The Iconometrical Perspective of the early Cōla Images

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ABSTRACT
Iconometry is the study of an icon or image of god/goddess or human being with reference to the measurements of the parts of the icons or images. The original works dealing with sculpture are *Kāśyapa Śilpam* and *Mānasam*. Both these works deal with very branch of *Śilpa*. The texts of *Agastya, Kāśyapa* and *Viśwakarma* are followed in carving sculptures in south India. These works describe in detail, the various systems and the material to be used for carving different god/goddess icons. The point to point measurement can be taken for the whole icon from head to toe by defining different parts of the body. This paper delineates the definition of several systems described in the *Śāstra* and the least square difference between the actual measurements of the icons and the calculated measure with respect to each system taken into consideration for the study. A random sample of the icons of the early *Cōla* period is collected and clusters are formed based on their classification of the *tālamāna* system.

General Terms
Image analysis, Information Processing

Keywords
Iconometry, *Tālamāna* system,.

1. INTRODUCTION
Iconometry is the study of an icon of god/goddess or human being with reference to the measurements of the parts of the icons. Iconometry is a science that deals with the measurements of the images that may differ from region to region and period to period in the Indian context. It helps to identify the *tālamāna* system used for an image that is different from Gupta to *Pandya* and *Cōla*. The details regarding measurements of the *anga* "parts" (e.g. the length of nose, the breadth and width of eyes and so on) are laid down in the *śilpaśāstra* and *āgama*. The original works dealing with sculpture are *Kāśyapa Śilpam*[1] and *Mānasam*. Both these works deal with very branch of *Śilpa*. Especially in South India the works of *Agastya, Kāśyapa* and *Viśwakarma* are followed in carving sculpture. In *Agastya Sakalādhikāra*[2] eleven ways are specified by which the height of an image can be determined. Sri. GANAPATHI STHAPATHI [3] in his book "Sirpa Chennool", has written the significance and elegance of making the icons using different materials and methods. This serves as the proper text book and guide for the artisans and students.

2. RELATED WORKS
A study of iconometric measurements will generally prove useful in dating sculptures, in restoration work, in checking whether any of the known canons of iconometry were followed by the sculptors, and for hypothesizing about the number of sculptors who executed the work, as GURALNICK.E[4] did in her pioneering application of statistical and computer methods to the study of Greek Iconometry. JOHN F. MOSTELLER [5] has surveyed the contributions made in Indian Iconometry during a period of 1900-1945. In an earlier study of iconometry, by SIROMONEY.G, [6] *et al*., point-to-point distances were measured and an analysis was done using multivariate analysis of the data for the carvings in the *Kailasanatha* Temple. Early *Pandya* Iconometry has been studied by GOPALAKRISHNAN.S, [7] using hierarchical clustering and correlation analysis. In another work SIROMONEY.G, [8] investigated the *tālamāna* system on Pallava Sculptures at Mamallapuram. JOHN F. MOSTELLER [9] has published a report on the development and application of a quantitative approach for the study of Indian art utilizing imaging technology. A project on Iconometry and Icon Makers has been executed by THANGAVELU. S [10] has detailed about the methods of carving the sculptures in his project report. C.N. RAVI KUMAR and MANIMALA. S [11] proposed a method constructing human middle finger from its fractional part using *tālamāna* system.

3. TĀLAMĀNA SYSTEM
Canons of iconometry follow the ancient "*Tālamāna*" system in which the basic units are the a*ṅ*gula and the *tāla*, and the latter stands for the length of the palm. The *aṅgula* is either a fixed length or a proportion. A span can be defined in many ways namely *Mulaberanglam*[1], *Mananglam*[2] *or Matharangulam*[3]. A *tāla* or span is defined to be 12 *aṅgulas* in the texts and an *aṅgula* is approximately equivalent to 3/4th of present day inch in use. *Aṅgula* may be defined as proportionate measure and fixed measure. The measurement of *aṅgula* is divided into 8 *yavas*. The measurement of the features of an image is of four types, namely (1)length (2) breadth (3) width (4) dealing with interspaces. According to the Indian iconometry system, a sculpture could be made according to one of the ten main types of proportions. Each type is further sub-divided into three sub-types. For each sculpture of a god/goddess' a standard height is defined and based on the standard height the measurement of other parts of the body are described. The heights are standard with due reference to each god/goddess and classified into ten[4] main measurement of heights from 1 to 10 *tālas*. Out of these ten measures if 4 *aṅgulas* are added from *Tritāla* to *Dasatāla*

