Chinese Calligraphy Illustration as Space Form Inspiration

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Abstract

In this paper we introduce Chinese calligraphy as an inspiration to space form exploration in design computation. The correspondence between Chinese calligraphy art and space form design, enhancing the abstraction concepts and expressiveness lying in Chinese calligraphy illustration, stimulates the imagination of design creativity. Thus for computation, we firstly ascertain the illustrative trait and mechanism to human-computer interactive process. Secondly, we computerise the symbol correspondence between the media and space form, as the design exploration policy. We wrote a prototype program to demonstrate the theory of this design exploration media, representing the design interaction process and thinking approach within.

1. Background.

Chinese calligraphy as its soft-line media: the hairy brush can often present both the sensory as well as form expression of design concepts. Therefore, if Chinese calligraphy can be applied as a design media for conceptual inspiration such as form exploration, we might be able to unleash the sensory design knowledge for further understanding. As well as Chinese calligraphy expresses the textual effects of hairy brush, it provides the structure and form with the strokes of Chinese characters, and the strokes visually become the tension of space and balance to compose.

Since the writing mechanism of Chinese calligraphy is on the skill and perception of stroke-based illustrating by hand kinesis strengths and motions, in respect of traditional Chinese calligraphy skills, designers might not have the skills but could have the concept to illustrate calligraphy with direct hand kinesis and motions for expressing their intentions. In computer supported design virtual environment, user can freely illustrate with a 3D hand input device.(Chang and Chang, 2005)

To define the research in this paper, several fields of topics are concerned. In earlier design stages, the concept of Chinese calligraphy art can be more stimulating than designing in later stages. Thus, we concentrate on design exploration of the media in earlier stages, as well as computer supporting for design activity. For introducing Chinese calligraphy media to design exploration, the difference

and correspondence between the media and conventional design drawing approach are compared. Combining with the interaction process of the illustrative media and its potential feasibility for design thinking, accordingly, the design model of the media can be established.

1.1 Early Design Stages with Computer Supporting

In the states of the idealized design process declared by (Braha and Maimon, 1998), the characteristics are described with the assumptions those convey the design theory. The assumptions are reflecting to the: 1) nature of design objects 2) their potential manipulations and 3) the feasibility to design. In earlier stages of design, the assumptions of design constraints are considered partially and provisionally by decreasing the number of requirements to an acceptable level and superimposing some ordering principle on the design. Each CAAD tool intended for use in the early design phase must allow the user to apply these techniques, otherwise the use of these tools will obstruct the design process. Thus, computer supporting in this design stage must allow the use of vague information to avoid requiring specificity too early in the design process. Basing the model on decisions instead of objects allows much more flexible approach to the design process.(deVries and Wagter, 1990)

1.2 Understanding Space Form Exploration

(Woodbury, 1991) defined a grammatical design exploration initialling designs, alphabets of symbols and rules. These are the core of grammars, and thus describe spaces of designs. A space comprise all designs that can be created beginning with a starting design and be recursively following all possible derivational arcs. Until a design is visited (generated) in a process of design its existence remains virtual, that is, only implied by the possibilities of recursive application of operations. The spaces are *languages* of which there are two types. *Derivable* or *extended languages* comprise all designs that are generatable by a grammar. *Terminal languages* or just *languages* comprise with no non-terminal symbols that a generated by a grammar.

1.3 Chinese Calligraphy Mind of Design

As a soft-lined brush media, Chinese calligraphy, literally the art of beautiful writing, have not only lifted writing to levels of technical perfection, but have used **words and word rhythms** to create **images** which transcend craft and have elevated it to a noble art form. Thus, as all art forms, calligraphy gives us new perceptions of ourselves and our very being (Harris, 1991).

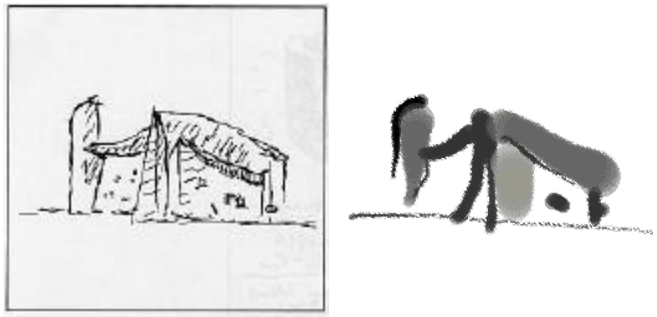


Figure 1: Design sketching media differences

Figure 1 shows the contrast between conventional sketching using pencil and using Chinese calligraphy brush as sketching media. The same idea using different media can give different imagination.

Writing with traditional Chinese calligraphy presents **rich textural** and **unstable linear trajectory** of brush strokes. Consequently, Chinese calligraphy provides both writing and drawing concepts at the same time. This presents more concentration on the emotional intentions within the writer's activity and media used than either the symbolic context of the written words or well declared edges (Harris, 1991).

On the other hand, the cursive structures and strokes of characters have the composition and limitation rules over the interaction in writing activity, contrasting to the rules perform as design knowledge and constraints, such knowledge determines how this sketch media can be different from totally free drawing. Therefore, the writer shall express the tension between the willing under and over of the rules.

1.4 Design Drawing Activity

When designer thinking through a design sketching and concreting to space forms, it is suggested that designer's perspective relating much more to not only the current state of the design or stylistics of the building but also to its potential and future uses (Grosz, 2001). The designer manipulates the visualized representation to evaluate the consequences of design moves. Once an object is positioned the designer elaborates and reformulates both the object and its context.

