Sandro Parrinello
Anna Dell'Amico

Salvatore Barba
Andrea di Filippo

editors

D-SITE

Drones - Systems of Information on Cultural Heritage for a spatial and social investigation

PaviaUniversityPress

D-SITE, Drones - Systems of Information on Cultural Heritage for a spatial and social investigation / Sandro Parrinello, Salvatore Barba, Anna Dell'Amico, Andrea di Filippo (edited by) - Pavia: Pavia University Press, 2022. - 684 p.: ill.; 21 cm.

(Prospettive multiple: studi di ingegneria, architettura e arte)

ISBN 978-88-6952-159-1
ebook 978-88-6952-160-7

The present publication is part of the series “Prospettive multiple: studi di ingegneria, architettura e arte”, which has an international referee panel. “D-SITE, Drones - Systems of Information on Cultural Heritage for a spatial and social investigation” is a scientific text evaluated and approved by double blind peer review by the Scientific Editorial Board.

Translation of chapters and treatment of citations and bibliography are due to the respective authors.

PaviaUniversityPress

Pavia University Press
Edizioni dell’Università degli Studi di Pavia
info@paviauniversitypress.it
www.paviauniversitypress.it

Via Salasco, 5 - 20136 Milano
Tel. 02/5836.5751 - Fax 02/5836.5753
egea.edizioni@unibocconi.it
www.egeaeditore.it

Editors
Sandro Parrinello, Salvatore Barba, Anna Dell'Amico,
Andrea di Filippo

Graphic project
Anna Dell'Amico, Francesca Picchio, Anna Sanseverino

On cover: Drawing by Francesca Picchio and Sandro Parrinello
First edition: june 2022.

Stampa: Logo S.r.l. – Borgoricco (PD)

The volume consists of a collection of contributions from the conference “D-SITE, Drones - Systems of Information on Cultural Heritage for a spatial and social investigation". The event, is organized by the experimental laboratory of research and didactics DAda-LAB of DICAr - Department of Civil Engineering and Architecture of University of Pavia, and MODLab of DICIV - Department of Civil Engeenering of University of Salerno. The publication co-funded by the the University of Pavia, the University of Salerno, and the Italian Ministry of Foreign Affairs and International Cooperation.

D-SITE Conference is organized by:

University of Pavia

DICAr - Department of Civil Engeenering and Architecture University of Pavia

Univeristy of Salerno

DICIV - Department of Civil Engeenering Univeristy of Salerno

DAda LAB - Drawing and Architecture DocumentAction University of Pavia

PLAY - Photography and 3D Laser for virtual Architecture laboratorY University of Pavia

LS3D -Joint Laboratory Landscape, Survey & Design University of Pavia

Laboratorio Modelli - Surveying and Geo-Mapping for Environment and Cultural Heritage University of Salerno

With the patronage of:

Italian Ministry of Foreign Affairs and International Cooperation

UID Unione Italiana Disegno

APEGA Scientific Society Expresión Gráfica Aplicada a la Edificación

SIFET Società Italiana di Fotogrammetria E Topografia

AIT Associazione Italiana di Telerilevamento

INGENIA DRON

In collaboration with:

Remote Sensing Laboratory of the Department of Earth and Environmental Sciences University of Pavia

Department of Information Engineering University of Pisa

Department of Agricultural, Food, Environmental and Forestry Sciences University of Florence

Institute for Electromagnetic Sensing of the Environment CNR

Museum of Electrical Technology University of Pavia

Italian Ministry of Defence Air Force

Italian National Council of Engineers

Italian National Council of Landscape Architects and Conservators

Order of Engineers Province of Pavia

Order of Landscape Architects and Conservators Province of Pavia

Enterprise sponsors:

Media Partners:

Organizer Committees

Sandro Parrinello	University of Pavia - Italy
Marco Limongiello	University of Salerno - Italy

