Archeologia e Calcolatori
Supplemento 1, 2007, 123-142

FROM THE OBJECT TO THE TERRITORY: IMAGE-BASED TECHNOLOGIES AND REMOTE SENSING FOR THE RECONSTRUCTION OF ANCIENT CONTEXTS

1. Virtual museums and contextualization: the case of Ur

One of the great revolutions of the computer age has surely been the introduction of digital imaging. As is usually the case with those innovations that threaten to upset the "conventional" situation, initially its appearance was met with scepticism and diffidence, especially in those professions associated with the classic and consolidated analogical techniques. It was precisely these professions however that were the main beneficiaries of a revolution that is still in progress, which involves multiple fields of human endeavour and inevitably also interests researchers from both the humanistic and technological fields.

It is no surprise that recent developments in so-called image-based technologies have demonstrated the considerable potential, perhaps still largely unfulfilled, of all those applications designed to survey, represent, study and reconstruct ancient landscapes, in which the use of images as an instrument of analysis and enquiry is fundamental. *Image-based Modelling* and *Rendering* represent a field of study which is relatively new but has nevertheless produced levels of interactivity and photo-realism that a few years ago were unthinkable. Furthermore, the availability for non-military purposes, for some years now, of high resolution satellite images of the earth's surface, highly detailed and up-to-date, has opened up new possibilities of enquiry for archaeological research and has provided a type of documentation that has enormous potential, which can be combined with traditional aerial photography in the study of urban and territorial contexts.

The results of this work have been achieved largely by recourse to these methods, image-based technologies and remote sensing, following an inductive approach that moves from the particular to the general, from the object to the territory, in order to achieve one of the main aims of modern archaeology: reconstruct ever more extensive scenarios of ancient civilizations, in an attempt to understand and interpret the past. These aims are inevitably connected with the urgent need to contextualize mobile objects – generally kept in museums – ideally re-collocating them in the sites they originally came from and thus correlating them more closely with the cultural identity to which they refer.

The experience that is presented here was gained in the context of the CNR Project entitled *Iraq Virtual Museum*, headed by Prof. R. De Mattei with the scientific coordination of Dr. S. Chiodi and Prof. G. Pettinato, whose goal was the construction of a Virtual Museum[1] that will allow the public to enjoy the main archaeological treasures of the ancient civilizations that flourished in the territory of modern-day Iraq[2]. Specifically we present here the exemplary case of the city of Ur, one of the most representative of the Sumerian civilizations.

The process of contextualization began with the modelling of the golden helmet of king Meskalamdug (around 2400 BC), of great value and particularly representative; it continued with the reconstruction of the place in which it had originally been placed, i.e. the tomb (PG 755) that held the bodily remains of Meskalamdug and the rest of the funerary objects. This tomb was identified within the Royal Cemetery of Ur, contextualized within the ambit of the urban layout of the city. The site as a whole was documented by cataloguing the most significant monuments, in terms of historical and topographical development, so as to provide the "visitor" with a complete image of the characteristics of the place where the artifact came from. Furthermore, the recourse to high resolution satellite images made it possible to observe and document the archaeological area as it is today, both as a substitute for a real visit that is currently impossible, and in preparation for a potential visit *in situ* in the future.

The results of this experience thus show the potential of using images as a considerably effective instrument for the study, analysis and reconstruction of ancient contexts. The process, which by a great leap of scale leads from the object to the territory, makes it possible to illustrate effectively the whole expressive universe of the various ancient civilizations of Iraq, describing their essential features. Furthermore, research activities aimed at contextualization have made it possible to acquire new knowledge of the objects, the monuments and the urban and territorial contexts, in turn making it possible to reconstruct the ancient layout of the archaeological monuments and the historical landscapes.

F.G., G.S.

2. 3D image-based modelling: the helmet and tomb of Meskalamdug

The greatest efforts made by computer graphics in the last few years have been in the field of photo-realism. The old processing systems mastered the sense of depth by combining simple algorithms for visualizing solids in perspective, helped only by lines that traced the outline (wireframe)[3]. This primitive form of representation soon gave way to algorithms that made it possible to eliminate the hidden lines, followed by systems of shading that simulated the illumination of

[1] For an epistemological treatment of the concept of "virtual" see Lévy 1997.

[2] Our thanks to the IBAM-CNR researchers that have worked in this project: M.P. Caggia and M. Cultraro (Research Staff), F. Ghio and G. Pellino (Graduate Fellow).

[3] For some modelling techniques using polygons or NURBS surfaces for the conservation of ancient buildings see Gabellone, Giannotta, Monte 2001.

the surfaces. Then came raytracing, which opened the doors to transparencies, reflections, the calculation of the shadows and other new features.

Today the quality of artificial images has reached levels of great realism with the introduction of radiosity, by means of which the calculation of the illumination takes account of the multiple environmental interactions and thus allows the digital artists to create images practically indistinguishable from real ones. Photo-realism is now welcomed by all sectors of the entertainment business. Hollywood cinematography and the development of videogames go for emotional impact, the astonishment factor, which computer graphics is able to provide thanks to hyper-realistic visual effects.

For a few years now this phenomenon has also affected scientific contexts in which study and communication by means of images is fundamental, from the simulation of physical phenomena to the reconstruction of ancient contexts in archaeology.

It is now, without doubt, that reconstructive archaeology must necessarily combine historical and humanistic knowledge with the use of modern computer technologies, in the effort to visually represent, with the highest level of reliability and verisimilitude, not only the individual objects, but also the monuments and the territory. It is reasonable to think that only by means of a great leap of scale is it possible to comprehend fully the mass of specific features that are associated with the expressive universe of a single civilization, which on different occasions manifests itself with the richness of decoration on a small object, the stylistic and typological features of a building, the layout of a city, or the signs of exploitation of a territory.

