Aerial Digital Archaeology and Data Ethics through the Lens of Actor-Network Theory

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Abstract: Actor-network theory emphasizes the importance of technology in archaeological research, particularly in aerial digital archaeology. It deconstructs objective narratives by revealing the complexity of knowledge production, including the archaeologist's expertise, excavation tools, technology, and the researcher's cultural background. Data are a dynamic output of the network, influenced by factors like tools, environment, and survey timing. The researcher's cultural context also plays a role, as Western archaeologists may have different approaches and interpretations from those of researchers from developing countries. The theory also highlights the power dynamics of the network, with those controlling it – through technology, funding, and interpretation – wielding greater influence. This raises ethical concerns, especially in cases of "parachute science", where foreign researchers conduct research in developing countries. A strong ethical framework is therefore needed to address these issues, and to promote collaboration and knowledge transfer. Actor-network theory encourages a more collaborative, ethically sound approach to understanding the past, especially when using aerial digital archaeology. This article systematically argues for such an approach.

Keywords: Actor-Network Theory; research ethics; aerial digital archaeology; parachute science; Power Dynamics.

I. Introduction

Digital archaeology has been praised as a major breakthrough for the field of archaeology, in the sense that, in addition to manpower, technology can be used with great efficiency to assist experts in identifying, excavating, analyzing, and distributing findings. Aerial digital archaeology, in particular, has also gained popularity. However, the application of such technology may be traced back to the 1900s, when airplanes were introduced and cameras became ubiquitous, resulting in airborne photography, which could then be used for a variety of purposes, including military surveillance and archaeology (Reeves 1936). As technology progressed, airplanes were supplemented by unmanned vehicles such as drones equipped with cameras, or by high-end remote sensing tools such as lidar, RGB imaging, and multispectral sensors, which can be mounted directly on unmanned vehicles or used for satellite-based photography (Kaimaris 2024). With all of these complex tools, the goal is to extract data for geographical surveys to map

an area – particularly cultural heritage sites when applied to archaeology (Verhoeven & Sevara 2016).

With the increasing ease of technological use, questions about ethics arise, particularly in the field of archaeology, where cultural objects and remains are held dear and serve as an identity for the host community and nations. It is noteworthy that research ethics exist in the form of law, institutional policies, professional codes, and personal conviction; however, there is rarely a uniform approach to research ethics, and it is frequently left to research institutions and individual researchers to uphold integrity and ethics. Coupled with the advance of technology, understanding how to properly use such a sophisticated tool without causing harm to the community remains critical.

Furthermore, remote aerial sensing technology such as drones or lidar raise ethical concerns due to their deployment without consent, the types of data obtained, the process of analyzing the data, and the distribution of data or findings generated by the technology, as well as how this technology will shape local epistemologies and interaction between the researcher and the local communities. Given these underlying concerns, it is critical to note that "parachute science" or "colonial science" should be closely examined to determine whether the introduction of such modern technology perpetuates such practices and, if so, how it affects research ethics. Parachute research or colonial science can be defined as when a researcher dashes in and out of the research site without concern for local interests or their future, eroding people's trust and inciting animosity against these researchers (Odeny & Bosurgi 2022). For example, when scientists come just to collect data or cultural objects and then send them abroad for testing and analysis without taking the proper steps and time to learn from the local community, and the result is not properly shared back, or the scientist may not even be an archaeologist but a chemist who wants to experiment with things (Armitage & Fraser 2023).

With this, the actor-network theory will be introduced to explain the relationship between technology and research practice, and how its unethical or ignorant use can lead to the phenomenon of scientific colonization. More importantly, the theory will be used to highlight the power dynamics behind the research findings, which were previously unseen with the naked eye. Rather than focusing only on research procedures and how they are presented on paper, it is important to look beyond that – to how the research is associated with the local community and whether it has caused harm, intentionally or unintentionally, such as in forms of colonial science that have led to the continuation of scientific colonialism by communities of researchers mainly from the West.

This article will proceed as follows: Section One will focus on the literature review, Section Two will explain the theoretical framework applied in this paper, Section Three will present the findings; Section Four will discuss the findings; and finally, there will be a conclusion. The article aims to raise awareness of the potential negative consequences of parachute science and the power dynamics that leave the developing world hostage to new aerial archaeological tools – at the expense of their cultural property – due to limited

accessibility and to the ignorance of the parachute scientist, which cannot be justified within actor-network theory.

II. Literature Review. Research Ethics and Digital Archaeology

Today's world is a result of technological advances. From the widespread use of global digital communication to the progress of health services and individual pleasure, technology plays a key role and has become an integral component of human life and social practice (Kickbusch et al. 2021). Despite this, technology has a dual function (Kickbusch et al., cf.): it can be good or bad, depending on how it is used. For example, nuclear power can be utilized as a nuclear weapon, endangering people, or as a nuclear power plant, providing humans with energy. The same is true for digital tools used in archaeology; if used correctly and ethically, they will greatly benefit the field.