Studies of diagrammatic reasoning and design drawings have become of increasing interest to cognitive scientists, artificial intelligence workers, and researchers in design studies. Researchers in these fields have argued that drawing is important to design as an external representation that helps in solving problems and generating ideas. (Do, Gross, et al., 2000)

1.5 3D User Interaction Process

Design exploration is performed upon the interaction with design media. Within 3D user interface as a computational design media, more degrees of freedom will be obtained for performing the more ambiguity perception of interactivity, so that the space of imagination is raised up.

Detailed tracking of information about the user's hands, such as how fingers bending or if two fingers have made contact with each other, provides the usability when intuitive interface is needed. An attempt of design is made needing the interaction between designer and design media, for acquiring the idea of imagination and perspective in design creativity (Bowman, Kruijff, et al., 2004).

2. Objectives and Approach.

2.1 Objectives

The proposed research is addressed to computerize the understanding of Chinese calligraphy art with the application of form exploration in space design domain, and to suggest the concept of Chinese calligraphy as an influence and inspiring design media. The use of 3D user interface for the interaction in space form exploration is the designer's regular lack of academic skills of Chinese calligraphy. In respect of traditional Chinese calligraphic skills, designers might not have the skills but could have the concept to illustrate calligraphy with intuitive hand kinesis and motions.

With the well-established perception and appreciation of the calligraphic characters illustrated as a design sketching, the work can be transformed into different perspectives to space forms. Further, variously interacting with partial by partial of its representations can give on the performance of design intention and point out the direction where designer is exploring space form.

2.2 Approach

Before we can decide any further move in this research, a structuralized model of the concept is drafted in Figure 2. In this research, we first analyze the significant characteristics base on numerous Chinese calligraphy theories, in order to connect the Chinese calligraphy media to virtual design environment fundamental issues, which are reflected to meet the principles of design in earlier stages. By separating the design media as three categories of 1)Perform: representation, 2)Process: interaction and 3)Prompt: inspiration, the mapping between Chinese calligraphy and the design system is discovered. Each category is reflecting to the characteristics of states in design: 1) nature of design objects 2) their potential manipulations and 3) the feasibility to design. Afterwards, we implement and examine the system as well as developing its theories.

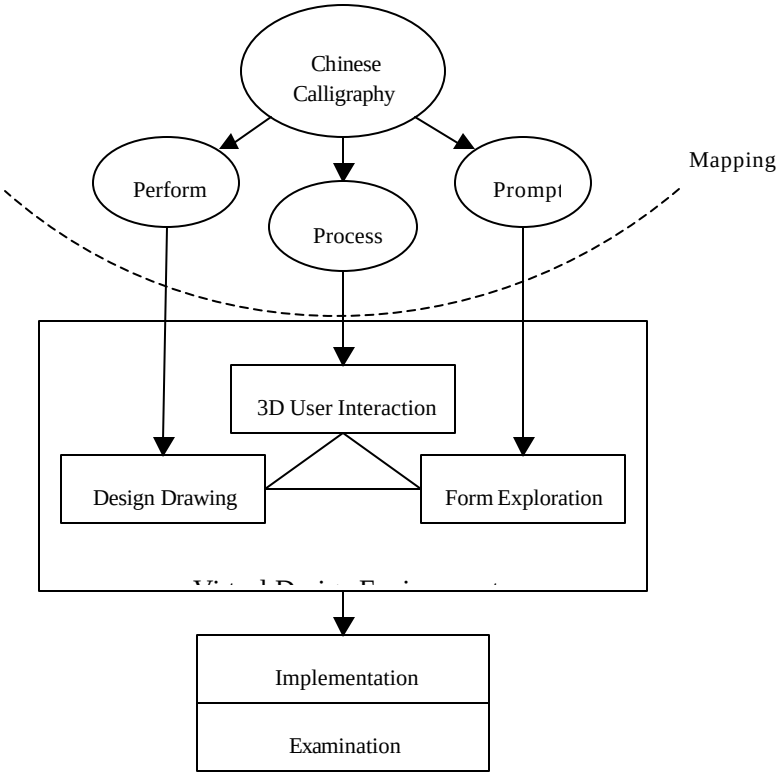


Figure 2: Structuralized concept of the research

2.2.1 Representation of Chinese Calligraphy as a Design Media

In Chinese calligraphy art, numerous of theories and branches have been developed from ancient times to the present. To connect the theory of Chinese calligraphy and space form exploration, we broadly retrieve and analyse the correspondence between the media to the approach. Most

apparently, visual cognition of Chinese calligraphy determines the textual and compositional features for form, thus brings up the feasibility to design exploration. With computer supporting design, symbol representations of Chinese calligraphy are discovered.

2.2.2 Interaction via 3D Hand Device

The writing mechanism of Chinese calligraphy is on the skill and perception of stroke-based illustrating by hand kinesis strengths and motions. A direct hand input device is to be beneficial to capture the illustrative intentions while user physically expressing the concept of Chinese calligraphy and invisible minds inside. Therefore, the interaction process of Chinese calligraphy illustration in 3D can be implanted to the design system.

2.2.3 Establish Illustration Functionality

We plan and establish the user interaction in the illustrative process according to analysis of design drawing activity and Chinese calligraphy illustration. To implant Chinese calligraphy to virtual environment of deign, the illustrative process is not only simulated with 3D hand device, but also expanded to appropriate the usability for specific design interactions.

