Computer modeling of a turtle pendant and a *moai kavakava* from Easter Island

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*Documentation of woodcarvings from Easter Island, as with any three-dimensional object, is complicated by the fact that even the best photographs show only a projection of the artifact on a plane. The creation of a computer model partially solves the problem, because such a model can be interactively studied at the computer. However, for printed works, the problem remains – how to present information about a complex three-dimensional object by means of two-dimensional imagery? Here we propose using cross-sections for an enhanced illustration of the object. Such cross-sections can be created by direct measurement in the case of simple symmetric shapes – such as ceremonial paddles (*rapa*). However, for more complex objects, it is obligatory to create a computer model to obtain the required cross-sections. The paper illustrates a simple way to reconstruct objects with an acceptable level of precision using a set of reference images showing the principal views (frontal, profile, etc.) of the artifact.*

*Documentación de las figurillas de madera de Isla de Pascua, como del cualquier objeto tres-dimensional, está complicada porque las fotografías solo representan la proyección del artefacto sobre un plano. Generación de un modelo tres-dimensional en la computadora resuelve este problema en parte, permitiendo estudiar el modelo en la manera interactiva en la pantalla. Sin embargo, para los artículos impresos, el problema de representación sigue vigente – ¿cómo se puede presentar la información sobre un objeto complejo tres-dimensional con la imagen impresa en dos dimensiones? En este artículo, estamos proponiendo el uso de secciones transversales como para una ilustración mejorada del objeto. Estas secciones transversales pueden ser creadas por mediciones directas en los casos de las formas simples y simétricas – tales como los remos ceremoniales (*rapa*). Pero, para los objetos más complejos, es obligatorio construir un modelo 3D en la computadora para poder obtener las secciones transversales requeridas. En este artículo estamos ilustrando una manera simple para llevar a cabo la construcción del modelo 3D con la precisión aceptable utilizando sólo un conjunto de las imágenes de referencia compuesto por las vistas principales (frontal, de perfil, etc.) del artefacto.*

Introduction

Easter Island (Rapa Nui) forms the east corner of the Polynesian triangle, located about 2230 miles west of the South American coast (Métraux 1940:7). It is believed that it was populated in a single event by a group of Polynesians, who developed a unique Neolithic culture that achieved its golden age in total isolation. The most famous icons of Rapa Nui heritage are the megalithic altars (*ahu*) adorned with stone statues (*moai ma'ea*). The tallest statue that was successfully erected over Ahu Te Pito Kura measures almost ten meters (Métraux 1940:294), which naturally caused a profound impression on the visitors calling at Easter Island after its re-discovery by Europeans in 1722.

However, colossal stone structures were not the only achievement of the Rapanui culture. The islanders developed their particular style in rock art, producing several thousand petroglyphs (Lee 1992:5). They were also skilled woodcarvers, creating true works of art in portable sculpture. Rapanui carving (*moai miro*) developed within the original artistic canon, producing artifacts of unmistakable style (Orliac & Orliac 1995:34-37). At the time of the first European visits, these carvings played an important role as objects of exchange between islanders and crew members of passing ships.

Collection of Rapanui Woodcarvings

At least six wooden carvings were collected from Rapa Nui during the 1774 voyage of James Cook. Many others were acquired during short contacts, mostly from islanders who swam to the ships. Many of the sailors, either from the Navy or whalers, actually knew the appetite of collectors for exotic artifacts. Thus, it may have appeared to the islanders that at the end of 18th century, carved objects were of more interest to visitors than offers of chicken, bananas, and sweet potatoes. The woodcarvings were part of all transactions with visitors, establishing genuine artisan production. It goes without saying that this activity was of particular

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importance, because almost a hundred ships dropped anchor at Rapa Nui since the end of the 18th century until the installation of the Mission in 1866. This implies that thousands of sailors became "regular customers" fueling the woodcarving industry of Easter Islanders.

The first European who lived on the island was Eugène Eyraud, the lay brother of the Congregation of the Sacred Hearts of Jesus and Mary (SS.CC.). During his short (but very risky and courageous) stay from January 2 to October 11, 1864, he observed an abundance of wooden sculptures and inscribed tablets, which were literally present in "all the houses" (Orliac & Orliac 2008a:61). However, the conditions of his sojourn worsened significantly so that Brother Eugène was glad to depart from the island with a passing ship. The crew picked him up at the shore almost naked and very weak – he brought nothing from the island, except for his memories.

Brother Eyraud was of a strong character and did not give up with the first failure; he returned with the persistence to establish the SS.CC. Mission on Rapa Nui in March 1866. It is worth noting that the large-scale outflow of Easter Island woodcarvings started around 1868, when the islanders were converted to Christianity and the cultural links to the old beliefs connected to the woodcarvings became significantly weakened. Many of these sacred objects of the past were handed over to Fathers Hippolyte Roussel and Gaspard Zumbohm, who also established the Mission on the island in 1866 (Orliac & Orliac 2008a:56). Actually, the Mission was one of the must-visit places on the island for every ship. The other place of importance was the house of Captain Onésime Dutrou Bornier, an adventurer who also arrived to the island in 1868. Dutrou Bornier later became a competitor of the Mission, obtaining profits from commerce with his Rapanui protégés.