Scientific Committees

Marcello Balzani	University of Ferrara - Italy
Salvatore Barba	University of Salerno - Italy
José Antonio Barrera Vera	University of Seville - Spain
Stefano Bertocci	University of Florence - Italy
Carlo Bianchini	La Sapienza, University of Rome - Italy
Mirco Boschetti	IREA, CNR - Italy
Enrico Borgogno Mondino	University of Turin - Italy
Stefano Campana	University of Siena - Italy
Massimiliano Campi	University of Naples Federico II - Italy
Gabriella Caroti	University of Pisa - Italy
Filiberto Chiabrando	Polytechnic of Turin - Italy
Gherardo Chirici	University of Florence - Italy
Antonio Conte	University of Basilicata - Italy
Krzysztof Cyran	Silesian University of Technology - Poland
Francesco Fassi	Polytechnic of Milan - Italy
Francesca Fatta	University of Reggio Calabria - Italy
Juan José Fernández Martín	University of Valladolid - Spain
Margherita Fiani	University of Salerno - Italy
Andreas Fritz	University of Freiburg - Germany
Diego González-Aguilera	University of Salamanca - Spain
Armin Gruen	ETH Zurich Faculty of Architecture - Swiss
Pierre Grussenmeyer	Institut National des Sciences Appliquées - France
Sorin Hermon	The Cyprus Institute - Cyrus
Xianfeng Huang	Wuhan University - Hubei China
Marinos Ioannides	Cyprus University of Technology - Cyprus
Falko Kuester	University of California - USA
Francesco Mancini	University of Modena and Reggio Emilia - Italy
Niccolò Menegoni	University of Pavia - Italy
Luis M. Palmero Iglesias	Polytechnic of València - Spain
Francesca Picchio	University of Pavia - Italy
Lorenzo Pollini	University of Pisa - Italy
Fabio Remondino	Bruno Kessler Foundation - Italy
Fulvio Rinaudo	Polytechnic of Turin - Italy
Mario Santana Quintero	Carlton University - Canada
Tesse D. Stek	Leiden University - Netherlands
Lina Tang	Chinese Academy of Sciences - Cina
Dieter Tengen	Technical University Braunschweig - Germany
Fabio Giulio Tonolo	Polytechnic University of Turin - Italy
Kyriacos Themistocleous	Cyprus University of Technology - Cyprus
Rebeka Vital	Shenkar College of Engineering and Design - Israel
Francesco Zucca	University of Pavia - Italy

Scientific Secretariat

Anna Dell'Amico (University of Pavia), Andrea di Filippo (University of Salerno), Silvia La Placa (University of Pavia)

INDEX

PREFACE

CONFERENCE PAPERS

Chiara Rivellino[1], Marco Ricciarini[2]

1 DICAr, Department of Civil Engineering and Architecture of University of Pavia, Pavia, Italy
2 DIDA, Department of Architecture, University of Florence, Florence, Italy

chiara.rivellino01@univesitadipavia.it

marco.ricciarini@unifi.it

Keywords:
Cultural Heritage documentation, Databases comparison, DJI Mavic mini, Donatello's Pulpit, Bas-reliefs.

ABSTRACT

The need to achieve a complete three-dimensional database has seen an increasing use of UAV systems in architectural surveying. In particular, special types of drones -mini-UAVs- are increasingly being used for surveys within historical centres or in critical areas. Through the case study of the documentation of Donatello's Pulpit at Cathedral of Santo Stefano in Prato, the paper aims to evalu-ate the acquisition’s reliability by mini-UAV of an architectural element characterized by a high level of detail. The evaluation is carried out comparing the results obtained by drone with those obtained by proven techniques of terrestrial laser scanner and photogrammetric survey.

Testing the reliability of mini-UAVs acquisition campaign on detailed bas-reliefs. The case study of sculpturing elements of Donatello's Pulpit

1. Introduction

One of the main objectives behind an integrated three-dimensional survey is the reliability of the results obtained from the management and processing of the collected data. For this reason, surveyors tend to use digital surveying tools of well-established reliability and geometric-morphological accuracy - TLS[1] - which, however, alone do not provide all the data needed to describe the surveyed object (Carnevali et al. 2018). This problem has led to the increasing use of UAVs[2] in architectural surveying for Cultural Heritage conservation. In particular, among the different remotely piloted instruments used in surveying campaigns, mini - UAVs, characterized by ease of manoeuvrability, low weight and low cost, have enjoyed considerable success in recent years; these characteristics allow mini - UAVs to be used in contexts that are often prohibitive for other drones and within historic centres (Parrinello, Picchio 2019). The versatility that characterizes these tools, however, must reckon with the reliability of the database derived from them, particularly with regard to architectural objects characterized by considerable formal and decorative complexity.

This contribution aims to verify the reliability of 3D databases from mini-UAVs - DJI Mavic Mini - comparing them with those from survey tools considered reliable - TLS and digital cameras-. The point clouds and mesh models on which the comparison is made concern the case study of Donatello's Pulpit of Santo Stefano's Cathedral in Prato.

2. Case study: Donatello's Pulpit

Donatello's Pulpit is a particular architectural element located at the intersection of the West and South elevations of Prato Cathedral at a height of approximately 3 metres above the ground; for this reason, it is the ideal case study to test the validity of using mini-UAVs as an integration to a survey carried out with TLS instruments (Figure 1). Using drones, it is indeed possible to perceive

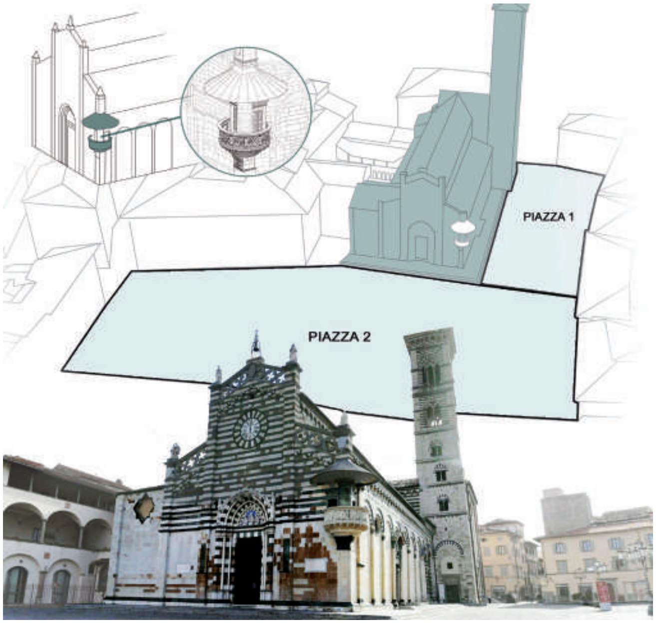

Figure 1. Contextualization of Donatello's Pulpit and Cathedral of Santo Stefano within the urban context of Piazza Duomo in Prato.

