Images as metadata: a new perspective for describing research data

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Abstract. Indispensable in many contexts, images are fundamental in the tasks of representation and transmission of information. In the scientific context, images can be tools for researchers seeking to see their data properly managed. Research data management guides in this direction as it determines necessary phases in the life cycle of projects. The description phase is fundamental as it is an essential means for data context, safeguarding, and reuse. The description often occurs through metadata models composed of descriptors capable of attributing context. However, there is one common aspect: the values associated with these descriptors are always textual or numeric. Through studies and work developed over the last few years, we propose a new approach to description, where images can have a preponderant role in the description of data, assuming the role of metadata. We present several pieces of evidence, point out their challenges and determine the opportunities this new perspective can have in the research. Images have specific characteristics that can be leveraged in improving data description. Historical evidence establish that images have always been used and produced in research, yet their representational ability has never been harnessed to describe data and give more context to the scientific process.

Keywords: Research Data Management, Images, Metadata, Description, Image as metadata

1 Introduction and Topic Identification

Images are dominant in communication and interpretation, and their abundance, diversity of origins, and diversity of holders create a multiplicity of practices regarding description, interpretation, and use.

Research Data Management (RDM) includes activities that organize and manage the life of a research project and is crucial for consistent work performance [8]. Some activities are related to the description, which is a fundamental step, since it allows data to be properly documented and interpreted, promoting their subsequent reuse and sharing. There are guidelines for research data

management, highlighting the most important aspects in each phase. In the description phase, one of the most important of RDM, the advantages of data description, as well as assisting tools are indicated. In the tools suggested for this phase, we find the metadata models, which are fundamental pieces for researchers who want to see their data properly described. However, this description is always oriented towards using text as metadata values. We believe that the exclusive use of textual description can be discussed, because, although the text is fundamental in the description and, therefore, should never be dispensed with, its use together with images can bring added benefits. This work puts into perspective how images can support research as metadata, contributing to the description and interpretation of data.

Given the importance of the image and its frequent inclusion in research, a set of general objectives have been defined:

- Show that the use of images as metadata can improve the description and interpretation of data,
- Present an innovative perspective for the description of data, highlighting the role of images in cognition and science.

2 Methodology

This work presents a new perspective for the description of data through the use of images and we decided to follow consistent methodological guidelines. We opted for an approach presented by the Journal of Biogeography[3], as it seemed to us that it well illustrated the objective of the work.

As shown in Figure 1, we start by identifying the topic under discussion and analyzing its current position. Next, a set of hypotheses that support the new perspective were defined. These hypotheses, as well as the need for a new perspective, emerged from the work carried out in recent years and support the idea that it is beneficial to include images and their potential in the data description process. Once the new perspective was defined, we identified the evidence that made it viable. Such evidence is supported by examples and relevant literature. As a final point in this process, it is important to clarify the strengths of the new perspective, without omitting possible weaknesses or increased challenges. The identified opportunities and advantages served as a basis to feed new positive implications in research.

The use of this methodology makes it possible to clarify the current situation, elucidate the existing limitations, show many evidences and examples, and, thus, strongly support the new perspective.

[3] https://journalofbiogeographynews.org/2021/05/22/how-to-write-a-great-perspective-article/

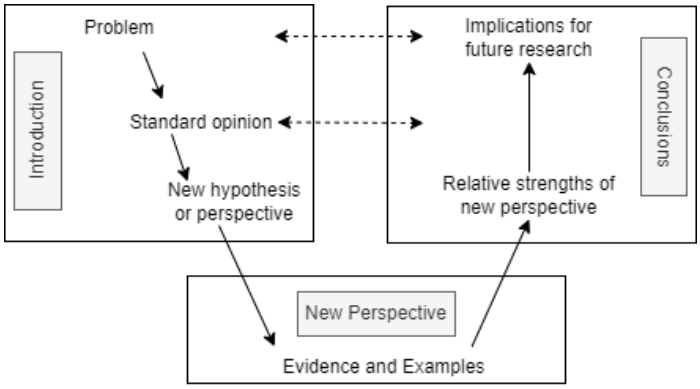

Fig. 1: Methodological Approach

Source: Adapted from the Journal of Biogeography, 2021
https://rb.gy/1r9g0

3 Data description in RDM: Standard Approach

In this section, we will present the current situation that opened doors to a new perspective. Understanding the current point it will be clearer to understand the importance of the new suggested perspective.