Thus, during the visit of the British frigate HMS *Topaze* (October 31 – November 8, 1868), an unknown number of important artifacts were acquired by the Mission and Dutrou Bornier for the sailors and officers. The majority of these disappeared without a trace, except for about a score of woodcarvings. Norwegian Captain Peter Arup visited the island in 1869, and with the help of the same intermediaries collected an unknown number of objects, from which a dozen ended up in the Kulturhistorisk Museum of Oslo. Seven others reached the Godeffroy Museum of Hamburg; with the closing thereof in 1879, the artifacts were acquired by the Ethnographical Museums of Berlin and Leipzig. In January 1870, the officers of the Chilean corvette *O'Higgins* visited the Mission and Dutrou Bornier; five or six objects collected by them are now in the collection of the National Museum of Natural History, Santiago, Chile.

When the Mission left the island in November 1871, its collection of Rapa Nui artifacts – the most numerous in the world – consisted of about fifty objects, including *rongorongo* tablets that were especially prized by Bishop Tepano Jaussen of Tahiti. Thus, taking into account the objects (the records about which were lost, but certainly far exceeded the number of surviving records), it is possible to estimate that there were about two hundred woodcarvings spread by the joint effort of the Mission and Dutrou Bornier. Only months after the departure of the Mission, in January 1872, Julien Viaud (Pierre Loti), with the crew of *La Flore*, was barely able to obtain about a dozen objects that generally were of recent manufacture, despite the offer of a high price. The high-quality ancient carvings became even harder to find for the sailors of *Seignelay* visiting the island in April 1877. Some exceptionally rare ancient objects were found later in caves or graves, but it seems that after 1877, Easter Islanders had only modern carvings that were improvised by sculptors, re-inventing largely forgotten forms to produce objects for commerce.

Easter Island Figurines

Classic Rapa Nui woodcarving is an elaborate work of art. There were several groups of conventionalized images – emaciated masculine figurines (*moai kavakava*) with explicitly shown ribs, flat feminine figurines (*moai pa'apa'a*), realistic male figurines (*moai tangata*), stylized lizards with human genitals and legs (*moai tangata moko*), birdman figurines (*moai tangata manu*), ceremonial dance paddles (*rapa*), power insignia paddles (*'ao*), Janus-face chieftain staves (*ūa*), battle clubs (*paoa*), crescent-shaped pectorals (*rei miro*) and egg-shaped pendants (*tahonga*). In addition to these, there were a large variety of woodcarvings that served as personal adornments (and thus containing holes for hanging) or were used as portable sculpture at feasts. The corpus of these "aberrant" carvings includes realistic depictions of octopuses, fishes, shells, turtles, migratory birds, chickens, chimerical creatures associated with lore or seen in dreams, composite sculptures merging several figures into one, ceremonial objects adorned with female genitalia (*komari*) that were possibly used in fertility rites, and so on. Authentic old Easter Island carvings feature highly-polished surfaces and surprise the spectator with attention to detail – including thin chevron lines delineating the eyebrows, delicate curved fingers, and intricate low-relief glyphs adorning the heads of many anthropomorphic carvings. The eyes are carved in an almond shape for *moai kavakava* / *pa'apa'a* / *tangata*; for animal forms they are usually round and protruding, though there are some notable exceptions. The iris and the pupil are formed by inlays made of fish or bird bone and small disks of black obsidian, respectively.

There are several books providing rich illustrations of woodcarvings from Easter Island (Heyerdahl 1975; Esen-Baur & Forment 1990; Orliac & Orliac 1995; Kjellgren 2001; Orliac & Orliac 2008a, 2008b). The aforementioned books frequently supply several views of the same artifact, allowing better understanding of its form. However, in many cases this approach is insufficient, because for any three-dimensional object, photographic presentation provides the reader only with projection on a two-dimensional plane of the page. There is a straightforward solution to the problem in computer media – to create a three-dimensional model of the artifact and rotate it on the computer screen. If the corresponding graphic interface allows a high degree of interaction and capability to output stereoscopic images, such a virtual study may provide a feel close to that of studying the original object or a good replica thereof, augmented with additional benefits of 3D model processing such as hiding particular parts of the object, making its material partially transparent, performing measurements, etc.

However, when it comes to traditional ways of presenting material in printed publications, such interactive content is still unavailable within the framework of present technology. Nevertheless, there are attractive ways to include extra information on the geometry of the carving – for example, supplying a set of cross-sections that would simplify reconstruction of the object's shape in the mind's eye of the reader. This approach was successfully used for crescent-shaped pectorals (Orliac & Orliac 2008a:228) and ceremonial paddles (Orliac & Orliac 2008a:182), reproduced here as Figure 1.

As one can see in Figure 1, cross-sections present important data that is not straightforward from a single (or even several) photographic image(s). That is, the ridges forming the eyebrows and nose of a stylized face on the upper blade of *rapa* actually do not project much over the surface of the wood (Figure 1, A); they are carved in low relief and thus low-angle slanting light is necessary to reveal them in photographs. The stylized ear ornaments are spherical in shape, being the most protruding detail of the upper blade (Figure 1, B). Below the stylized nose, the blade has essentially a diamond-shaped cross-section (Figure 1, C); the same is true for the upper part of the bottom blade (Figure 1, E). The lower blade in its widest part has a rectangular cross-section (Figure 1, F). The phallic appendage at the bottom of the *rapa* (Figure 1, G) is thicker than the bottom blade, which can be seen more clearly in longitudinal section (Figure 1, H). The latter also shows that the handle of the *rapa* has a bulge in its central part of circular cross-section (Figure 1, D) offering a more comfortable grip. With this information in hand, one can get a better impression of the true shape of the *rapa*.

