

THE NEW COMBINATION OF DIGITAL SKETCHING AND MODELING PROCESS IN IDEA-DEVELOPING STAGE

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Abstract. With the introduction of the computer into different forms of digital applications in the design process, Mitchell strongly recommended a wider application of the new technology in the design process -- implying the mutual influence between physical architecture and the sketches, and between physical and digital models. Most important is the possibility of using computer aided design (CAD) to develop ideas in early design stage. During the developing idea stage, the traditional design process from sketching drawings to forming ideas has been transformed to a process where the idea directly proceeds to computer modeling. The aim of this approach is to tackle the above issues created by the introduction of computer technology, trying to produce the same possibilities during the computer modeling process as that in the cognitive behavior of sketching. Also, the designer usually realizes the abstract concepts with the aid of the 2D sketches and the 3D physical models; but between the traditional sketches and the models, a large degree of disagreement always exists. Therefore, this work aims to develop a new formula for employing digital media, which will enable the designer to envisage 2D sketches and computer models simultaneously. In this scenario, the designer can remain aware of cognitive behavior in sketching while constructing computer models.

1. Reviews of design media

Design media -- ranging from early hand-drawn pictures; to three dimensional models; to computer based drawings, models, animations, and virtual reality -- transfer the abstract concepts in the human brain into a format of the reality. Various levels of design concepts could be achieved by applying different types of design media, although each is restricted in its own way. A hand-made sketch was the earliest means employed to outline the design ideas, and remains the quickest and most convenient design medium to this day. However, although perspective drawings on papers can represent reality fairly well, the sense of three-dimensional space is not easily achieved by 2D drawings. After the Renaissance, with the introduction of 3D models, designers began to have more freedom in the way they expressed the shape and size of an object; and accuracy also improved accordingly (Millon, 1994); The development of computer technology has given a new platform to the design media. Computer drawings and models gradually replaced the traditional sketches and models, allowing designers more control over different levels of space during the design process. Many researches in the computer based design methods have focused on the visual effect and have emphasized the importance of computer media (Rahman, 1992). Based on Rahman's work, Bai and Liu (1998) presented a new visual effect evaluating process. They indicated that computer media is of great importance to the understanding of the design topic, concept and further development.

Schön and Wiggins (1992) emphasized the importance of communication by using sketch media between the designers, even themselves. Many other studies also acknowledged that sketching was the most important part of the idea development process. The essential characteristics during this phase are the huge amount of drawing practice and communication through the sketches (Purcell and Gero, 1998). The influence of the designer and the sketch upon each other is undeniably mutual. Not only is sketching the outer representation of the designer's cognitive process, it also provides an important clue to the visual space envisioned by the designer (Goldschmidt, 1991). Meanwhile, she explained that the sketches in the design process could be used to stimulate more imagination from sketches by designers. When drawing, a designer does not simply demonstrate the images in his mind, but more importantly, the images are triggered through a visual display in the sketching process. Here, two distinctive cognitive behaviors are involved in the visual behavior, namely, the 'seeing as' and the 'seeing that'. Designer will re-illustrate the image through visual cognition, or search for the relevant pictures in the long-term memory (LTM), in order to trigger the unexpected design topic (Goldschmidt, 1991, 1992, 1994). At the initial stage, sketches are used to capture the ambiguous shape and space in

mind through freehand drawing (Kavakli, Scrivener, and Ball, 1998). Suwa and Tversky (1997) revealed that two different perspectives could be used to discuss the role of sketching in the design process: the characteristics of sketches and the relationship between designers and the sketches.

The physical model is another type of traditional design media. The first appearance of physical model was the Brunelleschi's famous representation of Florence Cathedral's dome, built during the Renaissance. Because of the limitations of 2D drawings which could not be satisfied by designers to consider the mass and space of a building, 3D models were used to give a more realistic result. Even detailed, sectional models were put to use, in order to investigate the properties of light, materials, and so on. After that, physical models became increasingly popular and were widely exploited for better accuracy, wider range of freedom and a much clearer insight into the designer's intentions (Millon, 1994). However, this obviously is not the only option for designers to draw sketches. A combination of 2D sketches and 3D models at different stages of the design process would give a versatile representation of an abstract concept.

