LUPINE PUBLISHERS

Journal Of Anthropological And Archaeological Sciences

DOI: 10.32474/JAAS.2020.02.000142

ISSN: 2690-5752

Opinion

Space Based Emerging Image Management System for Archaeology

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Received: July 02, 2020 **Published:** July 15, 2020

Opinion

Ever since the French Archeologist, Antoine Poidebard flew over archaeological sites in Syria and Lebanon and photographed from his biplane, a lot of progresses have been made in the field of archaeology using aero-space media as source of information. Particularly in the last two decades applications of satellite images in archaeology has increased many folds due to unprecedented growth of imaging and probing technology from space [1,2]. However, as the imaging technology advanced, the complexity of information extraction has also undergone sea change, often requiring very advanced algorithms for extraction of meaningful information. This is one of the many challenges faced by the archaeological community. The other important aspect is the dynamic nature of the planet earth and interplay of earth surface processes and features developed over last 11700 years since Holocene Epoc, during which oldest civilizations prospered, declined and transformed into modern day civilization. The recent acknowledgement of major global climatic event coinciding with Meghalayan Age, approximately 4200 Before Present (BP), further provides credence to the fact that climate, geology and anthropology is very closely interwoven, and integrated study in space and time is required to provide a better understanding of dynamic relation with nature [3]. The role of geodynamics on human civilization is very much pronounced at the plate boundaries such as Himalaya where Eurasia and Indian plate collision has shaped human civilization for centuries. Therefore, the relation between evolution of human civilization, global climate, geomorphological processes and landform dynamics is of paramount significance and it can only be appreciated through the holistic understanding of Earth System Science.

Therefore, the role of Earth System Science on human civilization need to be explored with the help of space and allied science dealing with imaging and geophysical probing. In this regard starting from high resolution imaging through panchromatic cameras to multispectral and hyperspectral imaging from both space and lower atmosphere using aeroplanes and Unmanned Aerial Vehicles (UAVs) provide unprecedented opportunities [4]. Thermal imaging provides diurnal variation of thermal properties of materials that aid in characterization and identification. Microwave remote sensing, particularly Synthetic Aperture Radar (SAR), due to all weather and cloud penetrating properties is capable of providing information on surface as well as sub-surface features, particularly by SAR operating at long wavelengths. The SAR provides information on backscattering properties of target, which is influenced by surface roughness, object orientation and water saturation, thereby providing opportunity to extract information based on subtle variation of such properties of materials.

The SAR and optical remote sensing is very useful in detecting features that are related to flow or storage of water, which is considered as the indicator of life. Numerous studies have been carried out to detect and map paleo channels and paleo mega rivers such as Vedic Saraswathi in India, which was traced from Himalaya to Arabian sea using remote sensing techniques [5]. The geodynamics at the frontal Himalaya has played a key role in its disappearance and migration of rivers that had played a role in human settlements in the past. Present day Global Navigation Satellite System (GNSS) based crustal deformation has revealed an anticlockwise rotational movement of the Indian Plate with respect to the Eurasia Plate, which is responsible for eastward migration of many rivers affecting flooding and shifting of human habitats. Similar examples can also be cited from the deserts of India and elsewhere [6]. Minerals and mankind have a symbiotic relationship and civilization in the past apart from agriculture and animal rearing had progressed due to discovery and use of metals through knowledge of mining and metallurgy. Therefore, hyperspectral

imaging which is ideal for detection for economic minerals and their path finder's such as old mining sites and mineral dumps, holds good opportunity in archaeology for this specific as well as general advantage of contiguous bands [7].

The height or relief information provides crucial clue to man-made objects created thousands of years ago. Subtle changes in relief in the order of few centimeters with respect to surroundings can be detected and mapped in 3-D providing unique opportunity to archaeologists. Many of the archaeological sites abandoned due to natural or cultural reasons are not mapped by traditional techniques at high resolution and such information is now available from remotely operating sensors. In this regard SAR using interferometry techniques, space-based laser scanning and stereo imaging by optical sensors on board satellites, Aeroplane and UAVs provide high precision DEMs. One complementary technique, terrestrial laser scanning (TLS) provides high precision details of any object, as a result, it has emerged as the default technology for digital archive of important monuments [8].

Recent developments in geophysical techniques such as Ground Penetrating Radar, Induced Polarization based resistivity (IP Resistivity), Ground Magnetic Resonance (GMR) provide details about physical properties of buried objects, features and its surroundings [4]. Most importantly these are non-invasive techniques and can be deployed effectively to optimise excavation which is expensive and time consuming. Similarly, the remotely operated vehicles (ROVs) fitted with appropriate sensors can image the sea-surface bottoms and remnants of human civilization sub-merged due to marine transgression, sea level rise and faulting. This will be very helpful to get an insight of the human civilization that had once flourished on the coastal plains. The recent discovery of remnants of human settlement at Dwarka on the western coast of India and many other parts of world is a testimony of this fact.

The whole gamut of imaging and probing can be grouped under Intelligent Image Management System (IIMS). Traditionally this field had dealt with 2-D images (in1st Generation) and with height/relief information, it became 3-D (2nd Generation) and subsequently due to good temporal coverages, 4th dimension could be added (3rd Generation) to the information content. Recently under water and sub-surface information by geophysical techniques and ROVs, respectively, added the 5th dimension to the information content (4th Generation), which requires a very advanced system of data analysis and visualization using Artificial Intelligence (AIs), Expert Systems, Data Mining and Deep Learning techniques. Therefore, the emerging areas for research and innovation in Space Recently needs capacity building and research in the field of 4G-IIMS, which is envisaged as the best technological solution for Archaeology as it would be able to acquire, integrate, analyses, discover and disseminate information on all possible dimensions of features ever made by mankind anywhere on planet earth and elsewhere. The aim is to re-discover the signs of civilization and challenges it faced from natural disasters and global change in last 10000 years. The Space Archaeology equipped with 4G-IIMS will immensely benefit our pursuit as we know from the words of William Shakespeare - "There are more things in heaven and earth, Horatio,/Than are dreamt of in your philosophy".

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DOI: 10.32474/JAAS.2020.02.000142