[1] The height of the *Mulasathanam* should be considered to find the measure of an *aṅgula.*
[2] *Yava* is a special variety of wheat grain/ 1/8th of an *angula* is *yava*. *Sali* is a paddy grain. The size of these grains should be considered to determine the *aṅgula* measure.
[3] The length of the palm of the *Yajamana* or the length or width of the middle part of the middle finger of the *yajamana* can be used for determining the *angula.*
[4] *Eka, Dvi, Tri, Cadur, Panca, Shad, Sapta, Ashta, Nava, Dasa.*

then it is called *Uttama*; and if 4 *aṅgulas* are subtracted then it is called *Adhama*, otherwise it is known as *Madhyama*. The classification of a *tālamāna* system for carving different god/goddess is specified in *Kāśyapa Śāstram*. For the study, the last three systems are taken into consideration with their sub-divisions.

3.1 Types of Tālamāna System

The classification of images into different *Tālamana* system from 1 to 10 *tāla*s is detailed below. (See Table 1).

Table 1 Tālamāna System

No	Tālamāna	Images
1.	*Uttamadasa*	Brahma, Visnu, Maheswara
2.	*Madhyamadasa*	Uma, Saraswati,Usha devi, Bhudevi, Durga, Lakshmi, Sapta Mata, Jyeshta devi
3.	*Adhamadasa*	Candran, Suryan, Asvini Deva's, Maharisi's, Navagraha, Ayyanar, Shanmugan, Candikeswarar, Kshetrabalakas (Bhairava)
4.	*Uttamanava*	Ashta Murti's, Vidhyadhiba's, Lokabala's, other Deva's
5.	*Madhyamanava*	Yaksha's, Apsara's, Asthra murty, mruthgana's
6.	*Adhamanava (Kanishta)*	Asura, siddha,Gandharva,Pithrukal
7.	*Ashta*	Sathiyar (Human Being)
8.	*Sapta*	Pisasanga
9.	*Shad*	Kupjakar
10.	*Panca*	Vigneswara
11.	*Madhyama Panca*	Bhuda ganas
12.	*Chadur*	Balabera
13.	*Tri*	Kinnaras
14.	*Dhvi*	Kimpurusha
15.	*Eka*	Kurmam

4. DATABASE DESCRIPTION

The sculptures of the early *Cōla* period are taken as the database for the study. The icons under study are all in the standing position. A random sample of the early *Cōla* icons is collected from the Tanjore Art Gallery, Government Museum, Chennai and also from the temples in and around Tanjore. The height of the icons and the linear measure of the parts are obtained in centimeter. Table 2 represents the variable description for the parts of the icon. There are 13 independent variables representing the parts of the icons and 1 dependent variable representing the height of the icon (sum of the measurements of the parts of the icon). The measurements are point to point and linear (length) in nature and their volumetric measures are not taken. As the structure of the parts is not regular in shape (cannot be mapped to any geometrical shape) there is no appropriate measuring tool to measure them exactly. The parts are mostly measured using vernier caliper or using the traditional system of threads.

Table 2 Variable Description

No	Variable Name	Description
1.	**TUFT**	The Length of the Tuft
2.	**FHLN**	Hairline on forehead to root of the eyebrows
3.	**EBEL**	Root of the eyebrows to eye lashes
4.	**NOLN**	Nose length
5.	**NCLN**	From end of nose to lower part of the chin
6.	**NELN**	From the end of the chin to bottom of the Adam's apple
7.	**NCHN**	From the bottom of Adam's apple to chest little below of nipples
8.	**CHNN**	From chest to centre of navel
9.	**NGLN**	Centre of navel to root of penis
10.	**THLN**	From root of penis to top of knee
11.	**KNLN**	Top to bottom of knee
12.	**CALN**	Bottom of knee to top of ankle
13.	**FOLN**	Top of ankle to root of foot
14.	**TOHT**	The total height from tuft to foot

Apart from the above described measurements the width of the shoulder, width of hip and the pointing finger length are also measured for investigation and to check whether any interesting results could be obtained during the analysis.

