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Research, Application, and Innovation of LiDAR Technology in Spatial Archeology

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INTRODUCTION: A NEW ERA FOR SPATIAL ARCHAEOLOGY WITH THE VTOL ADVENT AND THE NEED FOR LiDAR GUIDELINES

The paper is a research compendium on how Spatial Archaeology can benefit from LiDAR technology. Specifically, we refer to VTOL fixed-wing UAV LiDAR applied in Mesoamerica. In many European countries and the USA, the cartographic database of the entire national territory (Harding et al., 2008; Stoker et al., 2014) has been available on the Internet for many years, albeit at medium resolution. In Mesoamerica, from Chase's studies and surveys from the 2000s to the present, (Chase et al., 2014, 2020; Ebert, 2016a, 2016b; Caracol Archaeological Project, 2020, June 12) a long tradition of LiDAR investigation has yielded unexpected, incredible knowledge about the ancient Maya civilization. Although LiDAR has exploded in popularity, there is still a lack of systematic overview of how it has contributed to archaeological theory, especially at the landscape scale of spatial archaeology and from the perspective of digital application. Today, researchers acknowledge the need for specific LiDAR guidelines (*European Archaeological Council: EAC*. Eac site. (n.d.), which are still expected, while other geospatial techniques guidelines are already available, such as magnetometers or ground-penetrating radar (Schmidt et al., 2015). However, universities, departments, and international bodies are on the way and understand the importance of having common classification standards (Garstki, 2020) and metadata and paradata (Wise & Miller, 1997) to be shared in a network for digital archaeology and also on a global scale. Therefore, case studies and best practices are useful to demonstrate the magical utility of this technology that opens the field to multidisciplinarity and a new era of archaeological research (Barcelò, 2016,2017).

BACKGROUND: LiDAR UTILIZATION

In many countries, LiDAR data topography is already available on the web (Kissling et al., 2022; Organismo Autónomo Centro Nacional de Información Geográfica, n.d.); in others, it is available on request, so that a significant part of the world is openly accessible. The main reason for this choice by governments is the

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need to make accurate topographic data accessible to non-experts in the public and private sectors. There are also economic reasons; LiDAR is cheaper for surveyors than traditional surveying methods, especially in the environmental and planning sectors. On the other hand, there is a need for updated information (Calculadora Geodésica Online, n.d.; IGN. (n.d.) and monitoring of the areas that have been surveyed and mapped. In some countries, such as Scotland (Banaszek et al., 2018) and England, the evaluation of national archaeological data in their specific field and for management purposes is of the utmost importance and is described especially in relation to airborne lidar datasets (Historic England, 2023). This is because the UK has a long tradition of collecting and archiving archaeological data (i.e.: The Historic England Archive). One of the obvious features is the multidisciplinarity that LiDAR technology invests in, not just in management. It invests in archaeology and cultural heritage research in general, but with implications and connections to many other sectors: from the technical sectors of photogrammetry and remote sensing (Storch et al., 2022; Stylianidis, 2020), to the humanistic ones of digital heritage (*Using TDAR,* 2020) and virtual reality innovation, to the application of environmental-ecological models (Kellett & Jones, 2016). All these sectors will increasingly take advantage of LiDAR technology (Shan & Toth, 2017). There is a growing body of literature, mainly in the form of case studies as best practice examples. The authors report some references to their case study on Maya archaeological landscape (Canuto et al., 2018, 2021; Fialko, 2000; Ford &Clarke, 2015; Larmon, et al., 2022; Richards-Rissetto et al., 2021). In this paper, the authors describe the interrelationships and the relative implications, challenges, and benefits of LiDAR technology as it is applied to spatial archaeology.

Spatial archaeology is a branch of archaeology that aims to study ancient buildings in the context of the equally ancient landscape in which they were built and are located. In Mesoamerica, LiDAR has been applied to discover and map entire remote large areas hidden by the tropical canopy, and this is where our research has been conducted.

FOCUS OF THE ARTICLE: LiDAR FOR SPATIAL ARCHAEOLOGY ADVANCEMENT

Specifically, the paper examines whether and how archaeological theory has advanced through a review of the application of LiDAR in spatial archaeology (i.e., LiDAR for potential archaeological detection and the relative benefits, challenges, and limitations). The authors discuss how LiDAR has influenced technological innovations in archaeology and related sectors (i.e., planning, spatial vegetation control, topography) and how LiDAR has enriched theoretical innovations (i.e., spatial syntax analysis, management).

A Brief History of the Use of LiDAR

LiDAR is the acronym for Light Detection and Ranging. In the US, the National Geospatial Agency first used this name to denote active electro-optical 3D imaging and mapping. In this paper, the authors refer to the term "LiDAR", as this is the most commonly used term in modern applications. LiDAR is an active sensor that emits an electromagnetic wave and receives the reflected signal. The waves are between optical and infrared wavelengths, the same interval as passive electro-optical (EO) sensors. However, the LiDAR sensor provides its own radiation, with its own flashlight, rather than using existing radiation. As a result, LiDAR sensors can operate at night using near-infrared wavelengths when insufficient near-infrared radiation makes passive EO unavailable. LiDAR has a history of more than 50 years, although it was A.A. Lebedev who first used short pulses of light to measure distance in 1933. From the speed of

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