TWO-HANDED GESTURE-BASED CAR STYLING IN A VIRTUAL ENVIRONMENT

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ABSTRACT

Virtual reality offers stylists the possibility to immediately sketch and model in 3D, combining the sketching and modelling stages of the design process. In this paper we describe MOVE ON, a new two-handed gesture-based Computer Aided Conceptual Design application for use in a virtual environment. The use of two-handed form-descriptive gestures to sketch and deform automobiles three dimensionally, gives the stylist an intuitive and natural way of styling. With MOVE ON, the stylist is offered a computer supported approach that respects his creative, expressive and skilful profession, by giving him expressive freedom, personal style and a method that fits his motor skills. The virtual environment stimulates direct interaction with the designs, tools and environment, thus creating an idea generation, presentation and evaluation tool. We are currently experimentally testing the feasibility of MOVE ON for conceptual design.

1. INTRODUCTION

Most car stylists currently visualise their ideas with 2D sketches[1] on paper. This is a quick, intuitive and expressive way to generate, present and evaluate ideas. Drawing allows the stylist to make first rough impressions and also smooth detailed renderings. He can wield his own personal style by using different drawing tools, all with their own characteristics. Moreover, the tools fit his perceptual-motor skills[2]. The stylist experiences the tools as part of his arm and hand and the lines and surfaces made seem frozen movements. Sketching is a skill.

Despite all advantages of drawings, they have limitations and are inadequate to support solely the entire styling process. It is harder to judge and develop a 3D form in one view depicted on a flat

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[1] 2D refers to the medium (a flat surface) and not to the subject. So it can be a perspective drawing of a 3D car.

[2] Perceptual skills refer to the ability of a person to experience the world around him through his senses. Motor skills are the personal dexterity to interact with the environment, determined by a person's body coupled with the possibilities to move and act that the environment affords this person. The two aspects form a twofoldness: the ability to perceive gives a person the opportunity to pick up information about possible (inter)actions and acting and moving themselves give the person more perceptual information (Gibson, 1986; Smets, 1995).

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surface, then with a 3D model which can be inspected from all sides. Furthermore, drawings made on paper are outsiders in the digitally determined production development chain.
Digital 3D models, possibly together with clay models, can complete the visualisation techniques necessary to develop a prototype. The scope of visualisation techniques used in the automotive industry is discussed in the next paragraph.

2. THE TWO EXISTING WAYS TO CREATE A 3D CAR FOR EVALUATION, STARTING FROM SKETCHES

Two approaches are found in the automotive industry to create 3D models (see figure 1), which will be discussed below. We introduce a third and novel computer supported approach that is tightly coupled to present working method of stylists, namely sketching; it departs from the stylist's perceptual-motor skills and the goals he wants to achieve.

