6th Intercontinental Geoinformation Days

igd.mersin.edu.tr

Generating a thermal index map with unmanned aerial vehicles (UAVs) with thermal sensors

Yunus Kaya*[1], Abdulkadir Memduhoğlu [1] Nizar Polat [1]

[1]Harran University, Faculty of Engineering, Department of Geomatics Engineering, Şanlıurfa, Türkiye

Keywords
UAV
Photogrammetry
Thermal camera
Index map

Abstract

Unmanned Aerial Vehicles (UAVs) are more advantageous than traditional methods in terms of high-resolution imaging, low cost, and time. With the thermal camera placed on the UAV, the temperature reflectance values of large areas can be obtained more easily. This study produced a detailed thermal index map showing the potential of this approach with the preliminary applications using DJI Mavic 3 Pro T UAV at Harran University Osmanbey campus. Thermal index maps can be used to identify areas with different thermal properties and to detect environmental changes. Since the processing of thermal photographs does not yet allow for map production in terms of software, these images are processed with remote sensing and photogrammetric methods to obtain a thermal index map. This approach can also be used in many areas, such as urban planning, building energy efficiency assessments, and agriculture. This study investigated the effectiveness of UAVs with thermal cameras for mapping activities and many different application potentials, and preliminary results of thermal index map production studies conducted at Harran University Osmanbey campus were presented.

1. Introduction

The increasing focus on sustainable development and climate protection highlights the important role of cities in promoting energy efficiency and empowerment strategies. To achieve these goals, it is necessary to determine and analyze the thermal quality of existing structures, especially at the regional scale. The New Urban Agenda, announced by the United Nations in 2016, highlights the key role of cities in promoting sustainable development and climate protection in the building sector (UN, 2017).

Classical thermography studies examining the thermal conditions of large areas use handheld cameras at eye level to obtain high-quality thermographic images (Lucchi, 2018). However, terrestrial thermography cameras provide disadvantages in terms of time and cost in cases where many buildings at various heights and large areas need to be studied. In addition, components of buildings, such as roofs and upper floors, cannot be perceived by terrestrial methods.

Aerial photogrammetry allows us to create digital products in a short time. (Alptekin, A., & Yakar, M. (2021)Unmanned Aerial Vehicles (UAVs) have become practical imaging tools that have recently become widespread and used in many studies.(Yakar, M., & Doğan, Y. (2017), Alptekin, A., & Yakar, M. (2020).Advances in unmanned aerial vehicle (UAV) technologies have made it easier to model engineering projects Alptekin, A. & Yakar, M. (2020).In many projects The orthophoto of the region was created by unmanned aerial vehicle(Kusak et all. 2021, Yakar, M., & Doğan, Y. (2017). The UAV photogrammetry method was used to create the 3D point data and solid model (Karatas, et. al. 2022, Yakar, M., & Kocaman, (2018).

UAVs, which have found their place in many areas of use in the recent past, are also successfully used in ground observation applications, including energy transmission lines (Hartmut et al., 2020), gas and oil pipelines (Rathinam et al., 2005), agriculture (Honkavaara et al., 2013) and bridges (Metni and Hamel, 2007). Thanks to their small size, multi-rotor UAVs can move freely in the air, be easily controlled, and be easily used in many places. In addition, different sensors placed on the UAV allow more information to be collected. (Alptekin et al., 2019, Kanun et al., 2021, Şasi and Yakar (2017). While systems such as GPS and IMU placed in the UAV system ensure the correct positioning of the data obtained from the UAV, data in different formats can be

* **Corresponding Author**

*(yunuskaya@harran.edu.tr) ORCID ID 0000-0003-2319-4998
(akadirm@harran.edu.tr) ORCID ID 0000-0002-9072-869X
(nizarpolat@harran.edu.tr) ORCID ID 0000-0002-6061-7796

Cite this study

Kaya Y, Memduhoğlu A & Polat N (2023). Generating a thermal index map with unmanned aerial vehicles (UAVs) with thermal sensors. 7th Intercontinental Geoinformation Days (IGD), 6, 134-137, Baku, Azerbaijan.

collected thanks to the red, green, and blue camera (RGB), multispectral sensors, and thermal sensors.

