

Final report: Pose analysis on the flying Apsaras in the Mogao Caves from Liang to Tang dynasty

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Abstract—The goal of this project is to study the artistic characteristics appearing on the flying Apsaras represented on the walls of the Mogao caves in Dunhuang 敦煌市 (Gansu - China). This study aims to answer the following question: *How did the role as messenger of the Nikai in Greek iconography, and its associated poses, influence the Feitian Apsaras from fifth to tenth century in Dunhuang grottoes?*

I. INTRODUCTION

Paintings and art in general are often analyzed on their influence on each other. It is difficult to quantify similarity and influence and to find a way to operationalise qualitative analysis and observations. It is even more difficult, when the influence of one artistic style on another takes decades or even centuries to reach it. This is the case for the Apsaras in the Mogao caves in north-western China.

A. The caves of Mogao

The caves of Mogao are located near to the oasis city of Dunhuang in north-western China. They are carved into a cliff face along the Daquan river and are home to one of the world's most important sites of Buddhist art. Situated along the ancient Silk Road, by the late fourth century Dunhuang developed into an important stopover just before - or after- the most strenuous stages of the journey linking China with the West. Three sites for Buddhist shrines would develop during this time, as travelers and traders prayed for safe passage. Not only material goods were exchanged along the Silk Road, but also ideas, artistic styles and religious beliefs traveled along with the merchants.

The cliffs of Mogao, less than a day's journey from Dunhuang, are almost 2 kilometers long and the first caves were dug there in the late fourth century by wandering monks. More than a thousand caves were carved into the cliff face in the following millennium, and they became known as Qianfodong, or Caves of the Thousand Buddhas. Around 500 of them were decorated and used as temple shrines. The others were used as living quarters for monks. After three centuries of division China was reunited in 581, and the new regime officially sanctioned Buddhism and sent an envoy to commission a new cave.

In the interior, flying celestial beings called "Apsaras"

decorate the walls, sculptures of Buddha sit at the center of the chambers and the ceilings are painted with geometric panels. Originally intended as meditation cells, the caves later fulfilled also other purposes. Visitors came to worship or to meditate, others came to gain karmic merit by sponsoring a cave or to make offerings. Many of the paintings depicted historical events centuries after they took place and combined facts with legend, while others show events of daily life.

Buddhist art arrived in China accompanying the religion from India across central Asia. By the first century latest, Buddhism reached China, and the images that came with it were small and portable. Making images of Buddha or copying the sutras was an act of devotion, performed by clergy and laymen alike. The images could be very large but also small, as the ones covering large portions of the walls in the Mogao caves. The karmic merit of making an image was thus accessible to the poor, as well as the rich believers. [1]

Due to the fact that Mogao Grottoes contain Buddhist, Taoist and Chinese mythological artworks, as well as influences from Central Asia, the Middle East and Europe, we focus on the influences specifically from Greek culture. We can observe this connection from the caves built in Tang Dynasty. In the Mogao Cave 144, one part of the mural painting depicts that the Bodhisattva wears a crown and sits on the five horses in the sun. While Zeus's son Apollo, the god of sun and light, drives a chariot driven by fiery horses across the sky, whose imagery is similar to the Bodhisattva (see the figure 1 below). In the Mogao Cave 25, another immortal in Buddhism Kalavinka is depicted as a creature having a human head and a bird's torso. Both Kalavinka's appearance and its state of playing the instrument are closely related to the imagery of Siren (see figure 1 below).[2]

B. Research Question

In this project, we make an attempt to find similarities in pose between the iconography of Nike in Greek art and the Feitian Apsaras in the Mogao caves in Dunhuang, China. We base our analysis on secondary literature and a dataset of images of the Apsaras, that were all



Figure 1: Bodhisattva (left) and Kalavinka (right)

annotated by hand. Toward this goal, we shall try to answer the following research question:

How did the role as messenger of the Nikai in Greek iconography, and its associated poses, influence the Feitian Apsaras from fifth to tenth century in Dunhuang grottoes?

II. SECONDARY LITERATURE AND CONTEXT ANALYSIS

In this section, we shall put emphasis on the arguments presented by the multiple references that gave sense to our research question in the first place. It is not meant as a full historiography, but rather as a description of the takes on which relies the numerical analysis of the dataset.