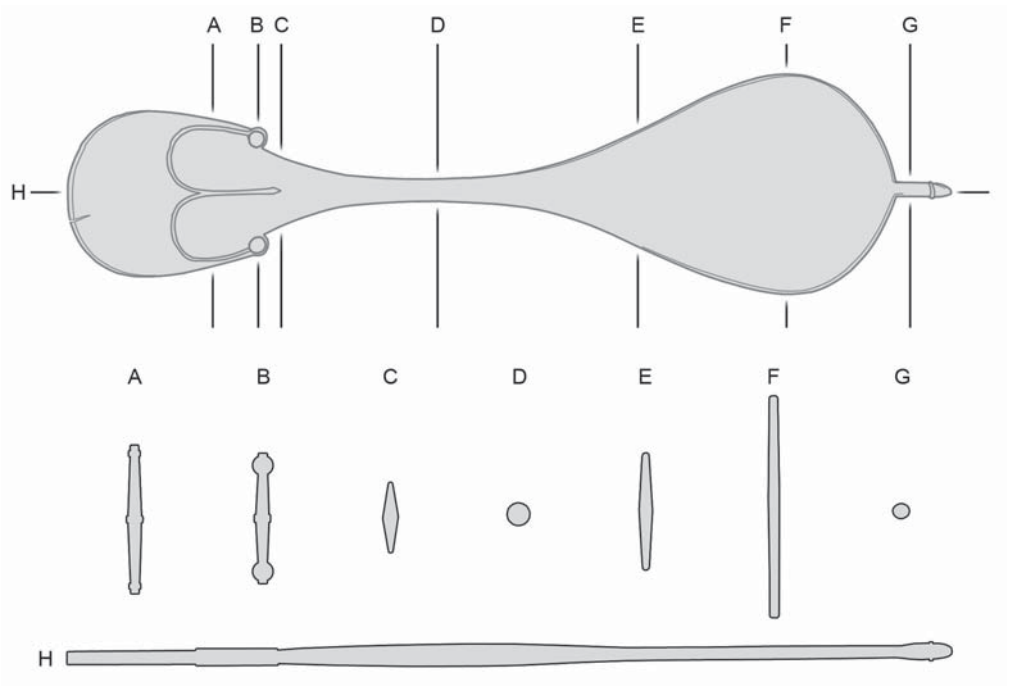

Figure 1. The ceremonial paddle (*rapa*) and its cross-sections. The upper blade with a stylized face is on the left; the lower blade with phallic appendage is on the right. The cross-sections are shown for: A) vertical ridges denoting nose and eyebrows of the *rapa*; B) the spherical ear ornaments; C) the base of the face; D) the middle of a handle; E) the beginning of the lower blade; F) the widest point of the lower blade; G) the phallic appendage; H) longitudinal cross-section along the central line of the *rapa*. Adapted from Orliac & Orliac 2008a:182.

Computer Modeling Procedure

Cross-sections shown in Figure 1 were constructed by direct measurement of the original artifact, followed by an accurate drawing of obtained data to match the scale. Of course, this approach is feasible only for comparatively simple and symmetric objects, such as *rapa*, *ʻao*, *rei miro* and *tahonga*. To build cross-sections of an artifact with a more complicated shape, one should first construct a 3D computer model that can be further sectioned by the set of planes to reveal the characteristic volumetric traits of the object. The most exact and detailed models can be obtained by laser scanning techniques, such as those which were already successfully applied to megalithic architecture and statues of Easter Island (Wellman 2003; Kersten et al. 2009; O'Brien 2009; Pitts et al. 2013). The resulting models may have millimeter precision for large stone statues, recording their geometry by a point cloud composed of several millions of points (Kersten et al. 2009:83-84). This naturally produces large data files (hundreds of megabytes in size) that put considerable requirements on the computers that are used to visualize them. On the positive side, such high precision allows one to monitor the changes in the object's state by comparing laser scans made in consecutive years (Kersten et al. 2009:86). However, high-precision lasers scanners are very costly and require considerable computing power to process the acquired data; also, direct physical access to the object is obligatory to perform the scanning.

But what can we do when the documentation of the object is limited to several images and the artifact itself is inaccessible (see Lee & Horley 2012)? Could it be possible to produce an acceptably reliable 3D model of such an object? We think that the answer can be positive. Here, we illustrate two sample cases of producing considerably accurate models of two fairly complicated woodcarvings – a turtle pendant from the collection of the Peabody Museum of Archaeology and Ethnology (Cambridge, USA) and a *moai kavakava* figurine from the collection of the Congregation of the Sacred Hearts of Jesus and Mary (Rome, Italy). Aiming for a low-cost solution, we performed the required modeling with free software called Blender (http://www.blender.org), following the positive experience of modeling the archaeological site of Ahu Tahiri, Vinapū (Horley 2010). The models were created based on a set of reference photographs presenting the principal views of the object – front, back, top, bottom, and the sides of the artifact. The set of six images is desirable because the carvings are usually not perfectly symmetrical. The obtained models consist of thousands of points, offering enough detail to study the main features of the artifacts, and on the other hand, requiring far less memory for visualization than their laser-scanned counterparts. The models were not textured on purpose to allow easier study of their shapes; photo-realistic textures can be easily applied to the existing models if desired. Small model size also can be promising for creation of a virtual exhibition, perhaps accessible over the Internet, which would allow a dramatic increase of awareness about the unique cultural and historical heritage of Rapa Nui.

