The Amalgamation – Product Design Aspects for the Development of Immersive Virtual Environments

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Abstract: Interacting in an immersive virtual environment we refer to the real world. The user gets to expect real world behaviour from virtual objects and functions. We explore the idea of bringing aspects of product design to the development of input devices and interaction techniques for virtual environments. We use ergonomics and *product language* to design the physical input device, the virtual representation and the connection between real and virtual parts. This connection, which we call *amalgamation*, is the most important element of the design, since it defines, if the user rather interacts with virtual objects as "virtual products" (via an input device), or rather interacts with an input device as a "real product" controlling virtual content.

1. Introduction

The more we use multimodal input and output systems as virtual environments which enable the user draw from real world experiences in order to interact with a computer system, the more the user reflects his behaviour to the use of real world things. Nevertheless he still uses a computer system, even if he is less aware of it.

Designing input devices for interaction with computer systems of any kind is quite different from designing a "real product". The main difference is, that the *practical function* of an interaction is not necessarily determined or limited by technical or mechanical restrictions. In a virtual environment, there is no intrinsic connection between a function and its use.

The result of this is that on one hand it is possible to implement *any* type of functionality and behaviour. On the other hand the user cannot rely on his understanding and common use of real world things to guess what the behaviour or function of a virtual object might be.

2. The tool aspect

In the real world, a tool is not only made to perform a specific task, but it also makes its own function "legible" to a user. With a good tool, a user, equipped with common world knowledge, can read the purpose and the way of use into the device, enabling him to apply it properly. Also, a tool "naturally" refers to objects it can be applied to and used with.

Although we don't have to respect physical constraints and necessities when designing virtual tools and functions, we have to create and establish this link between a tool and its affordance.

A tool for virtual environments consists of two interdependent parts: a physical input device and a virtual representation with a functional behaviour. Physical and virtual part work together and *amalgamate* to form a single tool. We use ergonomics and *product language* to design the physical device, the virtual representation and the connection of both parts. This enables us to control the effect of the *amalgamation*.

3. The product design aspect

Product design deals with the development of artefacts and their "connection" to the user, the interface. Although there are main differences between the design of real tools and input devices for computer systems, it is helpful to see, how product design theory describes the relationship between a user and an artefact. This relationship is called the *product function*.

The product function consists of the *practical function* of a product and the *product language*. [1]

The *practical function* takes emphasis of the technical function and ergonomic aspects of the use of the product.

The *product language* is concerned with the users understanding of the *practical function* of a product and its *semantic notion*.

The *semantic notion* describes the inferred "meaning" of a product. It reflects circumstances and the individual and cultural background and forms a kind of "behavioural function".

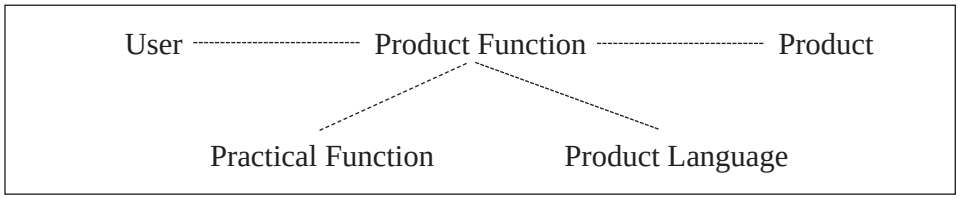

Figure 1: Product function

Example:

The *practical function* of a wristwatch is to keep the correct time, to be wearable and legible and to allow adjustments. While a Rolex is a wristwatch when its *practical function* is concerned, part of its *semantic notion* is its role as a status symbol and its reflection on the owners "style".

If we only look at the *practical function* of a product, we neglect that things in the world are not just experienced in their *practical function* but also in the context and relationships in which they appear.

Product language or *product semantics* as part of the design theory occurred in the 1970s in Europe and nowadays is established in the design process.

Methods like Lannoch's "semantic transfer", that transforms linguistic expressions (i.e. soft, beautiful, breakable, comfortable, etc.) into spatial forms [2], define "legible" shapes without a certain practical function assigned. However these semantic forms can be better representations for information and software functions than naturalistic ones, because they don't evoke a concrete real world experience.

4. Amalgamation

Designing input devices and interaction for virtual environments means to merge the real and the virtual world to a hybrid interaction space. The design has to take care of a well-balanced *product function*, which is anchored in both worlds simultaneously. This causes a new kind of "tool", consisting of a physical and a virtual part, connected to what we call *amalgamation*.

The "look and feel" of the *amalgamation* depends on where the main definition and weight of the *product function* lies, in the virtual or in the physical part.

An emphasis on the virtual part requires, that the main practical function has to be defined in the virtual representation of the software functionality.

The virtual objects and their functional behaviour have to be designed very precisely in order to enable the user to build a good mental model of the way he can interact with the objects. In this case, the physical device should be designed to be rather neutral and indeterminate, to allow the user to focus on the interaction indicated by the virtual object.

An emphasis of the *product function* on the physical part requires, that the shape of the input device has to inform the user about the possible input actions.

Although no additional representation in the form of a virtual object is needed to augment to the input device, the software implementation of the functional behaviour has great influence on the user's perception and handling of the device. It "determines" the devices options as they are experienced by the user. Therefore the implementation of the functional behaviour should be designed together with the input device and vice versa.