2. Problem and Objective

With the introduction of the computer into different forms of digital applications in the design process, in 1997, Mitchell strongly recommended a wider application of the new technology in the design process -- implying the mutual influence between physical architecture and the sketches, and between physical and digital models. In the mean time, computer technology continued to impact the traditional design process in many ways (Liu, 2001). Most important is the possibility of using computer aided design (CAD) to develop ideas in early design stage. During the developing idea stage, the traditional design process from sketching drawings to forming ideas has been transformed to a process where the idea directly proceeds to computer modeling. During this transition, the designer loses the visual cognition practice experienced through the initial sketching period and also the ambiguous shapes and spaces in mind (Kavakli, Scrivener, and Ball, 1998). However, the cognitive point of view that Mitchell proposed in 1993 indicated that creativity should evolve during the emergence of shapes on the sketches from designer's mind. Thus, with the absence of the sketching stage in the computer modeling process, many potentially valuable possibilities will be lost.

The aim of this approach is to tackle the above issues created by the introduction of computer technology, trying to produce the same possibilities during the computer modeling process as that in the cognitive behavior of sketching. Also, the designer usually realizes the abstract concepts with the

aid of the 2D sketches and the 3D physical models; but between the traditional sketches and the models, a large degree of disagreement always exists. In other words, the designer is not capable of thinking in both design media at the same time. Therefore, this work aims to develop a new formula for employing digital media, which will enable the designer to envisage 2D sketches and computer models simultaneously. In this scenario, the designer can remain aware of cognitive behavior in sketching while constructing computer models.

3. Methodology

In the traditional design process of industrial design, numerous sketches utilized in the early stage of idea generations is to generate preliminary design concepts, to develop design ideas, and to present design outcomes. In this process, designer will constantly create physical models in order to discuss and present design ideas, which could not be clearly expressed by 2-dimensional sketches. Then, designer form new ideas by drawing 2-dimensional sketches. Therefore, the 2-dimensional sketches and physical models will be alternately utilized by turns in the idea-generation process (fig. 1). Moreover, because the computer media intervene the design process, the computer 3-dimensional models will replace the role of physical models.

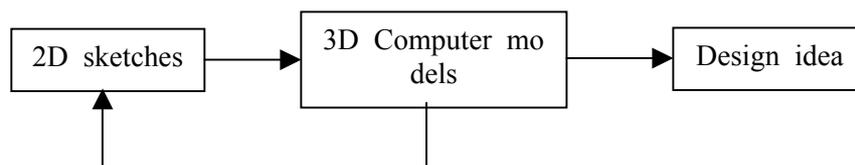


Figure 1. the traditional sketching and computer modeling process.

Different design media have their own design characteristics and limitations. Thus, it is indispensable that designers combine several design media to generate complete ideas in design process. However, because of the limitations of 2d sketching media, designers could not present a complete design idea by considering design concepts only from some particular points of views from the sketches. Consequently, by using various perspective views or detailed illustrations, they could present the whole design ideas, and these ideas would be transferred from 2D sketches into 3D computer models. However, in the transferring process, the ideas will be modified again, because designers can not consider the relationships of ideas between 2D

and 3D on sketches, simultaneously. Thus, the result makes a large range of differences between ideas on sketches and on computer models. In the 3D modeling process, designers have to re-consider the ideas again. Besides, in terms of the limited capacity of cognitive resource, designers who consider ideas by 2D and 3D only on sketches will take more cognitive resource to imagine 3D forms, corresponding to the ideas on sketches. On contrast, they only have less resource to yield design ideas.

