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Images to Describe Research Data: A Case Study on the Use of Imagery Metadata

Joana Rodrigues[1,2(✉)] and Carla Teixeira Lopes[1,2]

[1] Faculty of Engineering of the University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal
joanasousarodrigues.14@gmail.com, ctl@fe.up.pt
[2] INESC TEC, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal

Abstract. Research data management includes activities that organize and manage the life of a research project and is crucial for consistent work performance. 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. The description is usually done through text, but other typologies can also be used, such as images, taking advantage of their potential and particular characteristics to promote description. We used a qualitative method of investigation through an exploratory case study. We conducted 16 semi-structured interviews, with researchers who have produced, described, and published research data, in order to understand how images can assume the role of metadata in data description. We found that all interviewees would like to have the possibility of describing data with images, but they consider that the publishing platforms have to be prepared for this. Most researchers were able to identify descriptors that could include images and also describe those that they consider being the greatest advantages of the project. All researchers consider that images as metadata would be a more direct gateway to the data. The issue of data description through resources other than text has never been properly investigated. The existing literature does not develop the theme, although images have had an abrupt growth in society and science. This work aims to open new paths, raise new ideas and raise awareness of new and original practices.

Keywords: Research data management · Images · Description · Metadata · Images as metadata · Semi-structured interview

1 Introduction

Images are dominant in communication. Technological evolution and the new ways of dissemination have meant that its abundance, diversity of origins and diversity of holders have generated a multiplicity of management practices,

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description, interpretation and use. The production, preparation, and management of data imply tasks that consume a lot of time for researchers. The time dedicated to preparing procedures and analyzing results often overlaps with the time spent to conveniently manage the data, even though these are one of the most important components of the research process. Research data management (RDM) is concerned with ensuring that research data, generated during the course of the project, is properly organized and more easily accessed by others. There are guidelines for RDM highlighting the most important aspects in each phase. In the description phase, the advantages of data description, as well as assisting tools are indicated. Metadata models are fundamental pieces for researchers who want to see their data properly described. This description is oriented towards using text as the metadata value. However, we believe that other types of data can be used as a complement to the text. This work puts into perspective how images can support research as metadata, contributing to the description and interpretation of data. For this, we carried out a case study, through semi-structured interviews with 16 researchers who have previously deposited and described data, to understand how they see the possibility of a new perspective of description that includes images as metadata. The article is structured with the presentation of a state of the art regarding the theme, then moving on to the methodology that supports the study. The results will be presented with topics that guided the development of the interview questions. Finally, the discussion of the results, as well as the conclusion and future perspectives are presented.

2 Images in Research Context

Palmer, C.L., et. [8] 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 as metadata for research documentation. For researchers, images have a double purpose: they function as metadata (providing context) and as a 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 data. Palmer's study evidences the need to bridge the gap between researchers and data curators, while guidelines and tools to support metadata and RDM are being created. Vision is known as one of the most refined human senses. For this reason, images are essential in human perception. Science also benefits from images since the possibility of accurate registration enhances scientific research. 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 [5], for example. 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 [11]. Silva [1] states that images allow different brain actions of memory and recognition. He reportes 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 [3] and Elsweile, Ruthven and Jones [4] 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 is often a basis for developing 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 [10]. In Health Sciences, X-rays and ultrasound are high-valued images being used as clinical data and anatomical diagrams to communicate critical information [9]. 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 [2] 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 [6], Suh and Bederson [13], Sinha and Jain [12], and Mota Et al. [7] focus on the issues of automatic processing of images, reflecting on how it should be combined with human interaction for evaluation and error correction.

3 Methodology

The description is one of the fundamental phases of the research data management process. With this work, we raise the possibility of describing research data through images and assess how researchers assess this possibility. In this case, the images would not function as the descriptor itself, but rather as the value assigned to it. We use a qualitative method of investigation through an exploratory case study [14]. We chose the semi-structured interview as our methodological instrument selected for this approach was the semi-structured interview. To conduct a set of pre-defined questions to a group of participants, while still being adaptable to the course of the conversation and allowing deviations from what was previously established. This method of collecting information makes it possible to obtain answers with more specificity and direct the conversation when it moves away from the central topic. With this methodology, we aim to reflect on it and improve its understanding. Being the use of images as metadata novel, exploratory research, through a case study, allows the generation of new ideas and hypotheses that can trigger new dynamics in the field of research data management. We recruited, by convenience, 16 researchers from different domains. For the selection of participants, we contacted 26 researchers