the morphological and material complexity of the surveyed object in its entirety (Galasso, La Placa 2020).

Donatello's Pulpit (1428 - 1434) is a sculptural masterpiece composed of several elements, each richly decorated. Shelves with volutes and concentric finials, decorated in classical style and with mouldings, support a circular balustrade; this is divided into seven panels alternating with paired pilasters depicting a dance of angels (Guasti 1887)[3]. The balustrade is covered by an umbrella canopy, placed at a height of about 6 metres from the ground. The pulpit visible today on the facade is actually a copy of the original, preserved in the Museo dell'Opera del Duomo (Figure 2).

The presence of a rich decorative apparatus that characterises the morphology of the pulpit made it necessary to use photogrammetry techniques to supplement the data obtained from the terrestrial laser scanner in order to study and accurately survey the entire sculptural apparatus. The acquisition of the metric and photogrammetric data for the creation of a three-dimensional database is carried out during a survey campaign in the first week of August 2021. In addition to the laser and photogrammetric instruments on the ground, the documentation activities involve

Figure 2. Donatello's Pulpit and detail of balustrade's decorative apparatus.

the use of two different types of drones, all from the company DJI. (Figure 3) In particular, the use of a mini-UAV allows the detailed photogrammetric acquisition of the object, while the UAV instrumentation provides a general restitution of the entire complex's exterior of Prato Cathedral and the Piazza del Duomo, allowing the pulpit to be placed in the historical and architectural context of the public space in front of it.

The use of drones in the survey stems from the need to integrate not only the decorative apparatus of the pulpit, but also the canopy and church roofs respectively, in order to obtain a single integrated three-dimensional database.

3. Documentation and post-production of the decorative system

3.1 Range-based and image-based acquisition methodology

The detailed acquisition phase of the decorative devices of the external pulpit involves the use of the DJI Mavic Mini[4] drone which, thanks to its light weight and small size, allows the operator to safely approach the object and obtain high-resolution images. The planning of the acquisition phase sees the use of an 's'-shaped flight plan, dividing the balustrade and the decorative rings below into three horizontal bands with a certain margin of overlap between them (Figure 4). This scheme allows the complex decorative apparatus to be acquired from all perspectives, trying to obtain as complete an image database as possible. At each position, a single image is acquired while keeping the inclination of the camera axis perpendicular to the element. Within the same horizontal acquisition band, a certain percentage of overlap between contiguous images is considered, in accordance with the general principles of photogrammetry (Aicardi et al. 2016).

Photogrammetric acquisition also involves the use of a telescopic rod, the 3D - EYE. This, given the possibility of extension up to 9 metres, makes it possible to obtain

Figure 3. The Different types of instruments used by the Dada-Lab Research Laboratory during the acquisition campaign. From left: FARO CAM2 S150 terrestrial laser scanner, 3D-EYE, DJI Mavic 2 and Mavic Mini.

close-up images of the decorative elements (but without the possibility of reaching the highest parts or the umbrella roof). The acquisition phase with this tool again involves the use of an 's' pattern, dividing the decorative complex into 3 horizontal bands (Figure 5). In addition, for each position, the camera takes 4 types of photos: the first keeping the axis of the camera perpendicular to the element, while for the others the entire pole is rotated to the right and then to the left and finally the camera is tilted downwards.
A more general photogrammetric acquisition of the pulpit and roof portions of the cathedral is carried out using the DJI Mavic 2[5] drone. The spiral flight plan allows the acquisition of all necessary data that cannot be detected with laser scanners (Figure 6).
On the other hand, the range-based acquisition is carried out with a terrestrial laser scanner[6]. In particular, nine colour and high-density scans are carried out for the pulpit alone.

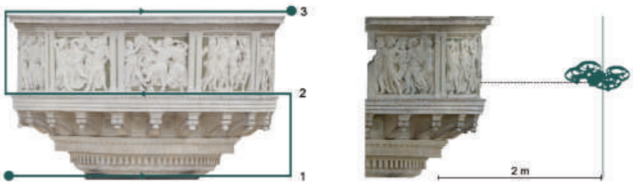

Figure 4. Acquisition scheme of the balustrade with DJI Mavic Mini.

