ULST Timisoara
Multidisciplinary Conference on Sustainable Development
21-22 May 2026

RESEARCH ON DIGITAL TERRAIN MODELING AND MORPHOMETRIC ANALYSIS THROUGH TOPOGRAPHIC, GNSS AND UAV DATA INTEGRATION USING GIS TECHNIQUES

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Introduction

The paper presents a modern approach to digital terrain modeling and morphometric analysis by integrating data from classical topographic measurements, GNSS determinations and aerial images obtained using unmanned aerial vehicles (UAVs). The study is based on real data collected in the field, supplemented with information resulting from the processing of aerial images using photogrammetry techniques. The dataset used included points with three-dimensional coordinates (X,Y,Z), determined by GNSS measurements, as well as aerial images used for the three-dimensional reconstruction of the terrain surface. Image processing was performed using Structure from Motion (SfM) methods, resulting in a dense point cloud and a detailed three-dimensional model. The integration of data from different sources allowed the generation of a high-resolution digital terrain model (DTM), based on which morphometric parameters such as slope, level differences and water runoff directions were analyzed.

Material and method

The study was conducted within the "King Mihai I" University of Life Sciences in Timișoara, on an area located within the university campus. The analyzed area is characterized by a mixed use, including concrete platforms, alleys, parking lots and green spaces, being representative for topographic and cadastral applications in the urban environment. From a geomorphological point of view, the terrain presents reduced altimetric variations, specific to plain areas, but sufficient to highlight the differences in level and their influence on water runoff and land use. This type of relief is frequently encountered in agricultural and urban applications, where even small differences in level can have a significant impact. The integration of data from GNSS measurements and UAV images allowed obtaining a digital terrain model with a high degree of detail and accuracy.

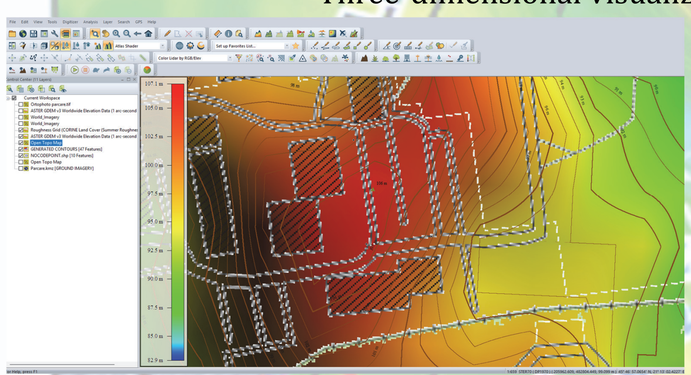
Result and discussions

Following the processing of data from GNSS measurements and UAV aerial images, a three-dimensional model of the analyzed area, located within the parking lot of the university campus, was obtained. The integration of data from different sources allowed obtaining a digital terrain model characterized by a high degree of detail and good positional accuracy.

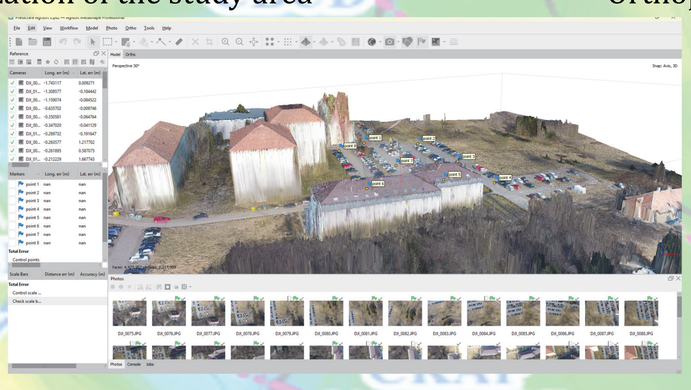
Three-dimensional visualization of the study area

Based on the aerial images captured with the UAV, an orthophotomap of the analyzed area was generated, shown in the following figure.

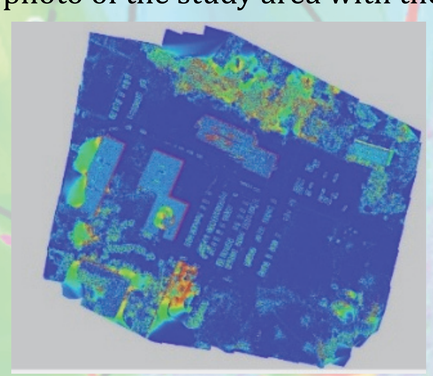
Orthophoto of the study area with the location of GNSS points



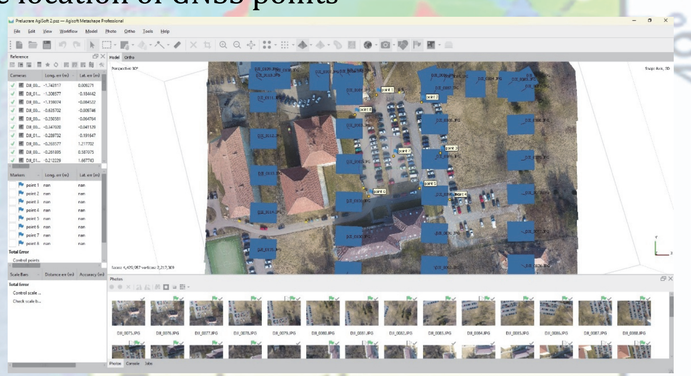
Digital terrain model generated in the GIS environment using the Global Mapper application



Three-dimensional surface model obtained by processing UAV images



Analysis of texturing quality and image coverage (UV Mapping)



Configuration of images and checkpoints in the SfM process

Conclusions

The integration of data from GNSS measurements with those resulting from aerial image processing led to a significant densification of the points and a more faithful representation of the analyzed surface. The determined level difference (≈ 0.18 m) confirms the relatively flat nature of the studied area, but also highlights the existence of some microvariations relevant for the analysis of water behavior at the ground level. The analysis of the residuals obtained in the photogrammetric reconstruction process indicates a good consistency of the model, with most of the values being located in small intervals, which confirms the stability and correctness of the adjustment. Also, the use of SfM techniques allowed the generation of a detailed three-dimensional model, suitable for practical applications. The results of the morphometric analysis highlighted low slope values (below 2%), as well as the existence of water accumulation areas, important aspects in the context of land use and the design of development works.

Acknowledgement: This research work was carried out with the support of GEOMATICS RESEARCH LABORATORY infrastructure, https://erris.gov.ro/LABORATOR- CERCETARE GEOMATICA, BIORESOURCES, ENVIRONMENT AND GEOSPATIAL DATA CENTER from BUASMV "King Michael I of Romania" Timisoara - Faculty of Agriculture. BIORESOURCES