This is the main conviction behind this work: to describe certain aspects of a past civilization by means of a process of learning that starts with the object, but, as it develops, then takes in the city and the territory.

The golden helmet of the king of Ur, Meskalamdug, is the starting point of this virtual journey. Among the published images of this object, found by Carl Leonard Woolley, the graphic and photographic documentation is scarce enough to discourage anybody from proposing a form of virtualization of the object based on scientifically reliable data. Luckily, we were able to retrieve a few amateur photographs that show the helmet still kept in a showcase (Plate IV, a). Thanks to these few images, it was possible to create, with a good level of precision, a "cage" of points that envelop the object and describe both its external shape and colour (Figs. 1-2).

The technology that made it possible to obtain all this is fairly well-known by now (photomodelling)[4]. Drawing its methodological basis from

[4] Photomodelling is recently used by CNR-IBAM for 3D surveying of Messapian tombs and the Terra d'Otranto lighthouses virtualization: Gabellone, Giannotta 2005; Gabellone, Monte 2005.

photogrammetry, it entails measuring an object using only simple photographs. In the system adopted by us, the user must calibrate the camera and identify the corresponding points on different photographs; with other similar techniques it is possible to obtain the models from a comparison of the silhouettes of the real object placed on a rotating base[5]. Obviously, the latter case entails interacting with the real object to be reproduced.

In the work presented here and in many other operational contexts aimed at a three-dimensional reconstructive study such an ideal situation is rare. Often the available data are extremely limited and frequently the objects to be reproduced are no longer retrievable or it is impossible to use other methodologies for an adequate survey; of these objects just a few images are often all we have left. But it is precisely in this situation that the great potential and usefulness of image-based technologies comes into its own: obtaining images or 3D models from other images. Of course the quality of the final results of the modelling process (Plate IV, b) cannot help but be accurate, since the restitution is obtained from images that are themselves intrinsically photo-realistic. This feature means that the technique is often preferred to radiosity rendering, currently the most advanced processing algorithm, both because the computational load is significantly lower, and because the dimensions of the file are always smaller.

Let us imagine, for example, that we wish to reproduce the inside of a baroque church with a high level of realism; we would need to conduct either a manual modelling or a laser scan, of all the architectural elements present, and subsequently tackle the problem of the texturing of each part, even the smallest. The operation would clearly require a considerable effort, both in terms of costs and the final size of the model (certainly composed of millions of polygons), with results that would be unlikely to achieve full verisimilitude with the original. In contrast, by applying the techniques described above, it would be possible to represent the space under study with minimal effort, for example by means of explorable or hybrid panoramas with a low number of polygons.

Clearly, these solutions would not have the same topological value of a complete 3D model, but would in any case be more realistic. Models of this type are suitable for publication on the web, are fully programmable in terms of interactivity and are thus ideal for spreading knowledge of the item. The visualization of the artifacts can focus not only on the aesthetic and formal characteristics (an exclusively aesthetic approach), but also contain specific content accessible on request. The historical and archaeological data can be accompanied by technical and archaeometric data, retrievable depending on the needs of the user, who decides the best way of using them.

[5] The technique set out has been implemented recently in numerous commercial software products. For a more thorough technical discussion of the issues, see the specific papers published for the Eurographics and Siggraph conferences, e.g.: C. Hernández Esteban, F. Schmitt, *Silhouette and Stereo Fusion for Image-based 3D Object Modeling* (http://www.tsi.enst.fr/3dmodels/).

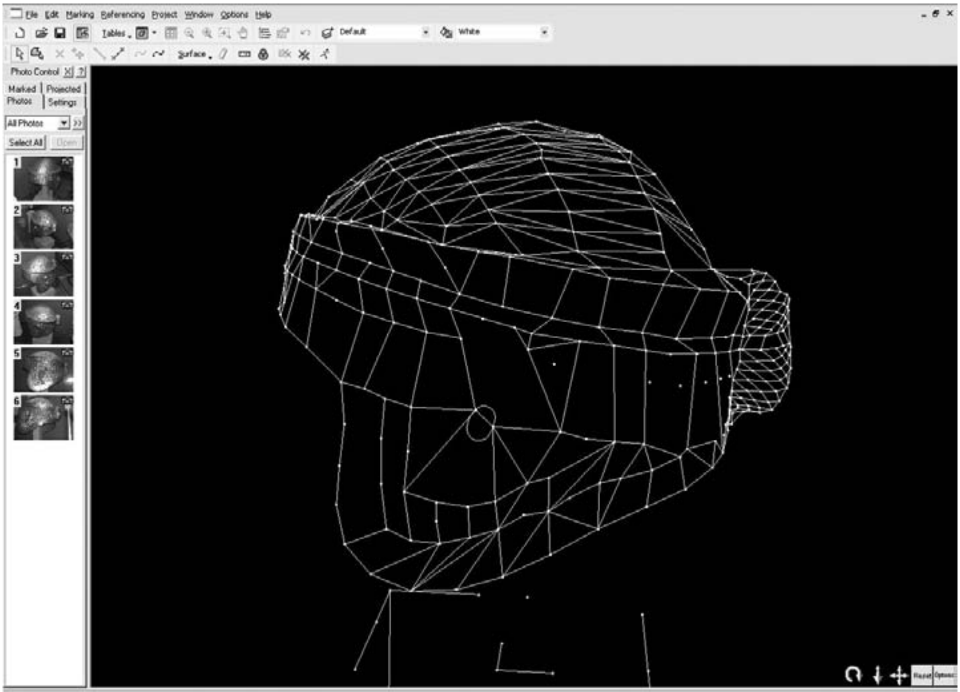

Fig. 1 – The helmet of Meskalamdug: photo-modelling restitution. Highlight of the control points grille.

