The use of laser scanner for analysis of a longobard burial

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Abstract: The capacities expressed by the new systems of data acquisition also have a spin-off for the archaeological field, not only for objects of great dimensions, but above all for objects of small height in which the accuracy of the datum accuracy allows hints for new types of detail analysis.
Through the combination in the use of some software, often coming from different fields of application, we can think about laser scanning as a base on which to make a series of direct and indirect derivation data meet that is. Both a series of data proper to the analyzed object (e.g. the texturisation and the simulation of optoelectronics behaviours) and data derived from the study of the same object.
If from one side it is therefore interesting to be able to submit the single object to a detail analysis, impossibile up to yesterday, the most important spin-off from the scientific point of view is felt in the use of this study on a great deal of analogous finds in a systematic way.
From here the possibility to develop typological analyses also substantialised by a metrological analysis supported by the precision of the numerical datum.
The further benefit of an investment in such a search of this type is the ability to represent the analyzed objects in a dynamic and interactive way allowing both a more expeditious analysis from the experts of the sector also for objects characterized by a complex morphology and for a more immediate and comprehensible popular fruition for the vast public of non-attachés, too.
Therefore, the online popularization of VRML models and STL files allows both an interactive consultation, and also the possibility to stimulate the diffusion of the datum aside from its geographical position and its state of maintenance.

Keywords: Laser scanner, metrological analysis, vrml

Every archaeological find is poetry! But can we understand it?
If this consideration is clear for the sculpture group of Laocoontes or for the Ara Pacis, is it the same for the rest of the archaeological heritage?
We think that the ability of material culture to give us information is largely underestimated, above all if this ability relates to objects belonging to populations characterized by an essentially oral history.
Can we fill our “ignorance”?
As a matter of fact, if we know everything, or almost everything, about these populations’ history (dates, kings’ names, battles etc.), what do we know about the History Marc Bloch [1] defined with capital H, that is about the way the examined populations lived and thought?
Can our “ignorance” be filled so as to simply become a cultural gap?
According to us, every object produced in a certain cultural environment feels its own esprit du temps and it cannot but show it.

Going back to our initial comparison, probably we have eaten only into the first level of the meaning of poetry for most of the archaeological heritage that is that of evidence. But what would happen if we could also understand the second, that is the one about the mode of construction, if not the third, the one about the cultural approach?

We will have a less partial and definitely a more exhaustive understanding and what is more amazing is that we could have all this without increasing the archaeological heritage but simply by taking more care of it.

Mark well! We are not accusing archaeologists of indifference to material culture. On the contrary, we are asserting that if we need a deeper understanding of the data coming from an excavation, a multidisciplinary analysis of the datum itself is necessary and these competences are not very often typical of archaeologists.

What can we do? What competences can we bring?

A study case:

The use of laser scanner for the analysis of a female longobard’s burial

Fig. 1 - The couple of stirrup brooches.

Our choice has fallen on the longobard people for their peculiar history of migrant population with no writing.

The longobards were affected by different cultural influences during their migration from Scandinavia to Italy[2]. Moreover, the only evidences that came to us from longobard writers [3] of longobard origins are, anyway, fragmentary and written in Latin.

The choice of the funeral kit of the tomb number 87 in Porzano di Leno [4] is linked to the type of dowry of a longobard noblewoman and to the typicality of the snap fibulae found in it.

The laser scanner employed is a structured light COMET V.

This peculiar technology allows us to acquire objects of tiny dimension with a scanning-mesh, also due to the overlap of different scanning, of 0,05 mm with a margin of few microns. This let us acquire the objects with a degree of precision and accuracy that in many ways surpasses our ability of naked-eye analysis.

The cognitive aspects of a find as the stirrup brooch of Santa Giulia confront us with different problems concerning the return of the datum acquired through laser scanning technologies.

First of all the morphological complexity of such manufactured products demands a great expenditure of hardware and software resources for each of them and this is incompatible with a documentation that must be extended to a large data base, that is to all those finds that present similar typological features and, at the same time, variations to be estimated through a comparison among digital models. Moreover, the refined brooch project, rich in details not only about decoration but also about further workmanship such as restoration (joint plate), cannot be recorded in an exhaustive way depriving the digital model of the precious information necessary for a multidisciplinary reading of the handiwork.