Although various kinds of research are trying to determine the thermal values in large areas and building inspections (Vollmer and Möllmann, 2010) through thermal UAV images, there are gaps in the literature regarding the processing of thermal UAV data. This study created a detailed thermal index map showing the potential of thermal UAV data by making a sample application at Harran University Osmanbey campus. In order to determine the areas with different thermal properties and to detect environmental changes, the thermal data obtained from the UAV data were evaluated by remote sensing and photogrammetry methods, and a thermal index map was created.

2. Method and Application

DJI Mavic 3 Pro T was equipped with a thermal camera to determine the temperature difference on different surfaces, such as water, vegetation, shade, and soil in the study area. Before the aerial inspection, a visual survey was performed to determine flight height relative to observed building heights to plan a crash-safe flight mission. The mission was carried out as a planned flight with the help of Pix4D Capture software. The measurement was done at 10:00 on 15 May 2023 in one go. The aerial survey was conducted with a UAV equipped with a thermal and RGB camera that captured 4682 images (2341 thermal and 2341 RGB images). The flight altitude was 40 meters from the take-off point, and the overlap rate was 90%. The area of 4.8 hectares was measured in approximately 35 minutes. Although there is a temperature scale on the photographs taken from UAV, images can be exported in 0-255 radiometric scale. In order to transfer the temperature values read from the photographs to the orthophoto, the minimum, and maximum temperature values were determined using an experimental method. A radiometric scale from 0-255 was converted to minimum and maximum temperature values with linear contrast stretch. As a result of the study, the values obtained from the orthomosaic and the values obtained from the source photographs were compared. The flow chart of the study is given in Figure 1.

3. Results and Discussion

RGB and thermal data obtained from the UAV flight were used to examine the temperature reflectance values of areas with different characteristics on the campus. First, orthomosaic was produced by the photogrammetric process (Figure 2).

Although there is a temperature scale on the photos taken from UAV, images can be exported in 0-255 radiometric scale. For this reason, the temperature information cannot be read on the produced orthomosaic. In order to eliminate this uncertainty, the minimum and maximum temperature values in the orthomosaic were determined with samples taken from different points in the orthomosaic. For this, the minimum (16.9 °C) and maximum (52.7 °C) temperature values in the study area were determined empirically via DJI Thermal Analysis Tool. 0-255 values were converted to 16.9-52.7 values by applying linear contrast stretch. In order to determine the difference between the temperature information read on the orthomosaic and the temperature information read on the photo, samples from the green area, water, and shadow areas were compared (Table 1). The temperature values in the orthomosaic were determined from the ENVI software, and the temperature values on the photo were determined from the DJI Thermal Analysis Tool.

When Table 1 is examined, it is seen that the temperature difference is higher on the water surfaces. The temperature difference between the two data in the green area is the least. Reflection, sun exposure time, and angle will affect the results.