Thus, by computerizing the traditional sketches and combining 3D computer models, this research advances a new design method “digital sketching-modeling process”, in which designers will have the traditional sketching behavior and computer modeling characteristics, simultaneously. In this new process, designers directly draw sketches in the perspective view by using digital tablet in the 3D computer-aided design software—Rhinoceros. The NURBS surfaces will be generated by designers while sketching lines are drawn. Finally, these surfaces will be joined and formed for 3D models. Unlike the traditional sketching behavior, designers, before drawing any lines, would have to decide upon which plane the lines will be drawn. The sketching lines will then be drawn and projected onto the plane. Then, fixing the perspective view and assigning the basic planes, designers will project the sketching lines on these planes. These lines could be observed by rotating the points of view, dynamically. Furthermore, in computerized modeling environment, the sketching lines are presented in 3-dimensional space. It means that these lines have their coordinates which are corresponding to the 3-D space. Designers can observe these lines on 3D space, while they are forming 3D models. Therefore, they can precisely conceive the developing results by observing 2D sketches and 3D models.

In the “digital sketching-modeling behavior” (fig. 2), the model does not be formed after the completion of the entire sketch. Instead, the sketches are divided into the basic and individual lines, and the model is conducted with these lines, simultaneously. After constructing some parts of model, the designer can view them in motion by 3D-observation way, receiving instant feedback on works that have just been completed. In doing so, designers can make decisions for the next developing stage of the design; whether to amend some parts of the design, or to create new lines, or to choose a completely different plane. The designer may also devise concrete actions for the next stage of the design. This new combination of digital sketching and modeling enables the designer to keep control of the fuzziness of the sketches, while developing computer drafts for the design. The design will also be able to make amendments in each stage of the construction, achieving more rational and specific results.

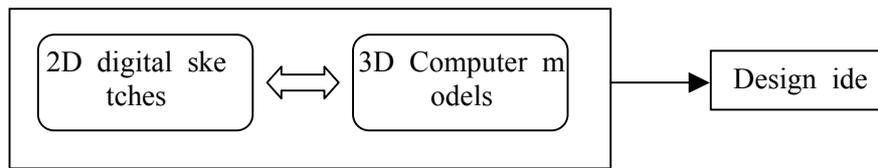


Figure 2. The new digital sketching and modeling process

4. Experiments and processes

In the research, to compare traditional 2D sketching and computer 3D modeling process, this research advances a new design method “digital sketching-modeling process”, combining digital sketches and computer models. In the experiments, a design task, therefore, is assigned to the subjects to contrast and compare these two distinct design processes. Thus, the selection of subject for the new process is the second of this paper because this new process is not popularized for developing new design. On the other hand, the subject for traditional process is an industrial designer, who is familiar with both sketching and computer modeling skills. In the experiments, the subjects are assigned a design topic—a joystick for PC or TV game, for subjects to develop design ideas, which have to match some assigned conditions. The reasons for determining the design topic is that this kind of product design involves complex form construction and human engineering considerations. Thus, designer has to integrate different design senses for developing the idea in the process.

Traditional sketching and computer modeling process

In the traditional design process—“sketching-and-computer-modeling process”, the designer will develop ideas by drawing sketches on papers. After well-developed design ideas by sketching, the subject will be requested to build a 3D model based on previous sketches. In the end of her experiment, the subject generates 5 sketches, and builds a 3D model on 3D Max 5.0 based on the final idea.

In the first sketch (fig. 3), the designer set several lines to define the basic surface on the important place of a joystick, and these lines showed below dimensions: (1) the scale and size of the area of buttons or keypad base; (2) the length of stick; (3) the angle between above surface and stick axis; (4) the shapes of stick cross-section in different heights.

In the second sketch (fig. 4), the form of the major button area had been developed more advance. The number, shape, size, function of buttons also revealed. In the sub-sketches, we discovered that the designer attempts to construct idea from different view of surfaces and generate various styles. The surfaces of the joystick’s head had divided into two or more parts, and

their shapes are also changed to fit the important buttons. The designer also thought about the form of base board by setting its axis, and tried to place buttons on it.

