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Using photography in history of science and technology: a methodological proposal

Utilizando la fotografía en la historia de la ciencia y de la tecnología: una propuesta metodológica

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Abstract:
Photography has been used to record different features of human societies since its invention in the first half of the nineteenth century. After years of being used as an illustrative tool in history, photography conquered its place as a primary source since the mid-1980s. In this article I add to this debate with a methodological approach to use photography in history of science and technology (including medicine and engineering). I argue that photography offers an exclusive view to understanding how science and technology were implemented, used, represented, and presented to the public. I offer both practical guidelines and a theoretical framework, based on Barthesian semiotics. I claim that this proposal has the potential to be used as a common denominator between assorted photographic collections and therefore to allow broader comparisons across different historical and geographic contexts. Moreover, it promotes the critical view of photography that should not be taken by its face value, but it should be understood within its sociotechnical and technoscientific context. I focus on photographs from the late nineteenth and early twentieth centuries, but this approach may be applied to more recent photographic collections. This reflection certainly has its limitations and shortcomings, and it is naturally open to improvements, through its practical application to photographic collections.

Resumen:
La fotografía se ha utilizado para registrar diferentes rasgos de las sociedades humanas desde su invención en la primera mitad del siglo XIX. Después de años de ser utilizada como herramienta ilustrativa en la historia, la fotografía conquistó su lugar como fuente primaria desde mediados de los años 1980. En este artículo me sumo a este debate con un enfoque metodológico para utilizar la fotografía en la historia de la ciencia y la tecnología (incluidas la medicina y la ingeniería). Sostengo que la fotografía ofrece una visión exclusiva para comprender cómo se implementaron, utilizaron, representaron y presentaron la ciencia y la tecnología al público. Ofrezco tanto directrices prácticas como un marco teórico, basado en la semiótica barthesiana. Sostengo que esta propuesta tiene el potencial de ser utilizada como denominador común entre diversas colecciones fotográficas y, por lo tanto, de permitir comparaciones más amplias entre diferentes contextos históricos y geográficos. Además, promueve la visión crítica de la fotografía que no debe tomarse por su valor nominal, sino entenderse dentro de su contexto sociotécnico y tecnocientífico. Me centro en fotografías de finales del siglo XIX y principios del XX, pero este enfoque puede aplicarse a colecciones fotográficas más recientes. Esta reflexión ciertamente tiene sus limitaciones y desventajas y, naturalmente, está abierta a mejoras, a través de su aplicación práctica a las colecciones fotográficas.

Palabras clave: Metodología; Ontología; Historiografía; Fuentes.

Keywords: Methodology; Ontology; Historiography; Sources.

1. Introduction

Until the mid-1980s, photography was used in historical studies as a mere illustrative tool that accompanied the narratives, reflections, and conclusions supported by written sources (Geary, 1986, p. 91; Tucker and Campt, 2009, pp. 2-3). Since then, many historians have been using photographs as primary sources in different fields, like colonial and post-colonial studies (Landau and Kaspin, 2002; Ryan, 2013), architecture (Nilsen, 2013), media (Leonardi and Natale, 2018), urban studies (Männistö-Funk, 2019), war (Brothers, 2011; Oldfield, 2019), and transportation (Pereira, 2022b).

In this article, I propose a methodology to use photography in studies of history of science and technology (encompassing medicine and engineering) that contributes to understand the sociotechnical complexities (comprehending cultural, economic, and political factors) of the implementation of technoscientific systems and practices in a historical perspective, and to allow broader comparisons between different geographical and historical contexts. Although my emphasis is on photographs from the late nineteenth and early twentieth centuries, this methodology can be used with more recent photographs of science and technology, despite the different technologies used in cameras, lenses, films, and printing and circulation of photographs.

Photography has been recording numerous features of human societies and history since its inception in the 1830s, from mundane affairs to leisure, military actions and, of course technoscientific transformations. Since then, several technical improvements in cameras, shutter speeds, film, lenses, colour, development, and other equipment increased the transportability and decreased the cost of photography, rendering it accessible to increasingly larger groups of people (Fang, 1997, p. 121; Freund, 1980, pp. 19-94). Throughout the decades a massive universe of photographs was assembled, a large part of which is available to historians in archives, digital repositories, illustrated journals, or social media, encompassing varied historical periods and geographical contexts.