Computer Modeling of the Turtle Pendant

Turtles – called *hōnu* in Rapanui – occupied an important position in the ancient culture of Easter Island, in accordance with pan-Polynesian traditions that connected turtles to royalty: "Formerly, 'when there were kings in Easter Island', turtles were caught by the natives both for their meat and their shell" (Métraux 1940:235). There are about thirty stone constructions called *tupa* located mainly on the north coast and at Hotu ʻIti shores (Englert 1948:237-243). According to tradition, the *tupa* served as turtle watchtowers. Indeed, their location generally matches the areas where turtle petroglyphs are found (Lee 1992:82). However, the construction of *tupa* does not offer any definite conclusion about their usage: "though they are along the shore, these towers do not give the watchers any better view of the sea than any near-by hill […] there is nothing in the *tupa* to facilitate access to the top of the tower, which is not a very comfortable place" (Métraux 1940:189-190).

Turtles were considered to be endowed with the sacred power (*mana*); on other islands, they were associated with celestial objects such as the belt of Orion and the Pleiades (Lee 1992:80). A petroglyph panel showing turtles accompanied by crescent moon shapes also exists on Rapa Nui, in the vicinity of Ahu Raʻai (Lee 2000:50). Turtles are considerably prominent in the lore of the islanders, appearing as messengers from the other world (such as the turtle Veri-pupura-vai-a-pakia, Métraux 1940:372), carrying people across the ocean (Uho and the turtle, Métraux 1940:372-373) and representing spirits, such as the turtle that landed at ʻAnakena Beach and mortally wounded Kuʻukuʻu, one of the seven explorers sent to Rapa Nui following the dream vision of Hau Maka (Englert 1948:25).

In contrast to thirty-two turtle petroglyphs recorded on Easter Island (Lee 1992:82), full-body turtles are rare in classical woodcarving, including (to the best of our knowledge) only two figurines – an eroded specimen (273244 from Chicago Natural History Museum, Chicago, USA) and a well-preserved turtle pendant (99-12-70/53608 in the Peabody Museum of Archaeology and Ethnology, Cambridge, USA). Turtle head pendants are far more numerous (though their identification is sometimes difficult because they may look quite similar to fish head pendants) including artifacts from the Cologne, Christchurch, Dresden and Kon-Tiki

Museums illustrated by Heyerdahl (1975:Plate 130), turtle head 2444 in the Oslo Kulturhistorisk Museum, eroded turtle head B.3573 in the Bernice Pauahi Bishop Museum, Honolulu (Heyerdahl 1975:305) and possibly several others. An image of a stylized turtle appears on a wooden pendant (*tahonga*) (artifact 2443 in the Oslo Kulturhistorisk museum, Heyerdahl 1975:Plate 52d) as well as on the head of a female figurine (artifact ST/5316 in the American Museum of Natural History, New York, Heyerdahl 1975:Fig. 36, Pl. 81a).

For modeling, we have chosen the beautifully carved naturalistic turtle pendant (99-12-70/53608 from the collection of the Peabody Museum of Archaeology and Ethnology) shown in Figure 2. It is 13cm long and 8cm wide; the thickness (measured between the dorsal and the ventral part of the carapace) is 5cm. The object was donated by the heirs of David Kimball, 1892, entering the collections of the Museum in 1899 (S. Haskell, pers. comm. 2011). The pendant is carved out of reddish-brown wood, perhaps *toromiro* (Heyerdahl 1975:298). The surface is carefully polished; the thin layer of varnish covering it was probably not the part of the original finish. The head is set on a straight neck; the eye sockets are deep and oval in shape. The left eye still has its pupil inlay made of black obsidian. However, one is inclined to think that it could be a provisional replacement of now-lost eye inlays that should be considerably bigger to fill the sockets. The rounded ridges above the eyes are clearly marked. The nostrils are located slightly to the right of the center of the head. The mouth is carved as a deep groove with a series of perpendicular cuts. On the bottom side of the neck, there is a bulge with a hole intended for suspension string. The carapace is heart-shaped and smooth, with a clearly defined dorsal ridge. The front flippers are gracefully curved and elongated; the rear fins are far smaller and rounded. What Heyerdahl cites as a "bulging egg-laying region" (1975:298), to our opinion, represents an emphasized scrotum. The tail of the image is quite long and rounded.

The turtle pendant was modeled using six reference images, showing the principal views of the object (Figure 2). First, the right side of the pendant was modeled using top, front, back, right, and bottom images. The obtained mesh was mirror-reflected to form the left side of the pendant, which was adjusted vertex-by-vertex to fit the reference image set including the left image. The smooth surface of the object and the lack of small details except at the head area permitted the creation of an acceptable model with reduced polygon numbers. In total, the model was composed of 1655 points (vertices) forming 3310 faces. As the side

Figure 2. Turtle pendant 99-12-70/53608. Images Copyright 2016 President and Fellows of Harvard College, the Peabody Museum of Archaeology and Ethnology, Cambridge, Massachusetts.