2.2.4 Chinese Calligraphy Aspects to Space of Design

To discover the transformations from Chinese calligraphy strokes to space form aspects, we study literature surveys in both appreciation of Chinese calligraphy art and thinking reflection of design drawing. For computer afterward to recognize strokes of calligraphy and produce forms, the symbol representations are applied and the exploration policies are defined in the system.

2.2.5 System Implementation

The implementation of the system confirms the results from each approach in the research, which are representing the requirements and expectations of the digital design media. The following components constitutes the performance of this media: 1) user interactive illustration process via 3D hand device and interface, 2) recognition of illustrations from Chinese calligraphy strokes to symbol representation, 3) transformations visually from the design media to space form exploring.

3. Reviews.

3.1 Design Drawing in Early Design Stages

3.1.1 Early Stage Design Model and Information

In the first place a designer uses vague concepts, especially in the early phase of the design process. Computer programs are not yet capable of handling this kind of data and require that the information be exact. At that point the information that can be generated by using CAAD tools can no longer be used effectively to improve the design, as it is already almost completed. As (deVries and Wagter, 1990) noticed, in the early design stages the designer does not need to consider all requirements in depth but can look at a very small subset. Instead, decreasing the number of requirements to an acceptable level and superimposing some ordering principle on the design will allow the use of vague information to avoid requiring specificity too early in the design process.

In the earlier design stages, 1) the sketches act as memory aids and contain only the most important

parts of the mental model, and 2) the mental model is based on decisions about units of the design and not on objects. The decisions are made about compositions of properties and requirements that have specific architectural meaning. This can either be a **function** or a building **property**, specific **activity** or **shaping**.

3.1.2 Design Drawing Activity

Free-hand of gesture drawing is presented as the primary way for designers, artists to grasp the essential visual character of design. It may also serve as the foundation, or 'rough' for the more sustained development of a particular image. The gestural spirit of search and discovery remains embedded, however, in the naturalness with which the subject has been represented (Enstice and Peters, 1995).

According to (Fish and Scrivener, 1990) an important feature of sketches is that contain uncertainties important to their function and play the roles of preserving alternatives. Conventionally designers explore design concepts by using hard-line media such as pens or pencils for their quick and effective expression. The feedback process is personal and recursive until a satisfied result comes up by seeing and moving sketched objects (Do, Gross, et al., 2000).

Perception of external sources of inspiration prompts new imaginations. Research on the role of externalizations in design thinking has concentrated on the role of sketching. Previous designs are not the only source of reusable chunks. Designers actively search for sources of shapes, patterns, motifs and color combinations that can be translated into aspects of designs (Eckert and Stacey, 2000).

Thus, Chinese calligraphy art, which has a huge amount of well-established theories, appreciations of the beauty and has become a part of living, shows up itself as a feasible entrance to design inspiration and searching.

3.1.3 Design Exploration Approach

In research of (Soufi and Edmonds, 1996) interacting with design drawings as "emergent shapes", the multiple reconstructions implies that a multiplicity of emergent shapes can be divided from a given pattern. In this approach two possibilities need to be considered for this interaction: 1) User specifies emergent shapes, and 2) System suggests emergent shapes. An overall representation and interaction model will is as Figure 3.

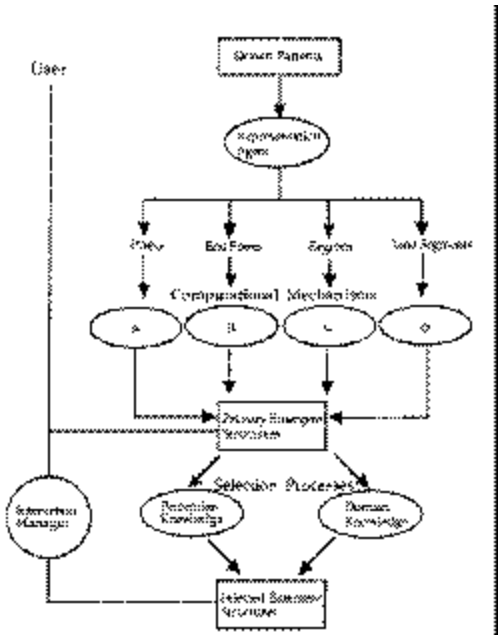


Figure 3: An overall representation and interaction model

3.2 Design Mind of Chinese Calligraphy

3.2.1 Mapping between Chinese Calligraphy and Architecture

The significant categories of the mapping are time and space of Spatial composition, which stand for the interactive process of illustration of Chinese calligraphy and the composition of spatial form.

3.2.2 Symbol: Expression and Representation

The expression and representation of Chinese calligraphy illustration convey the ideas and emotions through free-hand cursive strokes of the characters as **symbols**. Since the creation of Chinese characters is generally acknowledged to draw as well as to describe objective images, the characters have evolved to specific meaningful symbols, which are to represent and express human conceptualized experiences and ideas. The meaningful symbols turned the art of objective drawing into abstract expressions of characters. Chinese calligraphy is the art of Chinese characters and presented by the hairy brush cursive strokes. The form of cursive strokes is the primary expression Chinese calligraphy illustration.