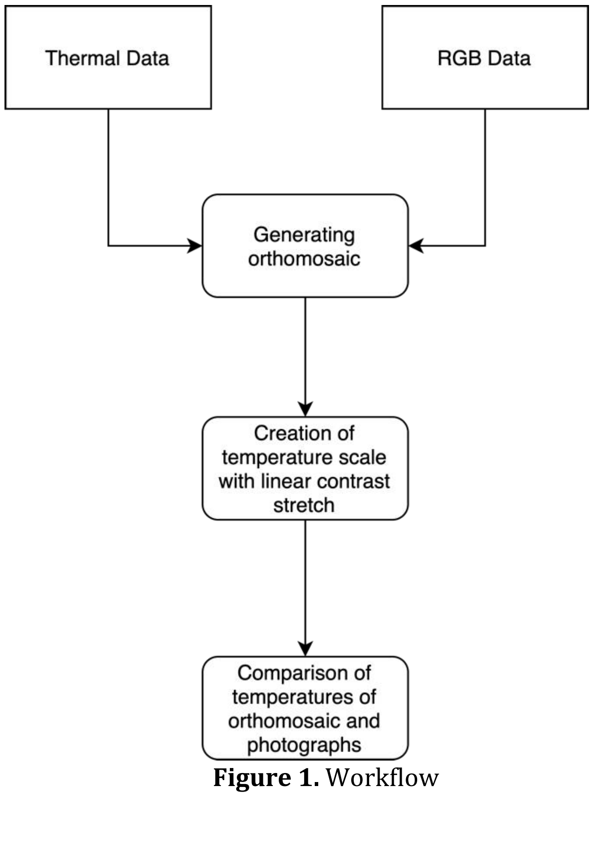

Figure 1. Workflow

Table 1. Orthomosaic and photographic temperature differences on different surface types

Surface Type	Temperature value in orthomosaic (°C)	Temperature value in the photo (°C)	Difference (°C)
Water (Lake)	19,8	21,2	1,4
Vegetation	20,2	20,3	0,1
Shadow	19,8	19,0	0,8

