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Marco Limogiello

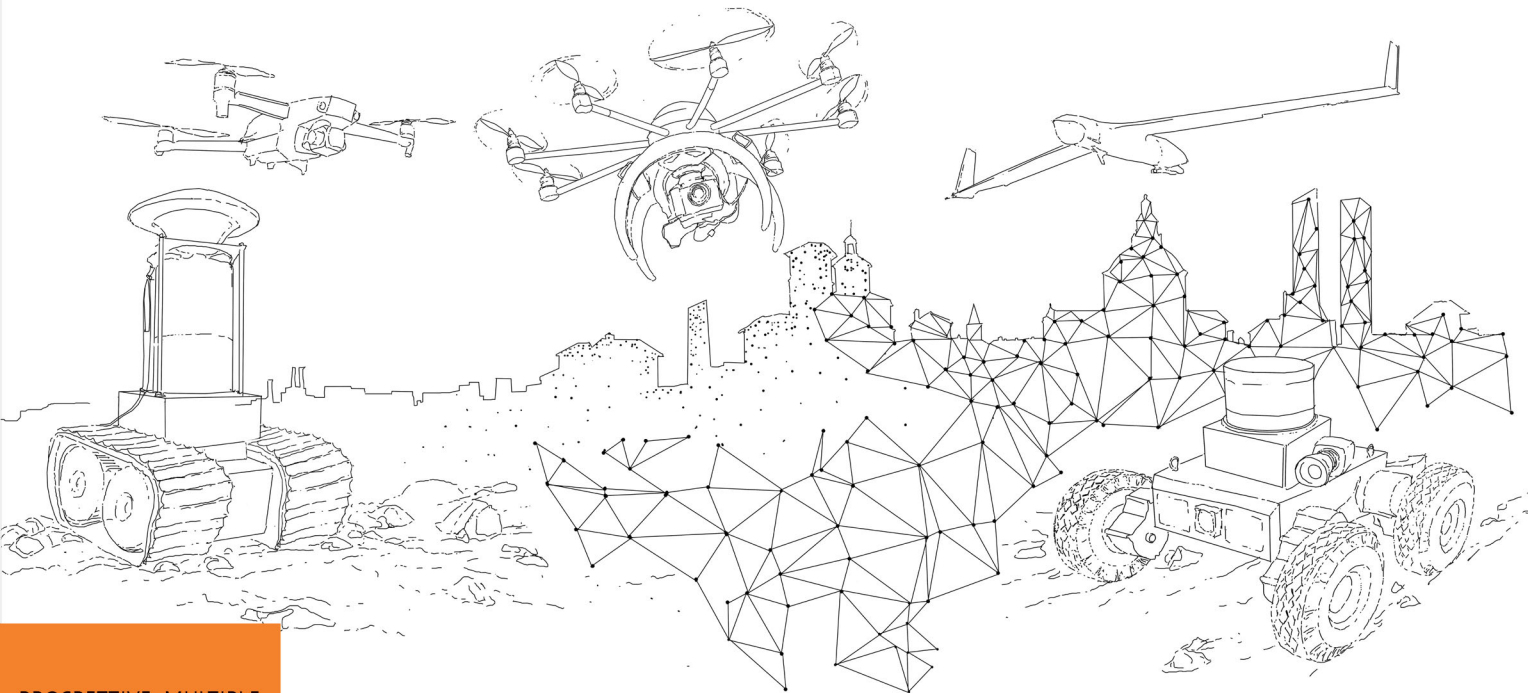
Sandro Parrinello
Anna Dell'Amico

editors

D-SITE

Drones - Systems of Information on cultural hEritage.
For a spatial and social investigation

Volume 1



Salvatore Barba

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UAVs, integrated survey, Shikumen, Shanghai.

ABSTRACT

The rapid evolution of images of unmanned aerial vehicles (UAVs) results in the multiplication of applications in various fields such as military and civilian surveillance, delivery services and wildlife monitoring. From the collaboration with the Jiao Tong University in Shanghai it was possible to experiment with aerial photogrammetry to understand the complexity of one of the most significant and meaningful historic districts of the metropolis.