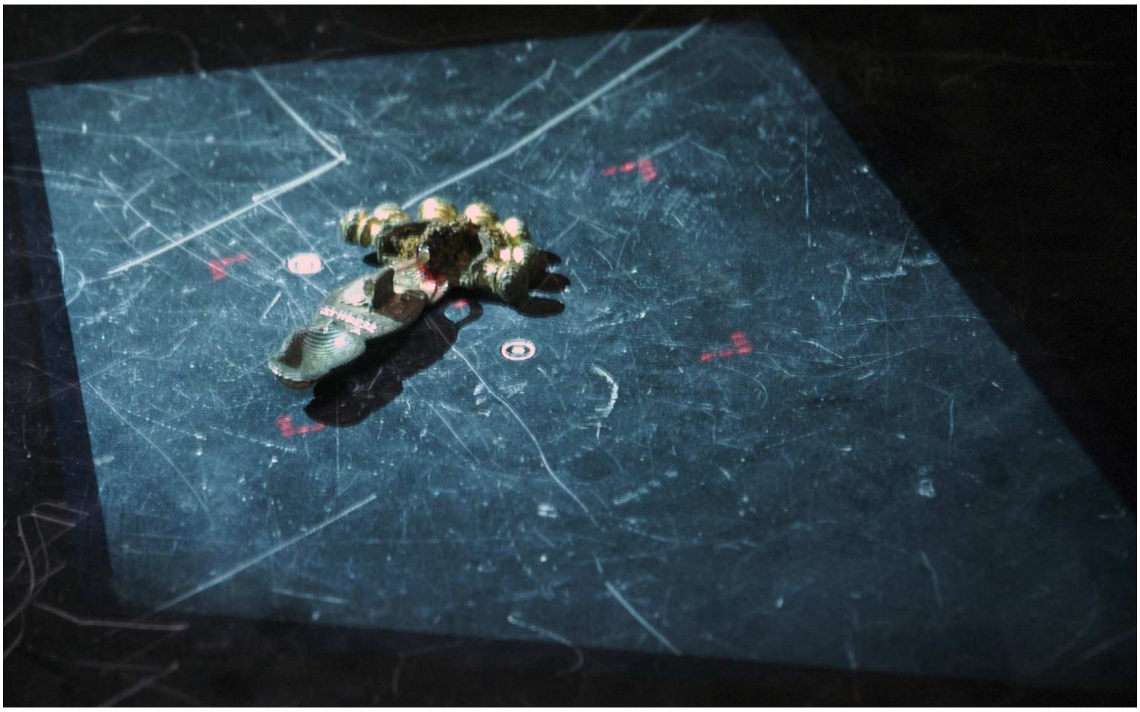
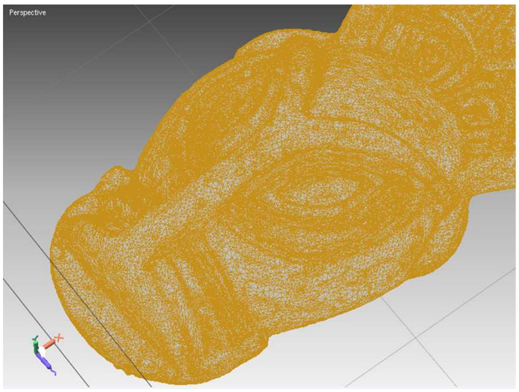


Fig. 2 - The acquisition of the stirrup brooch.

This needs all the accuracy typical of contemporary detection systems, but also the integration of the chromatic information acquired thanks to a specific campaign of photographic survey. Therefore, our goal is to make digital models able to store the maximum information with the minimum hardware requests, used to manage such models in real-time applications, multimedia applications and databases aimed at research.

After the model is decimated to make it compatible with 3D applications devoted to entertainment (texture editing, export as compatible formats for the web, etc.), the morphological detail of digital survey is usually integrated through bitmaps that technically need low-poly models. The result does not very often lead to the production of reliable documentations from the scientific point of view, because low-poly models have undergone drastic cut in the number of elements describing them (triangular faces).

