USING CASE-BASED REASONING TO AID SUSTAINABLE DESIGN

FATEN ABOREEDA, DINA TAHA
Alexandria University, Faculty of Engineering.
Email address: fatenaboreeda@gmail.com, ditaha@alex.edu.eg

Abstract. Since so far there is only one planet, *sustainable design* is considered the *ethical* future in all fields of design. Although both architecture and construction are being considered major emitters of greenhouse gases, a wise design not only can lead to minimizing this impact but it can also lead to restoring and regenerating the environment to a sustainable state.

This paper presents an on-going research that aims at simplifying the elements and facilitating the process of sustainable design by using *case-based reasoning*. This is achieved through learning from past experiences; both good and bad ones, by suggesting a database application with a process-friendly interface. Through providing designers with those past experiences, it is believed that deeper-studied designs can be more easily developed. Also a deeper analysis and understanding can be further implemented and produced with less effort for experienced and non-experienced architects in sustainable design. This would also decrease the consumption of time during the design process and encourage even more designers to integrate the sustainability concept into more designs.

This research discusses the influence of *sustainable design* within the architectural domain, and suggests a computer application that aids architects during the preliminary design processes.

1. Introduction

This on-going research presents a computer application that can effectively aid architects during preliminary design in choosing and evaluating different issues concerning sustainability decisions. It provides different solutions to sustainability concerns and issues by using case-based reasoning from well evaluated experiences.

2. Aim of the study

The process of using past knowledge to solve new design problems continues from being used in the education process to being widely used in design offices. This study aims at developing an architectural application to aid architects in the pre-design phase to easily take sustainable decisions. The application is meant to reduce the time architects spend to look for similar cases and solutions to the problems and issues they have at hand. It leaves the solutions adaptation process to be manually carried out by the architects themselves.

3. The suggested application

Different case-based design applications (CBDAs) have been proposed throughout the history of case-based reasoning (CBR) to solve different problems, but none of them has yet tried to integrate sustainable design with architectural design. This system is aimed to aid architects during preliminary design phases to tackle the sustainability measures and review well-evaluated alternative solutions to sustainable design issues.

3.1. MAIN CONCEPTS

The presented application makes use of some concepts of Archie II (Domeshek & Kolodner, 1997) and Precedents (Oxman & Oxman, 1993). It uses the concept of dividing large complex problems into sub-problems, as each building has a huge variety of different sized stories concerning the different measures of sustainable design. Also the application provides two ways for case retrieval by searching and cross-browsing. (Zimring, Bafna & Do, 1996; Heylinghen, 2000; Heylighen & Neukermans 2001).

3.2. CASE REPRESENTATION

Sustainable design measures have been grouped into different categories on different systems for instance LEED, AIA and BREEAM. These measures have been re-categorized and grouped into 7 main categories of stories that will be used as main categories in the application. (a) energy, (b) light and air, (c) location, (d) materials, (e) process, (f) water and (g) culture, economics, diversity and impact.

The data structure consists of three main pillars (building, story and team), each has its unique representation; but still they are all interconnected. Each building has many stories and a story can exist in several buildings. The same with teams, each team can work in many

buildings and each building can have many teams. So it's a many to many relationship schema for the three pillars (Fig.1). This helps in adding generic data for each pillar and specific data for each case as well as the links to the other pillars.

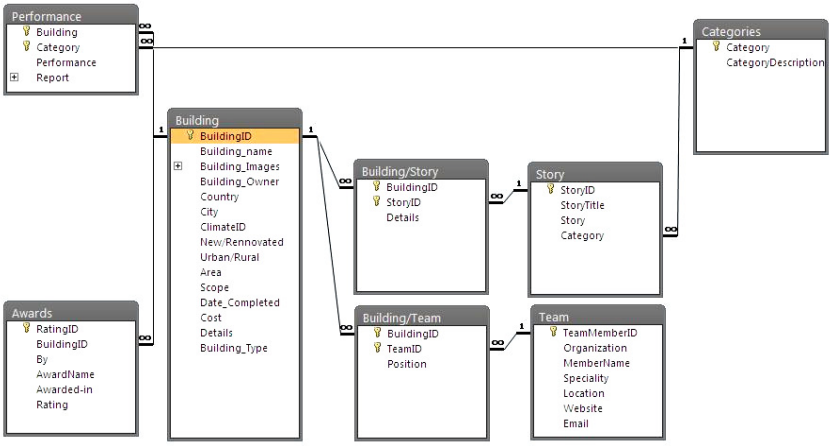

Figure 1. Database Schema.

The interconnections between 5 cases of buildings and different stories concerning the water issue are illustrated in Fig.2. It shows the unique stories for each of the buildings as well as the shared stories between different buildings.

Figure 2. Building/Story relationship.

For example the *Yale sculpture building and gallery* has 6 different stories concerning the water issues, some of them are shared with other buildings like the *Dual flush toilet* story which it shares with the *Nueva School* and the *Macallen building condominiums*. Other stories are found to be unique to a certain case, for example *Mechanical water collection* is unique to the *Macallen building condominiums.*

Another benefit that could be taken into consideration from this database schema is comparing the frequency of use of particular stories in buildings (Fig.3); this illustrates the importance and ease of application of that story as a solution.