For the purposes of this article, I wish to underscore the following aspects related to the history of science and technology, which can be observed and analysed in photographs, even if the original goal of the photographer was not to capture them, but to portray other details or perspectives (Männistö-Funk, 2019; Männistö-Funk, 2020, p. 172): (1) the varied dimensions of the implementation and use of science and technology: construction, implementation, operation, utilisation, experimentation, application in war, leisure, sports, tourism, transportation, healthcare, dissemination, outreach, research, urban planning, etc.; and (2) representations, perceptions, narratives, social constructs of science and technology in a historical perspective.

These elements provide the ground to the analysis undertaken in studies of history of science and technology. Before that, it is important to define what constitutes images of science and technology, and the associated fields of medicine and engineering. I recognise that any distribution of iconographic data based on these concepts is controversial, considering that they cannot be easily identified. In any case, categorisations are needed to make data discernible. I propose the following classification:

- in science, I include activities, events, uses, or infrastructures committed to research, education, or dissemination (laboratories, schools, universities, museums, conferences, experiments, fieldwork, etc.).
- technology comprehends artefacts, tools, or products (machinery, weaponry, vehicles, industrial products, etc.).
- engineering includes public works, technical systems, or infrastructure (bridges, viaducts, train stations, roads railways, assorted buildings, etc.), both during their construction and operation
- finally, in medicine I place those photographs that have some or all the characteristics of the previous categories, but in the context of human healthcare (hospitals, nurseries, spas, etc.).

2. Collecting and organising the sample

In the previous section I offered a broad overview of the importance of photography for the field of the history of science and technology (including medicine and engineering). Researchers and research projects will most likely focus on one of those categories or in a particular topic therein. Regardless, the methodology is roughly the same. The key factor is that the photographs selected for the analysis share a common ground: the same author, the same support (e.g., an illustrated journal or an album), the same topic, a given historical period, and so forth. Any common ground is acceptable, provided that the researcher provides an adequate and plausible justification. I recommend that three principles used in content analysis are followed (Bardin, 2013):

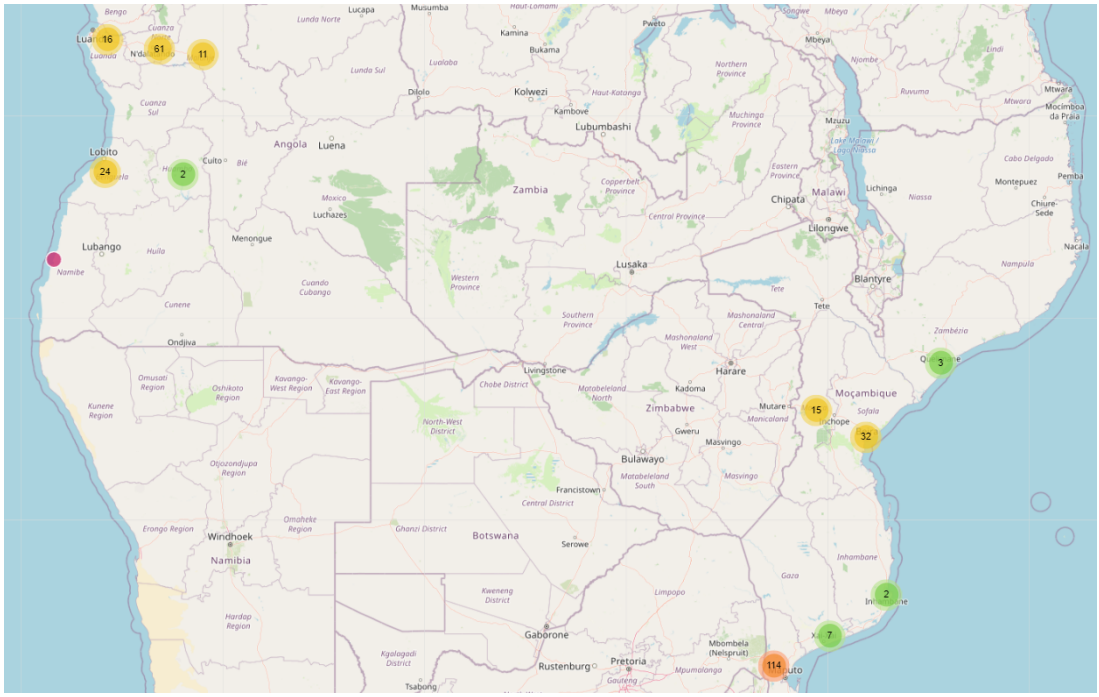
- pertinency: the photographs are adequate to the goals that prompted the research)
- homogeneity: of the selection of images
- comprehensiveness: all pictures should be analysable, that is, they should have enough contextual information about their origin and scene depicted; in other words, free-floating photographs, that is, those whose objectives and contexts of production are unknown, should be avoided (Giebelhausen, 2013, pp. 105, 118)