who deposited their datasets in the research data repository of the authors' research institution. Contact was made via email, explaining the study and its objective. Information was also provided on the estimated time of the interview, which could be carried out in person or remotely, and that informed consent would be drawn up which, among other details, ensured the anonymization of the data. Of these 26 contacts, 16 responded affirmatively to the interview invitation. After the positive response, the interview was scheduled. Soon after, the informed consent was prepared and sent. The sessions were all recorded via sound and image. All data were anonymized and recordings will be deleted at the end of the study. The interviews took place between November 2022 and January 2023. The interview consisted of eight open-ended questions. The first three questions approached the subject of images as metadata from a generalized perspective. The next three questions addressed issues related to the deposits and descriptions of each of the participants, in order to understand the applicability of the theme to specific datasets. The last two questions arise in an approach to reflect on the role of images in the process of research data collection, namely in the description phase. The lineup for the interview can be viewed in full at the following link. As support for the interview, we created a mockup 1 of the data repository where the participants have their data published, with a simulated example of a data deposit in which images were used as metadata. This mockup was shown to the participants to help them have a concrete idea on what we were studying.

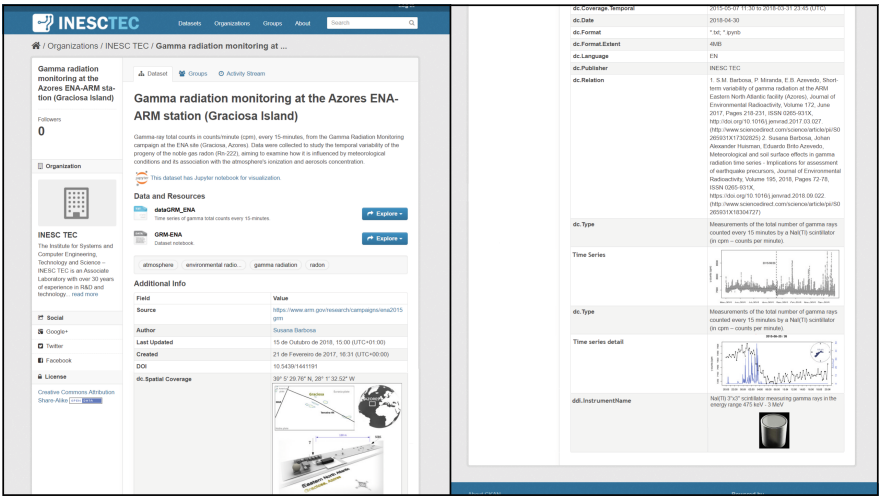

Fig. 1. Description simulation mockup with images

Table 1 shows the profile of the 16 interviewers. To maintain the confidentiality of the participants, we do not disclose all the information about them.

Table 1. Profile of researchers who participated in the interview

Researcher	Specific Work Area	Qualifications	Position in the Institution
R1	Computing	PhD	Senior Researcher
R2	Computing	PhD	Auxiliary Researcher
R3	Electrical Engineering	PhD	Researcher
R4	Intelligent Systems	PhD	Senior Researcher
R5	Bioengineering	PhD	Auxiliary Research
R6	Industrial Robotics	PhD	Research Assistant
R7	Industrial Engineering	PhD	Senior Researcher
R8	Energy Systems	PhD	Researcher coordinator
R9	Energy Systems	PhD	Auxiliary Researcher
R10	Energy Systems	PhD	Senior Researcher
R11	Chemistry	PhD	Researcher
R12	Chemistry	PhD	Researcher
R13	Multimedia	PhD	Researcher
R14	Urban mobility	PhD	Researcher
R15	Information Science	PhD Student	Research Assistant
R16	Information Science	PhD Student	Research Assistant

4 Results

In this section, we summarize the results obtained in the context of the interviews, organized by the themes of the questions that make up the interview guide.

4.1 Images as Metadata? Yes or No?

When confronted with the question about a scenario of describing data with images, ten of the respondents stated that they had never thought about this possibility. However, they all say that it makes sense because "the descriptions would become richer and more complete. Some of the researchers even say that they never thought about this possibility, although they think it makes sense" (R2). One of these ten interviewees stated that he always thought that "the inclusion of images for the dissemination of the studies would be interesting" (R5), however "never particularly in the description of the data" (R5). The remaining six interviewees said they had already thought about the possibility of data description with images. Four of them reinforce that this inclusion, although it can happen at any time, makes even more sense at the time of deposit and sharing because they see the description as a task that "helps others more than themselves" (R13). Most of the researchers regret the fact that deposit platforms do not encourage the inclusion of images as metadata. One of the researchers also stated that "images are needed to better visualize the data. Especially for series, maps, graphs" (R1).