Levy and Smith (Levy & Smith 2016) highlight in their chapter how digital technology has changed the way archaeology is conducted. The authors specifically state that field archaeology was primarily done on paper in the 1990s, but that digital technologies such as total stations, digital photography, GPS, and software such as ArcGIS, particularly for Geographic Information Systems (GIS), were gradually incorporated in the 2000s. The authors also underlined that with these methods field recording and surveying can be saved digitally, ensuring data transparency, rapid data processing, and greater precision and accuracy. While that is the case, the authors also observe that the tool is sophisticated, requiring a high-end computer to process all the digitally captured information, as well as a devoted and tech-savvy assistant and sufficient supervision from the field manager.

This positive approach to embracing digital tools in archaeology is also supported by Lasaponara and Masini (2016), who demonstrate how cutting-edge drones, LiDar, GIS, and ground surveying tools have greatly impacted the field, which they refer to as a "golden age of digital archaeology." The authors also map out how different digital tools are used: drones and LiDar to extract data from aerial imaging and topography, satellites contribute multispectral images that can be used for historical reconstruction; and these can also be combined with tools on the ground, such as ground penetrating radar (GPR), to detect whether there is anything beneath the surface. All of this data is then sent to a digital hub as integrated datasets for analysis and storage. Following this, the authors encourage the data to be housed on an open-source platform that can be accessed by a variety of stakeholders.

Having said that, two studies have focused more on the beneficial aspects of these technologies and their applications in archaeology. Two publications hinted at potential ethical concerns, though not directly. Levy and Smith (2016) pointed out that high-end tools and a computer are required to process the data, while the field manager must supervise data collection and analysis. This gives rise to two possible concerns. First, the involvement of local researchers and communities has been marginalized, as archaeology

appears to have evolved into a tech-driven sector. If this is the case, indigenous knowledge and epistemologies related to their cultural heritage risk becoming obsolete, which is the reverse of archaeology's original goal. Second, supervisors have the authority to make decisions and ensure that data is appropriately collected or analyzed. Although students and assistants are trained for these tasks, supervision is still required, which could mean that data collection and processing using these tools may be erroneous, incomplete, biased, or inaccurate in some cases due to negligence on the part of the supervisor or overreliance on the part of the assistant. Lasaponara and Masini, on the other hand, advocate for an operational platform that would allow stakeholders to access data. However, their article could have been extended, because it deals directly with ethics: data are collected, evaluated, and stored in a location where the hosts of the cultural heritage – or the subject of the studies – is unaware of the outcome and unable to participate in the research process.

The issue of lack of accessibility was also raised by Katsianis, Kalayci and Sarris (Katsianis, Kalayci & Sarris 2022), who discussed the possibility of integrating and encouraging the use of old data, which could be in the form of written data, outdated hardware or software, or prior knowledge practices. The authors are concerned that the digital technology currently in use is no longer compatible with such data and may render them obsolete, as new datasets are required to match the technology. The authors go on to argue that researchers should not rely solely on big data but should also assess the quality of the data and its context. The authors' criticism is valid, as overreliance on big data risks neglecting traditional knowledge and data, with significant implications for ethics, which should be emphasized. With that stated, the three studies reviewed thus far reveal that data ethics is a core issue, but the debate is still limited, highlighting the field's importance and the urgent need for future research. This paper seeks to elaborate on this line of thought, focusing on defining data ethics and aerial digital archaeology using actor-network theory as a theoretical framework.

The article by Kansa and Kansa (Kansa & Kansa 2021) expounds upon the definition of data in the new decade, incorporating field notes, pictures, and three-dimensional models, while also discussing the utilization of digital instruments to collect data pertaining to excavation, data collection, and analysis. The article emphasizes the significance of data literacy, specifically for pertinent research, to enable researchers to comprehend and interpret data in addition to having the ability to access it. In the article "UAV LiDAR Survey for Archaeological Documentation in Chiapas," Mexico (Schroder et al. 2021) explains that UAVs, or drones, are increasingly being used in fields such as ecology and archaeology for surveying, due to their enhanced efficacy and effectiveness. Aerial digital archaeology enables photography to generate three-dimensional models and maps; further research integrating thermal and multispectral sensors can complement this technology and serve as a foundation for future developments. Despite the fact that the two articles discuss data security, quality, and accessibility guidelines, they did not

go into detail about the possibility of using archaeological data for non-archaeological purposes or the intricate web that underpins technological advancement and how it interacts with users to maintain power.

In their article, Fisher and colleagues (Fisher et al. 2021) define data ethics as encompassing four primary domains: stewardship, humanity, politics, and dignity. Within these four domains, the researchers emphasize the need to uphold principles of impartiality, independence, accountability, and respect. However, the article does not comprehensively analyze how aerial digital surveillance, a nascent discipline, has transformed or compromised the current understanding of data ethics.

The article by Senger and Barnett (Senger & Barnett 2021) discusses the ethical implications of digital archaeology. It highlights the need to consider self-rule and independence, individual and collective confidentiality, cultural legacy, metaphysical powers and nonhuman beings, and the repercussions of unjustified and undesired monitoring. Nevertheless, this analysis did not consider the consequences beyond the above factors. The analysis should have encompassed the decolonization aspect of interpretation, the ramifications of data and surveillance for national security, and the knowledge deficit that impedes local information accessibility. Ignoring data ethics in this domain could lead to potential consequences.