Once the topic is defined, it is necessary to select the photographs and assemble the sample in a database with the following metadata:

- original caption (as in the source)
- given caption (by the researcher)
- date (when the photograph was taken or published)
- location (country and city)
- geographic coordinates (latitude and longitude)
- author (of the photograph)
- people portrayed (names, professions, ranks, gender, etc.)
- categories (limited list of terms that fundamentally characterise each photograph within the sample, namely science, technology, engineering, and medicine)

- keywords (additional terms that contribute to characterise the photographs)
- source (where the photograph may be found)
- support (gelatine, collodion, albumen, paper, etc.)
- observations

Some of these fields are self-explanatory, but others require an additional reflection. It is the case of the geographic coordinates, important elements to present the data in a visual format. With this information, it is possible to illustrate the geographic distribution of an array of photographs in a map (F1). There are different ways to do so, Google Maps arguably being the easiest and most accessible technical solution. For these reasons and considering the importance of the geographic dimension of photography (Schwartz and Ryan, 2003), this data and the possibilities it opens is a central feature in databases of photography.



F1. Distribution of photographs of railways in colonial Angola and Mozambique found in Portuguese archives and periodicals (1880-1914). Source: STEMgram (https://stemgram.pt/). © STEMgram

The definition of categories is done after a systematic observation and visualisation of the sample to distribute the photographs in groups with similar characteristics (Benetti, 2007, pp. 112-113; Possamai, 2008, p. 260).

For instance, for a broad analysis of photographs in the press, one may divide the sample in the abovementioned categories of science, technology, engineering, and medicine; for narrower collections, like groups of photographs of railways, one may highlight the objects or structure depicted and divide the images in categories of stations, engineering works, and rolling stock; or one could underpin the stage of the life of the infrastructure and classify the pictures depending on whether they depict the construction, the inauguration, or the operation. Keywords act here as subcategories, and they contribute to fine tune the characterisation of each photograph in the collection.

In this vein, it is crucial to consider the original caption that immediately directs the gaze of the observer to a particular object, person, or representation that the photographer, the publisher, or the archivist wished to underscore (Burgin, 2009, p. 33; Franklin et al. 1993; Landau, 2002, p. 15). This element is central to determine the category that better suits each photograph, as well as its defining keywords. A photograph may contain assorted elements that can place it in different categories, but usually there is a particular that prevails over the others (Jackson, 1984, p. 12). The caption helps to determine that element, by telling which the author, publisher or archivist of the photograph valued the most. I will return to this topic further down this article.

The remaining fields are meant to facilitate the process of querying or searching the database and to allow for a statistic treatment of the sample (prevalence of a given category, frequency of photographs from a given author, distribution of the images throughout the period, etc.), although some of them are also used in the interpretation of the photographs, as I will explain shortly.

To conclude this section, I add that this process of cataloguing and databasing groups of photographs offers a shared platform for multiple selections of images, allowing comparisons across different geographical and historical technoscientific contexts and a therefore a better understanding of a global history of science and technology.

3. Interpreting the sample

Photographic analysis is not an easy or straightforward process, as photography is a "message without a code", as French philosopher Roland Barthes (1977, p. 17) described it. Although presented and accepted as an objective practice and product that depicted reality as reality was, photography is a subjective activity, influenced by the goals and technical choices of the photographer. This subjectivity is more evident in older photographs, taken by cameras with low shutter speeds, that required people to stand motionless for a few seconds, which hints that a high degree of staging was present. What is more, as a visual expression, photography, besides representing existing knowledge, also created knowledge, representations, and values (Daniels and Cosgrove, 1988, p. 1; Daston and Galison, 2007; Drucker, 2014, pp. 11-38; Ryan, 1997, pp. 149-165). In this sense, photographs became

> enigmas, problems to be explained (...) they must be understood as a kind of language instead of providing a transparent window on the world, images are now regarded as the sort of sign that presents a deceptive appearance of naturalness and transparency concealing an opaque, distorting, arbitrary mechanism of representation (Mitchell, 1976, p. 2).