3.1 Contextualization

Research data management is a growing topic of discussion in the scientific context. RDM includes several phases that allow you to plan, organize, process, store, preserve, and share data. One of these phases includes data description. In 2016, with the dynamization of the FAIR principles, new ideas were discussed that could act as a guide for the management of research data [8]. Like other types of resources, images can be a part of these principles, whether in the data organization process, above all in the implementation of guidelines for accessing research results, fostering the entire Open Science ecosystem. The ability to make data findable, accessible, interoperable, and reusable can be promoted by including new perspectives, namely the use of images to describe data and improve its interpretation.

3.2 Data Description

A huge amount of data is produced daily, in different research contexts, and the description can be a fundamental piece in the project organization. Firstly, project researchers manage to have their data properly annotated, improving communication within the group and adding context to the data. Secondly, the description promotes the sharing, citation, and reuse of data, as interested parties

are able to retrieve/search more efficiently the data that are shared by their authors and can also more easily understand the context of the data and specific characteristics that only the analysis of raw data did not allow. These conditions encourage other researchers to cite the data more and reuse them for other projects [5].

The current requirements for open data in the European Union (EU) are increasing the awareness of researchers concerning data management and data publication [5]. Metadata is essential in research data management, namely in data discovery and reuse. The specialization of researchers makes them natural providers of domain-specific metadata, even more so in the long-tail of science [19]. As data creators, they have unique knowledge of the data production context, including domain-specific concepts and configurations used in the production of the data. Current practices tend to either leave metadata definitions to researchers or curators. The former typically results in ad-hoc descriptors, while the latter follows standards but lacks specificity.

Data descriptions produced by researchers were also found to be more focused on the details rather than on general features when compared to those made by information specialists, highlighting the difference between descriptions intended for personal archives and those meant for data repositories, with reuse in mind [26]. The relevance of RDM is visible in the growing body of studies in diverse areas, some with a focus on researchers' perspectives and practices regarding data organization and sharing, while others have a closer look at researchers' description practices.

Directives call attention to the need to describe data. The description process is fundamental in research data management. Many standards are used today to describe data. We have some of a more generic nature, such as the Dublin Core, and others specific to the domain, such as the Darwin Core and the Genome Metadata, within the scope of Biology.

Metadata models are important pillars in the description. They contain a series of descriptors/metadata that act as reference points on the data and allow circumscribing information about them. Metadata allows for classifying and organizing data, enhancing search and interpretation which, in turn, promotes citation and reuse. Metadata models can follow a pre-defined structure, however, new descriptors can be used in order to complement the description, until reaching the desired level of maturity [26].

In all cases of description, the options given to depositors refer to descriptors/metadata with textual or numerical values. Doing thorough research on the various deposit platforms this fact is easy to verify. At no time is the possibility included in one of the fields of the metadata model to include a value in image format. By this, we do not mean that the text must be replaced, but rather use the unique characteristics of the images as a complement.

3.3 Problem Identification

Images can be fundamental to describing data and should not be discarded. However, we believe that images can also be used as a metadata value, with text

not being the exclusive element for data description. Images are present in the context of research, so why not use this material to add value to the description of the data? In 2018 we began the in-depth study of images in the RDM and have carried out several studies in the context of images under research. In 2022 we reinforced the study on a new perspective of images as metadata, conducting a set of semi-structured interviews on how an image used as metadata can promote the description and interpretation of data. We use a simulated work task situation and a structured script as a tool. The results of this study will be published soon. However, we can say that all the interviewed researchers are interested in the use of images in the description of data. Incidentally, all researchers attest that they would do so if the deposit platforms allowed them. Most of the advantages pointed out are in the ability to contextualize the data, improving the understanding of the data, its framing and its interpretation.

