An Algorithm for Digital Authentication of Buddha Painting on Thangka

Abstract : **Pattern Recognition has developed itself into a mature engineering field with varied practical applications. This increased applicability leads to a direction of new research areas. An attempt has been made to apply pattern recognition technique in the field of feasibility study of digital authentication of the images of Buddha that appear on Thangka. Thangka or scroll depicting Buddha with his various supernatural attainments as believed is used for meditation and other methods for spiritual significance. The paper represents the methodology for digital authentication of the images of Buddha painted on Thangka. An iconometric analysis of images of Buddha reveals much more on religion and culture that have changed through ages. The research attempts to develop a prototype system that automatically divulges some religious inferences and authenticity of Buddha images. The prototype is expected to clear the difference between authentic and other images of Buddha that are not drawn according to the accepted authentic artistic norm of Thangka painting. The images of Buddha to be used are obtained from well-known authentic sources as prevalent in many monasteries of Sikkim.**

Buddhism has major presence in the Himalayan belt such as Sikkim, Ladakh, Arunachal Pradesh, Darjeeling in North Bengal and the Lahaul and Spiti areas of upper Himachal Pradesh from ancient historical period. Thangka is the spirit of Buddhism captured in a painting of well-defined specification of religious significance. For example, Tibetan Buddhist uses Thangka for various religious rituals and meditational practices[1]. Thangka, a Tibetan word, meaning "painted scroll", is painted on silk or cloth carrying the meaning of associated Mantras in its design. It is the important heritage of Tibetan folk over thousands of years. The contents of Thangka involve interesting and colorful stories related to the mythological events, personage, local conditions and customs, folklore, fairy tales, building layout, astronomy calendar, Tibetan medicine, Tibetan pharmacology and so on. Thangka is an important teaching tool depicting the life and teaching of the Buddha, various influential Lamas, other deities of protection and Bodhisattvas[2]. Traditionally, Thangka paintings are not only valued for their aesthetic beauty, but primarily for their use as aids in meditational practices. Practitioners use Thangka to develop a clear visualization of a particular deity, strengthening their concentration, and

forging a link between themselves and the deity for a specific spiritual attainment. Thangka paintings are the visual expression of the fully awakened state of enlightenment, which is the ultimate goal of the Buddhist spiritual path. For this reason, Thangka is sometimes called as 'the roadmap to enlightenment'[2].

Though the present study concentrates on authentication mechanism based on pattern analysis, there is varied applicability as indicated in the studies related to images of Buddha that appear on Thangka. Some of the studies are related to authenticated sculpture reconstruction of Bahmiyan Buddha, Afghanistan[3], others are related to pattern analysis of various artifacts of Buddhism such as lotus, VajraMukut[4-9] and recognition of various mudras and their corresponding deities[10-11].

To sketch the figures in a Thangka, the painter needs the knowledge of the exact measurements and proportions of each deity as established by the Buddhist iconography and artistic practice as per norms developed over the ages in various regions overlapping different historical periods[2]. The student who paints Thangka is required first to construct a grid of exactly positioned lines (thig khang) to draw within it the sacred figure of deity observing certain rules of proportions.

A grid containing these proportions is essential to establish the continuity of development and correct depiction of the figures on Thangka. Buddha images are to be constructed according to fixed measurements, which correspond to ideal physical proportions of an enlightened being and represent cosmic harmony between various spiritual beings.

The canonical rules of Buddhist art also govern the characteristics of a Buddha image that uniquely identify the figure as a Buddha (an enlightened one). These include the eight-spoked (Ashtachakra) wheel on the foot or palm, exaggerated earlobes, and, especially, the so-called "enlightenment-elevation" on the top of the head. This last feature is described in ancient texts as symbol which emerges out of the head of an enlightened saint and is the visible symbol of the spiritual generative power that strives towards heaven and passes into the spiritual sphere of cosmic world. Thus, Thangka has become an important manifestation for research in the world of image processing whereby images divulge different messages to match different Mantras and Mudras in an authenticated manner.

Iconometric Theory for Sketching Individual Figure : Tibetan authorities on sacred art generally divided the deities of the pantheon into less than a dozen iconometric classes. The basic system of iconometry that was accepted by them consists of six main classes of proportions, five for deities and one for humans[12].