For these reasons, the interpretation of photography as a historical source demand that some rules and principles are followed. In this vein, as I will explain below, the Barthesian approach still has many valid suggestions and recommendations that contribute to grasp how technology and science are presented to and represented by society and to understand the implementation of technoscientific structures and practices in a particular territory and historical period.

Although proposed half a century ago, the vitality of the semiotic analysis of photographs is noticeable in recent literature that uses and revisits it. For instance, in 2000, French writer Renaud Camus (2000, pp. 112-113) underscored the necessity of going back to Barthes to analyse photography and representations and levels of speech associated with it, while French

journalist and photographer Hervé Guibert (2000, p. 117) emphasised the intuitiveness of Barthes's thoughts for the study of photography. More recently, Australian art historian Geoffrey Batchen (2009) gathered different works reviewing Barthes seminal work, *Camera Lucida*, evincing its present utility and durability. I have also relied on Barthes teachings to analyse sundry aspects of the construction and operation of large public works in the late nineteenth and early twentieth centuries (Pereira, 2022a; Pereira 2023).

For the methodology, I propose in this article, one central Barthesian understanding is that photographs contain two messages: the denoted message, which is an analogue of reality, and the connoted message, which refers to how societies represent reality – or how abstract values like progress (a common concept in history of science and technology, usually connected with technoscientific innovations) are physically portrayed (Barthes, 1977, p. 17; Osborne, 2003, p. 164). Associated with this division, Barthes (1972, pp. 109-156; 1977, p. 37) identifies three distinct elements in photographs: the signifiers (the objects or characters photographed, hinting at the denoted message), the signifieds (the representation that is carried out, roughly the connoted message), and the signs (the myth constructed by those compositions).

The identification of the signifiers is important for the stage of categorisation of the photographs. The signifiers offer the first glimpse into which category each image should fit into. Here, Barthes (1981, pp. 26-27) adds another important theoretical reflection with that element he called the "punctum", that is, the detail which holds a higher value in the image and "rises from the scene, shoots out of it like an arrow, and pierces" the mind. The caption of the photograph influences the "punctum" for the reasons I mentioned above; but for an historian of science and technology the detail that holds the higher value in a photograph may very well vary from that which caught the attention of the photographer or the writer of the caption. Figure 2 provides a good example. The original caption and the composition of elements in the photograph highlights the human figures therein; but an historian of technology would likely be more interested in the bicycle on the right side of

the picture (its design, its user, how often other bikes appear in the same sample, etc.). That would be the "punctum" and the main signifier in the image that would place it in a category of urban mobility or soft mobility, for instance.

This is another important feature of photography when it comes to studying history of science and technology: photographs offer visual materialisations of structures and objects that cannot be found in written sources. In this sense, they provide a different perspective, for example, for the analysis of the use and the role of users in the co-construction of science and technology, that is, how users and technology mutually shape each other, including the tensions, conflicts, hierarchies of power between the actors involved in technological development and utilisation (Oudshoorn and Pinch, 2003).

F2. Afbeelding van een groepje poserende personen op de Om 't Hof te Montfoort (Image of a group of posing people at the Om 't Hof in Montfoort). Source: Het Utrechts Archief, Netherlands, 12473 (https://hetutrechtsarchief.nl/beeldmateriaal/detail/89f59b4c-d1a7-5497-b588-e1b93467e650). Public domain

The composition of a photograph may also illustrate the representations behind science and technology, by showcasing, for example, new

institutions/infrastructure/vehicles/practices side by side with older institutions/infrastructure/vehicles/practices that the former will replace.

The photograph in figure 3 (taken by German photographer living in Portugal Karl Emil Biel) shows the complex and gravity-defying arch of the new bridge Louis I in Porto (Portugal) standing alongside and overwhelming the old suspension bridge Mary II, inaugurated forty years before. The new bridge under construction pierces the viewer's attention and is the main detail that influences the categorisation of the photograph. Moreover, the choice of including the old alongside the new should not be considered accidental. It is "a way of moving into the future by reorienting oneself to the past" (Kelsey, 2016, pp. 80-81), to show the modern replacing the ancient, in sum to illustrate modernisation and progress. Similarly, the composition of the image (namely the angle that underscores the massive steel structure of the bridge) transmits the sublime associated with technology and science (Kasson, 1976, 162-180; Nye, 1999, xiii-xv). The technological sublime that underscores the pleasure of watching a working machine and the inventiveness of humankind to rule over nature is a well-known concept in history of science and technology that photography illustrates perfectly. Proposed by American cultural historian John F. Kasson in 1976, it is a concept common to and easily identified in different historical and geographical contexts. that has been naturalised throughout the decades and that is still noticeable today in the debate and implementation of technoscientific programmes or infrastructure.

