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RECOMPOSING THE LANDSCAPE USING STRUCTURE FROM MOTION SURVEY IN THE VILLAGE OF KORZA, KARELIA (RUSSIA)

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Abstract

This contribution relates to the experiences of applied research for the construction of three-dimensional models relative to landscape complexes through the use of so-called three-dimensional photogrammetry. Survey expeditions for studying historical architecture are increasingly in demand today and methods for producing metric data able to meet the descriptive requirements of drawings of buildings are constantly evolving. Many programmes have come and gone in recent years in an attempt to generate automatic 3D models to manage the complexity of real space; when the object of the survey is a multi-composition system covering different levels of investigation and scales of representation, the landscape needs to be broken down and recomposed using techniques for the discretization of architectural forms and images.

Keywords

SFM Survey, reality based survey, wooden architecture, GIS 3D

1. *Expression between photography and drawing*

The research contribution reported here attempts to expose the difficulties tackled in the approach of how to represent the landscape. In seeking a solution within this sphere the need emerges to give a *common sense* to our surroundings, a unique representation to the *chaos* of the scenario which the city or urban space analysed is immersed in. The problems related to the conservation and maintenance of many traditional centres, both urban, and small peripheral settlements, stimulates a desire to experiment survey and representation methods which, in the attempt to leave the sterile mechanism of self-reference behind, are able to activate a sense of awareness greater than the transversal nature of their spheres of application. In other words able to trigger multidisciplinary collaboration aimed at recognising the sense of the dignity of a given landscape within the complexity of the urban environment.

To recognize the qualities of a complex space, a place, and to be able to interpret, analyse it, to transfer its contents, enhancing those features which might hold meanings of social, cultural and symbolic significance, it needs to be considered from a dual perspective. A first perspective involves an aseptic approach to the place, dissecting it, breaking it down, decoding it and thus facilitating its interpretation on the basis of the formal relations linking its parts.

A second perspective instead, in collaboration with those areas dealing more with the social and anthropological aspects, aims to reconstruct in a single, qualitative image, very hard to represent, the intrinsic spirit of that place, those qualities which lead to its universal perception as a landscape full of values and identity. Faced with a view, a subject, one tries to identify the angle from which as many of the meanings present in that space can be transferred, that is, to grasp the *typicality* of the scene which determines its character[1]. For this type of analysis, art photography and art in general, have helped to give the image of the landscape its own dignity, offsetting aseptic planners and local governments who have always exploited the quantitative aspects at the expense of quality. However, the photographic image, since its invention, has become part of documentation and surveying activities, making a decisive contribution to

[1] Character is referred to as the constituent quality of the place, according to the theories of CN Schultz. Cfr. *Genius Loci. Paesaggio, ambiente, architettura*, Documenti di architettura, Milan, Electa, 1992.

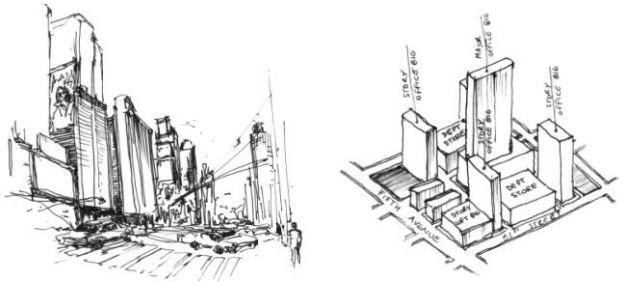


Fig 1: The selection process triggered when, interpreting an urban or suburban space, one tends to break it down and select some elements over others, is based on cognitive and representative structures specific to each culture, added to which are those of the individual. These pictures show the selection process of western culture which tends to simplify the complexity of the metropolis (left) into simple volumes. The central drawing is taken from a design by the architects Reinard & Hofmeister made for the Rockefeller Center project in New York.

Fig 2: A picture from "Simboli suburbani convenzionali", from the planning course held by Robert Venturi and Denise Scott Brown *Learning from Levittown*, Yale University, 1970.

changing the way of interpreting space not only in the sphere of works of art and visual communication, but also and above all in the measurement and research operations of qualitative and formal similarity to the real object. The need to identify and transmit the characteristics of the space (both those for which it is recognized an aesthetic value and those apparently degrading the image of the place)with a view to facilitating the understanding of how it is perceived, make the camera a preferred means of acquisition, able to capture all that information able to describe the environmental qualities of the space, depicted as fully and in as non-impersonal a manner as possible.[2] Photography, by integrating increasingly sophisticated programming and multimedia communication systems, sets out to clearly express the relations between the individual photograph and its orientation within a structure of the place, made increasingly simple and schematic.

