



Prospects of Applying Modern Technology in Rock Art Studies (3D Scanning and GNSS Positioning)

L.ABTAR Qadda

*Laboratory of Archaeological Heritage and its
Valorization, University of Tlemcen, Algeria*

*qadda.labtar@univ-tlemcen.dz
<https://orcid.org/0009-0004-7370-3222>*

Abstract ;

The use of modern technology in the study of prehistoric rock art sites represents a quantum leap in the field of archaeology and heritage. Among the modern technologies used are 3D scanning (BLK360) and global navigation satellite system (GNSS) technologies, which have been combined in this research. These technologies allow rock carvings to be recorded accurately and realistically, helping to preserve them from damage or loss. 3D scanning produces high-precision digital models that show the finest details in what is known as a digital twin, while the advanced GNSS system contributes to locating inscriptions with high geographical accuracy. These tools facilitate the analysis and comparison of archaeological sites, enhance our understanding of rock art history and the culture of ancient peoples, and contribute to facilitating data sharing with researchers around the world and promoting efforts to preserve human heritage digitally. Through this study, we will attempt to provide a comprehensive overview of the subject, highlighting the practical and scientific benefits of using modern technology in this field and discussing the possibility and means of integrating such technologies into the study of prehistoric sites, particularly rock art sites.

Article info

*Received
July 30;2025
Accepted
September 10;2025*

Keyword:

- ✓ modern technology
- ✓ 3D scanning
- ✓ GNSS
- ✓ prehistoric rock art
- ✓ digital twin

1. Introduction:

In view of the rapid technological developments of our time, there is an urgent need to use modern technologies to document and preserve human cultural heritage, particularly prehistoric rock art, which bears witness to the antiquity of human civilisations and their interaction with their surroundings across vast geographical areas, including the western part of the Algerian desert.

The study of rock art is of great importance in understanding human cultural development, especially in a period shrouded in mystery due to the absence of written records, as rock engravings and drawings are a rich source of information about the beliefs, rituals and lifestyles of ancient times. However, these archaeological remains face significant challenges in the form of natural erosion and human impact, which threaten to destroy them forever.

In this context, this research explores the potential for integrating 3D scanning (BLK360) and the Global Navigation Satellite System (GNSS) in documenting prehistoric rock art. These advanced technologies enable the accurate and comprehensive documentation of rock carvings and the creation of high-precision 3D digital models, with extremely accurate geographical positioning. In light of the above, we raise a number of questions, the most important of which are: What are these digital technologies? What are their potential and possible uses in rock art sites in southern Algeria?

This study aims to highlight the practical aspects of these technologies and emphasise their role in promoting the digital preservation of rock art heritage, facilitating scientific analysis, and providing researchers around the world with access to this data and the opportunity to participate in its study. It also seeks to

provide a comprehensive overview of how these technologies can be used in the service of archaeological and heritage research.

2. Introducing the BLK360:

BLK360 G2 is a compact and high-performance imaging laser scanner, designed for professionals in the fields of surveying, construction, architecture and related fields is a small but very powerful digital device in performing tasks related to 3D surveying, working on Lidar (Light Détection and Ranging) technology to collect accurate data about the surrounding environment, allows creating 3D models of archaeological sites such as rock art, in addition to providing high-resolution panoramic images (Smith & Johnson, 2021, p 45), the device is generally intended for surveyors and engineers: To obtain fast and accurate surveys to document existing structures, as used by architects and construction professionals: To quickly capture locations for incorporation into BIM models.