We believe that this new perspective associated with images as metadata in research data management is extremely innovative and brings numerous advantages and challenges. RDM cannot be watertight. It must be evolutionary and changeable. If the tendency is to produce more images and if this production is increasingly facilitated by new technologies, why not use this to promote such an important stage of RDM, such as the description?

4 Images as Metadata: A New Perspective

"A picture is worth a thousand words". We have all heard this phrase. The scientific character given to images dates back to the 19th century and was seen, essentially, as a replica of reality that was transformed into a "perfect imitation of its object of duplicity" [23].

Roland Barthes [7] sees the image as the only way to reach the veracity of something, because "in it, a pipe is always a pipe, infallibly". For the author, the image document allows the confirmation of the real, it is, deep down, proof of what happened. The image has grown, it is not watertight and its growth has allowed the conquest of freedom of expression and respect for visual language. Still, Barthes says that the objective of the image has always been, above all, to guarantee diversity in communication with others, so it is not strange to say that the image is a communication organ as capable as any other.

In science, too, the image can play an important role. Many times there is real value in using images in science as a means of promoting scientific content. The role of images in research is positioned in helping to understand, as they allow drawing attention to details and explaining concepts, theories, and methods that are difficult to explain in words [19,14].

The problem presented in 3.3 is the starting point for the presentation of this new perspective: using images as metadata in the description process, in research data management. As we mentioned in that section, we believe that there is a way to be unlocked in order to take advantage of the potential of images in the description of data.

In this section, the new perspective under analysis will be presented, presenting the evidence that supports it, as well as the challenges and opportunities it holds.

4.1 Evidence 1: Visual Processing and Memory

A considerable part of the human brain is devoted to visual processing, hence the human being is considered a visual being [3]. The inspiration and appeal that images have are related to cognition and, consequently, to the ability to pay attention to details [6]. Contrary to what happens with other typologies, images are agents that attract attention very quickly and easily. In fact, the human brain processes images at a very high speed [3]. Let's see: when we see an image, our capacity for analysis occurs in a short period of time, which allows us to very quickly understand the meaning and scenario of the image in question [12,6]. It is even faster if the object in the image is familiar, because, if so, the human brain recognizes the object in 100 milliseconds. One of the essential components in this cognitive process related to images is colors, as the brain is programmed to react to color, which is why it is evidence that the most active human sense is vision [6].

Still, in the field of visual processing, it is possible to verify that impressions and memories are based on vision, since the eyes and brain work with images constructively, superimposing them at the time of their analysis [6,11]. In research projects, which tend to cover a long period of time, memory is an important aspect, as researchers need to document various characteristics of the research process. Many times, the moment of documentation does not occur simultaneously with the moment of visualization of a procedure, discovery, data collection, or other [19]. Hence the use of images can be valuable in stimulating memory. The visual system processes sensory information about shape, color, distance, and movement of objects more quickly, in addition to enabling language functions, which is a necessary skill at different times in the scientific journey [6,14].

4.2 Evidence 2: Science and Society

When we look for data in platforms such as repositories, we look for a central place where we can find what we want without great difficulty. Metadata is a key element in this process, as they open the door to data discovery, offering important details and the possibility of finding a context that facilitates data interpretation [26]. In some cases, a more exhaustive description process is not used because the data management workflow can, sometimes, be conditioned by the difficulty of communication between the data producer/researcher and the data curator, which eventually limits a more detailed description. focused on specific metadata of different types, such as images. However, the need to assign context to data is increasingly visible in datasets that, in many cases, have other description elements, such as ReadMe files, for example.

The images can function as a facilitator in this search and interpretation. Reading, although fundamental, implies more time, and, therefore, the images can be allied at that moment. In addition, images are intrinsically related to memorability, and if the data has images in its description, its content will be memorized more efficiently [12]. Images, such as photographs, drawings, maps, graphs, diagrams, illustrations, medical images, and microscopic images, among others, enable the interpretive process to become more fluid.