1.1 Experimentation on a Karelian village

The survey work on the landscape and traditional wooden architecture in Karelia is part of the European research project entitled "*Wooden Architecture. Traditional Karelian Timber Architecture and Landscape*" deveoped by the Seventh Framework Programme, Marie Curie Actions, aimed at promoting international scientific research and at increasing scientific exchange between universities in different countries.[3] Karelian history and culture have resulted, over time, in natural and urban landscapes, unique of their kind, where old villages and new aggregates, monuments and archaeological sites coexist with the natural system of the imposing Scandinavian continuous forest albeit in a context of great transformation. [4] The local traditions of the peoples who inhabited these lands, like the Karelians, the Vepsians, the Livvick and many other ethnic groups who in some way defined their own customs and architectural models as well as autonomous linguistic forms, blended with

[2] Cfr. Fred Ritchin, *Dopo la fotografia*, Piccola Biblioteca Einaudi, 2012, pag XVII.

[3] The project, coordinated by Sandro Parrinello and conducted by Francesca Picchio, Sara Porzilli, Petri Vuojala, Kari Niskasari, Anna-Maija Ylimaula, Alexey Borisof and Alexandre Kosenkov, relates to the development of documentation methods of historic Karelian architecture so as to develop survey instruments for the planning and safeguarding of the historic architectural heritage. During the three years of the project numerous research and surveying campaigns were conducted at the villages of Karelia, during which sample landscape contexts were investigated for the study of historical settlements. In addition to the research activities, two international summer schools were organised, attended by students with an in-depth knowledge of surveying systems of wooden architecture.

[4] For a discussion of the research developed within the European project see. Parrinello Sandro, Picchio Francesca, Porzilli Sara: Architettura tradizionale lignea e paesaggio in Carelia. (Traditional wooden architecture and landscape in Karelia.) Considerazioni metodologiche per l'analisi ed il censimento. (Methodological considerations for its analysis and census). Disegnarecon, numero speciale DoCo 2012 – Documentazione e Conservazione del Patrimonio Architettonico ed Urbano

Fig 3: Picture of the study area in Karelia.

the Soviet models and administrative structures which radically changed the this landscape, as well as the individual architecture, at every level of human activity, from perceptual and behavioural impulses to planning and conservation dynamics.

Undertaking an analysis of the cultural resources and the architectural heritage and landscape existing in Karelia appears necessary today to test the formulation of an *ad hoc* system of regulations to address, in an informed manner, the changes and developments which are daily corroding the historical image of a landscape so loved by the entire Russian population. Specifically, it will be challenging, in the definition

Fig 4: Picture of Korza, traditional Karelian *village street*

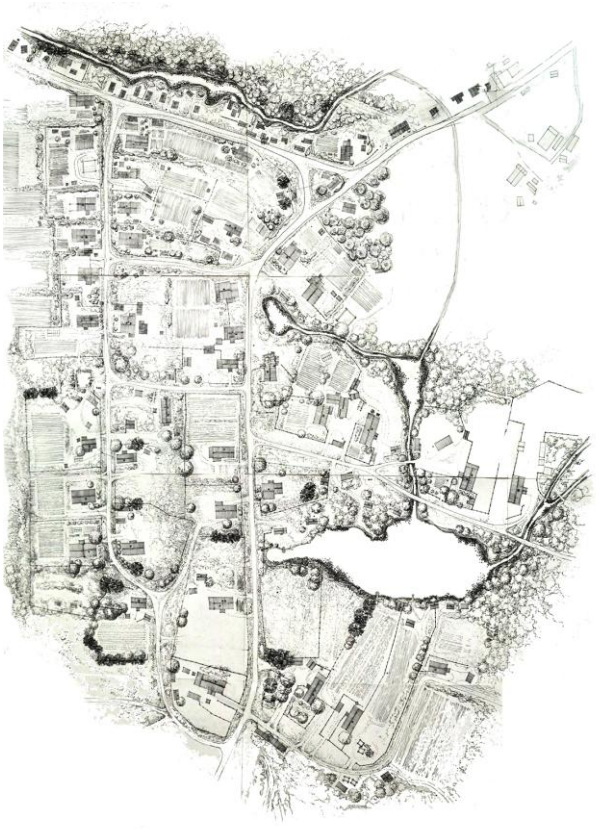


Fig 5: Map of the village of Korza. The basic maps dating back to the early '50 s were updated using direct drawing techniques.

of a vast area, to see at all levels, from the general to the most detailed, what small changes can help to avoid jeopardising the preservation and valorisation of the landscape and historic and architectural heritage.

During the period defined by the project a series of programmatic investigations, research missions and exchanges between researchers were planned to acquire a better understanding of the existing systems, including administrative. Specifically, survey campaigns of the villages, the most distinctive landmarks and in particular of the landscape were conducted by making drawings and considerations relative to the morphological and perceptive aspects of the places.

During these three years of work, over which the acquisition phase was performed in several field missions to Karelia (2012-2014), the instruments used in the research project were progressively refined with increasingly satisfactory results in the application areas of the various case studies tackled.

The method of survey expeditions based on the acquisition of images and aimed at processing the data to create three-dimensional models and/or virtual prototypes able to describe and summarise the surveys and the information obtained, proved able to meet the time and reliability requirements in terms of reconstructing the actual layout of the Karelian village.