Dennis' article (Dennis 2020) explains that the Computer Applications in Archaeology (CAA) organization introduced digital archaeological ethics in 2018. The author argues: "Even then, CAA [Society of American Archaeologists (CAA)] did not have a dedicated ethics policy for digital archaeology until 2018 (CAA 2018), and SAA and EAA [European Association of Archaeologists] (as of this writing) still do not" (Ibid.). This suggests that digital archaeology is a relatively new discipline that lacks comprehensive research. It is also possible to perceive that the responsibility for establishing an ethic has been delegated to the initiative of research institutions. Dennis (2020) also discusses archaeological ethics as a novel subject that is contingent upon individual institutions or universities establishing their criteria for acceptable and objectionable conduct. The author suggests greater emphasis should be placed on ethical considerations, specifically regarding the tools selected for archaeological purposes, so that they are perceived as respectful not only to the community but also to specific subjects, such as the handling of human remains and their connection to cultural practices. However, Richardson (Richardson 2018) stresses that a universally accepted code of ethics does not exist.

Consequently, numerous researchers are compelled to depend on the ethical standards established by their respective organizations. Additionally, Richardson (2018) further elaborates on how aerial surveillance may result in breaches of privacy, digital monitoring, and online mistreatment, specifically causing harm to the target or harassing members of their ethnic group. In addition, Niccolucci (Nicolucci 2020) insisted that archaeological data should not be regarded as solely archaeological data but rather as having the potential for additional discoveries that may or may not benefit the local

or host nation when combined with information from various scientific disciplines such as physics, chemistry, materials science, and biology. According to Price (Price 2011), foreign intelligence agencies, including the CIA, may employ archaeology and archaeologists for political gain with the financial support of a research institution or an individual archaeologist. Consequently, information and data are intrinsically linked to state security. This revisits concerns regarding data ownership, data accessibility, and the surplus of data that is not essential for archaeological objectives but warrants additional investigation, specifically in the context of Cambodia.

It is important to note that the literature has comprehensively discussed digital archaeology, aerial sensing, and data ethics, all of which are still in their early stages. The literature raises concerns about the rise of new technology in archaeology, which is closely linked to ethics. There has been some work with actor-network theory in archaeology, but the argument about using – or attempting to use – actor-network theory to address colonial legacies remains unresolved. The present article will attempt to bridge this knowledge gap.

III. Methodology and Conceptual Frameworks: Actor-Network Theory

This article employs a qualitative approach with an emphasis on desk research. Primary sources, if available, from relevant ministries, researchers, or institutions engaged in LiDAR activities are essential for identifying existing ethical concerns and investigating remaining gaps. Simultaneously, secondary sources, including academic journals and books, will be referenced for both the methodological section and to provide specific justification for establishing a comprehensive and practical data ethics framework and for outlining the way forward.

The article examines aerial digital archaeology systems, such as LiDAR, which are considered advances in archaeological technology. Undoubtedly, the use of such technology can significantly aid archaeologists, both domestic and international, in the process of gathering data and uncovering novel findings. This new technology has proven indispensable when confronted with complex geographical terrain or dense forest cover that conventional archaeological methods are unable to penetrate. However, it is crucial to consider the security risks, as well as risks to the host community, associated with using aerial digital technology, including data ownership, management, and ethics. This is because the data may reveal geographical information and archaeological findings that could expose the nation's security to threats or enable the exploitation of the community by foreign researchers. Aerial digital archaeology can also compromise personal data privacy while infringing upon the freedom of the local and spiritual entities being observed. At a higher level, archaeologists could assume the dual role of (1) archaeologist and (2) covert agent.

With this, the present article seeks to utilize actor-network theory as an important

approach to archaeology and as a theoretical framework because it aids in uncovering and revealing the interconnected network of material and non-material things that are not published or even hidden. It is also critical to emphasize the distinction between actor and actant in the archaeological process. As previously stated in the literature review section, human actors may include a team of archaeologists, such as the lead archaeologist, trainees, drone operators, GIS experts, local communities, and government officials (Levy & Smith 2007). They are directly involved in the gathering, interpretation, and dissemination of data (Ibid.). Furthermore, institutional actors play an important part in academic research in the archaeological field, and they can include universities, government institutions, archives and libraries, international institutions and sponsors (Fleming 2020; Schiappacasse 2019). These institutional actors play a critical role in approving research projects and making decisions on financial contributions and access to archaeological sites and objects (Fleming cf.). On the other hand, the actants that are also vital to the project are technological actors – such as drones, GIS, LiDAR, cameras, and GPR – which define the limits, standardize, and shape how data can be collected, based on their capacities (Kaimaris 2024; Menéndez-Marsh et al. 2023). Furthermore, data objects such as artefacts, as well as the site, location, and environment of the excavation, are also important, as it is crucial to determine how the items are retrieved and the meaning that they can offer to the data objects (Vadala & Duffy 2021).