5. The ergonomics aspect

Ergonomics are closely connected to product design. They have great influence on the usability and the shape and form of a product.

The operating devices of a product predetermine the users actions. They depend on the technical construction, which is necessary for the products main practical function.

The Design of physical and virtual artefacts for virtual environments, can use such ergonomic aspects in two different ways:

- In the common way, to design ergonomically optimized artefacts for better practical use.
- To give the user a hint, how to interact – as a kind of metaphor or "intuitive instruction manual" without any technical necessity.

The interpretation of ergonomics as part of *product semantics* brings a new quality to the design of input devices and interaction.

6. Examples

The following examples illustrate how product design aspects were applied to the authors´ work on input devices and interaction techniques for virtual environments.

6.1. “Mike” and “Boule”

The input device “Mike” and the virtual system menu “Boule” were designed as part of the interface of an immersive design review application for the automotive industry. The design review application “Boule” has won the “TOP3 IF interaction design award 2000” of the Industrie Forum Design Hannover e.V. [3].

The “Mike” is a stylus-type input device with a 6DOF tracking sensor and two buttons. It is a generic, 12 cm long, 2.8 cm diameter cylinder with a pointed tip. Its indeterminate shape allows three different grasps and symmetric rotation along the principal axis. The *practical function* of “Mike” is pointing along the principal axis, pressing of the two buttons and to facilitate different grasps. The neutral cylinder shape evokes very little “meaning”.

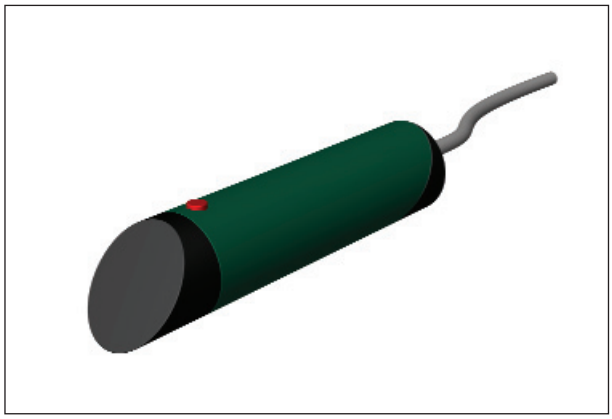

Figure 1:
The “Mike” input device

The “Boule” system menu is a virtual model of a ball. It pops up by pressing a button and snaps into position according to the spatial rotation of the tracked input device [4], [5]. Its *practical function* is the selection of five positions: centre, left, right, up, and down. The modelling is quite detailed and together with the snapping behaviour is designed to suggest a certain “weight” of the ball.

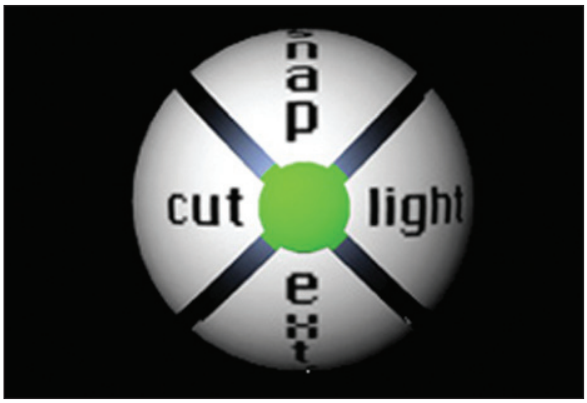

Figure 2:
"Boule" system menu

In the case of "Mike" and "Boule" the *product function* of the *amalgamation* lies in the virtual part of the combined tool. The input device is relatively indeterminate, whereas the virtual representation and behaviour of the virtual object is as detailed and defined as possible. In the design review allocation "Boule" the user is encouraged to concentrate on and trust the virtual objects, enabling us to embed rich functionality.

6.2. The "NoYo"

The "NoYo" was designed and developed as a dedicated input device for free and precise 6DOF navigation and object manipulation in large-scale immersive virtual environments.

Figure 3:
The "NoYo" input device

The “NoYo” is a joystick-type input device with a 3DOF orientation tracker and a 6DOF elastic force sensor. It is a slight conic grip, 10 cm long, 4 cm diameter, with a distinct, elastically attached controller cap on top. “NoYo” allows the analogue control of a total of 9DOF. The controller of the 6DOF force sensor gives elastic feedback to the user, with a counterforce proportional to the small motion of the cap. This allows the user to have precise control of the input force acting to the cap, giving him direct feedback through the “feel” of the device. The elastic controller’s output values of the device are proportional to the acting force [6].

The virtual part of the tool has no explicit visual representation and exists only in the functional behaviour of the rate-controlled motion model, translating the force applied on the cap into speed and direction.

In the case of the “NoYo”, the main *product function* lies in the physical device. The device delivers intrinsic feedback to the user, allowing him to use the device for precise navigation without even looking in the direction of motion.

7. Conclusion

The more interaction with computers becomes an interaction in space, the more we can refer to the competence of product designers. Their work traditionally is a work with three dimensional objects and space.

Although developing input devices and interaction techniques for virtual environments is not exactly the same as developing real world artefacts, the theoretical and practical background of designers is increasingly necessary to win user acceptance.

The aim of product design is not primarily concerned with making things look better, although this is part of a designer’s job too, but to help users to understand a product and its use.

The product design aspects illustrated in the article show how design can be effectively involved in the development of input devices and interactions in virtual environments.

8. References

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