

3D ADVANCED CARTOGRAPHY OF MARINE COAST IN ITALY: GIS DATA MANAGEMENT

Carlo MONTI

Full Professor, DIIAR Director

E-mail: direz@idra5.iar.polimi.it

Raffaella BRUMANA

Professor

E-mail: brumanar@idra5.iar.polimi.it

Carlo SAVI

Research Assegnist

E-mail: carlo@topo.polimi.it

Cristiana ACHILLE

E-mail: achillec@idra5.iar.polimi.it

2nd year Course of Doctorate

DIIAR Dipartimento di Ingegneria Idraulica Ambientale e del Rilevamento

Sezione Rilevamento - Politecnico di Milano

Laboratory of "Rilievo, Cartografia Numerica e GIS"

P.za Leonardo da Vinci 32 - 20133 Milano

ITALY

Abstract

Paper describes of data survey in the protected territorial area of two municipalities (Levanto and Bonassola) located nearby to the famous "CinqueTerre" coast in the Gulf of Liguria region: Aerial Photogrammetric taken, Photogrammetric taken acquired by sea, GPS from ship and from coast, Regional data and National Geographic Military Institute (IGM) Matrix data.

It has been experimented new cartographic representation, such as 3D visualization of different catalogues of raster maps digital 3D orthophoto and the map of the coast from the sea built on a 3D complex DSM.

The project is directed to emphasize the environmental heritage, on which Levanto and Bonassola base their own tourist economy, focusing the guide lines and the analysis required for the landscape insertion of the recovering project of the old railway tunnel faced to the seacoast, work over land and work over sea, through 3d virtual navigation on the gulf of Levanto and on urban centre.

The paper describes how GIS can support conservation process, environmental analysis and project orientation.

Software: StereoView (Nikon Instruments), ArcInfo (TIN, GRID), ArcView (Spatial Analyst, 3D Analyst)

The survey and 3D GIS data management of the coast heritage

The area studied is characterized by different phenomena, problems and aspects which ask to the survey first to support the different analysis with appropriated representations and new methodologies, second to support data management by GIS technology.

The research improves the experimentation of integrated data processing required by environment and urban complexity, to better correlate the semantic value of the different images with the digital metric data of the survey (the vectorial maps).

The research is divided into two main parts: one methodological concerning the new opportunities offered by new survey and GIS technology, the other concerning the data survey experimentation and implementation to generate integrated models inside GIS software.

The photogrammetric survey of difficult access and transit area like this one allows to describe the land without necessity to cross it (except for the ground control points). According to the peculiarities of the object different methodologies of survey and representation can be integrated. The research has been focused to study and to experiment the flow of the operations of survey and processing usable with the purpose to get a metric representation of the rocky walls of the coast heritage, considered environmental interest zone and hydrogeologic risk zone.

One of the duty of the research is to study if the implementation of GIS (Fig.1) based on advanced survey can effectively support different level of analysis in a such complex area as follows.

1. The coast of the area examined is considered a relevant environmental heritage due to the landscape, with the beautiful rock walls degrading to the sea, due to the richness of coast vegetation, marine protected fauna and flora: there are protected park areas of coast and sea (the Park of Mesco near Monte Rosso, the park of Punta Marmi near Bonassola). Consequently their knowledge is requested by technicians, experts in monitoring and tourist people (Fig.7).

2. The punctual analysis of the geographic characteristics: the slope, the hillshade (Fig.3) the position and catalogue of the beaches easily reachable by sea, the location of the accesses to the sea from the old track

of the railway (running along the sea inside system galleries). The organization of the access system by sea and by land through the use of the old track of the railway and of the sea access, is now at the study and financed by UE program. The project of cycle and pedestrian tracks associated to the sea access and the project for the new Promenade along the gulf ask for a detailed survey (Figg.2,5,6).

3. The analysis of the damages of the fire spread up in the summer all over the mountain on the Gulf of Levanto, now considerable in Italy a relevant phenomena interesting many beautiful tourist coastal heritage. It requests the 3D documentation and quantification of the areas interested by the fire in order to update the numerical cartography and to refund the damaged citizens and their own properties (Fig.4).

4. The same area is interested by the phenomenology of the presence of unstable limestone masses and zones with strong concentration of fractures with problems of sliding and of intervention to stop the deterioration of the mountain and the risks related, especially considering the port of Levanto is under this area and it is now projecting its expansion and development.

