SOME PHENOMENA OF TOUCH IN STUDY MODELS

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Abstract. The sense of "Touch" brings to people the feeling of reality, and human beings can always naturally sense the tactile impression. Hence we touch things and our sense tells us that our hands are touching something (Hinckley et al., 1999). Compared to the tools used by designers between traditional and new digital media in the design process, the greatest difference is in the sense of touch. This paper focuses on the sense of touch to point out the haptic experience which has been ignored in the past in design process. Four phenomena will be discussed in detail and some useful suggestions given for future study.

1. Introduction

In the architectural design tradition, designers used their hands and eyes to exploit ideas (Schön and Wiggins, 1992). The physical conceptual models play a key role in transferring our spatial imagination and various possibilities for continuous developments (Knoll and Hechinger, 1992). Nowadays, Some systems integrate sketching and modelling to adapt to the needs of designers and emulate traditional ways to allow designers to control tools more naturally (Schkolne et al., 2001; Igarashi et al., 1999; Wesche and Seidel, 2001). Moreover, issues are increasingly dedicated to the tangible interfaces for designers to develop ideas more intuitively (Lee et al., 2003; Wesche & Seidel, 2001).

However, while designers get used to facilitate new media and create study models in the early stage of design process, they even use the media tools, which incorporate haptic element into user interface. To synthesize the related works, we could attribute four deficiencies. First, few studies enhance the role of touch in the design process except Basdogan et al. (2001) and Brereton and McGarry (2000) have made it. Second, because of the haptic interfaces changes, designers' touch sensation has to adapt from traditional ways to new media era (Landay and Myers, 1995; Terry and Mynatt, 2002; Anderson et al., 2003). Third, new media is an effective and useful tool, but the physical feeling is already absent (Knoll and Hechinger, 1992; Lin, 2000). Fourth, lack of studies focus on the designer's haptic experience touch in study models.

As mentioned above, three of the attributes keep working with discussions, however, no one is concerned about the last onepoint. In addition, although many

researchers proposed systems or theories that evolved with haptic elements, no one has assessed the functions of touch. I suspose to understand the haptic experience in concept generation stage of design process to conduct the suitable haptic media or tools.

This paper concentrates on the sense of touch, one of the most significant components of the study model stage of the design process. The objective of the study is to observe some phenomena of touch in study models and elucidate the phenomena through cognitive approach.

1.1. WHAT IS HUMAN SENSE OF TOUCH

Touch is a significant human sensory channel. Touch aids people's emotional expression and makes people aware of responses when contacting someone or something (Hinckley et al., 1999). Our hands as communication tools usually combine actions or gestures to extend ideas (Bolt and Herranz, 2001; Sturman & Zeltzer 1993; Hinckley et al., 1999). Some studies add haptic components to input devices to offer many possibilities for novel interaction techniques (Basdogan et al., 2001). Besides, in design or art fields, more studies focus on the senses of touch with the hands. Yet, researchers are endeavouring to develop various interfaces or systems for designers though design processes. Several works of haptic-based modelling techniques have been announced (McDonnell et al., 2001; Bloomenthal and Wyvill, 1990; Markosian et al., 1999).

1.2. IN CONCEPT GENERATION STAGE

The early stage of design process, concept generation stage, is the key phrase to conduct design creativities (Huang & Liu). Designers usually use sketches and study models to exploit their concepts. Sketch as a media helps designers draw lines and planes with graphical elements to represent the ideas as well. And much of related studies are focused on visual thinking with sketching (Goldschmidt, 1994; Liu, 1996; Schön and Wiggins, 1992; Suwa et al., 2001). Another media, physical study models, allows designers observe the model's location unconstrainedly and discover detailed problems (Lee, 2002). Sketch and study models aid designers to develop unexpected results.

Nowadays, new media inspire more design developments. The variations of media make differences between designers' visual thinking and design behaviour (Won, 1999; Wong, 2000; Brady, 2003). Those new media enable designers use the mouse to click through several commands to accomplish everything in front of the computer screen. That is really effective and shorter time as well, but apparently this method lacks spatial awareness when inspecting and manipulating drawings displayed on the computer screen (Lee et al., 2003). Because many designers have difficulty conceptualizing with a mouse and a screen to manipulate the study models

or models, several systems combine virtual environments and hapticbased tools to assist designers creating 3D virtual models (Schkolne et al., 2001; Wesche & Seidel, 2001; Igarashi et al., 1999).