Our solution intends to employ low-poly models able to store through three-channel bitmaps (RGB) both the morphological aspects in detail (lost because of the necessary decimation), and those of the diffused chromatic part of the object thanks to the use of software that does not belong to the field of digital survey. The problem of software, able to manage a great amount of information such as that concerning digital survey, is often to export reference systems for texture application as formats compatible with entertainment software. On one side, there are scanners able to colorize clouds with dots (except polygons) through the projection of a photo over them. Differently, we can apply photos directly on a mesh, but the employed UV reference system has a structure deficient in our representation goals.



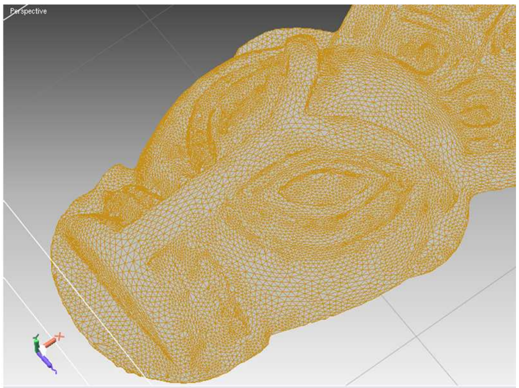


Fig. 3 - The high-poly model and the low-poly model.

To sum up, it seems that most of the digital survey software has as main goal documentation of the shape of an object, but not of its appearance because this aspect has a secondary meaning in many cases of digital survey application. Anyway, we consider these two aspects complementary to read a handicraft and we have charted a course that needs a series of passages, in most cases through the use of 3D applications taken out of survey context and belonging to the field of representation itself.

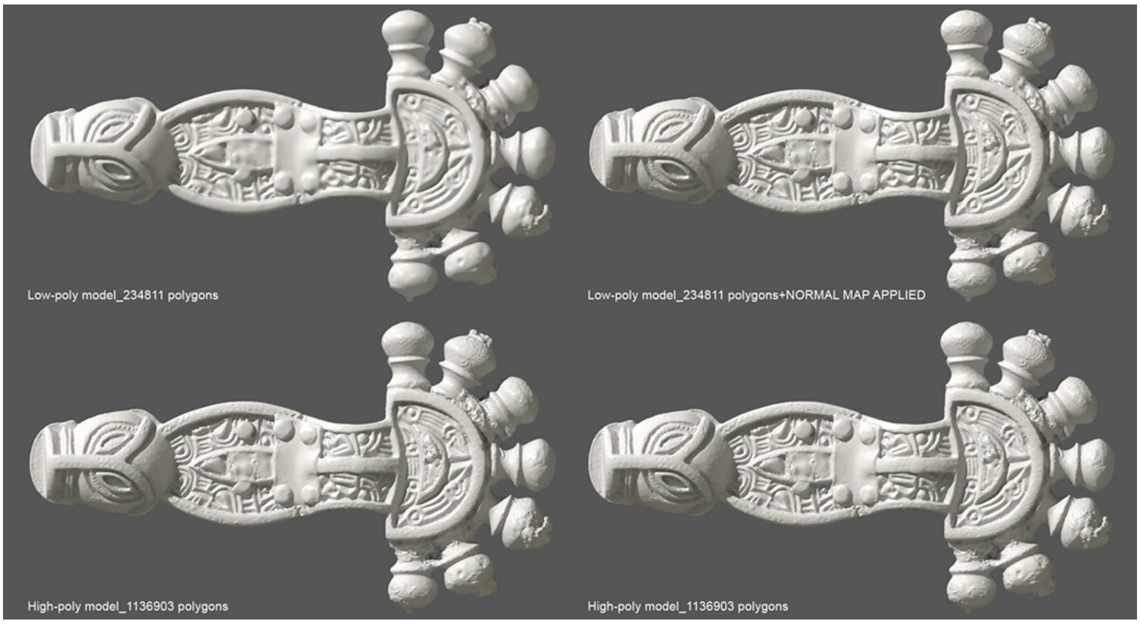


Fig. 4 - The comparison of the model low-poly and high-poly with the normal map applied.