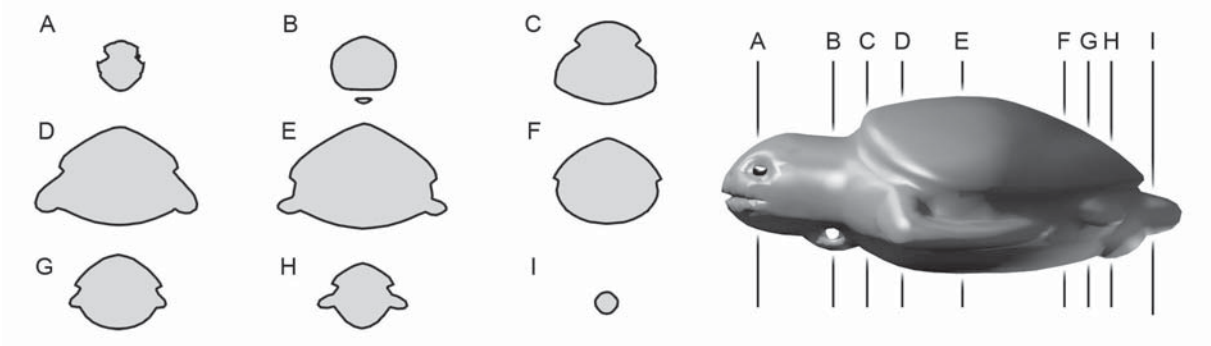

Figure 3. Computer model and cross-sections of the turtle pendant from the Collection of the Peabody Museum of Anthropology and Ethnology, catalogue number 99-12-70/53608. The letters stand for the cross-sections: A) at the eye inlay, B) hole for hanging, C) beginning of the carapace, D) the outward part of the frontal fins, E) the part of the front fins parallel to the body, F) the body between the fins, G) the profile of the rear fins, H) rear fins and the scrotum, and I) tail.

view of the object gives a good impression about its longitudinal section, we have chosen to construct a set of transversal cross-sections (Figure 3).

As one can see from the figure, the eye sockets are quite deep; the empty hole once housing the right pupil inlay was used to estimate the depth of the surviving inlay (Figure 3, A). The neck is elliptical in cross-section; the suspension hole with worn edges cuts straight through a small bump located at the base of the neck on the ventral side (Figure 3, B). The carapace starts with a pronounced ridge on the dorsal side of the image (Figure 3, C) and follows as an inverted V-shape with somewhat rounded sides (Figure 3, D, E). The frontal fins are large, emerging perpendicular to the body (Figure 3, D); after a graceful curve, they continue in parallel to the carapace (Figure 3, E). The body between the fins is considerably rounded (Figure 3, F). The rear fins emerge smoothly (Figure 3, G) but have their back part protruding considerably from the body (Figure 3, H). A rounded scrotum confirms that the figure represents a male turtle – a detail which is not so obvious from previously published photos (Heyerdahl 1975:Plate 131; Orliac & Orliac 1995:88). The tail has a rounded cross-section (Figure 3, I).

Computer Modeling of the *Moai Kavakava*

Emaciated male figures with protruding ribs (*kavakava* in Rapanui) and very apparent xiphisternum are, perhaps, the most iconic of Easter Island woodcarvings. They were mentioned for the first time by Georg Forster, who visited the island together with Captain Cook in 1774 (Métraux 1940:149). The head of the *moai kavakava* is disproportionally large and bald; the cranium of the classical carvings (usually collected before the 1880s) is adorned with elaborate designs of birds, fish, octopuses, and anthropomorphs carved in low relief, some of which are quite reminiscent of the signs of *rongorongo* script. The eyebrows are heavy and overhanging the eyes. The cheekbones are very prominent and contrast sharply with sunken cheeks. The eyes are emphasized with bone and obsidian inlays denoting the iris and the pupil. The mouth is executed in low relief, usually open and showing the teeth. In many cases, the mouth and nostrils bear the traces of red pigment (*ki'ea*) that probably denotes the breath of life (Orliac & Orliac 2008a:113). The body of the *moai kavakava* features many emphasized bones – protruding ribs, accentuated clavicle, flat scapulas, and exaggerated vertebra and pelvis. Some images have a fan-shaped bird tail carved at their pelvic region, which may evoke metamorphosis into a bird. The stomach part is deeply sunken under the rib cage, contrasting with a rounded belly and a low-relief navel. The genitalia are clearly shown. The hands are pressed to the hips and are very thin, with marked elbows and wrist bones. The fingers lack details and are marked with a set of simple grooves. The legs are short in proportion to the body and half-bent at the knees. The feet are very small, with ankle bones marked and toes denoted with a set of small notches.

A statuette with such geometry was never intended to be free-standing. Indeed, many *moai kavakava* have a hole drilled through the bump on the back of their neck, apparently for passing a hanging cord. However, the curved back of the statuette would preclude stable face-forward hanging if being worn as a pendant. To achieve such stability, it would be more reasonable to pass the cord under the armpits of the statuettes. Perhaps this was an option for the figurines with a non-perforated neck bump.

The exaggerated skeletal appearance of the *moai kavakava* suggests that they may depict beings from the other world, the *akuaku* spirits, or the spirits of dead people (Métraux 1940:260). Indeed, according to the legend, the first woodcarvings of this type were made by the king Tu'u Ko Ihu, who saw *akuaku* spirits Hitirau and Nuku te Mangō sleeping at Puna Pau:

"*he kavakava no, he ivi no, ina he hakari*" (Métraux 1940:260) – they were just ribs and bones, no body (flesh). The spirits were awakened and turned into their fleshy form, asking the *'ariki* if he saw something special about them. Tu'u Ko Ihu denied it several times, and, upon returning to his house, he carved the likeness of two *akuaku* in wood. The statuettes were an "instant hit" among the people, keeping the *'ariki* busy with carving. The story goes on, saying that:

> "El Ariki tomó un cordel hecho de mahute, lo trenzó y lo pasó por los sobacos de ambos lados de los moai. Así colgó los moai, dejándolos suspendidos en el cordel. Tomó otros cordeles y amarró con uno el cuello de los moai, con el otro los pies. Quedaron colgados derechos, puestos en fila; tirando con la mano las puntas de estos cordeles, hacía andar los moai. Se dió a su casa el nombre: "Casa de los moai títeres. Algunas personas visitaron la casa del Ariki Tu'u Ko Iho y, al ver que los moai andaban, contaron a otros esta novedad." (Englert 1948:82).
>
> [The Ariki took a cord made of *mahute*, braided it and passed it under the armpits by the both sides of the *moai*. In this way he hung the *moai*, leaving them suspended on a cord. He took other cords and tied them to the neck of the *moai*, and the other to their feet. Thus, they were hung vertically, set in a row; by pulling the ends of these cords with his hands, he made them walk. The name was given to his [the *'ariki*'s] house: "House of *moai* puppets. Some persons visited the house of the Ariki Tu'u Ko Iho and, seeing that *moai* walked, spread this news to the others.]

