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Impact of Underlying Design Motivations Upon Design Analogies

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Biography

I completed my undergraduate work at Norfolk State University and continued my education at Arizona State University where I received my Masters in Sustainable Engineering. My research was focused on the techno-economic evaluation of renewable energy solutions in remote communities. My current research interests look to uncover ways to use design analogies and ways to improve current design methodologies so they can be used to increases the effectiveness and sustainability of engineering and design for global development.

Overview:

Investigations into the nature of engineering design analogies have indicated when represented through the prism of a functional basis, differences can be attributed to similarity in functions, and to architectural arrangements of these functions. During a design, there are always explicit design goals, but there are also underlying design goals which may or may not be explicitly expressed, but occur as a result of the resident design culture within an organization. This research is considering the question of if and how these underlying design motivations affect the use of design analogies; both via the use or non-use of analogies, but also by the types of analogies used, in particular with respect to architecture.

Motivation

Studies of the activities of designers indicate that previous experience is used to identify solutions to many design problems [1 - 4] through a process of abstracting a design problem to a level that allows other related solutions to be identified (as analogies) and then to de-abstract the analogies into solutions specific to the design problem. This process of abstraction and de-abstraction with analogies is commonly used by the design engineers during development of a design [5]. Engineers also use a functional vocabulary to abstract designs away from form specific solutions, to a collection of functions and flows. Combinations of functions acting on a flow results in a performance metric by which the design can be evaluated. Collectively, these functions, flows and performance metrics define a chain within a design. It is these chains which are used to define analogies.

State of the Art

Comparisons between chains can be made on the basis of similarity and architecture, as shown conceptually in Figure 1. Similarity measures the commonality of functions (specific colors and shapes

in Fig. 1) between chains while architecture measures the organization of the chains. All of the chains in Fig. 1 are identical in terms of similarity.

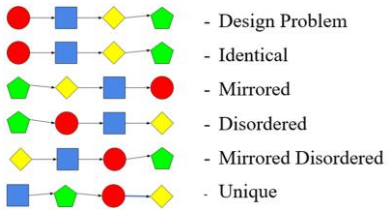

Figure 1. Chain Architecture Examples.

We know that mathematically, criteria measuring these characteristics match known design analogies more often than random chain comparisons [6].

Intellectual Merit

We hypothesize that different design motivations affect the use of analogies in the design process. Furthermore, we hypothesize that different design motivations lead to the designer focusing on particular architecture and similarity values. These design motivations are often intrinsic and even the result of corporate cultures impacting design. For instance, we hypothesize that a culture emphasizing DFMA uses analogies differently than a culture emphasizing DFE, even when these motivations are implicitly made to the design team, rather than being explicitly specified in the project.

Broader Impact

This preliminary research intends to lay the foundation for asking and answering these questions with the ultimate goal of being able to identify design analogies that enhance the creativity of design solutions by considering the intrinsic motivations of the design problem in the analogy search method.

Research Approach

We conducted a design study to determine if these hypotheses have merit by abstracting the function structures of 20 objects based on the D-APPS abstracting [7]. Once abstracted, the function structures were compared to 20 function structures of the same object that were abstracted based on different rules [8]. The rules consisted of 5 different levels of abstraction. The chain architectures that resulted were compared for similarity using the similarity metric for two chain architectures [6].

Findings to Date

Similarity metric statistics suggests that flow is just as important as function when looking to build analogies to improve performance because the flow is what is manipulated or transformed within the functions. Different design motivations result in different design outcomes, however, when considered about the critical flows and chain architecture's similarity increase drastically. This helps to uncover the reoccurring themes in design motivations that lead to similar design analogies.

Conclusions

This initial research intends to lay the foundation for asking and answering these questions with the ultimate goal of being able to identify design analogies that enhance the creativity of design solutions

by considering the intrinsic motivations of the design problem in the analogy search method. This work will lead to future work that enables us to better understand how to develop a computational model or tool that knows that to look for when trying to create analogies.

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