

The electronic sketch book of Tibetan Thangka painting

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The electronic sketch book of Thangka painting project is conceived as a way of using interactive video and computing technology to preserve and disseminate the craft of Tibetan Thangka painting – a 2000-year-old art form now threatened with deterioration. This paper first provides a description of the project and then examines the research questions about the relationship of electronic technology and design craft. Second, it illustrates the preliminary work towards the construction of a prototype electronic Thangka sketch book. The sketch book enables novice students of Thangka Painting to explore Thangka-related topics. Its multimedia database includes video records of finished Thangka paintings, compositional techniques, sample sketches, catalogues of painting elements, curatorial analyses, and scenes of Tibetan cultural life. The sketch book's interface permits novice students to explore the database at their own pace, through direct interaction with diagrams and images of Thangka paintings.

Key words: Tibetan Thangka painting – Visual language – Hyper media – Representation of design process – Craft preservation – Craft dissemination – User interface

1 Introduction

Among the many expressions of Tibetan art that we have come to admire are the paintings known as “Thangka.” Typically, images on Thangka paintings, like those expressed in stone and metal, represent the various deities that populate the Tibetan artistic pantheon (Tucci 1949; Pal 1983). Blazing with symbolism, their purpose is to transport the viewer into the supernatural and paradisiacal world of the deity, a world conceptualized by theologians and visualized by artists for countless generations.

Visually expressive and stimulating as these images are, the depiction of the various deities on Thangkas is regulated by precise rules of composition. Some of these rules of composition are represented in canonical treatises describing verbally the basic iconography of the various deities. Other rules are expressed visually through proportioning diagrams and sample sketches of deities. The sketches demonstrate, for example, various compositional schemes of Thangkas: the postures of deities, the gestures that deities make with their hands, the symbolic objects that their hands clasp, the rendering of the deities' garments and accessories, and landscape elements that echo the deities' spiritual qualities. These rules of composition are timeless, as they were passed down from master to pupil through successive generations, the medium of transmission consisting of proportioning diagrams, sample sketches, and verses in Tibetan canonical treatises.

Today a variety of forces threaten the practice of Thangka painting, moving the craft towards irrevocable simplification. As a part of a monumental task to preserve the artistic heritage of Tibet, the remaining Thangka painters, at the request of the Dalai Lama, have become wanderers, traveling the world as a living archive, and carrying with them the knowledge of the ways of Thangka painting. The electronic sketch book of Tibetan Thangka painting project is conceived as a way of using computing and video representations to preserve Thangka imagery and the cultural context in which it is created, and as a way to use these representations to reveal the process of composing Thangkas. The project is a collaborative effort between Senge Lama, one of the last two living artists of the “Karma Gadri” style of Thangka painting, Xerox researchers, the curators of the Asian Art Museum of San Francisco, and the Tibetan community. The sketch book has two roles: a passive preservation role and an active dissemination role. In the passive role the sketch book takes form as a chroni-



Fig. 1. Thangka painting of Goddess Green Tara, 15th century, the Cleveland Museum of Art, Purchase from the J.H. Wade Fund, 70.156

cle, an audiovisual diary of Thangka imagery like its traditional predecessors expressed by manuscript illuminations and narrative paintings. In the active role, the sketch book is a medium of transmission, connecting the Thangka master and beginning painters, mediating between painters and the records in the diary in electronic form, and re-integrating the historical practice with contemporary tools. Related work on interactive educational media projects are available in the references (Morrel and Trigg 1987; Yankelovitch et al. 1988; Wilson 1988).

This paper first exposes the research questions about the relationship of technology and craft. Second, it discusses preliminary research into the construction of a prototype sketch book for instructional use within the craft environment for Thangka painting. The sketch book contains a database of sounds and images of the process of Thangka composition, including audio recordings of conver-

sations, computational graphic representations, video-based re-enactments of compositions and sketches, and video stills. The content of the database serves to expose the beginning painter to the various deities of the Tibetan pantheon, their mythologies and symbolism, proportioning and rendering skills, the practice of Thangkas as a cultural activity. The scenes of action are complemented by scenes of Tibetan life, folk songs, verbal invocations and chanting of deities, and conversations with Senge and experts on existing Thangkas. The sketch book's user interface models the content of the diverse elements in the database and provides navigational mechanisms.

The student painter interacts with the Thangka sketch book, calligraphically using a diagrammatic language. The diagrammatic language provides a means for presenting the content of the database, as well as a means for indexing and retrieving categories of elements in the database. The interaction

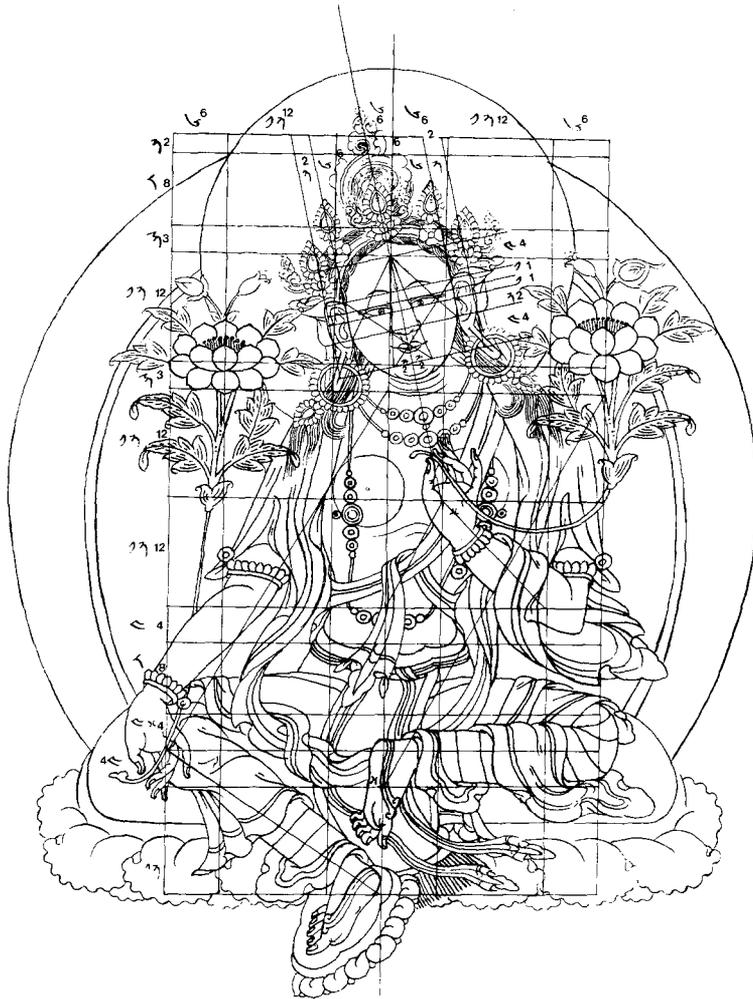


Fig. 2. Proportioning Diagram of Goddess Green Tara, drawn by Wangdrak, Copyright 1988, Snow Lion Publications, Ithaca

language provides a basis for examining themes of continuity and change as it bridges between Thangka representations in traditional media and process-oriented representations in electronic media. The remainder of this paper is organized into three sections: (1) the project's motivations and research questions; (2) database of Thangka imagery; and (3) diagrammatic user interface.