4.2 Third-Party Research Data Described with Images

The expectations of researchers who seek data from others to develop their own work or to study a particular topic can vary. In this section, we address the possibility and willingness of the interviewees to see third-party data described with images.

Advantages. All respondents said that they would like to see research data from other researchers depicted with images. Without exception, all researchers consider that images as metadata allow an overview of the data. They believe that it will not be possible to have a full understanding of the data in a first glance, but rather to obtain contextual information, which facilitates and accelerates the process of data perception. One of the researchers believes that with the use of images, it will be easier to understand certain descriptors, which would make the data more explicit and understandable. In addition, the images facilitate access to more information regarding the dataset, giving the charts as an example of an image for this situation. Other researcher characterized most repositories as "raw deposit spaces, with the bare necessities" (R8). This interviewee thinks that the images can play a decisive role here due to their "more aesthetic than interpretative nature" (R8), but he still sees this as a great advantage, as they can be very useful instruments to appeal to the data and offer initial information. One of the interviewees reinforced the idea that images, unlike text, help in a faster perspective of data, as they are "more efficient at transmitting information" (R15). Although the images do not allow a complete description, they make it possible to highlight and summarize specific moments of the project and data. One researcher made it clear that images as metadata are useful, however, this utility is not related to the search/retrieval of data, as the repositories are not prepared for this functionality. For this researcher, more than for any other reason, images are important to understand whether that particular data is of interest for a given purpose, help in decision-making and make it possible that in certain cases it is not necessary to download the data. Basically, the images would work as a "prior analysis mechanism" (R3). Two of the interviewees focused on the idea of knowledge graphs, as image tools for understanding data. In addition, this type of images as metadata would help, not only in the description but also in the organization of information about the data. For these researchers, the visual impact on the description of datasets is fundamental.

Disadvantages. It was necessary to understand if the interviewees would like to see the data of other researchers described with images. About this, not many disadvantages were identified during the interviews. Only 4 of those interviewed were able to list disadvantages. The first has to do with the possible poor quality of the images, namely in relation to size and format, as they believe that the images could be small or in a format not supported by the user and, consequently, become imperceptible. Another disadvantage is related to the potential

neglection of text if researchers start to use images. The third disadvantage mentioned was the fact that the deposit platforms do not have a component/option for the inclusion of images, in fact, this possibility is not even given in deposit platforms guidelines, which immediately limits this. Finally, the work and time required to produce the images to be included as metadata was identified as a disadvantage. The researcher who mentioned this fourth disadvantage said that "the images should be the most prominent factor and the textual description should be seen as an additional description. The only problem with the images is that you have to make them and not all the data have images to associate. As not all researchers have time to do them. (R10)".

4.3 Description of Research Data in Publishing Platforms

All respondents answered that they would use images in describing their data if the publishing platforms allowed it. Many of the arguments given in this question overlap with what was said in question *Advantages*. In this context, it would be possible to put on the platform more details about the data. These details, by their visual characteristics, would complement what is textually included and give more context. One of the interviewees said that one of the big reasons he would use images was that it would help to replicate the study because images are more attractive than text. Also, images cause a sense of truth because the information in the text, or in the results of the dataset, can be proven ("with the images, people will be able to verify that this is indeed the case" (R16)). Another researcher also went along with this idea. He says that he would use them, as long as it was possible to create sufficiently descriptive images. One of the advantages would be that eventually there would be more researchers interested in opening the shared data and thus replicating the study. Two of the interviewees pointed advantages regarding visualization. One of them gave an example he appreciates: the AI Assets (assets catalog where can browse, search and download all the AI assets currently indexed in the AI4EU AI-on-demand platform, including AI libraries, datasets, containers, and more), which has a simple list with illustrative images, to access the resource it is necessary to enter the link. In this case, the images would serve as a "gateway to the data". He also gave the example of IEEE Access (multidisciplinary, online-only, gold fully open access journal, continuously presenting the results of original research or development across all IEEE fields of interest) to talk about what he considers to be the ideal scenario: the use of graphical abstracts. He thinks that repositories should provide: the title of the dataset, the graphical abstract (which could contain images of different types), and the project name. If users wanted to know more about the dataset, they should access its full content. According to this researcher, "images are very important for dissemination (...) for interpretation the text is fundamental" (R13). The other researcher also addresses the issue of visualization, stating that "images would be the preview tool" (R14), eliminating the cases in which it is necessary to download data because the textual metadata is too basic and universal and does not allow a clear understanding of the dataset. This researcher believes that the images could be as valuable as some keywords,

so it would not be necessary to use several terms, many of them for similar expressions. Two respondents pointed out that while they would like to use this method of description with images, it is necessary to ensure that the platforms support the images you want to include, regardless of format or size that these can be had.

