Cooperative CAD System for Conceptual-Embodiment Design Phase of Product Design

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Abstract: In the modern globar market and manufacturing environment, industries have to put more focus on reducing time to market while reducing production costs on the development of new products. Collaborative product development is a growing trend that is being used to answer some of that problem. However, literature research has revealed that there are only a small number of researches that has talked about cooperative CAD systems. This paper will try to show that this type of system can be used in the conceptual-embodiment design phase while encouraging creative solutions from the designers involved. It will also list some functional requirements and areas of interest for these type of system that has been identified by this research at the time of writing.

1 Introduction

With the emergence of global market and the development of more sophisticated manufacturing technologies, customers now demand products with better quality while also having a low price. As a result, industries are trying to find ways to cut product development time and product development cost. One of the ways that these goals can be achieved is by applying collaborative techniques in product development, such as using a Collaborative Computer Aided Design (CAD) system.

These types of CAD system allow multiple designers to collaborate on certain projects, thereby enabling division of work and parallel work between designers. Collaborative CAD systems are also used to coordinate and spread important work informations among different functional areas, such as when applied in Concurrent Engineering methods between different functional divisions of a company.

In the future the development of CAD systems will take into account this collaborative aspect, along with the Cognitive, Conceptual and Creative aspects (the 4 C's of future CAD), as the base for subsequent CAD systems development [Go12]. Future CAD systems will aim to assist designers in the designing process itself, rather than just being a tool which is mainly used to document and spread design informations as the way it is being used now.

The obvious consequence of this development is that CAD systems will be used more in the conceptual-embodiment design phase of product design, as shown in Figure 1. It is in these phases that designers will need the most help to stimulate their creativities so that they can design cheap products that meet high quality specifications. [Wa02] has reviewed commercial and academical CAD systems that are available or being developed to support collaborative conceptual design and concluded that there are many opportunities for this field of research, as support for these phases of design from a CAD perspective is still relatively small.

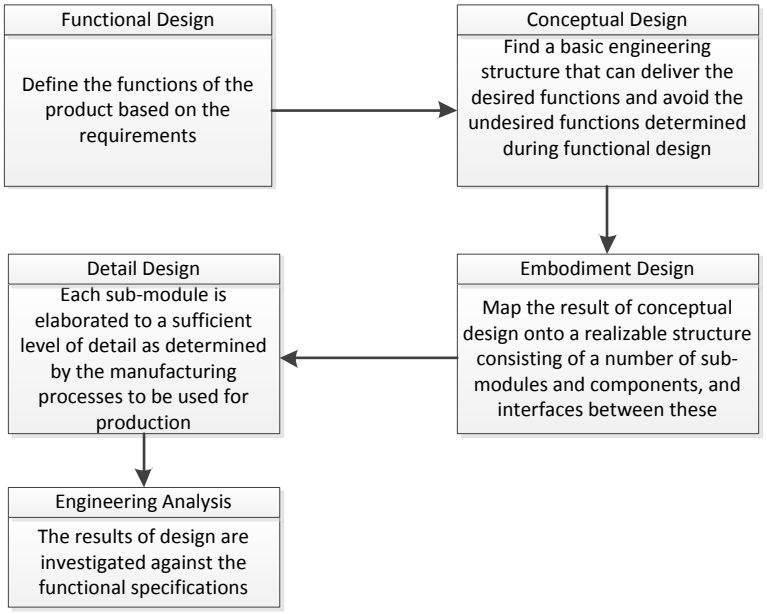

Figure 1 : Phases of Product Design, taken from [Ch12]

In accordance with the 4 C's of future CAD, this research will then try to develop a framework for a collaborative CAD system that will be used in the conceptual embodiment design phase of product design. Specifically, it will try to develop a CAD system that will enable multiple designers to cooperate on designing a product by allowing designers to exchange design ideas efficiently. The following sections of this paper will contain the results of literature research done during this research, the overview of the CAD system that will be developed, and the future development of this research.

2 Literature Research

In accordance with the topics of the research, further literature research has been done on the topics of general collaborative CAD systems, CAD systems for conceptual design

phase and creative CAD systems. The following section will detail some of the interesting findings from the reviewed literature.

2.1 Collaborative CAD Systems

There are many researches that have been done with the topic of collaborative CAD systems using many different technologies. Collaborative activites can be broadly organized into 2 different activities, Coordination and Cooperation activites [Ec00]. Coordination activites are activities where different designers work on parts of the same product and at the end those parts will be assembled into a complete product. On the other hand, Cooperation activities are activities done by different designers on a one product, as a whole complete product or a part of a product, at the same time.

Some researches, such as by [Wa09], [Mc12], [YM12], and [KK12] focuses on constraints settings by different designers. These constraints will then be propagated to all of the designers involved and every contraint violation will be broadcasted to each concerning designers. These designers must then negotiate to find a satisfying solution to those conflicts. These types of researches can be implicitly categorized as coordinative activities.

Other researches, such as done by [GLG10] and [LKB10] , try to solve the persistent naming problem, a significant problem in the collaborative CAD area that emerges from the interacting modeling operations of different designers. Traditionally, this problem is solved by file locking mechanisms, although these solutions increase the waiting time of designers during the design process. These types of researches usually work with the same file, so they can also be categorized into coordination activities.

