

## VISUALIZATION OF THE ARCHITECTURE THROUGH SIMPLIFIED MODELS: STRATEGIES FOR KNOWLEDGE SHARING PIEVE A SOCANA, CASENTINO, TOSCANA.

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### ABSTRACT:

The problem of the quality of architectural representation, in a dynamic use finalized in web or database publication, represents the main theme of the current debate regarding the ways in which to share knowledge between different disciplinary fields. Starting with the surveying operations with the *laser scanner* technology, it is possible to obtain complex three-dimensional models that, through the three-dimensional photogrammetry and UV mapping systems, are integrated in a useful model for various studies. The numeric models, however, that are characterized by a high level of detail cannot be used in web navigation; the restitution of formal, dimensional and chromatic data explain a communication problem linked by the expansion of its users and the quality of the information transmitted. Therefore, the construction of a web site that organizes the acquired and elaborated materials require two different categories of models: one linked by immediate web navigation and one in high detail that is capable of accurately describing the studied object. In such a system, the three-dimensional models become instruments of immediate visual communication, providing many *links* for in-depth examination. The diminishing of geometric information is substituted with maps that represent detailed and embossed maps. The normal-map are capable of increasing the perceptive quality of the low-poly models because it can substitute the normals of the model with the one obtained by RGB bitmaps that associate the components of the normal vector to the faces of the detailed numeric model with these three canals.

The synergy use of the PHP language, database MySQL and VRML allows for the creation of a web site that gives the user the opportunity to study the object differently, visualizing the outcomes in real time.

### INTRODUCTION

Technological fields that are seemingly distant, if put into relation on the basis of a well-defined objective, can give rise to new research possibilities and development, placing themselves in antithesis in respect to consolidated cliché cooperatives.

The process carried out beginning with the *laser scanner* of the Pieve of Socana provides new engagement possibilities of methodologies of representation and communication that originate in scientific fields that are very distant which, operating in synergy, offer the attainment of new quality standards.

The process of the metric datum acquired by means of the current laser scan technologies cannot forgo successive and onerous procedures, which as it is noted, eliminate the geometry of the objects surveyed in order to render them publishable in *real time* applications or dedicated to *renderings*. The numeric models discriminated are essential in order to render the results usable in a survey through the network, however, the procedures that currently manage to obtain such computations, cannot forgo the use of the *bitmap* in the integration of the geometric information; therefore the perception of the "arrangement" of the building device or of the apparatus must be implemented by means of the images that, in a different way, integrate geometry and chromatic datum.

The most significant developments in the field of the creation of simplified models, however capable of conveying an elevated number of information, are tied to the entertainment industry that notoriously produce software based on criteria that is very different in respect to the system of processing datum originating from the digital survey campaign.

Different approaches, at times clearly diverged in respect to the theme of representation, constitute a serious problem in respect to the operative praxis that, in the case of the object, have brought about the stabilizing of the criteria of new restitutions in order to use diverse technologies in respect to the current standards of modeling and *texturing* in the field of cultural goods. In the practical application in the case study of Pieve of Socana, the combined use of surfaces of subdivision and *normal map* has, without doubt, provided an alternative answer in respect to the current cliché of restitution in the field of cultural goods, with particular regard to the interactive applications and to multimedia elaborations. Surpassing, in this process, the confront with overload of information that characterize the model from the point clouds, a web model was created that allows for the direct and visual reading of the architectural object in its complexity on a diverse, detailed scale and, also the material and stratified data that is readable on the wall texture; lacking such detailed information, that constitute one of the substantial peculiarities of the object, the reading of this architectural object could result partial and incomplete, especially in the optic of the researcher that wants to render the object one of speculation and critical analysis.