Remarkably, Englert uses Spanish name of the house – "*Casa de los moai títeres*" – where "títere" means "puppet" or "marionette". In Rapanui lore, the house name is given as "*Hare hakahaere moai*" (Métraux 1940:261) which translates as "house where *moai* were made to walk" (cf. Métraux: "The-house-of-the-walking-images"). It is tempting to interpret this passage as if the ancient Rapanui approached the idea of string puppets (Knoche 1928). However, *moai miro* by no means can be qualified as true marionettes – they are rigid, with no articulated joints, so that all their movements were restricted to "spinning, swinging and swaying as a single piece of perforated wood hung on a cord would do" (Luomala 1973:37). The "walking *moai*" may have caused considerable amusement for their spectators; alas, no reliable accounts about these performances survived, so it is reasonable to take a cautious approach:

> "Examination of sources about Easter Island small wooden figures [. . .] shows that no true puppets or marionettes, let alone a theatre for their use, existed […However,] a nascent [emphasis ours] sense of theatre and drama is evident in Easter Island use of the little statuettes, the myths of marching stone statues, and especially in what may be a later custom of an orator climbing into a large, hollow, [*paina*] figure to eulogise the person his festival honoured and of his audience responding with chants and laments" (Luomala 1973:44-45).

There is far more information concerning how Easter Islanders handled wooden statuettes in their daily life and festivities. Eugène Eyraud made the following brief observations during his first stay on the island (Orliac & Orliac 2008a:61):

> "Religion seems to occupy a very minimal place in their life [. . .] I was never able to witness any positive act of a religious cult. In all the huts, one finds many little statuettes, about a foot high and representing figures of men, fish, birds, etc. These are doubtless idols, but I never noticed them being treated with any kind of honour. In certain circumstances, I saw them take these statuettes, lift them in the air, make some gestures, and accompany the whole thing with a kind of dance and an insignificant song… If you ask them what this means, they just answer, as with their games, that it is the fashion in their country."

It is unclear what kind of "honours" Brother Eugène expected to see to identify a religious ceremony, but his description actually *proves* that the Rapanui treated their wooden statuettes with a special reverence – when it was necessary, they lifted them in the air with a chant or incantation and even danced with them. The further proof of this statement is supplied by Geiseler, who visited the island in 1882:

> "At the main festivals which coincide with the maturation of the potato crop, of bananas, with the main fishing season or with the season for fetching eggs from Motu Nui island – homage is given to the chief gods through these lesser gods […] At the time of these major celebrations the entire population of the village, decorated in the most elaborate fashion and with painted bodies, parades to the designated place. Each person drags along as many wooden idols as he could make by this time. The more idols a man wears, it is that much better for him and that much more will his prayers be of use with the chief god. And this is how it comes about that a single person under the burden of 10 to 20 idols hanging around him will gaspingly sing along. At the place of celebration the idols are unwrapped [from bark cloth] and, accompanying by singing which is performed by three voices, rocked in the arms to the beat […] After the songs and the rocking of the wooden idols,

> the religious ceremonies are concluded by a general feast at which great quantities of food are devoured and thereafter dancing, games, and all sorts of amusements follow" (Ayres & Ayres 1995:67).

Thus, *moai kavakava* were important objects of the ancient culture, possibly allowing their owners to communicate with spirits they represented; when not being used in domestic rituals and communal festivities, *moai miro* were carefully preserved, wrapped in bark cloth.

For modeling, we have chosen the *moai kavakava* belonging to the Congregation of the Sacred Hearts of Jesus and Mary (Figure 4). The artifact bears collection number P008 and is carved from an unidentified pinkish wood with darker rings. It is 45.6cm high and 10.7cm wide at the shoulders. The weight of the statuette is 608 grams. *Moai kavakava* P008 is far from being an archetype because of its shortened proportions, general simplification of its shape, and by somewhat imperfect mastership. Its head is adorned with a low-relief symmetric double spiral, which perhaps depicts hair. The eyes sockets are deep and without inlays. Traces of red pigment are seen in the nostrils and mouth. The vertebral column is overlaid with a lumbar circle that is imperfectly traced. The iliac wings are marked with a triangular band that disappears between the buttocks. The worn-off nipples are slightly overhanging the thoracic cage, which features deeply carved ribs. Two pairs of ribs continue all the way up to the shoulder blades at the back, forming a characteristic U-shape. The genitals are not very prominent and show no trace of circumcision. The legs are slightly mismatched in length, with the left leg measuring 3.5mm shorter than the right one. There are five digits on the right foot and six toes on the left foot.