A. The artistic stages of Feitian

In the infancy stage (421-556), the Northern Liang, Northern Wei, and Western Wei dynasties are the periods when Buddhist art spread eastward via the Hexi Corridor. They are also the periods when Dunhuang mural paintings were created and changed abruptly. The art of flying Apsaras is a fusion of Western and Eastern Buddhist culture, as well as Chinese mythology. For the Western style of flying Apsaras we know that they have bald heads, deep eyes, big noses and ears, and they wear shawls or surplices. In the Eastern style of flying Apsaras they wear hair buns, loose robes and belts, and are slender in shape. The mythical ‘Feather Man’ style of flying Apsaras is composed of legendary immortals who have long ears, wings and half-naked bodies covered with feathers.[3, p. 17]

In the creative stage (557-618), although the Northern Zhou and Sui are short-lived dynasties, they possess the most imaginative and artistic flying Apsaras which have completely got rid of the influence of Western painting style and replaced it with Eastern design and technique. Since the Sui dynasty, the flying Apsaras have been depicted as charming and beautiful maidens or elegant noblewomen, with obvious female characteristics. With

the society becoming more open and secularised at that time, the imagery of bare breasted and barefoot flying Apsaras gradually formed.[3, p. 89]



Figure 2: Flying Apsaras in Tang dynasty of Gongbi style

In the mature stage (619-959), the Tang dynasty, which dominated China for nearly three hundred years, and is also the heyday of Buddhism. In the late Tang dynasty, it is the period when Tubo ruled Dunhuang. Tibetan and traditional Chinese Buddhism integrated and developed because of the active support and advocacy of the emperor Songzan Ganbu. The artistic style of flying Apsaras from the Tang dynasty to the Five Dynasties entered a phase of maturity, stereotyping, and tended to become programmatic. The flying Apsaras act as foils in the Sutra illustrations, painted in the exquisite Gongbi style. The brushstrokes are highly detailed and washes of colours and inks are added layer by layer to precisely depict court ladies as representations of flying Apsaras.[3, p. 155]

B. From Nike to Feitian

Greek iconography came to Asia with Alexander the Great’s territorial expansion through military conquest. He appears posing as Zeus with a flying Victory overhead on Greek-type coinage minted in Babylon around 332 BC. [4, p. 57]

Gandharan art is a Buddhist visual style, that developed in northwestern Pakistan and eastern Afghanistan. There are elements of foreign influence which are believed to have Greek and Roman origins.

Some of the Buddhist figures seem to be based on prototypes from the Graeco-Roman mythology. There are examples of Apsaras in Gandharan art, that have their origins in Greek iconography and are called



Figure 3: Porus Medallion (BM reg. no. 1926,0402.1); silver; Babylon, Iraq (?), local mint; ca. 324-321 BCE. [Image courtesy of the Trustees of the British Museum, London]

Nike-Apsaras. [5, p. 234] The first mention of Apsaras is in the context of the Sunga dynasty (185-75 BC) in now northern India, where they appear in a relief hovering above and taking the form of a Greek Nike/Victory (see figure 4 below). [4, p. 133]



Figure 4: Nike-Apsaras in Gandharan art, Shunga dynasty, early 2nd century BCE

There are accounts also of connections between China and people who had already adopted Greek iconography, after Alexander the Great's conquests in Asia. Russian archaeologists excavated a burial site at Tillya Tepe, which gave brilliant records of a once nomad people, with connections both to China and to the Greeks. [4, p. 110] One of the women found in the burial site, was 'richly decked out with golden objects of Greek inspiration, perfume flasks from the Mediterranean, as well as a Chinese mirror'. [4, p. 111]

The most spectacular of the jewellery features images of Dionysus and Ariadne, crowned by Nike.