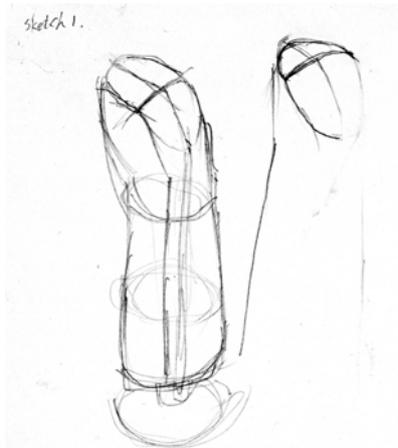


Figure 3. Sketch 1.

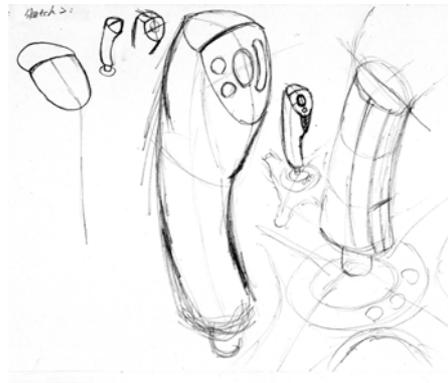


Figure 4. Sketch 2.

In the previous sketches, the designer drew the joystick in the same perspective view. From the third sketch (fig. 5), the designer attempted to draw the idea from different views--the front and side views. She also considered the relations of shapes with hand holding between front and side views. In addition, the subject developed ideas from the head part of joystick to the base part, and studied the base part on the fourth sketch (fig. 6). In this sketch, the subject considered the base part of joystick as a four feet-shaped form, and tried to place the buttons on the base for evaluations.

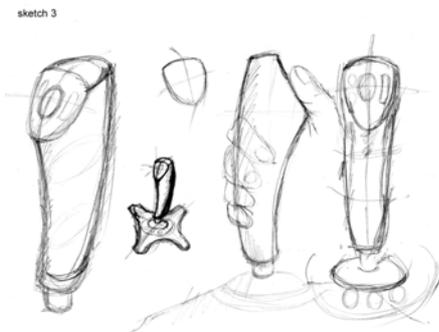


Figure 5. Sketch 3.

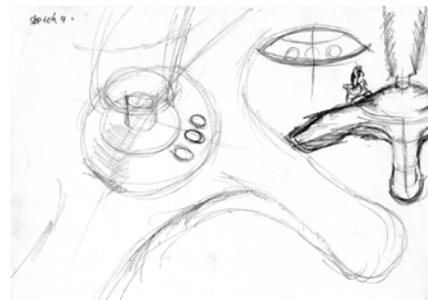


Figure 6. Sketch 4.

The last sketch (fig. 7) showed the head and base part of joystick together. The designer tried to adjust the scale of the two parts, and decide the positions of the buttons. After finishing the sketch phase (fig. 8), she continually generated a 3D model in 3D Max 5.0. The order of constructing model followed the sketching process, from head to base part. If comparing the processes of sketching and modeling, we could find that the subject can not follow the sketching process on computer after building the head of joystick.

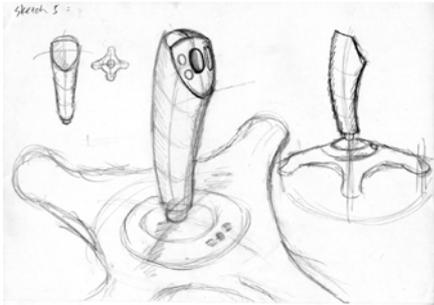


Figure 7. Sketch 5.

