A sense-archive of urban space

Piga, Barbara E.A. [1] Cibien, Laura [1] Legnani, Anna [2]
Mungo, Simona [2] Zappa, Davide [2] Signorelli, Valerio [1]
Morello, Eugenio [1]

Keywords: perception; simulation; urban archive; virtual tour; panoramas; time-lapse

Abstract How to fix and collect specific moments and conditions of the evolving life of the urban environment? How to record these accurately for future studies? How to share these properly? These are some of the questions we wanted to face when we started our research on sense-archives for the urban space. This is part of a wider research program we are developing on the themes of perceptual simulation for urban design.
Traditional urban representations are in many cases poor in describing the sensory stimuli generated by the urban environment, and often these elements are treated individually and in a quantitative way. The designer has to refer to other kinds of sources, as writings and photos, in order to indirectly understand the perceptual conditions. Even if this kind of information can be very useful, this data needs to be interpreted in order to envision an environment. In this process the risk of misinterpretation is high, and the envisioned image is difficult to share. So, is it possible to accurately record urban conditions, in order to create an archive of public space useful for the urban design practice? And mostly: is it possible to build this collection in order to grasp and reproduce, at least in a partial way, some sensory conditions of the urban environment? We argue that this is possible, and can be useful to inform urban transformation projects.
Following this premise we developed a method to collect a number of urban conditions of the visual environment in a qualitative way. We focused our attention on that sensorial aspect, without forgetting that sight alone is not enough to properly describe the real condition of a place.

Fig. 1 The interface of the visual archive of Pisogne with the navigable panoramas and the key-plan (courtesy of Paolo Bulgheroni, Marco Clauser and Marco Ghisla)

1. Laboratorio di Simulazione Urbana 'Fausto Curti', Dipartimento di Architettura e Studi Urbani (DAStU), Politecnico di Milano, Milan, Italy

2. School of Architecture and Society, Politecnico di Milano, Milan, Italy

Introduction and research focus

When architects and planners develop design projects they always refer to technical drawings and other visual material such as photographs and videos. This kind of bases are increasingly becoming a common reference used by students, professionals and public administrations in the design phase and the decision making process. Maps, sections and similar representations mainly depict the environment in its structure and layout, while photorealistic images tend to recall the sensory ambiance. In the former case, the accuracy of the bases is considered essential, and it is well governed by the professionals, but what about the latter one? Which is the gap that leads to misunderstanding between how we do perceive a photographic image and how we do perceive reality? And above all: is it possible to produce photographic reliable, accurate and replicable perceptual images for scientific studies?

Off course, every typology of representation is a synthesis and a simplification of reality, and each medium prompts us to focus the attention on some characteristics of the environment. Photographic images have a unique capability in rapidly grabbing a moment and reproducing it in a likely way; colors, texture, light and weather conditions, transitory elements, such as people and cars, as well as permanent ones, such as building and vegetation, are all clues that can stay within the same image. Although the essential mechanism of a camera is more or less equal along time and types (aperture, exposure time, lenses), and the elements of the environment live independently from their reproductions, the author's action is what really makes the difference in depicting the environment. As we all know, photographers are able to show us even unexpected conditions of a well-known place, and images of the same site taken by different authors can differ a lot. In these cases, the medium is the language of the artist, and the communication follows intangible messages: but is it possible to minimize the presence of the author in order to use the same tool for scientific purposes? This is what we assume, even though we know that some inaccuracies are unavoidable.

One of the main topics studied at our research laboratory[1] is about the (visual[2]) simulation of the urban environment, the anticipation of its transformations, and related and cumulative outcomes (Piga, 2011b; Piga et al, 2011a). Since the beginning of the early works we developed, it was immediately clear that the typology of medium used (panoramic image, video, render and so on) and its accuracy is essential to set the overall reliability of the simulation itself (Appleyard, 1976; Sheppard, 1989; Bosselmann, 1998): of course, this has an important leverage on the evaluation process, either this is part of the internal design process or the decision making one. This led us to develop a scientific method to create a perceptual photorealistic basis that can be used for analysis and design. We immediately realize that the setting of such a method was equally applicable for the creation of a sense archive of the urban environment; so, each time that we produce a base for a simulation we are creating at the same time an element of a perceptual archive.

