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RELIEF AND DOCUMENTAL REPRESENTATION OF MOSAICS TO SUPPORT THE RESTORATION

The relief and representation techniques concern big sectors of architecture and archeology.

Here we give particular importance to mosaics, in relation to specific researches led in recent time over the mosaics of the San Marco Byzantine Basilica floor in Venice ¹ and on the Villa with peristyle of the Mediana archaeological complex.

The mosaics

The mosaic art was considered an inferior art in old times, and, until when it was not recognized as an artistic art such as other representation forms (picture and sculpture), the restoration was limited to a simple renovation of the damaged surfaces.

¹ San Marco is made on the model of the Apostoleion (Saint Apostle's Church) built by the emperor Constantine in the IV century with the probable aim to make a mausoleum for his family. Constantine died in 337 in Nicomedia and his body was carried to Constantinople and buried some years later in the Apostoleion. During the reign of Justinian and Theodora, two centuries later, the temple was completely restored by the architects Isidoro of Mileto and Artemio of Talles. After its partial destruction made by the crusaders in the III century and the consequent pillaging of treasures and relics, mostly gone to Rome and to the San Marco Basilica in Venice, it occurs an earthquake in 1328 that destroyed the entire mausoleum. Reconstructed by the emperor Andronicus II Paleologo at the end of the XIII century, it never reached again its splendour and the significance of the past time. It was in this way almost forgotten and destroyed by the sultan Mehmet II in 1461, who built on its ruins his mausoleum, the so called Conqueror's Mosque. The basilica map was a Greek cross, with 5 cupolas, a biggest one in the centre and the other four each at the external part of each side. The altar was located under the central cupola. A columns line at the matroneum floor formed a gallery called Cathacumena. We have these information from the descriptions of Eusebio, F. P. and T. A. and especially from the poem of the X century of Constantine of Rhodes entitled Description of the Apostles' building written in honour of the emperor Constantine VII Porfirogeneto.

The mosaics are seen as the decoration of an architectural surface of small stones, of small pieces of baked clay or glass pulp, put over or well fixed on a plaster, externally forming a sleek surface mostly well decorated with geometrical or figurate representation.

The word *mosaic* has an uncertain etymology but it probably comes from the Greek word *μουσα*, it appears in Roman literature and, more precisely, in the *Scriptores H. A.* and is attributed to Spaziano on the Pescennio Nigro's life, in a verse where the emperor portrait is called *pictum de musio*.

The precise indications for the construction technique of a floor mosaic that we have from Vitruvio and Plinio are confirmed in a big quantity of original documents. The mosaic underlayer has to be made by 3 different strata to be put on the floor well planed and strengthened: the *stratumen*, a big cobblestone conglomerate, then the *rudus*, about 25 cm thick, made by three parts of cut stones and one part of lime and at the end the *nucleus*, the cement stratum of about 12 cm, made by three parts of pebble and one part of lime.

The surface of the mosaic tesseras, that are fixed on a light superior plaster stratum, was smoothed and in this way it was made compact and resistant by a final buttering made by marble dust, sable and lime. The general rule was that the artists looked for the materials for their mosaics first of all where they performed them, for the colours not existing in natural stones they had to use foreigners materials, and pieces of stones and important marbles could be used in the finest mosaics of big artistic centers.

We find glass tesseras already in the most antique mosaics, but, San Marco, for example, which was started to be constructed at the end of the first millennium, was influenced by the fashion of the end of the antique times, that is a carpet mosaic with all the surface covered by geometrical motifs such as squares, rectangles, rhombuses, octagons, hexagons, semicircles with a lot of subjects in each geometry.

The mosaics performance techniques of the oldest times are the *opus sectile* (made by the junction of marble pieces of different colours that form various geometries) and the *opus tessellarum* (made by very small pieces of marbles and glasses that created animals or flowers figures).

The mosaic relief and representation

The different features of the studied mosaics have led to the application of relief and representation techniques that include big difference between them.

The costs pulling down, due to the change from the optic-mechanic instrument to the informatic photogrammetric process, has improved to the diffusion of photo-metric representation techniques with a photography measurable in different modalities afterwards illustrated: rectified images and orthophoto 3D.