Currently, we see many research institutions that promote their scientific work through online services, such as blogs, using images as instruments for disseminating studies and new scientific discoveries. Other examples are the web platforms to increase the visibility and impact of scientific production, such as kudos[4]). In these cases, images act as a vibrant aspect to attract attention. In addition, they function as a faithful representation of reality, promoting a culture of truth in scientific work. Researchers and institutions see these as valuable tools for scientific communication. We have examples like Biocanvas[5], which provides photographs that report scientific beauty over time. The Great British Biosciences blog (BBSRC)[6] also provides the possibility to view bioscience images. Or even the blog Biomedical Picture of the Day (BPoD)[7] where we can see biomedical images.

The information and communication society, in which we currently live, tends to record all transactions [23]. The image should not be demoted from its prominent place in this society, as this documentary typology constitutes a social object, with materiality and associated ideas. In science, this also happens. Currently, motivated by new technologies, researchers tend to use image capture devices, such as tablets or smartphones, to record project moments, namely the data collection or production process. However, the studies we have been carrying out demonstrate that there are no specific criteria or guidelines for the proper use of these images [11,15].

Researchers state that images work to remember specific details, to reassess a scenario at the time of data analysis, to document or prove a situation, and for use in articles or conferences. Images constitute a benefit for the research process since they mediate the guarantee of communicational diversity and assist in interpretation. Lacerda [16] points out the capacity of images to record actions and information, and their competence to be a carrier of materiality and different communication and expression resources.

Although all these potentialities are pointed out, what concrete relationship and positioning can images have in a research context?

Images can perform several functions [21]:

– Recruit Participants: people reluctant to participate in research tend to enter more when they realize that their images help researchers to better understand a certain object of study. They feel that they participate, contribute,

[4] https://www.growkudos.com/?utm_source=navbar-logo
[5] https://biocanvas.net/
[6] https://bbsrc.tumblr.com/
[7] https://bpod.mrc.ac.uk/

and interact with the inquiry process in a way that is of value to them. Roger mentions that according to his experience, the images act as a favorable bridge in the recruitment of various types of participants, such as rural, indigenous, and chronically ill men;

- Enrich the data collection: the images help to understand certain aspects that are not easily perceptible. An interview can be enriched by recording in images details that words cannot always capture and that are important to deepen the understanding and knowledge of a topic, such as emotions or lived experiences that could be lost with text alone;
- Produce knowledge: images can work as the base element for the creation of new theories and concepts;
- Engage managers, decision-makers, and the community: publication of the images used during the research process, for example through exhibitions, can be an important element in raising awareness, education and changing perceptions on certain topics.

Current research is characterized by an unprecedented growth in the volume of data being produced, as powerful computational capabilities are available to even small research groups: the so-called long-tail of science [13]. Usually, small groups or individual researchers have minimal resources to ensure the long-term availability of their data. As such, they need adequate research data management practices supported by practical tools so that the datasets they produce can be made available to others [5]. This is especially important as more research funding agencies adhere to the European Commission's Guidelines on FAIR Data Management in Horizon 2020, which advocate for a set of principles to make data Findable, Accessible, Interoperable and Reusable [8].

In Figure 2, a simulated work task example of a data deposit can be seen in which the description model includes the use of images. The mockup has been made by the authors of this work during this study.