### THE CASE OF STUDY: OPERATIVE CONTEST

Settled near the intersection between important directions of the ancient and medieval viability, the Pieve of Sant'Antonino in Socana, in the commune of Castel Focognano in the Casentino area, the testimonies of the diverse civilizations that have existed in the valley are found within its structure. The current building, that extends only half of its original distance (as it is

seen in the moving back of a later façade), has three naves divided by rectangular pillars and ample arches in the first two spans and by a nearly square sectioned pillar in the third near the apse and of a reduced size in respect to the preceding ones; a large apse concludes the central nave. *“The wall texture of the apse, in the lateral position and at the level of the last two pillars is formed by alberese stone block well squared-off and flattened that is formed by horizontal and parallel lines. The other pillars and the respective arches are formed by arenaria stone blocks”*: Gabrielli has convincingly recalled attention on the different existences in the materials and in the wall technique between the zone of the first two spans and that of the second span, near the apse, identifying two different constructive moments: the first phase, for the apse, the third span and a part of the perimeter walls, attributed to the 12<sup>th</sup> and 13<sup>th</sup> century, the second phase, for the zone of the first two spans, attributed instead to the end of the 13<sup>th</sup> and 14<sup>th</sup> century. Until the present the dates have been thought to be anywhere from 11<sup>th</sup> century (Secchi, Scarini) and the 12<sup>th</sup> century (Salmi, Fatucchi, Bracco). The restoration work have highlighted, during excavations, the extension of the original layout articulated in six spans that are formed by pillars. For this last version of the Pieve (Socana II) it is a likely hypothesis that the reconstruction of the building, as in many other cases, initiated in the zone of the apse and proceeded slowly toward the facade substituting the previous Pieve (Socana I). In fact, the excavations of 1968-70 highlighted ulteriorly the rest of the previous church, found under the existing building and of the same dimensions, however, with three apse and three naves, formed by columns and divided in nine spans. Such a building, of which erratic discoveries were made during the excavation work, is attributed to Salmi at the beginning of the 11<sup>th</sup> century. Also connected to this first building, even if at the end of the 11<sup>th</sup> century, is the isolated cylinder bell tower (with a mixed wall parameter of stone blocks of arenaria, alberese stone and some fragments of brick), are placed vertically from lesene created with slabs of arenaria; the upper elevation is composed of polygonal sections and is a posterior addition. Still at a more inferior level than the rest of the church of the 11<sup>th</sup> century, the traces of a great Etruscan temple was discovered inside that extended beyond the the apse of the current church: on the exterior of this building a sacrificial alter was found. Such a multi-layer context leads to the multi-discipline examination in which the survey is a fundamental moment, both for critical interpretations that arise and for the finalized instrument in the elaboration of all the acquired information. In the specific case the operations of surveying of the complex, still in progress, were conducted integrating the data provided by the laser scanner survey, by the topographical survey, and the elaboration of the orthophotoplane. Contemporarily, autoptic readings were conducted on portions of the wall, in order to define the main characteristics and to evaluate the reciprocal relationship.

#### **FROM THE SURVEY MODEL TO THE SIMPLIFIED MODEL: INSTRUMENTS AND METHODOLOGY FOR THE DOCUMENTATION OF THE ARCHITECTURE**

##### **The subdivision surfaces and the generation of smooth surfaces beginning with arbitrary mesh geometry**

The informative models are subdivided in categories that refer to specific construction techniques of such topologies; these are referable to specific fields of use that, as is noted render the operative flow associated with various forms of restitution more

rational and manageable. The specialized literature has distinguished the modeling systems dedicated to architecture in two principal families: numerical models and mathematic models.

In recent years, many *software houses* have invested heavily in the implementation of a “hybrid” form, between the *nurbs* models and polygonal models constituted by the surfaces of subdivision or of Catmull-Clark. These surfaces are an alternative to the *nurbs* modeling that have made possible the utilization of arbitrary mesh topology as an instrument of control and of modeling of the *B-Spline* surfaces. In addition, the UV mapping systems, once associable only with mathematic models, are extended also to numerical models, rendering the texture application obsolete by means of planar, cylinder, and spherical projections.

