 4: a design made by scripting in 3ds max.



The program methodology aims at guiding users in creating their designs through the presented online modeling tool (Figure 3). Geometrical editing operations with constrains using a list of adjacent spaces are translated into

a finite automaton, which will be explained more thoroughly in the following section. The finite automaton is a main component of the methodology of DesignMap in terms of implementing the required concepts and functions.

DesignMap as Finite Automaton

A simple design process can be treated as a series of geometrical editing. Each process is a result or output of the current status. If the geometrical editing is regarded as the guides for transition functions and the collection of all design stages as a set of states, then the process can be defined as a finite automaton, which is formally denoted by a 5-tuple as $A=(S,A, i, \delta, T)$

A finite automaton consists of a finite set of all possible states “S” and a set of transition functions “ δ ” from state to state. Each state is represented as a set of symbols chosen from an alphabet “A”. One of the states, “i”, is the initial state where the automaton starts. Some states denoted by “T” are defined as final or accepting states [19].

Usually a finite automaton is used not for representing design outputs, but rather for programming state machines. The diagram shows all states in the system. On the other hand, DesignMap shows only the accepted states, whereas the unaccepted states are not visualized in the map. Some designs recognized as a subspecies are shown without linkages to the parent and children as shown in Figure 2 [20].

Methodology implementation

Through the methodology used in system implementation, three main objects are defined: Space, Design and Subspecies. Space is a list of cells occupying a grid. Each space has one property index number assigned from a predefined list such as 0 for OPENSPACE, 1 for BUILDING, and 2 for GREEN AREA. Design is a list of spaces, and is represented as an individual node in the designs layout. Subspecies is a class not for a new design but for the design whose topology is not changed from the parent design.

A new design is generally created when a new set of spaces or a new spatial relationship is created from its parent design. For example, when the size of space is changed without changing any relations to neighbour spaces, a new design is not generated but a subspecies is. The lists of all spaces, designs, and subspecies are saved in a file.

In DesignMap methodology, topology issues are created through a special rule to check if a new space layout design can be a new Design or be a Subspecies. The rule is described as follows:

- Calculating the adjacency list for each space. If a space, whose ID is 1, is adjacent to space 2, 3, and 4, the adjacency list will be (2, 3, 4).
- Modifying the design layout. If the adjacency list does not change, the output is registered as a subspecies. Otherwise, the design is considered a new Design.

- In the previous process, if the adjacency list is changed with more than two items at the same time, the modified design is not allowed to be added to DesignMap. This two-items-change design can be added to the map only when an additional design with one item change is added before it.

6.3. Functions

DesignMap acts as a tool to store a massive number of designs in both two and three dimensions, implementing a design map that emphasizes form generation through an online design tool, collaborative design, and networking. Each design is represented in a node (Figure 2); a new design can be generated and then added to the map when a new set of objects and new condition of object relationship is generated and created through Design Map's editing window (Figure 3).

The processes used in DesignMap are:

1. **Initial Condition:** The user must prepare two files, an initial space layout file and a space property list file. The space layout file should have at least one design with an array of (N×N) integer numbers such as (0 0 0 0 | 1 1 | ... 0 0 0). Each integer number represents a space property such as 0=OPENSOURCE, 1=BUILDING, and 2=GREEN AREA, from which the space property list file is defined.
2. **Add Design:** The user can add a new Design from an existing one in the map. First, the user selects an existing Design as a parent design. Then, the editor panel used to modify the design pops up. The modified design is checked to find out if it is a new Design or a Subspecies by calculating topological changes. If it is a new Design, the layout is posted on DesignMap with a link to the parent design. Otherwise, it is registered as a Subspecies and shown under the parent's design.
3. **Delete Design:** The user can delete any design in the map, where DesignMap allows any user to add, modify and delete any contents.

Generating 3D models

DesignMap provides only the list of space layout designs. The list of generation files is not provided in the interface of Design Map, in which any user can post the file to generate 3D models from any space layout design in DesignMap. In short, the process to generate a 3D model consists of the following steps:

- Select one design, multi designs or all designs in DesignMap.
- Select or create generation rules.
- A 3D model is generated for each selected design.
- Finally, the models are saved as 3D formatted files.