The aesthetic perceptions come from the space and order created by the writer's skills, and the rhythms and strengths within the manners of illustration and organization of strokes. Though the illustration is not apart from writing of character structures, the expression of meaningful strokes as symbols is still brought up. The hairy brush of Chinese calligraphy is a soft media dipping in ink and thus able to produce various texture of strokes, such as wide/narrow, sharp/rounded, dry/wet, fast/slow. (Chou, 1995)

3.2.3 Design Mind of Illustration

The illustration of Chinese calligraphy is base on the ink dipped hairy brush tool and the freedom of variation writing activity, however, it is a different matter than daubing. The free-hand illustration

reserves the cultural experiences and profundity. Also, the visual language has been purified and unified by the gray scaled inks and structural principles of characters.

The writing mechanism of Chinese calligraphy is on the skill and perception of stroke-based illustrating by hand kinesis strengths and motions(Huang, 1999), which are well-formed and therefore can be expressed in terms of computation as strength values and coordination of traces.

3.2.4 Potential Perception in Chinese Calligraphy

The strokes of Chinese calligraphy on still images on paper, however, different illustrative factors such as strengths and directions caused different stimulus for visual perception. Through our visual experience, we interpret and percept the tension of the illustrative kinesis and motion. While designer producing the variation of the strokes and shifting the visual flow of forces, the illustration builds the kinesis of the structure with more strengths and tensions. (Arnheim, 1974) addressed the Gamma movement of shrinking and expanding, to gather visual perceptions of dynamics and forces to elemental shapes. Further, Chinese calligraphy strokes can be created with much more complicated visual prompts. Consequently, the major mechanism of Chinese calligraphy is to apply the variety of illustrative skills to create the variety of conceptional forms.

3.3 Chinese Calligraphy Computational Models

3.3.1 Geometric

The stroke is defined by the user as a list of position and pressure samples. Both position and pressure are interpolated using a cubic spline to yield a series of nodes (Figure 4). The width of the stroke is computed for each node by a function of the pressure at that node, and the region between two nodes is covered by a quadrilateral defined below.

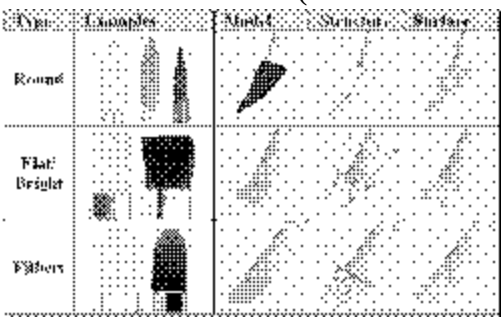
Figure 4: A stroke defined by 4 control points with intervening nodes generated by a cubic spline. The area covered by the stroke is approximated by quadrilaterals. (Strassmann, 1986)

Once the quadrilateral is found, a generalized polygon interpolation algorithm is used to assign each pixel within that polygon its position in "time" along the stroke, and the bristle which passes nearest to it.

3.3.2 Physically-based

To model a 3D paint brush requires developing both a geometric representation and a physics-based model for its dynamic behavior. (Baxter, Scheib, et al., 2001) modeled the brush head as a subdivision surface mesh wrapped around a spring-mass particle system skeleton. The particle system reproduces the basic motion and behavior of a brush head, while the deformable mesh skinned around this skeleton represents the actual shape of the head. Although the brush model may appear simplistic at first, it is designed to capture the essential quality of physical brushes to maintain interactivity at minimal computational costs.

TABLE 1: some real brushes and the model (skeletal structure and surface mesh)



3.3.3 Geometric + Physical Behaviours

The provided by (Wong and Ip, 2000), a model-based approach to simulate brush-written characters or images aims to take into account the physical process of brush writing such as the geometry of the brush stem, the interaction between the brush tip and the paper, the properties of the paper and the dynamics of stroke production such as the orientations of the brush with respect to the paper surface during stroke writing.

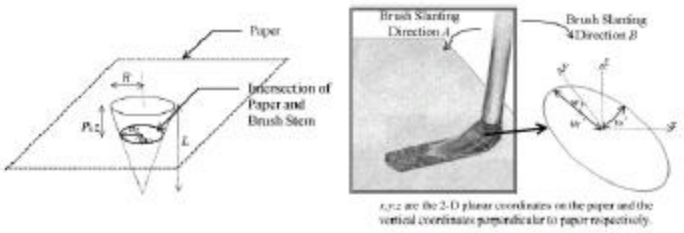


Figure 5: Computation of brush – paper intersection(Wong and Ip, 2000)

3.3.4 Summary

In addition to the three types of Chinese calligraphy models, the stroke illustration in 3D design environment would benefit the supporting of the space form exploring operation in the later stage. The data needs to be easy to operate, the symbol representations are based on the design decisions, not the objects.

3.4 Interactive Creation in 3D Virtual Environment

3.4.1 Virtual Reality Aided Design

Design would require its own unique virtual reality that gets people involved with design. Visual virtual realty experience may play only a subordinate role. The notion of moving, searching or exploring in a space of possibilities has a centuries long tradition in architectural thought and more recently a strong following in CAD. As a metaphor for design it reveals much and has coherence with other metaphors of design.

A design virtual reality presumes the existence of a visual virtual reality, but also requires much more – specifically the ability to travel, in apparent "real" time, in a virtual space of designs. The technology for the visual part of the virtual reality will take care of itself, for the motivation for it

exists in almost every field. In the main designers and design researchers need not waste time and effort considering its further development.

