Top Views and Technologies for Measuring Territories

Elia Di Nardo

The man has always nurtured the need to explore and represent the territory that surrounds him in order to know its qualities (including the extent) and, where it is possible, share the collected data. Over the centuries both the techniques and the methods of acquisition and restitution of information have changed, and that is extremely evident from the correlation between the different modes of representation of the graphic elaborations and the periods in which they were produced, so much so that chronological analysis makes the following reflection self-evident: the purpose for which these works were made changed according to culture and society.
The search for measuring methods and techniques in order to record one's observation point from above is continuous in the humanity history. The first representations of the territory dates back to the third millennium B.C. and refers to small portions of Mesopotamian urban and rural centers. In these works it is evident the will to document the conformation of the places according to a very different concept, for example, from that of indigenous communities that, to follow the herd to be hunted, had the need to represent from above the places of the journey to go on. The subsequent advent of societies which were founded on a commercial economy between far countries (such as China or the Americas) marks the beginning of the representation of far territories, often inferred on the sole basis of oral evidence collected from the voyages of navigators and merchants. In the mid-seventeenth century, the need to represent as many territories as possible marks the beginning of scientific cartography even if, due to the technological limitations of the measuring instruments used, the surveys from

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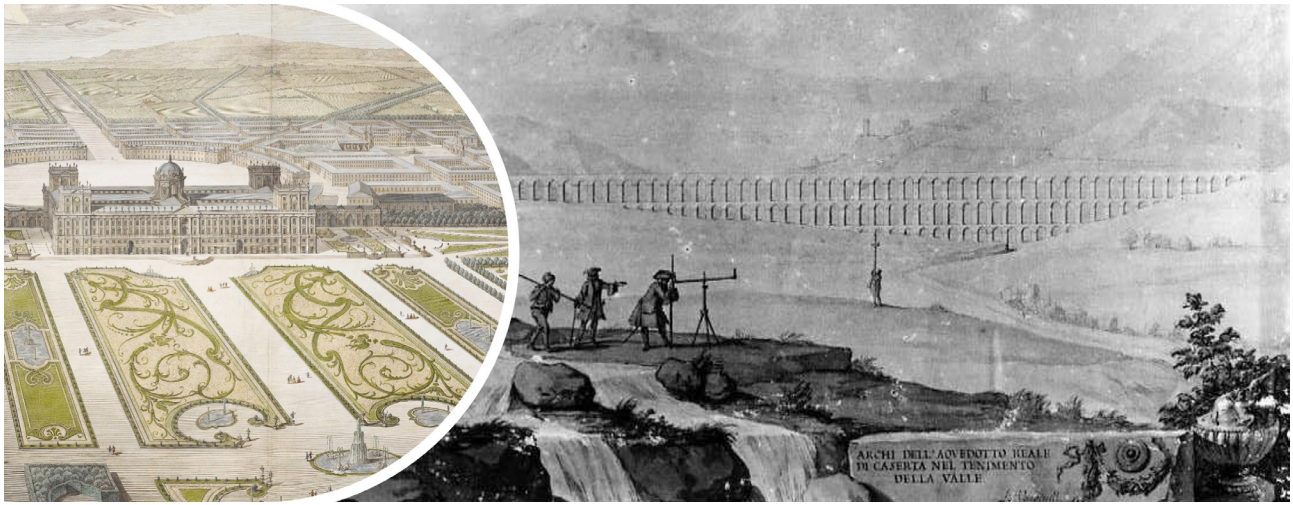

Fig. 1. On the right: drawings of Acquedotto Carolino for distance measurement. On the left: view of the great Parterre with the Palace in distance, hanging gardens and new town, in its first idea. In: Vanvitelli, L. (1756). Dichiarazione dei Disegni del Reale Palazzo di Caserta. Napoli: Regia Stamperia, tav. XIV.

above were often approximate. For a lot of centuries, in fact, the representatives of the 'measure' of the territories resorted to the use of their memory and imagination and, in the absence of tools able to 'benefit' the survey have privileged base points (natural and/or artifacts) characterized by a remarkable height in order to obtain visual observations and more performing graphic transcriptions. This type of solution was used to inspect the environmental context in a better way.

During the time, the representatives experimented with tools and techniques to gather as much geographical and territorial information corresponding as much as possible to reality and technological progress was the protagonist of epochal changes in the accuracy of the measurement and top-down detection. In fact, the search for methods, techniques and tools in order to increase the viewpoint height without the observer had his foot touching the ground, took a significant step forward with the advent of the first light aircraft (balloon) that allowed the operators to physically detach themselves from the ground, experience higher altitudes and direct their look downwards; it is evident that although they were able to represent the proportions of the real, it was still impossible to derive the precise measure.