Identifying the signifieds (the connoted message or the representations in each photograph) requires more than just the observation of the photographs or the inspection of the "puncta", considering the historicity of the connotation code, that is, how it is influenced by the historical context. The signifieds carry the sociocultural representations of the scene portrayed in the photograph. To examine those representations accurately, it is necessary to analyse the context (sociocultural, political, technoscientific) of the photograph – what Barthes (1977, p. 28; 1981, pp. 26-27) calls the "studium".

F3. Pormenor das obras de construção da ponte Luís I, vendo-se ainda a ponte pênsil, 1883. (Detail of the construction works of bridge Louis I, the suspension bridge still visible. 1883). Source: Arquivo Municipal do Porto, Portugal, PT-CMP-AM/PRI/EBC/F.NV:1-EB:12:4 (https://gisaweb.cm-porto.pt/units-of-description/documents/404029/?). Public domain

The most immediate level of the "studium" includes knowing the authors of the photograph, their commissioners, the probable audience/consumers of the image, and the motivations for taking the picture. Knowing the author of a source is a rule of thumb in content analysis in historical research (Bardin, 2013), although that information is sometimes unavailable, especially in older photographs. The motivations, commissioners, and audiences are more troublesome to ascertain, but they are connected to the photographer professional status. Were the photographers engineers, wishing to illustrate the evolution of their works and, consequently, their expertise to investors or policymakers? (Oliveira, 2018) Were they freelancer professional photographers hired by public works companies seeking to advertise their projects? (Baillargeon, 2013) Were they hired by illustrated newspapers who relied on the predominance of image of any kind to sell issues in a growing

visual economy composed of communities of consumers who craved for photographic testimonies? (Campbell, 2009, p. 53; Costa and Serén, 2004) Did they expect that their photographs were seen by the community at large or were they just for the eyes of a limited number of people? Depending on these details, each photograph must be analysed differently: an engineer with a camera sought different scenarios than a photographer working for the press; furthermore, they will have different audiences, as I will explain in section 5 of this article.

A broader area of the "studium" encompasses the sociocultural and technoscientific environment where the photograph was taken and published. This can be grasped in three different levels.

The first level considers the materiality surrounding the photograph, that is, the material characteristics of the group where a particular image is found. Photographs seldom appear isolated and decontextualised; most of the times they are inserted in larger groups, either in the archives, in private collections, in albums, in written publications (reports, books) in the press, or in social media. The organisation of the photographs in these collections has meaning, as it influences how images are viewed and interpreted. The same photograph has a different impact whether it appears alone in one page of an album or together with similar images in the page of a newspaper. This material organisation creates narratives, which may illustrate a journey across a territory (e.g., images of military campaigns) or across time (e.g., pictures of the construction of large engineering works). These narratives are not accidental, they hold meaning which should not be undervalued in historical analysis (Edwards and Hart, 2004, pp. 3 and 11; Heintze, 1990, p. 132).

The second level includes written documentation of the same period (parliamentary debates, technoscientific reports, legislation, private letters, the press, etc.), especially that which accompanies the photograph. Photography is intimately linked to discursive and textual forms produced by agents and institutions of the same historical timeframe, therefore, analysing written sources is an essential task. Moreover, comparing photographs with

associated texts minimises the influence of the observers' own preconceptions and brings them closer to the representations (the signifieds) embedded in the image (Barthes, 1977, p. 16; Daniels and Cosgrove, 1988, pp. 1-2).

The last level includes the literature on the topic that is being analysed with photography. History of science and technology of the nineteenth and twentieth centuries is arguably one of the most fruitful subfields of history, with varied approaches to different topics of science, technology, engineering, and medicine, either in regions of the technoscientific centre or in those of the periphery (Diogo et al., 2016). What is more, history of science and technology in Europe has been thoroughly analysed in the *Making Europe* book series, covering assorted perspectives from infrastructure to communications, technical standardisation, experts, and users (Fickers, 2020). My point here is that there are currently numerous books, edited volumes, articles, dissertations that discuss different aspects of the history of science, technology, engineering, and medicine in Europe (and outside Europe) that offer systematic knowledge to understand the technoscientific contexts of photographs of science, technology, engineering, and medicine.