THE SHIKUMEN OF SHANGHAI. THE USE OF UAV'S TECHNOLOGIES FOR THE DOCUMENTATION, REUSE AND RESTORATION OF A SHIKUMEN

1. INTRODUCTION

A city that has become a metropolis and is characterized by European contamination is the very essence of the city of Shanghai and the cosmopolitan culture it has been a part of since the mid-nineteenth century. Following the treaties that gave foreigners the opportunity to settle and operate in China, Chinese and Western culture began to merge into characteristic districts, a tangible sign of the slow process that has determined the current urban planning of today's metropolis. Today Shanghai is constantly and dizzyingly transformed and the traditional urban and architectural structure of its ancient core is being lost. The operations of construction speculation, necessary to satisfy the exponential population increase of the metropolis, have led to the replacement of many of the architectural 'inventions' that have made Shanghai famous - and which, in some ways, can be juxtaposed with the Beijing hutongs - the so-called longtang or lilong. These residential districts, which have sprung up within the nineteenth-century concessions and therefore characterized by a mixture of Chinese and Western architectural style, constitute, seen in a much larger plan and on a much larger scale, an extension of the Chinese 'backyard house' enriched by influences derived from traditional architectural types still found today in villages in southern China.

2. STATE OF THE ART AND RESEARCH NEED

The traditional dwellings, called Shikumen and developed along the Lilongs, the narrow alleys that

give the neighborhoods their name by extension, are the subject of a perpetual replacement due to a drastic program of demolition and renovation of the ancient buildings with new housing formulas that can accommodate a greater number of inhabitants.

The interventions made that preserve the structure are instead aimed at a change of use, from residential to commercial-tourist.

To slow this constant loss of historical fabric, the Survey Laboratory of the Department of Architecture of the University of Florence in synergy with Jiao Tong University in Shanghai has activated research for documentation and analysis of the fabric of one of the oldest neighborhoods: Dong Siwenli.

The district boasts about a century of age and the primacy of surface extension in the city of Shanghai and is linked to multiple periods of past splendor. Today, unfortunately, it is in an advanced state of abandonment



Figure 1. The intervention area.



Figure 2. Aerial shooting of the area of intervention.

and degradation, due in particular to the recent decision of the government to clear and demolish, a choice that fortunately has not been concluded, but which leaves the entire district in isolation.

From the ancient splendour only a few families resist inside these accommodations, waiting for precise

indications on the future of the area inhabit in inhuman and uncomfortable conditions. Located in the heart of the city, Dong Siwenli is a rectangle of 28,000 square meters of land that fits into a dense urban settlement consisting mainly of skyscrapers, but which heroically resists and identifies itself as a historical unit.

3. SURVEY METHODOLOGY

3.1 CASE STUDY FRAMING

The collaboration between the two universities developed a first phase of investigation following a precise methodology that described all aspects of the Dong Siwenli district. From the interpretation of large amounts of data acquired by sophisticated technological instruments, a precise and accurate morphometric model of urban survey has been obtained. The integrated acquisitions and the resulting three-dimensional model have proven to be effective tools for an objective and reliable interpretation of the place with the final result of an exhaustive product. Built on a former international concession and squeezed between the grip of major infrastructure arteries, the historic district containing Dong Siwenli and King Siwenli is in the floor plan as a rectangle with a total of 736 units built on about 48,000 square meters, approximating 20,000 square meters for King and 28,000 square meters for Dong, thus boasting the record for size in the entirety of the city. After following all the historical phases of stylistic transformation generated mainly by the sublet, the western part was destroyed following the phenomenon of "destruction-relocation", which began after the economic rebirth of the city and its housing reform in 1991. In 2012 the aforementioned phenomenon also occurred for Dong Siwenli, but in this case the demolition company did not work immediately, allowing to treat the abandonment of the residents through a payment, then buffering every empty dwelling and giving the area under management to staff, who took advantage of it to rent the houses. To date, therefore, only 6 families live there, opting to abandon themselves because of dissatisfaction with the solutions proposed to them. Siwenli, while making the previous forms readable, belongs to the typology of new Shikumen Lilong built under the Republic of China, recognizable by the arched medalls of baroque influence found above the doors, which show how, since the opening of China, the local architecture had embraced international styles. This settlement is also characterized by the density and linearity of the plant



Figure 3. Detail of ancient door.

along with the corner houses, symbol of the modern family that is home to only two generations.

