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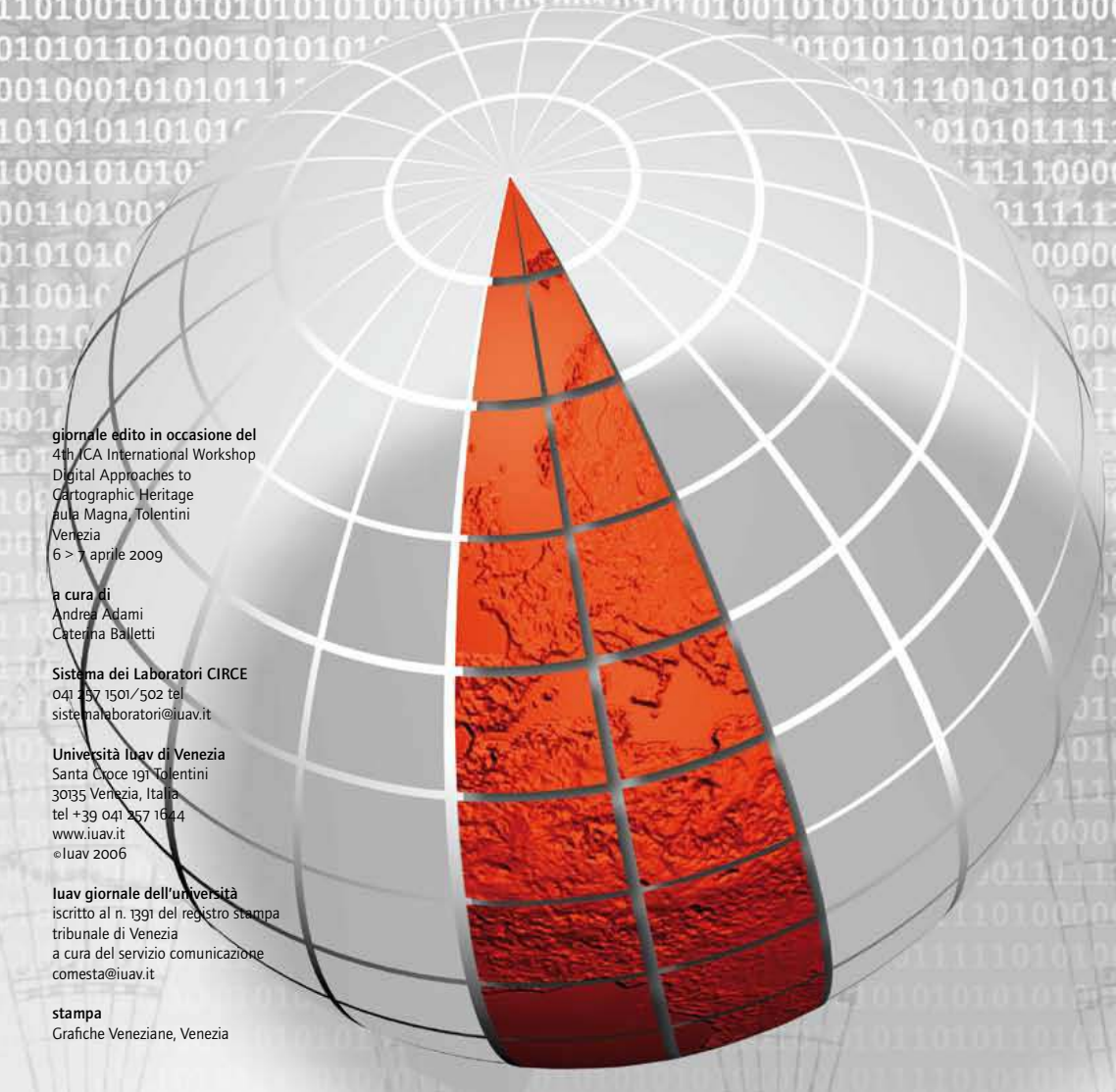
4th ICA International Workshop
Digital Approaches to Cartographic Heritage

VIRTUAL GLOBE



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The challenges of Cartographic Heritage in the digital world

Evangelos Livieratos

"Cartographic Heritage", as a regular working terminology, entered officially the glossary (vocabulary) of the international cartographic community in 2005 when the ICA Executive accepted the proposal for the formation of a relevant Working Group, during the A Coruña International Cartographic Conference.

From the beginning the term was coupled with "Digital Technology" not only to comply with the ICA technology tradition but also to serve as a bridge connecting the cartographic and mapping past with its present and future.

I recall some few reservations expressed at that time during the initial discussion at A Coruña. The argument was that since within the ICA and outside the ICA existed already structures dealing with "History of Cartography" it was a redundant repetition the establishment of the new structure.

It was obvious that in the origin of this reservation was mainly the misunderstanding or misinterpreting of the term of "heritage" and its substance. It was obvious that "heritage" was confused with the term and substance of "history". And of course, in a certain extend, this shortcoming was not surprising because we have to accept that many people are not in general so familiar with the concept of "heritage" as they are with the concept of "history".

Fortunately the persons who took decisions in ICA could recognize the difference and the new Working Group on "Cartographic Heritage" was born at the west extreme of the land of Iberia, almost three years ago, embedded in the immense domain of modern digital information and communication technologies.

The Working Group from its start was active in clarifying and promoting first of all the notion of "Cartographic Heritage" and its constituents and then in identifying and classifying from the digital technologies cistern the proper and relevant tools, systems and methodologies.

A second concern, but indeed important, was the broadening of the composition of this Group with colleagues coming not only from the world of cartography in the large, but also from the worlds of the libraries,collectionism and institutions dealing with the culture of maps, where archiving, conservation, restoration, management, visualization, access, diffusion, networking and communication are of vital importance as well as the research on map content. I think that we are successful in this effort as the broadening of our audience is now evident!

A number of interested and active colleagues gave the Group shape from the very beginning and the First Workshop held at the Byzantine Museum of Thessaloniki in 2006 was the promising test hosting a multidisciplinary group of participants. This event was reported in the ICA News, June 2006 and documented by the Group members Marcus Jobst, Bernhard Jenny (in German: Cartographica Helvetica), Ferjan Ormeling (in Dutch: GEO-INFO), Mira Miletic Drder (in Croatian: Kartografija i geoinformacije) underlining of course Chris Fleet's extended review in Imago Mundi, (Vol. 59, part 1). At the same year colleagues from Italy and Greece supported by colleagues from France and The Netherlands established "e-Perimetron" a free of charge international web journal dedicated to sciences and technologies affined to history of cartography and maps. From the very beginning the idea was to assist the Working Group and work in parallel, promoting mainly the new digital technologies in cartographic heritage. The two volumes of the journal count more that 600 pages with numerous links in very many university libraries in all continents around the World.