4.4 Scenarios Where Images Would Be Useful as Metadata

As for specific scenarios where images could take on the role of metadata, the answers were diverse. Seven interviewees said they had encountered description scenarios that fell short of expectations. However, only two of them identified that this problem was due to the lack of images as metadata. One said that the use of "too much text in a description, in some cases, makes it difficult to understand all the important information of the dataset" (R4) and the other that, at times when this happened, he realized that "the lack of complementarity of types of description, particularly images, may not help in sharing data" (R6). Of the remaining respondents, five said that they were not able to identify some scenario where the data description fell short because they could not use other values for description besides text. However, all respondents stated that the interview allowed them to reflect on the subject, as they believe that if they had already been confronted with this problem, at the time of the interview these scenarios could be more easily identified. The remaining four interviewees also said that they were not able to identify scenarios where images would be useful as metadata, but because for them, the moment of description boils down to "always following the indications that the platforms indicated", without questioning other hypotheses (R11).

4.5 Inclusion of Images in the Description Process

The following three topics of analysis refer to three questions asked to respondents about the datasets they deposited and described in a data repository. This moment was important to establish a real connection between the subject of the interviews (images as metadata to describe data) and concrete cases, well known by the interviewees.

Existing Descriptors Where Images Could Complement the Textual Description. All respondents answered that in various circumstances images could be used to complement the description. Twelve of the interviewees said that it is difficult to identify one or several particular descriptors because "what may make sense in the context of one dataset may not make sense in the context of another". All stated that although they work within one research domain, the data can vary greatly depending on the project, the method of data collection, and the treatment of the data. All twelve, without exception, clearly state that images can play a key role in supplementing description but believe that their positioning in the metadata model may vary. Still, respondents identified the descriptors seen in Table 2.

Table 2. Descriptors where it would be possible to include images

Descriptor	Justification
Description	"I would place an image referring to the structure and architecture of the data model that is being described. This would make more explicit the way the model is organized and the links between the different parts of the model" (R16)
Daily Load/Flexibility Profiles	"you could have an illustrative image of the profiles. Since it includes many time series (for several nodes), it would not be possible to simply illustrate all the content. Also included in these is a description of electricity distribution or transmission networks that although they could be translated into images of network diagrams, are rarely available" (R6)
Spatial Coverage	"a clear identification of a place through, for example, a georeferenced image, is much better to interpret. Besides, it's faster, because we don't have to go and look for the coordinates" (R1)
Methodology	"we could eventually using photos and videos of the moments of data collection and production would certainly make it easier to interpret, to report the reader to that moment" (R15)
Instrument	"there are many instruments that have small variations and, in several cases, it is difficult to report these small differences. A photo of the instrument in question helped clarify any doubts" (R13)

Existing Descriptors Where Images Could Replace the Textual Description. For this issue, fifteen of the sixteen interviewees stated that it is not possible to replace textual descriptors by images. Everyone said that the image can be very important in complementing the textual description, but not completely replacing it. There were several arguments pointed out by each of the researchers. One of the interviewees said: "what for me is the interpretation of an image for another may not be and that is where the text helps to clarify" (R10), for another interviewee "if there are only images, descriptive elements are lost that only the text provides" (R14) and for yet another interviewee "complete replacement by images would always remove key information that researchers need to know when looking for data" (R1). Only one researcher pointed out a scenario in which it was only possible to have images as a metadata value, namely when the images are graph This researcher gave an example of metadata he often uses: time series. The interviewee believes that, in these cases, graphs are "better tools for analysis and interpretation than the text" (R4).

New Descriptors Where Images Could Be Included. It was noticeable that researchers who deposit data tend to follow a formal pattern for description, not thinking much about alternatives, although they think there is room for

improvement. For this reason, the interviewees always have doubts when they are asked to propose alternatives because they do not have a deep knowledge of data description guidelines. Still, some of the interviewees, revisiting the dataset they have deposited, were able to identify new descriptors where it would be possible to include images. Those descriptors and their analysis can be seen in Table 3.