First of all, we must foresee the utmost degree of elements our system can compute easily. After that we decide the high-poly model arranging the number of elements which describe its shape on the basis of the previous evaluation. At this point, we have two models: one takes up little space of our hardware, while the other is far more detailed but far more difficult to display because of the great amount of elements that describe it.

For the low-definition model, we will have to define a specific UV reference system where we will develop the 3D model in a two-dimensional reference system.

The UV system is useful as a base for two different projections that are basically two different render images based not on projections starting from a proper or improper point (perspective or orthogonal projections) but based on the development of the low-poly 3D model. This procedure is called “baking”.

Baking is carried out with two different criteria. The first employs the UV system to encode in a RGB bitmap the normals of the high-poly model. Once they are applied as a map of normals to the low-poly model, this will implement the perception of it restoring the perception of the high-definition model over a model with a far lower weight.

Fig. 5 - The stirrup brooch rendered.

The second baking is based on the employment of plug-ins of a matching camera applied to texturing based on camera or front projection, according to the term used by the software house. It is often useful to find in a 3D scene the exact point from where a photo has been taken so as to set it as a background for a 3D model of a new building.

Proper algorithms can calculate the vector that points out the position and inclination of the camera compared to the suggested scene starting from a minimum number of 6 parameters. Physically, the process consists in identifying a minimum of 6 corresponding points on the frame and on the 3D model over which you want to project again the taken photo. Once the virtual camera parameters are set, we will use this proper projection centre to apply the image on the low-poly mesh.

The baking derived from this chromatic datum will be made into a mosaic, as if it were a photo plan, with as many render images that will cover all the surveyed object on the whole. The combination of normal map and colour map, both based on a single UV reference system connected to the object, will allow to appropriate in a single model the general morphology of the handiwork, its superficial data (saved in the normal map) and the chromatic features necessary to near the perception of the digital model towards the reality. The possible applications of this method, which aims at eliminating confused texturing techniques used to empirically solve a problem of representation, are manifold from real time applications for the web to multimedia contents inside the specific situation of a museum and an exhibition.

The result of all this work allows us to obtain the nearest simulation to reality in order to submit the object to the entire series of analyses that, if directly done, could be damaging.

The analytical abilities the modern archaeometry offers to us are for what concerns the chemical-metallurgical part much less invasive than in the past. In fact, we can submit the objects to a more superficial analysis without compromising the object itself since the necessary samples are of some tenths of millimetre size.

It is evident that the production of digital models is oriented more to the proper metric and component analysis of the object studied than to the chemical-metallurgical analysis.

For what concerns the specific case of our study, the use of laser scanning with its metric and zoom potentialities has highlighted some features that were not evident at first. This stirrup brooch of VI century A. D. is a traditional production object for the longobards and not only for them [5].

We can almost say it is an object of serial production. In fact, as it is melted in a mould, it can actually be similar to others. Therefore, the production of such a precious object as the stirrup brooch at issue was not impromptu, but it was based above all on a compositional tradition well established by then through a reasoned and mature project and drawing. Submitting the scanning to a modular analysis, we can extrapolate some data that are, in our opinion, interesting and not banal.