In 2007 the Second Workshop was held at the National Research Foundation in Athens jointly with a Forum on the emblematic Rigas Velestinlis Charta, the cartographic monument of Greek Enlightenment from the late 18th century, as part of the domestic celebrations for the 250 years from the birth of Rigas Velestinlis, the major figure among the fathers of the Greek national Resurgence of 1821. This event is the starting point for the advancement of new research on this major map of the southeast European cartographic heritage, which is still unknown internationally.

The philosophy of our Group was then presented by the Chair in an invited talk at the ICA seminar organized by Prof. Ferjan Ormeling in the frame of the 22nd International Conference on History of Cartography at Berne in 2007.

At that introduction the concept of "cartographic valuables" was given as the important huge backlog of maps, atlases, globes and the associated images and textual material which constitute an important part of the Cultural Heritage deserving a discrete place in the World's overall cultural heritage and the necessary care and forethought.

This backlog consists of 2-D and/or 3-D objects (let us call them all as "maps") which are defined, classified, evaluated and managed according to their material constitution, geometric and thematic content and communication power.

As 2-D and/or 3-D valuable objects belonging to the backlog of cultural heritage, "maps" are naturally subject to proper and accurate pictorial representation preferably in 1:1 scale, which is done today almost entirely by digital means without underestimating at all the high quality non-digital tools which in certain conditions could offer reliable results. The well known technologies in mapping sciences as it is the contact and non-contact digital plane scanning and the 3-D counterpart, the non-contact digital photography and the stereo counterpart are or could be used extensively in the geometric documentation of "maps".

Of course, since digitization affects the "map" material, its content and its communication properties a number of questions follow, especially in the desirable and feasible 1:1 scale. Questions concerning the vulnerability of the "map" under digitization of any type, the given dimensions of the digitization carrier with respect to those of the "map", the geometric deformations induced by any digitization process, the scale alterations of the digital copy, the difficulties and problems in the eventual need for stitching, the necessity for preserving as close as possible the colour reliability of the digital copy and last but not least the final digitization cost, the unforgettable and painful parameter in this process.

In the digital tradition the domain of treating the material, the content and the communication of "maps" as objects of cultural heritage, is unique. It unifies the approaches changing thus radically the philosophy in treating within the same digital domain issues like the conservation, preservation, restoration and protection of the material, the study of the geometric and thematic content and the access, diffusion and dissemination of "maps" in a communication scheme. And this is a real challenge never experienced before.

But what stands decisively behind this philosophy? Of course the need for a proper digitization, with the real meaning of the word which has nothing to do with the general term of "scanning" and/or "photo-capturing" even if the result is a digital product as well. Real digitization means that a point on the "map" retains on its digital image as close as possible the original "geometric" and "physical" properties. In poor words the original "position" and the original "colour".

As you can imagine a new complication is entering into the picture. What we mean by saying "a point" and what we mean by saying "as close as possible" in order to approach real digitization instead of just scanning and/or photo-capturing maps. The answer is obvious related to quality. The quality of know how, of expertise, of brainware and certainly of hard-ware.

If digitization looks as an important assisting tool for approaching the material of "maps" for the needs of conservation, preservation, restoration and protection, it is condicio sine qua non for the study of the content of "maps" as carriers of "geometric" and "thematic" knowledge and information. Here, both "geometry" and "thematics" are referenced to coordinates and the digital route is oneway. A number of possible items for new research on "maps" can then be listed, from rectification and stitching to geo-framing and geo-referencing, from deformation and scale analysis to comparative studies using best-fitting techniques, from the analysis of coastlines and map-projections to the analytic mapping and representation of globes plus an almost endless list of implementation of whatever thematic content of "maps".

Although the material and content issue of Cartographic Heritage in the digital domain are important engaging mainly experts and dedicated people, the communication component is of major interest because it is addressed not only to experts and dedicated but also and mainly to the broad general public. Needless to say that communicating cartographic heritage is indeed a social action.

Questions on access, diffusion and dissemination of the properly archived "maps" are of major concern to the great community of colleagues working in public and private archives and map libraries managing important map collections. The World Wide Web and the digital culture which is constantly propagated in the society and in the institutions thanks to the younger generation open new horizons to the up to now underestimated culture of cartography and maps in their multiform aspects as products of human perceptiveness, art, skill, history, ideology, geography, geometry, science, technology and power.

New concepts, like the distinction between knowledge and information which is crucial in the digital thinking, especially as far as communication is concerned, introduce weight criteria in the networking of the access and define levels of availability in communicating cartographic and map heritage.

In situ and web providers of cartographic heritage are now looking for a better communication management, understanding first the nature of the material to communicate and then getting profit from the continuously developing know-how, brain-ware and hard-ware in the digital.

The Third Workshop, in Barcellona in 2008, was a turning point in our vision, organization and work:

> first, because meets the ICA Group – established three years ago in Galicia at the Atlantic coasts of Spain – in the promoted status of an ICA Commission. The new Commission carrying the same name was established in Moscow on August 2007 by the ICA General Assembly;

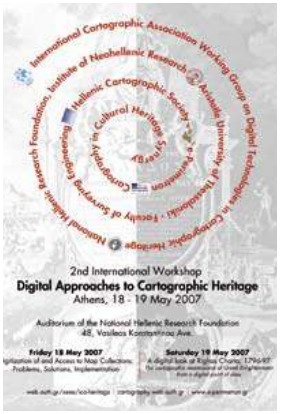
> second, because it looks now that the confusion caused three years ago by the use of the term "Cartographic Heritage" in distinction to "History of Cartography" has been definitively resolved. This is a quite natural consequence since the issue is already clear when talking about the difference between "History" and "Heritage" in the large. Christopher Chippindale gives a clear and up-to-date advice supporting this distinction "...heritage, in contrast to history and archaeology [is defined] as the place of the past in the present" or "...heritage is about the past as it is seen and understood in the present" or "...heritage is the past in the present so the judgments of the present actually decide, but since it is about the past, those knowledgeable about the past are supposed, or suppose themselves, to be in charge of it";

> third, because from the organization and the content of the sessions it was shown that the work of the Commission converges to concrete references points;

> fourth, because the pluralism in the background of the participants is the best proof that our initial estimate on the expected acceptance of a new structure on cartographic heritage was not random;

> fifth, because the young people are still present and active;

> sixth, because the increasing interest from the world of enterprises in constructing and adapting digitization tools, in archiving management, in providing know-how, is a promising indication for future partnerships and interactions with the academia and the world of libraries.



The globe: from art object to cartographic representation

Andrea Adami, Francesco Guerra

Studying the globes, the significance of the disciplines that study the shape and representation of the Earth becomes apparent from the methodical point of view as well as for the application of new digital technologies. Indeed, in some sections of this work it will become clear that, as a consequence of the necessary approximation and scale differences, the representation and study systems recall those used for the Earth. Some aspects and problems typical of Geodesy will also be highlighted, such as those related to coordinate systems and reference surfaces, even if applied to cartographic globes. Furthermore, the globes represent the exemplification of the problem known since ancient times of unrolling a double curvature surface on a plan. Other than studying their shape, it will also be important to recognize their cartographic content.