C. Nike, goddess of Victory

To study the proximity between the Apsaras and the Greek goddess of Victory, we first study Nike herself. She is one of the pre-olympian deities, being very close to Zeus¹. The main point to remember from the semiotic features of Nike is her role as a messenger. She is not only a personification of victory in battle, she is most importantly the figure that brings the message of victory to leaders as well as soldiers. This brings forward the problem of differentiation of the messenger deities in Greek mythology: multiple winged women bearing a caduceus can be candidates to the symbol of the messenger. This, in turn, makes the identification of such a deity more complicated. That problem is discussed in [6], to study the differences between Nike, Iris², and Eos³. Its conclusion states that with the exception of some vases in which we find annotations stating the name of the deity, it is difficult to state with certainty which deity is represented on a given support. This major confusion between multiple woman deities, as well as the presence of multiple other deities represented as messengers⁴, are both hindrances to any attempts to link the Apsaras and Nike visually.

Our choice regarding this problem was to focus mainly on the role of Nike as a messenger, rather than her role as an allegory of Victory. This means precisely that we are looking for features on Nike that could also possibly be significantly present in Hermes, Eos, and Iris semiotics at the same time.

D. Two main symbolic features of Nike: the Knielauf and a raised arm

The first positional symbolic feature of Nike that we found existed in multiple cases is the *Knielauf*, a position consisting of one bent leg, moving forward, with a straight body rushing in the direction of the bent knee. According to [7, p.135], this position is unlike the pose she has while landing, which may be somehow visually different because the legs look straighter. But this position is discussed further as a symbol of speed in [8, p.141]:

¹When Zeus fights his father, she is said by the Greek poet Nonnos to be the first to answer his call.

²Iris is studied as a major symbol of winged messenger, who is very similar to Nike.

³Eos is the deity who brought Ganymede to Zeus, this deity is also strongly linked to the concept of bringing a message (and is represented as a winged woman as well).

⁴cf. Hermes, who also bears the caduceus as Nike sometimes does.

"All [her divine features], in turn, make the function of [...] Nike crystal clear, and also explain [the] otherwise curiously old-fashioned 'pinwheel' or Knielauf pose"

The function of Nike evoked in this citation is precisely the messenger's attribute: this *Knielauf* gives her a sense of speed that we know is central in Greek semiotics⁵. The second main feature of Nike's pose is related to the position of her arms. According to [9, p.162], the arms of the Nike of Samothrace are raised, and it is a common feature among Nikai:

"The Victory' s right hand is raised, supported by a strut on her right shoulder. She must have held a long metallic rod [...]. The metallic rod held across her body may have been a ship' s mast (stylis), a common attribute of maritime Victories."

We then observe that this feature is traditionally linked to displacement or to various rituals⁶. Describing again the Victory of Samothrace, Olga Palagia adds:

"[...] left arm raised, right lowered, whereas the Victory' s arms are the other way round"

This quotation shows how the opposition in the arms positions is present in the Nike of Samothrace specifically, we can then suppose that it is part of the symbol of the messenger that Nike has in this representation.

III. DESCRIPTION OF THE DATASET, AND CRITICAL ANALYSIS OF ITS CONTENT

The dataset is called Dunhuang660. It contains 660 pictures of flying Apsaras from the Dunhuang grottoes. The dataset is already cleaned and labeled with the period and cave number they belong to as described in [10].

Artistic period	Number of sample images	dates (A.D.)
Infancy	220	421-556
Creative	220	557-618
Mature	220	619-959

Table I: Repartition of the dataset[10]

This dataset has already been previously used in [11] from a computational point of view, however our analysis is totally separate from this work.

Each image has different resolution and is in the RGB

⁵See also the figure of Pheidippides for example, and his obvious *Knielauf* on his statue in the town of Marathon, as well as the figure of Achilles who according to Photios I inherited as his famous heel the ankle of Damysos, the fastest of the giants, making him an amazing warrior.

⁶The arms, brought forward, can be attributed to the libation that Nike gives in some ceremonial settings, which is difficult to link to the idea of speed. In another hand, it can still be argued that this is somehow linked to a role of messenger, giving the ritual tools to other performers, but it would need much further investigation.

bitmap (bmp) format. An noticeable feature of this dataset is the problem posed by the framing of the images: by design from [10], a lot of images are identical to each other, only rotated. The Apsaras are also often cropped at some parts of their bodies, missing an elbow, a hand, or a foot. They have very varied postures, and some of their body parts may be invisible or hidden behind them or their clothing. The angles induced by their body parts are sometimes absolutely inhuman, especially in the Infancy period. The length of their limbs vary a lot, and their feet are sometimes difficult to locate in the drapery of their clothes. The faces are sometimes blurry, so the eyes are difficult to pinpoint exactly. Also, some mural paintings of the flying Apsaras suffer from severe deterioration so that they can hardly be recognized.