The final photographic elaborate, integrated with the traditional vectorial restitution, is today a rich information support that can be employed for different uses, by specialists, techniques and experts of different subjects, and inside ordinary maintenance process.

The Mediana mosaics

In the Mediana archaeological complex (located at about 4 km east of Nis) there is a rectangular villa (60m x 45m) with peristyle, rich of Constantine mosaics of the IV century.

The Mediana archaeological site presents an important territorial extension, with many buildings that present various degrade problems.

Important archaeological investigations have been carried on since many years, including, of course, the mosaics. Our survey campaign, performed last year, has been made to illustrate the mosaics both from a qualitative descriptive way and from a metric quantitative one.

The large representation scale chosen (1:20 for the figurative mosaics and 1:50 for the villa ones) is for sure a kind of modern and advanced application in the relief field later on described.

The relief campaign has concerned the mosaics of the peristyle east side on one of the two villa sides, on a length of 60 meters. (Fig. 1)

The intervention has been performed in agreement with the Serbia and Montenegro superintendence office and has been preceded by the removal of the ground put since some years to protect the mosaics.

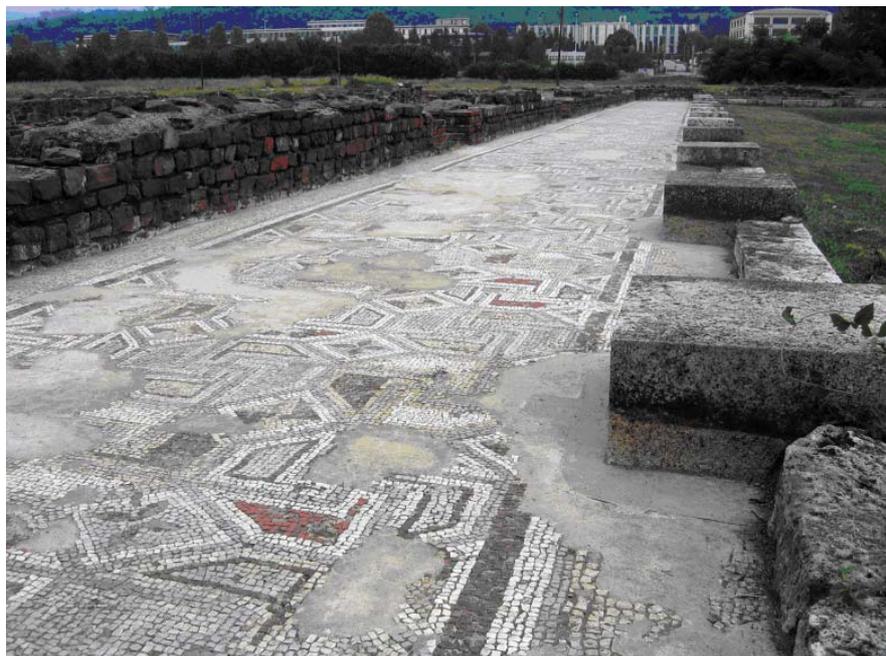


Fig. 1 Villa with peristyle at Mediana archeological site: east wing mosaics
Сл. 1 Вила са перистилом на археолошком налазишту Медијана: мозаици
у источном крилу

The photographic rectification

The photogrammetry can be synthetically defined as the transformation of a central perspective in an orthogonal projection. In the case that the object interested by the transformation has three dimensions the necessary perspectives are two and different between them.

The transformation can take place in two different ways: by calculation or by building an optic model of the object and by operating on the same object with projections and sections.

In the first phase we speak of analytical restitution, in the second phase of analogical restitution.

The 3D or 2D analytical digital is a recent restitution form.

In the case of the Mediana mosaics we can speak of orthophoto 2D or more simply of digital straighten of photograms of a plain object.