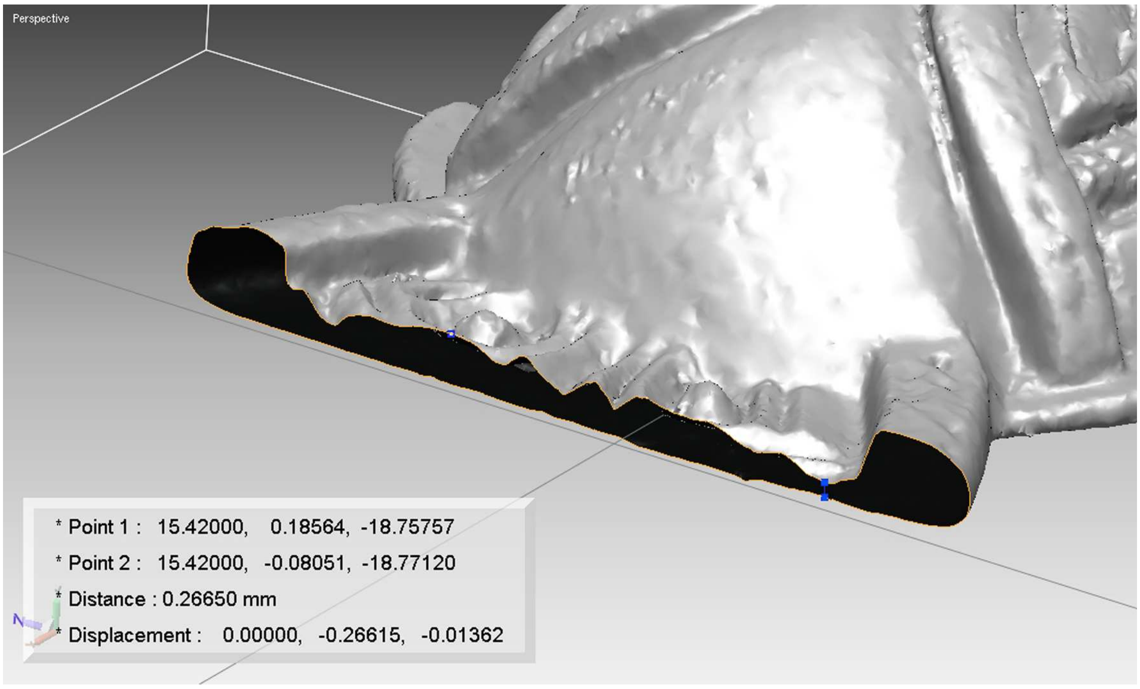


Fig. 6 - The longitudinal section of stirrup brooch.

First of all, if we consider the ring nut of the frame as base module, we can notice that the length of the entire object is composed of three modules. The structure of the ring nut apexes is equal to half a module if we consider the intrados of the ring nut.

This modular structure cannot be the result of chance, but rather of a traditional rule of the goldsmith's knowledge[6].

According to us, this modular system is subordinated to the production technique of the object itself. Unfortunately, the brooch has not been x-rayed yet, but simply starting from the analysis of the scanning, we can do manifold remarks about the construction technique .Let's start from the essence of any brooch, that is the tongue. As this is the most stressed structural element, it was made of metal. Its presence for over 1500 years inside the burial completely corroded it. Anyway, a significant trace of it is present in its junction to the body of the ring nut.

In the intrados of the ring nut, we can also notice many other excrescences caused by rusty efflorescence. Anyway, they do not come from the tongue but from the apexes where they were riveted on the body of the ring nut.