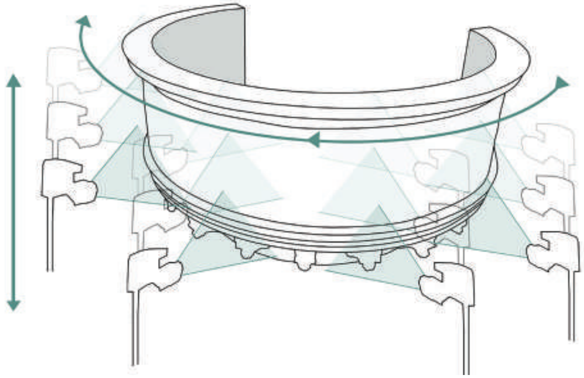

Figure 5. Acquisition scheme of the balustrade with 3D-EYE.

3.2 Processing of photogrammetric data

The data management and processing operations, with the aim of obtaining textured three-dimensional models of Donatello's pulpit, are conducted using Agisoft Metashape software for photogrammetric processes. The software is based on the sequence of several processes in succession. The first step consists in the alignment of the images, guaranteed by the overlapping margin between contiguous shots; then, a sparse point cloud is generated, which defines the volumetry of the surveyed object. From the sparse cloud is created a dense cloud on which the mesh and final texture are elaborated (Figures 7 and 8). For the

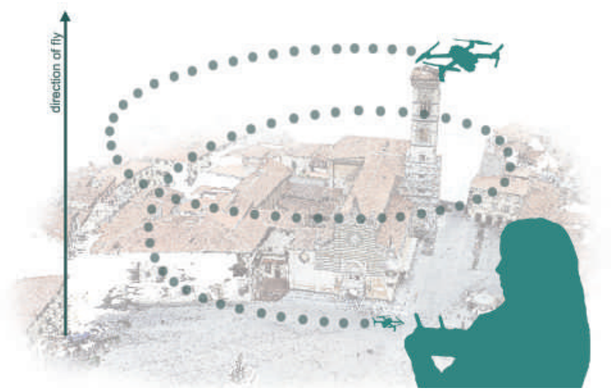

Figure 6. Spiral acquisition scheme of the Prato Cathedral complex and square with DJI Mavic 2.

present case study, 70 photographs from the DJI Mavic Mini, 360 photographs from 3D - EYE and 394 images from the DJI Mavic 2 are processed. In particular, the images coming from the DJI Mavic Mini are treated obtaining a model composed of 3,470,574 points and a mesh of 694,144 faces, those coming from 3D - EYE generated a model composed of 29,004,034 points and a mesh of 5,806,545 faces and finally those coming from the Mavic 2 141,432,585 points and 28,286,481 faces. All point clouds are aligned using morphological and architectural homologous points to those derived from the TLS point cloud. The model of the DJI Mavic Mini has an alignment error of 0.005 metres, that of the 3D - EYE of 0.002 metres and finally that of the Mavic 2 of 0.017 metres (Figure 9).

3.3 Comparison of models

Due to the decorative complexity that distinguishes Donatello's pulpit, it is decided to focus attention on the low-relief decorated surfaces of the balustrade and the decorative rings, making comparisons between the three-dimensional photogrammetric models obtained from the different instruments and those obtained by drone (Figure 10). In particular, the comparisons carried out are of different types: a first qualitative comparison within the Agisoft Metashape software, which allows us to understand the decorative reliability of the models generated by the data obtained from the mini-UAV; at the same time, a second comparison is carried out in the Geomagic Design X software, which permits to calculate the average standard deviation of the meshes. Finally, a metric comparison is carried out within the Leica Cyclone software, which allows to understand if the point clouds obtained from mini-UAV are metrically reliable compared to those obtained from the TLS.

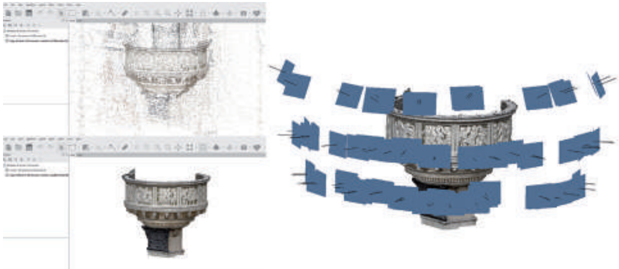

Figure 7. Point cloud processing through Agisoft Metashape software of the data acquired by Mavic Mini. On the left, the processing phase starting from the creation of sparse cloud to the dense cloud on which to build the mesh model. On the right, the acquisition positions of the images.

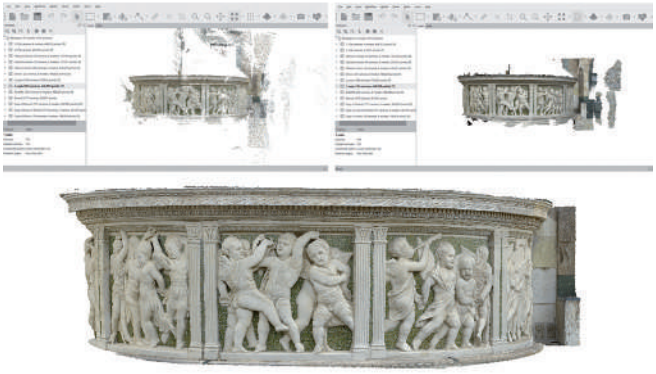

Figure 8. Point cloud processing through Agisoft Metashape software of the data acquired by 3D-EYE. Above, data processing from the sparse cloud to dense one; below, the final textured model.