The research starts from the observation that today cartographic globes, present in almost every museum and art collection, are deprived of part of their value. They are actually considered as art objects, meant to decorate the halls of historical buildings and now relegated in museums, without recognizing the cartographic value that they deserve.

From this consideration the work starts investigating the different aspects of these cartographic spheres. We intend to improve the knowledge of their cartographic value under the double aspect of the material support and the depicted (or applied) cartography. As for geometry, we intend to verify if the wooden support was built according to an ideal spherical shape or if some adjustments were planned to resemble the actual shape, even if it is clearly impossible to consider them as physical models of the geoid. As for their cartographic content, we intend to investigate the projective aspects in order to understand if the authors used some known representation. Moreover, we intend to compare the semantic content of the represented map with other historic or modern maps in order to detect similarities or differences.

The central focus of the thesis becomes therefore the transition from the sphere as an art object to the globe, intended as cartography to all intents and purposes.

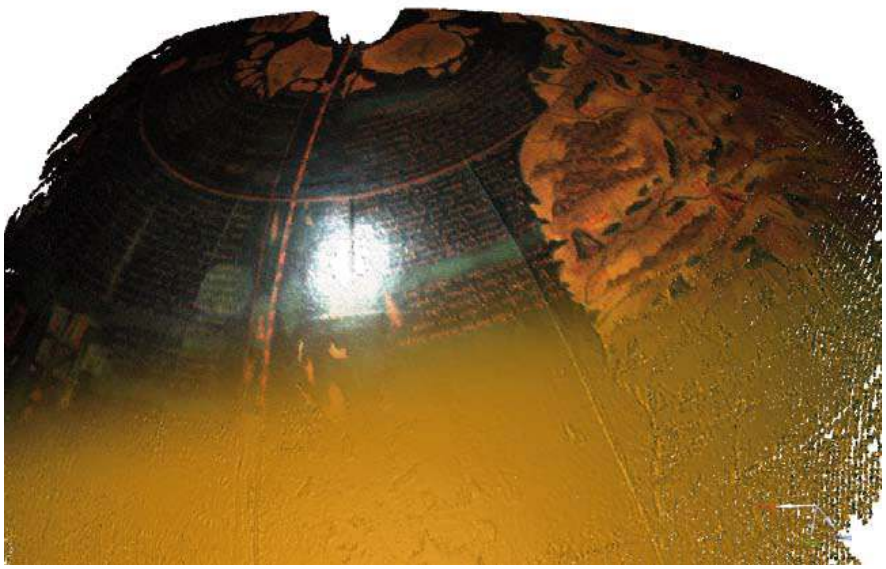
For the survey of the geometrical shape of the wooden sphere, different methods and technologies have been evaluated. Starting from photogrammetry, we moved forward to 3D scanners as effective instruments to acquire the geometry of these spheres.

To enable the cartography analysis, we needed to "peel" the cartography off from its wooden support. In this case, through photogrammetry and the theory of cartographic representations, it has been possible to extract a flat map.

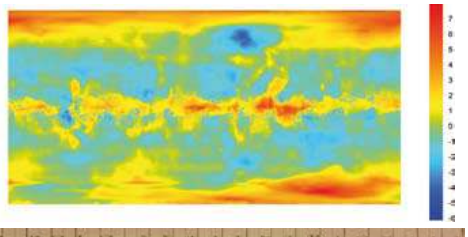
The cartography analysis obtained was mainly related to the projective genesis. It has been observed that we cannot talk of cartographic projection in the same way that we do today, but it has been attempted to detect the projective genesis that best approaches the one used in the description of the gores.

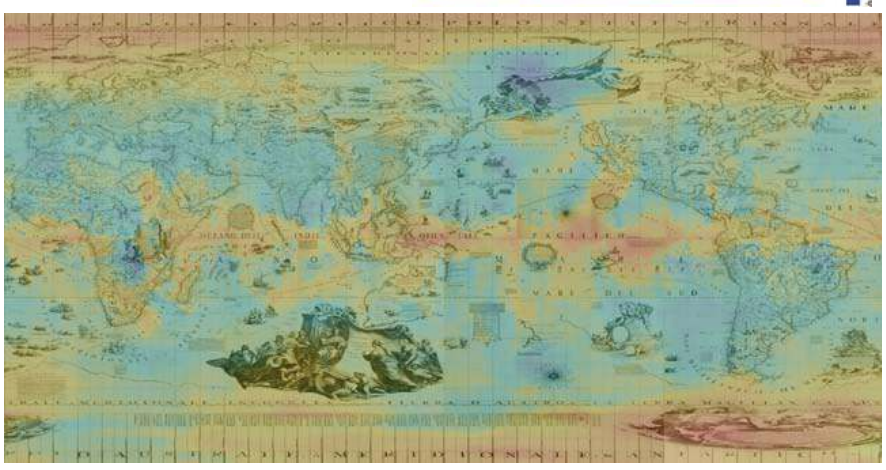
The semantic content has been studied in depth in various ways. First of all, we had to select a method that allowed an easy fruition of the globe or, better, of its digital copy. Then, by using computer software to navigate around the globe, we identified some map peculiarities that have been elaborated and represented with other instruments, offered by the digital techniques of analysis.

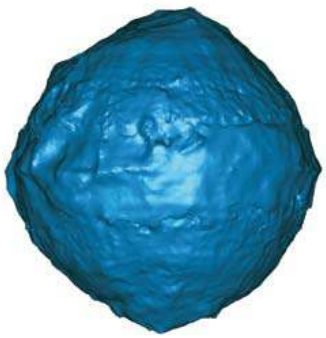
Tests and analyses have been conducted on the printed globes of Coronelli (top image) and the sphere of Sanudo (bottom image) which have been offered by the Correr Museum in Venice.

