

A GIS IN CULTURAL HERITAGE BASED UPON MULTIFORMAT DATABASES AND HYPERMEDIAL PERSONALIZED QUERIES

P. Chias^{a*}, T. Abad^a, E. Echeverría^a, F. Da Casa^a, F. Celis^a

^a Dept. of Architecture, Escuela Superior de Arquitectura y Geodesia, Universidad de Alcalá, 28801 Alcalá de Henares, Madrid, Spain – (pilar.chias, fernando.casa, flavio.celis)@uah.es, tabad@ciccp.es, evus@arquired.es

KEY WORDS: GIS, Cultural Heritage, Architecture, Cartography, Databases, Photogrammetry

ABSTRACT:

The Cultural Heritage has been usually studied from an objective perspective, using the objective data that can be collected through quantitative methods as the photogrammetry or the topographical measurements. But the study of the Cultural Heritage has also other perceptive dimensions -not just the visual ones- that must be considered when the final target is to investigate the Cultural Heritage as a whole. Those perceptive dimensions add a subjective information as they complete the usual objective data with other multiformat data sets that bring to the investigation other important informations, such as the urban soundscape or the historical memory of the users. The perceptual data sets must be obtained by means of other methods such as inquiries, mental maps, soundwalks, etc. that are yet being applied in other scientific branches like Sociology or the Environmental Psychology. With this transdisciplinary techniques we incorporate the user's point of view to the search and not only the experts' one. The traditional way to implement a GIS in Cultural Heritage has only considered the quantitative databases as a source of information and has got this information only through the standardized queries. We have got a methodology that joins both quantitative and qualitative data sets, that allows both the user and the expert to get a most complete and 'realistic' information of the Cultural Heritage, that includes the sonic, the tactile and the olfactory perceptions, as well as the historical memory of the inhabitants and users of the urban and architectural spaces.

1. INTRODUCTION

1.1 Historical townscape or urban scenery?

Each european historical town is unique and complex (Alexander, 1965; Wagensberg, 2003 and Castells, 1974), as it results from the processes generated by the relationships established between the values and other driving forces in each historic period.

The term 'urban scenery' is found more appropriate than 'townscape' because the scene surrounds the individual, needs action and calls for action. The urban scenery conforms ambiances and gives so many informations -not only visual- that it is not possible to manage them simultaneously. The town scape essentially implies observation, although it can cause great emotions.

Since the ideal towns of the Renaissance period until the paradigms of the Modern Movements, the 'hygiene of the visual' has prevailed (Pallasmaa, 2005).

To know deeply the historical town means to get into a labyrinth of space and time (Moles and Rohmer, 1972), where spaces change from one moment to another following a set of rules that the inhabitants know; this knowledge lead them to the functional appropriation of the town.

1.2 The recent assessment of the qualities of the urban cultural heritage

The interest on the quality of cultural spaces or monuments is not mentioned neither in the european protection laws of the cultural heritage nor in the urban policies. This concept is only managed in Sweden and Norway, where it focuses on several townscape subjects, and in France through the concept of *cadrage*, that means what surrounds a space, a scene or an action, and which implies a great participation of the inhabitants. The quality of the *cadre de vie* supposes essentially the environmental improvement, the noise limitation, the

reduction of the olfactive troubles or the prevention of risks (Fariña, 2006).

The study of the urban cultural heritage has focused traditionally on the quantitative aspects that can assure objective results and can be managed through spatial measurements obtained applying the usual photogrammetric or topographic methods, among others. Although those data sets are fundamental, they show an external vision of the monuments and the spaces and exclude the user as a multidimensional human being (Popper, 1975). That is the reason why the objective approach must be completed with the subjective dimension of the architecture and the city, which adds the experience of the individuals, modelled by their owns aims, culture and feelings, and that allows to assign to this cultural heritage a particular meaning (Knox, 1987).

In recent years, the importance of the qualitative dimension has increased, not only because it provides a more complete approach to the urban heritage, but because it has become a fundamental component in planning practices and in management strategies, specially applied in landscape assessment methods (Daniel, 2001 and Scott, 2002).