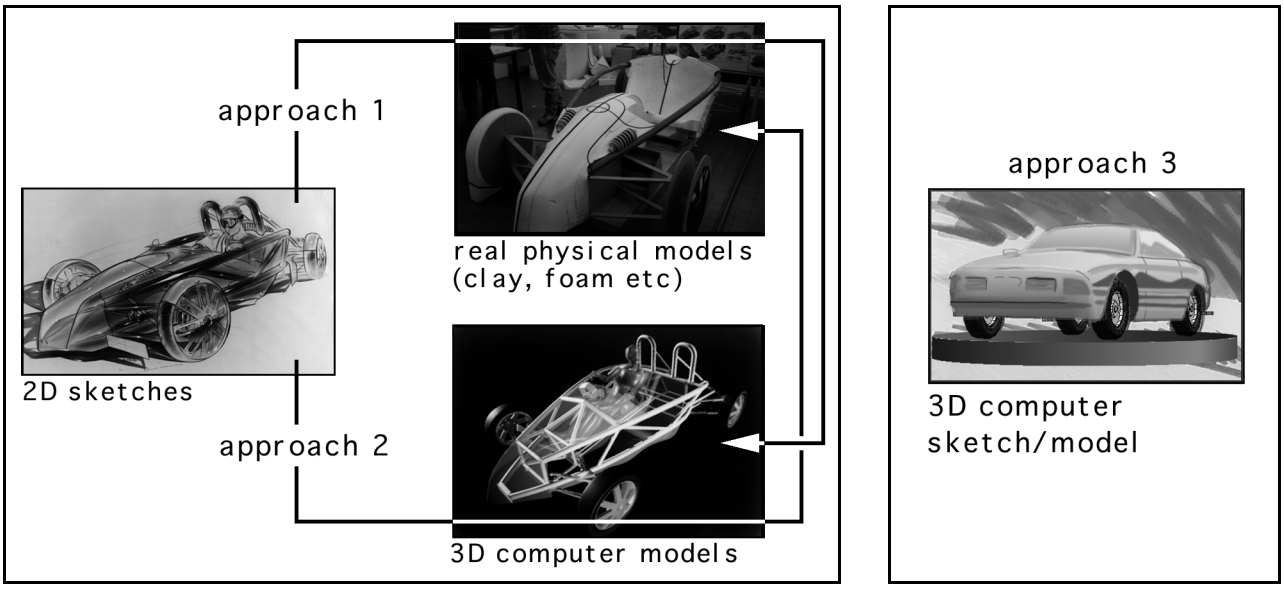

Figure 1. The two existing and one novel approach to create a 3D computer model:
1: from 2D sketching, through clay modelling to feeding measurements into the computer
2: from 2D sketching, through Computer Aided Styling to milling a foam model
3: combined 3D sketching and modelling in a virtual environment

Approach 1:
Generally, 3D clay models are made to evaluate and develop aesthetics aspects of the car and determine manufacturing aspects and marketing opportunities (INSTANCE, Brite-EuRam III project 95-2151). Clay modelling is a skill, likewise drawing, and the models are made by specially trained model makers. The working method fits closely to the modeller's tactile and visual skills. Although clay models lack some expressive quality of drawings, e.g. no vagueness and ambiguity, one material and colour , it adds other, e.g. texture. The 3D model is measured and a 3D computer model is created with the obtained data. This last phase is usually done with CAD-packages by geometric modelling engineers (Knoop, 1995). These computer models are solely used for engineering.
A major disadvantage of clay models is the labour-intensity (up to eight man-months for a full-size model) and consequently the high expenses. And a 3D computer model has still to be made.

Approach 2:
Nowadays Computer Aided Styling (CAS) and Computer Aided Industrial Design (CAID) packages are developed to support 3D modelling in the conceptual design phase. This way of computer modelling is performed by the stylists and model makers. Autostudio by Alias|Wavefront (www.aw.sgi.com) and the software developed within INSTANCE (Overbeeke et al, 1997) are examples of these applications. The computer models can be milled afterwards for further evaluation and presentation.
Although the CAS packages aim to replace traditional clay modelling, the working methods of these packages differ considerably from clay modelling. They are cognitive driven and take minimal advantage of the stylist's and modeller's perceptual-motor skills. There is no direct physical contact with the 3D model shown on a computer screen. The models are created through a complex set of mouse or pen strokes and numerical inputs they are largely built in orthogonal views. And last but not least, the expressiveness from the drawings and clay models is lost in these computer models. They look hyper-real, synthetic, anonymous with no rough stages and no graphical evolution and cold without a personal touch. On the other hand, it is not all misery. These CAS packages have powerful mathematical representation and evaluation techniques and they offer an enormous amount of manipulation techniques.
To conclude, the highly skilful profession of both stylists and modellers is transformed with these CAS-packages into a visual juggling with views, menus and indirect actions, disrespecting the perceptual-motor skills and creative expressiveness of the individual designer.