To test the approach we developed an experiment on our own campus, within the university research project named *Città Studi Campus Sostenibile*[3]. To face the issue we had to tackle questions about how to create a shooting plan and which techniques could best be employed to capture a specific ambiance. Of course, a dedicated part of the research was address to define a method for the storage and fruition of materials. Last but not least, we designed and implemented a browsing interface that allows to navigate the geo-located data through a virtual tour that recall the urban experience. Since experience is the result of a dynamic process in time and space, a sense-archive cannot skip those; for this reason, and in accordance with our research interests, a special attention was devoted to the dynamic and interactive types of media that allow to recall

[1] http://www.labsimurb.polimi.it

[2] We started our research on simulation from the visual sense, but we are now exploring other sensory aspects such as sounds and touch.

[3] http://www.campus-sostenibile.polimi.it

the urban experience: a dataset that can tell us something about real conditions along time (the images that we grab today will be urban memories of tomorrow), and that can be used as bases to depict potential conditions (e.g. simulation of a past situation or design proposals for a future transformation).

Moreover, especially if further information is associated to the images, these materials can become a useful reference for developing specific analysis, as described below. Even if perceptual images are primarily tools useful for qualitative studies, they can also serve as a base for quantitative analysis. These analyses can be applied both to images of the real conditions, and to simulations that prefigure a possible urban transformation: a comparison between the results can highlight the improvements and support the evaluation process.

The data of the perceptual archive and its elaborations can therefore become a useful tool for designers and planners, simply as a reference for recalling the site or as material for developing analysis and design. The method and the approach is still under development, but so far it has been experimentally tested through university theses and laboratory assignments.

Proposed methodology and techniques for the construction of a sense-archive

Since perception is the result of an interconnection between the environment (*object*) and the observer (*subject*), we are specifically interested in the reproducibility of the *relationship* that links them. Producing a support that can likely mimic the visual interaction with a site, like looking and moving around, can significantly improve the engagement and thus the understanding of the observer, as it is closer to the real experience; interactive simulations are therefore the solution that best respond to this requirement. For this reason we tested the usage of different media (Piga, 2010, 2011a), such as photos, videos, physical and virtual models. In this contribution we are specifically focusing our attention on the first two cases, as a first step towards a more complex and interactive sensory 3-D system.

Apart from the technical requirements that allow to produce good quality images, e.g. High Dynamic Range (HDR), bracketing and similar techniques, what is really relevant is the project for defining the viewpoints of the shooting survey. We aim to define a method that allows to freeze a specific sensory urban condition for studying it in laboratory through a virtual experience. Differently from Google Street View™, where the main goal is to maximize the land coverage in a homogenous way, in our case the attention is concentrated on the definition of relevant views that collaborate to generate the uniqueness of an urban space. This allows to look and compare past, present and future conditions related to the perceptual experience of places. As in the mentioned studies, we have experimentally identified a method that works with *nodes* and *paths* for depicting a site. The choice is related to the way we experience space: we move and look around.

Different paths are easily identifiable looking at the city structure, e.g. sidewalks, bike lanes and so on, while observation of their usage intensity in time can help us to define their hierarchy of importance. In the same way, it is easy to identify different typologies of intersections along these paths. Nodes often correspond to orientation and moments of choices about direction to go. It is our opinion that these are essential elements that could be easily identified, and should at least compose a virtual photographic tool that describes an urban place (Fig. 1).

