

# Collocated Social Practices Surrounding Photo Usage in Archaeology

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**Abstract** A domain where photographs are a necessary part is archaeology: here they are used in different phases of the archaeological work for many purposes, some of which are common to other domains or to home usage (e.g., archiving). We concentrate our attention one of the initial phases of the archaeological process, namely excavation, since the related activities use photographs in a very peculiar way and under the constraints of a very demanding physical setting. Moreover, in this phase the advent of digitalized photographs is recent and their adoption is still interestingly combined with the usage of photographs printed on paper.

Paper presents the results of a study performed at an archaeological site in the south of Italy: we report the observed collocated collaborative practices surrounding photos and discuss these practices to identify some functionality of a supportive technology.

## Introduction

The practices surrounding the management of photographs have been observed and studied mainly in the home where they are the objects of individual and collaborative activities [1–3]. These activities are aimed on the one hand at building a record of meaningful events, people, places, and on the other hand at retrieving this record and sharing it with relatives and friends both in co-located and distributed settings.

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This paper looks at photographs as artifacts supporting cooperation [4] as for example, in healthcare where X-ray films typically support diagnosis [5]; or in architecture where photographs support the design of buildings by documenting achievements or opportunities for the selection of some architectural detail [6]. This different perspective may change the actions performed on photographs: in any case it contextualizes both traditional actions (like archiving, searching, browsing, sharing that are typical of home photography) and the ones peculiar to the target domain in the framework of a broader goal and set of constraints. These goals and constraints define a framework against which actions have to be confronted to evaluate their effectiveness and their results. This is not the case of home photography: here the main goal is entertainment and social enjoyment [7].

A domain where photographs are integral to practices is archaeology: here they are used in different phases of the archaeological work for many purposes. We concentrate our attention on one of the initial phases of the archaeological process, namely excavation, since the related activities use photographs in an intensive way and under the constraints of a very demanding physical setting. Moreover, in this phase the advent of digitalized photographs is recent and their adoption is still interestingly combined with the usage of photographs printed on paper.

The paper presents the results of an ethnographic study performed on an archaeological site in the south of Italy. This study is part of a longer term project whose aim is to investigate the role of ICT in archaeology beyond the more traditional support of cataloging or setting up virtual exhibitions of various kinds of (material) cultural resources. In this joint investigation we had the opportunity to interact with archaeologists acting in the so called excavation campaign; that is, an activity aimed at starting or more often continuing an excavation that had to be suspended the year before because of adverse seasonal weather conditions. During these interactions, we collaboratively identified the main steps of the workflow defining the archaeological activities and the artifacts, tools and technology supporting them. Among others, photographs, their elaboration and management emerged as a basic support to construct and maintain the memory of what constitutes or has been found in the current excavation layer, before it is destroyed to access the layer below. The destructive and irreversible nature of excavation assigns to documentation, and specifically to photographs, a central role during both the campaign and the interpretation effort following it. The study was motivated by a question raised by the director of the excavation campaign: “how can ICT make our life easier in managing and exploiting the every day documentation we produce?” The question was challenging since the excavation work shows a serendipitous nature which has to follow some explicit and tacit rules in order to avoid the irreparable loss of relevant pieces of information. Moreover, the involved actors are not used to saying how they work, why they behave in specific ways, how they deal with unanticipated circumstances; in addition, archaeology provides only manuals describing very high level procedures that have to be instantiated in the current context (archaeological period, type of excavation, type of settlement, and so on). These considerations led us to start an empirical investigation based on observations and interviews to shed light on this unexplored domain. The next section describes the main aspects of

archaeological work during the excavation campaign. Then, the work setting and the method adopted during the empirical investigation is described. The role of photographs in the observed practices is the focus of the subsequent section. A discussion of the empirical findings and its implications on the design of a supportive technology conclude the paper.

## Archaeological Work

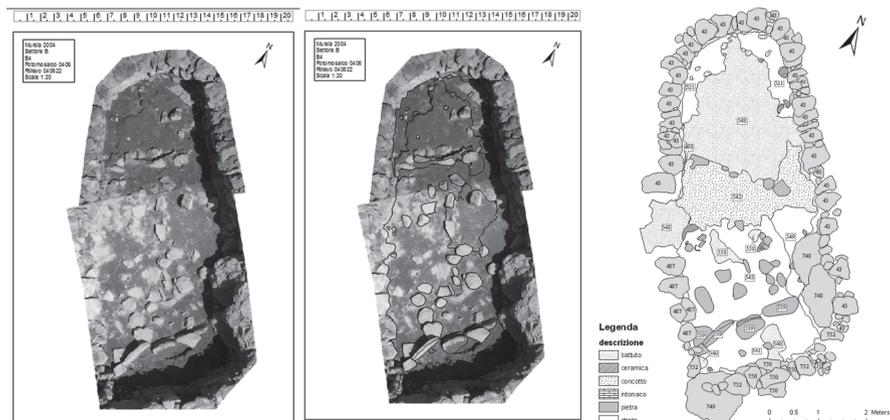
Archaeology is a discipline where photographs are an important tool supporting all archaeological activities since they require the documentation of disparate entities at different levels of detail: from the representation of the excavation area up to the memorization of information concerning the single material find. With the advent of the digital photos the use of the photography in archaeology has grown to integrate and, within some work teams, to replace more traditional methods of documentation that are based on hand-made drawings. These are based on observations and measures performed directly on the field with various (measurements) tools, and are completed manually by taking advantage of the artistic capabilities of the individual drawer.

