Cubby+, Exploring Interaction

J.W. Frens J.P. Djajadiningrat C.J. Overbeeke

Introduction

We see interaction design as exploiting peoples perceptual-motor skills. Real interactive products should elicit rich behaviour, to open up the product's functionality on a tangible level. To design such products, a designer needs new tools. In this design case we propose Cubby+, a design environment that not only allows for explorative prototyping but also for explorative interaction prototyping. Cubby+ is based on Cubby, an earlier developed desktop virtual reality system and it aims at the early phases of the product design process. 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. We feel that computers have much potential for the early phase of the design process when we restore the hands-on experience of the designer based on his perceptual-motor skills. He may more fully express himself and combine this with the strengths of the computer such as editability and reversability. This is what we try to achieve with Cubby+. In the remainder of this design case we present our approach to these matters. First we talk about the Cubby platform, the basis of Cubby+. Second we visually illustrate our ideas on creating sketchy three dimensional prototypes through five scenarios. Then we discuss and illustrate our ideas on explorative interaction prototyping. Finally we evaluate our ideas and approach and draw conclusions.

CubbyPlatform

Cubby

Three head-tracked, backprojection screens form a cubic workspace of 200x200x200 millimetres. The headtracking provides for depth-perception so that virtual objects seem to stand within Cubby's workspace. Because the virtual scene appears in front of the screens, it is directly accessible for hands or instruments. The display and manipulation spaces thus are co-located: virtual objects are manipulated at the place where they appear. Because of the compact workspace, accurate tracking of head and instruments can be maintained. (Djajadiningrat et al, 2001)

ManipulationTool&VirtualTip

In Cubby, virtual objects can be manipulated with six degrees of freedom using a tweezer-like, hybrid instrument. We call it hybrid as the instrument consists of a physical barrel and a virtual tip. The tip is rendered as an extension of the physical barrel.

As the tip of the instrument enters the sensitive zone of a virtual object the inscribed circle of the nearest polygon lights up and a collision sound is heard. The closer the tip gets to the object, the brighter the inscribed circle appears. Such visual and auditive feedback is intended to compensate for the lack of haptic feedback.

DIS2002, London. © Copyright 2002.
ACM-1-58113-515-7/02/0006...$5.00

ID-Studiolab,
Department of Industrial Design,
Delft University of Technology

Landbergstraat 15
2628 CE Delft
The Netherlands

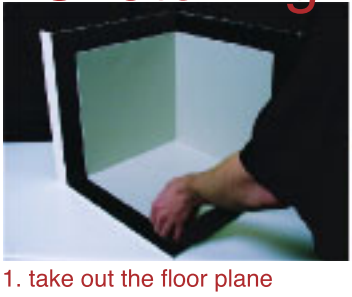
<author>@io.tudelft.nl

Cubby+

Cubby+ will be a computer system specifically developed for the task of early phase 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.

To investigate the solution domain of our Cubby+ design environment we built five scenarios. Our scenarios depict the design of an alarm clock within Cubby+. The emphasis of the scenarios is on building explorative prototypes.