The CC comes from a very distant field in respect to the CAD design for which, as often happens in these cases in which software is transferred from one field to another, we find that there are advantages as well as problems of practical and methodological character. The initial material with which we began was the point clouds of the Pieve di Sant'Antonino a Socana, acquired during the survey campaign completed in February 2007. The mesh model, obtained from the survey carried out using the Leica HDS 2500 laser scanner, shows characteristics that are not perfectly able to describe in detail the complex material articulation of the wall texture of the Pieve; however the objective that we set is to obtain a model that is capable of describing the architectural building in its complexity and its stratified situation, channeling the information by means of an optimized model capable of describing the analyzed object on a varied scale of representation. Choosing the subdivision surfaces leads to the inevitable choice of congruent criteria with this technology to which it is referred in virtually reconstructing the object; the familiar categorization (numerical number/mathematical number) indicates, aside from the informative aspects, the fields of advantageous use that often exclude the possibility to model the real object outside of the realm of metric certainty of which the truest model is still the point clouds. It is for this reason that we opted for the creation of detailed yet “regulated” model, because it is necessary to describe the beginning with a very limited number of elements is implicit in the restitution form utilized, although it could be said that this characteristic is the highest quality of the surfaces of subdivision. However, in order to better comprehend the reasons of a “geometric” model it is essential to understand the functioning of the surfaces of subdivision that, in the recent implementations of software dedicated to *computer graphics*, take the name of the two principal developers: Catmull and Clark. In effect, there are many criteria of the subdivision of the mesh topology that exists; the principal criteria are Catmull-Clark and Doo-Sabin, both are capable of subdividing geometries constituted by triangular polygons, quadrangular and n-gons, or more precisely, polygons with more than four sides. One or the other involve the passage or less than points of control of the initial mesh therefore in the field of a restitution, the utilization of an algorithm of the inter-polar type such as that of the CC implicates evident problems because, since we are not being able to model a surface beginning from the surveyed points, we must find a criteria that allows for the non-empirical specification of the vertexes of control of the CC that minimize the difference between the subdivision and the mesh of the survey. In the field of a comparison in respect to the *nurbs* surfaces, the necessity to plan the construction of the model creating a utilization that is diverse from the passing sections on the mesh obtained by the scans is evident: in the case of the

nurbs, the completed sections appear on the outpost of the surveyed object, therefore they can be super-imposed on operations of extrusion, revolution, loft, and so on, prior to the reconstruction of the curves on the basis of the allowances that are capable of eliminating the presence of “noise” due to the accuracy of the instrument.

In order to obtain the adherence of the CC with the outpost of the object, it is necessary to “recalculate” the vertexes of control of the single curves with the polygons that are super-imposed to subdivision. The CC guarantee, for every point of the surfaces, continuity of tangency and of the curvature if the mesh is constituted of quadrangular sides (otherwise for triangles and n-gons only the continuity of the tangents is verified); in effect, the objective of the programmers was to arrive at a bi-cubic B-Spline surface through the utilization of geometries of great simplicity that would exclude the use of spline generators and conductors in order to create a surface containing multiple curvatures. The criteria of the subdivision of CC is based on simple geometric rules that lead to the addition of vertexes and to the subdivision of the existing polygons in a process that can be reiterated by the user in order to obtain perfectly smooth surfaces. The fundamental steps in the subdivision of the geometry are the following three:

-For every face of the initial mesh a new point (face point) must be added that is the average of the positions of the four vertexes and that defines the face itself.

-New points are generated on the sides (side points) that are calculated as the average of the average points of the original sides with the new point side of the sides that share the share on which we operate the subdivisions.

-The position of the new vertexes is calculated based on the formula (1) that represents the average of the following factors: F, R, and P:

$$\frac{F + 2R + (n - 3)P}{n} \quad (1)$$

F is the average of the new side points of all the adjacent sides to the old vertexes.

R is the average of the average points of all the old sides coinciding in the old vertex.

P is the old vertex.

The CC can transform any arbitrary mesh topology into smooth surfaces constituted by quadrangular polygons that, at every subdivision, are verified also in the continuity of the second derived.