Within a computer, all data and operations are expressed as symbol structures and all representations must be built in symbolic terms. Designs are thus understood as symbol structures which to varying degrees *represent* aspects of a design. Changing designs occurs through *operations* to symbol structures. (Woodbury, 1991)

3.4.2 3D User Interface Studies

Bend-sensing data gloves are purely passive input devices used to detect hand postures (static configuration) and certain gestures (a series of postures). One of the major advantages of bend-sensing gloves is that they provide a large number of DOF, making it possible to provide a representation of the application. From a 3D user interface point of view, data gloves are commonly used for hand gesture and posture recognition, which can be applied to a variety of different interaction techniques. (Bowman, Kruijff, et al., 2004)

In some 3D user interfaces, a virtual representation of user's hand is required. Data gloves with an associated tracking system can provide such representation. In general, these types of representations are useful in virtual environments, where a user needs to see the hands in the scene with other virtual objects. A user might wish to get and understanding of where are in relation to various controls of the interface.

3.4.3 CAD System Studies

In the early days, CAD systems are focused on later stages of design developments. However, to support the earlier design stages in computer is recently paid more attention to, while the problem with using CAAD is its constant interruption of the design process. To use a CAAD tool the user must normally supply a geometric description of the design and a list of characteristics (material) for each part of the design. This means that the designer must temporarily stop the design process to translate his mental representation of the design into a form more suitable for the tool he is intending to use.

On the other hand, the CAAD tool interrupts the association link. During the design process every step is evaluated and may lead to new steps and new alternatives. Every attempt brings up ideas for improvements. Interruption of these steps for a long period makes it very difficult for the designer to find creative solutions to the problems he/she encounters. It is difficult to regain a line of thought and concentrating on one solution tends to block creative search for alternative solutions. (deVries and Wagter, 1990)

3.4.4 Related Projects

For finding an intuitive physical device in this research, several implementations with data gloves and other immersive environments are reviewed. (Kurmann, 1995) developed an intuitive design environment in three-dimensional modelling and design in architecture, new approaches and methods are needed in computer based design tools. This paper identifies key factors in designing with computers and presents a computer program called 'Sculptor' for intuitive and direct virtual modelling in architecture. The program focuses on new methods for design in the early stages such as conceptual and abstract designs for massing studies.

(Schkolne, Pruett, et al., 2001) presented *Surface Drawing* system for creating organic 3D shapes in a manner which supports the needs and interests of artists. The medium facilitates the early stages of creative design which many 3D modeling programs neglect.

Figure 6: Surface drawing device.

(Achten and deVries, 2000) presented DDDoolz, a desktop-VR three-dimensional voxel Sketch tool to explore the use of Virtual Reality technology in the early design stage. The aim is to offer a sketch-like environment in VR with an unobtrusive interface. (Benko, Ishak, et al., 2005) presented a set of cross-dimensional interaction techniques for a hybrid user interface that integrates existing 2D and 3D visualization and interaction devices. The approach is built around one- and two-handed gestures that support the seamless transition of data between co-located 2D and 3D contexts. Figure 7 shows several examples of hand gestures.

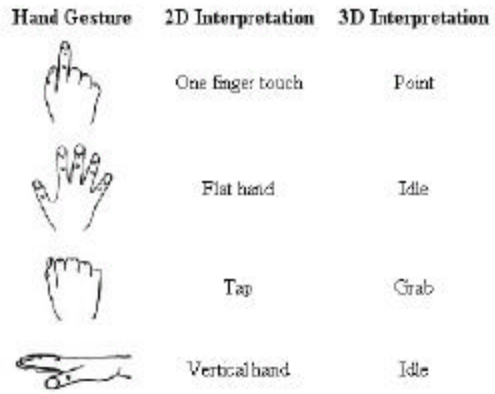


Figure 7: A set of basic hand gestures and their interpretations in 2D and 3D environments

4. Theory.

4.1 Chinese Calligraphy as a Design Media

According to the analyzing of Chinese calligraphy theories and branches developed from ancient times to the present, we found that mapping between Chinese calligraphy skills and spatial composition can be identified as table shown in Table 2.

TABLE 2: Mapping between Chinese calligraphy and spatial composition.

Chinese Calligraphy Skills			Spatial Composition	
Illustrative Process (Handling)	1.Brush holding			
	2.Motion	(1)Velocity	Time, kinesis	**Time**
		(2)Energy	Free line, contrast	**Line**
		(3)Curving	Direction, continuity	
		(4)Starting/Ending	Edge quality	
		(5)Tangency	Taste	
	3.Weight and Energy		Rhythm, expense	**Time**
	4.Inkiness		Surface	**Texture**
			Brightness, shining	**Light**
Character Structuring	1.Scaling and skewing		Boundary, edge	**Form**
	2.Stroke density and stress		Partitions, branching	**Space**
	3.Conflicting		Limitation, dimensions	
Chapter Composition	1.Position		Peripheral relation	**Space**
	2.Partitioning		Balance, contrast	
	3.Coherency		Direction, expense	**Time**

4.1.1 Design Media Representation

Since the strokes of Chinese calligraphy are the dominant elements of correspondence between the media and forms, the symbol representation of Chinese calligraphy as a design media is based on the stroke illustrative functionality. Each stroke created in the virtual design environment is recognized as one of the fundamental strokes in the predefined template. During the later stages of design exploration in the system, the strokes can be applied with their corresponding space forms by 1) User specifies emergent shapes, and 2) System suggests emergent shapes.

Practically, Chinese Cao-style calligraphic strokes can be identified by nine types shown in Table 2, which are defining traces of strokes for recognizing hand motions. Cao-style of Chinese calligraphy is chosen as the media not only because its brush strokes highlight various effects to brush strokes, but also because it is the most unrestricted style comparing among others to express visual and emotional intentions of writers through purely illustrating the linear and curvature strokes.