The aim of our search has been to get a methodology, theoretically sustained, that approaches and interprets all those complex phenomena (Pred, 1983), and that can be used as a guide to preserve, to manage and diffuse the urban cultural heritage, and to set the guidelines of the planning policies in the european historical towns.

As our methodology also introduces the subjective point of view, this methodology introduces the cognitive processes of the individuals and approaches to the way they appreciate the urban cultural heritage, as well as the decisions they take in relation to it (Scaramellini, 1985).

The multiformat data sets obtained from both approaches during the works are always geographically referred and are structured in relational databases. As a part of a GIS, they allow to get the information in the traditional way of the more or less standarized queries, or through the concept of the hypermedial

document that makes largely possible to personalize the information (Clément, 1994 and Weissberg, 2005).

1.3 Antecedents

The objective approaches to the monuments are based mainly in the quantitative data that are obtained by means of different measurement methods. Among them, the traditional topographic measurements are actually combined with the digital photogrammetry and the scanner-laser techniques (Cundari, 1983; Grazia, 1991; Docci and Maestri, 1992 and 1994; Fondelli, 1992 and Almagro, 2005) to get a set of spatially referenced points that can be transferred to a CAD 2D or 3D file and then placed as significant control points of a 2D design or a 3D model of the monument, as a most refined, acute and useful *rilevamento* (Forte, 2003 and 2004, and Frisher et al., 2002 and Santana, 2003).

Another step has supposed to integrate other kind of data with this 2D design or 3D model in a GIS, that allows to get a wide range of informations from the fabrics or the pathologies (Mas-Guindal, 1992; Azkárate et al., 1999 and Fernández and San-Jose, 2000).

The use of the new formats that have aroused with the multimedia technologies have been also applied to the knowledge of the cultural heritage, but as individual resources not integrated into a database (Piscitelli, 2000 and 2004).

Other studies are based on the visual aspect of the architecture and the city follow the Renaissance tradition, later inherited by Camilo Sitte. Among them must be considered the proposals of Gordon Cullen (1961), of Frederick Gibberd (1967) and of Kevin Lynch (1960 and 1984), among others (Rossi, 1970; Quaroni, 1967 and Bailly, 1977).

Lynch analyzed the way the inhabitants structure their image of the town as mental maps; inquiring experts and users and through drawings, he searched the guidelines of the urban legibility. He centered his search only in the visual aspects, linked to the habits and psychological grounds.

Looking at the investigations afforded in the Environmental Psychology, there are some searchers that have considered the architecture and the city as subjective facts; most of them have developed from an empirical and experimental point of view (Jiménez-Burillo and Aragonés, 1981 and Corraliza, 1987) and today there is still a lack in a general theory.

About the sonic experiences of the town and the landscape it is necessary to mention the important works of R. Murray Schafer in the World Soundscape Project (Schafer, 1973; 1977a; 1977b; 1978a and 1978b), of Barry Truax (2001), of the CRESSON (Augoyard and Torgue, 2005) and of Pascal Amphoux in the IREC (Amphoux, 1991 and 1993).

Finally, we are a team of searchers that compose the LIPSVAC (Laboratory of Investigations on the Sonic and Visual Perception of the Architecture and the Town) in the University of Alcalá (inside the searchers' group CTE2006/F34 "Intervención en el patrimonio y arquitectura sostenible"), and we have already developed several methodologies to document, study and diffuse the cultural heritage through an open GIS. The present project develops other ways of accessing to the knowledge of the urban and architectural heritage, by means of the use of multiformat databases and hypermedial documents.

2. METHODS

2.1 Adapting transdisciplinary methods

According to Sonnenfeld (1984) and Rapoport (1977), we have considered in our search both the external objective level and

the perceptual subjective space, that includes the tactile, the olfactive or the sonic experiences of the architecture and the city.

And to get both the objective and the subjective approaches in a single methodology, we have combined various transdisciplinary techniques with the traditional metrics.

The objective approach has managed the digital photogrammetry at two scales, the architectural and the urban. For both scales we have used the softwares Homograf 2002, Photopol and Pictram over a PC platform, with a digital metric camera Zenza Bronica. The files have been transferred to CAD, both to Autocad files and to MicroStation files.

Exceptionally we have used a laser scanner 3D Faro LS880HE80 22MW for the singular façades or elements; the 3D files obtained are reduced and set separately in a specific database located at the server.