#### **Simplified models and the maintenance of the appearance: mapping systems based on the normal map**

The optimizing of the geometries that was rendered necessary in the field of *real time* has brought about the development of solutions that integrate the detailed geometry without depending strictly on modeled geometries; the *bump mapping* is an example that, thanks to the use of the scale in gray, or more precisely to a channel, allows for the simulation of surveys that, if modeled, would risk overloading or delaying GPU and CPU. The perceptive limit of such a solution has a double nature: on one side we have the apparent contour of the object that, depending on the number of the actual polygons, can show an excessive geometric approximation; on the other side have a established limit of the *bump mapping* that, varying the process of the standard of the polygons effectively belonging to the simple model, can only confer the variation of the intensity of

the single elements. Therefore the information conveyed by the *bitmap* to only one channel are inadequate in the presence of the geometries that are greatly discriminated that must represent significant variations of the curvature. The *displacement* maps operate differently since they model the geometry of the surfaces upon which they are applied on the basis of the variations of the provided data of the *bitmap* on gray scales. In this case, an image provides the high metric data to a geometry on the condition that this can be adequately subdivided (*nurbs subdivision surface*). This solution can be used in fields that are distant from the visualization of the interactivity or to the rendering of an enormous quantity of geometry. The quickness and consistency of the representations are very difficult to reconcile in the field of the restitution of historical architectural objects; these objects, which enriched with details from the elevated complex geometry, render difficult the optimizing and the contemporary maintenance of the essential quality in the elaborations that are traditionally utilized in the communication of the architecture, therefore if on one side we can commensurate the creation of a virtual interactive space to the amplexness and to the monitor resolution or pre-calculate under the form of animation we must establish a form of progressive abandonment or if we want to renounce, we hope only temporarily, in respect to the complex restitutions of plans, prospects, and sections that can be obtained in the digital model that is the base from which to begin in the overall strategy of communication in continuity with the classic codes of the architectural representation. We know that the canonic restitution of architectural and archaeological buildings cannot forgo a preliminary phase of planning in respect to established objects of communication that currently find the interesting opportunity perceptual and useful implementation with software technology provided by *real time* that should become, in the near future, the standard upon which the combined criteria of modeling and texturing finalized by representations of particular complexity will be based. In such sense the *normal maps* constitute a form of alternative and of evolution in respect to the usual *texturing* systems, evading empirical forms of restitution based on discretionary criteria through coded and repeatable operative procedures. Possible advantages, but also new requirements for the planning of the operations of modeling in which the management aspects consider the foundation and the efficiency of the normal maps in combination of modeling and relative UV systems are put into effect on an operative level through the creation of two models: one that is densely detailed and modeled from the beginning or produced with a laser scan, and the other greatly eliminated (by means of specific algorithms of reduction of the number of polygons or through local interventions of the reduction of the geometry). The first model provides the second, by means of a three canal bitmap (RGB), the process of the normalities of the polygons are projected utilizing the *vertex map* UV associated with the simplified model. The principle upon which such a technique is based is constituted by the translation of the three components, XYZ, from the normal vectors to the polygons of the dense model, in the three components RGB in a bitmap completed by means of *baking* of the discriminated model. The models of the surfaces of the subdivision appear and continuous and “polished” with less complex *software* in respect to *nurbs* that, in addition to being more difficult to manage in the *meshing* phase, they give the created object a greatly geometric aspect; it is for this reason that the normal maps extracted from the surfaces of subdivision result perceptively more efficient in respect to those that are provided by the mathematical models in low resolution under the form of polygons. However, forgoing the technique of representation utilized in the

completion of the model, the systems based on *normal mapping*, in respect to those with survey maps in a gray scale, allow for the obtainment of solutions of *shading* much more efficient, as they substitute the existing normalities, more precisely, those of with the polygons of the *low poly* model, allow for the utilization of efficient photo-simulations. In the field of the study conducted on the Pieve di Socana, we conducted a series of experiments on the *normal maps*, beginning with the data acquired by means of systems of laser surveying. The tests carried out on the *normal maps* created by restitution models under the form of the surface of subdivision demonstrated a significant containment of calculation times necessary in the *rendering*, though maintaining the qualitative level unvaried from the *shading* in respect to the complex model. However the more interesting aspect is constituted by the possibility to work on the geometries that are reduced in such a way as to render possible the execution of the complex three-dimensional reconstructions of architectural buildings otherwise unmanageable in the field of *software* dedicated to visualization.