The photogrammetric operations moments are, shortly, the following ones:

- the photogrammetrical picture that can be performed, depending the case, from the ground or from the air;
- the restitution with analogical or analytical or digital instruments that consists in the photos transformations in maps, front, sections or three-dimensional vector or raster models or, as in the studied case, in the homographic solution of analytical straighten;
- the final elaborate drawing up that, always in our case, it is a mosaic of the analogical pictures, transformed into digital ones and elaborated with Geomatic Orthoengine PCI;
- the metrical reconstruction of the object optical model, seen with its three dimensions, employs, in general, the stereoscopic principle or in an automatic way uses the image correlation. This involves the independent position determination and quotes of at least three ground control points (nine co-ordinates) of the object clearly single out in the photogram or in the model (two object photograms taken from different position). This operation is necessary to give the right dimensions to the same model and to place them in the right position.

In the case of a plain object, as it is the case of Mediana, we have to recognise four points of the object to determinate the eight unknown parameters of the homographic correspondence.

We have to underline that the instruments for the metrical pictures are, in any case, very different from the commons photographic cameras. The images are, in fact, better defined with the term of photograms because their content is not only qualitative but also metric. For example, these cameras object lenses have a very high distortion correction and are at fixed focus or at step controlled by a focal length known until a mm hundredth.

At present the metrical cameras are mostly employed in air pictures while for ground pictures are largely used semi-metric a *reseau* cameras or even amateur ones or, in recent times, also very high resolution digital cameras.

For what it concerns the restitution instruments field the digital restitutors are taking an importance place and are going to replace the other ones. In digital restitutors the model takes form in video and the measures as well as the elaborations are performed by softwares of powerful computers.

The high precisions reachable with the photogrammetrical method (that are the same or even more homogeneous than the ones get through traditional surveys) are made possible from the progress of these last years of the digital-electronic construction of picture and restitution instruments.

The photogrammetrical architectonical applications are now spreading. This sector of the photogrammetric technique, that employs almost only pictures performed in the ground, is called close-up photogrammetry. Its most important component is the so-called architectural photogrammetry and the orthographic representation one of the most effectual representative form. Its importance is underlined from the presence of an international organisation, the CIPA, relied to UNESCO and to ISPRS.

The software employed for the Mediana mosaics straighten consents the insertion of the pictures taken from calibrate cameras (Rollei 6008) and the use of calibration parameters (focal example, optical distortion). The following figures regard the results obtained during the survey campaign and it is reported in the relation with the title of : "Relief and digital metric restitution of mosaic floor of Mediana"

A further simplification can be introduced by employing directly amatorial digital cameras, where through right softwares accessible from the net it is possible to calculate the internal orientation and calibration parameters from already known picture schemes. (fig.2; fig.3)

The San Marco Basilica mosaic

In the case of the San Marco basilica the floor mosaic lays on a strange church laying, with a consequent floor irregularity due to the fact that the Basilica stays on a low resistance ground, with an irregular geometrical stratigraphy, subject to subsidence phenomenon and to the well known problem of high water. Besides that we have to think to other interventions as, for example,



Fig. 2 A portion of an orthophoto: east wing mosaics, Mediana

Сл. 2 : Део орто фотографије: мозаици у источном крилу, вила на Медијани



Fig. 3 Detail of orthophoto, mosaics of Mediana
Сл. 3 Деталъ ортофотографије, мозаици са Медијане

the elevation of the cupolas furred with lead, made right after the Ducale Palace construction. (fig.4)

The mosaic floor has been modified in its conformity during the various interventions made in the past, since until the beginning of the XIX century it did not have a proper artistic quality. For this reason it was considered normal to change the used parts because of its exposure to visitors and humidity together with the chemical reactions caused by the salts of the flour rough lime, with new materials and new techniques, keeping only the original drawing. As a consequence also the floor irregularity, due to yielding and movements, was eliminated rebuilding the plane surface.

Only in recent times we have the idea that the floor irregularities are a feature of itself, that has to be preserved and has to be carefully considered in a conservation project.

The research of a mean to describe efficiently the undularity phenomenon, for a use in the yard, has led in these last years to prefer three-dimensional representation models as the Digital Orthophoto 3D in scale 1:1

The 3D digital orthophoto

In the case of three-dimensional objects, as can be consider the studied floor, the simple rectification does not give the altimetric information, but it underlines, on the other hand, this procedure limits, that is that it is not possible to represent the historical and natural situation and the tesseras disposition is not right for errors due, in the central projection, to the non plain object and to the objective distortion. These limits produce a position error of 1. 2 cm in the mosaics location.