TABLE 2: Illustrative strokes of Chinese calligraphy

4.1.2 Form Exploration Policy

The purpose of design exploring in the early stage of this design system is primary dealing with the operations over the form with the Chinese calligraphy design media. Unlikely spending concentration on any evaluation functions, the system supports design goals of the form inspirations by the Chinese calligraphy media and mind. The form exploration policy can be described as design decisions of: 1) Functions, 2) Building properties, 3) Activities, and 4) Shapes.

4.1.3 3D User Interaction Process

Designers who are not familiar with these skills can be enhanced by an intuitive interface through a digital device such as data glove. This gives the power for the user to conceptually illustrate Chinese calligraphy by multiple dimension of hand movement: 3D position, velocity, rotation and forces of five fingers. Translating the action of the hand into geometry is greatly aided by the chunking of a hand closing into a stroke. An initial implementation updated the surface one sample at a time, incrementally growing it. In the meanwhile, space of the virtual environment is being viewed and traveled of steady hand gesture, to discreetly shift the design perspective. In the same way, another hand gesture for picking up a stroke for transform interaction. Hence, there are three mode of the interface: 1) **Creating**, 2) **Viewing**, and 3) **Picking**, and each is being switched on by a steady hand posture during hand action.

4.2 Design Inspiration of the Design Media

In the design virtual environment, the mapping between the design media and the system is divided into three levels as 1)Perform: Design media representation, 2)Process: 3D user illustrative interaction, and 3)Prompt: Form exploration policy. Responding to design sketching as a seeing-moving-seeing process as it means to exploration, an iterative process naming Create-Modify-Inspire approach can represent the process of form exploration of sketching.

Consequently, the design media of Chinese calligraphy for generative form exploration combines 1) the levels of the design media and 2) the states of design process into a design media inspiration model, as the emphatic diagram shows in Figure 8.

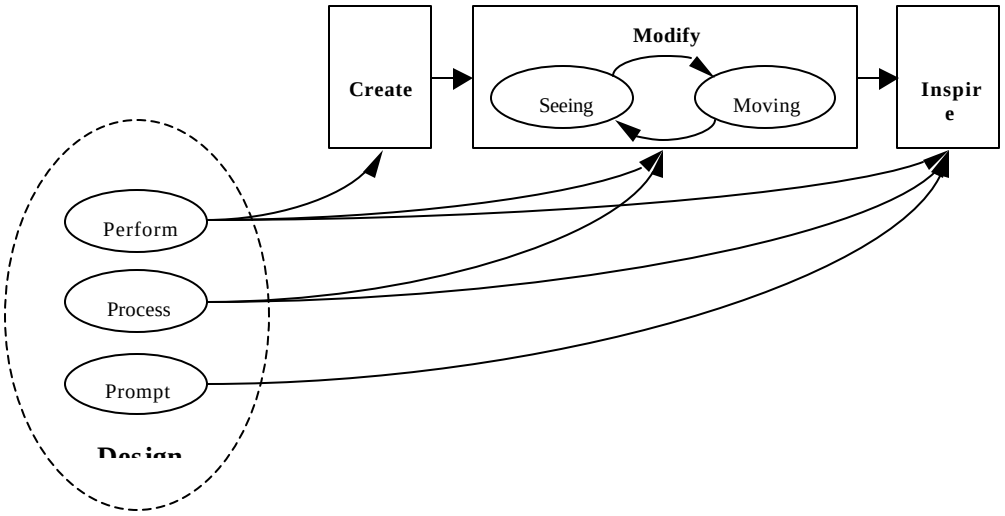


Figure 8: Design inspiration model of a design media

4.3 Create-Modify-Inspire Approach

First, create strokes of Chinese calligraphy characters as 'sketch' in the simulation illustrative space. Second, viewing and modifying as seeing-moving-seeing over 3D stroke creation. Third, transforming the work into space form partial by partial of its representations, which can give on the performance of design intention and point out the direction where designer is exploring space form. Further, transformation methods are declared by the policies as perspectives of design decision to evaluating design media of Chinese calligraphy as well.

A designer manipulates design objects through transforming shapes and locations, and changing viewpoints, drawing types, and media to explore design alternatives. Design sketches are used to generate alternatives and predict the outcomes of new proposals by applying transformations to various design objects. The designer manipulates the visualized representations to evaluate the consequences of design moves. Once and object is positioned, the designer elaborates and reformulates both the object and its context.

4.2.1 Create

The illustration starts with a defined base ground. While the user "sketch" freely using hand motion device, chunking by the palm closing, the system then analyzes and records trace data from the device. With the stroke interpreter, system dynamically visualizes Chinese calligraphy strokes generated by user's trace coordination information and strength data. For each hand movement, system will trace what user has made.

Designers who are not familiar with these skills can be enhanced by an intuitive interface through a digital device such as data glove. This gives the power for the user to conceptually illustrate Chinese calligraphy.

In this illustrative process of Chinese calligraphy, strokes are controlled by the conditions of 3D hand input device. Besides the conditions there are either the geometry of the calligraphy brush's

hard/soft and wide/narrow, or the ink's dry/wet, dense/rare, which are not directly affected by naturally illustrative process.

