# Computer Generated Freedom: Searching not Knowing

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## ABSTRACT

In this paper we present Cubby+, a computer-supported design environment aimed at the early phase of the design process. We describe the explorative nature of the early phase of the product design process and argue that existing CAD solutions are unable to support this process satisfactory. Our approach to building a computer supported design environment starts from designer's skills and aims for a dedicated system. We present five scenarios that clarify our interaction ideas. Finally we evaluate the scenarios and draw conclusions.

## INTRODUCTION

Traditionally, in the early phase of the design process industrial designers use a mix of sketches, drawings and pre-models to explore solutions (Figure 1). This early phase is rather of a searching nature, than of a knowing one. Different paths are tried and combined, and dead-end tracks are abandoned in favour of more promising ones. During their search designers fluently combine different media in a hands-on manner. A designer well versed in the use of these tools can express himself in his artwork. In other words, a designer's sketches and models are carriers of his style, values and beliefs [1]. Such "expression of designer-self" potentially contributes to product diversity between designers and companies and thus to a wider choice for consumers.

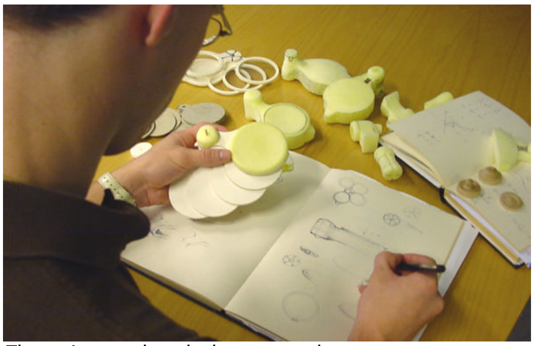


Figure 1. a product designer at work

With the advent of computer-aided design systems (CAD), computers found their way into the design process. CAD systems are highly useful in the later stages of the design process to create, modify, exchange and present final designs as well as to bridge the gap between drawings and production. Yet we have experienced both in practising and in teaching design that existing CAD systems are not well suited to support the explorative, creative phase of the design process. In fact, we discourage our students to use CAD systems at the start of the design process as we feel that such premature use of CAD systems stifles creativity [2]. CAD-systems start from the assumption that the designer already knows much of the geometry and configuration of a product before he starts drawing. This assumption is in conflict with the very nature of early phase design.

In our opinion, the main problem is that CAD-systems do not allow the designer to express himself through his perceptual-motor skills. The typical CAD setup with a 2D screen and a one handed, two degrees of freedom input device, does not support the hands-on skills that he has by training [3]. CAD systems leave little scope for the designer to interact with the system in his own way. Regardless of the person who uses it, a CAD system always forces its user to plan and go through the same sequence of actions. And regardless of the designer, a CAD system always displays the virtual scene in the same way. Furthermore, CAD systems do not allow designers to express the degree of finalization of a product in the appearance of their work. The software renders the virtual scene in the same photorealistic manner, suggesting that the product is in its final stage of completion while it may only be a design concept. This is not only misleading, it also suppresses the visual ambiguity which designers use as a source of inspiration [4]. In short, the rigidity of CAD-systems stands in the way of the aforementioned expression of designer-self which is so characteristic of traditional designer tools as sketches and pre-models.

We do feel, however, that computers have much potential for the early phase of the design process. If we could restore the hands-on experience of the designer so that he may more fully express himself and combine this with the strengths of the computer such as editability and reversability, then we could open up new possibilities. This is what we try to achieve with Cubby+. In the remainder of this paper we present our approach to these matters. First, we discuss our aim for a dedicated system rather than a generic one and the use of desktop VR technology to support the designer's perceptual-motor skills. Then we visually illustrate our ideas through a number of scenarios. Finally, we evaluate our scenarios and draw conclusions.

## CUBBY+, AN OVERVIEW

In this paragraph we will give an overview of the product design environment Cubby+. We will discuss the advantages of the system.

### Dedicated system

Personal computers as we know them in theory are capable of doing anything that they are instructed to do. One could say that they are tools that are not specifically good at anything in particular but that their acclaimed strong point is their multi purposeness. Yet as we look at non-computer based tools, we see that professional tools are dedicated ones. Two examples might clarify what we mean. A Swiss army knife might be used to cut meat when we are on holiday, a butcher however uses a specific knife for this job. A "leatherman" multi-purpose tool might incidentally be used for fixing a car, a car mechanic, however, uses specific tools for each problem he encounters. Similarly we think that it is rather strange that professional product designers use a generic computer solution for the very specific task of product design.