Table 3 System Description

S.No	Tālamāna System	System Number
1	*UttamadasaTāla*	**1**
2	*MadhyamadasaTāla*	**2**
3	*AdhamadasaTāla*	**3**
4	*UttamanavaTāla*	**4**
5	*MadhyamanavaTāla*	**5**
6	*AdhamanavaTāla*	**6**
7	*AshtaTāla*	**7**

5. ALGORITHM

5.1 Least Square Method

Let n be the number of variables defined which represent different measures of the parts of the image and m be the number of systems under study. Let x_i i= 1, 2,…,n be the actual measurements taken for the sample icons. Let y_{ij} be the corresponding calculated measurements for the i^{th} icon under the j^{th} system where i=1,2,…,n and j =1,2,…,m. Let d_j be the squared difference calculated with respect to each measurement of the parts of the body of the sample image for the j^{th} system. Let there be m clusters

$$d_j = \sum_{i=1}^{n} (y_{ij} - x_i)^2 ; i = 1, 2,\ldots,n ; j = 1,2,\ldots m \quad (4.1)$$

$$d = \min(d_j) \; ; j = 1,2,\ldots,m \quad (4.2)$$

Step 1

Let x_i be the actual measurements taken for each of the sample images for all the variables defined in Table.

Step 2

Let y_{ij} be the i^{th} variable measurement calculated based on the j^{th} system proportions. For every sample there will be m set of system based measurements.

Step 3

For each sample, using the formula (4.1) the squared difference is calculated between the actual measurements and the calculated system measurements d_j for j = 1,2,…,m.

Step 4

The minimum of d_j is obtained using the formula (4.2) for j = 1,2,…,m.

Step 5

The sample image is grouped into one of the m clusters depending on the value of d.

Step 6

The algorithm forms m clusters of images. No two clusters will have the same image. The total number of images in all the clusters will be equivalent to the number of sample images considered for clustering.

5.2 Implementation of The Algorithm

The calculation for two of the samples collected is shown in Table 4 (Sample No: 31 *Mahaviśnu*) and in Table 5 (Sample No:16 *Siva*. Column M shows the actual measurement taken from the icon and column C shows the calculated measurement. The measurements of different parts of the icon specified in Table 2 under the *tālamāna* systems described in Table 3 are shown.

In the present study, m is seven and the n value is thirteen. The result of the algorithm will yield seven mutually exclusive clusters. In our calculation the proportionate measure of *aṅgula* is used as described in the *sastra* instead of the fixed measure. The *aṅgula* measure is calculated by dividing the total height of the icon with the number of parts defined under each system. For example, under *Uttamadasatāla* there are 124 parts. Hence the total height of the Sample No.31 *Mahaviśnu* 164 cm is divided by 124 to get the proportionate *aṅgula* measure. The calculation based on the proposed algorithm is shown only for two images for reference.

From this analysis, the calculated proportional length of the parts described in Table 2 differs from the prescribed proportion. But when the overall proportion of the face, upper part, lower part and the feet of the icon are considered the calculated proportional length is equal to the actual measurement allowing a 2 to 5 percent of permissible error. For example the face length is divided in to 3 parts. The calculated length of the individual parts is not equal to the actual measurement. Instead if the face length is taken as a whole, then the In the same manner, if the length of the leg is taken as whole the calculated and actual measurements are equal. Hence the study gives the inference that there must be some deviation done by the artisans from the original proportions given in the *Śāstra* to the present day proportions from time to time. The future study aims to find out the reasoning behind this variation.