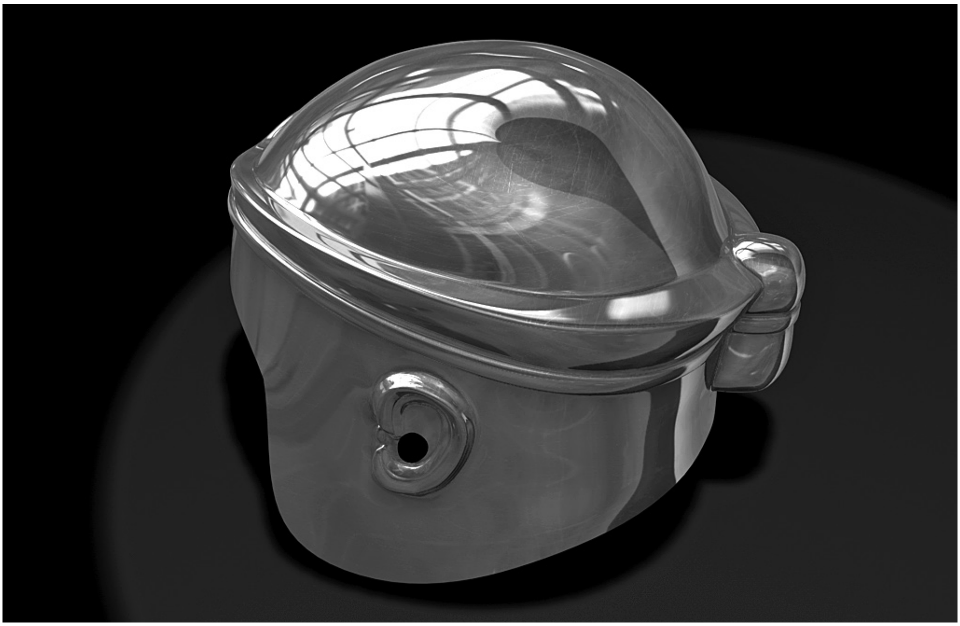

Fig. 2 – The three-dimensional model without texture maps. This representation allows to check the continuity of the polygonal surfaces.

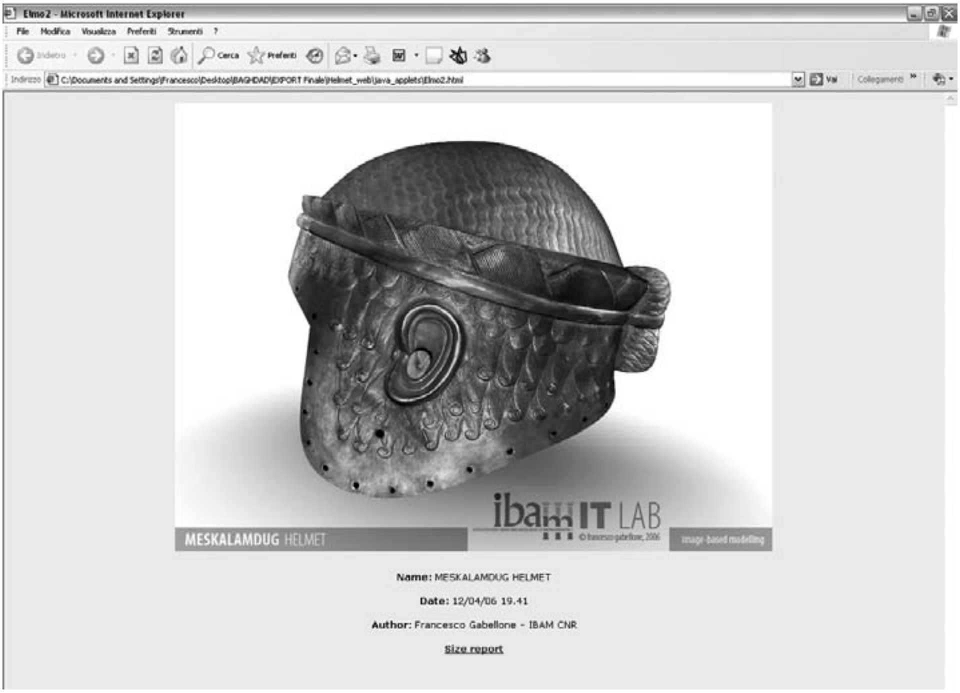

Fig. 3 – An example of the interactive web exploration.

The use of image-based modelling brings with it numerous other advantages, including the low cost of the restitution (Gabellone, Monte 2005). The model can be created with minimal investment and easily exported to any 3D modelling software for the necessary refining and editing. What distinguishes it from other restitution techniques however is the low number of polygons and the low level of geometric detail, which is compensated for by the wealth of the textures of photographic quality. This photographic approach can only be applied, for obvious reasons, to real objects, which must be studied or reconstructed by means of a survey.

In other situations, in which it is necessary to tackle the problem of reconstruction in the absence of surveyable finds, it is still possible to use other image-based solutions to improve the final quality of the artificial images. The most well-known of these techniques is used for illuminating the virtual scene by means of a radiance map (*High Dynamic Range Images*, *Image-Based Lighting, Open EXR,* etc.), generally obtained from the manipulation of spherical projections acquired in real environments, in which different exposures are computed which produce high dynamic range maps as a result.

Fig. 4 – The tomb from the outside.