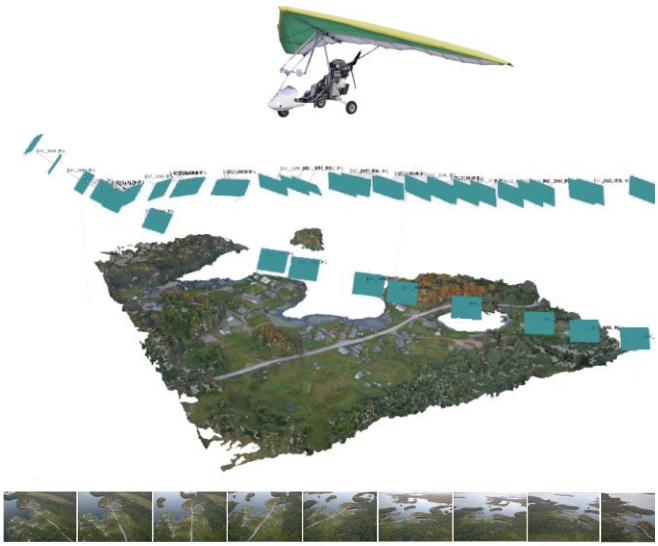


Fig 6: *Structure from motion* survey systems used during the missions for the documentation of Karelian villages.

The ease of transport, reduced costs and the speed with which it is possible to acquire all the necessary information made the camera the benchmark survey tool for the research carried out on Karelian territory.

It was therefore decided to apply the *structure from motion* method over a large enough portion of a sample village, verifying to what extent and within what limits the tool might be able to describe the complexity of the levels of investigation from the macro scale down to the smallest construction detail of the traditional, historic architecture . [5]

1.2 Features of the territory and choice of the acquisition instrument

The village of Korza, located near lake Siamozero, is part of a territory with a massive presence of birch , spruce and pine forests. This area immediately appeared of extreme interest for the co-presence of historic villages of various types subject to a decidedly rapid process of substitution and transformation capable of jeopardising their identity over the course of a decade. During the research the village was compared with a wide range of "case studies" offering a detailed description of the cultural,

Fig 7: 3D model of the village of Sierghilachta. The photographic campaign was carried out at high altitude using a motorised hang glider. Using this it was possible to fly over the whole village and take photographs from various viewpoints to cover the entire area. The uniform exposure of the various fronts and absence of clear-cut shadows made for a model without omissions, providing a valid basis for studies related to understanding the morphology of the landscape.

[5] The framework of the *structure from motion* experiment gave surprising results in the documentation and restoration spheres. Many of these results relate to applications performed on Italian and foreign archaeological sites. For a more in-depth treatises on the subject of the acquisition, producing, management and use of three-dimensional digital models whithin cultural heritage context see Pompeii case study in Benedetti, Gaiani and Remondino (2010).

social and natural situation of Karelia.

Unlike the villages analysed in previous years, the village of Korza extends along one of the main roads of the area. Its most obvious feature is the almost entirely historic nature of the buildings, spattered with a few examples of new constructions which blend in formally but not typologically with traditional Karelian style.

The area chosen for the systematic testing of the three-dimensional photogrammetry method, influenced by the accessibility to the area and the effective possibility of filming at various levels of the system (access to the inside of the fences or possibility of covering the entire outer perimeter of the lot), is part of the north-east area of the village, bordering the physical limit of the now fallow fields and forest. The architecture in this portion is in traditional style, entirely wooden (except for roof coverings in sheet metal or asbestos), and some of them have decorations and inlays of great value. Coloured fences define the perimeters of the properties inside which there are saunas, toilets, outbuildings, sheds and warehouses, on flat ground which borders the forest without any unbuilt space between them.

Fig 8: Identification of obstacles to the visibility of the façades, needed for the organization of the photographic campaign.

However, the primary use of such homes for the holidays, alters the formal characteristics of the village, transforming the specific qualities of historic architecture and increasing, in the absence of constant maintenance, the process of decay to which these buildings are subject.

1.3 Decoding and breakdown into levels of inquiry

Before undertaking and building an analysis framework a first decoding process of the main elements had to be performed, selecting the unique aspects of each rural aggregate and beginning a process of discretization and synthesis of the information collected. To understand and represent the complexity of the place the area of intervention first had to be broken down into levels of investigation. These levels, including both the formal structure of the place and the set of specific descriptive features of each subset, are defined through the structuring of a drawing capable of describing the sphere of interest that generated them. The drawing must thus include the physical limits between the different systems of relations, both at the macro-scale, setting the limits between clearings and forest, and at a smaller scale, going to define individual portions of building units to investigate further. To this end the choice of instrument for the acquisition of the elements

constituting these levels was crucial. The choice of an instrument taking advantage of *image based,* acquisition methods, able to develop a three-dimensional model closely corresponding to reality from a photographic sequence, in some ways constrained the organisation of the phase during which the data acquired was broken down and managed.

Fig 9: Images of the elements present. The photographic campaign, both for the documentation, and for the three-dimensional photogrammetric acquisition, was performed using a digital SLR Nikon D90.