All of these actors must be mediated in a network, and once it becomes stable, the outcome will reflect the stabilized network (Van Oyen 2015). A hypothetical example illustrates this: in order for research to be conducted in developing countries, one possible way to do so is to invite foreign research institutions to participate. The foreign research institution and its researcher may need to request a grant from a third entity or from their own institution, and from this grant standards and indicators may be established for the researchers by the donor. The researcher will use the tools at their disposal to attain the outputs specified by the donor and the inviting country.

However, the donor's interests may differ from those of the inviting country or the local community. For example, if the grant is small, the researcher has a limited amount of time but needs to collect data for publication to satisfy the donor's expectations, the focus is less likely to be on assisting the local community and local government with their interests wholeheartedly, while the research will be technologically led to save time. The outcome of the result will therefore favor the donor. However, the outcome would be different if the researcher had dedicated more time to the project, engaged more with the local community, and approached it with an ethical and scientific research attitude rather than a donor-directed mindset. However, these hidden networks are underexamined and people simply praise and accept the outcome of what they believe to be a sound scientific finding, regarding it as neutral, objective, and fairly obtained.

It is important to understand that actor-network theory does not distinguish between actors and networks, but rather asserts that they are all actors who interact

and influence one another. These relationships and this interconnectedness have evolved into a robust network that constitutes the social world (Latour 1996). It can be used to investigate the role of technology, particularly digital archaeology, and how it can influence social practice, specifically the field of archaeology. In some ways, digital technology is created by humans, but this is only true to a certain extent. On the other hand, digital technology also depends on other technologies such as chips, as well as other common materials such as glass, iron, and silicon. Furthermore, it is not complete; the available material influences various experts – such as programmers, engineers, students, companies, and others – to participate in the creation or consumption of the product, which forms a network and an assemblage. In the field of digital archaeology, specifically aerial digital archaeology, these relationships have given rise to equipment such as drones, LiDAR, and other aerial technologies. However, it is important to note that such technology and the networks formed to create or give birth to a specific thing carry meanings or are embedded with underlying power dynamics that, to a great extent, affect the balance of the network and create inequalities, particularly in aerial digital archaeology and ethics, which will be discussed below.

IV. Ethics and Aerial Digital Archaeology

To uncover the underlying unequal dominance of knowledge production and the power dynamics in the research process, especially in aerial digital archaeology, it is critical to first examine what ethics are. It is broadly defined as morality or a set of guiding principles that distinguish between right and wrong. In other words, ethics constitute the principles or norms that determine what is right and wrong (Tracy 2010). It is important to note that determining what is acceptable or not is difficult because there is a grey area that cannot be defined and may be shaped by a certain group, thereby influencing the others. However, if properly maintained and adhered to, ethical norms can produce fruitful results. That being said, in general, ethics are important in society because they help shape societal values, attitudes, and norms, as well as draw a line between what is acceptable and what is not, thereby preventing social anarchy (Guillemin & Gillam 2004). Furthermore, one society's norms and values may differ from another's.

The academic community or society has also adopted the concept of responsible and ethical research. Without ethics, there may be societal consequences such as increased crime rates, agitation, social fragmentation, and even cruelty. Similarly, without a proper research code of ethical conduct, research may invade subjects' (human) personal privacy or involve animal cruelty in laboratory experiments (Tracy 2010). Given the potential issue mentioned above, it is understandable that, in order to achieve the goal of disseminating scientific knowledge and evidence, research ethics and a culture of research integrity are required (King et al. 2021).

To reiterate, there are numerous methods for conducting research that may not

be acceptable or appropriate. In the current state, it is widely believed in the academic community and institutions such as universities that research ethics and integrity should encompass honesty and truth at every stage of the process – from the initial stage of proposing topics to the final stage of disseminating results (Cordner et al. 2012). It is important to note that the research community expects accuracy, exactness, respect, and fairness when crediting colleagues (Hofmann 2022).

To explain further, as previously stated, without caution, a research project could become a crime – for example, through animal cruelty; thus, care and respect for human, animal, environmental, and cultural subjects should also be considered. In addition, it is important to stress that scientific knowledge must be peer-reviewed, revisited, and reexamined by peer researchers and next-generation researchers, who may reinterpret or provide an alternative conclusion to earlier findings. Thus, it is critical for researchers to appropriately preserve the data and results for others, upholding the principle good stewardship (Wendelborn et al. 2023). Researchers must also act responsibly and with integrity, ensuring that there is no conflict of interest and that data can be shared while maintaining confidentiality and intellectual property rights.

To promote or ensure research ethics and integrity, four levels of consideration are used: law and regulations, institutional codes of conduct, professional codes, and individual convictions. To begin, a legal framework established by the government to regulate research conduct is beneficial because it serves as a beacon for researchers to maintain responsible conduct while also ensuring that the standards of operation and research conduct are upheld (Hofmann et al. 2020). There are critical factors to consider, such as research involving humans, animals, or chemical substances, which could have serious consequences if carried out without proper scientific methodology or by an amateur.