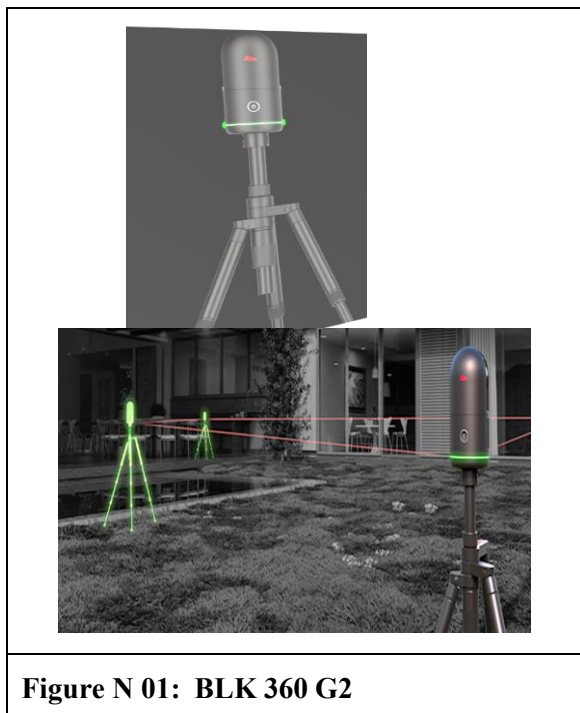


Figure N 01: BLK 360 G2

2.1. Key Features: BLK360 G2

3.1. Optimised speed and efficiency: Performing a range of optimised tasks, it

scans in just 20 seconds at 6mm resolution from 10 metres, and automatically pre-records surveys in situ.

3.2. High accuracy and wide scanning range: Range: Up to 45-60 metres in optimal visibility conditions, HDR imaging: (HDR) with a 360° panoramic image system with optimised dynamic range.

3.3. Compact and lightweight design: Weighs 1.1kg making it easy to carry, IP54 dust and water resistant

3.4. Enhanced connectivity and easier workflow: using Wi-Fi and Bluetooth for wireless control via the LEICA CYCLONE FIELD 360 app Available only for IOS.

- USB-C port for fast data transfer.
- Compatible with Leica Reality Cloud for cloud processing.

3.5. Excellence in a variety of applications: Ideal for Building Information Modelling (BIM), documentation of existing structures, facilities management and can be mounted on a tripod or stick for flexible scanning.

2.2. Software compatible with BLK 360:

- Leica Cyclone FIELD 360 for field recording.
- Leica Cyclone REGISTER 360 for computer processing.
- Autodesk ReCap, Revit and other BIM/CAD software

2.3.. The main disadvantages recorded on the device by specialists:

- Does not have a built-in GPS that requires manual registration or control points.
- The app is only available for the IOS operating system for iPhone, iPod Touch

and iPad, as it does not support Android Field Control for the rest of the devices.

3. Concept of Rock Art :

Rock art refers to the ancient drawings, paintings, and carvings created by humans on natural rock surfaces. This form of art has been produced for over 40,000 years and can be found in various locations worldwide, including caves, cliffs, and open landscapes. Rock art is categorized into three main types: petroglyphs (carvings), pictographs (paintings), and earth figures (large surface designs). These artworks often depict animals, human figures, and abstract symbols, reflecting the cultural and spiritual beliefs of the societies that created them.

The significance of rock art lies in its ability to provide insights into the lives and beliefs of prehistoric peoples. It serves as a vital connection to our past, revealing information about daily life, rituals, and the relationship between humans and their environment. However, many rock art sites face threats from natural erosion, climate change, and human activities, making preservation efforts essential to protect these invaluable cultural heritage sites for future generations.

4. 3D measurement and its importance for rock art sites:

The importance of 3D lifting for rock art sites can be summarized in the following points:

- Accurate documentation: Helps



Figure N 02: Leica Cyclone FIELD 360

<https://www.onepointsurvey.com/products/leica-cyclone-field-360>

permanently preserve the fine details of

rock drawings and engravings. (Anderson et al., 2019, p78).

- Cultural heritage protection: Digital models can be used to study the site without having to constantly visit the physical site, reducing the risk of damage (UNESCO, 2020, p12).
- Scientific analysis: 3D models provide data that can be analyzed to understand the artistic and cultural methods used by ancient humans (Roberts, 2018, p 234).
- Cultural promotion: These models can be used in museums or digital displays to introduce the public to rock art (Cultural Héritage Imaging, 2022, p56).

5. Definition of GNSS:

The system Global Navigation Satellite System (GNSS) is one of the most important technological innovations of the 21st century, providing accurate determination of locations and time anywhere on Earth (Hofmann-Wellenhof et al., 2008, p15). This system relies on a network of satellites, ground stations, and receivers, making it the cornerstone of many civilian and military applications. The system is based on the principle of triangulation (Leick et al., 2015, p67), The device receives signals from at least 3 satellites to measure the distance between it and each satellite. Using time and location data from satellites, the device calculates its location with an accuracy of up to a few meters (Langley, 1999, p123). Accuracy increases as signals are received from additional satellites (some devices receive from 10+ satellites).