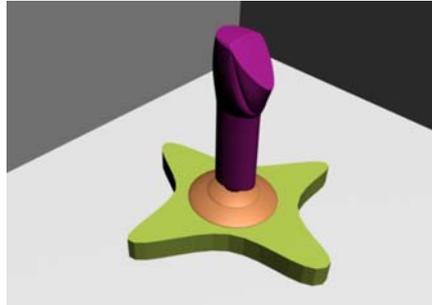


Figure 8. Computer model.

Digital sketching and modeling process

The equipment in the experiment included a notebook computer with the modeling software--Rhinoceros 3.0 version. This CAD software produces surfaces by defining lines or edges to construct a solid model continuously, and the way to construct models is called NURBUS modeling. During the experiment, the major input device was a digital tablet (6"x8") of Wacom.

In this new process of developing ideas, based on the structure which provided by the experimenters, the subject determined a particular view in the perspective window, and drew a rough sketch in the window by the "sketch" function of the CAD software (fig. 9). The sketch was projected on an invisible work plane, so it could only be understandable on the original perspective view which the subject determined. Therefore, the sketch only matches the model in that view. After finishing the projected sketches, he will start to construct a computer model.

In the modeling phrase from 2D sketches to 3D models, the subject first set aided lines on the skeleton of joystick for defining the limitations on the base or stick. When starting constructing the 3D model, no matter how the subject moved the cursor or executed commands in the rest of the sketched perspective view, he always matched the sketches or aligned points in the sketched window (fig. 10). The subject, therefore, produced curves or surfaces and matched the sketches by turns in this new process. And he also

shifted the working window to construct different parts of the model until the preliminary model completed (fig. 11).

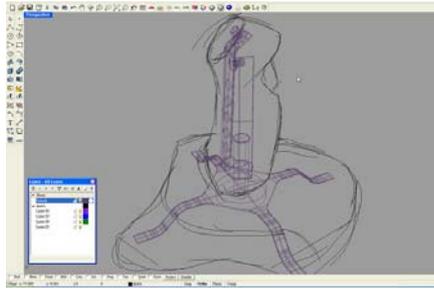


Figure 9. Digital sketches.

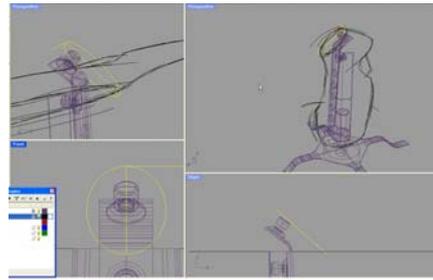


Figure 10. Generate computer form

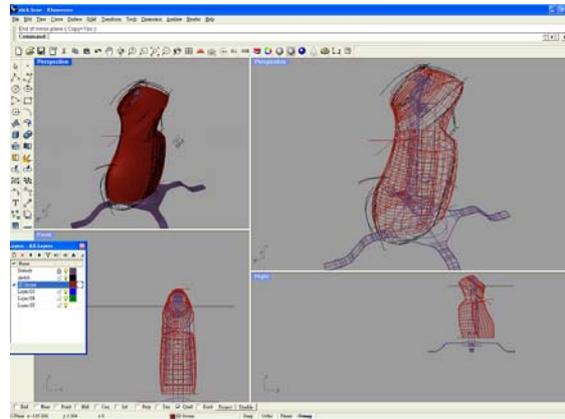


Figure 11. The preliminary model.

When the preliminary model had been done, the subject initiated to design the details. By utilizing the “sketch” function again, he directly drew the ideas of details on the surfaces of the preliminary model, and then rotated the view for evaluating the sketches on the model (fig. 12). Moreover, after evaluating the details and satisfying the ideas, he constructed the details on the previous model (fig. 13). By following the process, mentioned above, the subject continually drew the sketches of the base part of the joystick (fig. 14). Then, he constructed this part of computer model. At the end of the experiment, this subject eventually accomplished an idea of design topic by constructing the computer model (fig. 15).