Other quantitative visual studies can be fruitfully associated to the planning process for identifying relevant viewpoints. Isovist and viewshed analysis are very appropriate to highlight points or areas with peculiar characteristics of the physical space, e.g. area with maximum degree of visibility of the surrounding, and related inferable type of spatial perception, such as the feeling of spaciousness or enclosure. At the moment we are studying and testing the usefulness of these tools in association with visual perceptual archives (Fig. 2) (Magri, 2013). The development of the first step of this research, that associates quantitative with qualitative elements of a space, seems to lead to promising results. Of course each context is peculiar and the study of the points

of view should also be defined according to the different targets visible from several locations, and their social or cultural meaning.

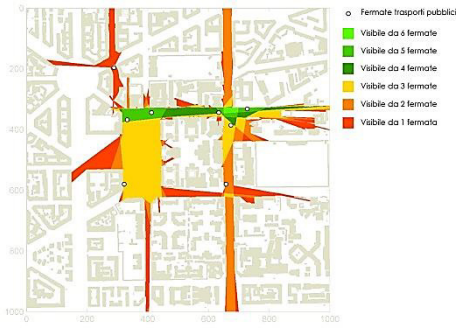

Fig. 2 The representation of the isovists computed at the university gates and their visibility from the public bus stops and showing the visibility of the university entrances

Other relevant circumstances that can guide the identification of the important points of view are the changes occurring in the urban environment, that we define as *inflection points*. These can change according to the scale of interest and the specific context (urban patterns, texture, visual permeability and so on). These are all elements relative to the physical environment, and generally they change only in long periods of time; hence, transposing a term from theatre vocabulary, we can call them as *the stage*. There are, instead, a lot of different *temporary elements*, such as cars and people, that strongly influence, not only in visual terms, the urban perception and ambiance of a place. It is possible to distinguish between *temporary recursive elements* and *temporary sporadic elements*. As all the city citizen know, many urban temporary condition are so constant that are perceived as part of *the stage*, e.g. traffic congestion in specific streets at certain hours along weekdays. Special events can on the contrary be considered temporary sporadic elements that can even modify the perception of the urban space; indeed, some of these events can permanently modify some conditions of the physical environment. Overlapping onto this grid of fixed locations a more flexible one is crucial in order to depict peculiar conditions, such as the *temporary sporadic elements*, which evolutions are not entirely predictable. In this case the author has to decide time by time a suitable shooting plan. In every case a certain ability with photographic and video technics is necessary.

In order to grab perceptual views different tecniques can be adopted, i.g *sequences of images* (time-lapse[4] or video) for the paths and *panoramas* (photograph or videos) for the nodes. In our research we employed and defined[5] three typologies of panoramic images that, if combined in series, can allow different modality of fruition, as shown in Fig. 3:

- Spherical: full 360-degree coverage of the panorama, the observer can look at every direction;
- Cylindrical: portion of the spherical panorama, the coverage is continuous but only for a section of the visible area, the observer can look around in a continuous way but following a single line;
- Planar: portion of cylindrical panoramas, the coverage is partial and the observer cannot complete a full rotation in a continuous way.

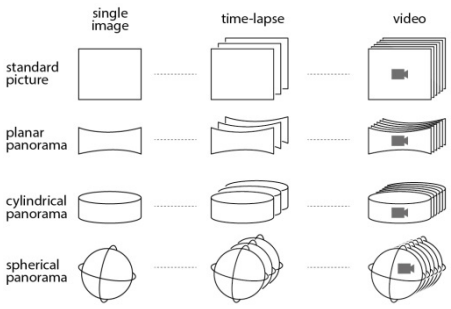

Fig. 3 The typologies of photographic images applied in the archive.