On the other hand, with the establishment or expansion of research institutions, including universities, proper guidelines and principles must be enforced – not merely to support academic research, but to ensure that guidelines and mechanisms are in place for each institution's researchers regarding necessary procedures, evaluation, and monitoring. As the law establishes an overarching framework for these procedures, it primarily assigns responsibility to the research institution and researcher while also requiring the actor to have institutional policies (Ibid.). It is also important to note that there is rarely a one-size-fits-all approach to policies because each institution's area of research varies; however, researchers are required to follow institutional policies to ensure that their research procedures and results are ethical (Ederio et al. 2023). It is important to note that the growing practice of interdisciplinary studies or research raises concerns about this issue, as collaborative research and researchers often involves researchers from different fields, and the codes of conduct or research ethics may differ (Chouinard & Cousins 2021).

Aside from the law and institutional guidelines, it is important to note that an ethical

code of conduct may be imposed by a professional association through a professional code that members will adhere to in accordance with their specific profession. With this, the professional code can be beneficial to young researchers, particularly in terms of introducing them to their specific research community, but it also provides an opportunity for amateur research to become aware of unwritten rules such as publication misconduct (Zhang & Grieneisen 2013). However, without personal conviction, it will be difficult to ensure that the research is conducted in accordance with proper research ethics (Skitka 2010).

It is important to explain how research ethics can be applied to cultural artefacts. The study of artefacts and human remains that date back hundreds of years or more makes archaeology an indispensable discipline. Ethnic, religious, and cultural factors must be carefully considered because these artefacts and human remains are more than simply artefacts from the past; they are significant elements of cultural heritage (Flewellen et al. 2021). Obtaining the necessary permits and adhering to all applicable codes of conduct and ethics are absolutely necessary when dealing with these genuine and historically significant artefacts. Researchers, especially those from outside the area, bear a number of responsibilities before conducting research in indigenous or local communities which will be further examined below. Ethical standards must be upheld at all stages, including excavation, analysis, curation, and display of the artefacts and remains (Ibid.). These include respecting and learning from local values and knowledge, getting permission from locals before doing any research (especially when collecting artefacts or remains), and ensuring that locals are treated fairly throughout the process (Colwell 2016).

Similarly, digital archaeology is comparable to traditional archaeology in terms of ethics, stewardship, and duty of care for archaeological sites and remains. As previously noted, the buzzwords used to address archaeological ethical obligations include honesty, trust, transparency, and integrity (Belford & Wait 2024). In general, it is standard practice for archaeologists to obtain ethical approval before commencing studies. This typically involves requesting ethical clearance from all stakeholders, obtaining archaeological permits from the government, securing consent and prior consultation for the communities, being cautious and respectful of the cultural sensitivities and spiritual significance, ensuring transparency in data processing, analysis, and storage, and engaging local actors (Cohan 2004).

There may be questions about why it is vital for archaeologists to be aware of these ethical issues. There are various explanations. The first is that such practices are protected by international and local legislation (Soderland & Lilley 2015). For example, Articles 11 and 15 of the UNESCO Convention for the Safeguarding of Intangible Cultural Heritage (2003) state that communities have the right to participate in the identification and management of their heritage. According to Article 2.1 of the UNESCO Convention on the Protection and Promotion of the Diversity of Cultural Expressions (2005), individuals and communities have the right to develop, access, and share their own culture because it

is protected by human rights. Furthermore, Article 31 of the UN Declaration on the Rights of Indigenous Peoples (2007) specifically recognizes that indigenous peoples have the right to access and participate in the interpretation of their heritage.

This international legislation also has been incorporated into local law in order to protect archaeological sites, while also initiating the creation of a law or code of ethical research (Soderland & Lilley 2015). Second, ethical awareness demonstrates respect for local people's rights and sovereignty, and helps maintain dignity, because the cultural landscape is sacred to them, not merely an archaeological subject (Watkins & Ferguson 2005). Third, it is important to improve a project's validity and scientific integrity, because if the project violates the ethical code of conduct, it may be discredited in the academic community, denied funding, or rejected for publication (Lövestam et al. 2025). Finally, ethical compliance promotes data accuracy, because when conducting research outside of the country – particularly in developing countries – benefit-sharing is critical, and local epistemologies and knowledge can help the research become richer, more equitable, and more accurate, leading to knowledge production sharing (Gupta & Nicholas 2022).

In aerial digital archaeology, the ethical approach requires considerably more caution. Simply put, when technology is emphasized, the tendency to incorporate human subjects – particularly local knowledge of archaeological sites – decreases (Levy & Smith 2007). The ethical process of aerial digital archaeology begins with obtaining flight authorization from local authorities in order to ensure safety and prevent unauthorized surveillance (Hill 2013). Furthermore, although the work is conducted from the air, cultural heritage is a protected site; therefore, unauthorized scanning or photographing is unlawful and may result in data theft or amount to illegal excavation (Ibid.).

Once the flight permit is secure, it is critical consult with the local people to ensure that they are informed about and consent to the project, and that there is a mutual understanding that the project will not disrupt their cultural heritage and will be carried out with respect (Gupta & Nicholas 2022). Once local approval has been obtained, the next ethical concern relates to epistemic negligence and knowledge hierarchy, in which the research team determines the significance of the research project (Ibid.). For example, a researcher may prioritize documenting the water management system of Angkor but ignore the religious, local, and historical knowledge that gives meaning to the water management system beyond the technical sphere (Ros 2025). Instead, the researcher, despite being armed with sophisticated equipment, should collaborate with local scholars and communities in designing the study process, survey, or target selection of archaeological sites (Gupta & Nicholas 2022).