2 Motivations and research questions

To glance for the first time at the painting illustrated on Fig. 1, is to be transported to an evocative world charged with fantasy and symbolism. The image depicted is not a portrait, but a symbol of the Goddess Green Tara, the mother of all the Buddhas. The painting is called Thangka.

The word "Thangka" literally means "something that is rolled up"; hence, a rolled-up image or a painting scroll.

The center stage of a Thangka painting is usually occupied by a deity. In this painting, the Goddess, sumptuously bedecked with jewels, is sitting in a relaxed posture with one leg locked and the other leg pendant on a double lotus pedestal. A lotus supports her pendant right leg for, indeed, her feet cannot rest on the physical earth. Her right hand extends over her knee with palm facing outwards in the gesture of "reassurance." Similarly, her left hand, expressing the gesture of "exposition," holds a blue lotus flower. Positioned around the perimeter of the throne and flanking the Goddess are elephants, deers, lions, and mythical animals, whose purpose is to emphasize the majesty of the central personage. For example, on top of the throne behind the goddess is a mask of a mythical

animal biting on two serpents; and below it are two crocodile-like mythical animals with their tails in curvilinear foliation. The Goddess is enthroned inside a tiered temple with three stupas on top. Surrounding the temple are numerous trees among which are bannana, palm, and the ficus religiosa, the tree of enlightenment. A small figure of a monk on the left is possibly the donor of the painting. These symbols of expressive postures, gestures, ornate thrones, and landscapes form a rich visual language, which is the accepted medium of communication between the painter and the viewer.

Despite the bewildering complexity of the painting, the technical basis for Thangka paintings is a series of rectilinear diagrams (Fig. 2). The depiction of the various deities on Thangkas is regulated and ordered by very precise rules of composition, among them the theories of the bodily proportions of the various deities that make up the Tibetan artistic pantheon. The rules of composition, handed down generation after generation from master to pupil, have been the means of transmitting the craft for the last 2000 years. These theories are not the work of one artist or generation, but the work of generations of craftsmen, the fruit of communal thought. According to the eminent art historian Coomaraswamy (1964):

This communal thought is not only the popular thought, but that of the greatest and wisest minds seeking to impress their

vision on successive generations. However there is a fatal weakness of communal art: it has no power to resist the corruption from without. It is beautiful by habit, rather by intention, so a single generation under changed conditions is sufficient to destroy it.

The annexation of Tibet in 1959 caused the exodus of Tibetans from their homeland. Tibetan monasteries, once the rich repositories of Thangka paintings and other cultured artifacts, were impoverished and many of their paintings were destroyed. Many of the painters and other craftsmen were scattered in various refugee settlements all over the world. In a battle to preserve and reconstruct the cultural continuity, Tibet's temporal leader, the Dalai Lama, has asked painters and craftsmen to disseminate the traditions in the West. Thus the painters have become wanderers, traveling the world as a living archive. It is in these painters, more than in collections of Thangka paintings in museums, that we find the knowledge of the "ways of painting."

We understand craft is a communal process of making artifacts in which the designers are involved with the whole process of design, especially in the development of tools and supportive traditions and the acquiring of hand skills. Historically, it has been identified with producing artifacts that were necessary for life and hence its beauty is born in communal use (Yanagi 1972; Smith and Lucie-

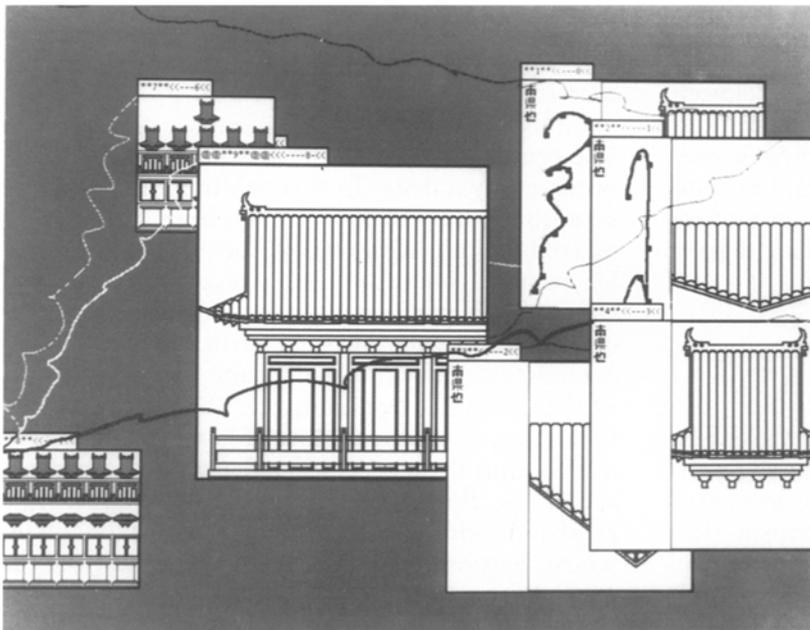


Fig. 3. Temple designer exercising a gestural language to interactively compose temple facades. Various threads tie up the different activities over time in a temple designer's derivative process

Smith 1986). The electronic sketch book project is conceived as a way of examining the potential of interactive computer and video technologies towards preserving and disseminating design craft.

Our experience with the use of computing and video to support craftsmen and designers arises from projects that we successfully completed (Makkuni 1987), in particular the composition of Chinese temple facades (Fig. 3). We explored the possibility of representing successful design processes – directly representing the “process of formation” of the artifact, not just the end artifact, in computational form – and of using the representations to preserve the successful processes. In other work (Harrison 1986; Stults 1986), we have explored the representation of design processes as records on video tape and video disk. Based on these explorations, we believe that representations of process, when repeated and re-enacted across situations, connect members in a design group across time, communicate experience between members and across projects, and provide a basis for formalized design craft. In addition, the representation of design experience are valuable in educating people about the craft. They can provide beginning designers with a rich library of previously preserved scenes which, in turn, may be assimilated into future design practice. When viewed over long periods of time, design craft can be viewed in a state of flux: some in the process of formation, experimentation, simplification or, as in the case of Thangka painting, in the process of deterioration.

We intend to extend our experience with representing process to Thangka painting. As we have noted, traditionally, Thangka painting has been transmitted by structured rules of composition. Although these rules are highly evolved and stable, they do not exclude artistic exploration.