Unlike a laser scanner survey, the shape from motion method, if applied over a large area, provides for the movement of the camera around each of the elements in the scene: only by means of a proper photographic campaign will these elements be acquired and prove complete with the information required. The amount of information that can be recorded during the photographic acquisition campaign is vast.

The purpose of the survey is to determine the degree of accuracy, i.e. the final quantity of useful data which the model will need to generate for the description of that particular object or spatial context.

Given that such information is generated from images, the minimum unit of reference is thus the pixel, the result will depend on the number and quality of photographs taken and therefore the intrinsic characteristics of the camera and of external factors, such as the question of colour, light, geometry etc.

Having acquired an awareness of the characteristics, the instrumentation and the framework of analysis as regards defining the structure of the place, according to the survey object, the operations were then organised so as to capture each single object present in the residential unit.

Filming was conducted following the logic of the investigation framework, trying to include the reference points around the object so as to be able to relate and contextualise it in the general model (system).

A photographic campaign was planned for the acquisition of each individual element from the general level to the details of the elements, using the drawing of the floor plan.

Each building unit was broken down into two broad sets defined by the residential unit and by the external contextual elements of the home but inside the fence. Where it was part of a larger and complex system, each element was broken down again, so as to acquire it separately and independently.

The photographic campaign was thus divided into two concurrent phases: the surveying at the various levels of detail of each residential unit, and the overall filmingable, through the use of a camera only, to spatially determine the entire area, identify the relative position of the individual building units, and integrate them using a subsequent *merging* operation of the

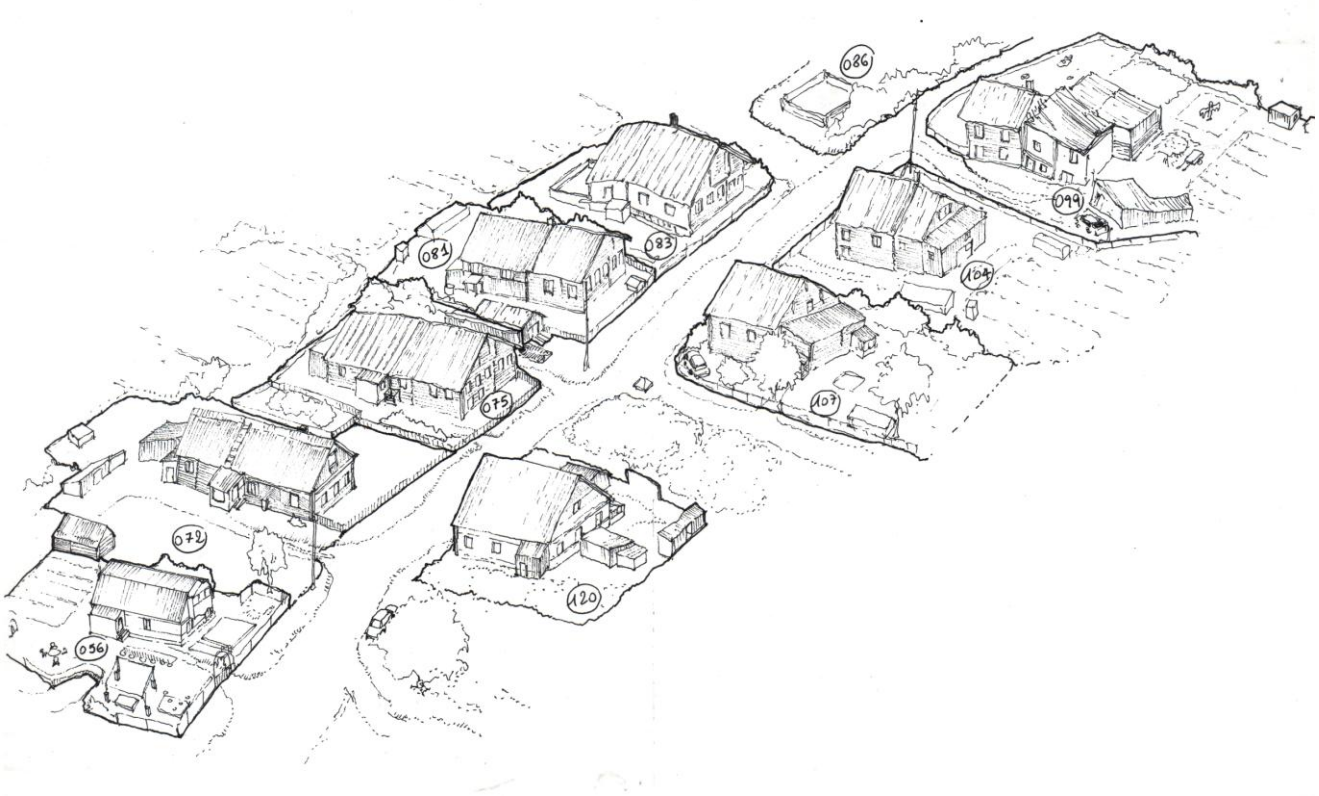


Fig 10: Identification of the physical limit within which all the characteristic elements of each unit were found.