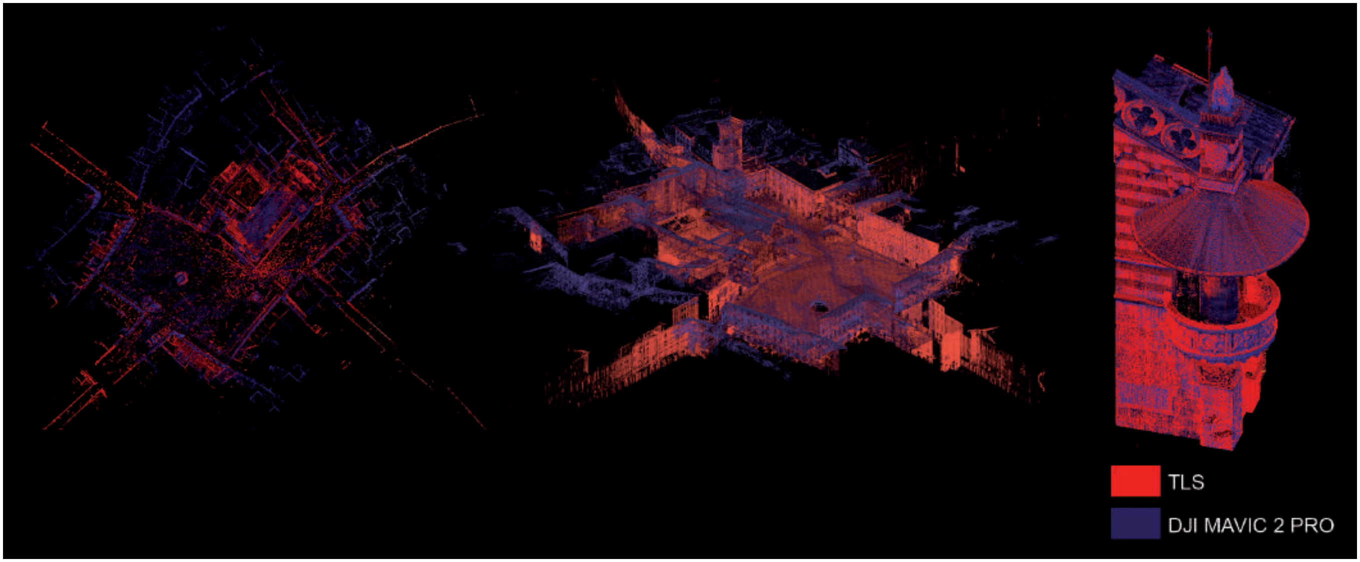

Figure 9. Overlay of point clouds generated from data acquired by FARO CAM2 S150 terrestrial laser scanner (red) and DJI Mavic 2 UAV (blue).

3.3.1 Visual comparison: 3D - EYE versus DJI Mavic Mini

A first visual and qualitative comparison is made by comparing the mesh model obtained from the photos taken by 3D - EYE and that obtained from the data acquired by the DJI Mavic Mini. The comparison permits considerations to be made on the level of detail of the mouldings detected. In particular, the decorative elements are clearer and more readable in their shapes in the model obtained from the 3D - EYE than that obtained from the mini drone. However, the floral decorations between the scrolling shelves of the mesh model obtained from 3D - EYE reveal some problems - e.g., lack of data - (Figure 11). The difference in accuracy is due to the fact that with the telescopic pole it is possible to observe the decorative details more closely; in fact, the drone acquisitions are taken from a more distant position, in order to avoid excessive proximity between the mini-UAV and the decorative apparatus of the pulpit. However, the chosen distance ensures that a good level of GSD[7] is maintained (Draeyer, Strecha 2014). Furthermore, the final image of the models depends on the number of polygons that compose the mesh: 5,806,545 faces of the 3D model - EYE versus 694,144 faces of the drone model. A high number of polygon faces corresponds to a greater possibility of obtaining models with a high degree of detail.

A second type of comparison is carried out within Geomagic Design X software. In this case, the two mesh models are aligned by points and then compared using the Mesh Deviation tool, which permits analysis of how far the surfaces deviate by setting different ranges of tolerance values.

The deviation study is done on visual information interpreted by a colorimetric scale where adhesion areas are in green, out-of-plane deformations in red and inward displacements in blue (Figure 12). The analysis shows good congruence between the models in the capital portion, while areas of inaccuracy are concentrated within the concentric volutes and corbels, with a maximum error between 5 mm and 15 mm.

Figure 10. Composition obtained by merging three-dimensional databases coming from different instruments.

