GEOMATICS, NATURAL HAZARDS AND RISK, 2017
https://doi.org/10.1080/19475705.2017.1315619

Taylor & Francis
Taylor & Francis Group

PREFACE

OPEN ACCESS Check for updates

Use of unmanned aerial vehicles in monitoring application and management of natural hazards

D. Giordan [a], A. Manconi[b], F. Remondino[c] and F. Nex[d]

[a]CNR IRPI, Torino, Italy; [b]Department of Earth Sciences, Swiss Federal Institute of Technology, Zurich, Switzerland; [c]3D Optical Metrology (3DOM) Unit, Bruno Kessler Foundation (FBK), Trento, Italy; [d]Department of Earth Observation Sciences, ITC Faculty, University of Twente, Enschede, The Netherlands

ABSTRACT
The recent development of unmanned aerial vehicles (UAVs) has been increasing the number of technical solutions that can be used to monitor and map the effects of natural hazards. UAVs are generally cheaper and more versatile than traditional remote-sensing techniques, and they can be therefore considered as a good alternative for the acquisition of imagery and other physical parameters before, during and after a natural hazard event. This is an important added value especially for investigations over small areas (few km^2). In the special issue 'The use of Unmanned Aerial Vehicles in monitoring application and management of natural hazards', we collected a number of case studies, aiming at providing a range of applications of monitoring and management of natural hazards assessed through the use of UAVs.

ARTICLE HISTORY
Received 20 March 2017
Accepted 1 April 2017

KEYWORDS
Unmanned aerial vehicles; natural hazards; pre- and post-emergency activities; search and rescue; monitoring systems; structure from motion

1. Introduction

In recent times, the use of spaceborne and airborne remote-sensing data has become a common practice to study natural hazards. This evolution has been mainly triggered by the increased availability of up-to-date imagery, as well as by the development in geospatial technologies (Joyce et al. 2009; Remondino 2011). These data have demonstrated to play an important role in the investigation of catastrophic natural events such as floods, earthquakes, landslides, subsidence, etc. The different acquisition modes and the capability to obtain high spatial and temporal resolutions allow deriving detailed information on landscape evolution over wide areas, and are an effective and complementary tool to field investigations.

In this context, unmanned aerial vehicles (UAVs) offer unprecedented spatial resolution and new mapping opportunities at local scales (Boccardo et al. 2015), where the survey covers few square kilometres and the use of aerial or satellite platforms could be considered too expensive. In addition, UAVs present various advantages, including: (1) the ability to fly at low altitudes (less than 150 m above ground level), (2) the ability to reach remote locations and capturing high resolution images, (3) the capability to host different sensors (cameras, laser scanners, navigation/inertial sensors, etc.), (4) the possibility to acquire imagery with different angles and (5) the flexibility of carrying out small, medium and large scale monitoring operations. Also for these reasons, UAV platforms are commonly used for assistance and management of emergencies. For example, UAVs can rapidly provide information on collapsed buildings after an earthquake, help to evaluate structural damages

CONTACT D. Giordan daniele.giordan@irpi.cnr.it

and to perform early impact assessments (Murphy et al. 2008; Pratt et al. 2009; Chou et al. 2010; Molina et al. 2012).

This special issue is a collection of the contributions presented during a session hosted at the European Geoscience Union meeting in 2015. Several applications of UAVs in natural hazard contexts are presented, following three main phases of the hazard documentation and monitoring: pre- and post-event data acquisition, emergency support and monitoring. The articles focus on: (1) data acquisition of pre- and post-environmental/geomorphological events; (2) operational support during emergencies due to a catastrophic event and (3) monitoring of damages in critical infrastructures.

2. Acquisition of pre- and post-event data-set

As previously mentioned, one of the most useful characteristic of UAVs is the possibility to acquire on demand a data-set of a limited area (Koeva et al. 2016). This is particularly relevant when these systems are adopted to gain valuable information over a particular environment and/or geomorphological process. In geohazards, the effects of the evolution of a geological/geomorphological process can be often achieved by the comparison of pre- and post-event information in the study area. In the past, this approach was often supported by the use of terrestrial (e.g. Baldo et al. 2009 and references therein) or airborne LiDAR (e.g. Nissen et al. 2012 and references therein), but the introduction of UAV represents nowadays a valuable alternative for a multi-temporal acquisition of data-sets that can be used for the study of natural hazards. In this special issue, several applications in the field of geological mapping are presented and discussed focusing on the fractures' identification of marble quarries (Salvini et al. 2016), the geological mapping of mountain areas (Piras et al. 2016) and the identification of interseismic shallow deformations (Deffontaines et al. 2016). Hydrogeological applications are instead related to the identification of subfluvial springs (Aicardi et al. 2016), measurements of open channel water surface velocities (Bolognesi et al. 2016) and measurement of flushed sediment in a reservoir (Pagliari et al. 2016).