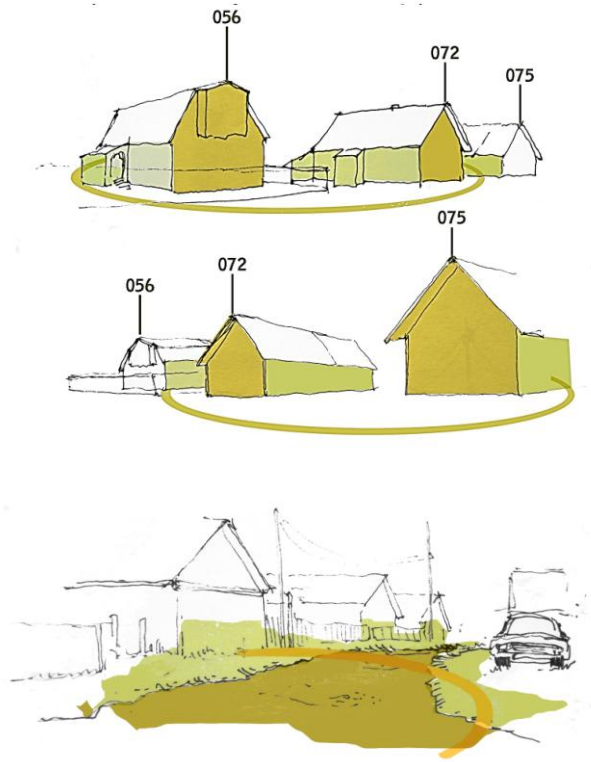


Fig 11: Acquisition by pairs of elements, to obtain a model able to represent the right spatial proportion between two macro sets and to capture the context, where, during filming, part of the fronts of the buildings were filmed in order to find points in common with the previous model.

various *chunks* (or groups) which the survey campaign was divided into. [6]

The acquisition phase threw up a number of problems: the presence of trees, the different exposure of the façades on the road, differently illuminated by the sunlight, and the difficulty of access inside some units, made it necessary to arrange a time schedule of acquisitions during the day.

This organisation was crucial for trying to get a uniformity of exposure between the various façades of the houses. In addition, to optimise the colour balance, a reference panel (ColorChecker 24 notches), able to balance the whites and optimise the material component of the 3D model was used to carry out the sequence for the residential units. [7]

[6] The decision to use this approach to the structure from motion process was also influenced by an awareness of the potential of the software used. Agisoft PhotoScan makes it possible, using homologous points, to join up various chunks on the same file and thus obtain a complete model of an object or a portion of land.

[7] In digital photography ColorChecker X-Rite is used to balance the white using Raw converter software. A ColorChecker was positioned on site and a double image taken in raw format of the same scene, one with and one