### Management of data and visualization systems

Parting from the supposition that an in-depth examination of a complex architectural object must be with an interdisciplinary approach, the focus is placed on the structure of a functional system, and not only on the classification, but also on the mutual interaction of a quantitative order of information having a heterogeneous characteristic. Such a system, for our intensive purposes, must respond to the necessity to unify the relational possibilities of a database with the intuitive and multi-perceptual three-dimensional graphic field. The topographical data, the laser scanner point clouds, the photographic images, the texts, and all other information collected during the research process were inserted into an easy consultation container specifically created in which the three-dimensional graphic model constitutes the favorable interface with the user at diverse resolutions. During the elaboration, in order to homogenize the content, it is convenient to meet a series of conventions and of standards, in order to guarantee the most ample availability on the WEB. It is the Internet network itself that defines such standards and that proceeds to the introduction of new languages, oriented to the implementation of new functionality and to the use of other media. In this field, the activity of the W3C (World Wide Web Consortium) is fundamental, which has the objective of improving the existing protocols and languages for the WWW and aids the WEB in its potential development. In anticipating the publication and the sharing of information on-line, the utilization of a common language for everyone that use the databases, for example, SQL1, that allows for the utilization of open source programs such as DBMS (Database Management System), has become necessary and is useful in the creation and in the manipulation of data banks available to many users or in the use of a language, such as PHP (Hypertext Preprocessor) that is now wide-spread and used in the creation of dynamic web pages. Another requirement for which a database was conceived for the communication and the sharing of knowledge is the necessity for organization and the need to be scalable, or more precisely, to be capable of being updated, adequate, or wide-ranging in relation to the development of the research project. In the case study introduced the structuring of the database by means of a hierarchically system organized in Units of

Reference was therefore proved functional. Here we are dealing with the division of a complex building into smaller units that have the characteristic of a functional or structural homogeneity and are studied on a progressively rising analysis. This is a consolidated praxis in the disciplines of archeology and of architecture, both during the excavation activities and the stratified studies regarding of the walls and that demonstrate efficiency under many perspectives. Firstly, this allows for the operation by means of analysis of high resolution details aimed at the possibility of conducting the stratified reading in an extensive manner without losing sight, however, of the general characteristics and the structural outline of the building. In addition to this subdivision it is easy to progressively update the information, for example with the simultaneous activity *in situ* in diverse operative units.