IV. METHODOLOGY

In order to find similarities and differences within Chinese flying Apsaras 'Feitian' in different time periods as well as between Feitian and Nike portrayed in Greek arts, we first use 13 key points to annotate the images containing clear and complete flying Apsaras manually for the pose estimation. Then we implement KMeans and DBScan algorithms to cluster the poses. To get from our original goal to realizable algorithms, we need to translate these tasks to a sequence of computational operations.

A. Task sequence for clustering

- The positions of the Apsaras can be described by a multidimensional vector. We choose thirteen points⁷ that we pinpoint in the two-dimensional pixel frame. We infer the articulations from the images by hand, by computing the 2d coordinate of each of the articulation of all the Apsaras and store them in a json file.
- Those coordinates can be transformed into a consistent data structure by stacking the coordinates in a rank 3 tensor of shaped as (n° of the Apsara, n° of the articulation, x/y coordinate).
- To analyse various "representative positions", we use two techniques of clustering:
 - KMeans clusters the data for a number of clusters fixed by the user.
 - DBScan clusters the data according to a minimal distance ϵ to separate clusters, and with a set minimal number of so called "representative" points, namely MinPts value, that make up the core of the clusters, both set by the user. The clusters are build according to the flattened tensor.

⁷2 for the hands, elbows, shoulder, eyes, knees and foot, and 1 for the belly

- Since we want the clusters to be built according to common rules to all time periods, we set rules to tune the hyper parameters:
 - For **KMeans**, we plot the mean distance to the cluster centers (inertia) with respect to the number of cluster, and find the point of maximum curvature.
 - For **DBScan**, we plot the sorted mean-distances between the k -Nearest-Neighbors for each point of the dataset, with k twice the dimensionality of the data. We pick the ϵ parameter at the maximum curvature of the distances. As for the MinPts value, it is suggested that MinPts value should be two times the dimensions of the dataset if the dataset has more than two dimensions.[?]
- We extract the representative poses by analysing either the center of the clusters, or the core samples for **DBScan**.

B. Rotation invariant analysis

There is a major problem with the rough clustering of the 26-dimensional vectors: the pose in the pixel frame of the picture will be considered very different in euclidean distance from a rotated version. So in addition to the previous method we build a method of analysis, which is at least rotation invariant. The transformation that we propose is the extraction of the angles on target articulations.

We operationalise the identification of the Knielauf by computing the angles between the belly, a knee, and the corresponding foot. One knee bent and one straight leg can be interpreted as the typical Knielauf observable in the dataset, while two straight legs or both legs bent can have multiple other meanings, but are usually not the typical shape of a Knielauf.

For the arms, the procedure is similar: two angles are computed between the belly, the shoulder, and the elbow, and then between shoulder elbow and hand, for each arm. If all angles are wide for a single arm, we consider that we observe a "raised arm". One raised arm, and the other not being raised corroborates the sources on possible poses of Nike, so we register them as the positions of interest.

It is important to notice that the analysis based on the angles has a major drawback: it cannot make the distinction between a Knielauf and a "Pinwheel" pose for example. This lack of distinction can be compensated by the regular 26-dimensional pose, but the two feature sets must be studied together in order to ensure that the detected Knielauf positions and the raised arms detected through the angular computations are not mistaken "Pinwheels", or other exotic positions.

C. Interpretation

For the Knielauf, we are looking for an acute angle on one knee, and a wider angle on the second one. This means that in the $[0, \pi]^2$ square defined by the two angles, in radians, of both knees, we are looking for clusters in the bottom right or the top left sections. In the case of the arms, we are looking for clusters on the top right for the marginal distributions on the hand-elbow-shoulder and belly-shoulder-elbow for a given arm. Then, for the other arm, we want a cluster anywhere but on the top right corner.

V. RESULTS

A. Temporal analysis

In order to analyse the evolution from Nike-Apsara to Feitian, we group the images in the dataset according to dynasty. Then K-Means clustering was performed on each group, with three cluster centers. The results can be seen in II.