Cubby+ is a computer system specifically developed for the task of product design. The great advantage of such an approach is that a system can be built that is specifically tailored to the needs and tasks of product designers so that he can focus on his design task instead of the system. We aim to develop a product design environment that fits the skills of product designers, a system that makes life easier, not more difficult.

### Using VR-technology to support designers perceptual-motor skills

In the introduction we mentioned that CAD-systems as they exist now emphasize the learning and remembering of sequences of actions in order to make CAD-models of products. When one step in those sequences is forgotten or when a wrong sequence of actions is chosen the desired result will not be reached. The designer will have to start all over, and he has to rethink the sequence of actions he needs to follow in order to build the CAD-model he wants.

Instead we suggest that by not only addressing the cognitive skills of designers but also respecting their perceptual-motor skills, we can restore the hands-on experience of the designer [5]. And, as said, we feel that by restoring the hands-on experience of the designer we can access the strengths of the computer without losing the designers expressiveness.

To achieve that we propose to make use of the Cubby platform [6] (Figure 2).

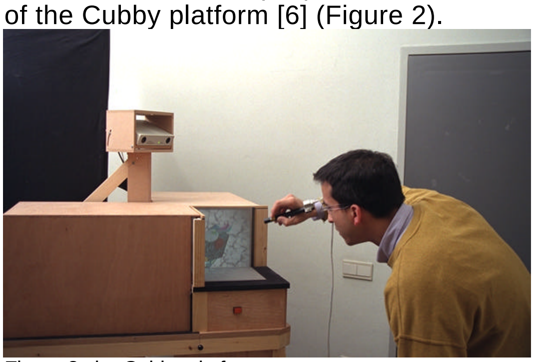


Figure 2. the Cubby platform

Cubby is a desktop VR-system that has three orthogonal screens forming three sides of a 200x200x200 mm. cube. It is capable of providing 3D imagery. The 3D images are created by movement parallax. The position of the spectator's head is tracked by means of a small reflector on the head. The images projected on Cubby's three screens together form an image that is correct from the position of the viewer. If the viewer moves, the images are corrected for the new position of the viewer. Thus objects seem to exist within the cube defined by cubby's three screens. As the images appear in front of the screens, within the cube, it is possible to reach them with help of a hybrid tool. The tool is partly physical and partly virtual (Figure 3). The use of a hybrid tool assures correct occlusion of the tool by virtual objects so that the 3D image is not disturbed.

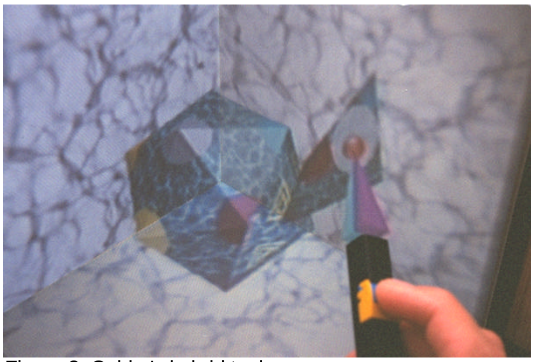


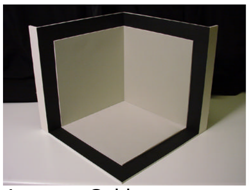
Figure 3. Cubby's hybrid tool

Since the manipulation and display spaces coincide, physical objects can enter the workspace and share it with the virtual scene. This makes Cubby well suited for tangible interaction. Physical tools which have the benefits of rich expressiveness and tactile feedback can be used to operate on virtual objects.

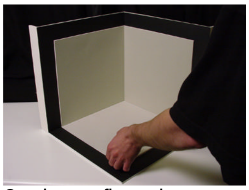
## CUBBY+, A SCENARIO

To investigate the solution domain of our Cubby+ design environment we built a scenario. Our scenario depicts the design of an alarm clock within Cubby+ and exist of five sub-scenarios.