For example, figure 4 shows a photograph of a medical appointment in Ozerne (present-day Ukraine). It is part of an album illustrating the activities of the Royal Cultural Foundation Prince Carol in Basarabia (Romania). Its interpretation cannot be dissociated from the interpretation of the album. Recent literature underscores the varied activities of that foundation (from training and education to art, heritage, and healthcare) fostering the sense of community and national unit in the region (Noroc, 2023). Therefore, the photograph may me interpreted as a tool of propaganda of the foundation and a promotion of healthcare, besides illustrating medical practice in interwar Romania.

In practical terms, the task of detecting the signified does not require the analysis of the full sample, unless, of course, the number of items therein is not overwhelming. In larger selections (recommended), after a systematic observation, representative images of each category (see above) should be

chosen to conduct the task of identification of the signifiers. This selection should then be the subject of an iconographic examination that looks for the prevalent representations of science and technology within the photographs (Benetti, 2007, pp. 112-113). This task should be conducted together with an analysis of the "studium" so that the signifieds are labelled correctly (as explained above).

F4. Consultație de medicină umană, Babele (General Averescu), Ismail, Basarabia, 1936-1939 (Medical appointment, Babele (General Averescu), Ismail, Basarabia, 1936-1939). Source: Dimitrie Gusti National Village Museum, Romania, 7300300, Clișoteca, 000228 (https://culturalia.ro/entities/83538e42-5a4a-4eaf-ada7-3c2a839f5614/view). Public domain

The repetition or accumulation of signifieds brings the researcher closer to the signs or the myths associated with photography and illustrates photography's ability to create ideology and legitimate systems, including those of a technoscientific nature (Kelsey, 2016, p. 90; Weiss, 2020, p. 743). For instance, a selection of photographs depicting locomotives, train stations, and engineering works in the colonial context may convey representations of speed, technical ingenuity, or urbanism and the overall myths of "progress", "civilisation", and "domestication". This reflection brings me to a different

concept which I find useful in the relationship between photography and history of science and technology: landscape.

4. Technoscientific landscapes

In 1973, Welsh academic Raymond Williams supported the necessity of relating architecture, gardening, and landscape painting with the history of their territories and societies, presenting landscape as a social construct, and opening avenues of research for social scientists to investigate landscape. A few years later, American writer and publisher John Brinckerhoff Jackson (1984, pp. 5-8) theorised two distinguishing characteristics of landscape: "a degree of permanence, with its own distinct character, either topographical or cultural, and above all a space shared by a group of people"; and "a human-made system of spaces superimposed on the face of the land functioning and evolving not according to natural laws but to serve a community". American historian of technology David Nye (1999, p. 3) added to the debate the role of technology in shaping the territory to meet the needs of its dwellers. Finally, English art historian John Taylor (1994, p. 12) emphasised the importance of sight in the construction of landscapes.

Departing from the latter reflection, German social historian Jens Jäger (2003, p. 121) and American historian of photography Robin Kelsey (2016, p. 71) argued that landscape as a cultural representation, as a practice, and as a social construct has been greatly influenced by photography. If sight is essential to the construction of landscapes, photography, with its accepted objectivity, contributes to define them as objective facts. Additionally, by focusing on specific features of land, photography can generate specific landscapes, in line with those elements that the photographer decided to underscore: urban landscape, rural landscape, academic landscape, and, of course, technoscientific landscape (Pereira, 2023, p. 742).

Technoscientific landscapes created by photography are those where technoscientific structures, artifacts, or practices prevail, in cohabitation with human and non-human elements (animals or landforms). They should not be

limited only to those scenes of engineering prodigies; they also encompass smaller works, prosaic artefacts, or everyday activities of science, technology, engineering, and medicine (Macedo, 2012, pp. 17-18; Spero, 2013).

Here it is important to note that landscapes and technoscientific landscapes are also imagined landscapes. They embody the perception and the imagination of the photographers and their anticipations about what will emerge in the future, in technological and scientific terms (Ingold, 2012). What is more, through photography, they tend to be generalised and presented as an ever-present truth, although those photographs are merely small glimpses and narrow windows of reality.