5.1. GNSS system components:

- Space segment: It consists of a group of satellites (usually 24 or more satellites) orbiting in specific orbits around the Earth (Kaplan & Hegarty, 2017, p32). These satellites send signals containing exact location and time data.
- Ground segment: includes ground control stations that monitor and update satellite

orbits and correct any timing or data errors (Misra & Enge, 2011, p45). These stations ensure system accuracy by addressing deviations caused by factors such as the atmosphere.

- User part: includes receivers (such as smartphones, car navigation devices, and specialized devices as shown in the image below) (Parkinson et al., 1996, p78). These devices calculate location using satellite signals.



5.2. Main satellites in the GNSS system:

- **GPS** (US): Most widespread, operated by the US military, and provides global coverage (Spilker, 1996, p 112)
- **GLONASS** (Russia): An alternative GPS system, capable of operating in polar regions (Revnivkykh, 2018, p 56).
- **Galileo** (EU): A civilian system offering higher accuracy, designed to be independent of military systems (Hein et al., 2002, p 89).
- **BeiDou** (China): Covers the entire world since 2020, and is widely used in Asia (Yang et al., 2020, p 34).

6. Steps to use BLK360 to document rock art:

6.1. Field preparation:

Step 1: Site Selection: First we need to determine the location of the rock art that will be documented, and then ensure that the site is safe and easily accessible (Field Techniques in Archaeology, 2020, p 34).

Step 2: Determine the geographical location of the site using GCP observation points using the GNSS positioning system.

Ground Control Points (GCPs) are like fixed reference points on the ground that surveyors and mappers use to ensure that measurements and maps taken by drones or other mapping tools are accurate and match the real world.

They are kind of like the anchors that keep your map in the right place and prevent it from being distorted.

Think of them as the crucial dots on a giant grid, ensuring that the drone-collected data lines up with the real-world locations.

GCPs help us create precise maps and 3D models, and they also help us compare data collected at different times.

They are the foundation of accurate **mapping and surveying**, making sure everything is in the right place. (<https://www.jouav.com/blog/ground-control-points.html>)

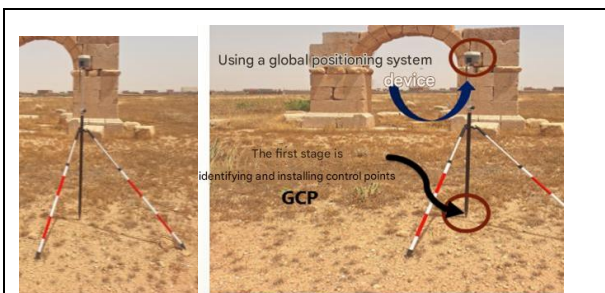


Figure N 04: Determining the geographical location of the site using GCP public observation points (by the researcher)

Step 3: The process goes through the following stages:

- Place the device on a tripod (Tripod) at a suitable point that covers as much of the site as possible.
- Ensure that the device is completely stable and horizontal (Leica Geosystems Manual, 2021, p12).
- Point Layout: If the site is large, we may need to select several points to place the

device at to ensure complete site coverage (Surveying Techniques Handbook, 2019, p 89).

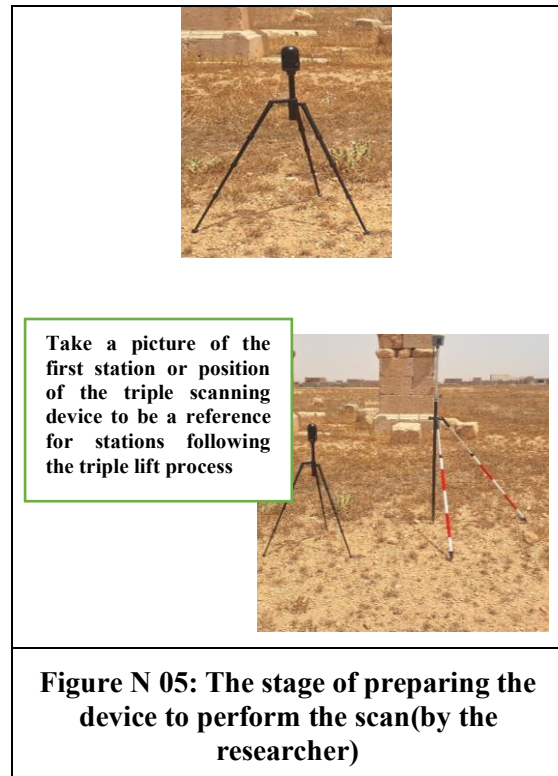


Figure N 05: The stage of preparing the device to perform the scan(by the researcher)

6.2. Field survey process: It goes through the following stages:

6.2.1. Device operation:

- We turn on the device and make sure it connects to its Leica Cyclone FIELD 360 app.
- We adjust the necessary settings such as scanning resolution and viewing angle (Leica BLK360 User Guide, 2020, p 25).