The images of deities commonly depicted on Thangkas, along with their counterparts expressed in a variety of media – such as stone, metal, or wood sculptures, ink manuscript illustrations painted on paper and cloth, acrylic and water color paintings on cotton and silk banners, and mural paintings and inscriptions on the walls of monasteries – certainly illustrate the technical prowess of the artists in adhering to the rules of composition but, at the same time, also illustrate the artists’ imaginative power of visualization. Though all artists obey the rules of composition, no two paintings or sculptures are alike. The many different executions of the same deity illustrate the delicate rela-

tionship between, first, the artists’ technical virtuosity in the medium to express the theologians’ visions and, second, the imaginative power of the artists in rendering these visions to reflect the artists’ love, devotion and admiration of the deity being depicted. This relationship, between the remarkable conformity to basic iconography and the ethnic stylization of the deities, is also felt in the various countries where Buddhism flourished (Pal 1984).

These images, regardless of medium, time and place, illustrate the artists’ faithfulness to the well-established rules of composition, and their ability to accommodate artistic exploration within those rules. This makes the expression of Thangkas by applying structured computing and video machinery a domain worthy of examination.

Admittedly, it would be scholarly conceit blinded by optimism to believe that in bringing electronic technology to the craft of Thangka painting change is not inescapable. Electronic technology heralds change with the potential of both improvement and degradation of the process of craft. Amidst this dilemma of change, we cannot remain satisfied by merely shirking the use of electronic technology to preserve and disseminate the craft of Thangka painting. In any event, our use or avoidance is measured against the forces endangering the craft: rapid collecting of Thangkas, commercializing Thangkas, simplifying the process of creating Thangkas to meet the tourists’ demand for mementos, and painters abandoning their craft in search of economic opportunity. These forces are already moving the practice of Thangka painting toward irrevocable simplification, transformation, or degradation. Timeliness is important; delay might leave only an extinct craft. Hence, we propose to bring electronic technology to Thangka painting now, and to do so with great reverence for the craft, as did the countless generations of painters who produced these ageless, admirable paintings.

2.1 Preservation of the process of composing Thangkas

The purpose of the electronic sketch book is to aid in the practice and instruction of Thangkas. The craft environment will still include actual paintings, but the purpose here is not to study or display the finished paintings, for museum exhibitions and books do that well enough. Rather, our

purpose is to introduce into the craft environment a medium that is fundamentally about process, and hence about the sense of time. A craftsman takes actions towards a Thangka, such as generating an element or composing a whole painting. Like the scholar or museum curator who examines and collects finished paintings, we are concerned with representing and collecting the scenes of actions in which the craftsmen create the Thangkas.

Through these scenes, each action, however large or small, whether it is the shading of a deity's eyes, or examining the different compositional schemes for a whole painting, will be capable of re-enactment. By the re-enacting process, beginning painters or spectators can retrace the actions of the Thangka master and learn the craft through action.

The introduction of a new communication and representational medium is bound to affect the practice of Thangka painting. The research challenge is to examine the nature of a craft process that is being renewed – and altered – using the electronic sketch book. Thus, we will be led to ask: How can the visual world of the traditional media be brought into stable balance with the visual world of color monitors and color printers, both in the sense of their appearance (receptive action) and of the craft-person's ability to act on them (productive action)? How can the craft-person acquire, experience, and subsequently impart the learning of hand skills using electronic technology? How will the electronic environment support the craft-person's evolving contribution to the craft? Will the aura

“electronic media” influence the sensibilities of the Thangka master?

2.2 Dissemination

The idea of disseminating traditions, whether painted or written, by re-enactment is deeply rooted in ritual. Even today, Tibetan shrines and Indian temples witness a familiar initiation ritual: a young child, the child's parents, and a renowned teacher sit around a large metallic urn filled with an auspicious heap of rice. Eventually, the teacher sits beside the young child, clasps the child's arm, and ceremoniously guides the child's fingers to mark the form of letters on the heap of rice. The resulting letters are undoubtedly lacking in grace, but the act of the first writing symbolizes the child's entrance into the literate world of learning under the guidance of a teacher (Smithsonian 1986).

Similarly, our vision of disseminating craft is inspired from the role of the teacher enacting and guiding the child's hands in the initiation ritual. Through the re-enactment of the painting process – outlining a deity's proportions, rendering a deity's lotus throne, shading the clouds that whirl in the background – the beginning painter will feel the spirit of the master and the timeless ways of generations of Thangka masters, guiding the acquiring of painting skills. The masters' sketches diagramming the composition and rendering of the various deities have been passed down, generation through generation, in pupillary succession, to

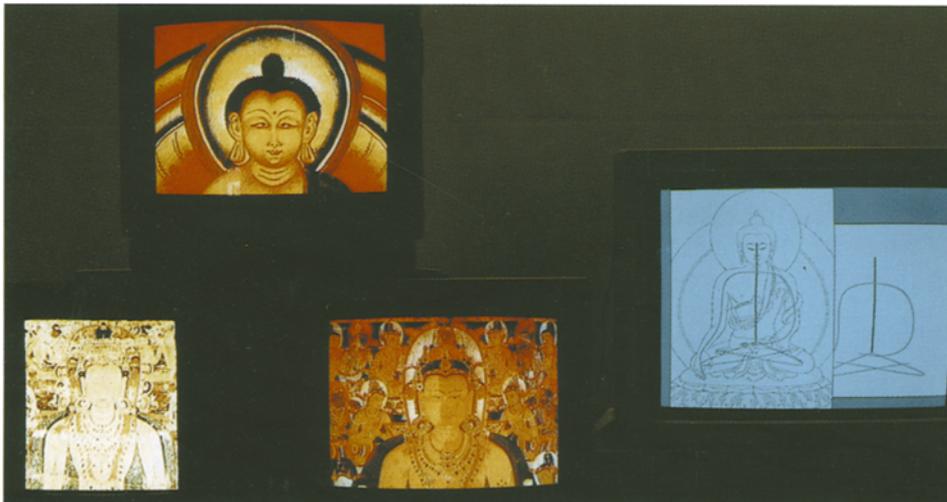


Fig. 4. A prototype electronic sketch book: video monitors on the left display images from the database; computer-user interface provides the student access into the database

guide the dissemination of their craft in ways that would guarantee the immutability of the compositional principles.

This section provided a description of project and the research questions about the relationship of technology and craft. The following two sections will discuss the construction of a prototype sketch book of Thangka painting. The prototype enables novice students of Thangka painting to explore Thangka-related topics. Its multimedia database includes video records of finished Thangka paintings, compositional techniques, sample sketches, catalogues of painting elements, curatorial analyses, and scenes of Tibetan cultural life. The sketch book's interface permits novice students to explore the sketch book at their own pace, through direct interaction with diagrams and images of Thangka paintings. Figure 4 illustrates the outward appearance of the electronic sketch book: the video monitors on the left display images from the database; and the computer user interface on the right provides the student access into the database. Accordingly, the next two sections will discuss: the construction of a database of Thangka imagery; and the user interface to the database.