The traces of shaping have been removed by polishing. The general dark brown color of the object is not the natural wood color, but that created with a uniform dye. There are traces of multiple violent actions resulting in gashes, cracks and fractures that required various actions of consolidation and restoration. Small pegs were used to amend the damage: one is implanted into the exterior of the left leg on knee level; the other is set in the heel of the right foot. The most peculiar detail of this statuette concerns the prosthetic parts that replace the ears and nose, masterly fashioned from the carefully chosen wood to blend the prosthetics with the original material. The internal extent of these implants was studied by X-ray photography (Orliac & Orliac 2008a:128). The nose prosthetic was fixed in its place by two pegs (now lost) that were set in the holes drilled through the side wall of the eye sockets; perhaps, these repair actions modified the socket diameter, loosening the inlays. The prosthetic ears are held in place by small pegs (still surviving today) set in the outer corners

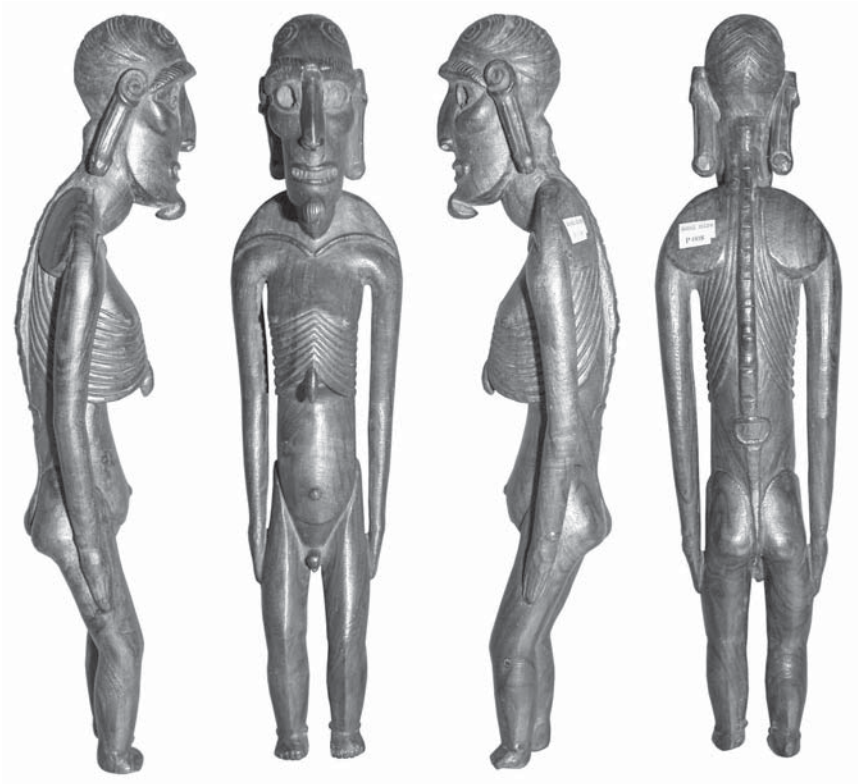

Figure 4. *Moai kavakava* P008 (Images courtesy of the Congregation of the Sacred Hearts of Jesus and Mary, Rome).

of the eyes. The traces of the same operation can be seen on *moai kavakava* 24780 from the collection of Rautenstrauch-Joest-Museum (Cologne).

The modeling was performed following the strategy developed for the turtle pendant: first, the right side of the statuette was modeled using front, back, and right side photographs. The result was mirrored and individual vertices were adjusted to fit the geometry of the left side, using front, back, and left side photographs. The finished model has 8003 vertices forming 15671 faces. Figure 5 displays the main cross-sections of *moai kavakava* P008. The original wood and implants (Orliac & Orliac 2008a:128) are distinguished by shading.

The head shape is roughly elliptical in cross-section, with cranial carvings slightly protruding (Figure 5, A1). The cavity for the nasal prosthetic starts just above the eyebrows (Figure 5, A2). At the level of the eyes, the cross-section includes all three implants and two pegs (Figure 5, A3). The nasal cavity extends considerably deep into the head, but the nose prosthetic ends before reaching the back side of the cavity at this height. The sockets for eye inlays are clearly seen. The carving of the frontal cavity removed the interior corners of the eyes, suggesting that the original nose might have been somewhat narrower. To fix the nose implant in its place, the carvers made perforations in the interior part of the eye sockets. The ear implant stems were assumed to enter the head perpendicularly to its surface at a depth, allowing fixation with pegs inserted perpendicularly at the external corners of the eyes. In this configuration, the angle between the pegs and the implants would be acute, which is not very practical, because the strongest fixation could be achieved with pegs perpendicular to the implants. Perhaps an additional X-ray study may discover the definite answer to the mechanism of ear implant fixation. At the middle of the nose (Figure 5, A4) the nasal prosthetic approaches the back of the cavity, fitting it almost perfectly at the height of the nostrils (Figure 5, A5). The bump on the back of the neck is clearly seen on cross-sections. The mouth (Figure 5, B1) displays slightly elevated lips and teeth denoted with very shallow grooves. The cheeks are almost flat surfaces, forming practically right angles with the lower surface of the jaw. The cervical vertebra is very prominent. The section of the ears shows the sunken region corresponding to ear plugs carved at the bottom of the distended lobes.