I would like to conclude this section by pointing out that to an extent the creation of landscapes also entails the naturalisation of landscapes and with it the reification of abstract concepts. History of science and technology often has an interest on how novel infrastructures, institutions, or practices, albeit very disruptive, are presented as smooth additions to their surroundings; and, in the same vein, how abstract values are materialised in technoscientific achievements. It is the case of the concept of "progress" that any dictionary defines as a gradual betterment, but that throughout the years was linked and restricted to technoscientific development (Adas, 1989). Another good example is the concept of "civilisation". In the late nineteenth and early twentieth centuries, photography contributed to create the idea that non-European territories were not "civilised", as they lacked western science and technology; moreover, photography of western science and technology in the colonial settings supported the notion that imperial nations were "civilising" those same regions (Costantini, 2008; Hall, 2002; Jerónimo, 2015). Again, science and technology became materialisations of "civilisation".

In sum, photographs (and the landscapes they create) are valuable sources to analyse these questions as well as the role played by science and technology therein. Photography illustrates like any other historical source how technoscientific knowledge, artefacts, and infrastructure shaped the territory and its relationship with human communities, and how that shaping was

normalised and accepted by society. Hence, the importance of including landscapes and photography in discussions on history of science and technology.

5. Dissemination and circulation

When one wishes to discuss whether a decision has any impact one often asks: "if a tree falls in a forest and no one is around to hear it, does it make any sound?". A similar question may be posed regarding photography: if a photograph is taken and no one is around to observe it, does it carry any consequence? To this question, authors like Canadian geographer Brian Osborne or architect Trevor Pringle answer that icons and myths created by photography "must be revered to be meaningful and by a significant proportion of the populace" (Osborne, 1988, p. 172; Pringle 1988). These questions and insights bring me to another key feature in the analysis of photography as a primary source that should concern historians: photography's ability to circulate to travel and extend its impact to broader audiences (Edward and Hart, 2004, p. 1; Vicente, 2014, 339-340).

In the previous sections, I argued that photography has the potential to act as an ideological tool, but its potential to shape public opinion is only realised when it circulates in larger groups or, to use another metaphor, when photographs serve as vehicles carrying information, ideas, experiences, memories, representations, and myths between or within different communities. This is a comparison that will likely resonate with transport historians who often claim that the degree of accessibility to vehicles and transportation infrastructure carries different consequences for the evolution of territories and communities. Something similar may be said about the accessibility to photography, both as a user and as an observer. The capability to access this "vehicle" to produce narratives (by taking photographs) or the be influenced by those narratives (by visualising those photographs) should not be underestimated in historical analysis of science and technology (Pereira, 2022b).

With this I do not mean to imply that only those photographs that found their way to highways of communication and information are worthy of historical analysis. Those that circulated exclusively in stricter circles are also valuable for the study of the production of representations. The study of the circulation of photographs is important for a different reason, to understand which representations were disseminated more broadly (and which were not) and how myths and dominant narratives were created. Additionally, this impacts the photographic analysis, because one photograph should be interpreted differently whether it was taken to circulate communitywide or just for the eyes of limited circles.

The breadth and speed of circulation of photographs has been increasing exponentially since the invention of photography. For decades, photographs had to make their own circulation, as there were no technical and financially viable solutions to print copies. With the development of techniques such as the collotype[1], it became possible to republish photographs in albums that circulated in wider fora (Fang, 1997, pp. 69-76; Freund, 1980). For the purposes of this article, it is important to mention those albums of industrial photography (railways, engineering works, industrial sites, etc.), which became quite popular in the nineteenth century (Baillargeon, 2013; Oliveira, 2018). They often travelled to international events (especially World Fairs), showcasing the technological and industrial prowess of nations and engineering companies alike (Aimone and Olmo, 1993). Regardless, the circulation radius of these albums was limited, as they were very expensive to make (they were assembled to look like precious objects – Edwards and Hart, 2004, p. 11) and they were destined to the eyes of the elites (members of parliament, ministers, visitors of World Fairs).