3. A NEW APPROACH IN COMPUTER AIDED STYLING

Virtual Reality (VR) offers the possibility to revalue the stylist's skills and expressive creativity in a computer environment. At the Laboratory for Formtheory we are currently developing MOVE ON, an application for computer supported design in VR based on the designer's expressive skills.
MOVE ON combines the sketching and modelling stages and creates a 3D hybrid styling application, see figure 1. This new approach covers six aspects determining the traditional working methods, based on the stylist, the product, process and the application:

1. The technique fits the stylist's perceptual-motor skills.
   Styling is a skill and it should maintain a skill when it is computer supported.
   In MOVE ON the stylist can immediately sketch and model in 3D. The stylist uses two-handed gestures[3] to make a 3D trace in time and manipulates this created surface directly with his hand, see figure 2 and 3. The sketches appear as frozen movements, just as drawings on paper and these traces are manipulated through direct contact with the stylist's hands. The stylist uses both hands and every hand has its own specific function; This fits in with research about the functional differentiation of both hands. (Guiard, 19987; Bier et al, 1994). The stylist prolongs his natural way of acting through two-handed gestures. The few supporting tools he uses, e.g. a copying tool, form together with his hand a twofoldness. His hands are his tools, thus creating the optimal fit, assuming that the hand has more possibilities in VR.

[3] A gesture is a motion of the body that contains information (Kurtenbach and Hulteen, 1990)

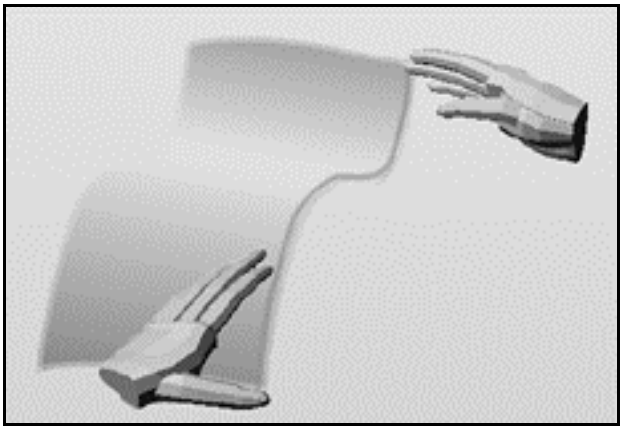

Figure 2. 3D sketching by leaving material behind in space

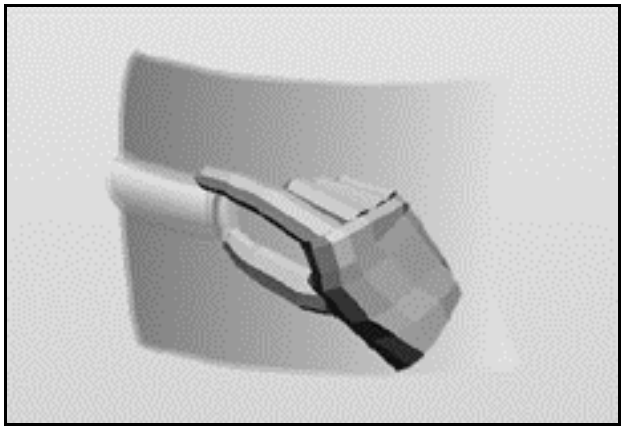

Figure 3. Manipulating the model with the hand as tool

2. The stylist can adjust his working methods and the expressive quality of the visualisation to the stage of the design process.
   "The styling process is holistic" with the result that the stylist tries *"to create a solution proposal as a whole, and work out the details later."* This is often a process *"in which the initial design is represented as a hazy, undetailed sketch, and as the design progresses it is as if the sketch was gradually brought into focus and more detail was seen."* (Tovey, 1997).
   The indeterminacy's in sketches also serve to stimulate idea generation. *"Confused things rouse the mind to new inventions"* according to Leonardo da Vinci (Gombrich, 1966).
   In MOVE ON the 3D sketch/modelling approach facilitates vagueness and ambiguity in the visualisations by gradual intensity of lines and surfaces and indefinite edges, see figure 4.