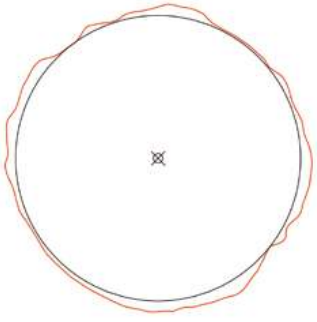


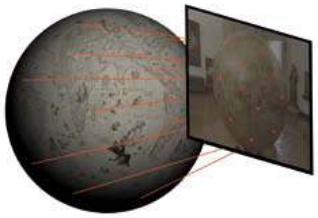
The first part of the work consists in the survey of the physical support for the cartographic surface, typically a wooden structure covered with fabric, stucco and other materials. First of all, the knowledge of the shape is necessary to understand if there was a project held under the generic term of sphere. In fact, it will be interesting to understand if the globe has a precisely round shape or not, and possibly to study the differences from the ideal shape, trying to attribute it to the project or to the effects of usage and time.
Among current analyses, many aim at evaluating, processing and developing dimensional survey techniques and 3D rebuilding of objects and surfaces, with special attention to the metrological aspects of the problem, by using current improvements in computer science, optoelectronics and optical techniques to study Cultural Heritage. However, these researches have to face some difficulties that affect the collection and the analysis of data, due in part to globe location as well as to the general shape and the finishing of the globes themselves.
After many different tests, performed on both instruments and acquisition procedures, we can affirm that range cameras represent suitable instruments to survey complex objects. First of all they do not require the application of positioning targets on the surveyed object, nor the materialization of a reference system. Moreover they allows simultaneous acquisition of geometric and radiometric information in a few time. As concerning the metric aspect, they guarantee high resolution on the object and high precision achievable.
Globe acquisition phases are not significantly different from other applications, for which an extended literature is available. The crucial moment, as usual, is the planning stage, when fundamental parameters of the operation are defined. While planning the survey, it is necessary to focus on some aspects such as the resolution on the object, the precision that we want to achieve and cloud overlapping, needed to record data in a single system.
By observing the triangulated mesh at the end of the acquisition step, we will notice that the surface is not smooth, but has features, i.e. discontinuities caused by various factors. In particular, scanners detected some discontinuities in overlapping areas of two gores, and there is actually a variation compared to the general curvature. However, all scans highlight other discontinuities that are not actually visible on the object. After accurate observation, it appears clear that these discontinuities correspond to cartographic zones where the transition from bright to dark elements is abrupt. In this example, it results clear that the coast line is a three-dimensional element, because of the transition from bright land to dark water. In the middle of the ocean, we can also notice islands in relief and the corrugation effect is clearly due to the presence of bright writings on a dark background. These observations, common to all scans performed with different instruments, are caused by the ability of dark colors to absorb light. Since the triangulation algorithm works on the acquired images, this luminosity transition causes the appearance of features in relief compared to the general sphere curvature.
This finding allows on one hand an approximate reading of the cartographic surface starting from the scan, even before we start using the textures acquired. However, discontinuities, both physical and real, are significant, because they characterize univocally part of the globe, i.e. the scanned spherical cap, that would otherwise have been difficult to record.
For this reasons we used the ICP (Iterative Closest Point) for the registration of the range maps also thanks to the possibility to consider color from a texture as an additional coordinate for each point in an ICP optimization where a color triplet is associated with each 3D point. The closest point search now becomes a search in 6D space, and a 6D k-d tree is used to accelerate the search.
The 3d model obtained throught the registration of all range maps gives the possibility of studying the shape of the globe and its possible deformations.
This analysis can be conducted starting from the deformations of the model generated by the laser scanner compared to the best interpolating sphere. For this analysis we realized an ad hoc software that calculates the interpolating sphere as well as producing a plane representation of deformations present on the sphere. We can determine the globe's deformation compared to the ideal sphere, according to the classical cartographic problem of representing the equipotential surface of a geode compared to the reference surface of the ellipsoid. In this case, the reference surface is further simplified and corresponds to the interpolating sphere previously calculated. Specifically, deformation is expressed by means of an m x n matrix, with m = longitude e n = latitude, where the value in each single cell derives from the difference between the ray of the interpolating sphere and the ray calculated for that point.
To allow a better understanding of the deformations, we wrote another software application, which generates a three-dimensional representation of the deformed sphere, following the example of the classical representations of the geoid. each point has been transformed into spherical coordinates λ and φ and the radius Rxyz where radius is the distance between the centre of the best fit sphere and the point P of coordinates x y z... Then we calculate the difference between Rxyz and the radius Rsph of the best fit sphere to found Δr. After this the value Δr is amplified for a scale factor S, so: $\Delta r_{new} = \Delta r \times S$. In the final model the radius is calculated $R_{final} = R_{sph} + \Delta r_{new}$ so each point P is represented by $\lambda\ \varphi\ \Delta r_{new}$ and the it is transformed in $P_{xyz\ final}$.
In this way, we obtain the equivalent of the classical cartographic representations, where the Z value is enhanced by a known factor. In cartography these are the so called two-and-a-half-dimensional representations, while the deformed model obtained is definitely three-dimensional. It can be viewed in the 3D space and we can use all spatial navigation operations typical of three-dimensional models. Moreover it's possible to attribute a color to each point function of the real RGB value of the point (from the cartographic surface) or of the dimension of Δr_{new}.
There is also the possibility to obtain some slices to represent the punctual value of deformation. This operation cannot be done on the real sphere because deformations have a little value and it is not possible to apply the exaggeration only to the value of deformation. Instead it is possible to apply the scale factor to spherical coordinates because we can amplify only the radius value.