4.2.2 Modify

After the calligraphy strokes are created in the design virtual environment, they are needed to be modified by user for satisfying subjective design purposes. The strokes in the virtual space are described geometrically with the data structures, and thus can be operated for design in computer. The hand created 3D strokes are arbitrarily resulting free-formed shapes, which meet the appreciation in the terms of Chinese modern calligraphy. However, for each stroke user made which has strength and position data, it may still be partially unmindful and has uncertain identity to Chinese calligraphy characteristics. The system thus simply recognizes the stroke traces by comparing with four-segment paths with a library of Cao-style calligraphy templates, and applying refined strokes as surfaces to original stroke traces. This becomes to a space illustration of Chinese calligraphy upon an architectural form within form exploration strategy.

4.2.3 Inspire

Inspire is the stage for transforming Chinese calligraphy strokes into space form partial by partial of its representations, which can give on the performance of design intention and point out the direction where designer is exploring space form. Further, inspiration methods are declared by several theories as perspectives and attitude of mind to evaluating design sketching and Chinese calligraphy as well.

Moreover, a stroke could be viewed as any other objects else by other different point of view. In this research only several of most typical form operations are concentrated on. Any other operations could be additionally scripted as a future work for the system flexibility. The created stroke and trace data can be stored with edit points and strengths for iterative modifications. Views can also be output as still images for inspiration or other purpose.

4.4 Inspiration: Space Form Exploration Policy

In the early design stages, design information about problems is implicit and not need to consider all requirements in depth. Thus, the requirements are decreased of form exploration policy. The decisions are made about compositions of properties and requirements that have specific architectural meaning:

1) Function- Specify requirements of the unit: Room, Stair, and Passage.
2) Property- Common units about properties: Vista, Axis of symmetry.
3) Activity- Specify the building type combines with other units: Entrance, Going up.
4) Shape - Decide the look of outside edge, adopting appreciations of Chinese calligraphy.

5. Implementation.

5.1 Technical Evaluation

For the requirement of a multidimensional (position, rotation, pressure and fingers bending) input device, is captured by the Essential Reality's P5Glove hand motion device. The information is further analyzed by the API of the device. The system is developed with Dev-C++ environment,

which is using GNU C++ for accessing the data glove through the data glove API. Also, we are using Irrlicht Engine SDK for GUI interaction control and scene graph management.

5.2 System Framework and Data Structure

A prototype of space form exploration interface, the intuitive device: ***CalliHand*** is developed for form creation and inspiration in space design domain. It works with the P5 Dataglove 3D hand device for input and a 3D scene graph management API for viewing and GUI manipulation. CalliHand is Chinese calligraphy-like hand movement form sketch device. The system components of CalliHand are shown in Figure 9.

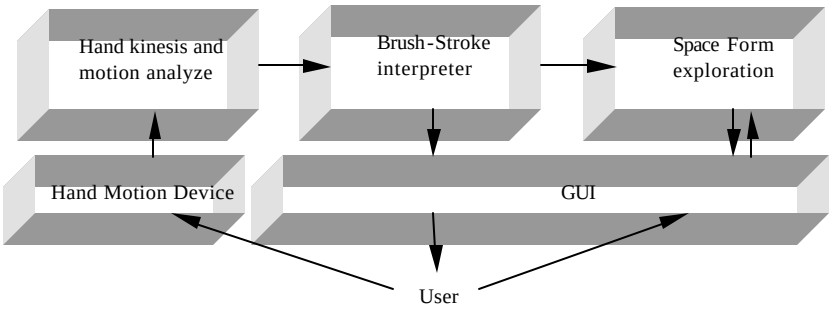


Figure 9: The system components

With CalliHand, user can construct geometry models for representing conceptualized Chinese calligraphy writing skills which can be divided into representations declared as Stroke, and LineSegment. The model of strokes is constructed with linked-lists of Stroke, LineSegment with their vertices to represent connected line segments of the strokes. In Figure 10, each linked segment has its individual position, strength and drip sphere. The attributes Node of Stroke and Drip of LineSegment are instances of the Irrlicht SDK for displaying.

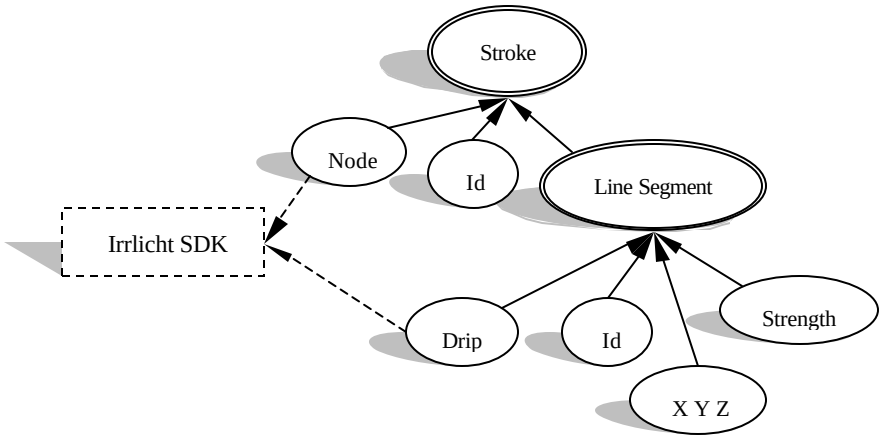
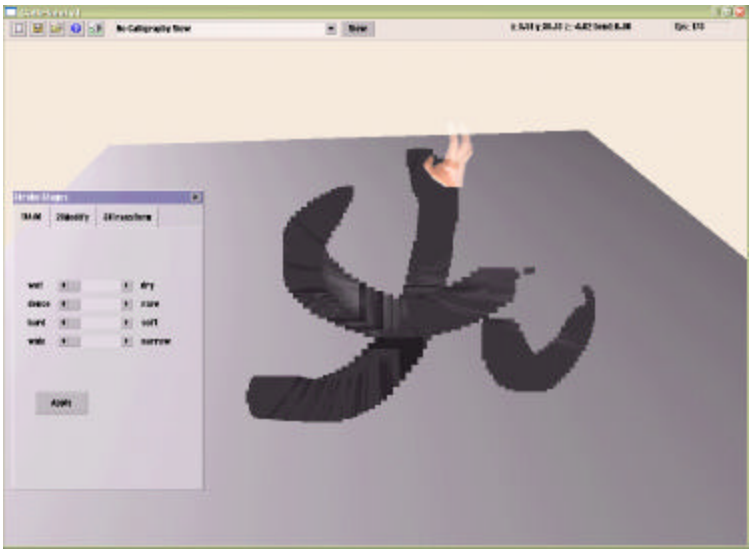