3 A database of Thangka imagery

The artistic pantheon of Tibet is populated by various divinities of the Buddhist faith, nature spirits who reside in the mountains, passes and rivers of Tibet, and various mystics and saints who have attained enlightenment. The different members of the pantheon generally personify knowledge, insight or compassion (Bhattacharya 1968; Coomaraswamy 1972).

The representation of the various members of the artistic pantheon and narrative biographies of the members are favorite themes of Thangka painters. Thangka painters have long been required to learn precise rules of composition of the various deities which were documented in iconographic manuals. The iconographical manuals provided the painters with both visual and verbal models: The visual models (Lama 1981; Jackson and Jackson 1984) prescribe proportioning relationships between the parts of the whole of various divinities and provide sample sketches rendering the divinities; the verbal models (Goswamy and Dahman-Dallapicola 1976) are the descriptive invocations of the different dei-

ties in the artistic pantheon and, as such, provide the infrastructure for the visual models. Together, the descriptive guidelines in Tibetan verse (verbal models) and proportioning diagrams (visual models) have served as the medium of transmission of the craft of Thangka painting across time.

Like the verses in canonical treatises, or the prototypical sketches and proportioning diagrams of the Thangka masters, the electronic sketch book records the verbal and visual models, but does so using computing and video media. This section reviews the different audio-visual records that make up the source material for the electronic sketch book's database: the instructional ingredients of Thangka painting.

3.1 Recording verbal models

Verbal models provide the Thangka painter with a description of the basic iconography of the deities. Verbal models are the descriptive invocations, known in Sanskrit as *Dhyana* of a deity. They are vivid, graphic, precise, detailed, and evoke more fantasy than the paintings. For example, consider the following *Dhyana*, which instructs the painter on the rendering of the goddess Saraswati (Wayman 1977):

Surrounded by delectable herbs of a Mt. Meru grove, within a white and pure ocean of milk, she [Saraswati] is seated on a white lotus with large petals, she has a white body, one face, two arms, her face calm, smiling, and lovely with charming youth of sixteen years, breast firm and high, narrow waist, in squatting posture; with her hands holding an instrument of many strings of lapis lazuli.

For the database, *Dhyanas* were recorded in conversations with the master in a "question and answer" style. *Dhyanas* provide the beginning painter with descriptions of expressions on the various divinities' faces, metrics and nuances of rage or tranquility in their appearance, the attire of deities, the settings in which they are to be depicted, their residences, vehicles, thrones, weapons and other possessions.

3.2 Recording visual models

The visual models consist of both prototypical sketches and proportioning diagrams of the various deities. Figure 5 illustrates a catalogue of landscape elements. Thangka masters use these models

as aids to instruction so that their pupils, in faithfully redrawing and rendering the diagrams and sketches, acquire proportioning, compositional, and coloring skills.

The proportioning diagrams of the Thangka masters are set forth on iconometric theory which, according to Gerasimova (1978) is "the grammar of drawing, the science of mathematical proportions which imparts harmony to an image." The Thangka iconometry is based on the study of the proportions of the human body. Hence, the measures of man – face, palms and fingers – were its units of measurement. Compositionally, members of the Tibetan pantheon are divided into three basic classes: peaceful divinities, wrathful divinities, and ordinary human beings. The Thangka iconometry relates the appropriate proportioning of the figures in accordance with this classification. For the electronic sketch book, proportioning diagrams for important deities were recorded as video still frames to

serve as reference material. Next, catalogues of various gestures, offerings, landscape elements, and sample sketches of deities were recorded (Fig. 5).

The sample sketches preserved rendering sequences, for example, generating a proportioning grid, outlining within the proportioning grid the form of a naked deity, clothing the deity with robes, seating the deity on a throne, drawing the nimbuses or halo around the deity, placing symbolic offerings before the deity. The preservation of painting sequence is most important for the student painter, because the sequence is related to mythological beliefs, and the process of drawing is considered an inviolable ritual. For example, the last strokes in the depiction of Buddha's head are the outlining and rendering of the eyes. Just as the masters describe, the final strokes of outlining Buddha's eyes, indeed, brings the deity of life.

Other electronic records of visual models include images of Tibetan cultural life, landscapes, people, sounds, ceremonies, example paintings of Thangkas in museums, and curatorial analyses of museum Thangkas. Scenes of cultural imagery and Tibetan landscape aid as visual references in the recordings of Dhyanas. Museum Thangkas, and curatorial analyses were selected to provide examples of artistic exploration and improvisation.

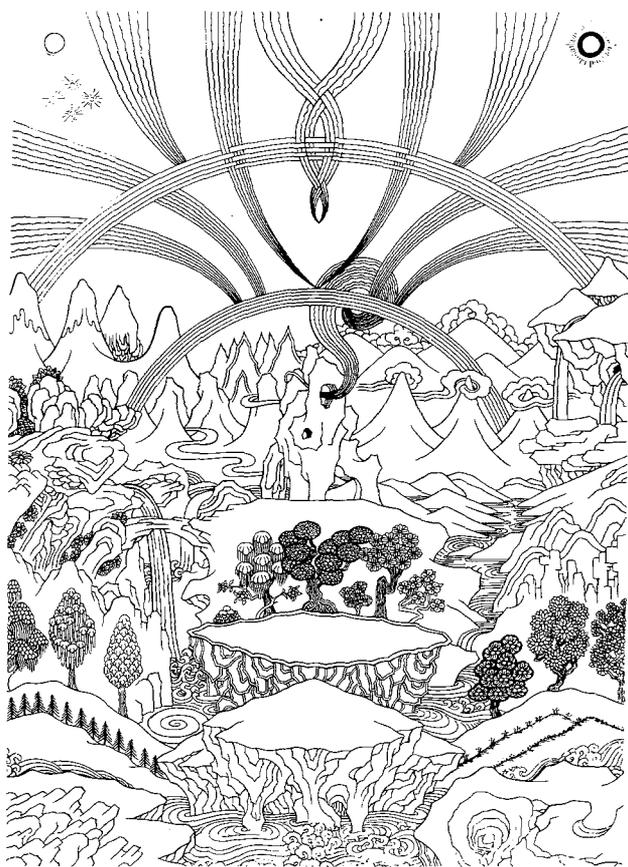


Fig. 5. Catalogue of landscape elements, drawn by Robert Beer, Copyright 1988, Snow Lion Publications, Ithaca

3.3 Video recording of the compositional process

Video records can be played back under computer control. Unlike static sketches and diagrams in traditional media, video representations introduce into the craft environment a medium that is fundamentally about process. Along with static diagrams and sketches, the sketch book collected action sequences in which craftsmen create Thangkas. Beginning painters or spectators can replay the scenes and experience them, almost as if they were actually present with the master, and thus learn the craft by re-enacting process.