3. Support during emergencies

The second typology of applications considered in this special issue is the use of UAV during emergencies. The use of these systems for supporting the management of emergencies can be critical particularly when the meteorological conditions are unfavourable. In this special issue, an application of UAVs for search and rescue operations for missing people in a natural environment (Jurecka & Niedzielski 2016) and a multipurpose UAV for mountain rescue operations (Silvagni et al. 2016) are presented. Jurecka and Niedzielski (2016) demonstrate that the use of UAVs for quick and reliable localization of lost persons in natural areas is a suitable approach. The application is based on the concept of a crow's flight distance travelled by a lost person and its probability distribution. Instead, Silvagni et al. (2016) present a multi-rotors flying platform and its embedded avionics designed to meet environmental requirements for mountainous terrain such as low temperatures, high altitude and strong winds. The system is able to host different payloads (separately or together) such as: (1) avalanche beacon (i.e. the ARTVA) with automatic signal recognition and path following algorithms for the rapid location of snow-covered body; (ii) cameras (visible and thermal) for search and rescue of missing persons on snow and in woods during day or night light conditions.

4. Monitoring damages of infrastructures

The last typology of applications considered is the use of UAV to monitor damage at infrastructures. The use of UAV for 3D reconstruction of anthropic structures, and in particular for monuments, represent the first applications developed and published during the last decade (Çabuk et al. 2007; Lambers et al. 2007; Sauerbier & Eisenbeiss 2010; Remondino et al. 2011). In this special issue, Dominici et al. (2016) presented their experience after L'Aquila earthquake (occurred in central Italy in 2009), by considering the identification and evaluation of damages of several historical settlements. Another case study is presented by Lazzari and Gioia (2017) and refers to the study of the effects of gravitational processes on the Uggiano castle, a highly degraded medieval archaeological site located in Basilicata (southern Italy).

5. Conclusion

The aim of this special issue is to present, through different case studies, different UAV-based methodologies in operative conditions for the assessment and monitoring of natural hazard scenarios and effects. Three main phases have been considered in the reported articles, where UAVs support the documentation and management of natural hazards: pre- and post-event data acquisition, emergency support and monitoring. Existing approaches are very promising and many researchers are continuously developing innovative solutions in this direction.

Acknowledgments

We would like to thank referees who helped us to improve the quality of the published papers. We would also like to extend our thanks to the editor for his continued support, as well as his important contribution in the submission and revision process. Special thanks to all the Taylor and Francis staff who made the publication of this special issue possible.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

D. Giordan http://orcid.org/0000-0003-0136-2436

References

Aicardi I, Chiabrando F, Lingua A, Noardo F, Piras M, Vigna B. 2016. A methodology for acquisition and processing of thermal data acquired by UAVs: a test about subfluvial springs' investigations. Geomat Nat Haz Risk. 13.

Baldo M, Bicocchi C, Chiocchini U, Giordan D, Lollino G. 2009. LIDAR monitoring of mass wasting processes: the Radicofani landslide, province of Siena, central Italy. Gemorphology. 105:193–201.

Boccardo P, Chiabrando F, Dutto F, Tonolo FG, Lingua A. 2015. UAV deployment exercise for mapping purposes: evaluation of emergency response applications. Sensors: 15:15717–15737.

Bolognesi M, Farina G, Alvisi S, Franchini M, Pellegrinelli A, Russo P. 2016. Measurement of surface velocity in open channels using a lightweight remotely piloted aircraft system. Geomat Nat Haz Risk. 14. Available from: http://dx.doi.org/10.1080/19475705.2016.1184717

Çabuk A, Deveci A, Ergincan F. 2007. Improving heritage documentation. GIM International. 21:1–2.

Chou TY, Yeh ML, Chen Y, Chen YH. 2010. Disaster monitoring and management by the unmanned aerial vehicle technology. In: Wagner W, Székely B, editors. ISPRS TC VII Symposium – 100 Years ISPRS. Vienna: International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences; p. 137–142.