Next, after the design is complete, data gathering and analysis must be conducted in an ethically responsible manner (Nicholson et al. 2023). For example, airborne digital archaeology can scan landscapes and discover buried structures that the local population may not wish to discuss, possibly for spiritual reasons (Sanger & Barnett 2021). It may be argued that aerial digital archaeology, or the extraction of data from the sky, is comparable

to ground archaeology and the excavation and removal of objects from the community that are protected and sacred (Sanger & Barnett 2021).

On the other hand, extracted data are often taken to a lab, usually abroad, and this approach frequently creates a separation between the local community, local scholars, and the data that is stored overseas (Ros 2024). Without participation, responsibility for the interpretation and analysis of data, particularly aerial digital archaeology, falls to the foreign researcher, who is assumed to be knowledgeable enough to give definition and meaning to the data obtained (Dennis 2020). The challenge is whether data interpretation will reflect what local populations perceive it to be (Dennis 2020).

If so, isn't this a type of coloniality of knowledge in which the original cultural context has been transformed by an external interpretation and accepted as objective? Last but not least, there is the issue of knowledge dissemination and accessibility: data that have been published often cannot be accessed by the local community, possibly due to intellectual property rights and paywalls, and the dissemination of information back to the community also tends to be lacking, causing local voices to become increasingly marginalized (Costa, Beck, Bevan, & Ogden 2013). It is clear that, while integrating aerial digital archaeology is advantageous to archaeologists, it also requires additional effort from the researcher to be aware of any ethical issues that may arise. These ethical issues will be examined in the discussion below.

VI. Networks of Inequity: Power, Technology, and Ethics in Digital Archaeology

In reality, archaeological research procedures are so complex that research ethics may not be fully achieved by researchers, particularly when working in another country, as highlighted in previous section. In any case, issues such as "parachute scientists," "parachute research," "helicopter research," or (neo)colonial science remain and occur when researchers – mostly foreigners from advanced countries – travel to less-developed countries to conduct research, thereby disturbing the principle of good citizenship, integrity, and transparency mentioned above (Hicks & Parham 2022).

The problem arises when researchers exploit participants and subjects, particularly local communities, who were unaware of the researchers' objectives, the risks involved, or how the data from the research will be used, resulting in unequal research relations and leading to the neglect of research ethics (Simwinga et al. 2018). At the same time, this raises the question of whether the researcher benefits more from the research than the local community, despite the fact that they are subjected to it without proper compensation. In the real world, reciprocity is unbalanced. For example, while there may be no observable benefit to the local community, the researcher gains credit and publications abroad for their own benefit, whereas the community may be exploited and underpaid for their time and effort (Pearce et al. 2009). In addition, while the local community, their ancestors,

and cultural objects are the subjects of the research, the parachute scientist often seeks a short-term perspective, focusing solely on data collection before leaving – ignoring the importance of engaging and building the research capacity of local communities, as well as empowering them or transferring skills and knowledge necessary for conservation or research on their own heritage (Mwampamba et al. 2022). This may result in exploitative relationships and continued reliance on outside specialists.

Furthermore, the "parachute scientist," as mentioned in the introduction, may disregard locals' knowledge and experience, which will result in lack of cultural appreciation. Furthermore, there have been cases where local researchers were excluded from the research process, resulting in further disruption, disrespect, and harm to the local community (Miller et al. 2023). That is why, in terms of research ethics, it is critical that the practices and procedures are fair, transparent, and involve all stakeholders. In the context of archaeology, parachute science may result in the forced removal of cultural objects and remains without consent for research purposes, at the expense of the local community's heritage (Genda et al. 2022). This concern is also relevant to aerial digital archaeology, in which data are acquired without consultation with the local community and placed in databases that preventing future access and limit local research opportunities (Gupta & Nicholas 2022).

While the parachute-scientist mentality should be eliminated, it is also important that, when visiting the host country to conduct research, the focus is not on the researcher's knowledge of the subject, but on the locals' knowledge of it. For example, early interpretations of Peru's Nazca Lines, based solely on aerial observations, focused on astronomical alignment. However, additional research and collaboration with local communities revealed a possible link to water rituals and pilgrimage routes (Scire et al. 2016). Similarly, the study "Geoglyphs of Kazakhstan: Aerial Surveys" identified geometric earthworks in Kazakhstan which were initially interpreted as defensive structures. Later research, based on local knowledge, suggested they could be ritual sites or animal enclosures (Shaygozova et al. 2018). As a result, it is critical not to fall into the trap of ignoring local knowledge when there is a need to engage with it, and local participation, consent, knowledge, and input should be valued and acknowledged when publishing.