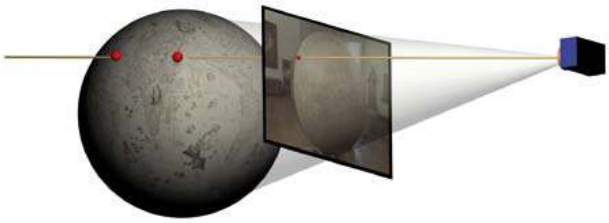






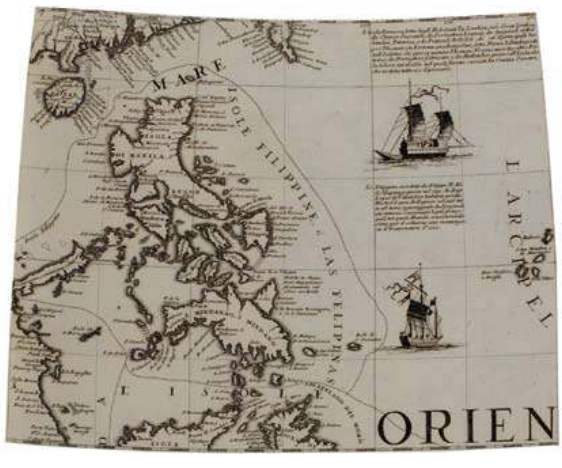


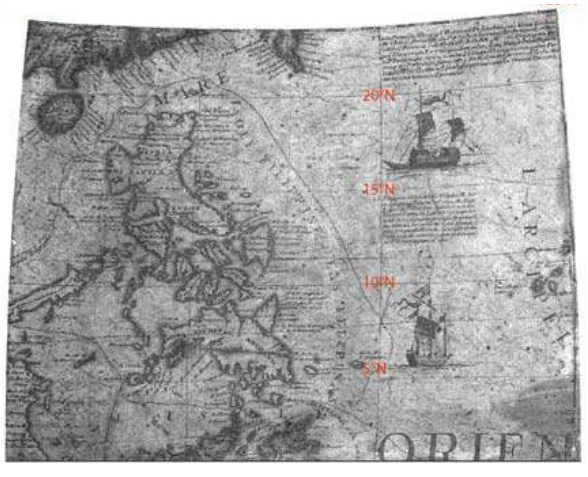




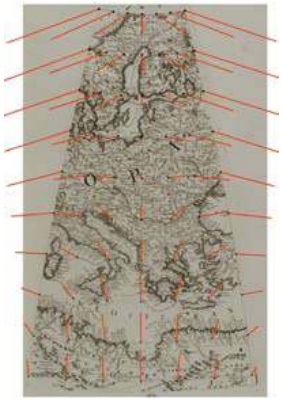
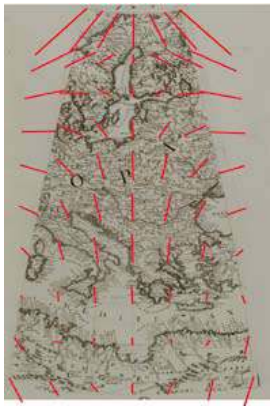
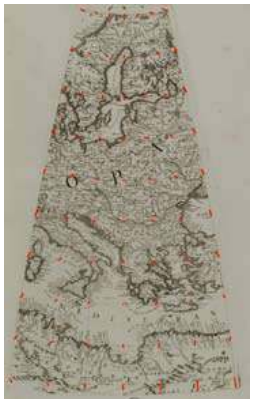
Once we determined the shape of the wooden sphere, the next step is the survey of the cartographic surface. The goal is to obtain an exhaustive knowledge of the cartographic globe, by assigning a cartographic content to the wooden support. This process can ben divided into three different steps:
a) photographic acquisition;
b) image orientation by DLT;
c) reprojection of images in a known matrix.
Photographic acquisition is the first procedure planned to survey the surface. This operation, apparently free of issues, encountered many difficulties due to the specific characteristics of the object. First, obstacles are due to the shape of the spherical object and to the operating mechanism. Moreover, the poor conservation status may prevent the globe's rotation, while keeping the camera steady on the tripod. We have to resort to inconvenient shooting positions, made more awkward by the long acquisition time required in low light conditions.
Another problem encountered during photographic acquisition was related to the reflective surface of the globe itself. The surface is often in bad conditions and the covering varnish acts as a mirror, causing annoying reflections in the photographs, which make them useless for the map extraction process. Moreover, the reflective surface makes the use of photographic lighting equipment more complex due to glares in the picture so it is necessary to use more sophisticated acquiring system (polarized light: lamps and filter).
For the photographic acquisition we used a NikonD700 with 35 mm lens and a Rollei 6008 with a digital back of 39 Megapixel and with 80 mm lens. To reduce the glares, the images have been acquired with polarized filters on the lens and on the lamps.
Proceeding with the proposed process, the next step is the orientation of film frames. The goal of this phase is to position film frames where they were when the picture was taken. D.L.T. is the algorithm used in this step, expressing the direct relationship between image coordinates and the corresponding object coordinates. The Direct Linear Transformation is an alternative method for facing the problem of analytical orientation that finds an optimal application in photogrammetry with non metrical images.
In the last phase of this process, we move from the spherical surface to a known projection.
Like for the Earth's surface, the link between a point on the surface and one on the map is not immediate, but it is solved by means of a reference surface of known and simplified geometry. When we consider the Earth, the surface used is the rotational ellipsoid, while when we consider cartographic globes the geometrical shape used is the sphere. This approximation is introduced to bypass the deformation of the wooden sphere during the reprojection of the cartographic sphere.
The suggested method aims to obtain a digital picture positioned in a given cartographic projection.
By writing the software, we obtained a custom product that can be used on the cartographic globes. At the same time, we implemented and tested an algorithm specific for the sphere. Combined with the application described above, we created a software package useful to the examination of the globes under study.
For this application we wrote a custom software to associate the spherical coordinates, describing the sphere's points, to the pixels of the oriented digital image. The algorithm creates an empty image (matrix), where its coordinates φ, λ are the spherical coordinates of the model.
By using the classic sphere formula and determining the angular step in latitude and longitude, it is possible to reconstruct a sphere of known center and radius, according to the formulas that allow to transform spherical coordinates into Cartesian coordinates.
Then we calculate the correspondence between each point of the reference system and the pixels of the oriented image. The equations are those used by the D.L.T. algorithm, which, once given the parameters calculated in the previous phase and object coordinates of the point, allow the identification of the corresponding pixel.
Once we identified the pixel, it is possible to extract its RGB value. However each pixel of the image can correspond to two distinct spatial points, because the sphere is a round shaped object. To avoid this effect, we searched for an empirical method to place the color extracted from the pixel onto the precise corresponding point. The solution consists in introducing a point P between C and O, defining the distance CP. The constraint imposed is the distance CP, which has to be always less or equal to the distance OC, where OC is the segment that links the camera center to the sphere center.
By applying this constraint, the surface implied in the picture corresponds to a spherical cap at the most. First, the software calculates the CP value and, subsequently, it allows to modify it. In fact, to avoid the stretching effect of pixels corresponding to the sphere's outermost areas (where CP is closer to CO), we can decrease the CP value with this software.
Finally we build the final matrix. On a grid characterized by the angular step set in the first part of the procedure, we insert the RGB color values extracted from the pixels corresponding to the surface points. If during the computation there is no correspondence between an image point and a globe point, the corresponding cell in the matrix is filled with a constant value (black). This situation happens regularly in the areas of the image where we do not see the globe, but the surrounding environment.
The resulting matrix can be imported in Matlab and therefore reprojected, choosing each time the cartographic projection most suitable for our representation requirements.

At the same time, the software creates an image in a known projection, the equirectangular one, where the longitudinal degree is equal to the latitudinal degree for each point.
Of course, the rows and columns size of the matrix corresponds to the dimensions of the digital image and is determined by the angular step chosen. For example, if we choose a angular step equal to 0. 1°, the matrix and the finale image will have the following sizes: 3600 pixel (360°/0.1°) in width-longitude and 1800 (180°/0.1°) in height-latitude.
To obtain the final cartography, the last phase is image composition. If the images are realized with the same angular step, there is no necessity of mosaicking because they have the same dimension, and so the same reference system. Simply it's necessary cut images and to realize a radiometric correction.