In the press, at least until de 1890s, publishers relied on wood engravings to print replicas of photographs. A tracer drew a model of a photograph, which was cast by an engraver in a wooden block, which, in turn, was used to

[1] Process invented in 1855 by Alphonse Louis Poitevin, a French chemist, which was modified and developed by varied innovators in the following years. It allowed the reproduction of photographs in different tones by exposing glass or metal plates with gelatine sensitised with potassium bichromate under a negative (Defibaugh, pp. 2-3).

duplicate the original image. Any other technique was difficult and expensive. The tracer or the engraver often made small modifications in the replicas to increase its visual impact. The caption usually assured readers that the engraving was a reproduction of an original photograph, as to bolster its credibility (Beegan, 2008, 12, 156 and 177; Leonardi, 2018, p. 72), but the result was no more than a translation of the original.

By the end of the nineteenth century, the development of the halftone allowed the publication of photographs in generic newspapers and specialised press. In the halftone process, the photograph was photographed through a glass scored by a lattice of fine lines onto a layered zinc slab. The plate was outlined with acid to split dark and light zones. The latter, eaten away by the acid, did not attain the ink. With the halftone, images were presented and accepted as facsimiles of the original and not as the translations offered by wood engravings, although they were still subjected to a great deal of manipulation and retouching. The halftone merged photography and printing and paved the way for photojournalism well into the following century. Throughout the twentieth century, new innovations and machines hastened the publication and circulation of photographs in the press and outside the press, namely in the blogosphere and in social networks After World War II, periodicals switched to offset lithography and later to photocomposition, benefiting from additional technical innovations based upon the principles of photoelectricity, ranging from the copier, the laser printer, the facsimile machine, the computer, faxing, and the Internet (Beegan, 2008, pp. 15, 26, 135, 160, and 177-178; Fang, 1997, p. 54-55, 75-76, 217-224, 226-228).

The point here is that photography gradually became a part of daily life and helped readers and viewers to create and conceptualise society. Bearing in mind that photography is a product that can be consumed immediately, on a regular basis it transmitted, repeated, and reiterated glimpses of technoscientific modernity that, through accumulation, and “like the dots of the screen [...] provided a comprehensible picture of modernity” (Beegan, 2008, p. 23). Many platforms where photography circulated had a national

coverage; therefore, it may be argued that this "picture of modernity" was seen by thousands of observers at the same time, thus contributing to a uniformisation of public opinion, creating communities of individuals merged in the observation of the same images, sharing the idea of a presumed national community beyond their closer vicinities (Anderson, 1983, pp. 39-40; Beegan, 2008, pp. 1-3, 14, 21, and 23-24; Green-Lewis, 1996, p. 113; Tarde and Clark, 1969, pp. 297 and 318).

These are important remarks historians of science and technology should consider when analysing photography as a primary source, as they contribute to an accurate interpretation of the images that goes beyond their mere immediacy.

6. Conclusion

Proposing a methodological approach can be a troublesome and controversial task, considering that the approach, at least in its first iteration, will certainly have shortcomings. While understanding and accepting this fact, I counter that the methodology I propose in this article has enough merits to be applied efficiently, and that its weaknesses and shortcomings can be corrected through use and with time.

In my opinion, one of its strengths is its simplicity in how it applies semiotics to historical analysis of photography. Another advantage is its potential for making comparisons between different geographical and historical contexts. The database built with the fields I mentioned earlier offers a common denominator that allows such comparative studies regarding how science and technology were used, (re)presented, and advertised in different territories and timeframes.

In this respect, this methodology can be used to study the history of technology in Africa, a recent and emerging field in history of science and technology (Mapunda, 2023; Mavhunga, Cuvelier, and Pype, 2016). Originally a tool of empire that served the "civilising missions" of imperial nations to catalogue and advertise the population and landscape of colonial

territories, colonial photography has been used for a few decades to analyse its own role in the colonisation of Africa and Asia and to counter the imperial narrative. Likewise, those same photographs can provide glances of the technology and material culture of the colonised populations, refuting the imperial representation that Africa and Asia lacked technology, knowledge, and science. A different perspective is offered by collections of African photographers that may also be analysed using the methodology proposed in this article.

To conclude, I would like to add that the methodological approach I propose contributes to the debate and the use of photography as a primary source and underscores that photography should not be taken at face value but should be understood in the complex sociocultural interactions that were in its inception, including technoscientific utopias, political machinations, and hierarchies of power. To paraphrase Portuguese art historian Nuno Porto (2014, p. 494), a photograph is not worth a thousand words; it requires a thousand words to be fully understood.

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