A. Units of Measurement : The Tibetan Buddhist practitioners use two main units of measurement: small units (cha chung) and large units (cha chen). There are always twelve small units to every large unit for the classes considered in the paper. They are merely used to indicate the proportional relationships between various parts within each sacred image. The small unit is commonly referred as *sor.* The main proportional classes according to height are:

- Buddhas -125 *sor.*

- Peaceful Bodhisattvas – 120 *sor.*

- Goddesses – 108 *sor.*

- Tall wrathful figure such as Bodhisattva Vajrapani – 96 *sor.*

- Short wrathful figures – 72 *sor.*

- Humans – 96 *sor.*

In the first three classes, the height of the figure is equal to the arm span, and the measure of the upper half of the body equals to that of the lower half. But in the case of the wrathful figures and humans such balanced proportions are not necessarily present to the same extent. The proportion of the standing Buddha, for example as follows:

Vertical measures

Head protuberance (usnisa)	4
Top of skull to hair line	4½
Hair line to urna	4
Urna to tip of nose	4
Tip of nose to chin	4½
Neck	4
chest	12½
Stomach	12½
Lower abdomen	12½
Hips	4
Thighs	25
Knees	4
Calves	25
Feet	4½

Horizontal measures (one side of the body including extended arm)

Spine to armpit	12½
Armpit to elbow	20
Elbow joint	1
Forearm	16
Wrist	1
Hand	12
One side	62½
Full arm span	125 *sor*

The proportion of the grid for seated Buddha as follows:

Intervals between horizontal lines:

Crest jewel	2
Head protuberance (usnisa)	4
Top of skull to hair line	4½
Face	12½
Neck	4
Chest	12½
Stomach	12½
Side of hip	4½
Thighs to pubic zone	8
Junction of crossed legs	4
Lower extension of Knees	4
Lunar disc seat	6
Lotus seat	12

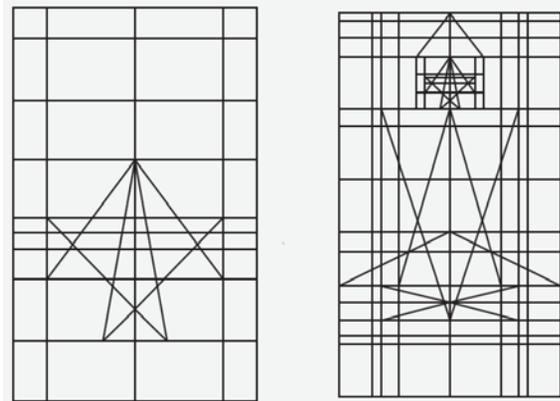The proportion mentioned above is used to construct the following grid structures:

Fig 1: Grid Structure of face of Buddha

Fig 2: Grid Structure of seated Buddha

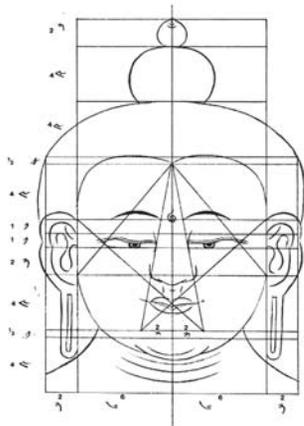The corresponding sketches of Buddha as per the grid structure are as follows:

Fig 3: Face of Buddha   **Fig 4:** Seated Buddha

Detection of Authentic Buddha Images : In the light of above iconometric analysis, an algorithm is developed to analyze and authenticate the image of Buddha.

The proposed algorithm is divided into the following three steps:

1. Grid mapping algorithm

2. Authenticity determination

3. Testing Criteria for test cases.

In the last step the result is obtained for verifying authenticity.

Proposed Methodology for detection of Authentic Image : The technique is to map the grid of same ratio into Buddha images and check for various parts of the body in the image other than the worldly accessories such as Vjra Mukut in case of Vajrayana Buddha images. So, this methodology is carried out in the following steps:

- *Measurement:* The measurements of various parts of the body considered are as per the input image from certain pre-determined points[3]. The measurement must follow the criteria of ratio between various portions in a precise manner.

The database of ratio considered for authenticity is presented in Table 1

TABLE 1

	Fig 1	Fig 2
Ratio	2 : 4 : 4 : 4 : 1 : 1 : 2 : 4 : 4	2 : 4 : 4½ : 12½ : 4 : 12½ : 12½ : 4½ : 8 : 4 : 4 : 6 : 12

- *Line drawing:* Grids mentioned in Fig 1 and Fig 2 are drawn using the above measurements. Thus, grid drawing is nothing but the depiction of ratio of body proportions in geometric mesh of non-uniform section as outlined in authentic Buddha image input.

- *Creation of Database:* A database has been created using the following authentic images of Buddha taken from the Internet and other sources from monastery.
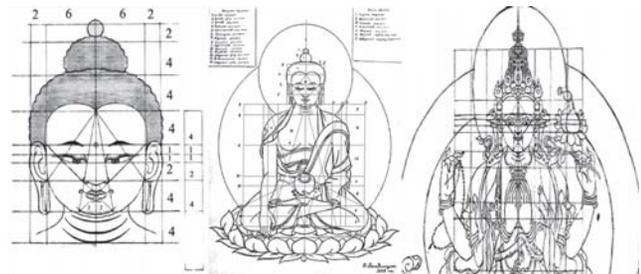

Fig 5   **Fig 6**   **Fig 7**

The authenticity database is presented in Table 2.