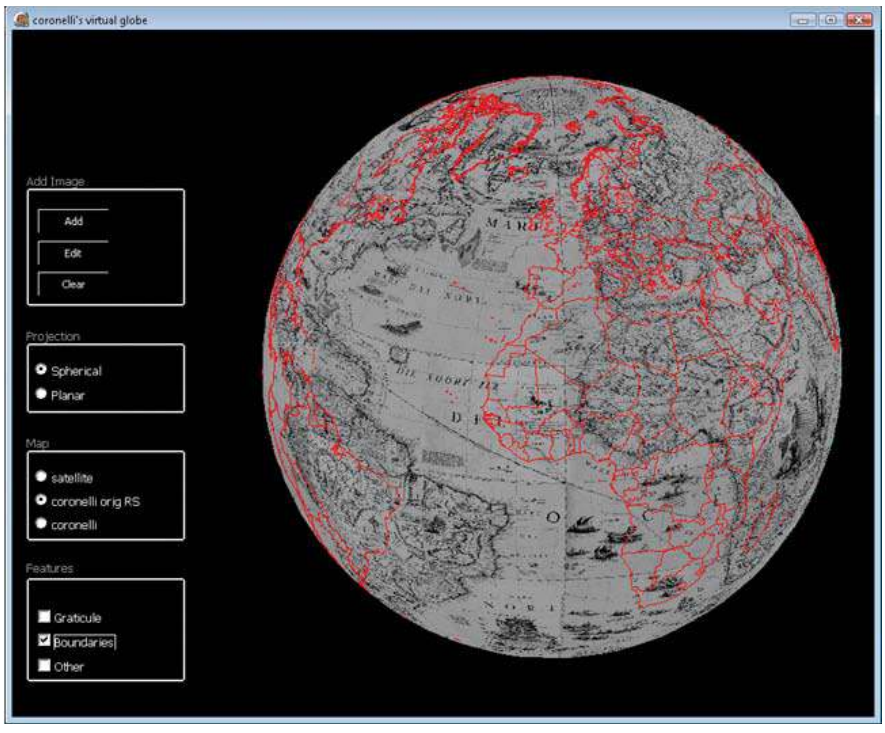


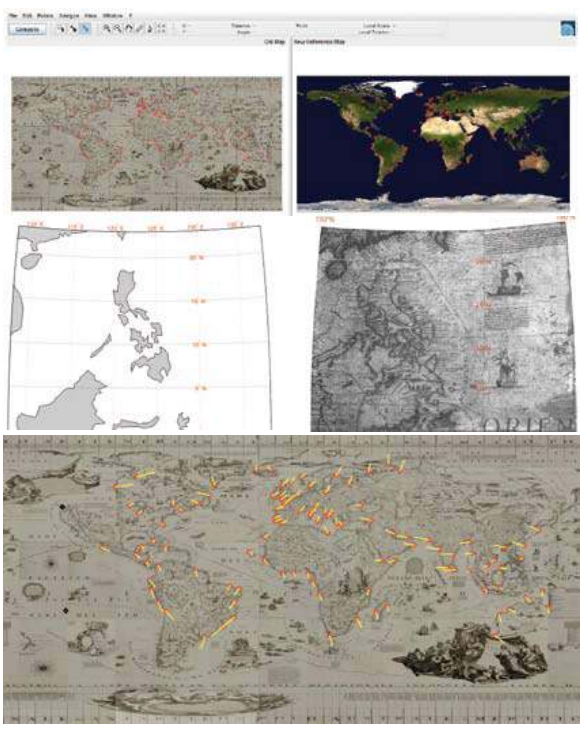


The analysis of the cartographic surface of the globes can be split in two parts, one each for the projective and semantic content levels.
The projective content of the printed globes is meaningful, being expressed in many phases and representing a direct as well as an inverse problem. First the author unfolded the double curvature surface of the Earth on a plane to build the gores, then he recreated a cartographic sphere starting from the gores themselves.
If it is not possible to identify a known projection in the author's writings, at least it is possible to understand the projective genesis of the map.
According to Tobler's approach, the problem is the investigation of a projective system that was probably in place, but is not one of the systems we know. A possible solution is the comparison between the map under study and other known reference models.
For globes in particular, the comparison takes place between the transforms of the gore drawn by Coronelli and those of the cartographic projection chosen. In the specific case of Coronelli's gores, the procedure is simplified by the possibility to use the geographic grid of the map, instead of its content, to perform the comparisons.
The search for similarity consists in applying a global geometric transformation to the gore sector and the projected grid, testing in sequence the grid's "adaptation" (best fitting) to the map under projective study.
The best fitting is assessed based on the residual values calculated after the deformations induced by the applied model. Depending on the results, we can define the projective system that better matches the historical map.
The analysis of the cartographic grid is carried out by generating a chart, which allows a clear view of the results obtained. The same analysis, conducted analytically, of comparing the coordinates of different cartographic projections, implies the knowledge of the source of the reference system.


The comparison has been performed using MapAnalyst software, which allows allows us to link the homologue points of the two maps and to perform a global geometric transformation in order to calculate the best fitting surface. The geometric transformation we used is Helmert transformation, which is conformal and doesn't deform the map. The tested projections are (in the image from the left: Apianus, Mollenweide, Cassini and Transverse Mercator).
The analyses aimed to highlight the cartographic characteristics of globes as concerning the semantic content were performed using new technological digital devices, both to visualize the map and to conduct tests on it. Today, virtual globes represent a trendy and developing subject. In fact they allow a high degree of interactivity for the user, who can observe the sphere from different points of view, and most importantly, can question the globe to get real time answers like a Global, rather than Territorial, Information System. Among other aspects, real time update capability and scalability, which allow a multiscale usage of the cartographic content, encouraged the circulation of these virtual worlds.
Other advantages and uses emerge when these instruments refer not to the actual geography of the Earth, but to a historic cartographic product.
A new concept of accessibility becomes possible for the historic cartographic heritage thanks to the creation of digital copies of printed cartographic globes such as those of Coronelli. The choice of writing specific software for the Coronelli's globe was due to the need for software that, in addition to virtual navigation, would allow the visualization of certain characteristics emerged during the analysis.
The software surveys the sphere by using the classic functions of rotating and zooming. It allows to view the map in different ways. Usually, we have the classic view of the digital globe, where the map image is wrapped on a sphere. However, there is the possibility to change view and select a plane representation among those codified in cartography. The software also allows the overlapping of several images, both raster and vectorial. On the sphere we can overlap: the original cartography, taken from the globe; a current satellite image; and Coronelli's cartography, modified with respect to the Greenwich Meridian (this topic will be discussed in the following chapters).
As for vector elements, it is currently possible to upload the geographic grid with the same latitudinal and longitudinal graduation of the globe and current geographic borders. Another interesting application to the study of the globe is, for example, uploading the course of explorations as shown on the map, to verify the course tracking and therefore verify if errors are due to imprecise sources or to inaccurate course tracking.
It Both with raster images and vectorial features, the overlapping is immediate if we have georeferencing files available. The images uploaded so far into the software are in equirectangular projection and are automatically mapped on the spherical cartographic globe along with the present status of that geography using both vectorial and raster images, highlighted some characteristics otherwise difficult to visualize. Thanks to the digital comparison, we notice how the coast profile differs from a positional point of view as well as in the drawing of the coastal line itself, even where the grid lines overlap with those of the original map.
We can easily find an explanation for the differences in coastal drawings. In fact, we should consider the diverse sources represented by the exploration reports and the old maps used and the varying levels of accuracy of each document.
The cause of the differing coastal positions still needs to be explained. Indeed, we notice a translation between the globe map content and current coastal profiles.
The first answer to this question comes from the author himself. Coronelli tells us that in his globes the Prime Meridian corresponds to Ferro's Meridian, as determined by cardinal Richelieu. The differences in the coastal lines have also been examined by means of a geographic comparison by representing the actual Earth in the same projective system. This comparison allows us to leave out the effect of the different reference systems, because it needs only one georeferenced map, the current one. As for the gores analysis, the comparison was carried out with digital instruments. In this case, too, we performed a Helmert transformation. We located some points on the coastal lines of the two maps, so as to create homologue point pairs between the two maps.
In this case, too, vectors allow us to measure the shift between the correct position of the point and its position on Coronelli's map.