Figure 10: The data structure

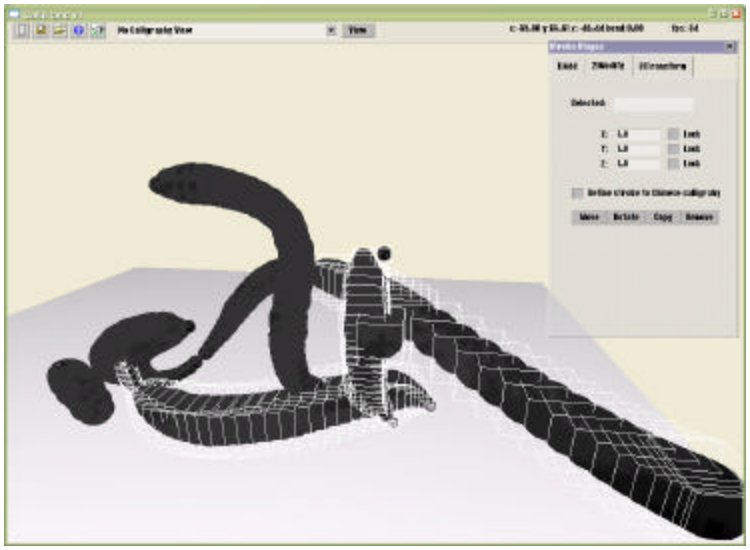
5.3 Virtual Design Environment

Figure 11(a) shows that the virtual design environment window. In this virtual space, user creates

the Chinese calligraphy strokes with 3D hand device, and changes the view to observe the strokes in the virtual environment. The virtual environment and the 3D hand device are integrated for user's interaction process, while user illustrates and modifies strokes, changes viewing and explores forms with the hand device. Before actually producing space forms, the stage is for Chinese calligraphy illustration as design sketching. In Figure 11(b), space form is produced as a design form in white edges for inspiration.



(a) Calligraphy stroke illustration



(b) Inspire: Space form exploration

Figure 11: Screen shots of the virtual design environment

6. Conclusion.

In our work, Chinese calligraphy illustration is as a design interaction in space form exploration, which is to provide the exceptional interactivity and exploration behaviors with: 1) 3D strokes as

their edit points as meanings of design media, 2) transformation from 3D strokes to space forms such as frames, surfaces, solids through variable perceptions and design decisions, 3) traveling and viewing in the space of writing, and 4) motion of writing behavior as spatial form visual expression.

The significant characteristics of Chinese calligraphy are: 1) the variety and ambiguity in expressiveness of illustrative process, 2) the structural constraint of Chinese calligraphy strokes. These will enable a generalized inspiring design media with the mind of Chinese calligraphy. We develop the design approach of the Chinese calligraphy media by reflecting the illustration and perception of Chinese calligraphy to design drawing in virtual design environment computation and its model. Through the creating, modifying and inspiring approach, the design media of computation supports the concept of design drawing, Chinese calligraphy illustration, and inspiration by the specific design media.

6.1 Contribution

With the Create-Modify-Inspire approach which is carried out for reflecting to design drawing process and visualizing the invisible exploration mind, from strokes to space forms, and that is the core of the digital design media which we propose. We have developed an intuitive interaction process of 'sketching' in 3D space. Also, we brought up the idea of rich textural design drawing media of Chinese calligraphy strokes in, and suggest the approach of thinking design through Chinese calligraphy perception.

6.2 Scope and Limitation

Design is performed by the interaction between designer and the media as an exploration interface. Thus, it is concentrated as making all effort to 'design interaction' that the proposed research focused on, including the interactivity and design thinking with the design media of Chinese calligraphy.

How far Chinese calligraphy may be computerized is reflecting to the interaction and design thinking of form exploration as well as its expressions in the subject of the proposed research. It is also reflecting the intention of suggesting Chinese calligraphy concept as well as its media characteristics and perspectives, embracing the development of interaction and form exploration approach of the design media, which are going to be done in the research.

6.3 Future Work

The expressiveness of Chinese calligraphy lies in the rich textural media and the illustrative interaction. Although in this research, the primary issue of Chinese calligraphy as a design media is the interaction process, the variety of the textural expressiveness is another interesting issue for further research.

The system is developed in a windows visual virtual environment for the similarity perspective to design drawing. On the other hand, virtual reality aided design environment topics are suggesting more existent feeling for user to be with the design system. The virtual design environment under the technologies such as Augmented Reality or Immersive Reality would be another significant issue.

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