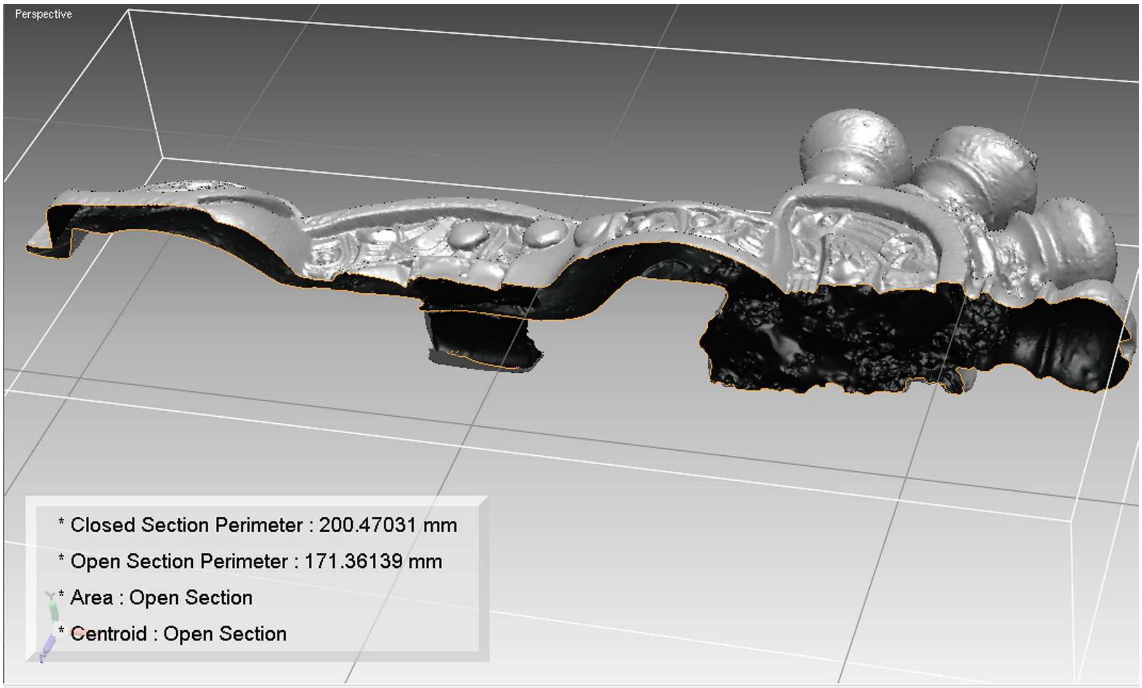


Fig. 7 - The vertical section of stirrup brooch.

But the external appearance of these apexes is bronze. Therefore, it is clear that these apexes have an iron core[7] that afterwards was dipped into bronze or more probably the apex was made of bronze and after that it was fixed with a cylindrical iron rivet. This hypothesis is supported by two details. As a matter of fact, where the riveting was made and the external layer was damaged, there is significant unequal rusty efflorescence in every apex. Moreover, the apex head has a small dimple. In this case, too the rusty efflorescence was present only in the apex heads, which had not been well sealed with bronze later.

(In this specific point we can notice the typical mushroom rusty efflorescence).

Starting from these observations, we can deduce that the brooch body is made of iron, too, as long as the x-ray does not confirm this. On the contrary, as the external appearance is bronze, we must investigate if this is due to a simple bath or to a real second casting poured around the iron core.

Further refinements of the aesthetic appearance are due to the embellishment of the brooch with a superficial golden layer in its decorative aspect both geometric/abstract and zoomorphic/stylised.
In the end, the object was further enriched with some inserts in glass paste.
During the life of the object, a traumatic event happened which caused a crack in the weakest point of snap fibulae that is on the junction between the base and the arc itself. The object was precious enough to deserve a division instead of being melted again to get the metals back. This was probably a habit in this kind of society, and generally all over the ancient world, to hoard capitals with family jewels handed down from generation to generation or objects given as a present by important guests.
The repair was made with two silver plates, which secure the stirrup brooch with rivets.
In this way, we can notice that behind a "banal" object such as a stirrup brooch [8] there is a complex producing process that implies a hand-crafted ability that comes close to the artistic one and a competence in the use of materials that reveals experience and ancient knowledge. If we think about a migrant population that "does not let" its smith have a stable forge but a transportable one, we can understand how the manual-artistic skills of the craftsman were higher than what we could have imagined, considering the few equipment he had at his disposal [9].