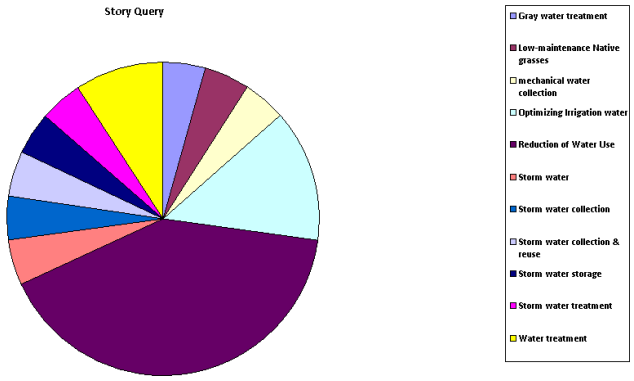

Figure 3. The frequency of use of stories in different buildings.

3.3. THE GUI

The initial GUI shows the 3 pillars as a starting point to begin browsing or searching. Once a choice has been done; different representations for each pillar along with browsing, searching and linking to the other pillars are made possible.

The building is considered the biggest entity as it hosts data for its general data, awards, performance, its stories and teams (Fig.4). The stories/teams are linked to the stories/teams interfaces. When a record is selected, the interface opens that record and locates all the buildings that contain that same story/team. This shows the interconnections between them and facilitates gaining general and detailed knowledge.

Also the interface generates periodic reports about stories (and buildings); these reports help to clarify which aspects mostly influence sustainable design.

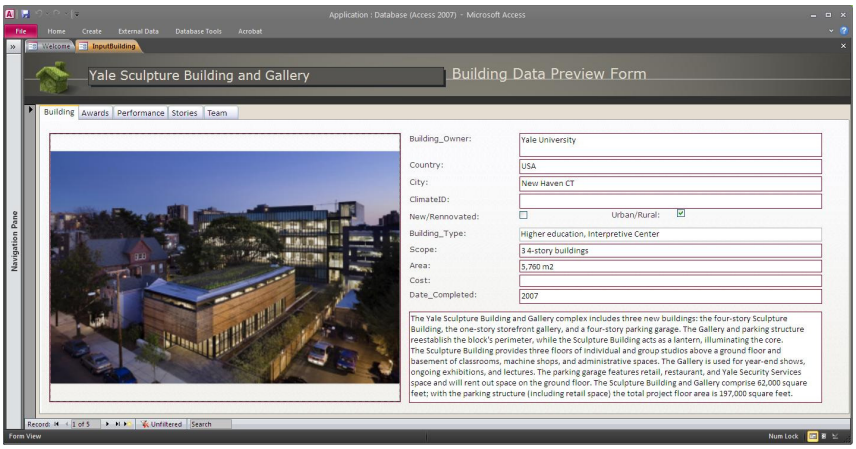

Figure 4. Building representation.

3.4. DATABASE STRUCTURE AND SIZE

Currently the database contains a limited number of cases of the top rated sustainable buildings in AIA and LEED. It is planned to expand the size of the database and also expand the scope of the cases by using well-evaluated good and bad cases.

4. Evaluation and conclusion

This system will be tested by a variety of users; architects who are interested in integrating sustainable design concepts, architects who are not interested in the sustainability concepts and architectural students. By evaluating the results of these tests, the system's efficiency to achieve its goal (facilitating sustainable decisions through the design process) will be evaluated.

4.1. FUTUTRE DEVELOPMENT

The application is planned to be a free online open source application, in order to facilitate its spreading and use and to make it useful to a larger scope of architects and users interested in environmental solutions.
Also the database size and number of cases is planned to increase, along with the range and varieties of buildings in different zones and climates.

References

DOMESHEK, E. AND KOLODNER, J., 1993, *Using the Points of Large Cases*, *AI EDAM,* **7**, 87-96.

DOMESHEK, E. AND KOLODNER, J., 1997, The Designers' Muse: Experience to aid conceptual design of complex artifacts*, In:* M. Maher & P. Pu, eds. *Issues and Applications of Case-Based Reasoning in Design.*

HEYLIGHEN, A., 2000, In Case of Architectural Design: *Critique and Praise of Case-Based Design in Architecture*, PhD, Katholieke Universiteit Leuven.

HEYLIGHEN, A. AND NEUCKERMANS, H., 2001, *A Case Base of Case-Based Design Tools for Architecture*, Computer-Aided Design, vol. 33, 1111-1122.

OXMAN, R. AND OXMAN, R., 1993*,* PRECEDENTS: Memory Structure in Design Case Libraries, *In:* Flemming, U. & Wyk, S. eds. *CAAD Futures '93,* 273-287.

ZIMRING, C., BAFNA, S., AND DO, E., 1996, *Structuring cases in a case based design aid*, J. Vanegas & P. Chinowsky (eds), 308-313.