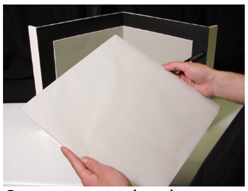
**Sub-scenario 1, sketching shapes:**



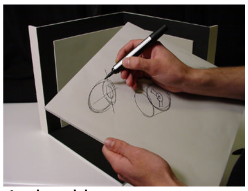
1. empty Cubby+



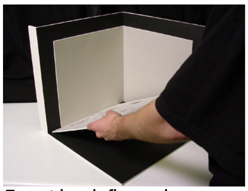
2. take out floor-plane…



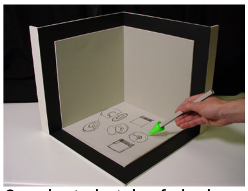
3. ...to act as sketch tablet



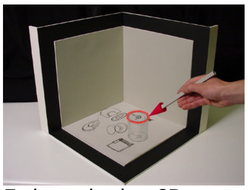
4. sketching



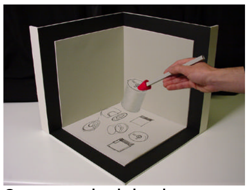
5. put back floor-plane



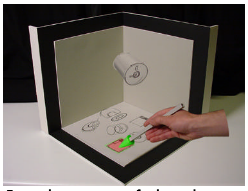
6. select sketch of clock face



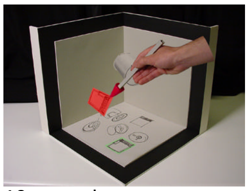
7. drag edge into 3D



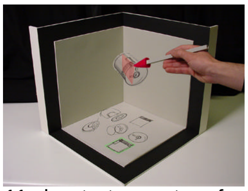
8. move clock body to new position



9. select part of sketch to act as texture map



10. move image

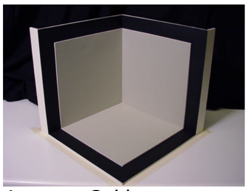


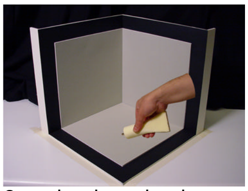
11. drag texture on top of clock body

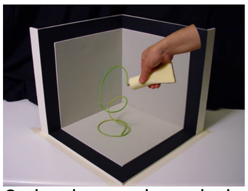
12. finished 3D sketch of alarm clock

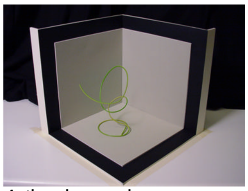
The sketch scenario is all about giving the designer a natural way to input data. A sketch is made in the traditional way, by taking out one of Cubby+'s floor screen to act as a drawing tablet and make sketches of an alarmclock with a stylus on it. The result looks sketchy and doesn't loose its handdrawn appearance when it is turned into a 3D shape. The sketch of the clockface is selected by "drawing" a line around it by using a hybrid pointing device. The selected clockface highlights in green. The designer now has two options. He can either take the edge of the selected area and drag this out of the surface to create a 3D object. Or he can grab the selected area in the middle, the selected area will be copied onto a small plane that can then be stamped on 3D objects. Of both options, edge manipulation and area manipulation, an example is given.

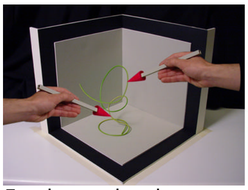
**Sub-scenario 2, virtual wire:**

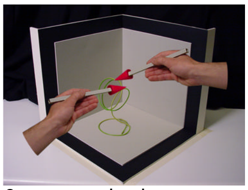

1. empty Cubby+

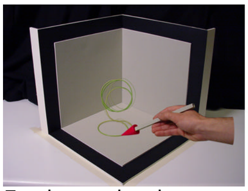

2. a tube shaped tool

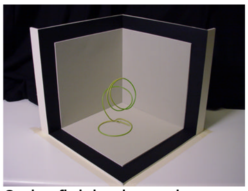

3. drawing an alarm clock stand


4. the drawn shape


5. using two hands deforms the wireshape

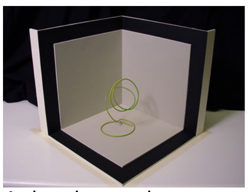

6. no control points

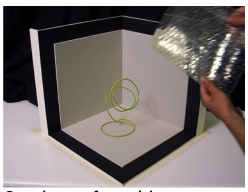

7. using one hand moves or rotates the wireshape

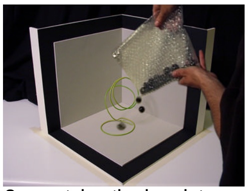

8. the finished stand

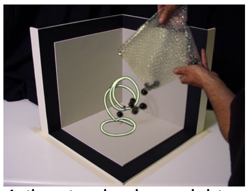
The virtual wire scenario uses a physical tube that is held in the hand. When in the Cubby+ manipulation and display space, out of this tube virtual wire can be spouted. Wire shapes can be generated this way. Those wire shapes will react like metal wire (perhaps with different characteristics). As a result the shape of the wire can be adjusted as if it is metal wire. When the wire is manipulated with two hands it will be deformed. One hand holds the shape, the other hand bends the wire. Hybrid grasping tools are used for this. When only one hand is used the wireshape can be moved or rotated. It will act like a natural body being pushed or dragged in one point.