With this technique it was possible, in the context of this work, to illuminate the inside of the tomb of Meskalamdug (Plates V, b and VI, a-b), in which all the funerary objects documented in Woolley's discovery were re-collocated, including the golden helmet, completed in computer graphics with the addition of internal leather padding (Plate V, a), traces of which were found inside it. As a tangible result, at the end of this phase, the helmet was exported in order to allow interactive exploration (Fig. 3).

The tomb was animated and integrated into the virtual museum, in the section dedicated to Sumerian civilization. In the virtual space the user has the opportunity to understand the specific characteristics of each individual object, re-collocated in the position of its discovery and to appreciate its forms, colours and materials (Figs. 4-5).

Thus conceived, the reconstructive operation entails the insertion in a virtual museum of an item that requires adequate presentation and contextualization, so that the public may fully comprehend its intrinsic value as artistic, historical and cultural evidence, not only as an example of a lost civilization, but also as part of the living and current heritage of all humanity.

F.G.

Fig. 5 – The final reconstruction with HDRI algorithms.

3. The contribution of satellite images to the virtual visit to an ancient city, including contextualization and acquisition of new knowledge: the city of Ur

A fundamental problem for the contextualization of objects in a virtual museum is that of enabling the "visitor" to view their site of provenance, introducing him or her to the original territorial context, thus re-collocating (ideally) the finds in their place of discovery, operating on different scales of detail. On the one hand, the objects need to be re-collocated in the monument (for example a tomb, a palace, a temple, etc.) in which they were found; this, in turn, must be inserted in the archaeological area in which it stood (for example a necropolis, a residential area, a sanctuary, etc.), which needs to be contextualized within of the ancient site to which it belongs (a city and the historical landscape where it lay).

This process of contextualization can then be implemented on three temporal levels: the ancient epoch, the moment of the discovery and modern times. For the first two the virtual reconstructions, including those based on excavation photos, make it possible to obtain excellent results, with issues that vary in accordance with the scale of detail on which one is operating; as one shifts to the broader context, the scarcity of scientific data available makes it difficult to obtain philologically accurate reconstructions. Concerning the third temporal level, allowing a virtual visit to the place of provenance in its current situation, the photographic images, both aerial and from the ground, allow the user to view, with a high degree of detail, the archaeological area in question.

Considerable problems arise, however, in situations where the contexts are not easily accessible and adequate photographic documentation is not available. This was the situation in the case of the contextualization of the helmet and the tomb of Meskalamdug in Ur; we have only a few terrestrial images of the city and some oblique aerial photographs of limited portions of the archaeological areas, together with the documents (graphic and photographic) of the excavations conducted between 1919 and 1934 by the British Museum and the Pennsylvania University Museum (from 1922 under the direction of Carl Leonard Woolley).

An important contribution to the resolution of this problem, as well as to the recovery of documentation that serves to complement any photographic material that may be available, has been provided by high resolution satellite images of the ground, which have been on the market for some years now at reasonable prices; their level of definition is sufficient for them to be used for detailed archaeological research.

Use was made therefore of a panchromatic image taken on the 6th of April 2004 by the American satellite QuickBird 2, available in the archive of the DigitalGlobe™ company, to which it belongs[6]. This image had the necessary characteristics for it to be suitable for our purpose; specifically, the period of acquisition was outside the dry summer months, and its only slightly off-nadir angle (7 degrees) guaranteed a geometric resolution of 62 cm, very close to the nominal maximum of the panchromatic sensor[7]. The high resolution at ground level of satellite images with these characteristics makes them similar, in terms of definition, to vertical aerial photographs on a scale of about 1:12,500; their use can thus guarantee both an overall planimetric vision of archaeological areas and a detailed analysis of individual monuments.

Furthermore, the reading and the detailed examination of these images, fundamental in order to be able to correctly "narrate" the site under study, also constitute an important opportunity to acquire new knowledge of

[6] Catalog ID 1010010002D68F01. The satellite, launched on the 18th of October 2001, orbits at 450 km from the Earth. For recent cases of the use of QuickBird 2 satellite images in archaeological research, see: Campana 2002, 2004; Georgoula *et al.* 2004; Scardozzi 2004, 2006a, 2006b; Lasaponara, Masini 2005a, 2005b, 2006a, 2006b, 2006c, 2006d, in press; Lasaponara *et al.* 2006; Masini *et al.* 2006.

[7] QuickBird 2 is the commercial satellite that transmits images with the highest geometric resolution, which at the nadir can reach 61 cm in panchromatic mode and 2.44 m in multispectral mode; the data are acquired with a radiometric resolution of 11 bits, corresponding to a maximum of 2^{11}, i.e. 2048 levels of grey. The image, acquired via the Telespazio company S.p.A., is in "Standard Ortho-ready" mode, with a re-sampled pixel dimension of 60 cm.

ancient topography, specifically concerning contexts that have been studied for many years or that are characterized by a history of study focused above all on individual monuments or a wealth of finds. Indeed, it is possible to detect anomalies in the terrain which may constitute traces of ancient buried structures or of paleo-environmental elements: it should be noted that given the impossibility, as in this case, of detecting these traces on the ground, it is often possible to formulate only hypotheses.

The case of Ur exemplifies the potential uses of high resolution satellite images. These make it possible to obtain a detailed vision of the current state of the remains of the city and its urban layout and also to recover interesting elements for the reconstruction of the ancient topography; the view from above, which reveals even minute details, enables us to identify phenomena that are not perceptible on the ground and to recognize the traces of structures that are still buried or have become buried again since the excavations carried out by Woolley in the 1920s and 30s[8].