Deffontaines B, Chang KJ, Champenois J, Fruneau B, Pathier E, Hu JC, Lu ST, Liu YC. 2016. Active interseismic shallow deformation of the Pingting terraces (longitudinal valley – eastern Taiwan) from UAV high-resolution topographic data combined with InSAR time series. Geomat Nat Haz Risk. 17. Available from: https://doi.org/10.1080/19475705.2016.1181678

Dominici D, Alicandro M, Massimi V. 2016. UAV photogrammetry in the post-earthquake scenario: case studies in L'Aquila. Geomat Nat Haz Risk. 17.

Jurecka M, Niedzielski T. 2016. A procedure for delineating a search region in the UAV-based SAR activities. Geomat Nat Haz Risk. 17.

Joyce KE, Belliss SE, Samsonov SV, McNeill SJ, Glassey PJ. 2009. A review of the status of satellite remote sensing and image processing techniques for mapping natural hazards and disasters. Progr Phys Geogr. 33:183–207.

Koeva M, Muneza M, Gevaert C, Gerke M, Nex F. 2016. Using UAVs for map creation and updating. A case study in Rwanda. Surv Rev. 1–14. doi: dx.doi.org/10.1080/00396265.2016.1268756

Lambers K, Eisenbeiss H, Sauerbier M, Kupferschmidt D, Gaisecker Th, Sotoodeh S, Hanusch Th. 2007. Combining photogrammetry and laser scanning for the recording and modelling of the late intermediate period site of Pinchango Alto, Palpa, Peru. J Archaeol Sci. 34:1702–1712.

Lazzari M, Gioia D. 2017. UAV images and historical aerial-photos for geomorphological analysis and hillslope evolution of the Uggiano medieval archaeological site (Basilicata, southern Italy). Geomatics, Natural Hazards and Risk, in press.

Molina P, Colomina I, Vitoria T, Silva PF, Skaloud J, Kornus W, Prades R, Aguilera C. 2012. Searching lost people with UAVs: the system and results of the close-search project. Int Arch Photogr Remote Sens Spat Inf Sci. 39:441–446.

Murphy RR, Steimle E, Griffin C, Cullins C, Hall M, Pratt K. 2008. Cooperative use of unmanned sea surface and micro aerial vehicles at Hurricane Wilma. J Field Robot. 25:164–180.

Nissen E, Krishnan AK, Arrowsmith R, Saripalli S. 2012. Three-dimensional surface displacement and rotations from differencing pre- and post-earthquake LiDAR pointclouds. Geophys Res Lett. 39:L16301.

Pagliari D, Rossi L, Passoni D, Pinto L, De Michele C, Avanzi F. 2016. Measuring the volume of flushed sediments in a reservoir using multi-temporal images acquired with UAS. Geomatics, Natural Hazards and Risk. doi: 10.1080/19475705.2016.1188423

Piras M, Taddia G, Forno MG, Gattiglio, Aicardi I, Dabove P, Lo Russo S, Lingua A., 2016 Detailed geological mapping in mountain areas using an unmanned aerial vehicle: application to the Rodoretto Valley, NW Italian Alps. Geomat Nat Haz Risk.

Pratt KS, Murphy R, Stover S, Griffin C. 2009. Conops and autonomy recommendations for VTOL small unmanned aerial system based on Hurricane Katrina operations. J Field Robot. 26:636–650.

Remondino F, Barazzetti L, Nex F, Scaioni M, Sarazzi D. 2011. UAV photogrammetry for mapping and 3d modeling – current status and future perspectives. In: Eisenbeiss H, Kunz M, Ingensand H, editors. Proceedings of the ISPRS ICWG I/V UAV-g (Unmanned Aerial Vehicle in Geomatics) Conference. Zurich: International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences; p. 25–31.

Remondino F. 2011. Heritage recording and 3D modeling with photogrammetry and 3D scanning. Remote Sens. 3:1104–1138.

Salvini R, Mastrorocco G, Seddaiu M, Rossi D, Vanneschi C. 2016. The use of an unmanned aerial vehicle for fracture mapping within a marble quarry (Carrara, Italy): photogrammetry and discrete fracture network modelling. Geomat Nat Haz Risk. 19.

Sauerbier M, Eisenbeiss H. 2010. UAVs for the documentation of archaeological excavations. In: Mills JP, Barber DM, Miller PE, Newton I, editors. Proceedings of Part 5 Commission V Symposium. Newcastle upon Tyne: International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences; p. 526–531.

Silvagni M, Tonoli A, Zenerino E, Chiaberge M. 2016. Multipurpose UAV for search and rescue operations in mountain avalanche events. Geomat Nat Haz Risk. 16.