3.3.2 Metric comparison: TLS versus DJI Mavic Mini

In addition to the visual comparison, a metric one is made by comparing point clouds obtained from ground-based laser scanners and DJI Mavic Mini.
The analysis of the deviation between the two clouds is conducted with the Leica Cyclone 9 software.
In particular, the point cloud of the mini-UAV is aligned considering the one obtained from the TLS as a reference. Then a section plane is inserted into it; in the frontal view, it is possible to calculate the distance between the two clouds at different points and thus understand how reliable the cloud from the data obtained with UAV systems is. In general, the analysis shows a good congruence between point clouds; the verification allows us to assess the deviation by measuring the distance between them by defining two points and using the measuring instrument.
It is verified that the error tends to increase close to architectural elements characterised by more complex shapes, where the drone cloud discretizes the information more. The error also increases near the decorative rings of the pulpit, where a loss of geometry is visible. In addition, the cloud obtained by drone in these areas generates "swipes" of points, creating noise (Figure 13).
The inconsistency error interval is instead due to a previous error of cloud drone's reference to that coming from TLS.

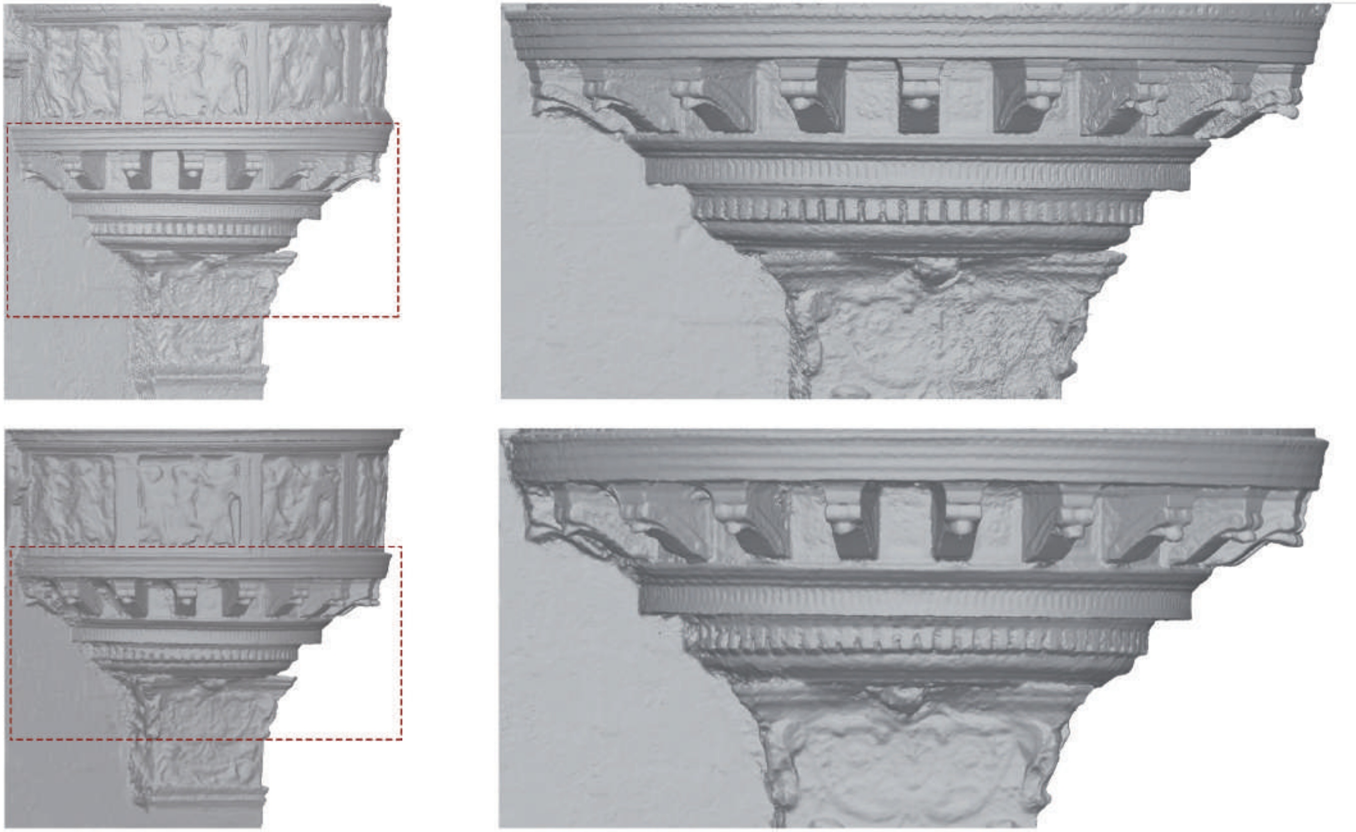

Figure 11 . Visual comparison between photogrammetric models. Above, the model obtained from Metashape software by processing data obtained from 3D-EYE. Below, the model from Mavic Mini.

4. Conclusions

The article analyses the reliability of the use of mini-UAVs in the context of an integrated investigation aimed at the knowledge and documentation of an architectural element characterised by a complex decorative apparatus.