7. DESIGNMAP APPLICATIONS

The use of enterprise portals and portlets through the Internet can be summarized as following. The public Web portals like AltaVista, AOL, Excite, and Yahoo appeared in the mid-1990s. These sites have portlets that provide self-contained boxes for different features like news, e-mail, weather, stock, and search. Enterprises of all sizes began to see a need for a similar starting place for their variety of internal repositories and applications. By the late 1990s, software vendors began to produce pre-packaged enterprise portals, which would be toolkits for enterprises to quickly develop and deploy their own customized enterprise portal. In 2003, vendors of Java-based enterprise portals produced a standard known as JSR-168, for interoperability between enterprise portals and portlets [21]. There are many enterprise portal vendors like, Apache Software Foundation (its product name is Jetspeed 2.1), IBM (its product name is WebSphere Portal Server 6.0.1), Microsoft Office (its product name is Sharepoint Server 2007), Oracle (its product name is Oracle WebCenter Suite), and Sun Microsystems (its product name is Sun Java System Portal Server 7.2) [22].

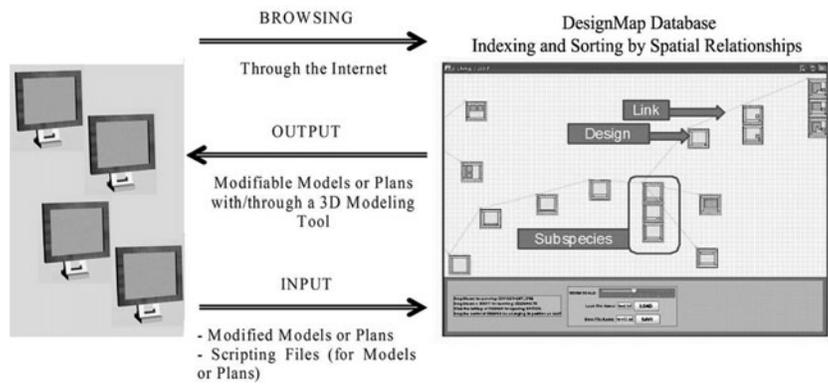
DesignMap is programmed as a Portlet, which is a reusable interface for online applications, and it is running with JetSpeed2 framework provided by Jakarta Project, (Figure 2). DesignMap can work in Enterprise Portal Program as a portlet. It, therefore, can be integrated with any kind of applications including database management systems. The portlet can be run through all kinds of Portal applications.

7.1. Uniqueness of potential applications

In general, the databases of previous research and online libraries can be indexed, in image or text format, according to specific information, such as architect, date, place, and function or type of design. These applications previously introduced miss a major requirement that originates from the three dimensional nature of architecture and urban planning. This nature makes viewing the presented designs in three dimensions essential; whereas the use of design knowledge can be greatly affected by the way it is presented to the architect or urban planner.

DesignMap offers among other functions this unique functionality of viewing designs in three dimensional models (Figure 5). Through networking, DesignMap introduces three dimensional designs that are categorized according to their formal features, and allows its users to explore and modify design forms by implementing and introducing an interactive modelling tool represented in a separate window that is accessible from DesignMap, Figure3

► Figure 5: DesignMap contributions.



7.2. Case studies

In our first use of DesignMap, we employed some design objects classified in 10 categories, which help in conceptual drawings. These design objects, repeated throughout modelling processes, are street, sidewalk, driveway, front yard, façade zone, private zone, side yard, alley yard, house, and garage. These design objects are pre-defined in “Architectural Pattern Book” by Urban Design Associates [23]. The 20x20 grid cell is used in creating designs that are added to DesignMap.

Four case studies with realistic rendering made through DesignMap are displayed in Figure 6. The first design in Figure 6 was displayed earlier in Figure 2, but by scripting in 3DMax instead (to demonstrate the two methods of creating a design). For the 2D and 3D designs in Figure 6, once the image is specified in the code, the 3D geometry and rendering bitmap images (640 x 480 pixels) are generated in less than one minute.