Different media allows as many different kind of interaction, i.e. panoramic images allows to look around from a single point of view (*punctual view - interactive navigation*) while standard time-lapse and videos reproduce the motion view in space (*view in motion - not interactive navigation*). While in the first case the observer can decide where to look at, as if s/he is inside an endless still moment, in the second one time passes (and moving objects with it) but in general it is not possible to choose where to gaze at; anyway,

[4] Sequence of close pictures along a path.
[5] This was crucial for organizing the storage of the images.

photographic technologies are moving fast, and they are opening new interesting possibilities applicable for urban purposes, such as the use of interactive 360-degree videos (*view in motion - interactive navigation*). Of course, single images describe punctual exploration, static in the case of standard pictures and dynamic for panoramas and videos, while sequences of images can also describe liner paths. In both cases the usage of interactive 360-degree spherical videos would allow the user to choose the target point, and thus would be the best solution since it would contribute to increase the final engagement of the observers; anyway, we have to notice that the production and analysis of videos requires a better technical ability than the one required for static images.

In all the cases mentioned above, however, the point of view is the one of the camera, and the observer is not free to wander around; only Virtual Reality (VR) gives this possibility, thus getting closer to the real experience in space; the limit is that VR is often accompanied by a decrease of the photographic likelihood and a complex and costly process of production. These last two aspects are crucial in the definition of the best path to follow according to the specific purposes and resources at hand. Even if in photographic panoramas and videos the degree of freedom of the observer is limited, since s/he is confined in pre-determinate view[6], these tools can result professionally very helpful if it is clear to the final user what the images are not telling us, and how we can best take advantage of these (Piga, 2010, 2011a). As a matter of fact, this typology of supports are largely used, and are becoming everyday more accessible in terms of (self)production and fruition. Moreover, the increasing development of several online resources, such as Google Street View™ and similar, demands for a deeper study about potentiality and limits of such tools and their consequences for the profession, and consequently the relative implications on our cities and lives.

Starting from sense-archive images it is possible to apply different methods of analysis for scientific and professional purposes. For instance, if several images from the same point of view are taken along time they can be compared and tell us a story about the evolution of a place. For this reason, it is really useful to fix on a map paths and nodes, and repeat the shooting survey from these locations in different moments along a day, a week, or a year (Fig. 4). In fact, cities and frequently city lives, change along time, sometimes in a recursive way, as we have seen before. The physical condition as well can be modified in time by external factors, such as the climate one, and thus influence the life of a place; e.g. the intensity of the sun can modify the perception of a building texture, that can even become dazzling, shadow casting in different moments induces a different usage of the urban space, and so on. The *method of comparison* is more effective and reliable if the images in time are taken and reproduced with the same technique (Bosselmann, 1998, 2008).

Fig. 4 Pictures taken at different times from the same point of view, before (2007) and after (2013) the cladding of the office building at the end of the Corso Como in Milan, Italy

Starting from the analysis of the current situation is the first step to deal with, in order to define a shooting plan. But what about simulations of past or future conditions? The design for such a shooting plan is more complex, because it is necessary to envision a place that is not yet, or not more, there. The navigation of physical and virtual models is really useful for this purpose, but

[6] These limits can be overcome by interactive virtual models.

the understanding of the life of this place should be deducted from other sources. Here too, the method of comparison can be used to evaluate outcomes of a proposed project from a perceptual point of view. The same base can be of course used as a reference for comparing and monitoring a building site and its post occupancy. Monitoring the development through time allows to better comprehend city transformations and sometimes enables to make urban changes visible and measurable. In this way the archive can also be used as a monitoring tool.

When a certain amount of data is collected, it becomes immediately evident the importance of a unique method for organizing the archive. Of course, like every archivist knows, there are several valid criteria to arrange information, and the final option depends on the main goal of the archive itself. In our case we decided to structure a hierarchy of information that includes the geo-location, the date, and the typology of image. A number of pre-defined and other tags, such as types of activities recorded or climate conditions, are associated to each image and embedded in the metadata. In this way, it is possible to run simple queries for searching materials. The same method will be applied to store other sense information, such as registrations of the soundscape, in order to allow a multisensory fruition of the archive.