The points altitude of a 3D object can be taken with other restitution kinds, such as the contour lines, profiles or sections and with the use of digital photogrammetry, by a surface digital model (DSM). The DSM is a product made by digital photogrammetry that gives the situation of a three dimensional object surface, by the images elaboration. (fig. 5)

The DSM is a product made by digital photogrammetry that gives the situation of a three dimensional object surface, by the images elaboration.

To obtain this kind of representation it is necessary to use softwares that manage all the photogrammetrical process of images elaboration, by applying the principles of analytic photogrammetry.

With the use of a digital restitution station, that has precise characteristics, like softwares, we can elaborate many photograms, creating, as in the San Marco case, a 3D orthophoto at the nominal scale 1:1 of the 2000 square meters of the surface of mosaic, with a mm precision.

The employed method to perform an orthophoto, which we think is the best representation form since we have semantic and metric aspect, is the photogrammetrical classic one, that states a correspondence between the images points and the correspondent points of the real object.

The 3D orthophoto restitution of the San Marco floor has been performed by step that can be here resumed inside the Socet Set 5.2.0 software of BAE System.

- photograms development: from photograms made with the Rolley DB44 metric camera to TIFF format and radiometric equalization;
- performance of a photogrammetrical block from the objective centres;
- collimation of some GCP that fix the block, in georeferencing it;
- TA: aerial triangulation;
- DSM performance;
- orthophoto generation and photomosaic.

In the aerial triangulation phase the software consents a comparison between the topographic coordinates of every point that is part of the calculus of the orientation parameters (appoints points and reference points) and the coordinates calculated in the T.A.

For what it concerns the DSM generation, the most modern and more used is the one in which the elaboration starting data can be obtained by automatic correlation on digital images, by this technique the digital orthophoto construction is totally automatic.