Other objective data are directly obtained as topographic measurements with a digital station Topcon.

And we complete the objective data sets with other data related to the spatial reference, obtained with a GPS, as well as the name, the category that each architectural or urban element has, the town, the address, the accessibility, the administrative dependence or the owner, the maintenance and the pathologies, among others.

The subjective approach is perhaps the most innovative, because it tries to get the simplified image of the architecture and the town that the individual has.

This part of the search needs the collaboration of a group of inhabitants as well as of a group of experts. The first one was composed by thirty two users in the case study A, and of fifty one in the case study B. The experts' team was composed by twenty five people in both cases, that were architects, urban planners, sociologists and art historians. With all of them we could assure a reliable result of the inquiries and the mental maps.

To get this simplified image we have combined the techniques developed by three main approaches of the Environmental Psychology: the structural, the assessing and the preferential one (Milgram, 1977 and English and Mayfields, 1972).

But we have extended this methods to other perceptual senses and not only to the vision.

The structural approach works over the structure and identity of the perception of an urban environment, as well as with the cognitive image of a defined space that a group of citizens has.

This approach uses a kind of inquiries that allows to detect some degrees of connection between the urban elements. The questions proposed are, for instance:

- Could you enumerate three meeting points in the town?
- Could you describe the 'sound' and the 'smell' of an itinerary?
- Free associations: we show a set of pictures and the individual has to recognize them and to connect them.
- Any particular sound, olfactive or tactile memories of a neighborhood?
- Perception of distances and orientations: define the distances and the relative orientations between a set of elements.
- Simulation: recognize some images and refer them in a map of points.
- Listen to a sound record and try to recognize the itinerary that has been followed.
- Draw a mental map of the town, placing the elements and the associated perceptions that you find that are necessary to the adequate knowledge of the town (Downs and Stea, 1973 and Gould and White, 1986).

The assessing approach aims to get the personal assessment or the group assessment of some aspects of the environment, that lead them to act in a definite way. The questions are, in this case:

- Name the three best things and the three worst things of the town.

- Which are for you the main streets or places in the town.

- Which are for you the main sounds or odours of the town.

- Select an idea that somehow characterises an aspect of the town, and try to express it with images and sounds (the *diaporama* is a usual way to do it, but is not accesible to all the individuals).

- Semantic differentials or opposite meanings: select a value from a scale from 1 to 5 between opposite meanings such as clean/dirty, noisy/silent, monotonous/various, etc. that fit with the study area.

The preferential approach defines the priorities that individuals have about some facts, elements and defined urban spaces. The examples of queries can be in this case:

- Where would you live, if you were free to decide it?

- Which are your favourite streets or squares in the town? Why?

- What sounds and smells of your town do you prefer?

We have also prepared a set of questions related with the visual attributes of scenic beauty, coherence, legibility, complexity, mystery, perspective, diversity, risk, colors, pattern and patch-shape (Appleton, 1975 and Kaplan and Kaplan, 1982) that have been applied to ten photographs and measured according to a five-point scales.

2.2 The multiformat databases of the GIS

As a part of the objective approach we obtain sets of pictures, video recordings and audio recordings.

To work with image and sound we use the Macintosh platform.

For instance, the audio recordings are made with an omnidirectional microphone directly connected to a Powerbook G4, with the software iTunes.

The video files are recorded with a Sony Handycam with Leica optics.

On the other hand, the subjective data obtained through the inquiries are statistically managed, attending to the degree of coincidences and dispersions of the answers. Those data must be analysed separately, and they allow to quantify the elements that have appeared, to adscribe them to different categories, to establish a ranking of coincidences and to compose a derived map (Appleyard, 1969).

All those relational data sets are implemented on the open GIS. We use two different softwares: ArcView and MicroStation Geographics. We use also two different databases: Access from Microsoft and FileMaker, both for PC and for Mac.

On one hand, ArcView is useful and easy, and admits several different graphic formats. On the other hand, we find Geographics easier to draw the digital cartography and construct 3D models and rendering operations.

About the databases, both are useful and compatible with a wide range of data formats, including the audio and video ones. But FileMaker has two advantages: it works over Mac platform and the files are smaller than those from Access, and the databases are then easier and quicker to be consulted.