As shown in Fig. 5, according to the different goals, we created different types of layouts that allow a specific fruition and navigation of the images, for instance layouts that allow analysis such as the comparison of images of the same place in time (Fig. 5b). In every case we located the images onto a map. This is important for several reasons. First of all, the user can easily understand the images coverage of an area and decide which elements to navigate; not less important is the possibility to associate the layout of the urban structure (*conceptual representation*) to its perceptual outcomes on site (*perceptual simulation*) (McKechnie, 1977; Piga, 2010); in fact, while navigating a panoramic image, the map indicates where we are looking at. In some cases it is also possible to preview and download some linked documents, such as text descriptions, tables, drawings and similar.

Certain types of analysis can be made using the elements of the sense-archive; we tested these possibilities in some laboratory assignments and university theses (Bulgheroni et al, 2012; Legnani and Mungo, 2013; Magri, 2013), developed at our laboratory in accordance with the lab research topic about perception and urban design. For instance, starting from perceptual images it is possible to calculate the percentage of the different elements visible from a specific point of view. As shown in Fig. 6 the study allows to quantify perceived elements, and thus comparing their conditions in time or between different locations[7]. This typology of study is also useful for informing the design phase, and as a base for defining and communicating guidelines. Another useful usage of perceptual images was tested, where paths and nodes were associated to pedestrian travel time and visual experience (Bulgheroni et al, 2012; Radaelli et al, 2011). In other cases these kinds of support can be used for the analysis of the visual experience of different users. For instance, the use of eye-tracking techniques that allow to highlight urban elements that mainly grab the user attention can be easily adopted (Piga et al, 2011b). Moreover, the use of simulations with different users can allow a comparative study of the results directly reported on the images.

The future evolution of the present research will be addressed to simplify procedures, and to better integrate the proposed approach with on-line available resources. Moreover, a future integration with social networks, and collaborative platforms in general will be desirable. In any case, it is important to remember that, even if this typologies of tools can be very useful for supporting analysis, design and evaluation phases, they cannot themselves guarantee a high quality of the outputs. These are just tools that can help to highlight urban conditions or outcomes of design projects. Evaluation is another task: *"Visual simulation is only descriptive. It does not release the planner from the difficult task of evaluation"* (Lange, 1994).

[7] In this case the lowest common denominator for comparison are the types of perceivable elements.

Fig. 5 A series of interfaces for the sense archives under construction at the Laboratorio di Simulazione Urbana 'Fausto Curti'. (a) the visual archive of the public space (courtesy of Davide Zappa). (b) comparison of two panoramas taken from the same place at different times. (c) The interface of the sustainable campus archive developed with Unity3D™. (d) The simulation of different design solutions compared to the current situation through navigable panoramas

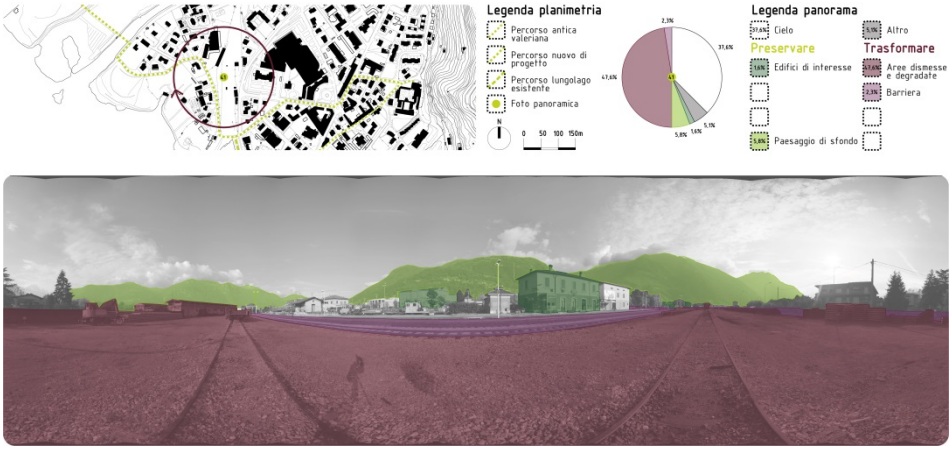

Fig. 6 Map showing the types of visual content for the digital archive of Pisogne; above: the unwrapped panorama with the indication of physical features and views to be preserved (in green) and transformed (in red)
(courtesy of Paolo Bulgheroni, Marco Clauser and Marco Ghisla)

References

Appleyard, D. (1976). *Understanding Professional Media. Issues, Theory, and a Research Agenda*, Institute of Urban and Regional Development, Vol.2, No.150, 58-59.