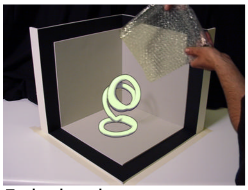
**Sub-scenario 3, adding weight:**

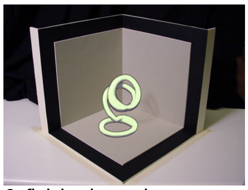

1. the wire stand


2. a bag of marbles


3. emptying the bag into the stand

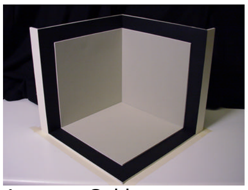

4. the stand gains weight

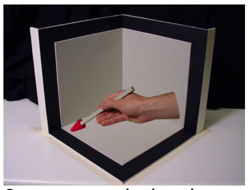

5. the bag is empty

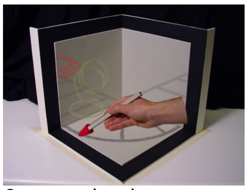

6. finished stand

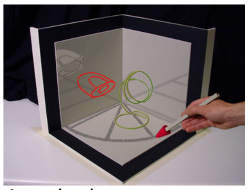
The adding weight scenario uses a physical pouch filled with physical marbles. When shapes need more volume, like the wire shape from the previous scenario, weight can be added by dropping marbles into that shape. The physical marbles will move in the pouch (but not leave the pouch), virtual marbles will be rendered in the Cubby+ work space. When the shape has gained enough weight, the stream of marbles is stopped by moving the pouch away, out of the Cubby+ workspace.

**Sub-scenario 4, navigating:**


1. empty Cubby+

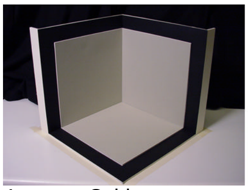

2. movement in the plane

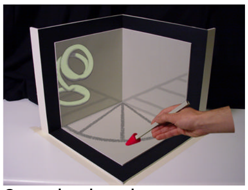

3. previously created shapes appear

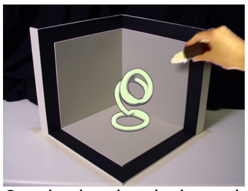

4. navigation

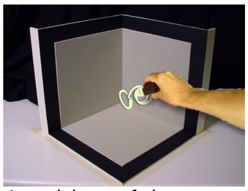
This scenario is about navigating the shapes made in earlier sessions. One could conceivably need previous shapes to alter or to re-use. The hybrid pointer/grasping tool is inserted and dragged through the floor surface of Cubby+. Cubby+ reacts with showing a moving grid. Previously made shapes and objects appear on this grid, they move according to the movement of the tool. All previous shapes can thus be browsed.