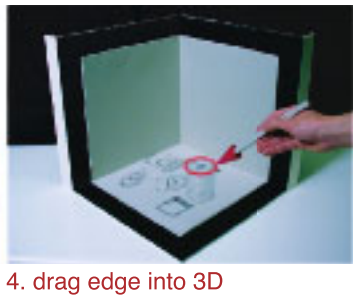
1SketchingAClock



1. take out the floor plane

2. use it as a sketch tablet

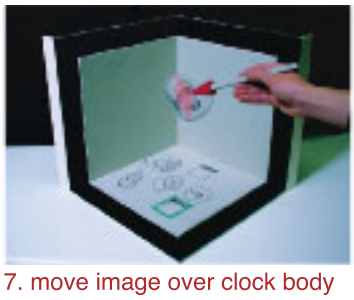
3. select sketch of clock face



4. drag edge into 3D

5. move clock body

6. select part of sketch to act as texture map



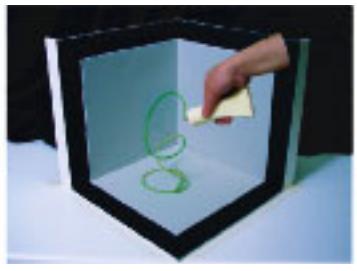
7. move image over clock body

8. finished clock body

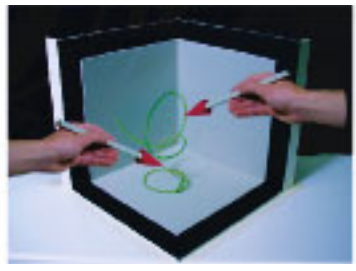
The sketch scenario is all about giving the designer a natural way to input data. A sketch is made in the traditional way, by taking out Cubby+'s floor screen to act as a drawing tablet and make sketches of an alarmclock with a stylus on it. The result looks sketchy and doesn't loose its handdrawn appearance 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.

2VirtualWire

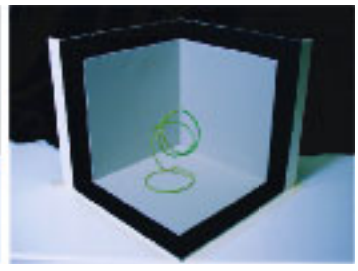
1. a tube shaped tool



2. drawing an alarm clock stand



3. using two hands to shape the stand



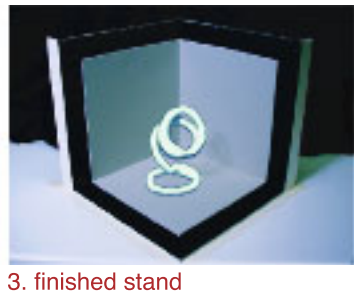
4. finished stand

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.

3AddingWeight

1. a bag of marbles

2. emptying the bag into the stand



3. 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.

4Navigating

1. dragging the virtual tip on the bottom plane

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.

The KlikKlak

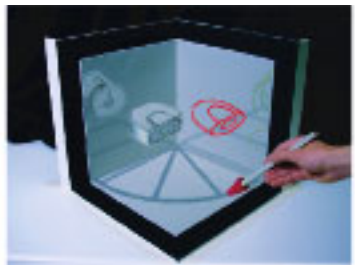
One of the modalities that is currently missing in Cubby is haptic feedback. As we wish to preserve Cubby's minimally encumbering nature, we regard force-feedback arms and exo-skeleton approaches unsuitable. Instead we have experimented with a system with a simple recoil effect which we call a KlikKlak. The KlikKlak is a tweezer-like instrument equipped with a solenoid. The solenoid is activated when the tip of the instrument enters a virtual object within Cubby and is deactivated when the tip is withdrawn. Although basic, this force-feedback in combination with visual and auditive feedback heightens the multi-modal nature of Cubby and thus the feeling of presence of the virtual scene (Wegner, 2001).
We are now working on a new version of

the KlikKlak which uses a servo-motor instead of a solenoid. This makes it possible to influence the strength of the recoil and thus simulate the hardness of a virtual object.

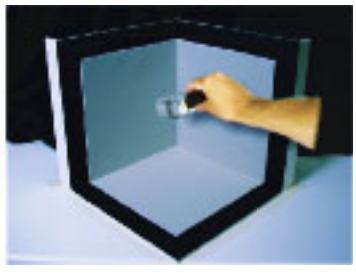
5CombiningShapes

1. Navigating shapes

2. suck stand into tool

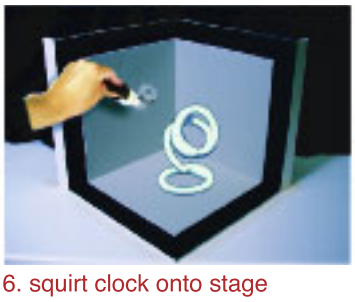


3. more navigating

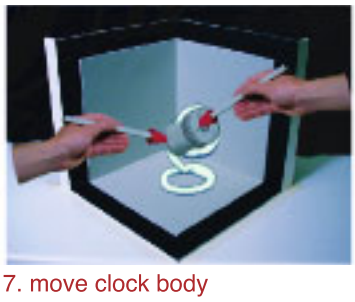


4. suck clock into tool

5. squirt stand onto stage



6. squirt clock onto stage



7. move clock body

8. 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.