Bosselmann, P. (1998). *Representation of Places: Reality and Realism in City Design*. Berkeley; Los Angeles; London: University of California Press, Berkeley.

Bosselmann, P. (2008). *Urban transformation: understanding city design and form*. Island Press

Bulgheroni, P., Clauser, M., Ghisla, M. (2012). *Percezione e progetto: sviluppo e sperimentazione di un metodo per un approccio percettivo alla progettazione urbana*, unpublished Master of Science in Architecture thesis, Politecnico di Milano.

Lange, E. (1994). Integration of computerized visual simulation and visual assessment in environmental planning Landscape and Urban Planning, Vol. 30: 1-2, October 1994, 99-112.

Legnani, A., Mungo, S. (2013). La simulazione urbana per la pubblica amministrazione: proposta di metodo per l'analisi e la valutazione delle trasformazioni urbane, unpublished Master of Science in Architecture thesis, Politecnico di Milano.

Magri, R. (2013). *La misura dello spazio percepito: l'isovista come strumento d'indagine e di progetto dell'ambiente urbano*, unpublished Master of Science in Architecture thesis, Politecnico di Milano.

McKechnie, G. E. (1977). *Simulation techniques in environmental psychology*. In: D. Stokols (Ed.), Perspectives on Environment and behavior: Theory, research, and applications (pp. 169-189). New York: Plenum Press.

Piga, B.E.A. (2010). *La simulazione visiva per l'urbanistica. Il punto di vista percettivo nella comprensione delle trasformazioni urbane*, unpublished Doctoral dissertation, Politecnico di Milano, Milan, Italy.

Piga, B.E.A. (2011a). Simulazione e percezione dell'ambiente urbano. In: R. Salerno (Ed.), *Teorie e tecniche della rappresentazione contemporanea*, Rimini: Maggioli, 183-194.

Piga, B.E.A. (2011b). The Urban Simulation and Projects Evaluation Laboratory at the Politecnico di Milano: an educational and research facility. In: Projecting Spaces: Conference on architectural visualisation. Cottbus, Germany, 24-26/09/2009, w.e.b., 114-119.

Piga, B.E.A., Signorelli, V., Morello, E. (2011a). *The experience of an academic simulation laboratory: The use of visual simulations for education and research*. Respecting Fragile Places: Proceedings of the 29th Conference on Education in Computer Aided Architectural Design in Europe . Ljubljana, 21/9/2011 - 24/9/2011, Ljubljana: ecaade and UNI Ljubljana, 734-741.

Piga, B.E.A., Tangredi, C., Signorelli, V. (2011b). *"Investigating the traveler experience: the use of eye-tracking for urban design purposes"*, Proceeding of the 10th Conference of the European Architectural Envisioning Association, Delft, Netherlands, 14-17/09/2011, Delft: Delft Digital Press, 161-168.

Radaelli, R., Salerno, G., Villani, V., Piga, B. E. A., Morello, E. (2011). "*Designing child-friendly urban environments: a proposal for a method of investigation based on visual simulation*", Envisioning Architecture: Proceeding of the 10th Conference of the European Architectural Envisioning Association, Delft, Netherlands, 14-17 September 2011, Delft: Delft Digital Press, 181-188.

Sheppard, S.R.J. (1989). *Visual simulation: A user's guide for architects, engineers and planners*, New York: Van Nostrand Reinhold.

Zappa, D. (2012). *Urban visualscape: la costruzione di un archivio virtuale dello spazio pubblico*. Unpublished Bachelor of Science in Urban Planning thesis, Politecnico di Milano