6.2.2. Scanning procedure:

The device emits laser beams to measure the distance between it and all surfaces within its range.

- Each survey takes approximately 3 minutes to collect data (Laser Scanning Applications in Archaeology, 2022, p 45).

6.2.3. Repeat the scanning process when needed:

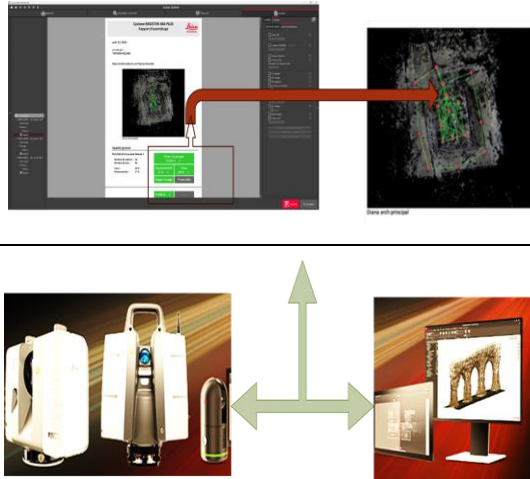
If the location is large or complex, we move the device to other locations and repeat the process (Advanced LiDAR Techniques, 2021, p 67).

6.3. Digital data processing and analysis:

6.3.1. Data Transfer:

After completing the survey, we transfer the data to a computer via special software such as Leica Cyclone REGISTER 360 (Data Processing for Archaeological Sites, 2021, p102).

Figure N 06: represents the data transfer process (by the researcher)



6.3.2. 3D Model Creation:

Using appropriate software, we combine data from all survey points to create an integrated 3D model of the site (D Modeling in Archaeology, 2020, p 56).

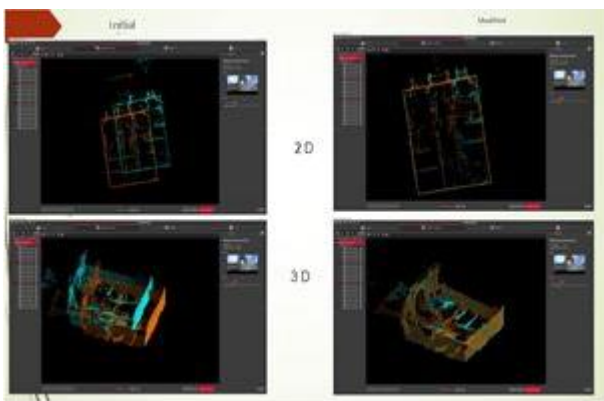


Figure N 07: 3D model preparation stage (by the researcher)

6.3.3. Model Analysis:

The model can be used to analyze fine details of drawings and engravings, such as line depth and angles (Archaeological Analysis Using 3D Models, 2019, p 78).

6.3.4. Add panoramic images manually if needed:

The device also takes high-resolution panoramic images that can be combined with the 3D model to provide additional visual details (Panoramic Imaging in Cultural Heritage, 2022, p34).

7. Advantages of using triple lifting with the device on rock art sites:

- **High resolution:** Provides very accurate location data (Precision in Archaeological Documentation, 2021, p 23).
- **Ease of use:** The device design is simple and easy to transport and operate (User-Friendly Technologies in Archaeology, 2020, p 45).
- **Speed:** Scanning can be performed quickly compared to traditional methods (Time Efficiency in Site Mapping, 2022, p67).
- **Cost:** Although the device is expensive, it offers significant value compared to other technologies (Cost-Benefit Analysis of LiDAR Systems, 2021, p 89).

8. Difficulties and obstacles in working with the BLK360:

- Difficulty accessing remote sites: Some rock art sites may be in hard-to-reach areas (Remote Site Challenges, 2020, p 12).
- The high cost of the device and associated software (Economic Aspects of Archaeological Technology, 2021, p34).
- Complex processing: Creating the final model may require significant time and effort (Complexity in Data Processing, 2022, p56).

9. Other applications of 3D scanning technology:

- The same technique can be used to document other archaeological sites such as ancient buildings, tombs, or historical sites (Applications of 3D Scanning in Archaeology, 2021, p78).