From a general image of *Tell al Muqayyar* (the "Hill of Bitumen"), the rise on which Ur was built, it is possible to see, besides the current situation of the area (with some modern buildings in the northern part of the *tell*, the restoration works and the eastern access road), the whole perimeter of the city with its circuit of walls (Fig. 6), and the position, planning and reciprocal relationships of the buildings and the monuments that have been excavated (Fig. 7)[9].

The *tell* is composed of successive stratifications and rises approximately 20 metres above the surrounding plain: a digital model of the terrain could better document the morphology of the territory and be of superior communicative value if integrated with the satellite images. In the highest part of the *tell,* the sacred area with the Ziggurat and the other main monuments (Fig. 6, A) are visible, while at the northern end and in the south-eastern part of the city it is possible to make out the depressions corresponding to the two

[8] In general on Ur see the recent Invernizzi 1992a (especially 288-296); Invernizzi 1992b (especially 8-23, 49-51, 119-122, 303-304, 320-328); Matthews 1993; Pinnock 1995; Matthiae 1997 (especially 93-97); Pollock 1997; Bienkowski, Millard 2000, 309-311; Matthiae 2000 (especially 9-30, 68-72) and Leick 2001, with preceding bibliography. The site of the city was occupied from the 6th-5th millennium BC, but it was in the final centuries of the 3rd millennium, particularly with the kings of the so-called 3rd dynasty (21st century BC), that Ur took control of a large part of Mesopotamia; to this period may be dated an intense building phase which included the definitive layout of the urban area. Subsequently the city was occupied by the kings of Isin followed by those of Larsa, losing its political importance but keeping its commercial and religious status; in the second half of the 2nd millennium it was for a long time under the control of the Kassite kings, who also carried out restoration work. The last period of monument-building occurred in the neo-Babylonian period, in the course of the 6th century BC; the drying up of the branch of the Euphrates on which the city lay and also of the canals that linked it to the sea, led to the silting up of the ports and the definitive decline of Ur itself, which was abandoned in the Hellenistic period.

[9] The plan shown in Fig. 7 includes the plans of the most recent phases of each monumental complex: this is the situation that may have left identifiable archaeological traces in the satellitary image.

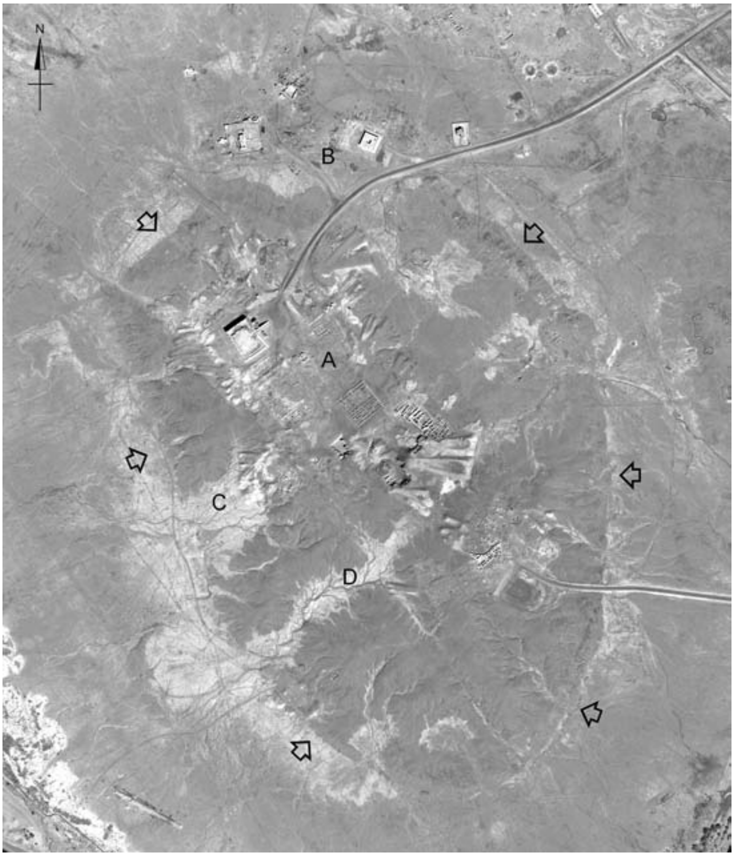

Fig. 6 – The hill of Ur in an image taken by the QuickBird 2 satellite in April 2004: the arrows indicate the traces and the remains of the defensive walls.

ports of the city (Fig. 6, B and C), today silted up[10]. Note also the presence of another depression stretching southwards from the northern port, passing to the East of the sacred area; it then curves towards the South-West (Fig. 6, D), terminating to the South of the south-western port: this depression probably corresponds to the canal that crossed the city from the northern port and which was built or restored by order of Hammurabi (1792-1750 BC).

In the northern part of the urban area, the satellite image shows in detail the depression corresponding to the harbour of the main port of Ur, which,

[10] The ruins of Ur lie 10 km from the right bank of the Euphrates, which originally ran past the walls of the city; in ancient times the sea was also close to the town and reachable via canals, and the city was an important trading center.

Fig. 7 – General plan of the city (drawn up by F. Ghio): 1, City Wall; 2, North Harbour; 3, Palace of Ennigaldi-Nanna; 4, Harbour Temple; 5, Houses on City Wall; 6, Kassite Fort; 7, Enclosure of the Sacred Area in the neo-Babylonian period; 8, Enclosure of the Sacred Area during the 3rd Dynasty; 9, Nanna Court; 10, Etemenniguru; 11, Ziggurat; 12, Nanna Temple; 13, Boat Shrine; 14, Ningal Temple; 15, Giparku; 16 Edublamakh; 17, Ganunmakh; 18, Ekhursag; 19, Mausolea of the 3rd Dynasty; 20, Royal Graves; 21, Nimintabba Temple; 22, Houses (EM District); 23, West Harbour; 24, Houses (AH District); 25, Neo-Babylonian Houses; 26, Enki Temple.