For the infancy period, which was still influenced heavily from western art styles, we see two types of poses: One where the legs are thrown above the Apsara, giving them a sense of weightlessness and also of speed, and another more upright position. Here we often find the Knielauf position, where one leg is bent and the other isn't. Additionally to the position of the legs, the arms give insight into the function of the Apsaras as well. Often they appear half-raised, giving the impression that the Apsara is handing something to someone or carrying something.

Going back to the original images, it becomes clear that the role of the Apsaras in the overall painting is an ornamental one. They float around Buddha, always facing him, and their bodies and positions are part of the overall art. They are making offerings or playing the instruments, and are not the main focus of the artwork. We find that the positions of the Apsaras don't drastically change over the other time periods. The development and evolution is mainly in terms of artistic style and depiction. This is in line with what is known from the secondary literature.

For the creative and mature period, we see again similar poses as with the Infancy period. Interestingly there are no strikingly dissimilar poses appearing in the new eras, which supports the idea, that the Apsaras had a clear function in the overall paintings. As their style changed, their function remained the same, which is a possible explanation for why their poses remain stable over all dynasties.

We then analyse the clusters obtained in the dataset by period also in terms of appearance of the Knielauf position and raised arms.



Figure 5: Apsara from the infancy period with annotations

B. Knielauf and raised arms

We observe that the results for the inference of Knielauf appearance are at least a little conclusive: the Knielauf appears distinctly during the Beiling period (IVa), stays during the Beiwei period (IVc), but disappear mysteriously during the Xiwei period (IVE). It then reappears rather distinctly in the Beizhou period (IVg), and stays consistently visible during the Sui and Tang periods (IVi and IVk). The population of the Wudai period is too small to draw significant conclusions, see IVm, but it appears to be in a bent knee position too. For the arms, the results are far less obvious. We see in IVb that the arms are both raised at the same time (red cluster), or both close to the body (white cluster). The same distribution occurs in IVd. For IVf in another hand, we observe in the plot in position (1, 3) a red cluster associated with a raised arm 1 (wide angles for both elbow 1 and shoulder 1), while the same red cluster is in bottom left in plot (2, 2) showing elbow 2 with respect to shoulder 2. What this means, in turn, is that there is a consistent and well-separated cluster representing a raised left arm during the Xiwei period. This is not visible anymore during the Beizhou period (IVh), reappears slightly during the Sui period (see the

white cluster in IVj, which is in the center of the plot for the right elbow-shoulder, but on the bottom/bottom-left for the left arm). The Tang period in IVl are too widely distributed to form relevant clusters, and in the contrary the Wudai period contains only a few samples that are in the center of the plots (see IVn).

VI. CONCLUSION AND DISCUSSION

Through the secondary literature, we could find evidence that there is a connection between the iconography of the Greek goddess Nike, the Nike-Apsaras in Gandharan art and the Feitian in the Mogao caves. We made an attempt to quantify and operationalise the search for similarities through pose annotation and clustering. As discussed previously, clustering based on all 26 key points is not rotation invariant. Because of this, we additionally analysed the poses of the Apsaras on the angles between key points. Particularly, we were searching to find the so called Knielauf position and raised arms, as this is very common for Nike in Greek iconography.

To further analyse the development and evolution of the Apsaras, we considered the different dynasties and looked for similarities as well as differences.

Measuring influence of an artistic style on another is very difficult and our project has only explored a very narrow aspect of the art in the Dunhuang caves. Possible future analysis on the Apsaras can be done in terms of style, use of colours, body type and its depiction and so on, leading to some supplementary historiography. In complement to this, it would be interesting to look into the meaning of certain poses and positioning of limbs in art.

There are other more obvious drawbacks in our analysis, importantly the annotation process. Some of the images are of bad quality or the paintings have deteriorated heavily over time. Such images we excluded from the analysis. Furthermore, as the poses of the Apsaras are often impossible for a human to do, or because limbs were hidden behind clothing or behind the bodies in the paintings, we inferred some key points in the annotation process. This of course biases the annotations we used for the analysis. For example in II we can see that the third cluster of the Wudai dynasty seems to have a very long right arm, which might be an annotation error, or an inferred hand.

All in all, this project made an attempt to find similarities in pose between ancient Chinese mural paintings and Greek iconography. We found a way to quantify the poses and to analyse them in a way that is invariant to rotation.