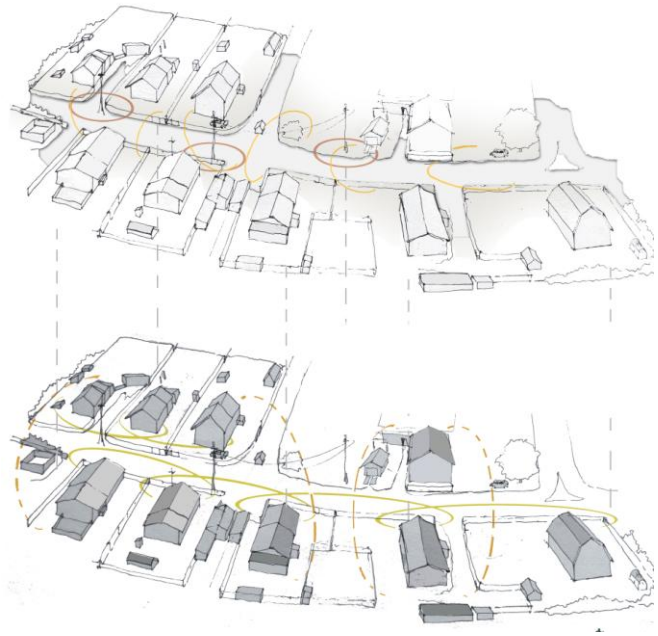
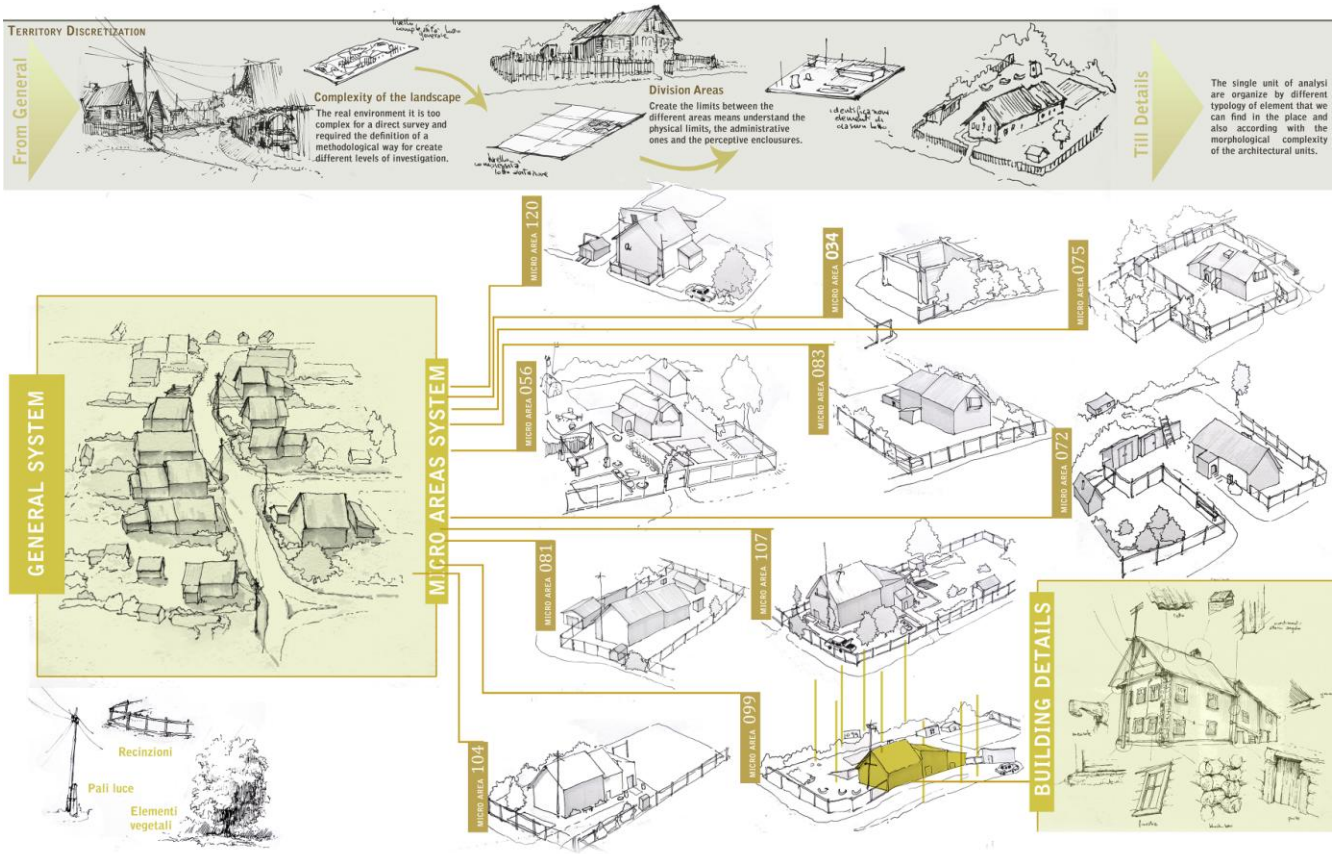


Fig 12: Summary of the operations performed on two areas: above, the surrounding roads, below the individual residential units.

After the acquisition phase, namely the transition from an understanding of the overall complexity by breakdown into levels of lesser and more manageable complexity , the reconstruction phase of the overall picture of the lot followed, surveyed by means of a single model in which the qualitative and quantitative characteristics of all the separately acquired elements in the scene could be recognised.

Using the *Agisoft PhotoScan* programme it was possible to align the sequence of each single chunk, or each of the smaller units into which the residential units had been organised. The product thus generated, describing on the one hand the elements inside the fences, and on the other the pieces of furniture, made it possible to obtain a model in which all the complexities at various levels of investigation of the entire area, were reproposed spatially, and the relations between

Fig 13: Breakdown of the general system into micro areas. Each of these contains all the detailed elements to be acquired individually



without the panel; in the converter the white balance was set on the second notch of the last row (corresponding to a light neutral grey).

Fig 14: Photographic acquisition of the individual object and macro systems of the structure constituting the lot.

the spatial elements and colour tones of the scene represented. [8]

The reliability to the centimetre of this surveying method is difficult to verify except with laser scanner or topographical surveys with which to compare the product obtained. However in this case study, direct drawing of the façades of the individual residential units was performed and integrated with an experimental topographical method using 360° panoramic photographs.[9] By aligning homologous points in three panoramic images the spatial position in a vector of such points can be traced. The topographic points obtained using the Sphera software were used to verify the correctness of the mutual relations between the façades facing the street.

Thanks to the development of photogrammetric software such as 'Autodesk 123DCatch' or 'Agisoft PhotoScan'[10] and their integration for documenting the landscape, the relationship between the real image and photographic image seems to seek a renewed confrontation: the space of representation becomes virtually three-dimensional, and the photograph is modelled in this space, describing each surface, to make it as similar as possible to the reality perceived. [11]

With a view to digitalising the architectural heritage and safeguarding the territory to ensure its proper management, the 3D model has proved an effective support for documenting and investigating the transformations of an object to facilitate its diffusion in the community.