The video records were created to capture the presence of the master. In scenes containing the recitations of verbal models and discussions about theology, the records capture the master's presentation style, countenance, and demeanor. The medium provides the ability to connect process-related records such as proportioning details and iconographic descriptions to the master's personality. As a meta-medium, video allows us to inter-mix and

uniformly present representations originally in diverse media. Combined in this way, visual models, verbal models, still images of catalogues, sketches, and curatorial analyses provide beginning Thangka pupils with a rich compositional schema.

3.4 Computational model of the video scenes

The recordings of the master were edited into discrete video segments. Each video segment corresponds to a computational record in a relational database. Fields in the record characterize the segment's content, its visual format, and the beginning and ending video frame numbers. The content of the video segment includes a painting's name and historical information, such as date, stylistic period, the deity depicted on the Thangka, etc. In the case of verbal models, key words identify deities, deities' compositional details, the embodiments of theological concepts, etc. Included with each recorded segment is information about the visual format of the segment, whether the camera-shot is a close-up of a painting, a wide-shot, detail of a deity's part, or a close up of the master, etc.

The database records for the segments were created by transcribing the conversations to text, and then by defining or extracting key words from the transcript. Parsing the video record into discrete segments works well for cataloguing the still images of proportioning diagrams, Thangka compositional elements, museum paintings, and other reference material. However, this tactic flounders in organizing the conversations with the master painter. In the course of conversations, he made diverse associations, ranging from aspects of Thangka composition to discussions on theology. Also, in the process of discussing a particular deity, he alluded to other deities or digressed into other topics. Thus, instead of viewing conversations as a series of segments, we view the conversations as a continuous performance whose content can be examined by a system of overlapping entry and exit points.

For the prototype sketch book, we have deferred issues arising from the use of the database by multiple audiences. For example, in the section of video that shows drawing an eye, one index might point to the master just marking on the paper (for the art student), another might show a longer version that begins with the master picking up the pencil (for the audience in an art gallery), and another

might begin with the master talking about the significance of eyes and end with him just starting to draw (for those interested in the details of Tibetan Buddhism). In this important way, parsing of the video records should be "soft." Looking in on any one point of view loses too much of the interest value for another perspective.

4 Diagrammatic user interface

The previous section described the diverse process records that make up the database of Thangka imagery. This section will discuss the computational tools that allow a beginning painter to access the records and navigate the database.

Tibetan painting can be appreciated on one level for its form alone, but more deeply based on its content. At a purely compositional level Thangka painting is accessible to all, pleasing the viewer's eye with its vividness and decorative charm. Deeper appreciation is usually reserved for the student of Buddhism, who has the ability to translate the symbols into the religious experiences whose spiritual fire the paintings seek to express. The approach from both composition and religious experience informs the student, on the one hand, of the Tibetan's preoccupation with ornamentation, and on the other, of the inner spiritual life of the Tibetan people. The initial approach to Thangkas may be made from either perspective. Starting from composition, the student might discover the expression of the doctrinal principle in symbols. Starting from theology, the student might discover the visual representations of its religious ideals.

Thus, the different video representations, whether of composition or of theology, illustrate different views of the same Thangka process. Traditionally, the records exist in different media, offering to the painter different perspectives of the same compositional process, and different experiences of the process. The experience of these media occur in various settings, such as circambulating around temple walls frescoed with murals, or reciting verbal models, or painting while chanting verbal incantations. These different representations of Thangka process are like transparent overlays, elucidating the inter-relatedness of expressions in diverse media. Thangka painters carry with them the implicit knowledge of the relationships among the representations in the different media.

The purpose in the structuring of the representations is to make explicit the relationships between the overlays, illustrating the inter-relatedness of the representations. In a basic sense, this involves filtering of rich inter-connections between proportioning grids for any deity in the pantheon, re-playable compositional sketches, catalogues for rendering garments and landscapes, previously executed Thangkas, discussions on mythology, verbal models of iconography, etc.

4.1 Classification of deities

The basic unit of organization is the deity. Following traditional classification of the artistic pantheon, the deity serves as the basis for assembling diverse representations. Since the classification schemes for the deities in the Tibetan artistic pantheon are straightforward and complete, representations for them can be easily expressed in the Smalltalk programming environment (Goldberg and Robson 1983). The Smalltalk class hierarchy enables easy definition of classified objects according to shared and differing properties.

The iconometric classification of deities into peaceful deities, wrathful deities and ordinary human beings comprises the uppermost layer of classes, each with its own sub-hierarchy. For example, under the peaceful deities are the different types of Buddhas, and Bodhisattvas. Smalltalk provides a framework in which deities can be represented in terms of their differences from other deities. The classification allows for the inheritance of all the video representations related to a deity's class. At the upper layers of the hierarchy, the associated video segment give overviews; at the lower layers they convey focused treatments of specific topics.

4.2 Computational access to video segments of deities

In art historical analyses of Thangka paintings and in traditional educational settings of Thangka painting, curators and teachers employ sequential methods to describe and analyse the visual language. The methods identify a deity, and reveal its emblematic characteristics. The master typically leads the student's eye across the painting, from one point to the other, progressively revealing the

deity's emblematic characteristics – meditative postures, hand gestures, objects that the hands clasp, lotus thrones, clothing, landscape elements, and surrounding characters. Deities are identified by postures, hand gestures, thrones or mounts, differences in ornaments and garments, and the various symbols that they hold.

4.2.1 Laying out and presenting video records

The *Layout Editor* uses the visual presentation language as a frame for organizing and presenting video records. It consists of a display window containing a line drawing image of a deity. The deity's image provides a graphic basis for organizing and laying out the video representations related to that deity. The editor decomposes the deity's image by regions, such as the region of the face, halo, nimbus, clothing, jewelry, offerings, hand gestures, thrones, and landscape elements. It arranges and distributes related video representations across the graphic regions of the deity's image. Figure 6 illustrates some of the different regions of a deity.