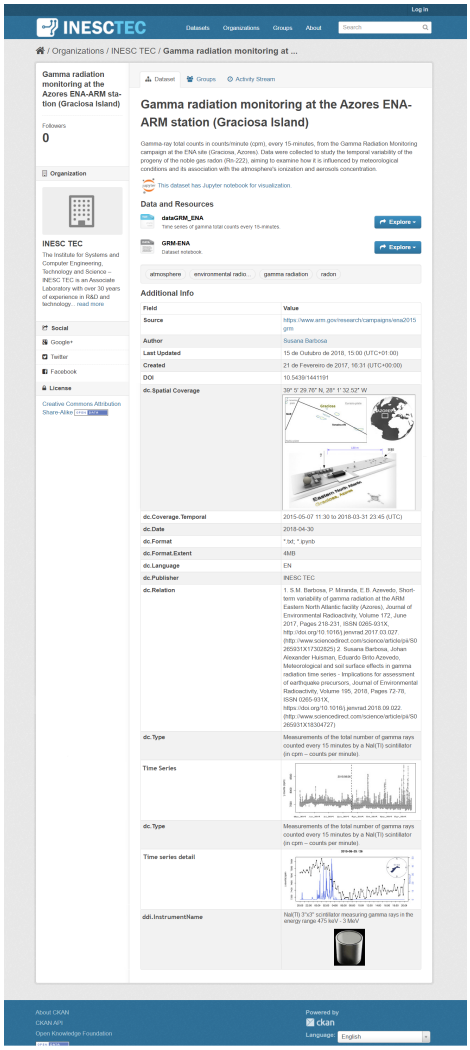

Fig. 2: Methodological Approach

4.3 Evidence 3: Practical Examples in Research Context

Palmer et al. [18] analyze the importance of creating a structure of principles and processes that help to articulate and support the description of data. One point of consensus was the crucial role of images in research documentation. For researchers, the images have a double purpose: they provide context and as a vital medium to record the object of study. This approach leaves room for positioning an image in RDM as a fundamental asset in the description and interpretation of specific domains. Palmer's study is evidence of the need to

bridge the gap between researchers and data curators, while guidelines and tools to support metadata and RDM are being created.

If, in its beginnings, the image records were related to tribal peoples or new species discovered, with the passage of time it allowed to evolve in studies in which successive photographs were shot (one of the most famous studies in this regard is from 1881, by researcher Eadweard Muybridge, in which he took photographs in a sequence of running horses, in order to study the gallop), even others in which the technology associated with this documentary typology has boosted innovative studies in the scope of brain mapping and in the human body assessment, for example [14].

Images appeared in science in the nineteenth century when they began to be produced in Astronomy projects [1]. It was soon realized their potential, given their high capacity of representation [23]. Silva [1] states that images allow different brain actions of memory and recognition. In this study, it is reported that when confronted with images or videos, users tend to remember more quickly what had been forgotten. To prove this thesis are the studies of Czerwinski and Horvitz [9] and Elsweiler, Ruthven, and Jones [10] who state that, although humans forget many details of the tasks they perform, with the help of images, they easily recall what was no longer remembered.

In History, the use of images often serves as a basis for the development of the process of analysis and interpretation. With the digitization of images and the creation of digital collections easily accessible via the Web, historians now have access to images that could not be accessed in their physical format, as well as tools that enable the discovery of new details in images [22]. In Health Sciences, X-rays and ultrasound are high-value images being used as clinical data and anatomical diagrams to communicate critical information. The production of images, in this area, has an important role in clinical practice, surgery, histology, physiology, and forensic medicine [1].

Al Nasar, Mohd, and Ali [4] talk about the role of human behaviors in the life cycle of images. They mention the awareness and education of institutions for the practices of interpreting research projects with the use of images and comment on the importance of this for eliminating description mistakes that the automatic systems contain and the forgetting of some details by the researchers. Also, Kang, Bederson, and Suh [15], Suh and Bederson [25], Sinha and Jain [24], and Mota et al. [17] focus on the issues of automatic processing of images, reflecting on how it should be combined with human interaction for evaluation and error correction.

5 Challenges and Opportunities for RDM

Research data management is increasingly a concern for researchers who need support in the organization of their data [5]. This constitutes a valuable contribution to information management, since, through the description, data keep their meaning and are more easily interpreted. Also, data management can be fundamental in the communication between researchers and the scientific community, where images can play a central role in the “teaching-learning” process [2].

In many cases, the description of the data appears at the time of its publication/deposit, with a view to proper storage, data sharing, or even following requirements that some journals and scientific conferences.