2.3 Case study A

We have applied this methodology in two main spanish historical urban scenes that allowed us to verify the adequation of the methodology: the old towns of Atienza in Guadalajara, and San Lorenzo de El Escorial in Madrid. Both have great interest as cultural urban scenes and both have many of important monuments inside them, but they also show different urban problems and developments.

Atienza is a small medieval city founded on the 10th century and has several romanesque monuments that have been yet

catalogued as cultural resources (BIC or Bienes de Interés Cultural). It is placed in a FEDER Zone about 150 km far away from Madrid. It has preserved its medieval morphology, and it has been suffering from depopulation for a lustrum. But it preserves yet the medieval urban structures, even a jewish quarter or “judería”, as well as the salt exploitations that were early exploited by the Romans in the 1st century BC, and that along the centuries have guaranteed the wellness ad the economical power and supremacy of the town.

The territory that surrounds the medieval town yet preserves the old land structures that characterize an old important crossroad: one can walk round the roman streets, as well as round the medieval ways that were used by the itinerating livestock of La Mesta. Also, in a townscape like the one of Atienza, one can yet investigate the particularities of its monuments and old architectures, one can fill the databases with the plans and the measures of each Romanesque church –there are six-, but one can also recover the historical sounds –the different ringing of the bells that have different meanings and that can be heard far away from the town, for instance. And it is also possible to study its different perceptive features, visual, tactile, sonic, olfactory, and the evolution of the urban scene.

2.4 Case study B

San Lorenzo de El Escorial is famous for its Monastery, founded in the 16th century by the King Philip II of Spain. The nearby town started its development in the 18th century, because before this century the kings did not want to have any population near.

Its urban scene is a very interesting one because of its baroque structure that climbs up to the mountain; but it continues its development since then until now without disruptions, and the former city centre has expanded and derived to a residential suburb of Madrid.

The problems that set this urban scene are very different and more complex from those that one can find in Atienza, and this has allowed us to check the design of our methodology. Here the old baroque urban scene risks to be suffocated by the modern town, and one must discover the old sensations through the new superimposed structures.

The new inhabitants have no historical memory and are creating their own spaces and perceptions, very far and different from the antique ones.

2.5 Queries and hypermedial documents

The traditional queries fit well when they are proposed to the three main ways that the GIS offers: only to the numerical databases, only to the graphical databases, or to both of them together.

This traditional way brings the information as tables, maps or informs, as well as personalized formulars.

The hypermedial concept allows to get a personalized document based on a structure of hyper-links, that is more suitable and versatile, because it connects the different files independently of the structure of the databases, creating each time a new spatial grid with the information.

2.6 Results

The aim of the search was to establish an open transdisciplinary methodology to document, manage and diffuse the urban and architectural cultural heritage.

As it has been applied to the two case studies, each one with its differences and particularities, the methodology has been totally successful, because it allows to manage several data formats

and to get the information properly both in the traditional way of the queries or through the new hypermedial concept.

It is also important to notice that the condition of the open GIS, that allows to introduce new data, opens the door to the study of temporal sequences, which is specially important in the study of the evolution of the historical environments in every possible approach, objective or subjective.

2.7 Discussion

The image that the inhabitant has from the architectural and urban spaces has several attributes: its objectivity is limited, but has an identity, a meaning and a structure. It also changes according to the characteristics of the people inquired: their age, sex, and cultural and socioeconomic level.

But this image is also submitted to the communications codex, and the consequence is that the model that we get is a simplified one.

We have also found that the results showed the relationships among the perceptual attributes to be consistent to the previous reports that we had from both urban spaces.

3. CONCLUSIONS

In both cases, the results of the research are very interesting because they allow us to approach the characteristics of the urban scene from several points of view that together give the most complete image of such an important kind of Cultural Heritage, by considering such essential factors as are the qualitative perceptive ones and including the user's perspective. This search is focused to get a better knowledge of the architectural and urban historical heritage and to diffuse it. But it also has a prospective and practical intention that will help in a future and more conscious urban planning that will respect the traditions of the past.

And it is also engaged in a conscious architectural design that considers all the different senses and situations and that will satisfy to all possible kind of users.