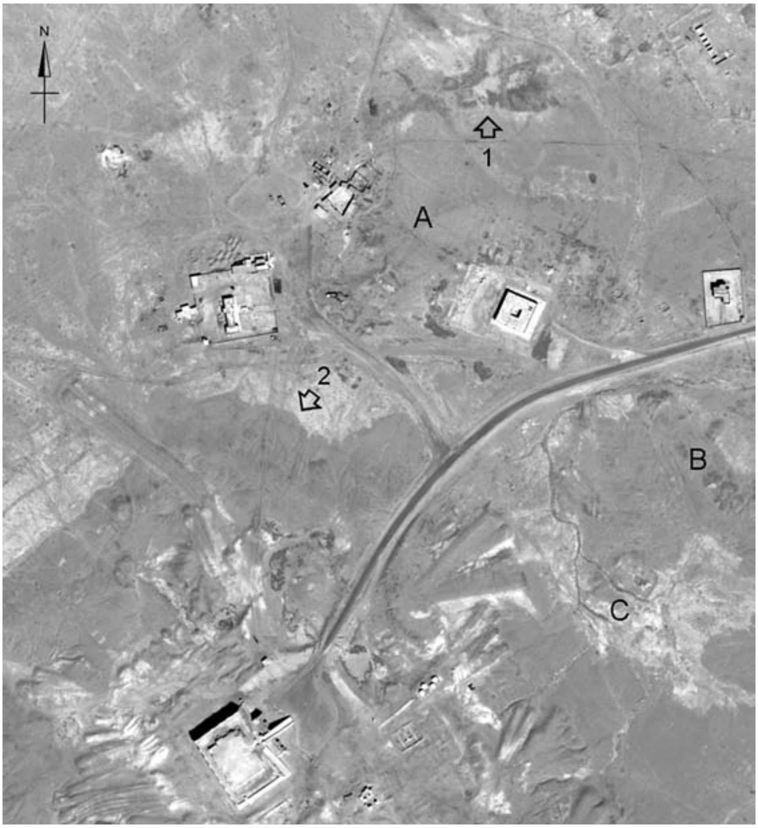

Fig. 8 – The northern part of the urban area.

besides being buried, is also partially occupied by some modern constructions (Fig. 8, A); it is, however, possible to make out a few traces of the inner edge of the northern and south-western docks (Fig. 8, nn. 1 and 2). Further South may be seen the remains and the traces of the Palace of Ennigaldi-Nanna (Fig. 8, B), and the residence of the high priestess of Nanna/Sin, built by order of the neo-Babylonian king Nabonidus (556-539 BC); the view from above makes it possible to have a complete image of the planning of the edifice, excavated by Woolley and today partly re-buried. Immediately to the South the scant remains of the so-called Harbour Temple (Fig. 8, C), also built by Nabonidus are visible.

On the other hand, in the north-eastern sector of the city, the satellite image shows quite clearly the traces of the fortifications, only partially excavated, that encircled the entire urban area (Fig. 9, A), closing off a surface area of 60 hectares. Also visible are the scant remains present on the surface

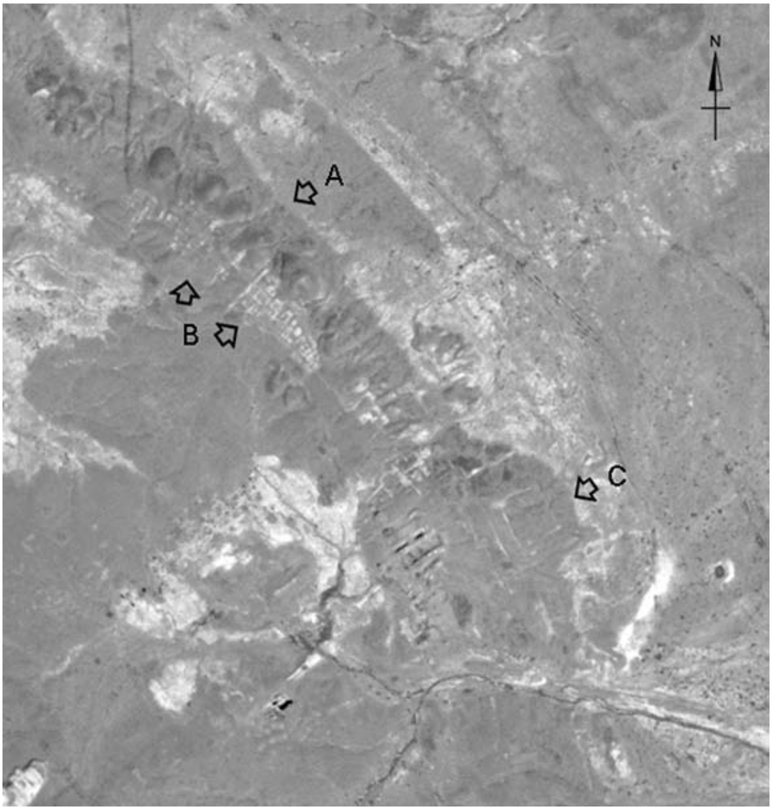

Fig. 9 – The north-eastern area of the city.

and the traces of a few houses built against the walls (Fig. 9, B) and of the quadrangular fortress that stood in this sector of the fortifications (Fig. 9, C); both complexes date back to the Kassite period, particularly to the building ordered by king Kurigalzu II (1332-1308 BC). Only the view from above makes it possible to obtain a complete image of the area, barely perceivable on the ground, also showing the traces of the ancient structures that were covered over again after the excavations, and enables us to reconstruct planimetries and reciprocal relationships between the monuments[11].