The seriousness of research-ethics issues should not be overlooked or minimized. It is critical that, as a host nation and local community with strong ties to cultural remains and objects, collaboration and equal engagement take place – particularly when the foreign expert is unable to take charge of the research and the local researcher must assume responsibility (de Vos & Schwartz 2022). Researchers and research findings published in international peer-reviewed journals may shape the discussion about certain cultures and traditions to a significant extent, because people expect that proper scientific processes and procedures have been followed. However, as mentioned above, loopholes remain – often due to a lack of personal conviction in some cases. If taken lightly, the scientific production of knowledge, particularly in the case of archaeology and parachute science,

will inevitably continue to suppress the authenticity of local perspectives from a Western or European point of view. This happens because such narratives dominate international forums, while local communities and researchers are unable to contest or challenge them. This is unfair because as hosts, the local actors should be able to share their own meanings and interpretations of their history. Without knowledge and technology transfer, developing countries will continue to face the phenomenon of parachute science and the dominance of the powerful few – an enduring global phenomenon of the West's so-called civilizing – and colonizing – mission.

Digital archaeology is becoming increasingly popular among researchers because it can be used for 3D scanning, while other modes include drones and photogrammetry, all of which are applications and digital tools that can be used to document, analyze, and locate archaeological sites. In comparison to humans, these tools can provide more detailed records, enable remote access, and are highly reliable (Campana 2017). For example, in aerial archaeology, photography, remote sensing techniques (e.g., LiDAR), and drones can be used to conduct landscape surveys and map landscape and features. These data can be important and useful, even uncovering information that traditional topographic studies have missed, providing breakthrough findings that offer a comprehensive explanation of the past. The approach is convincing and quick, and it can also save money on human labor. Additionally, there is almost no need for local community assistance (Hill et al. 2020).

Particularly in the field of digital archaeology, parachute science raises several ethical concerns, including the lack of local access to documentation and interpretation using digital tools, unequal access to technology due to its high cost, and the effort required to utilize such tools. Data ownership also remains an important issue, as the host community may not be able to control with whom data are shared or how they are used (Dennis 2020). It is important to note that digital devices make it easier to analyze and interpret data, but they also make it easier to ignore or overlook the inclusion of local input in digital documentation. Furthermore, the publication of findings becomes more accessible to larger audiences and communities, which may lead to incorrect interpretations of a culture's history and identity (Olsen & Witmore 2015; Richardson 2018). It is also important to note that the local community has the right to know about the researcher's activities, and research should not be carried out without the local community's awareness and consent, which is one of the overarching principles of research ethics (Gupta et al. 2020).

Having said that, actor-network theory can be used to understand and investigate the nature of 'parachute science' – which violates research ethics – its causes, and its relationship to technology. First, it is noteworthy that narratives such as "this or that archaeologist or historian said this about the past or made a breakthrough through their discovery" are usually treated as final and complete. The human factor here is significant. However, according to actor-network theory, achievement or breakthrough

extend beyond humans and include technology and material things as actors. It argues that without excavation tools – be they a pickaxe or modernized equipment such as LIDAR – demonstrating the influence of technology, a specific scientist or historian may be unable to determine the result (Collar et al. 2015). In other words, data are the result of a network, not a static or passive product.

Moreover, each digital technology differs from the others, providing different information, and having different capacities and limitations. While the archaeologist or historian decides whether to use one or more pieces of equipment, the timing and the environmental conditions of the survey or excavation will also vary accordingly (Ibid.). It is important to note that data produced by digital technology, including aerial archaeology, are not objective, and that many factors can influence data variation as a result of the network's involvement. In other words, there is no single, objective path, but rather a network-influenced perspective, specific to the time, place, and people involved (Law 2007). As a result, believing archaeological data and research findings generated by aerial archaeology to be final and complete is incorrect. Rather, such results provide only one finding or interpretation among many others.

While scientific in nature, data, findings, and knowledge are culturally or socially specific. Researchers from the West, for example, have been raised in a specific educational system, exposed to specific technologies, and shaped by a different environment. In developing countries, however, access to education, technology, and research infrastructure, particularly in cultural research, may differ significantly (Carvalho & Agosto 2023). As a result, when a foreign researcher or archaeologist conducts research in the developing world, informed by the norms of their own society and technology, these factors will inevitably influence the subject matter being investigated. Whether the object of study concerns human remains or an artefact, it will be influenced by their research procedures and the equipment used, demonstrating the construction of knowledge or subjective truth, which should not be considered an absolute truth for the local in any way, shape or form (Morgan et al. 2015). It is important recognize this network connection that demonstrates the power dynamic, because actors, both material and nonmaterial, will influence knowledge production and data. Those who are ahead of the curve, have an advantage, or exercise control over this network will have a greater say in knowledge production. The omission possibilities for local input, acknowledgement, or contribute casts further doubt on the results of the archaeologist's investigation, which may ultimately constitute a finding devoid of accuracy.

To be more specific, digital archaeology and aerial digital archaeology are new technologies that allow researchers to approach the subject, collect data, analyze it, and interpret it digitally (Caraher 2019). Aside from ethics or parachute science, the digital tool itself is not free from the networks and assemblages in which algorithmic bias could be present, because engineers and experts from a certain society created the tool for others to use. As a result, when algorithms are fed a single subjective data set, and

when the data are biased, the system is inevitably biased and leads to a discriminatory outcome (Armitage & Fraser 2023; Östborn & Gerding 2014). It cannot be assumed that interpretation of data from these tools yields an objective truth. For instance, an aerial survey may show that the Banteay Chmmar temple has a waterway that appears to serve ordinary irrigation purposes; however, it was later discovered that the waterway also served as a route for moving stone to construct the temples (Evans & Moylan 2013; Uchida et al. 2023).