Experimentation and implementation of integrated models of the environment and urban area

Since the simple integration of data and images in a 2D environment is not enough to represent the complexity of the urban context, research has been developed in the study of the most suitable methodologies for the survey data integration to obtain three dimensional representations and integrated digital models of surfaces and images (raster-vector). This integration can offer great potential to confronting the problems involved in the safeguarding processes and to verify the sustainable changes and transformations in the architecture and the environment introduced by the interventions and project.

The objective of the research is to build a methodology to relate Digital Surface Model (DSM) to the digital images, to obtain three-dimensional mathematical model integrated and dressed by the semantic content of the images. Among the objectives of the research is fundamental to go on with the experimentation on new forms of survey technology for the production of DSM of complex shapes like the sea coasts with particular use of laser scanning.

Contextually the research is oriented toward the integration between different images, the aerial traditional taken with the images of the fronts of the protected sea coast areas taken also by ship.

The research program is particularly focused on the processing of all the images on the 3D generation of orthophoto images.

The research is performed in the following different steps:

- *GPS from ship and from coast;*
- *aerial photogrammetric survey; acquisition of stereoscopic imagery of urban and not urban areas;*
- *survey of the front of the coast by the sea from Punta dei Marmi to Punta Mesco;*
- *representation of Digital Surface Model (DSM) of the area of the two Municipalities of Levanto and Bonassola (Fig.1) with the related vector map of the photogrammetric restitution;*
- *realization of Digital Terrain Model to environmental monitoring;*
- *3D urban city model (Fig.2) of Levanto;*
- *DEM analysis as slope and hillshade (Fig.3) of coast areas by the implementation of the photogrammetric survey of the two Municipalities of Levanto and Bonassola, of the vertical walls of the sea coast;*
- *integration of the images obtained from the sea by ship for the protected coastlines;*
- *a new representation of the sea front of the coast by the sea mosaicing the takens (200) acquired by Metric Camera (Rollei 6008) at the scale circa 1:1000;*
- *processing 3D digital orthophoto maps to be navigated and examined from different points of view for the landscape analysis of the environmental heritage (at the scale 1:10000), the assessment of the environmental impact of anthropic works (1:2000) and the historic urban centres (1:500);*
- *implementation inside GIS software of different 3D Model raster-vector, related to database acquired by geological, botanical and landscape experts, in order to share to the potential users (the public administrations);*
- *the coastline mapping and change detection managed by 3D GIS;*
- *realisation/updating of digital urban mapping;*

The 3D GIS raster-vector model of Levanto and Bonassola. Orthophoto 3D.

It is obtained a metric representation by superimposing the stereoplotting (vectorial restitution) of the contour line (1:2000) of the urban centre of Levanto (1996) with the digital 3D orthophoto (Fig.5) obtained from the aerial photogrammetry realized at the end of the summer in order to update the cartography.

It has been get two Digital Surface Models: 5m-10 m grid for the area faced to the Gulf of Levanto, and 10m-20m grid for the territory of the two Municipalities.

The first model is obtained from the contour line *dxf* file (1:2000) by managing data with TIN module in ArcInfo, introducing the break lines (the line of the coast, of the river...) and the clip polygon.

The second model is obtained by the integration of IGM data (grid of 3"/60m circa) with contour line digitalized from the raster Regional Technical Cartography (1:10000) of the Liguria, since it isn't available a numerical vectorial cartography at the scale 1:10000.

It has been implemented in a Geographic Information System the 3D digital orthophoto, georeferenced to the TIN model. The model it has been built using the TIN module in ArcInfo.

The GRID transformation of the TIN Model allows to extract an xyz ASCII file of the Grid in order to obtain a dxf file of the DTM surfaces, requested by the photogrammetric Software image processing (StereoView, Menci Software-distributed by Nikon). The Module of StereoView to obtain 3D metric orthophoto uses a referring model of 3dface (DXF file).

The processing of elaborated 3D orthophoto generated the following models:

- 3D orthophoto of the terrain for landscape and environmental impact studies (coastline and anthropic territory of Levanto and Bonassola) at the scale 1:10000;
- 3D orthophoto of the Gulf of Levanto and the urban centre at the scale 1:2000.

It has been used 10 aerial takens (600 dpi) to obtain the orthophoto of all the area and one taken (1200 dpi) for the gulf. For the internal orientation of the takens it has been introduced inside the software the calibrated certificate of the aerial photogrammetric camera, the external orientation is obtained by space resection, using about 10 ground control points for each one.

Once obtained the digital mosaic of all the orthophotos (Fig.7) it has been georeferenced inside ArcInfo (tifw) and it has been built a 3D GIS.