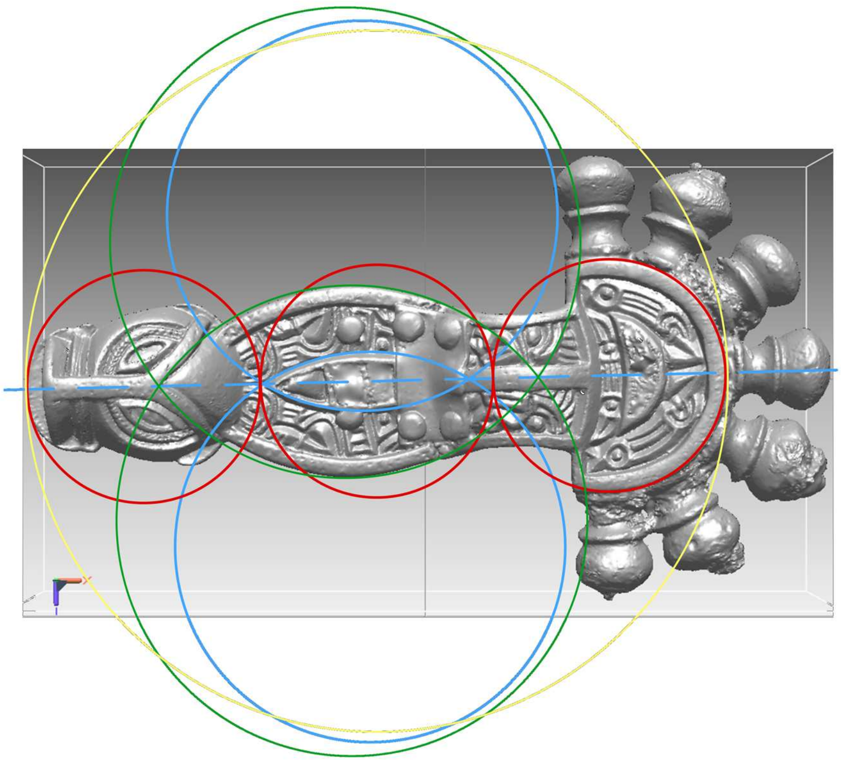


Fig. 8 - The modular system of stirrup brooch.

Submitting the archaeological finds to laser scanning allows further more to create a low-poly model conceived for didactics. In fact, if the visit to a museum were presented through a series of interactive tools[10], undoubtedly more appealing for a young audience than an ex-cathedra lesson in front of a display cabinet, the communicative aspect of the school trip itself would be largely increased. This would let the student/visitor handle the objects on display directly, even if only virtually, see the hidden side of them and interact with their functionality. It would be interesting if starting from the virtual model, we could invest in prototyping the object on display and in this way give students/visitors, but also partially-sighted people, the possibility to get to known the morphology of the object itself through touch.

Moreover, the production of a high-poly model, that is the one directly produced by scanning, will improve the artistic skills scholars offer. As a matter of fact, the scholar could compare the sections and morphology of the object with endless others, but he could also compare pieces that cannot be moved and belong to different varieties by decomposing the object into bits and through the overlap of high-poly meshes also check if two or more melting objects derive from the same mould or they simply have a similar typological structure but no objective connection.

What are the possible results of this study?

First of all, from any brooch on display in a museum at present, we have obtained a small data bank of information. We agree that most of it is only hypotheses that must be corroborated through chemical-metallurgical analyses.