Still others, such as [Bo10], [GM11], [Ch12], and [Ka13] focuses on how to share the modeled product with different individuals using various technologies, such as VR devices or smart devices. The goal is to facilitate reviewing and sharing among collaborators so as to increase the efficiency of collaborative design.

2.2 Conceptual CAD Systems

[Sa09] has developed a CAD system for Servive/ Product Engineering, while [KT12] and [No12] are examples of conceptual CAD systems for mechanical / electronical engineering. [KT12] focuses the collaborative aspect of their research on constraint control through parameter settings and the use of skeletal model, while [No12] focuses on reviewing activities by different collaborators.

Other researches focus on assisting concept generation, such as the computer aided TRIZ system developed by [Be12] or the computer aided collaborative shared design thinking platform developed by [DJL12]. In general it can be concluded that researches in this area are still relatively small, as concluded 10 years ago by [Wa02].

2.3 Creative CAD Systems

Creative CAD systems are CAD systems that are able to assist designers by giving creative alternative solutions for the problem at hand. Usually this is done by providing a creative database containing solutions, such as in [Li11], [CLX12], and [Go12] . When paired with a functional decomposition techniques, these database can then be matched to find creative solutions that may not be evident from the beginning.

In trying to create these kind of systems, researches, such as by [NZ12], [Mu12], [HCD08], are also being done to clarify what is meant by "creativity" and how can interacting with design tools affect a designer's creativity. These researches try to bridge the gap between cognitive creativity theory and the practical tools that designers use in the creative process itself.

3 Cooperative CAD System for Conceptual-Embodiment Design

Traditionally, collaborative CAD systems are used for coordination activities, so that multiple designers can be used to shorten the product development time. However, as mentioned in the earlier sections, the trend for the future is to design creative CAD systems. When extended as a collaborative system, it is clear that the cretive collaborative CAD system is more suited to be used in coordination activities, where several designers must work together to design new products that will conform to a set of specifications. This will enable designers to exchange and discuss creative ideas with each other, possibly leading to a better solution than from a single designer. Again, as mentioned before, these systems would be more suitable to be used in the Conceptual Design and Embodiment Design phase.

The proposed solution is by designing a CAD system that works in a hybrid top-down and bottom-up design approach. The designers using the system must work in phases, which are the functional design phase, the individual design phase, and the convergence phase. In the functional design phase, designers must model the product specifications into a functional decomposition of a complete product and the designers must agree on a particular part of a product that they want to design. After that, each designers can work on their individual workspace to find their preferred solution. On the convergence phase, remote meetings are held through the assistance of the CAD system to converge the probably dissimilar ideas into a convergent design. This process is then repeated until all of the product is finished. Figure 2 illustrates the workflow of the proposed solution.

4 Closing Remarks

In order for the system to be of use in a creative collaborative process, the system must also fulfill some requirements. This system should enable real time communication between designers, so that designers can easily understand each other's design intent and therefore decide the best solution. Furthermore it should also encourage the leveraging

of other designer's design . Lastly, as with all computer systems, it must be able to maintain data integrity and function with efficiency.

This research is currently still in its early phase, as such in the future more work will be done on the technical aspects so that the system as described here can be realized in its entirety.

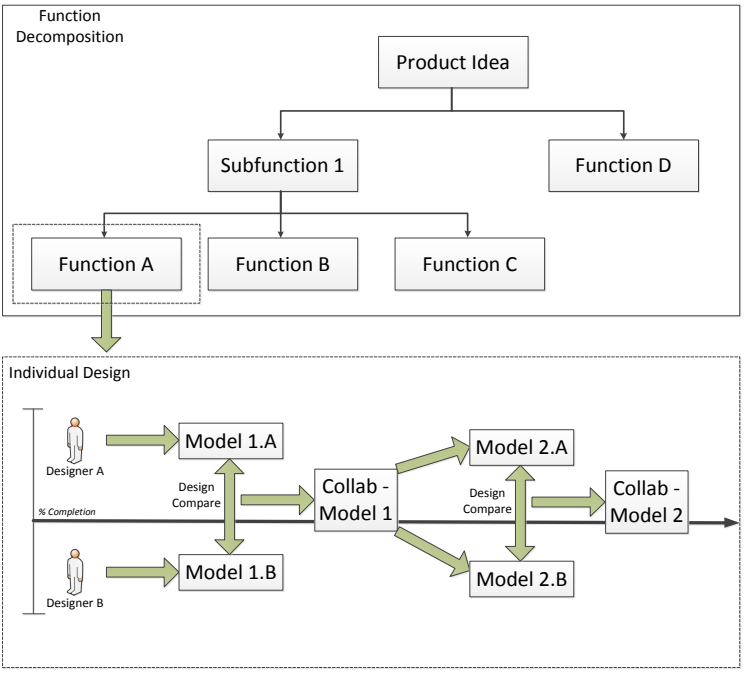

Figure 2 Workflow on the proposed CAD System

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