The results of our research show that there are *Knielauf*

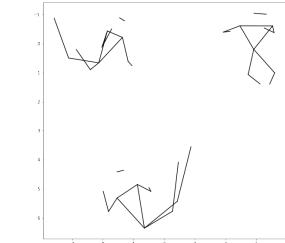
positions present in the dataset and that there are similarities between the depiction of Nike and the Feitian. It is difficult to conclude if and how the depictions of Nike influenced the Feitian directly from the images and the annotations, however the secondary literature suggest that such a connection exists.

So far we have found no way to measure the similarity between an Apsara and the depictions of Nike in a robust way. Hence, possible future analysis could be based not only on a dataset of Apsaras, but also of Nike. A dataset like this needs to be found or created, as we have no knowledge of any such pre-existing material to date.

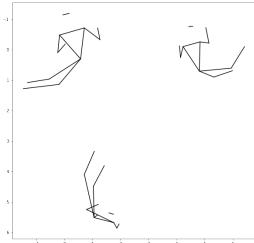
REFERENCES

- [1] R. Whitfield, S. Whitfield, and N. Agnew, *Cave Temples of Mogao at Dunhuang: Art and History on the Silk Road*, 2nd ed. Getty Publications, 2015.
- [2] D. C. Wong, *Buddhist pilgrim-monks as agents of cultural and artistic transmission: the international buddhist art style in East Asia, Ca. 645-770*. NUS Press, 2018.
- [3] D. Academy, *Collection of Dunhuang Grottoes: Picture of Flying Apsaras 15*. The Commercial Press, 2016, no. v. 15. [Online]. Available: <https://books.google.ch/books?id=N3LQzAEACAAJ>
- [4] J. Boardman, *The Greeks in Asia*. London: Thames & Hudson, 2015, oCLC: ocn892891685.
- [5] R. Wannaporn, P. Stewart, and University of Oxford, Eds., *The global connections of Gandharan art: proceedings of the Third International Workshop of the Gandhara Connections Project, University of Oxford, 18th-19th March, 2019*. International Workshop of the Gandhara Connections Project, 2020, oCLC: 1197810642.
- [6] A. Caillaud, “Reconnaitre une déesse ailée au caducée: Réflexions sur l’identification dans la céramique attique à figures rouges,” *Cahiers « Mondes anciens »*, no. 8, Apr. 2016. [Online]. Available: <http://journals.openedition.org/mondesanciens/1705>
- [7] R. T. Neer, *The emergence of the classical style in Greek sculpture*. Chicago ; London: The University of Chicago Press, 2010.
- [8] Maria Lagogianni-Georgakarakos, *Known and Unknown Nikai In History, Art and Life*, 1st ed. HELLENIC ORGANIZATION OF CULTURAL RESOURCES DEVELOPMENT, 2021. [Online]. Available: https://www.academia.edu/71712402/Nike_in_the_Athenian_Agora
- [9] O. Palagia, B. D. Wescoat, and J. R. McCredie, Eds., *Samothracian connections: essays in honor of James R. McCredie*. Oxford [England] ; Oakville, CT: Oxbow Books, 2010.
- [10] C. Zou, Qin, Q. Yu, Li, W. Huang, Chuanhe, and Song, “Dunhuang660 flying apsaras,” 12 2014.
- [11] Q. Zou, Y. Cao, Q. Li, C. Huang, and S. Wang, “Chronological classification of ancient paintings using appearance and shape features,” *Pattern Recognition Letters*, vol. 49, pp. 146–154, 2014. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S0167865514002086>