1.3. DIGITAL MEDIA AIDED DESIGN BASED ON HAPTIC SENSATION

Some researchers brought out haptic issues and technologies that were not mentioned formerly (Brereton and McGarry, 2000; McDonnell et al., 2001; Bloomenthal and Wyvill, 1990; Markosian et al., 1999). In addition, various media tools based on the tactile sensation are supposed. For instance, Free Drawer is created to be a 3D Sketch system. It is a free-form sketching system on the responsive workbench for product design. In this field, the visual appearance is one of the most important aspects of the overall development process. The authors propose 3D tools for curve drawing and deformation techniques for curves and surfaces, adapted to the needs of designers. The user directly draws curves in the virtual environment, using a tracked stylus as an input device. A curve network can be formed, describing the skeleton of a virtual model (Wesche and Seidel, 2001).

Surface Drawing is another system for creating organic 3D shapes in a manner which supports the needs and interests of artists. This medium facilitates the early stages of creative design which many 3D modelling programs neglect. Much like traditional media such as line drawing and painting, Surface Drawing lets users construct shapes through repeated marking, and the hand is used to mark 3D space in a semi-immerse virtual environment (Schkolne et al., 2001). Bae et al. (2004) present tangible interaction techniques for fine-tuning one-to-one scale NURBS curves on a large display for automotive design. They developed a new graspable handle with a transparent groove that allows designers to manipulate virtual curves on a display screen directly.

2. Cognitive approach and steps

Based on the objective of this paper, the cognitive approach (protocol-analysis) consists of three steps. The first step is to set the experiments environments. The subjects the experiments need should have with at least two years' design background. Furthermore, three cognitive experiments are conducted. In the second step, is collecting the verbal data from the designer's descriptions of modelling process. Also, to find out possible components which affect the experience of touch from designers and coding the verbal data. Finally, to conduct relevant phenomena of touch that were analyzed from the experiments.

2.1. EXPERIMENTS

Three cognitive experiments are included for the object of this paper. Three kinds of media are chosen, namely clay, boxboard and computer. The purpose of the experiments is to record the developing process of study models by the subjects. Any behaviours and verbal descriptions derived from touching or tactile sensation will be the essential part to be dwelt upon.

The process of experiment will be recorded by digital video, which would catch visual images and audio. The requirements of this protocol analysis experiment are clarified as following. Exclusive of three media (clay, boxboard and computer), others principles are made the same. The design topic of the experiments is to develop an observatory in one hour, and the subjects are asked no sketching to start the design. During the experiment process, the subjects speak out their behaviours and thinking. The subjects are asked to explain any actions they intend to do.

In Experiment A, subjects use clay as design medium to develop a concept model (physical study model). No other tools to assist with just their hands. In Experiment B, subjects use boxboard as design medium to develop a concept model (physical study model). Subjects are able to use rulers, glue and knife, but no sketching, even using a pen. In Experiment C, subjects use computer as design media to develop a concept model (study model).

2.2. FOUR CODING SCHEMES

This step involves collecting the total analytical information, including verbal data from the subjects, the study model making procedure, which is recorded by video, and the image of the study models. Afterwards, conducting the relevant haptic components that were derived from the subject's verbal descriptions. Then, starting the coding and analyzing works. The coding scheme is found through the experiment's process. To synthesize the data, the author arranges four coding types, namely E.M., I.M., G.C. and D.F.. Those four types are acquired from the developing process of study models. Four coding types represent four activities inspired by subjects' haptic experience (Table 1).

TABLE 1. Four coding types are represented four activities inspired by *Touching.*

Coding scheme	Clarification
E.M.	E.M.: Explore Media properties
I.M.	I.M.: Induce Memories to be represented
G.C.	G.C.: Induce Memories to be represented
D.F.	D.F.: Develop Form and space

The main four coding scheme are described in the details.

E.M.: Explore Media properties. Using different ways to explore or test the media, such as touching, folding or twisting.

I.M.: Induce Memories to be represented. The similar sensations or actions of haptic experience recall the designer's memories, and represent them like static images or dynamic activities.

G.C.: Generate design concepts. The design ideas were stimulated by touching, and generated the concepts.

D.F.: Develop Form and space. Inspired by haptic experience, designers can develop diversely form and space.