4. REFERENCES

Alexander, Ch., 1965. A city is not tree. *Architectural Forum*, 122 (1), pp. 58-61 and (2) pp. 58-62.

Almagro, A., 2005. *Fotogrametría arquitectónica*. Instituto de Estudios Árabes, Granada.

Amphoux, P., 1991. *Aux écoutes de la ville: la qualité sonore des espaces publics européens*. (n° 94). Institut de Recherche sur l'Environnement Construit, Département d'Architecture, École Polytechnique Fédérale de Lausanne, Lausanne.

Amphoux, P., 1993. *L'identité sonore des villes européennes - Tome I: Techniques d'enquêtes. Tome II: Répertoire de concepts*. (N° 117). Centre de Recherche sur l'Espace Sonore et l'Environnement Urbain, École d'Architecture de Grenoble / Institut de Recherche sur l'Environnement Construit, Département d'Architecture, École Polytechnique Fédérale de Lausanne, Grenoble, Lausanne.

Appleton, J., 1975. *The experience of landscape*. John Wiley and Sons, London.

Appleyard, D., 1969. Why buildings are known. A predictive tool for architects and planners. *Environment and Behavior*, 1, pp. 131-156.

Augoyard, J.-F. and Torgue, H., 2005. *Sonic Experience. A Guide to Everyday Sounds*. McGill-Queen's University Press, Montreal & Kingston.

Azkárate, A. et al., 1999. *Catedral de Santa María Vitoria-Gasteiz, Plan Director de Restauración*. Diputación Foral de Álava, Vitoria.

Bailly, A., 1977. *La perception de l'espace urbain: les concepts, les méthodes d'étude...* Centre de recherche d'urbanisme, Paris.

Castells, M., 1974. *La cuestión urbana*. Siglo XXI, Madrid.

Clément, J., 1994. L'hypertexte de fiction: naissance d'un nouveau genre?. Communication au Colloquede l'ALCC, Sorbone, Paris, France. <http://hypermedia.univ-paris8.fr/jean/articles/allc.htm> (accessed 22 april 1994)

Corraliza, J.A., 1987. *La experiencia del ambiente. Percepción y significado del medio construido*. Tecnos, Barcelona.

Cullen, G., 1961. *Townscape*. Reinhold Pub. Corp., New York.

Cundari, C., 1983. *Fotogrammetria architettonica*. Kappa, Roma.

Daniel, T., 2001. Whither scenic beauty? Visual landscape quality assessment in the 21st century. *Landscape and Urban Planning*, 56, pp. 267-281.

Docci, M. and Maestri, D., 1992. *Il rilevamento architettonico: Storia, metodi e disegno*. Laterza, Roma.

Docci, M. and Maestri, D., 1994. *Manuale di rilevamento architettonico e urbano*. Laterza, Roma.

Downs, R.M. and Stea, D., (Eds.) 1973. *Image and environment. Cognitive mapping and spatial behavior*. Aldine Publishing Co., Chicago.

English, P. and Mayfields, R., (Eds.) 1972. *Man, space and environment*. Oxford University Press, New York.

Fariña, J., 2006. *Formas de regulación de la escena urbana en varias ciudades europeas*. Instituto Juan de Herrera, Madrid.

Fernández, J.J. and San-José, J., 2000. El sistema de información del patrimonio SIP. Apuntes sobre la gestión y el soporte de datos. In: *Actas del VIII Congreso Internacional de Expresión Gráfica Arquitectónica*, Valladolid, Spain, pp. 311-316.

Fondelli, M., 1992. *Trattato di fotogrammetria urbana e architettonica*. Laterza, Roma.

Forte, M., 2003. Realtà virtuale, pensiero ecologico e logiche dell'apprendimento nei beni culturale. In: *Atti Convegno "Contesti virtuali e fruizioni dei beni culturali"*, Napoli.