One of the great challenges of using images as metadata in the context of RDM arises precisely in the publication/deposit phase, especially with regard to existing technological solutions. Many of the data deposit platforms, like repositories, provide the possibility to select one or several descriptors and metadata models to assist in the description process.

Applying a single metadata model may not fully match description needs in a specific context. In these cases, the collection and selection of descriptors from one or more models are carried out to build a combined scheme, without losing the interoperability of the base schemes. The final result is the application of a profile characterized by allowing to specify of the controlled vocabulary, format, and relations of the elements, refining definitions of the standards used, and combining different models to specify their use and thus support a particular application, function, community, and environment (Castro et al., 2014; Heery and Patel, 2000; Duval, Hodgins, Sutton, and Weibel, 2002).

Even knowing the benefits of a flexible description model, deposit/publication platforms do not support the functionality of including other types of descriptors other than text. In fact, there are several hypotheses that can be implemented in the most diverse platforms, such as the possibility of uploading images stored on personal computers or even direct searches on the web. However, none of them have been applied.

In an article we developed in 2022, we carried out a comparative study on the data sharing and storage solutions most used by the scientific community, where we put into perspective eight data repositories used worldwide. In this work, we can verify the specificities of these solutions and prove the lack of solutions for using images as metadata [20].

Over the last few years, we have developed several studies on the potential of images in RDM. One of the great opportunities is related to the use of current technologies for capture and dissemination. Currently, a simple mobile phone allows you to capture an image in a few seconds and store or disseminate it quickly. The data can, therefore, be easily reached, without the need to invest in large means of collection, unless the quality of the images is a key point. But even in this, we find an opportunity: the exponential growth of tools for image production is notorious, with a high impact on quality and editing. In addition, we are increasingly finding programs that allow us to analyze images in detail, in different formats, and of different types.

A major challenge of this new perspective for RDM is the concrete understanding of the various roles that images can play. If, on the one hand, we have images as data, generated, obtained, or used during the course of the research project and that serves as a tool that supports scientific evidence, on the other hand, we have images as metadata that provide a better interpretation of the data, attributing context. In fact, we believe there is another challenge associated with this one: images can often take on both roles. That is, at a given

moment they can be seen as research data, fundamental elements in the collection of facts, but at another, they may not have that characteristic of data, but of metadata, insofar as it provides that other data are properly described and enabled to greater detail. And this is the beauty of the images because, after great potential, we managed to verify another. Its characteristics allow its use to be extended to several dimensions, in order to obtain the best results.

As previously mentioned, one of the advantages associated with the image is its ability to represent and prove reality. This fact is unequivocal. However, it should be noted that with the new artificial intelligence techniques, namely deep fake, this feature can be rethought. We believe that this does not compromise this characteristic of the images, however, it is always necessary to consider issues related to editing and image quality, in order to guarantee the integrity of the results.

6 Conclusion and future work

It is always necessary to remember the potential of images, as a result of their specific characteristics. This does not mean that they should be overvalued in relation to other resources. The text, the sounds, the figures, among others, have particularities that make them unique in certain contexts. The image, due to its unique capacity of faithful representation and the impact it has on human cognition, awakens to countless challenges and opportunities that can be a valuable tool for researchers who want to see their projects and, consequently, their data, properly managed.

We consider it very important to reinforce the idea that this new perspective is not intended to replace the text, or other resources, but rather to complement their use, through the unique characteristics of the images. However, the producers of the images that will be used as metadata, must be aware that they must fulfill their purpose - properly describe - and, therefore, must guarantee their quality, that they do not cause interpretation doubts and that they are always accompanied by text that necessary.

Soon we will present a work where several researchers, from different research domains, are confronted with this new perspective. This case study will corroborate the idea presented in this work, showing a practical side of this perspective that we believe to be a great challenge, but also a giant opportunity for the scope of description in RDM.

Acknowledgements Joana Rodrigues is supported by research grant from FCT - Fundação para a Ciência e Tecnologia: PD/BD/150288/2019.

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