3. Analysis

Before analysis, the core idea of objective, the sense of touch, should be defined as well. Touching includes any sense of entities, yet, sometimes people can acquire the sense accommodating with actions, such as folding, twisting something. This phrase is going to analyse the subject's behaviours, actions, and understand what kind of situations the sense of touch affects subject's motivations or design thinking. Along with the four coding schemes, the experiment data will be analysed per minute, also recorded if one of the activities is happening.

3.1 EXPERIMENT A

In Experiment A, subjects are asked to use clay as a design medium to develop a study model after the experiment principles. According to the analysis schema, the subject usually explores media properties in the beginning of design process. One example is shown in Figure 1, where the subject tried many ways to test the media (clay): squishing, kneading, twisting, etc. Besides, it comes out with several images, places or activities visions through touching and the relevant actions. In the same time the subject starts to develop the model's form and space. The subject continues to induce the memories and attempts to interact with form shaping, and then the concepts or ideas will be stimulated (Figure 1).

3.2 EXPERIMENT B

In experiment B, subjects are asked to use boxboard as design media to develop a study model after the experiment principles. From the observation of the experiment B, the common state with experiments A, subjects explore the properties of media (boxboard) first. This medium is hard and flat so there is not much elasticity to change the character, but subjects still keep testing the medium's extremity, such

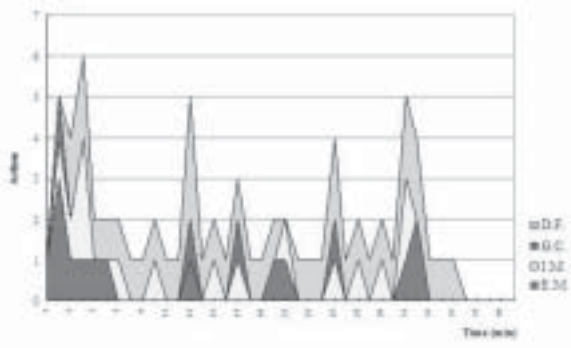

Figure 1. The analysis scheme derived from one of the subjects from experiment A.

Figure 2. Three study models completed by three subjects in experiment A.

as folding, twisting. However, it came up with some instant ideas during trial and error. The analysis results indicate that E.M and D.F often occur at the same time, and the concepts will be formed alongside. Maybe this medium needs to work with other tools, the sense of touch doesn't make the I.M. work all the time. And the subject is familiar with this medium also. Subjects usually have a preliminary idea, and regard the boxboard as just a represented material. But I.M. sometimes appears with G.C., it can be deduced that when the sense of touch induces memories, subjects generate concepts at the same time (Figure 3).

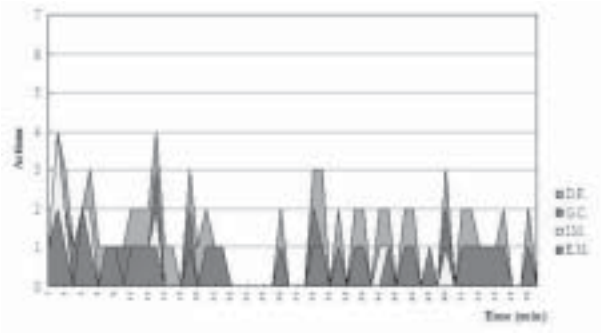

Figure 3. The analysis scheme derived from one of the subjects from experiment B.

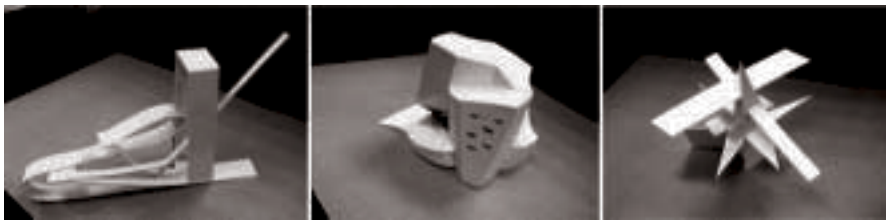

Figure 4. The study models completed by three subjects in experiment B.

3.3 EXPERIMENT C

In experiment C, subjects are asked to use computer as design media to develop a study model after the experiment principles. Retracing the developments of experiments, there is no haptic experience from the study models, but a mouse. The chief difference in haptic experience is the object (study model or tools) that subjects touch. Experiment C shows great functions of designer's visual ability, but totally ignores the assistance of touching. The study models were printed by 3D Rapid Printer (R.P.) to see if the models are exactly what the subjects really wish. Because the subjects were not able to sense the substance, texture and gravity factors, the study models have to be readjusted from the original one. Since the computer was an efficient and colourful tool, which is fitted to represent the design process with the powerful drawing software, but the haptic experience can bring out other functions.