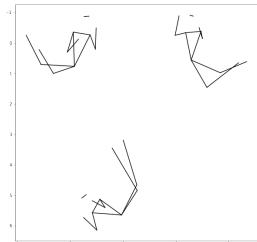
APPENDIX



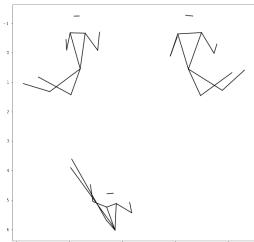
(a) Beiliang dynasty clusters



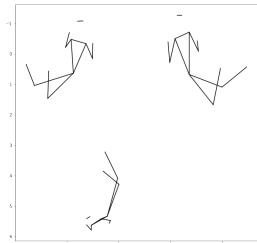
(b) Xiwei dynasty clusters



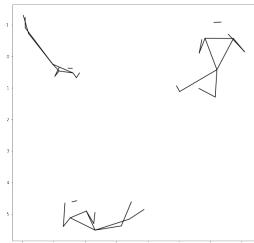
(c) Beiwei dynasty clusters



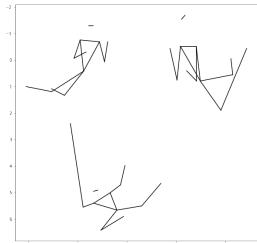
(d) Beizhou dynasty clusters



(e) Sui dynasty clusters

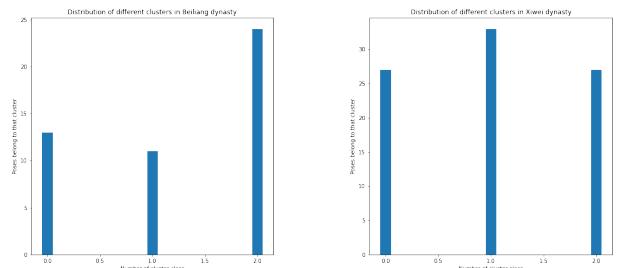


(f) Tang dynasty clusters



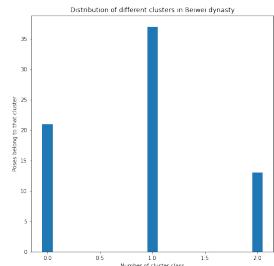
(g) Wudai dynasty clusters

Table II: Visualization of the cluster centers for each dynasty present in the dataset



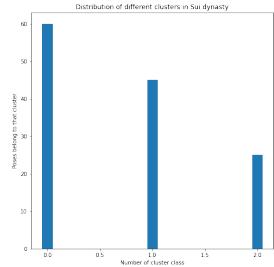
(a) Beiliang dynasty cluster distribution

(b) Xiwei dynasty cluster distribution



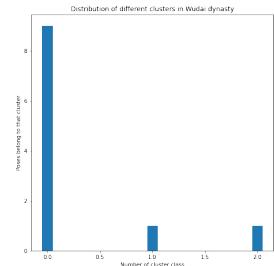
(c) Beiwei dynasty cluster distribution

(d) Beizhou dynasty cluster distribution



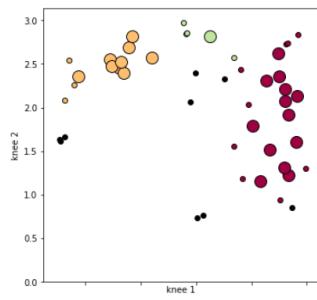
(e) Sui dynasty cluster distribution

(f) Tang dynasty cluster distribution

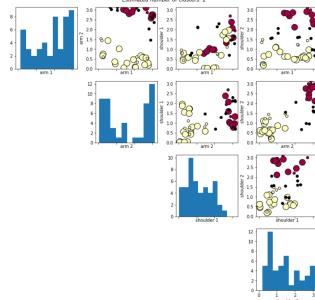


(g) Wudai dynasty cluster distribution

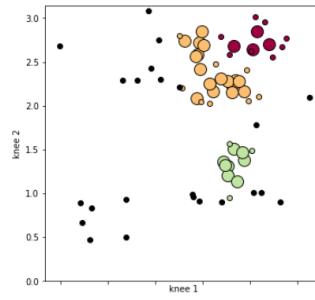
Table III: Visualization of the distribution of images per cluster center for each dynasty present in the dataset



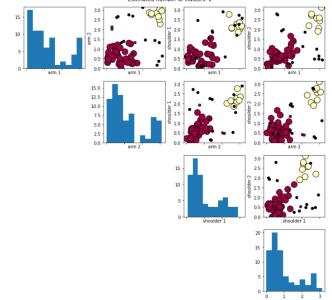
(a) Knielauf clustering for the Beiling period