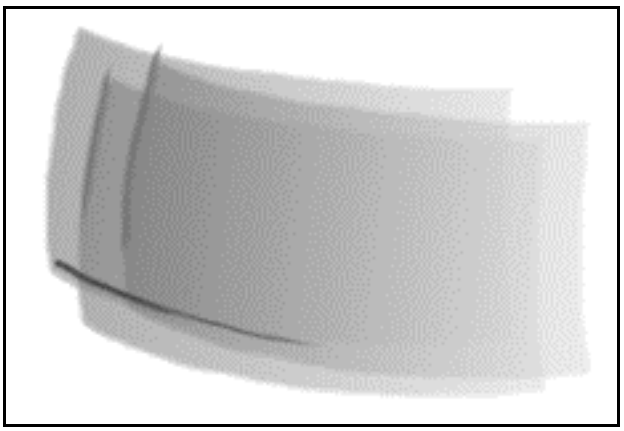

Figure 4. vague and ambiguous surfaces.

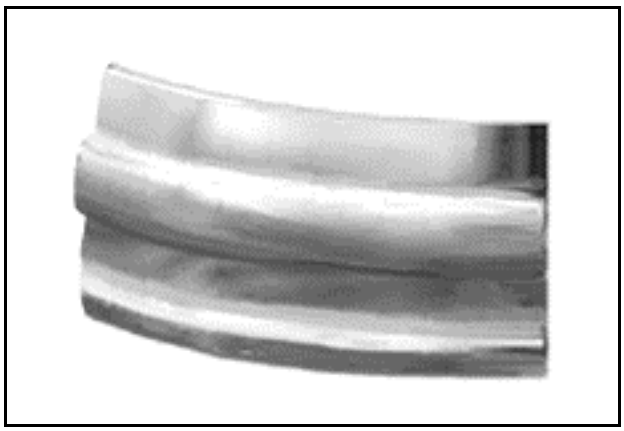

Figure 5. unambiguous expression.

These gradual intensities are controlled by the stylist through the tension of his arm. By increasing the force in his arm as if he is pushing against a surface, the line/surface is displayed with more emphasis. Sketching allows the stylist to quickly visualise his ideas and when more precision and details are desired he can manipulate the surface more accurately and the visualisation shifts slowly towards a more unambiguous one, see figure 5. The 3D styling hybrid allows for gradual changes in the process instead of the sudden transitions as seen in approach 1 and 2.

3. The technique allows for expression of the stylist's personal style, reflected in the visualisation, the used working method and the stylist's motor system .
   The allowance of personal style is essential for the stylist because it is his signature, a weapon in a competitive industry and a release of aesthetic preferences and personal motory characteristics. He can take advantage of his own strong points.
   In MOVE ON the designer can choose several materials with their own physical (e.g. elasticity) and visual (e.g. colour and texture) characteristics. He can determine his own path and time to come from the first rough sketches to more determined models, because the methods are interlinked. And finally, he sketches and deforms these sketches with gestures, which means that the stylist's own characteristic way of moving his body, arm and hands is visualised.
   This way the stylist regains his signature in a computer environment.

4. The stylist must have enough form freedom to design cars.
   "Form and feature lines must be put into automobile body panels to give them stiffness and strength .....Virtually no surface on a automobile is flat, almost every panel is curved in more than one direction. ....., possibly with other indentations and piercings in the basic surface. The automobile form is build up of several such surfaces which meet as intersections, are filleted, or blend smoothly into each other. The forms may be hard and rigid, or soft and flowing, or a judicious combination of both." (Birtley, 1990)
   In MOVE ON the stylist sketches, deforms, intersects, trims and stitches curves and surfaces. He can influence the smoothness of these intersections by the tension of his arm, just as the control of colour intensity (see nr. 2).

5. The stylist can present his ideas to the management team for evaluation, beside using the application for generation of ideas.
   Management needs broadly two categories of intervention, during concept design which is characterised by a number of quickly produced sketches and during design development which is characterised by a full-size realistic representation of the product (Tovey, 1997).
   In MOVE ON several car concepts can be evaluated at the same time in the virtual design studio. This can be both scale models and full-size models. VR allows for interaction with the car, you can walk around it, evaluate it from all sides and even experience the interior when this is defined. Furthermore, the stylist can adjust the graphical quality for presentation and evaluation and model production.