Figure 5. The virtual study models completed by three subjects in experiment C.

Conclusion

According to the experiments of results, the author contributes four main phenomena from the subjects' verbal data while using different design methods.

5.1. SENSE OF TOUCH AIDS DESIGNERS FOR MEDIA PROPERTIES EXPLORATION

The experiment results indicate that some designers (subjects) prefer to use their sense of touch as the first method to explore the property of the media. In the beginning of the experiment, the designers would touch the design material and use their feeling as part of the experience of understanding the media. Sometimes, they would accommodate with actions like folding, twisting, squishing to explore the diverse usage of the media. Also, to sense the feeling brought by the media, such as soft, hard, rough, smooth, or fine, etc. are also important to determine the characteristics of the media. Once the characteristic of the media and its usage has been explored, designer would be able to try various ways to develop concepts with the media.

In addition, a more experienced designer usually can explore the potential of the media better, and apply its ability more dexterously. As a result, this study believes that haptic experience greatly assists designers in knowing the media characteristic during the concept generation stage. Therefore the designers can further use the media to develop concepts and study models toward their final design.

5.2. SENSE OF TOUCH HELPS DESIGNERS INDUCE MEMORIES

During the observation of the designers developing their concept model, it was found that some related design thinking appears. The sense of touch experience inspires explicit memories from the brain when the subject is touching the media. The subject conducts a series of trial and error to make the connection with different memories and concepts, and then reassemble them into relevant information toward the design process.

As mentioned earlier, the states of memories described by the designer sometimes get displaced in a static image or space. However, some memories represented like the dynamic environment or even the related activities reappear as part of memories. The designer was inspired to further develop the concept model by the interaction between the sense of touch they obtained with the media and their memories.

5.3 SENSE OF TOUCH ENDOWS DESIGNERS WITH FEELINGS OF SUBSTANCE, TEXTURE AND GRAVITY

By analyzing the cognitive experiments with three kinds of media, the subject's haptic experience changed from diverse to single sensation (only mouse). The interface of the last experiment used the mouse to displace all the haptic experience, the moment, the feelings of substance, texture and gravity that the designer should have were simply absent. However, the subjects keep remaking the haptic functions

and reacting intuitively with those real tactile feelings in experiments A and B. Hence, is concluded the reference value with the sense of touch in the real world, and designers are able to generate concepts practically.

5.4 SENSE OF TOUCH CAN AFFECT DESIGNERS TO DEVELOP UNEXPECTED FORM AND SPACE

During the concept generation stage, designers use materials in study models for representing the concept and idea. Exceping the point of media properties influence design development, designers often adjust back and forth between various unexpected or uncertain detections, and search for the possibilities of space. This behaviour is like the visual thinking observation. From the observation of "sketch-inspect-revise" (Schön & Wiggins, 1992), designers used to draw the idea that came out of their thought on paper and inspect it. While inspecting, designers could discover some unexpected graphics, then revise the drawing or design. This is the same as developing study models. The haptic experience can stimulate designers to develop more possibilities of unexpected forms and space.

Discussion

Form shaping is an essential part of the design process. New 3D modelling media allow designers to develop models precisely and rapidly. However, the next steps should place more efforts on the requirements of designers, not simply concentrate on just focusing on the efficacy of machines. This study reports the phenomena of touch in design process, from which the important components of touch can be recognized, and the designer can gain further experience. The study suggests how well the haptic impression would work in the aid-design tools or media in the future.

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References

Anderson, L., Esser, J., Interrante, V. 2003, A Virtual Environment for Conceptual Design in Architecture. Proceedings of the workshop on Virtual environments 2003.

Basdogan. Cagatay, Ho. Chih-hao, Srinivasan. Mandayama and Slater. Mel: 2001. An Experimental Study on the Role of Touch in Shared Virtual Environments. Massachusetts Institute of Technology

and University College London, U.K.

Bae, S.H., Kobayash, T., Kijima, R. Kim, W.S. 2004, Tangible NURBS-Curves Manipulation Techniques Using Grapable Handles on Large Display. Proceedings of the 17th annual ACM symposium on User interface software and technology.