Proceeding in a south-easterly direction, the satellite image again clearly shows the path of the walls (Fig. 10, A); nearby are visible the scarce remains of the small Temple of Enki (Fig. 10, B), built by king Amar-Sin (2047-2039 BC),

[11] Along the line of the walls, the mounds of earth resulting from the old excavations can also be seen.

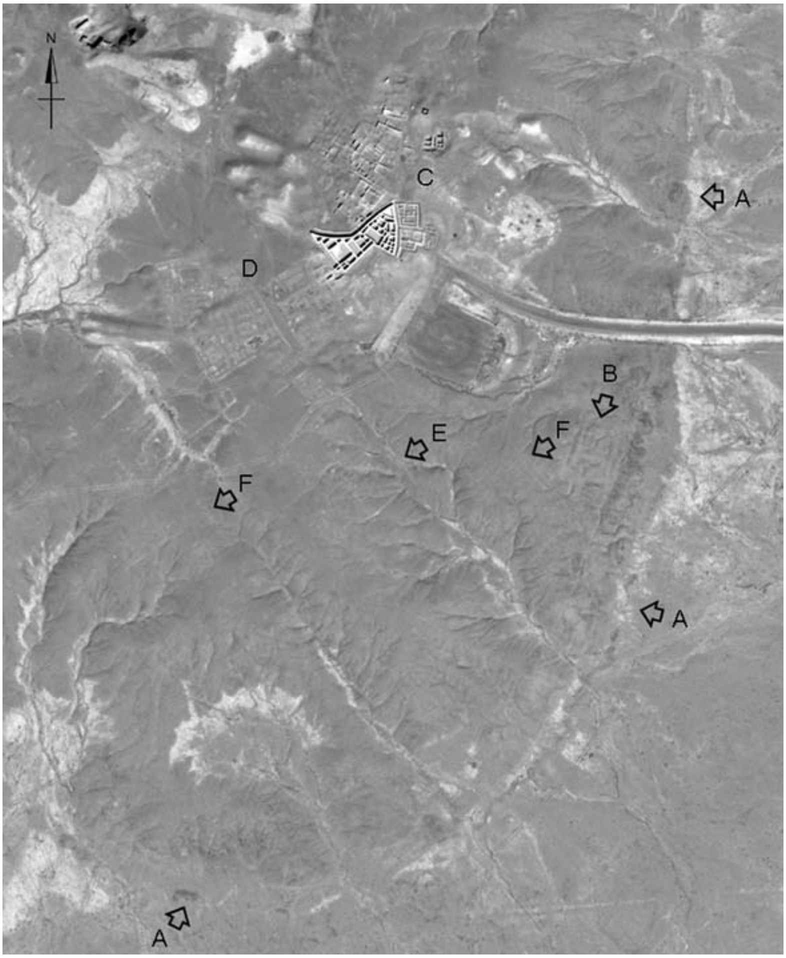

Fig. 10 – The south-eastern sector of the hill of Ur.

towards the end of the 3rd dynasty, and completely rebuilt by the king of Larsa, Rim-Sin (1822-1763 BC). Clearly visible to the North-West are the remains of the so-called AH Quarter (Fig. 10, C), the residential sector dating back to the period of the Isin and Larsa dynasties (the first centuries of the 2nd millennium BC), which continued in use in the Kassite period; the view from above shows the planimetric development of the area, with the houses built up against each other and separated by narrow winding streets. Here the restorations of the area lying between Paternoster Row and Store Street stand out; they include streets which Woolley named after those of the University of Oxford.

Fig. 11 – The central area of Ur: for a better understanding of the conserved structures, the image has been oriented with the shadows below.

To the South-West are visible traces of the structures, partly reburied after the excavations of the 1920s and 30s, of another residential district (Fig. 10, D), datable to the neo-Babylonian period and the building activity encouraged by king Nebuchadnezzar II (605-562 BC); it may be seen clearly how, unlike the nearby quarter from the age of Isin and Larsa, the houses were inserted in a regular urban layout, marked by broad straight roads. It is possible to make out the four dwellings excavated by Woolley, of bigger dimensions than the houses of AH Quarter. The satellite image makes it possible above all to identify even traces of buried or semi-exposed structures, which help to shed light on this sector of the city and its layout; indeed, it is possible to see the traces of the extension towards the South-East (Fig. 10, E) of the main road of the excavated area, which continued in this direction up to the line of the walls, where there is likely to have been a gate. Parallel to this road there are visible traces of at least two other streets, one to the North-East and one to the South-West (Fig. 10, F); they mark out this portion of the city in a regular aspect, showing how the urban planning initiated by Nebuchadnezzar II concerned a broad section of the south-eastern part of Ur.

Arriving at the central zone of the city, in the highest point of the *tell*, it is possible to read the entire planimetric layout of the sacred area, the monumental heart of Ur, and verify which of the buildings excavated by Woolley are still visible[12]. The Ziggurat (Fig. 11, n. 11), which was built by king Ur-Nammu (2113-2096 BC), stands out, perceptible on account of its impressive visual impact which is made even more evident by the modern restoration; on the other hand, traces of the Etemenniguru, the wall that surrounded the platform on which the Ziggurat stood, are scarce.