The results obtained highlight two fundamental aspects of the use of mini-UAVs in the documentation of Cultural Heritage. Firstly, the work carried out on the case study demonstrates how the use of the drone within a survey allows us to obtain a complete database focusing on the decorative and plastic aspects, especially if positioned at heights where ground-based instrumentation alone (range and image-based) cannot be effective. On the other hand, the work emphasises the potential of using mini-UAVs in architectural surveys, especially in areas where flight regulations are restrictive. The visual comparison, but especially the metric one, highlights the qualities of these drones in terms of reliability and accuracy of measurements.

Figure 12. The model deviation coming from data acquired with 3D-EYE compared with that from DJI Mavic Mini acquired data. The tolerance value is set at 5 mm on a maximum deviation of 30 mm. It can be observed that the surfaces are fitted in the lower part, while the deviation values increase in the upper one.

Future research developments see the possibility of implementing acquisition methods with these particular instruments at altitude, in order to obtain final results that better match the goals set by the documentation.

Credits

The research project on Donatello's pulpit in the Cathedral of Santo Stefano in Prato, scientific responsible Prof. Francesca Picchio, has been developed within the research laboratory DAda-Lab of the University of Pavia (responsible Prof. Sandro Parrinello) within a joint activity with the Department of Architecture – DIDA - of the University of Florence, and the Museo dell' Opera del Duomo of Prato.

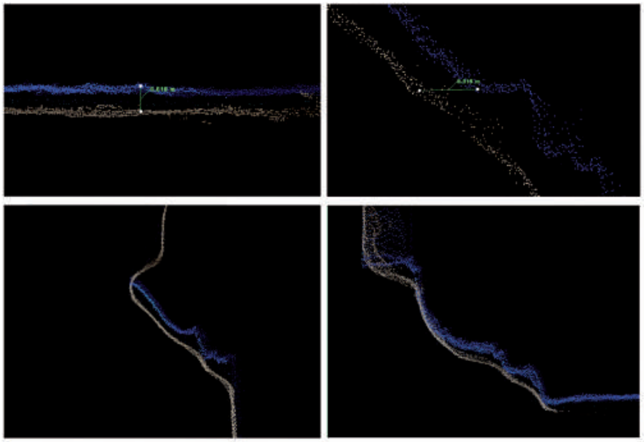

Figure 13. Above, metric comparison between point clouds obtained from TLS and Mavic Mini. Below, geometric deviation of the point cloud obtained by drone to that obtained by terrestrial laser scanner. The discretization of information obtained from drone is relevant.

Notes

1 Terrestrial Laser Scanner.

2 Unmanned Aerial Vehicle.

3 For an in-depth reading on the historical and constructive aspects of Donatello's pulpit, see Bonsanti, Giorgio (2000). Il pulpito di Donatello. In Donatello restaurato. I marmi del pulpito di Prato, pp. 11-30. Pistoia: maschietto&musolino, 2000.

4 The main features of the DJI Mavic Mini: weight less than 249 grams, open dimensions with propellers 245×289×55 mm, upward speed 1.5 m/s - 4 m/s, downward speed 3 m/s, flight time 31 minutes, 20 MP camera, 35 mm lens, f/2.8 aperture, shutter speed 4 - 1/8000 s (for additional information see https://www.dji.com/it/mavic-mini/specs).

5 The main features of the DJI Mavic 2: weight 907 grams, open dimensions with propellers 322×242×84 mm, upward speed 4 m/s - 5 m/s, downward speed 1 m/s - 3 m/s, flight time 30 minutes, 12 MP camera, 35 mm lens, aperture f/2.8-f/11, shutter speed 8 - 1/8000 s (for additional information see https://www.dji.com/it/mavic-2/info).

6 The range-based acquisition is carried out using a FARO CAM2 FOCUS S150 terrestrial laser scanner. The point clouds obtained from this instrumentation are aligned and recorded through the use of SCENE software, produced by the same manufacturer of the laser scanner. In particular, the maximum referencing error obtained in the registration phase of the total cloud is 0.0042 metres.

7 Ground Sample Distance.

Bibliography

Aicardi I., Chiabrando F., Grazzo N., Lingua A. M., Spanò A. (2016). *UAV photogrammetry with oblique images: first analysis on data acquisition and processing*. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information System, XLI-B1, 2016, pp. 835-842.

Bolognesi M., Furini A., Pellegrinelli A., Russo V., Russo P. (2014). *Accuracy of Cultural Heritage 3D models by RPAS and terrestrial photogrammetry*. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information System, XL-5, 2014, pp. 113-119.

Carnevali L., Ippoliti E., Lanfranchi F., Manconero S., Russo M., Russo V. (2018). *Close-Range mini-UAV's photogrammetry for architecture survey,* International Archives of the Photogrammetry, Remote Sensing and Spatial Information Science, Vol XLII – 2, pp. 217-224.

De Marco R., Pettineo A. (2022). *The recognition of heritage qualities from feature-based digital procedures in the analysis of historical urban contexts.* International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences.

Draeyer B., Strecha C. (2014). *White paper: How accurate are UAV surveying methods*. Pix4D White Paper.