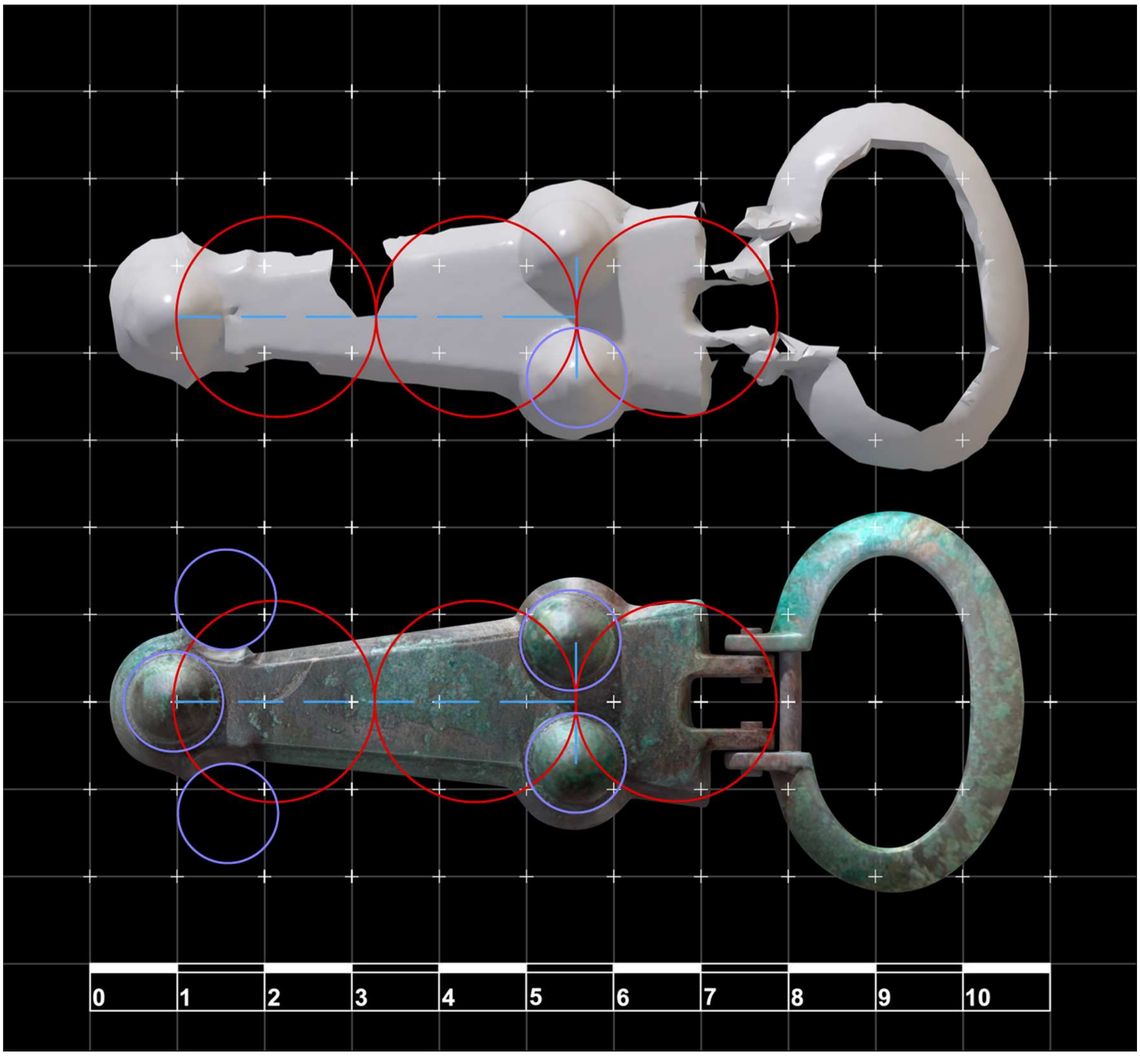


Fig. 9 The same module on another longobard brooch.

Then, we can suppose we have a first way out of this single object with an expansion of the analysis spectrum and consequently a check and a new formulation of the hypothesis suggested so far.
In our opinion, the most interesting solution is to enlarge the statistical base with the same integrated survey methodology that would allow us to process some statistics with a sufficiently wide base to have a general and not precise nature. This probability would broaden our understanding of the two levels of interpretation of our “poetry” and would open great glimmers over the third level, too.
Moreover, as the longobards were a clan-based population, we could identify some primary features of every single clan and also describe the history of their migration to Italy and, generally, of their migrant track.

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[1] See March Bloch, Apologia of History, Turin 1969.

[2] Their descent from Scandinavia passed through Denmark (I A. D.) to low Germany. Then they settled in Pannonia in V/VI century A. D. and finally reached Italy in 568 A.D.

[3] The most important is undoubtly the “Historia Langobardorum” by Paolo Diacono but it is late and incomplete.

[4] This necropolis so important for Brescia is characterized by burials of the 1st, the 2nd generation at most.

[5] The stirrup brooch is an object common to all the populations that appear at the Roman border in the present low Germany from III to V century A.D. For the typology of stirrup broochs, I will bring to your attention an exhibition at the Archaeological Museum of Basilea open till the end of 2008, which tries a first cataloguing of the repertoire found to this day.

[6] Just remember that in every ancient society, the smith was an important figure who, however, kept his art secrets jealously inside his workshop.

[7] The use of iron cores is due to the less laboriousness of the casting and to the more elasticity of the material itself.

[8] From the longobard world we have found hundreds if not thousands of them. In the ancient Germanic world there are thousands of them.

[9] In order to know what equipment a barbaric smith had at his disposal, see the content of the Herouvillete burial of the half of the VI c. A.D., now kept in Caen, France, Musée de Normandie.

[10] An interesting application of these new technologies for archaeological didactics can be seen at the Virtual Archaeological Museum of Ercolano (Naples), Italy.