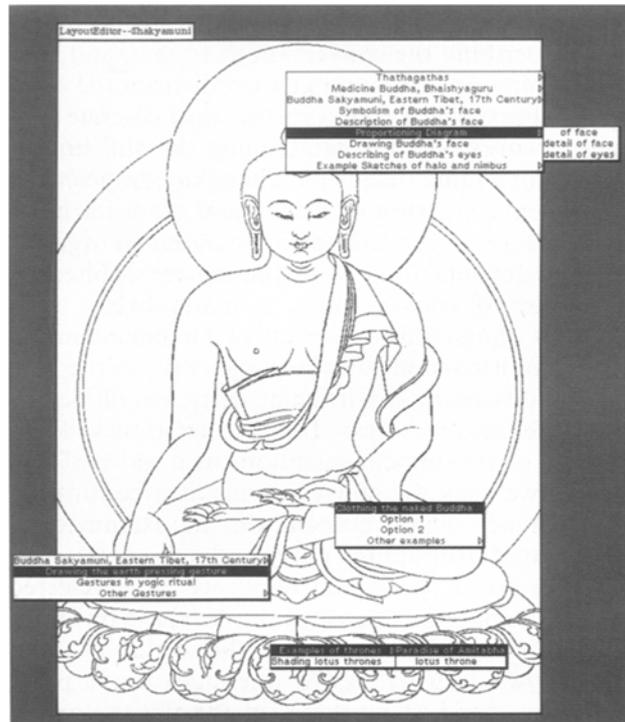


Fig. 6. Layout Editor illustrating mouse sensitive regions of the Buddha Shakyamuni's face, clothing, left gesture, and lotus throne

The regions of the deity's image are mouse-sensitive for a painter's interactive query. For example the student painter, by clicking at the region of the hands of a deity, obtains a menu of the titles of video records associated with that region. Video segments for the region of a deity's hand include, depiction of that hand gesture, similar hand gestures of other deities, drawing exercises of that gesture, symbolism of the gesture, stories, etc. Similarly, clicking at the region of the face reveals the titles of the video records describing the deity's face: the proportioning diagram for the face, verbal models for the eyes, stories, etc. Virtually every line on the deity's image is available for questioning.

A selection from the menu of titles in the Layout Editor plays back the corresponding scene. Or the selection may be temporarily stored in a script. This permits the definition of a series of video segments that might, for example, show related compositional steps for a number of deities, or show several discrete steps in a single compositional process. Scripts are made by selecting menu items from the Layout Editor, and creating a list of titles in sequential order in a script. The script can include the coordinated replay of video segments across multiple players. For example, the student can combine the audio segments of verbal models with other visual images of that deity.

The Layout Editor transparently provides for the accretion of new items into the database. It periodically reviews the records in the database to find new entries. For any particular deity, it retrieves all the video segments that are relevant to that deity, distributes the segments across the different regions, and constructs a pop-up menu of the scene titles.

The master authors and clusters video records relevant to the deity onto the deity's image using various authoring tools. The authoring tools allow the master to: prepare line drawings for the various deities; interactively specify regions on the line drawings; create the different lists containing titles of video representations for the different regions; assign these lists to various regions.

4.3 Diagrammatic language

Now that we have a means of assembling video representations and relating diverse representations of video in terms of an organizational unit, i.e., the deity, let us examine how a student navi-

gates the database and how this process of navigation provides a glimpse of the content of the database.

Deities are specified by means of a diagrammatic language: a collection of diagrams that represent various deities' essential graphic characteristics. A deity's diagram is pictorial representation (Fig. 7), which includes the dimensions of body parts and proportioning relationships among parts. Based on the positioning relationships of body parts, a deity's yogic posture may be extracted from the diagram. Hence, a diagram is a concise representation that serves as a graphic index to an image of particular deity. It provides the means to interact as well as index and retrieve elements from the database.

4.3.1 Representation of Deities' Diagrams

Deities are modeled after ritual yogic postures. Figure 7 illustrates graphical indices (diagrams) for two deities. Consider the posture, "Dhyana-asana," which is a common meditative pose for all the Buddhas. In this pose the deity's legs are loosely locked, and both the hands are resting in the lap, right hand over the left hand, with all fingers extended and palms up, in the gesture of equipoise. Or consider the pose "Lalit-asana" in which one leg is pendant, usually supported by a lotus flower, while the other is in a squatting pose. Various energy centers of a yogi's spinal column – eyes, throat, heart, navel, etc. – serve as points for the construction of the center of axis of a deity's diagram. A deity's spinal column might be vertical, as in the case of Buddha, or may lean to the right or left as in the case of Goddesses. Arms may be raised, may stretch outward, or may relax in the lap, etc. Legs may be in locked, standing, or dancing positions, etc. Gestures, the varying positions of the deity's hands, are identified by the direction they point to and are based on the position of its connecting arm.

In the electronic sketch book, such a diagram of a deity's posture is computationally represented as a collection of splines. These splines represent various parts of a deity's skeletal structure, such as the spinal column, the upper arms, lower arms, hand gestures, legs, and feet. A spline is represented as collection of knot-points which will be useful in re-constructing it. The different splines preserve connectivity of the deity's skeletal structure. For

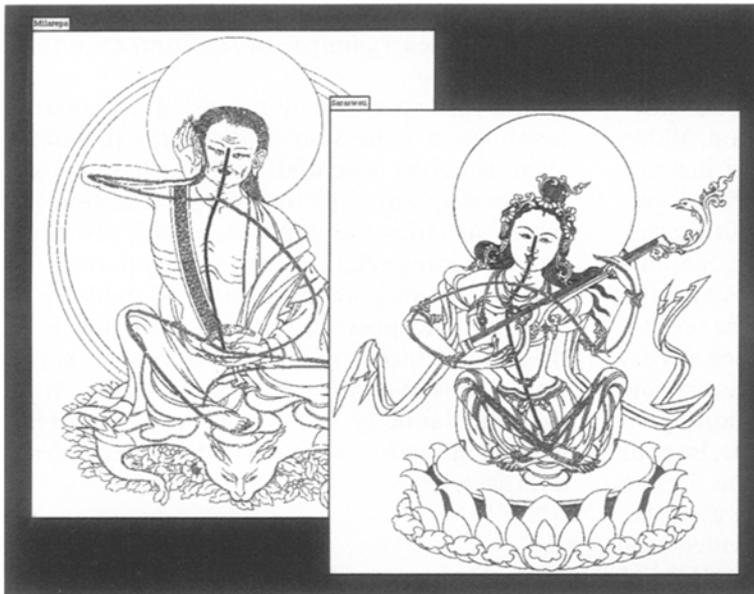


Fig. 7. Diagrams for Milarepa and Saraswati

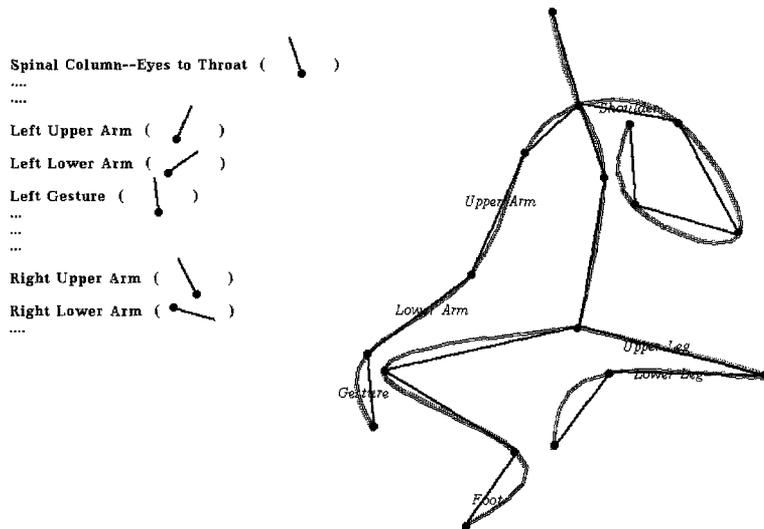


Fig. 8. Directional representation of a deity

example, hand gestures rotate about the lower arm, the lower arm rotates about the elbow, and the upper arm rotates about the shoulder. Related work on notational systems for dance, stick figure representations, and criteria for the selection of representations are available in the references (Marr and Nishihara 1978; Hutchinson 1984; Lansdown 1977; Zeltzer 1982; Larkin and Simon 1987).