The map of the sea front of the coast

Owing to the verticality of the rocky walls, the photogrammetric survey of the Coast must be terrestrial, with the inherent additional observation of the specific characteristic of the walls turned toward the sea and therefore with the practice impossibility, above all for the part to valley of the road that coasts along the coast, to follow the classical scheme of the taking (camera sets on the dry land). To solve this problem we took the metric photos by boat equipped with metrical camera and GPS, with a distance of circa 100m from the coastline. A new evolution of the old "Portolano" map is represented by the sea front map of the coast obtained by the mosaic of the 200 takens (Fig.6).

In the future it has to be improved the operation of topographic survey of the ground control points applying and testing the Aerial Triangulation using only one single strips of stereoscopic models of photogrammetric takens, in order to get the orientation of all the takens. It will be experimented a project of new Ground Control Points: shape, dimension, number and distribution on ground, using also natural Points surveyed with GPS technology.

One of the objective of the research is the verification of effectiveness and the correspondence to established requisite of precision of non traditional methodologies, suitable for the survey of vertical surfaces in situations of difficult transit. We experimented the possibility to effect a survey from the boat that answers to requisite of effective operativity and reliability for the achievable results and to study specifics on the equipment of the boat for photogrammetric surveys as well as on various problems connected with the acquiring and elaborating phase. The cooperation of different Italian Universities in national research (MURST – COFIN2000), if financed, will be develop the research in order to obtain metric photographic representation in the form of the orthophoto not in the traditional representation of the territory (the planimetric view) but in the prospect view by the sea, using as surface model the DSM of the terrain integrated with 3D city model of urban area.

Interactive navigation inside 3D raster-vector model of the coast heritage and of the urban city model faced to the gulf

The research also experimented interactive navigation within the three-dimensional models obtained by the simultaneous comparisons of architectural buildings and environment to better support transformation analysis and project modifications .

It has been developed the following applications:

- navigation around the coast, comparing vectorial maps and raster images, and visualizing in real time the sea front images to the plan coastline: the coast is similar to a fractal and it becomes difficult to locate the rocks and coves of all the fronts (QuickTime VR);
- correlation routes over the territory having either a natural or constructed reality, as in for example, the route of coastline, placing the plan map in relation to the corresponding urban fronts of the Centre of Levanto along the axis of the railway tunnel faced on the sea (QuickTime VR).
- urban 3D city model integrated to the beach surface and the axis of the railway tunnel faced on the sea (ArcView 3D Analyst).

The next step of the research will be oriented to obtain the navigation within the raster-vector 3D GIS model of the territorial zones of Levanto and Bonassola (1:10000) and of the 3D model Gulf of Levanto in order to provide new interpretative instruments of the evolution of the 'anthropic' environment and of all the little settlements wide spread placed in the mountain territory on the back of the Centre of Levanto. To update

raster-vector cartography in the urban area it has been now introducing and studying new stereoscopic navigational methods (Digital Stereoscopic Navigator - Menci Software - distributed by Nikon Instruments).

The expected result

The 3D GIS development and the integration of the different representations, the 3D urban centre and the territory, can contribute to support:

- the analysis of urban or territorial transformations;
- the evaluation processes of environmental and landscape impact, risk analysis, carried out by the experts in the different disciplines involved;
- support the safeguarding of the urban heritage and historical centre inside particularly environmental contexts, in the logic of programming ordinary maintenance processes as opposed to the logic of special interventions;
- support effective landscape integration of the projects in the areas to protect;
- developing 3D GIS on line accessible from the network and easy to use, in order to guarantee the access, consultation, and transfer, from remote to local, transferring the different types of geographic to the users (State cartographic agencies, Public Administrations, Civil Protection, Regional Government, Tourist Office, citizens and tourists).