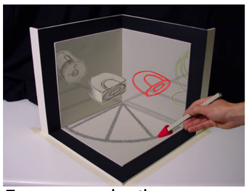
**Sub-scenario 5, combining shapes:**

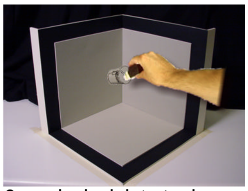

1. empty Cubby+

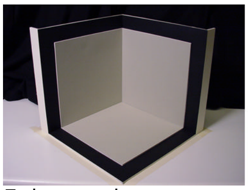

2. navigating shapes

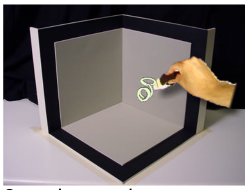

3. selecting the clockstand

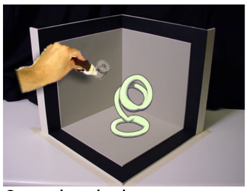

4. suck it out of the scene

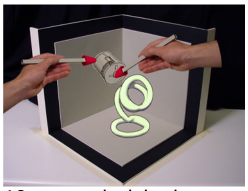

5. more navigation

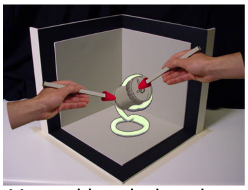

6. suck clock into tool

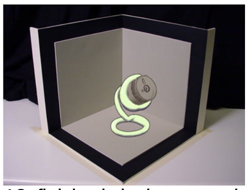

7. the stage is now empty


8. squirt stand onto stage


9. squirt clock onto stage


10. move clock body


11. combine clock and stand


12. finished clock on stand

This scenario is about combining previously made partial sketches into a more finished sketch. This scenario starts with navigating, first the previously made clockstand is centered onto the stage and cut from it with a suck&squirt tool. This tool can be squeezed, when empty it can be used to suck an object out from the stage. When the tool is thus filled with an object, it can then be squeezed back onto the stage when needed. The tip of the tool will change color to indicate if it is filled or not. After this has been done for both the clock and the clockstand they are then squeezed onto the empty stage. The objects can then be moved and rotated. In this case on of the objects is fitted into an other object thus creating an alarm clock on a stand.

## EVALUATION

While creating the scenarios we became aware of the fact that a literal imitation of the design practice on the computer doesn't add anything. When we recreate the "real" world in the computer environment we have a simulation of the design practice that is at best just as good as the design practice we already have. This seems pointless. Design practice metaphors could conceivably limit the possibilities of the system. So care has to be taken when imitating reality.

On the other hand we argue for the restoration of the hands-on experience of the designer in the Cubby+ design environment. We argue that we should respect the perceptual-motor skills of the designer in order to make Cubby+ accessible to designers. In other words, we say that we want to support but also make use of the physical skills like model making and sketching of the designer. We want to tap into the experience of the designer with the physical world.

We think that a balance has to be found between a strict use of metaphors and the use of clues out of the physical world on how to use things. Our ideal is to create a product design environment that is not limited by metaphors out of the design practice but that uses designers knowledge of how to use physical tools to function. The Cubby platform already uses hybrid tools, the tools are part physical and part virtual. We went further by using differently shaped tools in our scenarios. We use a stylus to sketch, two pointer/grasping tools to manipulate, a tube shaped tool to spout virtual wire and several suck&squirt tools to cut, paste and store virtual objects. We use the dedicated-tool aspect out of the professional non-computing world in Cubby+. Furthermore we let the tools convey their functionality through their appearance. We do this without restrictive use of design practice metaphors. We free the designer's to use their experience with the physical world.

Another issue we want to discuss here is the use of scenarios as a means to investigate the functionality of complicated systems such as Cubby+. Our approach to the problem had a double purpose. We want to try out interaction ideas on the one hand, and on the other hand we didn't want to start the time consuming task of implementing those ideas in software right away. We feel that this approach brings useful insights. Besides, a visual scenario is better suited to start a discussion about the concept than a plain text. On the other hand it does not offer the opportunity to actually test the setup. However we do feel that we have reached a useful compromise. We have been able to explore the use of meaningful tools in Cubby+ and to explore a way of introducing the computer in the early phase of the design process. We can now compare Cubby+ to existing CAD solutions, without implementing the ideas in software. We still have a way back to change Cubby+ at relatively little cost compared to the cost that would have been made if the we had implemented our ideas in software.

## CONCLUSION

CAD systems as they exist now are not suited for use as explorative systems. Since the early phase of the design process is of a searching nature, CAD solutions cannot be used to support such a process unmodified.

Personal computers as we know them are quite similar to each other in appearance and in interface while the tasks performed on them are wildly different. In the non-computer world professionals use specific tools for specific tasks. Similarly professional designers should have tools specifically built to support the design process.

The skills of product designers are physical in nature. Designers excel in sketching, drawing and modelmaking for example. Cubby+ will be built with those skills in mind. However, Cubby+ should not be too imitating. By using the Cubby platform equipped with tangible tools that convey their function through their appearance we avoid a too strict use of metaphors and we surpass the meaningless menustructures of conventional computer systems.

Finally we feel that by simulating the Cubby+ environment with a scenario we have had the opportunity to get a feel for the kind of solution we need for Cubby+ that cost us little time.

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Joep Frens (1974) studied Industrial Design Engineering at Delft University of Technology (the Netherlands). After doing research on perceived emotional content of products at the Swiss Federal Institute of Technology in Zürich, he returned to Delft University as a PhD student. His project focuses on a computer aided product design environment which is called Cubby+.

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