The research was also an opportunity to assess the effectiveness of the methodological/procedural system adopted, aimed at describing all the aspects that characterized the Lilong: the historical evolution, the relationship between the street and the Shikumen, the

characteristics of the architecture sign of the uniqueness of the neighborhood, the presence of discontinuity and/or superfetations etc. The integration of advanced techniques and methods of architectural importance were the result of distinct phases of investigation through the use of different tools. The methodology followed, in fact, is that of integrated survey, with detection phases that took place through the use of instruments such as: Laser Scanner Terrestrial system, Photogrammetric Survey. The survey of the area was carried out with the help of a Leica Laser Scanner Laser Scanner Leica ScanStation C10 3D. The data captured by the various scans is reported on the PC via an operation called 'buffering', then the various scans were superimposed via a recording made through the Cyclone software. From the point cloud obtained, the various snapshots were processed, which were used for the subsequent graphical return.

The amount of environments and spaces documented necessitated an orderly and always up-to-date cataloging of photos. The photographic relief on the ground was performed with Samsung PRO 815 camera, with which you captured every surface of the different architectural elements. The photos taken were then used for the creation of three-dimensional models and two-dimensional perspectives with the software Agisoft Photoscan. The greatest difficulty was found in creating quality photos as urban spaces offered cramped environments where the room was properly placed. Finally, to get a complete reading of the neighborhood and given the complexity and morphology of the site to be detected, a further step was needed for the information acquisition campaign to support the photographic survey. This phase was operated at the air level by drone instrumentation. The drone, Phantom 4, was used to photographically detect the entire site in order to create a complete three-dimensional model and a high-definition ortho-photogrammetry. The photogrammetric survey of an unmanned aerial vehicle (UAV) in the Dong Siwenli district proved to be particularly efficient at the expense of the complexity of



Figure 4. Diagram of the photographic acquisition path.

the area, which has covers of different heights and little movement.

It was necessary to carefully design the flight plan and geo-referencing, also evaluating the accuracy rate indicators, in order to achieve highly accurate and reliable results.

The photogrammetric survey of an unmanned aerial vehicle (UAV) in the Dong Siwenli district proved to be particularly efficient at the expense of the complexity of the area, which has covers of different heights and little movement. It was necessary to carefully design the flight plan and geo-referencing, also evaluating the accuracy rate indicators, in order to achieve highly accurate and reliable results. In particular, it was chosen to operate with a DJI Phantom 4 Pro drone for the SfM photogrammetric survey based on a number of instrument specifications, such as the camera and gimbal system. In terms of other hardware used, there was a backup battery, and an Ipad, which was used to control and monitor the UAV through the use of the DJI Go app. The survey area has been divided into 15 systems related to each individual alley of shikumen, to roughly define the



Figure 5. Three-dimensional model made from photographic images obtained from the flight plan of survey.

main architectural areas of each residence. The different flight plans were designed using the app. DJI GPS.

For each alley, about 100m long, 3 different types of flight were planned: a first photographic campaign that maintains the tilt axis of the chamber perpendicular to the ground and two more shots along the main front and on the tergal front with a tilt of the room that would allow a better acquisition of the roofs and upper fronts of the architectural complex by converging the axes to obtain a geometric reconstruction of the buildings according to the principles of photogrammetry.

Drone-acquired images become a key resource as they facilitate the reading of the context and implement the photographic investigation from the ground, made complex due to the narrow alleys that conform the neighborhood. The photographic campaign from the ground has found some critical issues due to

the presence of clutter of the last inhabited houses: kitchens, chairs, work tables, vases, climbing plants, workers' depots, such as concrete sacks, shovels, signs, and mainly due to means of transport, such as cars, bicycles and mopeds parked at the site.