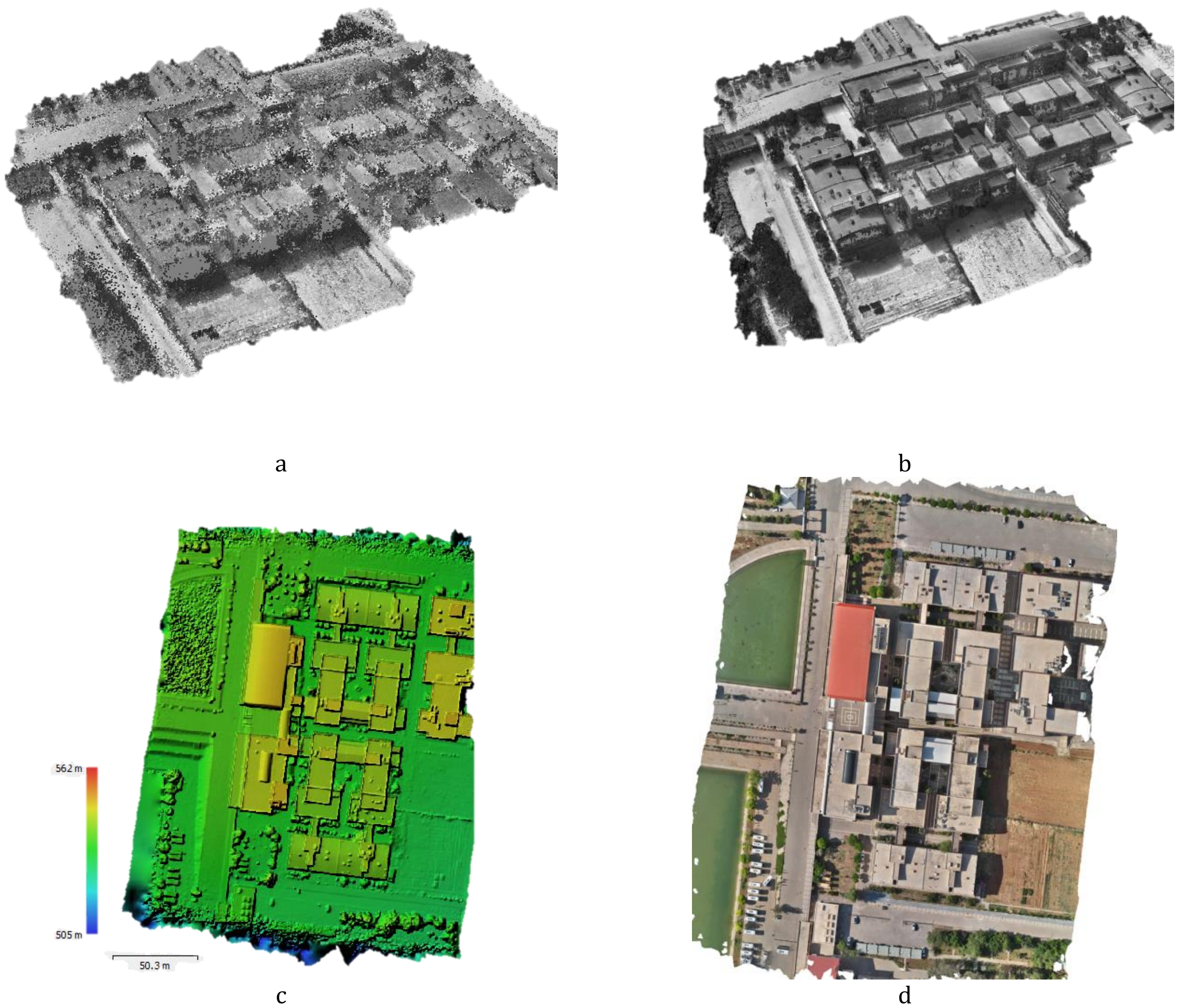

Figure 2. a) Point cloud, b) Dense point cloud, c) Digital Elevation Model, d) Orthomosaic

4. Conclusion

This study presents a method and application example for generating thermal index maps from UAV data with the thermal camera. It is unknown whether the negative aspects of the method used in the study are the same as the point determined on orthomosaic and the photo point used in orthomosaic production. In addition, among the study's shortcomings, it was not determined how much the photo shooting hours would affect the temperature. In future studies, the data obtained at different times of the day will be compared on different surface types, and a more comprehensive analysis will be carried out.

References

Alptekin, A., & Yakar, M. (2020). Determination of pond volume with using an unmanned aerial vehicle. *Mersin photogrammetry journal*, *2*(2), 59-63.

Alptekin, A., & Yakar, M. (2020). Heyelan bölgesinin İHA kullanarak modellenmesi. Türkiye İnsansız Hava Araçları Dergisi, 2(1), 17-21.

Alptekin, A., & Yakar, M. (2021). 3D model of Üçayak Ruins obtained from point clouds. Mersin Photogrammetry Journal, 3(2), 37-40.

Alptekin, A., Çelik, M. Ö., Doğan, Y., & Yakar, M. (2019). Mapping of a rockfall site with an unmanned aerial vehicle. Mersin Photogrammetry Journal, 1(1), 12-16.

Honkavaara, E., Saari, H., Kaivosoja, J., Pölönen, I., Hakala, T., Litkey, P., Mäkynen, J., & Pesonen, L. (2013). Processing and Assessment of Spectrometric, Stereoscopic Imagery Collected Using a Lightweight UAV Spectral Camera for Precision Agriculture. Remote Sensing, 5, 5006–5039.

Kanun, E., Alptekin, A., & Yakar, M. (2021). Cultural heritage modelling using UAV photogrammetric methods: a case study of Kanlıdivane archeological site. Advanced UAV, 1(1), 24-33.

Kanun, E., Alptekin, A., Karataş, L., & Yakar, M. (2022). The use of UAV photogrammetry in modeling ancient structures: A case study of "Kanytellis". *Advanced UAV*, *2*(2), 41-50.

Karataş, L., Alptekin, A., & Yakar, M. (2022). Detection and documentation of stone material deterioration in historical masonry structures using UAV photogrammetry: A case study of Mersin Aba Mausoleum. *Advanced UAV*, *2*(2), 51-64.

Karataş, L., Alptekin, A., Kanun, E., & Yakar, M. (2022). Tarihi kârgir yapılarda taş malzeme bozulmalarının İHA fotogrametrisi kullanarak tespiti ve belgelenmesi: Mersin Kanlıdivane ören yeri vaka çalışması. İçel Dergisi, 2(2), 41-49.