Taking Cubby+ a step further

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 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 specifically focus the system on the task of product design. Furthermore we let the tools convey their functionality through their appearance.

We like to think that our Cubby+ proposal succeeds in restoring the hands-on experience of the designer by offering a design environment focused on the task of product design. However, we aim to create a system especially suited for the design of real interactive products. The tools we propose in our scenarios are meant to build geometry. Therefore we concluded that we have to take Cubby+ a step further to exploring interaction itself.

Interaction

Movement tokens

We started with designing a computer tool to support the exploration of form. Our next step is to move towards a tool that will let the user explore form and interaction concurrently in the early phases of the design process. We are striving for a tool that allows the designer to simultaneously explore the feel of actions, the affordances of form and the behaviour of interactive products.

Currently we are exploring an idea of movement tokens. This is a collection of physical objects, each of which is equipped with location and orientation sensing. Using a movement token, a user can position an action within Cubby's work space. When the user carries out an action with a movement token he 'stamps' a virtual controller or virtual actuator within Cubby's space. First we will explain our movement tokens, then we will discuss their possible applications.

Such virtual action geometry can then be connected on a separate network layer to define the interactive behaviour of the product to be designed. Once such a behaviour network is in place, re-entering and operating a movement token in Cubby triggers a sequence of events.

Though currently our movement tokens are rather conservative (buttons, sliders and LEDs) our ambition is to create a set that goes beyond the current product interaction language to match the richness of actions which is currently reserved for art installations.

slider tool

With this tool, slider action and geometry can be input into the Cubby+ workspace. The slider tool can be bent to allow for different shaped sliders on the to be designed product. First the slider tool is positioned. After which the knob of the slider is squeezed and moved. When the desired slider length is reached the knob is released.

turner tool

Turner action and geometry can be input into the Cubby+ workspace. User adaptable turning knobs define the expression of the turner geometry. First the turner tool is positioned in the Cubby+ workspace and activated by a little button at the side of the tool. The desired amount of turns is input after which the little button at the side is released.

display tool

Displays of different sizes can be input into the Cubby+ workspace. First the display tool is resized to the desired dimensions. Then it is positioned and activated. A display of the desired size is thus input.