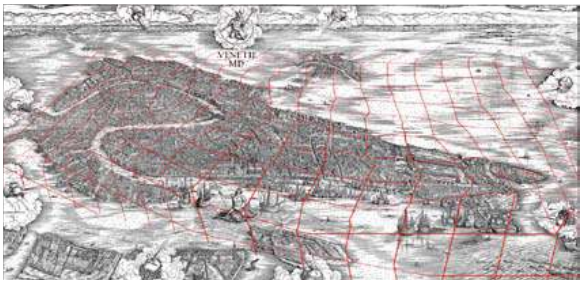
1999

Historical photoplan of Venice 1911

Francesco Guerra, Luca Pilot

Photoplans allow for new and more precise analysis and interpretations of that complex phenomenon that is today Venice. Venetian photoplans realized in 1911 and 1982, while substantially the same type of photographic map, show some important differences. The 1911 photoplan experimented on a completely new technique, while the one from 1982 represents the fundamental element in a complex cartographic system, designed and constructed using the instruments offered by a proven discipline. Their comparison is concrete evidence of the progress made in the survey discipline as well as urban representation. We can see how they both represent the desire to use modern techniques to establish and describe the shape of Venice and to record its memory. From the above, it would seem that the formation processes of the 1911 photoplan and the 1982 photoplan were very different undercertain aspects.

The result is two different photographic charts per scale (1:2500 for the 1911 photoplan and 1:500 for the 1982 photoplan) by cut and by orientation. In order to reach the aim of placing two photo-plans side by side and deriving, from their compared readings, a picture of the transformations of the urban texture, it 's necessary to homogenize the charts in order to give each the same geometric arrangement by using geometrical transformation which are the base of today cartography.



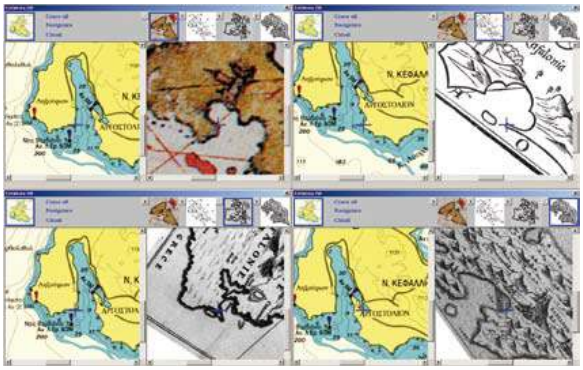
2000

The perspective view of Venice of Jacopo de' Barbari

Caterina Balletti, Paolo Vernier

The understanding of the contents of the old maps is undoubtedly difficult just because, on one hand, it assumes that there is an understanding of general cartography; on the other, a knowledge of the interpretative codes from the time period and the atmosphere of their production. The result made be a difficulty in their reading on the part of the general public both of the geometric content and the semantic content. The fundamental idea is that of allowing anybody to extract information from the historic cartography, rendering more transparent the complex yet necessary operations of geo-referencing.

The preliminary remark is to recover the metrical content in historical maps using analyses which lead to a definition of a methodology for the quantitative analysis of historical cartography. This implies to use procedures that treat of global and local transformations. The plane transformations allow for the deformation of a map in a way which makes them assume the metric and geometric content of another reference map. The choice to use the perspective views of Venice by Jacopo de' Barbari was motivated especially for the geometric and cartographic characteristics of this map that represents the most exciting example of the new method of representation of the city based on perspectives. The main problem was to understand whether the perspective construction of the work was quite rigorous, based on existing plans and charts, or whether it had been produced by a preliminary survey campaign, and in this case, which instruments and methods had been used.



2001

2WINSoftware

Francesco Guerra, Silvia Mander

The procedure of referencing-transformation is based on the application of two types of sequential transformation; first, a global transformation and then local transformations.

These two types of transformations are each carried out on the basis of two sets of corresponding points, the first control points, which could originate from a survey, a map or an image, the second set identified on the image to modify. But considering the procedure of referencing-restoration-transformation, the metric nature of the initial map is lost: the map has been mapped on the reference map. The term "mapping" is exactly in the meaning given to it in computer graphics: the adaptation of a texture to a form.

Warping techniques can be used, not to transform maps but in order to create correspondence, realising special software which manage and visualise these correspondences between the maps.

The procedure of referencing-transformation remains valid but is combined with and in some cases replaced by the procedure of referencing-correspondence.

What has just been described must be realised with special software that allows for the loading of digital maps and the identification of homologous points. The name 2WIN software is inspired by the fact that the screen is organised into two windows. In these, on the left window, the reference cartography is visualised and on the right, the map to transform. The methods of functioning are quite commonplace: by identifying a point on one of the two maps, the program calculates the position on the other and highlights this by centring the two windows on homologous points. The centre of the two windows is always on two corresponding points.

2006

Fra Mauro's digital worldmap

Caterina Balletti, Giovanna Fanello

Recently it was published a new important work on Fra Mauro's mappamundi, a masterpiece of historical cartography, composed around 1450 in Venice (Fra Mauro's world map, a book and a CD published by Brepols, 2006), that aims at an analysis and an in-depth study of this important document, offering the reader an understanding within its contemporary cultural framework. The particular characteristics of Fra Mauro's world map – which contains not only geographical and topological information but also a large number of descriptive features (toponyms, inscriptions, comments) – implied an approach which was focused on the design and the development of an innovative fully interactive software that combined a facsimile-level of reproduction of the original with the ability to navigate within the map and extract information from it. The main concern of this design was to give the general public an easy way to operate virtually into a now digital Fra Mauro's mappamundi environment. This interactive software makes possible to examine each visual detail of the work; it provides a veritable research instrument covering all the visual and textual contents of the map. All the inscriptions within the digital images that make up the world map were linked together with a database containing not only the transcriptions of those inscriptions but also notes and comments upon each. The instrument for this link between image and text involves a window that makes it possible to consult the transcription of Fra Mauro's inscription, an image of the geographical area to which the inscription refers and the associated notes and comments.