- 3D models can be used in virtual or augmented reality to deliver an educational and interactive experience (Virtual Reality in Cultural Heritage, 2022, p90).

10. Field examples of the application of triple lift to prehistoric sites:

A field example of the use of reflection photography on prehistoric sites is the work carried out by the Wadi al-Hudi expedition. Wadi al-Hudi is located in the Eastern Desert of Egypt, southeast of the city of Aswan. The valley was an important mining center in ancient times due to the unique geological formation of the area, as the region contains twelve archaeological sites dating back to the Paleolithic era (about 200,000 years ago). (<https://wadielhudiarabic.com/innovative-techniques/>)

The team used reflected ray imaging to document and record inscriptions found on the rocks surrounding the site and in the desert, in addition to those inscriptions found on artifacts and paintings found during archaeological surveys and excavations. Reflex imaging is a modern technology developed by the French Cultural Heritage Photography Foundation. It uses a series of images taken from the same perspective using different lighting angles. Next, the reflected ray imaging software creates a reflective model of the imaged surface.



Figure N 08: Wadi Al-Hudi website mission about:

<https://wadielhudiarabic.com/innovative-techniques>

It is almost the same system as working with 3D imaging, which gives a high probability of the success of this technique on rock art sites in southwestern Algeria.

We also mention, but are not limited to; The valuable study conducted on the Ain al-Naqa website in Djelfa, and prepared by researcher Ahman Fayza and Professor Sahid Tariq Aziz; Under the title:

Techniques de relevé des gravures rupestres, exemple: relevé 3D par photogrammétrie de la station de Ain Naga (région de Djelfa).

Published in Afak Science Magazine, Issue 3, Volume 9, 2024 (pages 603/620), the study highlighted the importance of using photogrammetry in field lifting of rock drawings and engravings from the Ain al-Naqa station and the positive results achieved. This is what makes us emphasize that the use of scanning and triple lifting techniques can value such studies and be generalized to all rock art sites from the prehistoric period.

11. Conclusion:

Using the BLK360 device to document rock art is an important step towards preserving cultural heritage in a scientific and modern way. The device provides unprecedented accuracy and speed in data collection, making it an indispensable tool for researchers and historians in the field of archaeology. However, good planning and adequate training are required to ensure the best results are achieved (Preservation of Rock Art through Modern Technology, 2021, p112).

The BLK360 is used to document rock art in high resolution through lidar scans and create 3D models that help preserve and scientifically analyze cultural heritage. (Smith & Johnson, 2021, p 45; Anderson et al., 2019, p78).

As a general result, the possibility of using 3D lidar lift and ground observation points (GCPs) for prehistoric rock art sites in

southwestern Algeria represents a very effective approach to documenting and analyzing these sites, and this methodology also provides several main advantages that can be limited to the following points:

- High-resolution documentation: LiDAR technology enables millimeter-level accuracy in recording petroglyphs, even on complex or eroded surfaces, especially when combined with GNSS-defined ground observation points. The data maintains its geospatial integrity, allowing for accurate mapping and long-term monitoring.

- Non-damaged preservation of these sites, as the contactless nature of lidar scanning protects fragile petroglyphs from physical damage.

- Create symmetric digital models (Digital Twins) for archiving and analysis and make them available virtually.

As for the challenges that could hinder the implementation of this system and that could be taken into account in the future:

- Harsh environmental conditions and desert terrain, which may require advanced equipment and careful planning of field work.

Cost and technical expertise remain barriers, but they are offset by long-term benefits for heritage preservation.

As for the targeted results and future applications, they can be summarized as we see in:

- Facilitating comparative studies of rock art styles and distributions in the region.
- Support AI-assisted analysis (such as pattern recognition) and enhance global research collaboration through shared digital data warehouses.