The neck projects considerably from the body (Figure 5, B2) with the goatee seen in front of it. The flat upper chest and scapulae form a roughly triangular shape. At the back side, the deep notches denote two ribs curving up, in parallel to the spinal column, and passing between the scapulae. The flat surfaces at the sides of this section denote the exterior parts of shoulder blades. The next section (Figure 5, B3) shows the clavicles executed in low relief; at the back, the scapulae make a step to accommodate the upper part of the arms. Fully developed rib relief can be appreciated in Figure 5, B4. The front of the chest is smooth; the "bridges" connecting the chest with arms correspond to the armpit

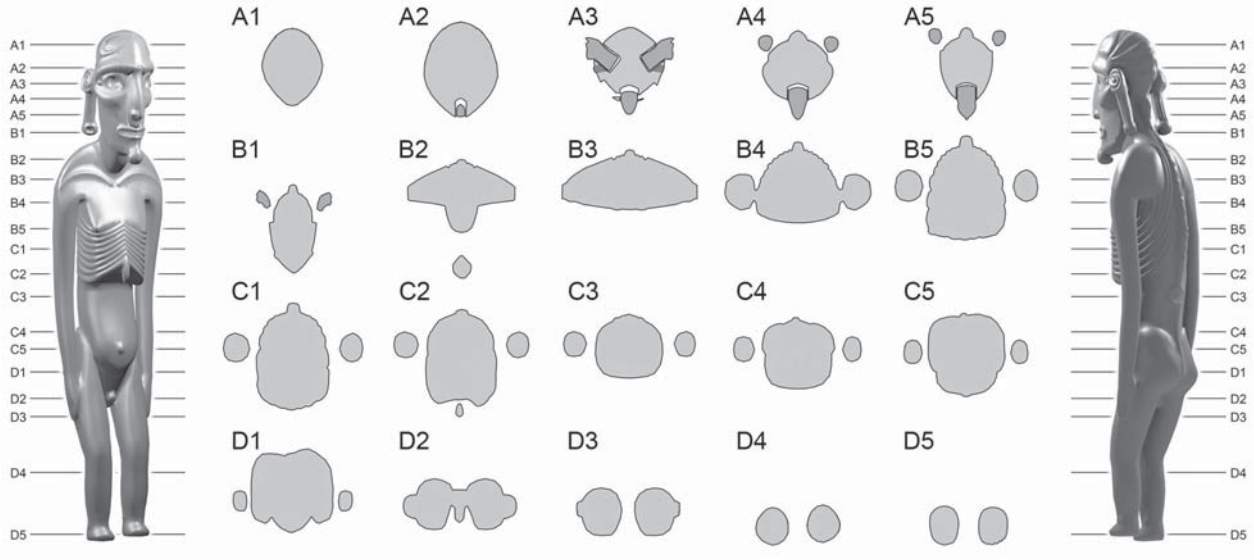

Figure 5. Computer model and cross-sections of *moai kavakava* P008 from the Collection of the Congregation of the Sacred Hearts of Jesus and Mary. The original wood is shown in lighter color, the prosthetic parts are shown in dark color. The sections are made at: A1) top of the head with cranial designs; A2) above the eyebrows; A3) eyes; A4) middle of the nose; A5) nose at nostrils; B1) mouth level; B2) neck at the goatee; B3) chest at the clavicle; B4) middle of the chest; B5) chest at nipples; C1) chest at the middle of the rib cage; C2) chest at projecting sternum; C3) at the lumbar ring; C4) at the top of the pelvis; C5) at the navel; D1) at the middle of the buttocks; D2) at genitalia level; D3) at fingers; D4) legs below the knee; D5) at soles of the feet.

area. The exaggerated vertebra profile is seen at the back. At the nipple level (Figure 5, B5) the ribs appear in the front of the chest; the ribs at the side of the body make elongated profiles by being practically parallel to the section plane in this area. The arm sections are elliptic. Getting further along the rib cage (Figure 5, C1), one can see the same pattern – the rib profiles at the front and the back of the body are narrow, while those at the side of the chest are wider. The distance between the arms and the body increases slightly. At the xiphoid level (Figure 5, C2), the rib cage ends with an abrupt and asymmetric cleft. The rib profiles are seen on the sides of the image only – the back is completely smooth at this height. The next section (Figure 5, C3) displays the flat front side of the stomach and the ridges denoting the lumbar disk on the back of the statuette. The elbows are located at the same height.

The pelvic girdle makes pronounced steps at the back of the *moai* (Figure 5, C4). The sacrum is carved much narrower than the thoracic vertebrae. The pelvis becomes completely developed in section C5; the asymmetry of the buttocks is clearly seen here. The belly of the statue becomes more rounded, with a protruding navel. An emphasized fold separates the belly from the pubic area with a different curvature (Figure 5, D1). The coccyx is marked in very low relief, almost disappearing between the buttocks. The arms (with slightly projecting wrist bones) approach the body. The genitals (Figure 5, D2) are considerably small but detailed. As they are invisible on profile photographs, we had to use three-quarter views of the statuette (Orliac & Orliac 2008a:126) to model this part. The hands merge with the hips at this height. The flat surface between the legs seen from the back side corresponds to the rear of the scrotum (see the back view of the *moai kavakava*, Figure 4). The fingers (Figure 5, D3) are denoted with shallow incisions. The leg section at the level of the calf is somewhat asymmetric (Figure 5, D4). Due to the difference in leg lengths, the section D5 passes through the central part of the right foot, which corresponds to the level of toes (denoted by shallow notches) of the left foot.

Conclusions

We present a feasible approach to model Rapa Nui woodcarvings with Blender software using a small set of photographs showing the principal view of the artifact. The accuracy of the model can be improved by increasing the number of the photographs involved. The obtained mesh features a moderate number of vertices (thousands, in contrast to millions obtained by laser scanning techniques), which makes it especially suitable for real-time visualizations. These may include virtual objects shown at exhibitions, virtual artifacts viewable online on web sites of museums, etc. The constructed 3D models were used to produce sets of cross-sections offering interesting insights on the geometry of woodcarvings.

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