2009

Image matching for historical maps comparison

Francesco Guerra, Caterina Balletti

The aim of the research is to test an algorithm of area based image matching to compare copies of maps with small differences, such as maps of the same cartographer but published in different years, presenting updating in contents.

The comparison can be supported by ACM (Automatic Correlatin Map) software, written by the photogrammetry laboratory of Sistema dei Laboratori - Circe, which find areas that are candidate to contain differences.

Image matching is a key component in almost any image analysis process. Image matching is crucial to a wide range of applications, e.g. to navigation, guidance, automatic surveillance, robot vision, and to the mapping sciences. Stereo image matching in particular is of fundamental importance to photogrammetry.

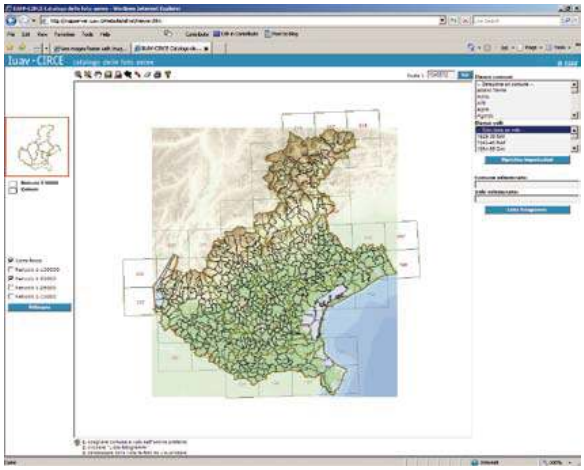
Any automated system for three-dimensional point positioning must include a potent procedure for stereo image or dual image matching. The matching tecniques have the ability to recognize similar image characteristic (texture, shake...) in small regions from two different images.

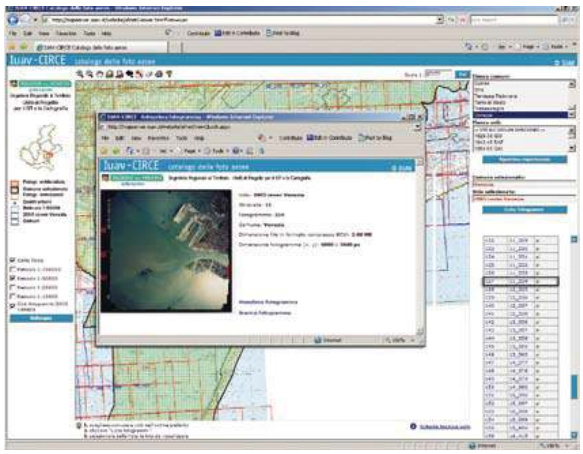
A common task of these techniques in photogrammetry, using stereoplotters, is to place the floating mark at a three-dimensional model position of an object point. There are three general categories of algorithms: area based, feature based and hybrid based. All three approaches have particular advantages in different application field: in order to compare maps with small differences the most useful method is the area based using the least squares matching such comparison criteria.

The implemented algorithm allows the realization of a map containing the correlation values that has to be overlapped on the original map.

Aerial photos on line
Sistema dei laboratori CIRCE
Regione del Veneto

CIRCE and the Territorial Information System Department of the Regione del Veneto, started years ago to gather and to classify territorial data and documents into files that are nowadays spread known and consulted by a large and various number of users, professionals, students, public employs, researchers and amateurs that are willing to analyse territory and town development and transformation through aerial photos.
The plentiful legacy of iconographic documents is a detailed portrait of Veneto's territory history, of the current state of Italy and of other European and extra-European countries, and represents the cartographic evolution up to satellite images. Both Institutes developed wide and articulated agreements of cooperation that produced significant results as the publication of their data archives. They both are willing to work on projects of mutual interest, using common communication standards and programs that could be a useful tool to study and to elaborate territorial data on scientific bases. According to this aim a digital file and the publishing on the Web GIS of the Veneto's aerial photographic database have been realized. These are new instruments that offer a qualified service in accordance with the latest Italian institutional reform of the Public Administration and they allow a rational and simpler management of administrative activities and access to data. They also involve a new interaction between the Public and the Public Administration thanks to new computer technologies and the wide spread use of internet.
The web site and the digital database helped to develop Geographic Information and allowed to easily consult aerial photographic databases from wherever. It gives a valuable contribution to preserve the contact print. The on-line hint of the aerial photos, which are published at high resolution and equipped with specifications on the photographic sortie, reduces the damages caused by moving the material.
The digital archive is composed by more than 32.000 aerial photos of Veneto's territory, mainly produced by Regione del Veneto and by the Istituto Geografico Militare Italiano (IGMI), but there are also historical shots by Royal Air Force (RAF) and by Gruppo Aeronautico Italiano (GAI flight) plus photos produced by other Local Administrations or private institutions. The aerial photos are organized and recorded in a functional database, their representative scale ranges from 1:3.000 to 1:60.000 and they date from the beginning of the 20th century to recent years. Images have been acquired with a scanner of specific technical characteristics and the resolution of all scans is of 600 dpi, both coloured and black and white. The images have been compressed in a tiff format, without loss of quality, or in ECW format, for internet browsing. The images obtained are of good quality, the best fit between scan resolution and file dimension, which allows keeping the original characteristics. The acquirement of photographic sortie, a geometry information necessary for the geographic automatic query and search on line, were realized in two phases: the first consisted in collecting the few vector photographic sortie available, concerning flights made during the '90s, the second phase, the longest and the hardest, has been that of digitizing paper data with a digitizer, calibrated for each photographic sortie.
Afterwards all paper photographic sortie of aerial shots have been georeferenced in Gauss-Boaga coordinates (the Italian reference System) West Zone and the coordinate of each paper vertex has been extrapolate by the official IGMI cartography: that at 1:50.000 scale has been used for photos at large-scale and that of 1:100.000 for photos at small-scale. Each strip and each photogram has been delimited with a closed polyline, they both have been numbered and the name of the Institution / the producer and the year of the flight have than been recorded inside the database of each frame.
The access to the aerial photo online is through the website of Venice's University IUAV CIRCE at page: (http://circe.iuav.it) through the link Cataloghi-Foto aeree-Catalogo geografico and from the website of Regione del Veneto at page: (http://www.regione.veneto.it/Territorio+ed+Ambiente/Territorio/Cartografia+Regionale/Area+SIT/web +gis.htm) or through the website (http://mapserver.iuav.it/website/afnet/Viewer.htm)





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Sistema dei laboratori

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in Cartographic Heritage

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