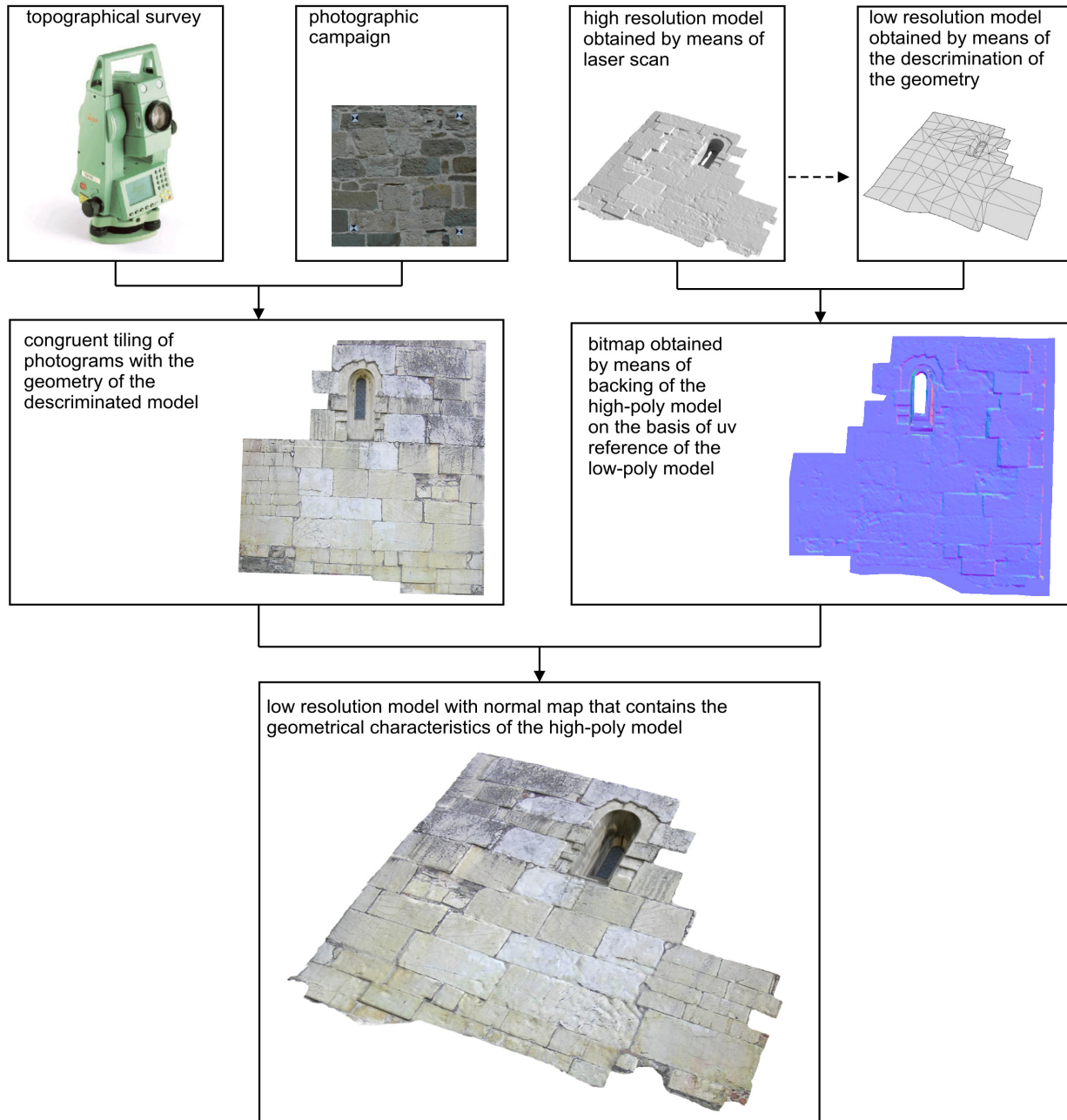
In the presented case, although one of stratified analysis of the walls is not the only study to conduct, such a subdivision in Units of Reference is useful to conserve, maintaining a strict tie between the hierarchy of the subdivision and the level of detail of the digital works that were completed. Also this allowed for the introduction of a macro scale at a territorial level within the reference system, with the objective of gaining access to information regarding the contexts or the similar architectural realities in the sub-regional field. This subdivision in reference units is not the only form of consultation of the *database*, as it can be studied also through the traditional characterization of the fields and themes. In order to allow for a rapid visualization by means of the WEB, the formatted cards in the phase of planning of the site, image content, texts, and 3D models regarding the studied object are referred to and the system of three-dimensional visualization is that of the VRML language (Virtual Reality Modeling Language) that was designed for use on the web for 3D interactive graphic representations. Such a format utilizes a simple textual format, within which the geometric characteristics of the visualized element are described. In addition, it is possible to associate graphic elements of the URL file with links to ulterior pages.

### Conclusion

We know that the highest is the technological gradient constituted by the procedure of the survey and the processing of the datum, most importantly there is the need to manage critically the attribution of sense to the acquired information.

For these reasons, it is necessary to provide systems that are capable of selection, structure and relate the acquired datum in synthetic and isomorphic processes with the perceived reality, and finally to render it available for the surrounding scientific community and for those who intend to document and study distant objects in space.

Undeniable, regarding this subject, is the efficiency of the systems of the virtual reality with which the use of the 3D models implemented by means of systems of normal maps offer the possibility of verifying in real time, through immersive situations, a plurality of aspects favoring multiple and dynamic perceptions of the object through intuitive approaches in which the geometric information is integrated by means of these new three-dimensional texturing and modeling instruments.



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