The 3D model generated, as well as offering a useful aid to the qualitative understanding of the spatial development of the elements present in the area, develops a new approach to education, to the image, and thus to new forms of representation aimed at more conscious landscape management. The complexity is acquired, processed and interpreted in a single three-dimensional object, with all the quantitative and qualitative information needed for its complete configuration.

The output of this application ranges from virtual navigation to the realisation of GIS systems, with which to draw thematic maps essential for the understanding of the different natural and human systems in the area, identifying possible intrinsic dynamics of the areas that have determined unusual developments or specific urban phenomena; investigations of systems for the restoration, conservation and valorisation of the architectural heritage and landscape; analysis and studies of the formation, development and current structure of villages and urban centres; censuses and profiling systems of urban aggregates, architectural elements, environmental systems for the production of atlases to aid the analysis of the areas studied.

[8] The purpose of the 3D model must be established before starting the acquisition campaign. The amount of data which the shape from motion method is able to convey is vast and only by establishing the scope and purpose of the model in advance is it possible to optimise and make the data produced easily utilisable on different scales and for different types of users.

[9] This method has been developed and extensively tested in several case studies by Prof. Gabriele Fangi (University of Ancona). Thanks to the cooperation offered by the department of civil engineering at the University of Ancona with the Joint Landscape, Survey & Design Laboratory of the University of Florence we were able to apply the non-commercial software *Point Records* and *Sphera* to Karelian territory.

[10] For a treatise on the development of the software see. Parrinello Sandro, Picchio Francesca. 2013. Dalla fotografia digitale al modello 3D dell'architettura storica, in Disegnare con, a cura di Pablo Rodríguez-Navarro, Vol.6, n°12