6. The interface of the computer supported styling application allows for direct and intuitive styling of cars. This way the interface fits in with the traditional intuitive styling process.
   In MOVE ON the stylist uses form-descriptive and manipulative gestures and seldomly symbolic ones. This minimises a learning period. The stylist is standing in a virtual design studio and can see around him what his options are. The materials and supporting tools afford grasping and immediate use, because they are three-dimensional instead of the generally used 2D icons, the

format and size of the material and tools fit a hand and the functionality is coupled to the material and tool.

4. MOVE ON: A SCENARIO

We are currently implementing MOVE ON on a extended Virtuality Elysium III VR system with a head-mounted display. The stylist wears two gloves, manufactured in our own laboratory, to measure his finger and hand movements. The muscle tension in the arm is measured with Electromyography (EMG) equipment. MOVE ON is amplified with the following scenario. The video of MOVE ON is replaced by stills for reproduction reasons.

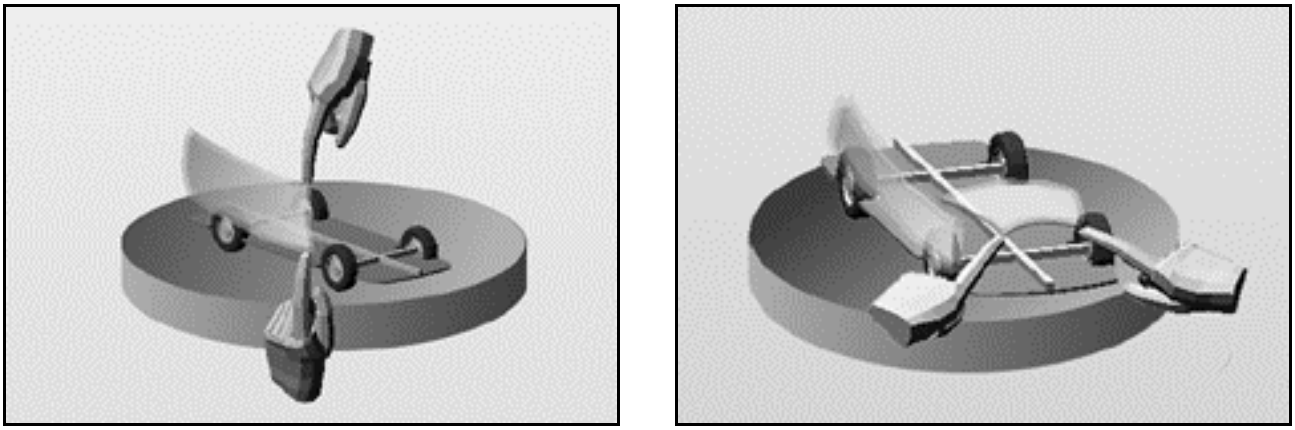

Figure 6. The stylist can put the visualised package data on his workbench. To start sketching, he picks material first , describes a curve with his finger and pulls this curve through space, thus leaving a trace. The tension in his arm influences the colour intensity (left). When the material he picks is flexible, he can influence the form of the curve during sketching in 3D (right).