4.6 Description Time with Images as Metadata

Confronted with the possibility of time being a factor to be taken into account when using images as metadata, only two researchers stated they considered that a description model with images would not have an impact on time expenditure. For these, from the moment that "it was a well-understood and properly applied methodology, time would not be a problem" (R12). The remaining fourteen interviewees said that the description with images would probably involve a greater expenditure of time, but all, without exception, say that this is not an obstacle or problem. One of the interviewees stated that "by using images and uploading them to the research data description platform, the description process could be more time-consuming, namely with regard to the selection of images referring to each one of the descriptors. However, this time would make a difference in the specification detail of the different research data, making them more explicit and easier to understand" (R16). Another researcher justifies this greater expenditure of time with the creation of images. For this interviewee, "the description with text and images (or even just images) would imply spending more time in the process. This happens because the specificity of the shared data does not favor the immediate creation of images that summarize well what the data translates" (R16). One of the interviewees stated that, although he does not consider the extra time a problem, he does not know the opinion of other researchers. Therefore, he believes that this description model with images "should be optional, because it really can take more time and lead to researchers stopping publishing the data. But I think it is important to have this functionality. If it starts to become the norm, in the near future no one will think about whether it takes longer or not, they will do it because it is the right practice" (R9). The role of technological systems in this description process was also discussed by a researcher. For this, "if the systems were optimized for these dynamics, it could even be faster because there would already be a defined process for this task" (R7).

Table 3. Descriptors where it would be possible to include images

Descriptor	Number of times mentioned	**Justification**
Location	7	Emerged mainly to identify concrete data collection locations, through images. (R1, R3, R4, R7, R9, R12, R13)
Context	5	Researchers consider that often the description or the abstract is too brief and focuses on the project in general and not on the data in particular. (R2, R3, R5, R14, R16)
Equipment/ Instrument/ Instrumentation	4	Researchers consider that this descriptor (mentioned in different ways but with the same meaning) would be useful with images. Two of the respondents say that it should be mandatory to include an image whenever the methodological process includes the production of the data. (R6, R7, R13, R16)
Example	4	Researchers consider that an image can illustrate the data and give an example of what can be found in the dataset. (R2, R8, R10, R15)
Methodology	3	Researchers consider that a good understanding of the methodological process helps to understand the data even better. For the researchers, the methodology, besides textually, can be described with photos or videos. (R13, R15, R16)
Profile	1	The researcher who spoke about the profile works in the field of energy and, for him, images can help in the description of specific profiles. (R6)
Pathology	1	For the researcher who talked about pathology, images can be relevant when it comes to medical data. According to this interviewee often the data reports a disease or condition. In these cases, an image in the dataset description could redirect directly to the location of the pathology by signaling in the image. (R11)

5 Discussion

During the interviews, we found that researchers are sensitive to the idea of using images as metadata. All were able to identify the advantages of including images in the data description process. However, it was clear that, for most this idea was novel. In fact, many of the researchers who use and produce data are not aware of all the RDM guidance as well as the opportunities that exist. Many follow institutional procedures or technical guidelines to ensure they comply with some data management good practices. This shows the importance of having a professional provide guidance for proper and effective research data management. Not only showing the procedures to follow but also opening new possibilities for discussion, with new theses, new panoramas, and new perspectives. One of the most debated points of discussion was the alignment of publishing platforms on the dynamics of including images as metadata. The description process must occur in a preliminary phase of the project to properly document the procedures and work phases. In these cases, the description occurs internally such as laboratory notebooks or personal storage platforms. However, it is clear that researchers' greatest concern with regard to description occurs in the data-sharing phase. It is at this point that greater importance is given to properly described data so that they can be duly recovered, interpreted, and reused. This is where deposit platforms, like repositories, play a key role. Even if the data are not open access, the metadata must be, enabling the dissemination of results. Therefore, publishing platforms should allow the inclusion of images in fields assigned to metadata values. This does not happen, which prevents this description option. In a work published in 2022, we performed a comparative analysis of the most used publishing platforms (omitted for review purposes). One of the evaluation components referred to the description and, as described in the article, we were able to verify that this scenario, which we identified as necessary, does not exist. The limitations of the platforms do not end there: it is necessary to ensure that, in the same way, that we can search for text, we can also search for images. Once again, this does not happen. Therefore, it is necessary to feed this theme, showing its potential, in order to promote public discussion.

6 Conclusion and Future Work

It became clear that the topic of images as metadata is not widely discussed in the research community. However, most see it as major challenges, opportunities and advantages for research data management. It is necessary to make room for new conceptions and practices. RDM does not include any procedure that limits the researcher's field of action to the point of being limited to the guidelines mostly followed by the scientific community. Images pose a huge challenge. They have specific characteristics that can be useful in data management, namely their ability to faithfully portray a reality. Soon we will publish a work in which we explore these potentialities and particularities of the image, showing the impact that they can have in research, as well as the influence on the cognitive processes of those who produce and use them. This work will result in a

perspective paper, where concrete scenarios will be analyzed in which the image has a relevant and differentiated role, namely its implication in human cognition (necessary in several moments of research projects), the role they play in the scientific context and its evolution and positioning in research practices over several decades. 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. 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.

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