M-Actual Measurement **C**- Calculated measurement

Table 4 Calculation for Sample No: 31 *Mahaviśnu*

		C	M	C	M	C	M	C	M	C	M	C	M	C
System		**1**		**2**		**3**		**4**		**5**		**6**		**7**
TOHT		164.00	164.00	164.00	164.00	164.00	164.00	164.00	164.00	164.00	164.00	164.00	164.00	164.00
Face Length		17.99	17.00	18.38	17.00	18.30	17.00	18.22	17.00	18.29	17.00	18.36	17.00	18.27
Angula		1.37		1.41		1.46		1.52		1.57		1.63		1.70
EBEL		6.00	5.00	6.72	5.00	6.59	5.00	6.07	5.00	6.10	5.00	6.12	5.00	6.09
NOLN		6.00	9.50	6.36	9.50	5.86	9.50	6.07	9.50	6.10	9.50	6.12	9.50	6.09
NCLN		6.00	5.50	5.30	5.50	5.86	5.50	6.07	5.50	6.10	5.50	6.12	5.50	6.09
NELN		6.00	10.50	5.66	10.50	5.86	10.50	6.07	10.50	5.90	10.50	6.53	10.50	5.95
NCHN		18.34	18.00	18.38	18.00	18.30	18.00	18.22	18.00	18.29	18.00	18.36	18.00	18.27

FOLN	CALN	KNLN	THLN	NGLN	CHNN	NCHN
3.9	26.29	3.9	26.29	13.03	13.03	13.03
7	21	8.5	29	13.5	14.5	12.5
4.02	26.11	4.02	26.11	13.06	13.06	13.06
7	21	8.5	29	13.5	14.5	12.5
4.16	26	4.16	26	13	13	13
7	21	8.5	29	13.5	14.5	12.5
4.31	25.89	4.31	25.89	12.94	12.94	12.94
7	21	8.5	29	13.5	14.5	12.5
4.19	25.98	4.19	25.98	12.99	12.99	12.99
7	21	8.5	29	13.5	14.5	12.5
4.06	25.5	4.64	25.5	13.04	13.04	13.04
7	21	8.5	29	13.5	14.5	12.5
4.23	25.96	4.23	25.96	12.98	12.98	12.98

FOLN	CALN	KNL N	THLN	NGLN	CHNN
5.48	37.02	5.48	37.02	18.34	18.34
6.50	36.50	7.50	41.50	20.50	21.00
5.66	36.76	5.66	36.76	18.38	18.38
6.50	36.50	7.50	41.50	20.50	21.00
5.86	36.61	5.86	36.61	18.30	18.30
6.50	36.50	7.50	41.50	20.50	21.00
6.07	36.44	6.07	36.44	18.22	18.22
6.50	36.50	7.50	41.50	20.50	21.00
5.90	36.58	5.90	36.58	18.29	18.29
6.50	36.50	7.50	41.50	20.50	21.00
5.71	35.90	6.53	35.90	18.36	18.36
6.50	36.50	7.50	41.50	20.50	21.00
5.95	36.54	5.95	36.54	18.27	18.27

Table 5 Calculation of Sample No:16 *Siva*

NELN	NCLN	NOLN	EBEL	Angula	Face Length	TOHT	System	
4.26	4.26	4.26	4.26	0.97	12.78	116.5	**1**	C
9	5	7	3.5		13.5	116.5		M
4.02	3.77	4.52	4.77	1	13.06	116.5	**2**	C
9	5	7	3.5		13.5	116.5		M
4.16	4.16	4.16	4.68	1.04	13	116.5	**3**	C
9	5	7	3.5		13.5	116.5		M
4.31	4.31	4.31	4.31	1.08	12.94	116.5	**4**	C
9	5	7	3.5		13.5	116.5		M
4.19	4.33	4.33	4.33	1.12	12.99	116.5	**5**	C
9	5	7	3.5		13.5	116.5		M
4.64	4.35	4.35	4.35	1.16	13.04	116.5	**6**	C
9	5	7	3.5		13.5	116.5		M
4.23	4.33	4.33	4.33	1.21	12.98	116.5	**7**	C

6. CONCLUSION

In the above study, we conclude that the iconometry is very helpful in investigating the *tālamāna* system which used to carve a particular icon, of the period and the place of its origin using the Least Square Difference Method. The Least Square Difference Method sounds to be promising and easy to calculate as it does not include complicated calculations. Further, any icon from Gupta, *Pallava*, *Cōla* may be classified to one of the *tālamāna* systems, which results in the application of data mining of the image database. Thus, the clusters formed will be useful in image retrieval using iconometry particularly for the digital images of the sculptures. As iconometry is proved to be a powerful tool in investigating the icons using their measurements, restoring the damaged icons into their original form would be easy, which depicts the significance of our rich culture.

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