TABLE 2 : Iconometric Proportions of the authentic images stored in the database

	Fig 5	Fig 6	Fig 7
Ratio	2 : 4 : 4 : 4 : 1 : 1 : 2 : 4 : 4	2 : 4 : 4 : 4 : 1 : 1 : 2 : 4 : 4	9 : 2 : 1 : 1 : 2 : 4 : 3

Proposed *Grid mapping algorithm* for authenticity follows the following steps:

- Grid proportion is to be determined with a unit of measurement.

- Label all the intersections of grid lines with alphabets.

- Calculate the actual measurements of all the line segment in the grid.

- Calculate the ratio of all the lines with end points intersecting the Grid line.

- Same Grid is mapped on the test image and the ratios are calculated.

- Compare the ratios of the test image with the authentic sample image.

- If the ratios are more or less equivalent (± 10 %), the images satisfy the authentication criteria, if not, they are not authentic.

Test Case: The following two test images are considered for checking the authenticity as per authenticity
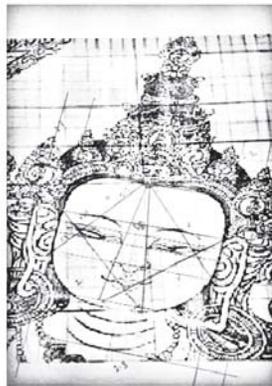
Fig 8   **Fig 9**

criteria presented above.

The result obtained are presented in the Table 3

TABLE 3 : Iconometric proportions of the test images

	Fig 8	Fig 9
Ratio	9 : 10 : 9 : 15 : 3 : 4 :7 : 14 : 12	4 : 1 : 1 : 2 : 4: 3

It is found that Fig 7 does not satisfy the authentication criteria, as there is large variation in the ratio of the authentic sample. Fig 8 is considered as authentic image as the variation is within the permissible limit.

Working Plan of The Prototype Development : A computational model will be generated for authenticating the paintings and sketch images of Buddha from digital scan of original image. The database used in this model contains a set of authenticated images against which a new image is compared for pattern analysis.

Limitations of The Study : The research study was undertaken with a focus towards a methodology for detection of authenticated patterns in Buddhist Iconography that has been standardized by ages of spiritual and research study in religion or 'Dhamma'.

The purpose is to some extent achieved, though not fully. The research-working plan reveals that

● Authentication of patterns such as Buddhist images and sketches can only be performed when standardization had been fixed by a particular school of painting (e.g Thangka painting). Even that was not enough, standardization varies from school to school, painter to painter, period to period, sect to sect, country to country and Yna to Yna.

● The claim of detection of authentic iconographic pattern is largely limited due to such variation of standardization.

● The larger the database, variations are more. The research study,therefore, confined to a narrow strip of Tibetan Thangka Painting of one master painter and his disciples. The focus on fully automated detection is far cry. However, an semi-automated decision support system to be used by archeaological surveyers, historians, Museum visitors etc is envisaged to be obtained from the present work plan.

The pattern recognition algorithms designed and developed are capable of producing detectable information in binary i.e whether the pattern satisfies the standard features or not. It is technically difficult to design learning mechanism of detection with ever increasing guideline of standards; especially when one guideline comes in conflict with another while incorporating the same.

Such limitations may be considered in depth while researching or generating authentic patterns and may be used in artificial learning mechanism in order to reduce false positives and false negatives.

Conclusion : The study concludes successfully on the authenticity of Buddha images based on the assumption of some practiceoriented grid used for Buddhist Thangka painting by various schools of Buddhist. One such practice has been followed in this paper to showcase the applicability of the algorithm. The algorithm can be implemented for digital authentication of Buddha images after extracting the image and mapping against authentic grid. The success or failure of mapping within threshold will ascertain the result on authenticity of Buddha image testing the prototype. The paper redefines the criteria of authentic Buddha images with mathematical precision and religious significance attached to authentic Buddha images. The proposed study is being continued and is expected to produce outcome capable of derivation of results contributing to scientific analysis of historical data. The system can be extended to include other set of data to draw important inferences. In future, this work may also be extended to the detection and classification of emotions present in the images of Buddha from Hasta Mudra. The results of detection methodologies are left for further improvement and testing. This research may be used as a Decision Support System for Museology and Archaeological studies. The proposed algorithms and techniques suggested are likely to be applied for real life experience in the artifact and sculpture of recently excavated Buddhist Monastery at Moghulmari, West Midnapur in West Bengal (as reported by Alakh

Mukhopadhaya[13]) to determine the school of painting and sculpture according to the normative features.

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