Clearly visible are the remains of the Edublamakh (Fig. 11, n. 7), the portal with three chambers built by order of king Amar-Sin, which gave access from the South-East to the wall of the Ziggurat. There are few visible structures pertaining to the so-called Court of Nanna, datable to the program of monumentalization of the sacred area implemented in the reign of Ur-Nammu (Fig. 11, n. 10), of which some portions of the eastern side remain. Clearly visible in their planimetric layout are the Ganunmakh (Fig. 11, n. 8), built by king Amar-Sin, the Giparku (Fig. 11, n. 6) and the Hekhursag (Fig. 11, n. 5), buildings whose original plan is again associated with the activity of Ur-Nammu; immediately to the South of the Hekhursag may be seen the remains of the wall that surrounded the sacred area during the 3rd dynasty of Ur (21st century BC). It is possible to observe the structures and traces of two other monuments excavated by Woolley, the Temple of Nimin-Tabba (Fig. 11, n. 3) and the so-called EM District, a poorly preserved residential sector datable to the Isin-Larsa period (Fig. 11, n. 4).

Clearly visible to the South of the Hekhursag is the broad pit resulting from the excavation of the so-called Royal Cemetery (Fig. 11, n. 2), the vast necropolis (about 2000 tombs) used for nearly six centuries from Proto-dynastic period IIIA (about 2600 BC). The area is characterized by the presence of numerous burials of high dignitaries and even some kings of Ur, including that of Meskalamdug; immediately to the East the great Mausolea of the kings of the 3rd dynasty (Fig. 11, n. 1), partly restored, are visible. The Royal Cemetery

[12] Along the edges of the sacred area lie the enormous mounds of earth from the excavations of the 1920s and 30s.

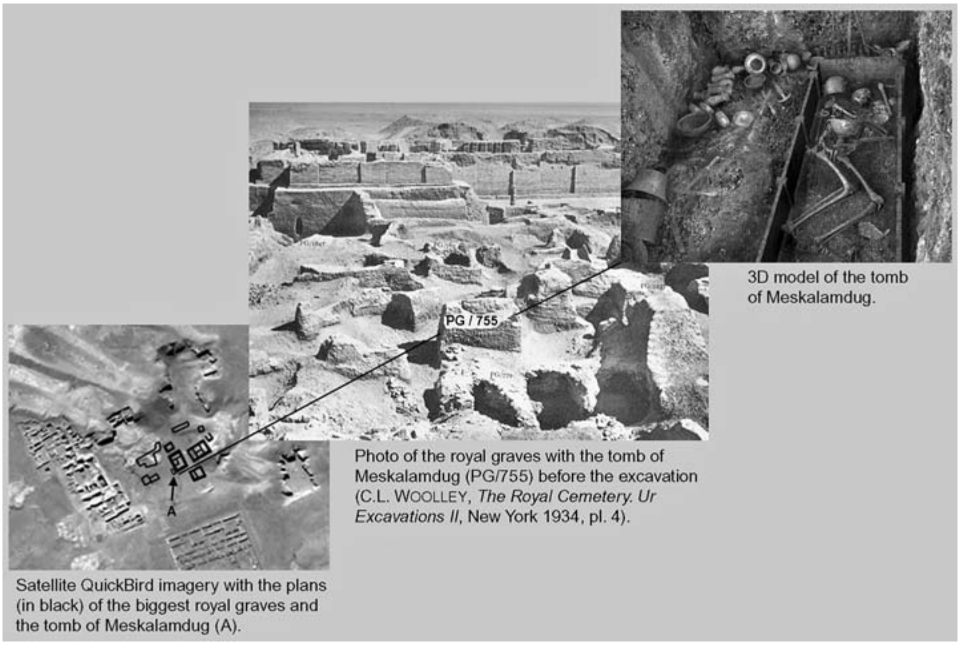

Fig. 12 – Virtual visit: from the current situation to the moment of the discovery (photo of the excavation by Woolley) and the reconstruction of the context.

originally lay outside the *temenos* of the sacred area. In the neo-Babylonian period the area was expanded, and the wall that enclosed it was re-built on the top of the cemetery and the nearby Mausolea of the 3rd dynasty; of this double curtain wall, built on the orders of Nebuchadnezzar II, only a few structures of the eastern side can be seen (Fig. 11, n. 9), near two of the access gates.

The situation described above demonstrates the potential of satellite images for the topographical framing of the city and how it may constitute the basis of a virtual visit that allows the user to view the place in which the tomb of Meskalamdug lay and how it fitted into the urban planning of Ur; furthermore, satellite images can constitute the starting point for a “visiting route” going back in time, from the current situation of the Royal Cemetery to the moment of the discovery of tomb PG 755 and from here to the virtual reconstruction of the burial of Meskalamdug (Fig. 12).

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ABSTRACT

This paper deals with the results of an experiment that was conducted as part of the CNR Project entitled *Iraq Virtual Museum*, the goal of which is the construction of a Virtual Museum that will allow the public to enjoy the main archaeological treasures of the ancient civilizations that flourished in the territory of modern-day Iraq. The work was aimed at the contextualization of the ancient objects in the territory of origin. This result was achieved by recourse to image-based technologies and remote sensing. In the exemplary case of the city of Ur, the process of contextualization began with the modelling of the golden helmet of king Meskalamdug, and continued with the reconstruction of the tomb in which it had originally been placed, with the rest of the funerary objects. This tomb was then contextualized within the Royal Cemetery and the urban layout of Ur. High resolution satellite images made it possible to observe and document the archaeological area as it is today, for a virtual visit and in preparation for a potential real visit in the future. Furthermore, research activities have made it possible to acquire new knowledge of the objects, the monuments, the urban layout and the historical landscape.