Based on the parallel arrangement of the 15 alleys that make up the neighborhood, image-based detection operations were planned, and it was thus possible to merge the two different photographic campaigns and obtain the entire three-dimensional model of the analyzed area.

4. CONCLUSIONS

The use of a multirotor drone to make aerial footage and photographs on the area set out to achieve a reliable point cloud to be integrated with the acquisition campaign carried out with laser scanners to obtain a 3D



Figure 6. The 3D model.

model of the Dong Siwenli district, capable of generating an exhaustive picture of the built. Given that the area of the Dong Siwenli lilong is among the most relevant in the metropolis and that having programmed in advance parameters such as GSD, flight paths and models and camera orientation, to minimize the waste of time on

site and there were no problems or special constraints to consider for the proper detection of the whole area , UAV detection stretched out for a full week of work due to the inability to recharge the batteries on site, as the area was in a state of disrepair. The complexity of the context and the strategy of capturing oblique images

for the top of the buildings, implemented to the data processed by the Earth survey, have yielded adequate results for the creation of groups of general floor plan and general elevations.

From using PhotoScan to the initial image to align and process dense clouds, we switched to ContextCapture for mes generation. The work process turned out to be a workflow of which produced adequate quality work of the orthophoto products.

The real cognitive process of the area is therefore the result of the two distinct phases of survey and representation. The natural working practice of acquiring dimensional geometric elements once developed triggered a process of interpretation that defined qualitatively the descriptive character of the real.

UAVs (Unmanned-Airborne-Vehicles) are now an important instrumentation for the acquisition of morphological information of architectures, context and environment that offer an interesting platform for the acquisition of photogrammetric elements.

The research highlighted the possibility of obtaining a 3D model of an important urban space from the interpretation of data obtained from the integration of the point cloud obtained by the terrestrial laser scanner survey and the point cloud obtained from high-resolution photographic information.

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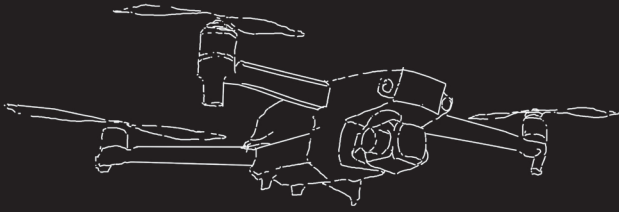
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The use of UAVs is increasingly widespread in activities related to Heritage documentation. In recent years the development of methodologies of data integration, obtained through surveys that exploit drones to reach privileged observation points, has been witnessed by the numerous computation platforms, software and tools, that populate the exchange. The definition of increasingly reliable methodologies and procedures of close-range photogrammetry has produced considerable results in the survey of Architectural Heritage.

Nowadays, several Universities and Research Centres, together with enterprises, are working to optimize documentation services whose goal is, in any case, the representativeness of technical data aimed at the project development. Parallel to aerial documentation, even the applications of remote-controlled terrestrial drone systems is renewing the inspection and survey practices in architecture and on territory, overtaking barriers and access dimensions to sites and contexts in emergency otherwise impractical for human operators.

Surface rovers and submarine robotics, equipped with controlled cameras and implemented survey devices, in terms of stability and compartment, contribute to complete an extremely scientific and innovative field, where the central theme of robotics applied to Cultural Heritage documentation is expanded and consolidated in correspondence to the international categories of UAS (Unmanned Aerial Systems), USV (Unmanned Surface Vehicles) and UUV (Unmanned Underwater Vehicles). Drones, in the wider terms of their definition, are now used for documentation, management, protection, maintenance, and monitoring, integrating imaging systems and or measuring instruments that contribute to define three-dimensional databases on Cultural Heritage. This conference is promoted with the aim of collecting recent experiences on that topic and of providing a moment of reflection between academic and enterprise realities for the promotion of updated frameworks for the development of research in the architectural survey field.



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