The most important event came with the advent of photography linked to aircraft. At the beginning of this phase, the photographic survey of the territory was added to the traditional topographic survey by points, until its complete replacement thanks to the improvement of the aero-photogrammetric survey and the subsequent photogrammetric restitution, which constituted an accurate representation in scale of reduction of the planimetric and altimetric characteristics. More than half of the 20th century was characterized by the pre-eminent use of aerial photogrammetry but, with the advent of satellite technology and the consequent possibility of taking images beyond the Earth's atmosphere, the performances are increased especially in regard of the relationship between viewpoint and survey from above, and the opportunity to acquire a great deal of data in the most varied aspects. Since the second half of the 20th century, our society has been witnessing a phenomenon of rapid innovation of digital technology which appears to be immeasurably rapid in its new acquisitions and transformations to the point that it has interested the public and disciplinary opinion about the possibility of having to fear its autonomy. In this regard, consider the many of articles published in a few months about Artificial Intelligence and about

Fig. 2. UAS photos over Reggia di Caserta and Acquedotto Carolino.

the fears that this technology is raising in terms to control decision-making processes.
If we come back to the issue of surveying from the top of the territory, current electronic and information technologies based on the miniaturization of sensors offer unimaginable perspectives and play a significant role not only for data collection activities but also for their visualization. In fact, while the data acquisition and processing phases are realized by observing specific methodologies, the choice of technologies to be used is a function of the objective and the object of the study as well as the intrinsic skills of the instrument in anticipation of possible integrations and/or inclusion of all products in a single database. The added value which this technology offers is the preparation of a digital graphic platform where to join and overlap the existing surveys and data in order to derive thematic, upgradable, interoperable and interrogable territorial views.
However, in the presence of a great deal of varied combinations of methods, techniques and tools, it is essential to make a conscious choice from the critical viewpoint of the issue, and therefore, wonder about the proper understanding and full awareness of the benefits that these new integrated technologies are able to offer in the field of land surveying. For example, UAS (Unmanned Aircraft System), aircraft (especially helicopters) and satellite constellations (SAR, Synthetic Aperture Radar) are among the most widely used systems referring indirect and top-down spatial measurement operations. These systems are united by the possibility of detecting data by means of photographic cameras and/or LiDAR sensors (Light Detection And Ranging). In the latter the distance from buildings and/or surfaces is determined by measuring the reflection time of the laser pulse (ToF, Time of Flight principle). In addition, the different sizes and types of LiDAR sensors act as a discriminator where, in the case of small or larger sensors, they are installed on drones or aircraft. On the other hand, the photogrammetric instrumentation captures high resolution shots to recreate portions of investigated territory; then, by means of specific software, the shots are processed and assembled in order to create 3D models (georeferenced and measurable) and/or detailed 2D real world maps.
Another critical reflection concerns the definition of absolute precision as the ratio among centimeters and pixels. It is known that, by direct scanning, LiDAR systems are able to generate hyper-detailed point clouds by allowing accurate visualizations of the ground and its characteristics. Unlike photogrammetric camera detection, this technique is more adapt to measure and capture small and narrow objects (think of power cables or pipelines and elements with sharp edges). Moreover, while traditional photogrammetry does not allow to return an accurate representation where the vegetation covers the ground, LiDAR is more effective even in detecting areas with high plant coverage as the pulses are able to penetrate the spaces between leaves and branches reaching ground level. Contemporarily, another aspect to the detriment of the use of cameras is the low lighting (especially by night), which greatly influences the results of a flight with drone especially if influenced by dust or cloud cover.
The differences between the two detection techniques are also due to the effort that is necessary to achieve the objectives. For example, investment in equipment varies from sensor to sensor on the base of accuracy, assessed on the amount of data collected and generated. In this sense, being the sensors installed on smaller UAS systems, the performance is reduced in the same way. On the contrary, the effort expressed in working hours is greater in the photogrammetric survey because it requires to detect the so-called 'ground points' with GPS systems that need to correct the GPS data of the drone and orient the taken photos; that is also valid in the case of the latest drones equipped with GPS RTK (Real Time Kinematics). Moreover, in the case of LiDAR, the time resources needed for data processing are significantly reduced because, unlike photos, they are clouds of points that must first be transformed and then georeferenced.
Among the latest digital technologies, the top detection system is represented by the SAR (Synthetic Aperture Radar) which allows to obtain high resolution images from a great distance. The SAR system sends radar pulses laterally and, thanks to this, the radar returns to the sensor the signals that affect different objects on Earth at different times. This makes it possible to distinguish objects while the lateral radar pulses form the image lines; therefore, the dimension in azimuth is formed by the motion and direction of the sensor which continuously sends and receives radar pulses. Satellite SAR Interferometry is therefore a remote sensing technique through which it is possible to derive displacement maps of current and past processes; it is based on the comparison between two radar images (acquired at different times), on the same

Fig. 3. Aydın Büyüktaş, multidimensional photos inspired to Flatland by Edwin Abbot: <https://www.collater.al/flatland-le-fotografie-multidimensionali-di-aydin-buyuktas/> (accessed June 17, 2023).

area from the same sensor, normally installed on satellites in polar orbit around the Earth.
In conclusion, our contemporaneity requires the detectors of territories to understand the changing potential of techniques and technologies that, for decades, do not stop their development especially in relation to the changes in research, which, over the centuries, is increasingly directed towards methods that would 'broaden' the viewpoint. If the studies initially focused on methods especially used in order to physically reach the remarkable viewpoints, in the following periods we turned towards insights on the transposition of what is possible to see, by means of technological tools, and how to return this information. So, it has to image no more but it has to document what is real in order to achieve maximum accuracy.

Author

Elia Di Nardo, Campania Sistemi Srl, edinardo@campaniasistemisrl.it