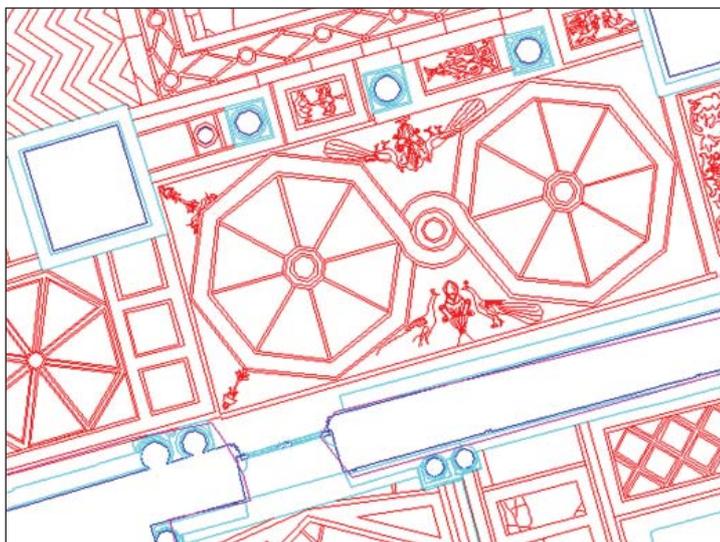


Fig. 4 Detail of floor scheme for mosaic fitting at San Marco basilica in Venice

Сл. 4 Деталј подне схеме за постављање мозаика, црква светог Марка у Венецији

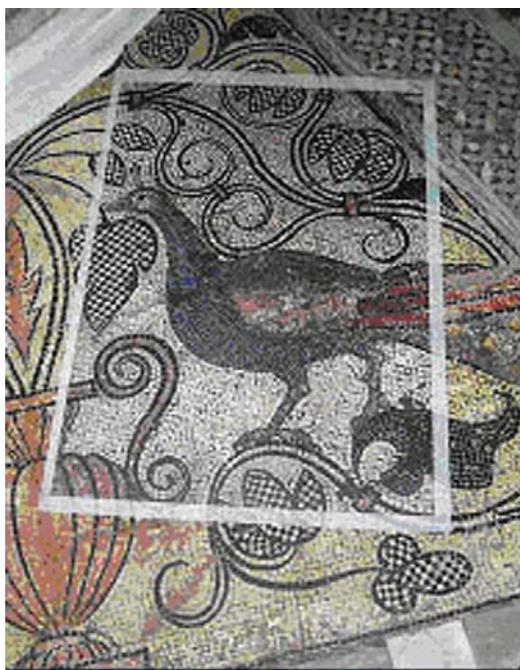


Fig. 5 Orthofoto plotted on a transparent medium and positioned over the real mosaic floor, basilica San Marco in Venice

Сл. 5 Орто фотографија снимљена на транспарентном медијуму и позиционирана изнад стварног подног мозаика, црква светог Марка у Венецији

The restoration and conservation of the mosaic floors

The San Marco Procuratoria has always tried to invest to get more and concrete information over the most important degrade causes of the Basilica elements in order to give useful information to the conservation and the use of the monument.

The floor mosaic degrade state is, for example, already visible at a superficial observation, even if it was subject to constant restorations by specialist Procuratoria hands and that they try to preserve big portions from the tourist traffic aggression (about 2 millions visitors every year) through various physical barriers (obliged paths, carpets).

The floor restoration has always been the object of particular care, with the experimentation of different laying techniques: from the modern cement use, to the utilization of already made floor portions laid on marble plates, to the laying performed following the antique technique, with the "pastella" made only with lime and similar. (fig.6; fig.7)

The kind of work, used already since many years, permits to put the composition tesseras over mobile supports and then to work on mosaics portions, light and easy to carry.

Once we finish the cleaning and restoration work on the mosaics we carry all the pieces on spot, to locate them on the floor, pasting the mosaic on paper sheets where we have the upside coloured drawing of the interested part.

We transfer later the composition on the lime in the area to be decorated, leaving it to dry.

The original drawing is surveyed by a photo in which we employ the negative on a special tissue.

The until now used proceeding from the Basilica technicians to floor photo rectification reported in a real scale is not, by the way, particularly apt to represent the floor undularity, while it is the digital orthophoto 3D.

This consents to obtain a detail and metric level never reached before and to dispose of a excellent instrument for an immediate use in the conservation, in project and in activity yard.

The digital orthophoto at the scale 1:1 fixes the tesseras disposition from photographic images, in which the metrical informations are associated to the visual ones.



Fig. 6 Orthofoto of mosaic floor, basilica San Marco in Venice

Сл. 6 Орто фотографија подног мозаика, црква светог Марка у Венецији



Fig. 7 Orthofoto detail in scale 1:1

Сл. 7 Детаљ орто фотографије у размери 1:1

The application of the orthophoto comes from its digital format that permits to obtain immediately all the floor portions in which it was divided in the restoration project phase, until the definition of little parts of mosaic.

Once we dispose of the three-dimensional model it is also possible to get, as already stated, automatically the sections that are retained to be more representative of the irregular floor way and from that will be realised the *dime* used by the workers to calculate the quotes to remake the floor foundation.

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РЕЉЕФНО И ДОКУМЕНТАРНО ПРИКАЗИВАЊЕ МОЗАИКА
КАО ПОТПОРА ЗА РЕСТАУРАЦИЈУ

У односу на истраживања која су се пре извесног периода обављала на мозаицима Византијске базилике светог Марка у Венецији и у вези са скорашњим истраживањем започетим на археолошком комплексу Медијане, развили смо рељефну и репрезентациону технику која у дво и тродимензионалној ортофотографској форми омогућава најреалнији приказ. Дигиталне метричке слике представљају веома добру основу за конструкцију реалних модела мозаичких површина, који су корисни или чак неопходни за почетак дијагностичког процеса и за каснију конзерваторску рестаурацију. Ортофотографије, које имају мерљиве метричке форме, омогућавају да се касније сачине слике које су и саме мерљиве, и у географском смислу одговарају својим моделима. Ово ће бити јасније објашњено кроз неколико слика.