Bloomenthal, J. & Wyvill, B. 1990, Interactive techniques for implicit modeling. 1990 Symposium on Interactive 3D Graphics, pp. 109–116.

Bolt, Richard A. & Herranz, Edward: 2001, Two-handed gesture in multi-modal natural dialog. Advanced Human Interface Group, The Media Laboratory, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139.

Brady, D. A. 2003, Ideation: Metaphorical Explorations and Digital Media. eCAADe 21. Graz University of Technology, Australia. pp. 87–190.

Brereton, Margot & McGarry, Ben: 2000, An observational study of how objects support engineering Design thinking and communication: Implications for the design of tangible media. Proceedings of the SIGCHI conference on Human factors in computing systems.

Goldschmidt, G. 1994, On visual design thinking: the vis kids of architecture, Design Studies, vol. 15, pp. 158–174.

Hinckley, Ken & Sinclair, Mike: 1999, Touch-Sensing Input Devices. Microsoft Research, One Microsoft Way, Redmond, WA 98052.

Igarashi. Takeo, Matsuoka. Satshi & Tanaka. Hidehiko: 1999, Teddy: A Sketching Interface for 3D freeform Design. University of Tokyo and Tokyo Institute of Technology.

Knoll, W. & Hechinger, M. 1992, Architectural Model: construction techniques.

Landay, James A. & Myers, Brad A. 1995, Interactive Sketching for the Early Stages of User Interface Design. Proceedings of the SIGCHI conference on Human factors in computing systems.

Lee, Hui-Lin. 2002, A comparative study on concept development process using computer and conventional media, Graduate Institute of Architecture, National Chiao Tung University, Hsin-Chu.

Lee. Chia-Hsun, Ma. Yu-Pin, Jeng. Taysheng: 2003, A Spatially-Aware Tangible Interface for Computer-Aided Design. Information Architecture Laboratory, Dept. of Architecture, NCKU, Taiwan 701. Taiwan. Tangible Interface. pp. 961–962.

Lim, C. K. 2003, Is a pen-based system just a pen or more than a pen. National Chiao Tung University. Hsinchu, Taiwan.

Lin, Cheng-Yuan: 2000, A study of computer models in terms of space and media, Graduate Institute of Applied Arts, National Chiao Tung University, Hsin- Chu.

Liu, Y. T. 1996, Restructuring shapes in terms of emergent subshapes: a computational and cognitive model. Environment and Planning B: Planning and Design. pp. 313–328.

Markosian. L, Cohen. J.M, Crulli, T. & Hughes. J.F. 1999, Skin: A Constructive Approach to Modeling Free-form Shapes. SIGGRAPH 99.

McDonnell. Kevin T, Hong. Qin & Wlodarczyk. Robert A: 2001, Virtual Clay: A Real-time Sculpting System with Haptic Toolkits. Department of Computer Science, State University of New York at Stony Brook, Stony Brook, NY 11794–4400.

Schkolne, Steven, Pruett, Michael, & Schröoder, Peter: 2001, Surface Drawing: Creating Organic 3D Shapeswith the Hand and Tangible Tools. Caltech & Bell Labs.

Schön, D. A. & Wiggins, G. 1992, Kinds of seeing and their functions in designing. *Design Studies*, vol. 13, no 2. pp. 135–156.

Sturman, David J. & Zeltzer, David. 1993, A Design Method for “Whole-Hand” Human-Computer Interaction.

Suwa, M., Gero, J. S., Tvesky, B. & Purcell, T. 2001, Seeing in to sketch: Regrouping parts encourages new interpretations. Visual and Spatial reasoning in Design II. pp. 207–219.

Terry, Michael & Mynatt, Elizabeth D. 2002, Recognizing Creative Needs in User Interface Design. Proceedings of the fourth conference on Creativity & cognition.

Wesche, Gerold & Seidel, Hans-Peter: 2001, FreeDrawer – A Free-Form Sketching System on the Responsive Workbench. Fraunhofer Institut, Sankt Augustin, Germany & Max-Planck-Institut für Informatik, Saarbrücken, Germany. ISBN: 1-58113-427-4.

Won, C. J. 1999, The comparison between visual thinking using computer and conventional media in the concept generation stages of design, Automation in Construction.

Wong, C. H. 2000, Some phenomena of design thinking in the concept generation stage using computer media. CAADRIA. Singapore. pp. 255–264.