A deity's diagram (a collection of splines), when parsed by direction, provides a table of angles that the different body parts make with respect to some

fixed origin and, in turn, a table of angles that the different body parts make with each other. These angles determine, for example, whether a deity's lower arm is pointing towards the heart, pointing towards the lap, or pointing towards the knees, etc. Various angles of the upper and lower legs identify whether the deity is squatting in still repose, or in dynamic poses, etc. Together, the different angles of all the body parts, and the relationships of parts between each other, uniquely identify a deity's yogic posture (Fig. 8). In the sketch book, various posture diagrams were defined, and from

these diagrams angular ranges and directional topologies were extracted. This allowed the construction of a table of deities, and their identifying posture diagrams. Characterised this way, the diagrams can be used for recognition or pattern matching.

4.4 Interaction by creating diagrams of deities

A deity's diagram can be transformed into another through a sequence of manipulations. The *Diagram Editor* consists of a window upon which the Thangka painter may sketch or manipulate a posture diagram (Fig. 9).

A Thangka painter manipulates the diagram by rotating the parts to change the positions of the deity's parts or by changing the dimensions of the parts. Changes to the positions of parts are constrained by the acceptable ranges of relative rotation (between that body part, and the body part about which it can rotate). A painter might begin with the lotus position ("Dhyana-asana"), subsequently select the deity's left arm and gesture, reposition the right arm to point towards the knee, and change the right gesture from the gesture of equipoise (pointing to the right) to the gesture of

earth touching (pointing vertically down to touch the lotus throne). In doing so, the painter transforms the lotus posture into the diamond posture ("Vajra-asana"). Thus the painter is gesturing over a prototype diagram, progressively varying the positions of a deity's parts (Fig. 9).

The modified posture diagram is matched against the dictionary of pre-defined diagrams by comparing its body parts with those of the diagrams in the dictionary (Fig. 10). The closest match identifies the deity, and a Layout Editor providing access to the video records for that deity is invoked. The cyclic process of manipulating diagrams, matching against deities, retrieving and viewing video segments, and manipulating diagrams, once again, is how the Thangka student navigates and browses through the Thangka database.

Interacting through diagrams has pedagogical value as a way of discovering the compositional essence of deities (Coomaraswamy 1977; Yanagi 1972). The diagrammatic language provides the student with a taste of the compositional flavor, as well as glimpses of the content. It aids in the understanding of the visual language of the varying hand gestures and postures. The student's diagrammatic strokes also can be recorded over time, and this historical sketch reveals the process of discovering the deities' characteristic postures.

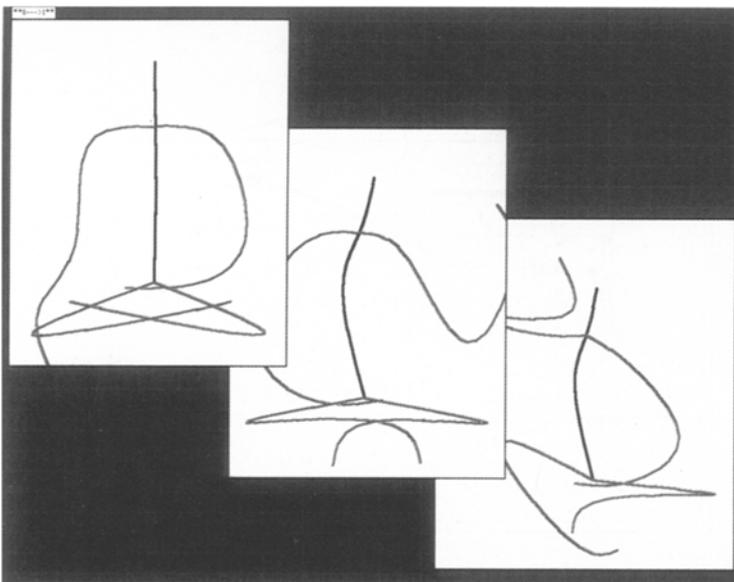


Fig. 9. Diagram Editors showing the student gesturally manipulating diagrams of deities