Kusak, L., Unel, F. B., Alptekin, A., Celik, M. O., & Yakar, M. (2021). Apriori association rule and K-means clustering algorithms for interpretation of pre-event landslide areas and landslide inventory mapping. Open Geosciences, 13(1), 1226-1244.

Lucchi, E. (2018). Applications of the infrared thermography in the energy audit of buildings: a review. Renewable and Sustainable Energy Reviews, 82, 3077–3090. doi: 10.1016/j.rser.2017.10.031.

Metni, N., & Hamel, T. (2007). A UAV for bridge inspection: Visual servoing control law with orientation limits. *Automation in construction*, *17*(1), 3-10.

Mirdan, O., & Yakar, M. (2017). Tarihi eserlerin İnsansız Hava Aracı ile modellenmesinde karşılaşılan sorunlar. *Geomatik*, *2*(3), 118-125.

Mohammed, O., & Yakar, M. (2016). Yersel fotogrametrik yöntem ile ibadethanelerin modellenmesi. *Selçuk-Teknik Dergisi*, *15*(2), 85-95.

Rathinam, S., Kim, Z., Soghikian, A., & Sengupta, R. (2005). Vision-Based Following of Locally Linear Structures using an Unmanned Aerial Vehicle. 44th IEEE Conference on Decision and Control, Seville, Spain, 15 December 2005, 6085–6090.

Surmann, H., Holz, D., Blumenthal, S., Linder, T., Molitor, P., & Tretyakov, V. (2008). Teleoperated visual inspection and surveillance with unmanned ground and aerial vehicles. *International Journal of Online and Biomedical Engineering*, *4*(4), 26-38.

Şasi, A., & Yakar, M. (2017). Photogrammetric modelling of sakahane masjid using an unmanned aerial vehicle. *Turkish Journal of Engineering*, *1*(2), 82-87.

UN. (2017). New urban agenda United Nations Conf. on Housing and Sustainable Urban Development (Quito, Ecuador). ISBN: 978-92-1-132731-1

Ünel, F. B., Kuşak, L., Çelik, M., Alptekin, A., & Yakar, M. (2020). Kıyı çizgisinin belirlenerek mülkiyet durumunun incelenmesi. *Türkiye Arazi Yönetimi Dergisi*, *2*(1), 33-40.

Villi, O., & Yakar, M. (2022). İnsansız Hava Araçlarının Kullanım Alanları ve Sensör Tipleri. *Türkiye İnsansız Hava Araçları Dergisi*, *4*(2), 73-100.

Vollmer, M., & Möllmann, K. P. (2010) Infrared Thermal Imaging (Weinheim, Germany: Wiley– VCH). ISBN: 978-3-527-41351-5.

Yakar, M., & Dogan, Y. (2019). 3D Reconstruction of Residential Areas with SfM Photogrammetry. In *Advances in Remote Sensing and Geo Informatics Applications: Proceedings of the 1st Springer Conference of the Arabian Journal of Geosciences (CAJG-1), Tunisia 2018* (pp. 73-75). Springer International Publishing.

Yakar, M., & Doğan, Y. (2017). Mersin Silifke Mezgit Kale Anıt Mezarı fotogrametrik rölöve alımı ve üç boyutlu modelleme çalışması. *Geomatik*, *2*(1), 11-17.

Yakar, M., & Doğan, Y. (2017). Uzuncaburç Antik Kentinin İHA Kullanılarak Eğik Fotogrametri Yöntemiyle Üç Boyutlu Modellenmesi. 16. Türkiye Harita Bilimsel ve Teknik Kurultayı. TMMOB Harita ve Kadastro Mühendisleri Odası, Ankara.

Yakar, M., & Kocaman, E. (2018). Kayseri-Sahabiye Medresesi 3-boyutlu modelleme çalışması ve animasyonu. *International Journal of Engineering Research and Development*, *10*(1), 133-138.

.