Galasso, A., La Placa, S. (2020). *Comparative data processing methods: analysis and considerations on photogrammetric outputs obtained from UAV. The case study of the facade of the Church of the Certosa di Pavia*. In: Barba S., Parrinello S., Limongiello M., Dell'Amico, A., (eds) D-SITE Drones - Systems of Information on Cultural Heritage. For a spatial and social investigation. Pavia University Press, Pavia.

Guasti C. (1887). *Il pergamo di Donatello pel Duomo di Prato*. Firenze: Forni.

Parrinello S., Picchio F. (2019). *Integration and comparison of close-range sfm methodologies for the analysis and the development of the historical city center of Bethlehem*. Int. Arch. Photogram. Remote Sens. Spatial Inf. Sci., XLII-2/W9, pp. 589-595.

UNIVERSITÀ DEGLI STUDI FIRENZE
DIDA
DIPARTIMENTO DI ARCHITETTURA

Dichiarazione stesura paragrafi del contributo

Il sottoscritti:

L'architetto Chiara Rivellino nata a Campobasso in Provincia di Campobasso, il 04/05/1997 residente a Campobasso in Provincia Campobasso, in via Strada Guado della Stretta, 9 Riccia;

Il Ph. D. Marco Ricciarini nato a Prato in Provincia di Prato, il 17/06/1979 residente a Cervia in Provincia di Ravenna, in Via Delle Azalee, 25.

consapevoli delle sanzioni penali in caso di dichiarazioni false e della conseguente decadenza dai benefici eventualmente conseguiti (ai sensi degli artt. 75 e 76 D.P.R. 445/2000) sotto la propria responsabilità

DICHIARANO CHE IN MERITO AL CONTRIBUTO DAL TITOLO

TESTING THE RELIABILITY OF MINI-UAVS ACQUISITION CAMPAIGN ON DETAILED BAS-RELIEFS. THE CASE STUDY OF SCULPTURING ELEMENTS OF DONATELLO'S PULPIT

L'architetto CHIARA RIVELLINO è l'autrice dei paragrafi:

- ***2 CASE STUDY: DONATELLO'S PULPIT***
- ***3 DOCUMENTATION AND POST-PRODUCTION OF THE DECORATIVE SYSTEM***
- ***3.2 PROCESSING OF PHOTOGRAMMETRIC DATA***
- ***3.3 COMPARISON OF MODELS***

il Dottore di Ricerca MARCO RICCIARINI è l'autore dei paragrafi:

- ***1. INTRODUCTION***
- ***3 DOCUMENTATION AND POST-PRODUCTION OF THE DECORATIVE SYSTEM***
- ***3.1 RANGE-BASED AND IMAGE-BASED ACQUISITION METHODOLOGY***
- ***3.3.1 VISUAL COMPARISON: 3D - EYE VERSUS DJI MAVIC MINI***
- ***3.3.2 METRIC COMPARISON: TLS VERSUS DJI MAVIC MINI***
- ***4. CONCLUSIONS***

DICHIARANO CHE IN MERITO AL CONTRIBUTO DAL TITOLO

I sottoscritti dichiarano inoltre di essere informati, ai sensi del D.Lgs. n. 196/2003 (codice in materia di protezione dei dati personali) che i dati personali raccolti saranno trattati, anche con strumenti informatici, esclusivamente nell'ambito del procedimento per il quale la presente dichiarazione viene resa.

Firenze, 21giugno 2023

Chiara Rivellino

Marco Ricciarini

Marco Ricciarini
Piazza Lorenzo Ghiberti, 27 - Firenze
tel. 3389015259 marco.ricciarini@unifi.it

REPUBBLICA ITALIANA
MINISTERO DELL'INTERNO

CA75279ER

CARTA DI IDENTITÀ / *IDENTITY CARD*

COMUNE DI / *MUNICIPALITY*
RICCIA

COGNOME / *SURNAME*
RIVELLINO

NOME / *NAME*
CHIARA

LUOGO E DATA DI NASCITA
PLACE AND DATE OF BIRTH
CAMPOBASSO (CB) 04.05.1997

SESSO / *SEX*	STATURA / *HEIGHT*	CITTADINANZA / *NATIONALITY*
F	165	ITA

EMISSIONE / *ISSUING*
29.07.2019

SCADENZA / *EXPIRY*
04.05.2030

FIRMA DEL TITOLARE
HOLDER'S SIGNATURE

NRHF

661980

COGNOME E NOME DEL PADRE E DELLA MADRE O DI CHI NE FA LE VECI/
FATHER AND MOTHER'S-TUTOR'S NAME

CODICE FISCALE
FISCAL CODE
RVLCHR97E44B519Z

ESTREMIATTO DI NASCITA
N.341 P.1 S.A anno 1997

INDIRIZZO DI RESIDENZA / *RESIDENCE*
STRADA GUADO DELLA STRETTA,9 RICCIA (CB)

C<ITACA75279ER1<<<<<<<<<<<<<<<
9705043F3005040ITA<<<<<<<<<<<4
RIVELLINO<<CHIARA<<<<<<<<<<<<<