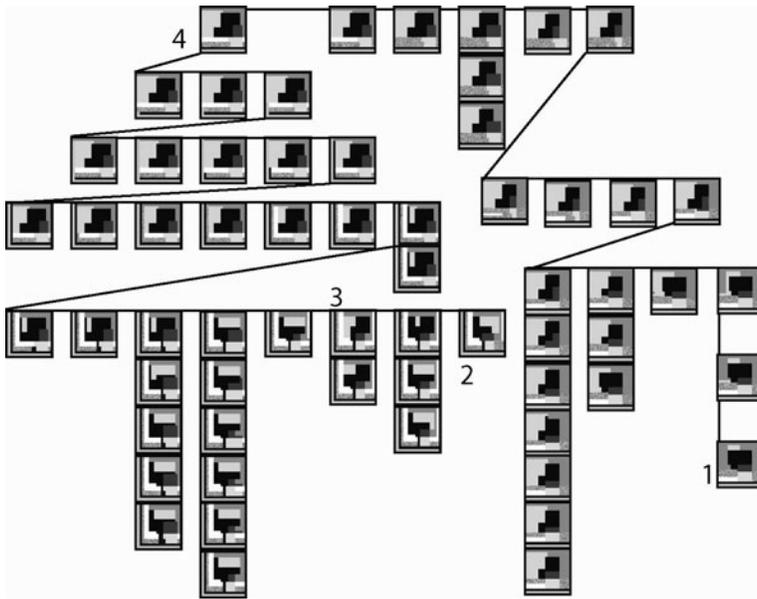
► Figure 6: From left to right are case studies 1 to 4; sample 3D output images generated from bitmap designs in DesignMap.



DesignMap has many applications and implementations in various avenues. It could be employed in the previous research work and applications, which have been investigated in the literature review section of this paper, but with further potentials that are generated from the offered functions and the Internet use.

Figure 7 shows a part of DesignMap’s interface. DesignMap has been employed as an online database for home designs. Over 60 home designs are displayed in Figure 7. These case studies are examples for how to build up the database of visual designs with the available functions of adding and

modifying in DesignMap. A Dell workstation PC, Precision 670, was used to generate and render the models from images in DesignMap. The geometry is automatically generated by a MaxScript code, but the materials assigned in the code to the model are prepared beforehand. The 3D trees created in a commercial software package, Onyx Tree (Onyx Tree: Product Information) [24] are also predefined. V-Ray 1.5 (V-Ray: Product Information) [25] is used to generate the realistic output images. Rendered images help in realistically displaying the designs for users. Moreover, they add additional potentials to the functions of DesignMap.



◀ Figure 7: Topology of DesignMap's interface including the four residential home designs displayed in Figure 6; the four designs with indices are used to generate 3D models in Figure 6.

8. CONCLUSION

This paper introduced and analyzed the previous research related to online design communities and forums and networking. The paper highlighted the main characteristics and applications of these areas, and discussed contributions introduced by DesignMap.

The research presents and reports the concepts, methodology, and functions of DesignMap that is considered an innovative tool and could be visualized as a visual design map, an online design environment, an online community, and a networking database.

As an online database of visual designs, the applications of DesignMap could provide better support capabilities for various disciplines such as online libraries, design precedents, and conceptual design. In particular, DesignMap provides the abilities to search and modify an existed design quickly and more effectively by using the offered functions.

Although the implementation of DesignMap provided innovative support

for databases' management in terms of indexing, searching, modifying, and saving, the software can still be improved in several respects in the future:

- More realistic objects in rendering can be added to the modelling system (editing and modifying window) of DesignMap.
- More components that can be used in designing and urban designing can be added to the modelling system (editing and modifying window) of DesignMap.
- Besides the applications discussed in this paper, DesignMap could be employed in more various directions. For example, creating series of urban designs in DesignMap introduces more categories to the areas covered by DesignMap, or the offered map as a source of design precedents can be used in conceptual designing.

There are common applications of enterprise portals and portlets like content management system, document management system, collaboration software, customer relationship management, business intelligence, email management, and intranet [26]. DesignMap can be integrated with any kind of these portal applications including database management systems. DesignMap Portlet, therefore, can be run through all current Portal applications, which adds more effectiveness to applications and implantations of DesignMap.

In addition to the previous concluding remarks, the main two concepts, the DesignMap and the accompanied modelling system, presented in this paper are a part of an ongoing research project (Design Wiki) that is conducted by the authors. The research project applies a third concept besides the main two concepts of this paper, which is the concept of Wikipedia but employed within visual designs of two and three dimensions. This presents another future path to DesignMap applications.

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