Image index :

1. Figure N 01: BLK 360 G2
2. Figure N 02: Leica Cyclone FIELD 360

3. Figure N 03: Examples of navigation devices for measuring ground coordinates

4. Figure N 04: Determining the geographical location of the site using GCP public observation points

5. Figure N 05: The stage of preparing the device to perform the scan

6. Figure N 06: represents the data transfer process

7. Figure N 07: 3D model preparation stage

8. Figure N 08: Wadi Al-Hudi website mission

Bibliography :

1. Advanced LiDAR Techniques. (2021). Multi-Site Mapping with LiDAR . Tech Archaeology Journal, pp. 67-72.

2. Ahman faiza ,Sahed tarek aziz, Techniques de relevé des gravures rupestres, exemple : relevé 3D par photogrammétrie de la station de Aïn Naga (région de Djelfa). Revue afak science asjp. V9.N 3. 2024 PP 603-620

3. Anderson, M., et al. (2019). Digital Preservation of Rock Art . Heritage Studies Journal, pp. 78-85.

4. Cultural Heritage Imaging. (2022). 3D Imaging in Museums . CHI Reports, pp. 56-62.

5. Dardari, D. et al. (2016). Satellite and Terrestrial Radio Positioning Techniques. Elsevier.

6. Data Processing for Archaeological Sites. (2021). From Raw Data to 3D Models . Archaeological Data Journal, pp. 102-108.

7. El-Rabbany, A. (2002). Introduction to GPS: The Global Positioning System. Artech House.

8. Field Techniques in Archaeology. (2020). Practical Guide to Archaeological Surveys . Archaeological Society, pp. 34-40.

9. Grewal, M. S., Weill, L. R., & Andrews, A. P. (2007). Global positioning systems, inertial navigation, and integration (2nd ed.). Wiley.

10. Hein, G. W., Avila-Rodriguez, J. A., & Wallner, S. (2002). Galileo frequency and signal design. GPS World, 14(6), 85-92.

- 11.Hofmann-Wellenhof, B., Lichtenegger, H., & Wasle, E. (2008). GNSS: Global navigation satellite systems (2nd ed.). Springer.
- 12.Kaplan, E. D., & Hegarty, C. J. (2017). Understanding GPS/GNSS: Principles and applications (3rd ed.). Artech House.
- 13.Klobuchar, J. A. (1987). Ionospheric time-delay algorithm for single-frequency GPS users. IEEE Transactions on Aerospace and Electronic Systems, AES-23(3), 325-331.
- 14.Langley, R. B. (1999). The mathematics of GPS. GPS World, 10(7), 45-50.
- 15.Laser Scanning Applications in Archaeology. (2022). Advances in LiDAR Technology . Archaeological Review, pp. 45-52.
- 16.Leica Geosystems Manual. (2021). BLK360 User Manual . Leica Publications, pp. 12-15.
- 17.Leick, A., Rapoport, L., & Tatarnikov, D. (2015). GPS satellite surveying (4th ed.). Wiley.
- 18.Misra, P., & Enge, P. (2011). Global positioning system: Signals, measurements, and performance (2nd ed.). Ganga-Jamuna Press.
- 19.Parkinson, B. W., Spilker, J. J., Axelrad, P., & Enge, P. (1996). Global positioning system: Theory and applications. American Institute of Aeronautics and Astronautics.
- 20.Pullen, S., Gao, G., & Tedeschi, C. (2009). GNSS jamming and the impact on maritime navigation. Journal of Navigation, 62(2), 173-187.
- 21.Revnivykh, S. (2018). GLONASS status and modernization. Proceedings of the 31st International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+ 2018), 1-12.
- 22.Rizos, C., Roberts, G., & Kealy, A. (2019). Next-generation GNSS: Evolution and disruption. In Geospatial innovation for society (pp. 45-62). Springer.
- 23.Roberts, L. (2018). Technological Advances in Archaeology . Archaeology Today, pp. 234-240.
- 24.Smith, J., & Johnson, K. (2021). Modern Techniques in Archaeological Surveying . Archaeological Press, pp. 45-50.
- 25.Spilker, J. J. (1996). GPS signal structure and theoretical performance. In B. W. Parkinson et al. (Eds.), Global positioning system: Theory and applications (pp. 57-119). AIAA.
- 26.UNESCO. (2020). Guidelines for Cultural Heritage Documentation . UNESCO Publications, pp. 12-18.
- 27.Yang, Y., Mao, Y., & Sun, B. (2020). Basic performance and future developments of BeiDou global navigation satellite system. Satellite Navigation, 1(1), 1-8.
- 28.Zhang, N., Wang, M., & Wang, N. (2002). Precision agriculture: A worldwide overview. Computers and Electronics in Agriculture, 36(2-3), 113-132.
- 29.Zhao, L., Qiu, H., & Feng, Y. (2015). GNSS for search and rescue. SpringerBriefs in Electrical and Computer Engineering.
- 30.<https://wadielhudiarabic.com/innovative-techniques/>
- 31.<https://www.jouav.com/blog/ground-control-points.html>