Furthermore, with influence and power over the network, parachute scientists may travel to developing countries to conduct experiments or tests on other cultures' objects. Such experiments may or may not be beneficial, but the local community may be unable to reject them due to a lack of research capacity, knowledge, or leverage (Huggett 2021). In the absence of consent, with indifference towards and pressure on the local community, these factors contribute to the formation of network assemblages that, according to actor-network theory, remain concealed and unacknowledged – despite the fact that the truth or data being distributed or interpreted are merely subjective, yet erroneously believed to be objective (Durepos & Mills 2012).

Additionally, not adhering to or exploiting an ethical code is almost like having an innate desire to dominate others or pursue one's own interests at any cost, which will inevitably harm others. Without proper consideration of the code of conduct and research ethics, and if the host lacks sufficient capacity or ignores the monitoring and evaluation of the foreign scholar's research ethics, scientific colonialism will undoubtedly persist. Taking archaeology out of context but still in connection with sophisticated non-material and material networks, for example, in Western society, data collected by archaeologists can be used or shared for further analysis by other experts, such as chemists, mathematicians, engineers, and doctors (Niccolucci 2020). Data samples from developing nations can further contribute to and strengthen the sophisticated network of knowledge production in the West; those who are more knowledgeable advance further, whereas those with limited learning capacity are unable to participate in knowledge production. This also implies that Western nations may continue to dominate both material and non-material resources, as well as power in the network and its assemblage.

Furthermore, in the world of foreign affairs, information can be used for a covert mission, and an archaeologist can act as a spy for their host government, either directly or indirectly (Richter 2008). Particularly, the dual use of digital technology, such as aerial surveillance, will undoubtedly raise concerns. These interconnected webs of complexity should not be taken lightly, and it is important to remember that there is no objective truth based solely on findings or data.

To address the abovementioned issues, a proper ethical code must be implemented, and ethical approval must be obtained in the host country, rather than relying solely on the laws and institutional policies of the researcher's home institution (Haber 2016). Additionally, research must be conducted more closely, collaboratively, and in accordance

with local standards, to satisfy ethical requirements. This allows the local populace to actively engage in subsequent endeavors, exert influence over the network, and ultimately move closer to objective data, revelations, and the truth. Further emphasis should be placed on the transfer of technology and knowledge through support for local communities and researchers as they investigate and study their own civilizations and artefacts within the confines of their own networks and understanding.

VII. Conclusion

This article has argued that, while digital technology – particularly aerial digital technology – has been extremely beneficial to the archaeological profession, it is not neutral. Actor-network theory is a valuable tool for dissecting ostensibly objective narratives about archaeological discoveries, especially in the field of digital archaeology. Actor-network theory exposes the intrinsic subjectivity of knowledge generation by dispelling the illusion of a single actor (the archaeologist) and identifying the extensive web of material and non-material factors that impact the research process. This integrated network encompasses not just the archaeologist's expertise, but also the excavation instruments (from pickaxes to LiDAR), technology (drones, software), and even the researcher's cultural heritage. Each factor influences the data collected, the interpretations made, and, ultimately, the 'truth' presented. In other words, data are not simply the result of network scientific investigations, but are created by a network of human and non-human actors. To examine ethics, it is also necessary to comprehend the implications of these networks, particularly when technologies are used in the third world without being recognized or integrated into the research process.

The author also believes that the existing ethical framework for digital archaeology and areal digital archaeology is limited, underexplored, and does not fully account for the asymmetry inherent in these technologies. Algorithms and technology systems have the potential to lead to digital colonialism and contribute to the historical pattern of developing-world exploitation through extraction and exclusion. In this respect, ANT demonstrates that, while these appear to be regular functions of the archaeological process, activities such as surveying timelines, tool selection, and data ownership all contribute to a stronger system of epistemic and knowledge inheritance and control. It is vital to emphasize that, while these technologies are celebrated for their precision and apparent movement toward greater accuracy, they also have culturally sensitive impacts and limit local involvement. This will further widen the gap between foreign and indigenous knowledge.

It is noteworthy that, although aerial digital archaeology is non-destructive, it can result in a form of invisible extraction in which local cultural knowledge, meanings, and beliefs are excluded because the processes of scanning, recording, interpreting, and storing data can be carried out entirely by foreign experts who own the tools. If such

limited local involvement continues unchecked, it will undoubtedly reduce the value of local culture and civilization.

That being said, it is critical to recognize the importance of data control and integration, as well as the access issues that technology contributes to and dictates, which in turn determine how it should be used to address new ethical challenges. Given this pressing concern, a sound and proper ethical code of conduct is required to reimagine and re-network the relationship between foreign experts, local communities, and digital technology. Until then, aerial digital archaeology risks becoming another field that contributes to the neocolonization of science under the guise of technological progress.

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