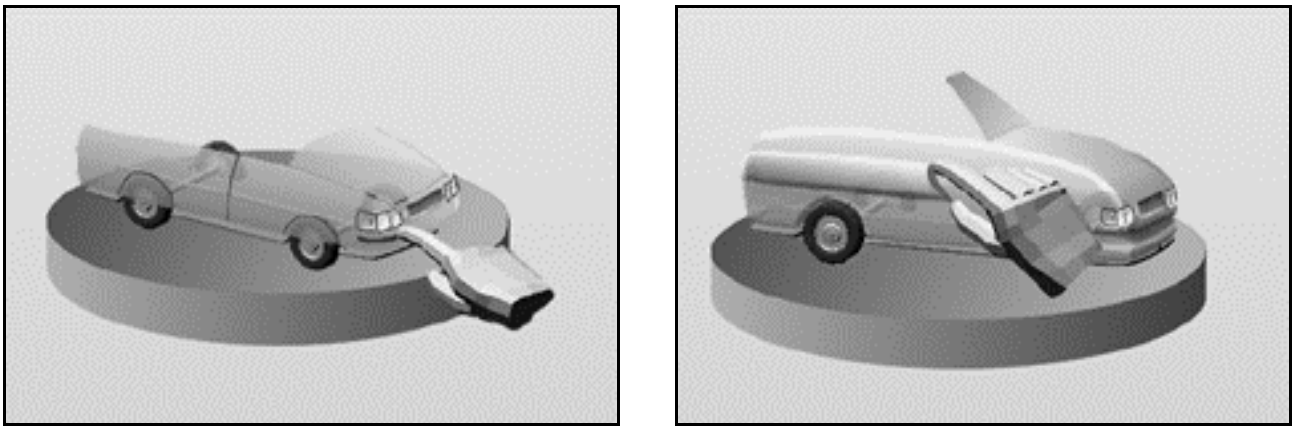

Figure 7. The stylist can freely sketch in space, or he can sketch onto a surface and quickly add details (left). Surfaces can be connected and manipulated comparable to the sketching method. The created curve, this is the active region between the fingertips, deform existing material (right).

5. DISCUSSION

We have introduced a new 3D hybrid styling method starting from the stylist's skills and needs combined with the new possibilities that Virtual Reality offers. Six advantages derived from several creative methods are integrated in MOVE ON. In MOVE ON, 2D sketching followed by 3D modelling on a computer or with clay, is replaced by a combined 3D sketching and modelling approach using two-handed gestures. General question is: "How do stylists visualise their ideas directly in 3D using two-handed gestures to sketch/model?"

We conducted an observational test to get a first impression of the feasibility of 3D form descriptive gesturing for design. We asked forty designers and non-designers to express in gestures how they would design a specified product. No computer equipment was used; the subjects didn't have any feedback of the forms they described.

Although the subjects had no feedback, they experienced this way of designing as pleasant and promising. The observation showed several aspects concerning working methods and motor skills:

1. Not all designers sketch a product (surface) in 3D. One group created a chunk of material first, which they deformed. This divided approach should be accounted for in further development.
2. Designers have their own personal style of working, shown by the number of gestures used, the different forms used to describe predetermined surfaces and the character of the gestures.
3. Two-third of the gestures they make are two-handed and one-third is one-handed and 70% of the gestures with the non-dominant hand have a referential function.
4. A few designers mentioned afterwards their concern regarding the absence of tactile and force feedback. The actual observation showed no clear answer about tactile and force feedback. Further experiments with visual feedback should give more insight into the absence of tactile and force feedback.

In general, the observation supports the basic approach of MOVE ON.

We are currently experimentally testing the first implementation of MOVE ON. We compare four tools:

1. Traditional paper drawing.
2. A "traditional" CAS system. The way models are defined and manipulated is tightly coupled to the mathematical representations used to represent these models.
3. A "traditional" CAS system with a Virtual Reality interface. This application is comparable with nr. 2, except that the 3D environment allows for direct contact with the tools and models.
4. MOVE ON. The tight link between visualisation, manipulation and representation is replaced by an approach which is determined by the stylist's expressive skills.

Clay modelling is left out because this experiment concentrates on "drawing-like" techniques where the product is created with curves and surfaces instead of solids.

Ten subjects will design a specified product with all four methods. Experts and the ten designers themselves will judge the product designed, the process gone through and visual quality, for all four conditions. These three criteria, product, process and presentation, are standard criteria to judge design exercises at our Faculty of Industrial Design Engineering. The six requirements for MOVE ON mentioned in paragraph 3, are implicitly present in these three criteria, but will also be observed separately.

With this experiment we try to establish the advantages of MOVE ON as compared to 2D sketching, clay modelling and existing CAS techniques. Hopefully with MOVE ON we can tempt stylists to work the entire conceptual design phase in our virtual environment.

ACKNOWLEDGEMENTS

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