Forte, M., 2004. Virtual Heritage: Progetto per la ricerca, la formazione e la fruizione digitale dei beni culturali. In:

- Workshop su "Tecnologie digitali e patrimonio culturale 'I Mondi Possibili'", Roma.
- Frisher, B. et al., 2002. From CVR to CVRO: the past, present and future of cultural virtual reality. *VAST*, Oxford.
- Gibberd, F. 1967. *Town design*. Architectural Press, London.
- Gould, P. and White, R., 1986. *Mental maps*. Allen & Unwin, Boston.
- Grazia, V., 1991. *Rilievo e disegno nell'archeologia e nell'architettura*. Kappa, Roma.
- Jiménez-Burillo, F. and Aragonés, J.I. (Eds), 1986. *Introducción a la psicología ambiental*. Alianza, Madrid.
- Kaplan, S. and Kaplan, R., 1982. *Cognition and environment: Functioning in an uncertain world*. Preager, New York.
- Knox, p., 1987. *Urban Social Geography. An Introduction*. Longman, London, pp. 99-162.
- Lynch, K., 1960. *The image of the city*. Technology Press, Cambridge, Mass.
- Lynch, K., 1984. *Good city form*. MIT Press, Cambridge, Mass.
- Mas-Guindal, A.J., 1992. *Los métodos informáticos en el diagnóstico de edificios antiguos: el acueducto de Segovia*. Ministerio de Cultura, Madrid.
- Milgram, S., 1977. *The individual in a social world. Essays and experiments*. Addison-Wesley, New York.
- Moles, A.A. and Rohmer, E. (1972). *Psychologie de l'espace*. Casterman, Tournai.
- Pallasmaa, J., 2005. *The eyes of the skin*. Wiley-Academy, Chichester, West Sussex, pp. 28-31.
- Piscitelli, M., 2000. La rappresentazione multimediale per la conoscenza dell'architettura. *Quaestio* 5-6.
- Piscitelli, M., 2004. *La rappresentazione nell'era digitale. Nuove tecnologie per disegnare e comunicare*. Napoli.
- Popper, K., 1975. *Objective knowledge: an evolutionary approach*. Clarendon Press, Oxford.
- Pred, A., 1983. Structuration and place: on the becoming of sense of place and structure of feeling. *Journal of the Theory of Social Behaviour*, 13 (1), pp. 45-68.
- Quaroni, L., 1967. *Torre di Babele*. Marsilio, Padova.
- Rapoport, A., 1977. *Human aspects of urban form: towards a man-environment approach to urban form and design*. Pergamon Press, Oxford, New York.
- Rossi, A., 1970. *L'architettura della città*. Marsilio, Padova.
- Santana, M., 2003. *The use of three-dimensional techniques of documentation and dissemination in studying built heritage*. Leuven.
- Scaramellini, G., 1985. Raffigurazione dello spazio e conoscenza geografica: i resoconti di viaggio. In: E. Bianchi (Ed.), *Geografie private. I resoconti di viaggio come lettura del territorio*. Unicopli, Milano, pp. 27-123.
- Schafer, M.R., (Ed.), 1973. *The Music of the Environment*. A.R.C. Publications, Vancouver.
- Schafer, M.R., (Ed.), 1977a. *European Sound Diary*. A.R.C. Publications, Vancouver.
- Schafer, M.R., (Ed.), 1977b. *Five Villages Soundscape*. A.R.C. Publications, Vancouver.
- Schafer, M.R., (Ed.), 1978a. *The Vancouver Soundscape*. A.R.C. Publications, Vancouver.
- Schafer, M.R., (Ed.), 1978b. : *Handbook for Acoustic Ecology*. A.R.C. Publications, Vancouver.
- Scott, A., 2002. Assessing public perception of landscape: the LANDMAP experience. *Landscape Research*, 7 (3), pp. 271-295.
- Sonnenfeld, J., 1984. Equivalence and distortion of the perceptual environment. *Environment and Behavior*, 1, pp. 83-99.
- Truax, B., 2001. *Acoustic Communication*. Ablex Publishing, Westport.
- Wagensberg, J., 2003. *Ideas sobre la complejidad del mundo*. Tusquets, Barcelona.
- Weissberg, J.-L., 2005. *Présences à distance*. Éditions L'Harmattan, Paris.

5. ACKNOWLEDGEMENTS

This study was financed by Project CAM/UAH 2005/028 of the Comunidad de Madrid and the University of Alcalá. We thank the Delegación Provincial de Cultura de la Junta de Comunidades de Castilla-La Mancha for his collaboration.