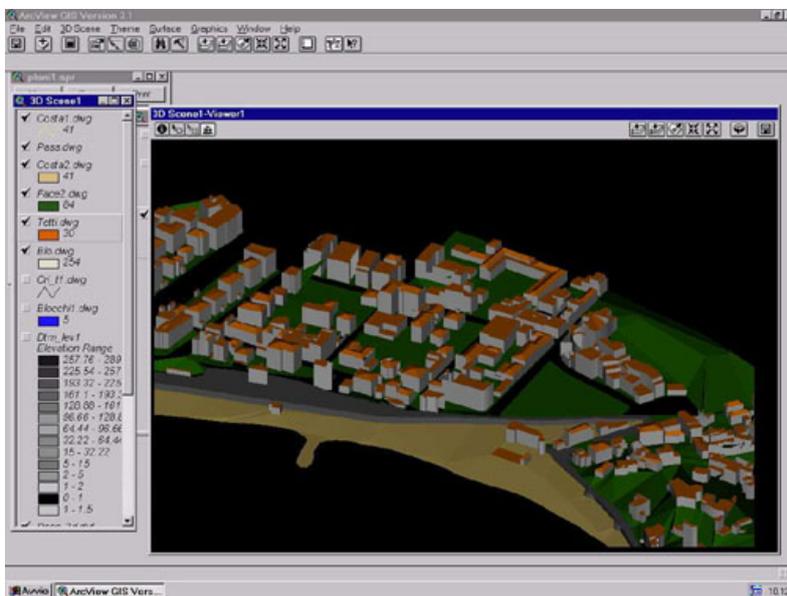


Fig. 1: Projection of vectorial photogrammetric restitution on DTM

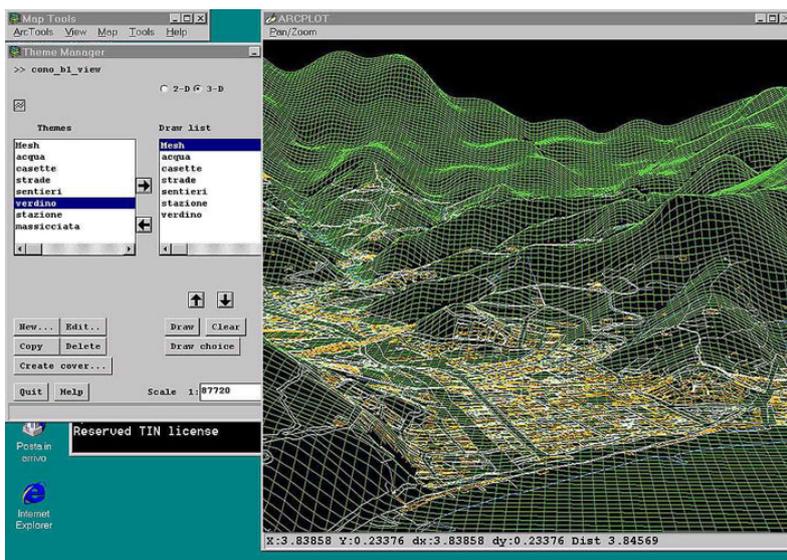


Fig. 2 3D City Model: old railway tracks to support new promenade faced on sea project.

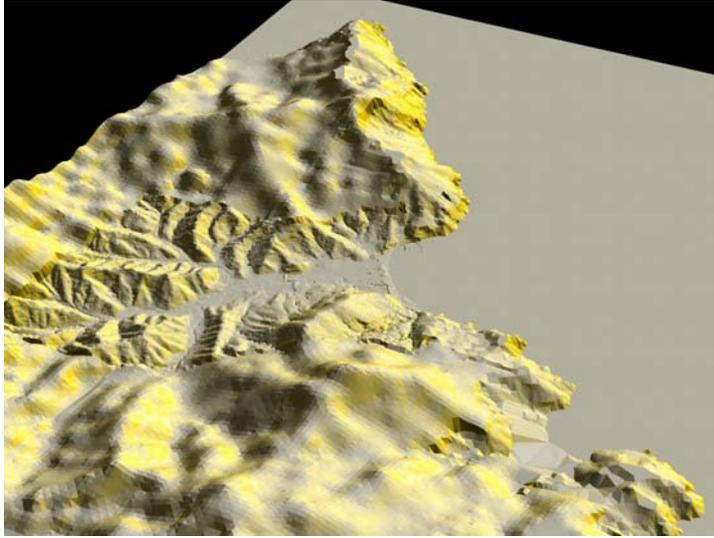


Fig. 3 Representation of Levanto's Bay Hillshade.

Fig. 4 3D View: Projection of digital orthophoto on DTM: On left side the result of fire (Summer '99)



Fig. 5 Digital Orthophoto of Centre of Levanto obtained from high resolution aerial photo



Fig. 6 Sea Front Map: particular of gulf of Levanto and old railway tunnel to support sea access system and cycle tracks



Fig. 7 Digital Orthophoto from Bonassola to Monterosso coast georeferenced in Arcinfo to support safe guarding policies of protected Sea Park.

Fig. 8 Digital Orthophoto of Centre of Levanto with overlapped data from georeferenced numerical restitution: torrents, paths, railway, etc.