[11] For a more in-depth treatise of the topic See. De Luca, 2011

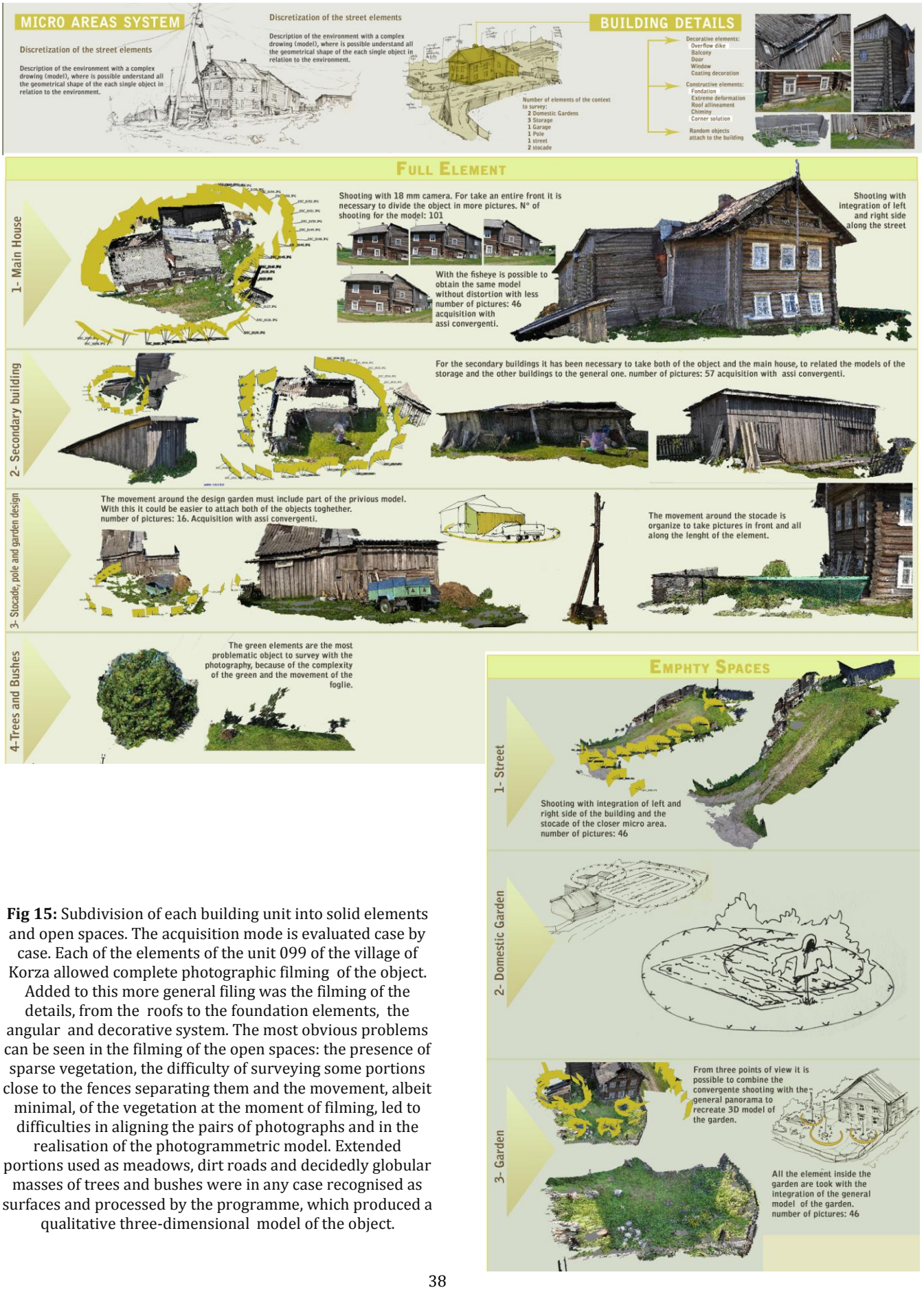


Fig 15: Subdivision of each building unit into solid elements and open spaces. The acquisition mode is evaluated case by case. Each of the elements of the unit 099 of the village of Korza allowed complete photographic filming of the object. Added to this more general filing was the filming of the details, from the roofs to the foundation elements, the angular and decorative system. The most obvious problems can be seen in the filming of the open spaces: the presence of sparse vegetation, the difficulty of surveying some portions close to the fences separating them and the movement, albeit minimal, of the vegetation at the moment of filming, led to difficulties in aligning the pairs of photographs and in the realisation of the photogrammetric model. Extended portions used as meadows, dirt roads and decidedly globular masses of trees and bushes were in any case recognised as surfaces and processed by the programme, which produced a qualitative three-dimensional model of the object.

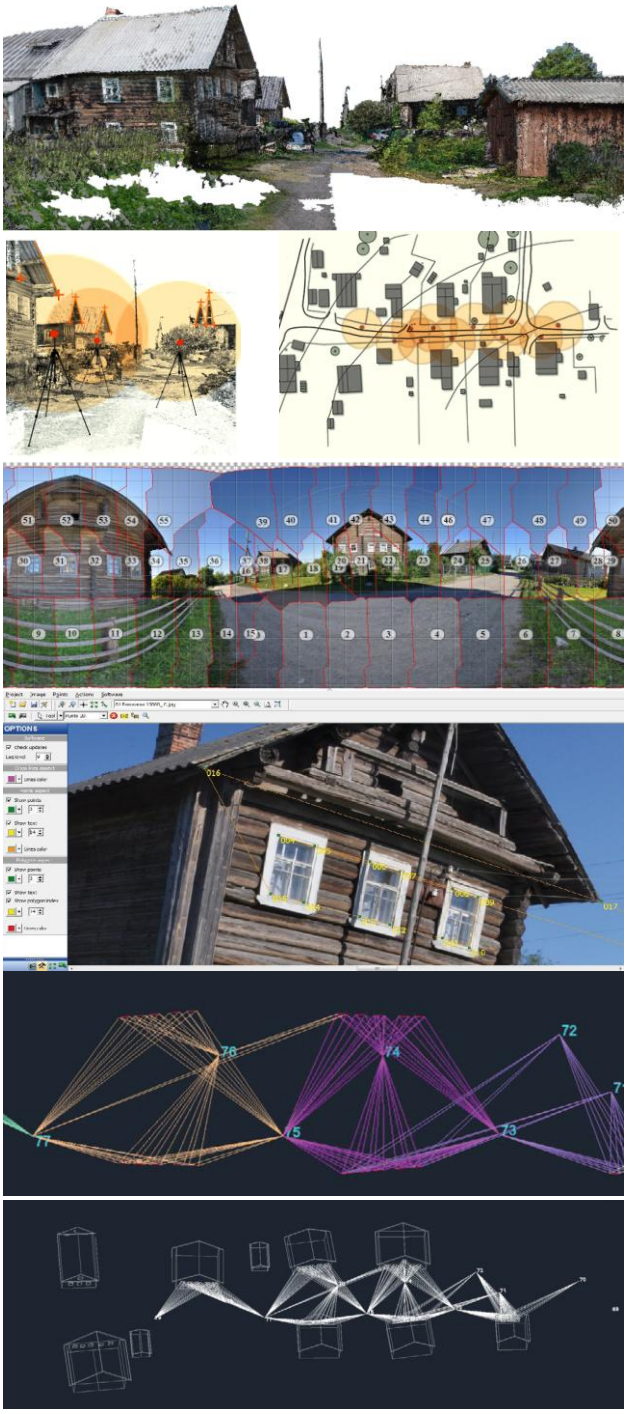


Fig 16: Positioning of the spherical panoramic views, alignment of the panoramic views with identification of homologous points and creation of the model on sphera software. Superposition in CAD of the map obtained from the three-dimensional photogrammetric model and of the model coordinates obtained from the panoramic views.

Fig 17: ArcGis software screens for the creation of 3D GIS databases. The models obtained, appropriately reduced in the number of polygons and optimized in the mesh, can be used and interrogated, integrated by whole range of information that in an instant can provide valuable support to the operations of the documentation of the actual architecture condition.

Fig 18: Zenith view of the 3D model. The individual buildings have been joined to the 3D model using reference markers, identifying at least 4 common points between each pair of models.

Fig 19: View of the three-dimensional model obtained by joining two chunks: the street and contextual elements level and the housing level.

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