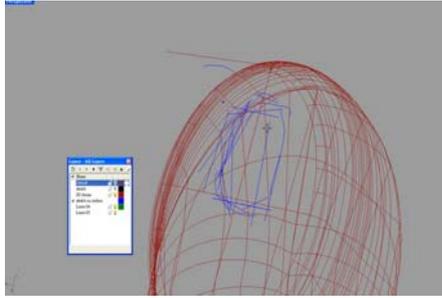


Figure 12. Sketching on model.

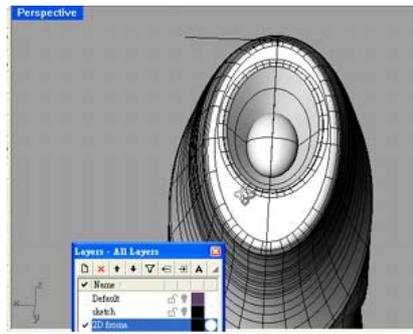


Figure 13. The detail design.

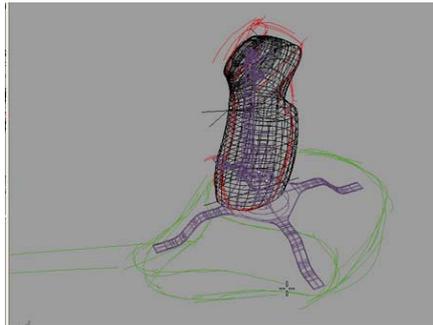


Figure 14. the sketches of the base part.

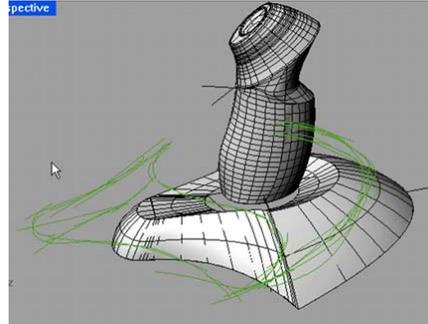


Figure 15. The final model of joystick.

5. Results and discussions

In the traditional sketching-and-computer-modeling process, the subject has to draw the perspective sketches on papers, while she imagined the 3D form of ideas in her brain. However, when she attempts to consider the idea from another point of view, the subject has to re-draw the idea again on papers by another perspective view (fig. 5 and 7). Furthermore, in the case of detail design, for example of the handle of joystick, the subject also has to re-draw the idea in different scales, and then to design the details. However, in the process of constructing model, this computer model is only the presentational media for the subject. And, it is hardly observe that there are any interactions between these two design media.

By contrast, in the digital sketching-modeling process presented in the research, the subject immediately constructs the computer model while he completed the idea sketches. During the modeling process, he generates the featured curves, and matches the sketches in the perspective view. Then, the form of idea will be constructed by following the process – “generate

featured curves – match the sketches – form surfaces or models”. In this process, the subject could dynamically modify the ideas and rotate the view points to evaluate the forms and scales. In doing so, these ideas generated by this process will be more reasonable and feasible for constructing a 3D model. In addition, the subject could directly draw sketches on the preliminary computer model (fig. 12) and, then, construct the details on it (fig. 13). This behavior is a phenomenon that could not be experienced in the traditional sketching and computer modeling process. Moreover, based on this new process, the subject not only could determine some specific details for designing, but also could evaluate the relationships between detail designs and the whole design concept.

This new combination of digital sketching and modeling enables the designer to keep control of the fuzziness of the sketches, while developing computer drafts for the design. The design will also be able to make amendments in each stage of the construction, achieving more rational and specific results.

6. Further studies

This work proposes a new design method for combining computer media, which remains to be tested, in order to draw conclusions on the differences between this new method and the traditional design processes in their cognitive and design achievements. The traditional sketches and physical models both have drawbacks, but development of computer technologies enables both of them to be reinvented as new design methods. The new method not only gives new emergence of a new style in design, but could also present new way of generating creativity in design process.

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