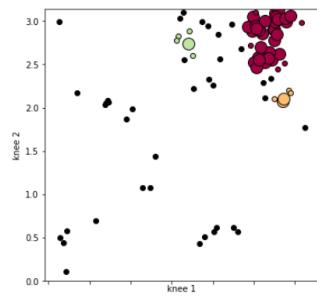
(b) Arms angles clustering for the Beiling period



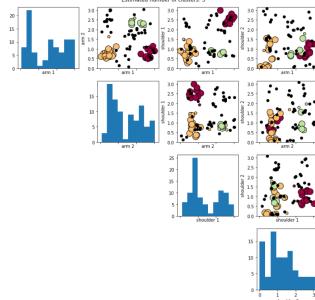
(c) Knielauf clustering for the Beiwei period



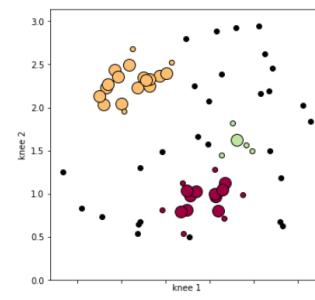
(d) Arms angles clustering for the Beiwei period



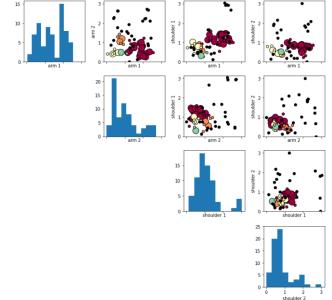
(e) Knielauf clustering for the xiwei period



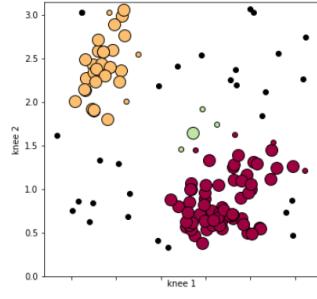
(f) Arms angles clustering for the xiwei period



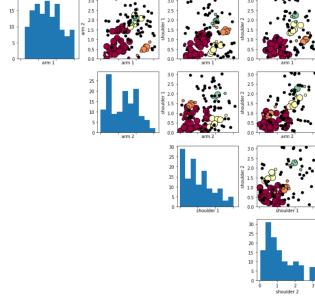
(g) Knielauf clustering for the Beizhou period



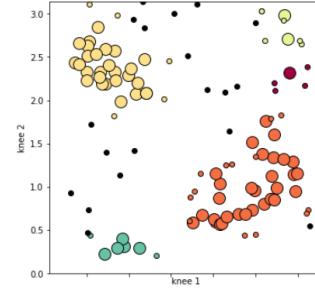
(h) Arms angles clustering for the Beizhou period



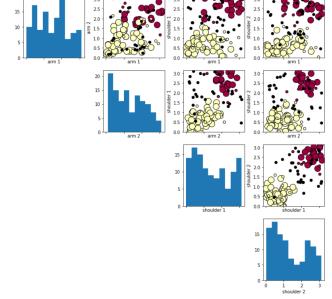
(i) Knielauf clustering for the Sui period



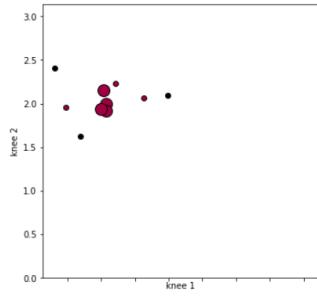
(j) Arms angles clustering for the Sui period



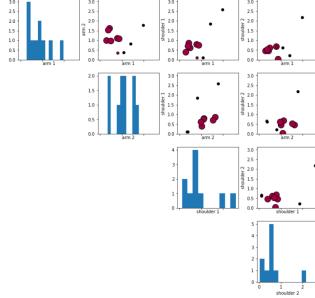
(k) Knielauf clustering for the Tang period



(l) Arms angles clustering for the Tang period



(m) Knielauf clustering for the Wudai period



(n) Arms angles clustering for the Wudai period

Table IV: Evolution of the clusters through time, as measured by a hand-tuned DBScan, for both the knee angles (Knielauf) and the arms angles. For the arms angles distributions, the plots are organized by projections on 2 coordinates, by pairs (as in a double-entry table), in the following order from left to right and top to bottom: elbow 1 angle, then elbow 2, then shoulder 1, then shoulder 2.

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