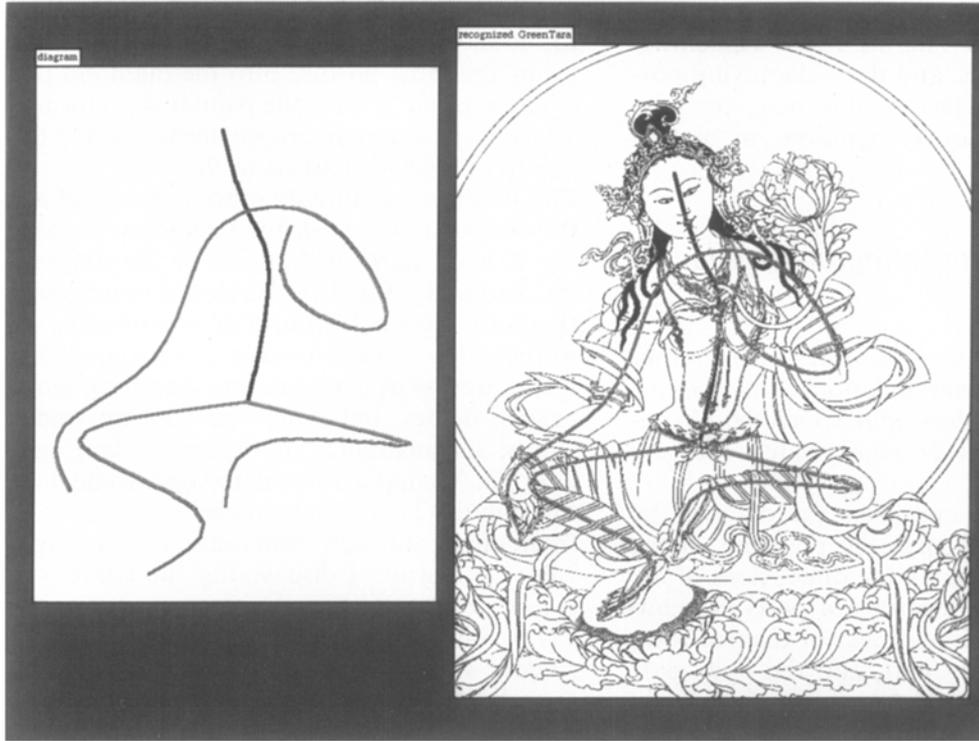


Fig. 10. Deity identification

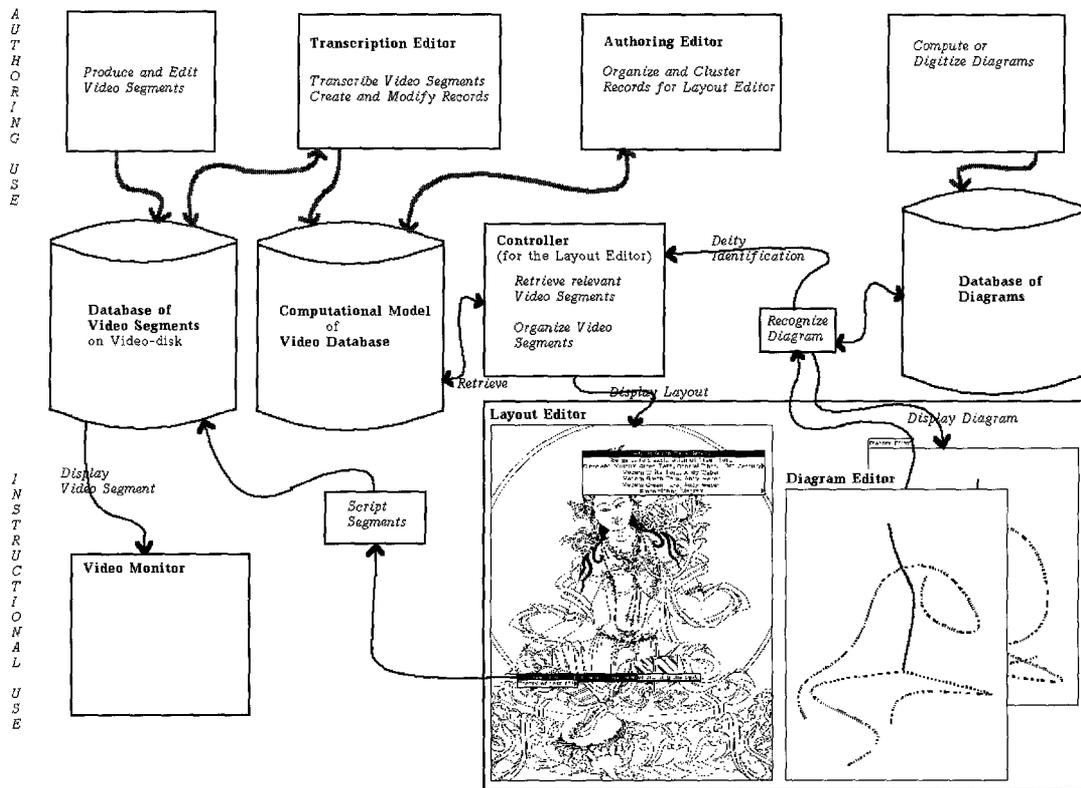


Fig. 11. Sketch book in authoring and instructional use

4.5 Implementation

Figure 11 illustrates the various activities involved in the construction of the sketch book. Basically the activities are in two modes: authoring of the database; and the instructional use of the database. The various authoring activities of the Thangka master are: recording and editing video segments, transcribing conversations and defining key words from the transcripts, constructing a computational model of the video records, clustering and connecting records for use by the Layout Editor, and constructing a dictionary of deity diagrams. In the instructional mode, the student painter manipulates the diagrams by gesturing in order to navigate the database. The resulting diagram is recognized by pattern matching with a dictionary of diagrams. A Layout Editor containing video records of deities for the identified deity is created, from which, the student selects and reviews video segments, or scripts video segments for replay.

5 Conclusion

We outlined our motivations for constructing the electronic sketch book. As scholars of design methodology, we wish to display our appreciation for the ingenuity and exquisite skills involved in the creation of Thangka painting; we wish to learn from the design of expressive craft media as we collaborate across design cultures. As researchers studying the use of electronic technologies, we would like to increase the awareness of the greater research community about preserving and disseminating the sense of process and craft and hence understand the potentials of electronic technology as supportive to deteriorating traditions.

We illustrated a prototype craft medium for documenting and disseminating Tibetan Thangka painting. The elements of the sketch book's database illustrate diverse views of the Thangka compositional process. The sketch book's user interface provides intimate connection to the database, deriving its character from Thangka iconography and visual language and expressing continuity from representations in traditional media to electronic media.

The rewards from engaging in this project are reflected in the words of Lewis Mumford (1934):

What we need, then, is the realization, that the creative life, in all its manifestations, is necessarily a social product. It grows with the aid of tradition and techniques maintained and transmitted by society... [even though] the addition to this heritage made by any individual or even by any generation is small in comparison with the accumulated resources of the past.

Indeed, our contribution will be small in comparison with the accumulated resources of the past. Nevertheless, we are inspired by the imagination and skill of Thangka craftsmen and hope that the practice of their craft will continue, as we move from the old tools to new.

Acknowledgements. This paper is extracted from: (1) Makkuni, R., *The Electronic Sketch Book of Tibetan Thangka Painting, A Project to Preserve and Disseminate Design Craft: Project Description and Motivations*, Xerox PARC report, 1987; and (2) Makkuni, R., *A Diagrammatic Interface to a Database of Thangka Imagery*, to appear in the Proceedings of the IFIP Conference on Visual Databases, Tokyo, 1989. The author wishes to thank Robert Stults and David Robson of Xerox PARC, and Terese Bartholomew and Rand Castile of the Asian Art Museum of San Francisco for supporting the project. Senge Lama provided the instructional materials for the Thangka database. In conceptualizing and developing the technology, the project benefited from discussions with Enrique Godreau, Steve Harrison, Axel Kramer, David Liebs, Randy Smith, Bob Stults, and Frank Zdybel. Karon Weber contributed her video production expertise. Figure 1 was provided by the Cleveland Museum of Art. The diagrams in Figs. 2 (drawn by Wandrak) and 5 (drawn by Robert Beer), are reproduced from Jackson, D., Jackson, J., *Tibetan Thangka Painting: Methods and Materials* (Copyright 1988, Snow Lion Publications, Ithaca). The rest of the Thangka illustrations in the paper were drawn by Senge Lama and his teacher, Gega Lama; they are provided courtesy of the Karma Sonam Gyamtso Ling, Belgium.

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