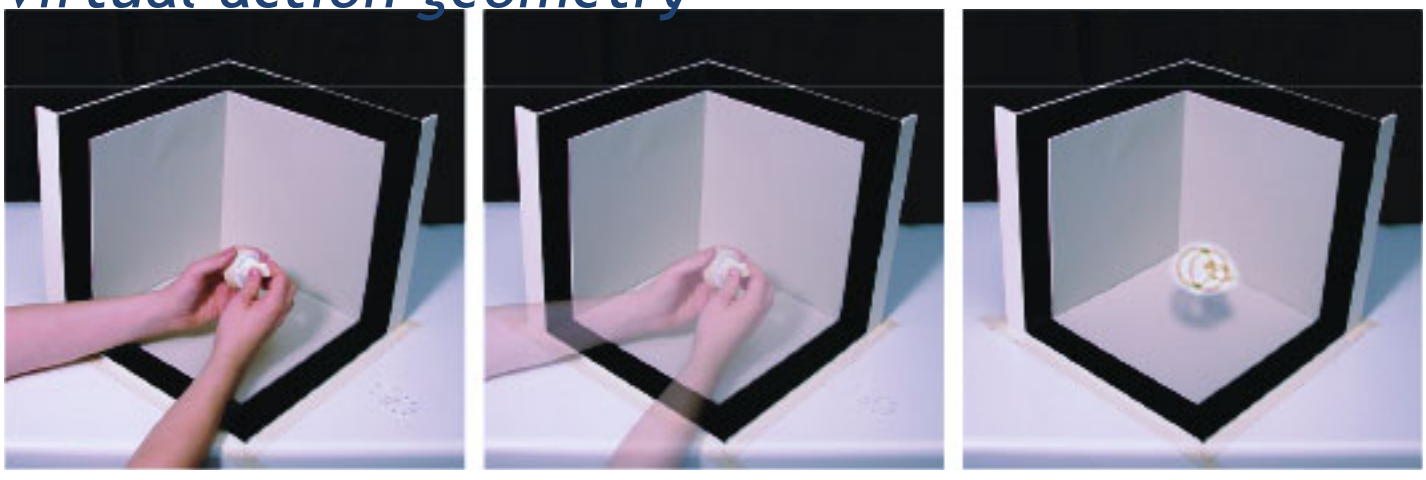
light tool

Different kinds of light can be input into the Cubby+ workspace. Several light patterns can be made with this tool. Grids of light dots can be defined, but it is also possible to draw lines of light.

Linking

Earlier we mentioned a separate network layer. We would like to explain shortly how this works. The tokens are equipped with a linking button and an activation button. When a new imprint of a token is created and a functional link with an existing imprint is desired one does as follows. The desired token is brought into the Cubby+ workspace. The linking button is pressed and the token is dragged through an existing imprint with which the link is desired. The existing imprint and the one in progress are now functionally linked. When the token is activated within the Cubby+ workspace the process of linking is completed. The links can be visualized in 3D similar to MAX/msp, an existing program. A screenshot of MAX/msp is shown below. MAX/msp is a product of cycling'74.

virtual action geometry



Exploring possibilities
When the movement tokens are being used, both the action of the tool and the geometry of the tool is "stamped" into the Cubby+ workspace. We call this imprint of the tool in Cubby+, "Virtual Action Geometry". This geometry also affords action. An impression of virtual action geometry is shown above. Currently we are exploring different possibilities of the movement tokens. The expression of the geometry is important, a geometry can afford a delicate motion or a rough motion. The shape of the virtual geometry and thereby its expression can be defined in several ways, we like to describe three of them.

One of them is depicted below in three incarnations of the turner tool. In this example we show the turner tool with three different turning knobs. The turning knobs are user definable, by making them in clay or foam. The knobs are scanned by a 3D scanner. After the imprint of the turner tool is made in the Cubby+ workspace, the virtual action geometry adopts the shape of the physical, user defined, turning knob. The other movement tokens can be user definable in similar ways.

As opposed to a direct copy of the shape it is also possible to postpone the exact geometry creation. The use of movement tokens would then result in unspecified virtual geometry that only indicates its ability to be controlled. The imprint of a movement token would look like a cloud of faces that slightly moves to indicate how it can be controlled. Only after a product is defined functionally by different movement tokens, the definition of geometry would be started. This can then be done by using shape creating tools as proposed in our scenarios. In this way the desired expression of the physical interface of the product can be made.

Yet another way of defining the shape of the virtual geometry is an indirect way. The movement token is manipulated by a product designer in the process of defining virtual action geometry. In the behaviour of that product designer clues can be found as to how the expression of the virtual action geometry should be. For example the designer could desire a delicate control for fine tuning some function of the product in progress. He probably indicates this with delicate manipulations of the movement token. When this delicateness could be picked up it could be translated into the shape of the virtual action geometry thus defining the expression.

Conclusions
Within Cubby+ we aim for an early phase computer-supported design tool that enables us to explore form but also to explore product interaction in 3D. Although we have not actually built the system yet, we are confident that the ability to simultaneously explore form and product interaction has true value. We think that our Cubby+ design environment will offer new tools that will complement existing tools.

In this project we have experimented with new techniques to explore virtual reality concepts. We started by building short scenario movies which combine computer graphics with real objects and hands using blue-screen techniques. Although these movies are not interactive, we have found them to be highly useful as they allow us to explore and discuss the user experience very early in our design process in a time and cost effective manner. In effect we have shifted from implementation to simulation.

References
Djajadiningrat, J.P., Overbeeke, C.J., & Stappers, P.J. (2001). Cubby: A Unified Interaction Space for Precision Manipulation. Proceedings of ITEC2001 (CD-ROM), Lille, April 24-26 2001.

Wegner, K. (2001). Data Sonification for Simulation, Training, and Guidance in Critical Environments. Proceedings of ITEC2001 (CD-ROM), Lille, April 24-26 2001.