To observe how the use of digital photography influences the practices characterizing archaeological work we studied the archaeological excavation of a bronze-age settlement in Mursia (Pantelleria, Italy): the excavation was directed by a professor from the University of Bologna. For several years, the Mursia archaeological setting has been a training field for students earning a degree in archeology. They are requested to perform the typical work in charge of “experienced” archaeologists, with the supervision of the more experienced colleagues. Since the latter are few in number, students actually work by themselves and ask for help only in specific circumstances: this reflects the labor division characterizing the archaeological work in almost all non-training situations as a consequence to the endemic scarcity of available resources. On the other hand, the activities going on there are also targeted to scientific investigations concerning methodological issues: then the practices reflect an experimental but rigorous attitude to new approaches and techniques. At the time of our observations (see Fig. 1), the *graphic survey* of the excavation area (that is, the representation of all its most remarkable parts) was no longer constituted of hand-made drawings: since the drawings have a strong component of subjectivity and formal simplification [8]<sup>1</sup> the excavation director decided to introduce the usage of digital photographs. After this innovation, the survey is based on the so called *photomosaic*, that is a rectified and geo-referenced composition of *zenithal* photographs (that is, perpendicular photographs in relation to the target object). The survey obtained with this technique is called *photographic survey*.

The interviews with the excavation director highlighted that the use of the photographic survey offers important advantages in terms of informative content,

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<sup>1</sup>This is one of the reference manuals that is adopted for the training of the students.



**Fig. 1** The (digital) photomosaic on the *left*, the (digital) photomosaic with the graphic survey, and the final excavation map on the *right*

rapidity of execution and accuracy of the resulting measures. In fact, the use of digital photographs (1) allows the recording of more information (e.g., real colors and details, more accurate perception of the 3D view); (2) asks only for the time necessary to set and take the photo, whereas hand-made drawing would stop other excavation activities in the same part of the area; (3) if equipped with metric references, allows the computation of precise dimensional data of the photographed objects. However, the director emphasized that hand-made drawings are still used when the entity to be reproduced and its surrounding context is worth the subjective interpretation implied by the drawing: in this case the latter is very accurate; or when the environmental conditions make photographs of too low level quality: in this case the representation can be a very rough sketch of the real entity.

Photographic elaboration was performed partly at the excavation area and partly in the laboratory (Fig. 2), according to the following practice:

1. The zenithal digital photographs of the area were taken in the field; then they were elaborated and assembled into a rectified and geo-referenced photomosaic by dedicated software applications available in the laboratory where the photomosaic was printed using a large plotter.
2. The printed digital photomosaic was brought to the field to play the role of the reference map of the pertinent excavation area.
3. The digital photomosaic was further elaborated in the laboratory to become the reference artifact on which the relevant entities of the current layer (e.g., ceramic objects, fireplaces, tools) were put in evidence by drawing an irregular perimeter around them, this way obtaining what is formally called the *digital graphic survey*.

The senior archaeologists told us that at the end of every archaeological campaign all the digital graphic surveys produced have to be collected in a folder, named according to a naming convention, integrating location, year and the keyword “fotomosaici” (e.g., Mursia-2005-Fotomosaici). The relevance of this convention



**Fig. 2** The setting at the excavation area and at the laboratory

was motivated by the fact that the collection of the elaborated photomosaics produced during the excavation, both in its digital and paper format, is usually searched and browsed at different points of the archaeological workflow. The *searching* activity is particularly intense during the planning of the archaeological mission: to this aim it is necessary to collect all the existing documentation concerning the areas in which the archaeological activities will be performed, in order to check their state after the past campaign.

On the other hand, the *browsing activity* generally occurs during the post-campaign data elaboration in order to control the consistency and completeness of the collected documentation: to this aim, the browsing of all directories allows one to verify that everything was checked and appropriately organized. However, we observed that the browsing and searching of the printed photomosaics collection also occurred during the excavation: the archaeologists systematically checked the recently constructed photomosaics to analyze them against the physical changes produced by the excavation and then planned the next excavation phases accordingly.

## Method

To uncover and understand archaeologist's practices we conducted a qualitative study of the archaeologists' work to identify the activities they perform, the strategies they adopt to coordinate their work, and finally the tools they use.

The data about the archaeological practices surrounding the usage of photographs during the excavation campaign was collected in two stages: the first one in summer 2006 and the second one in summer 2008. The study performed during the second stage was more systematic since it could build on top of some preliminary results obtained in the first stage. The qualitative study is based on the data collected in the 2 week observation of the work done by the archaeologists, both at the excavation site and when they work at the laboratory. Each day after the observation

session, we discussed the observed practices with the team members to check and complete the collected information. In addition, we also reviewed our observation with the field director and one area manager when we were back from the campaign.

The professor who was the main responsible of the excavation campaign informed the people involved in the study about the presence of an observer: he clearly told them that the role of the observer was not about assessing the quality of their work, rather to “help them becoming more aware of what they were doing”. In fact, the main goal was that their best practices could become part of the teaching/learning activities targeted to students involved in the next excavation campaigns. This perhaps unusual situation was made possible due to the presence of a really unique trust relationship between senior archaeologists and their young collaborators. This trust was generated by the behavior of the field director in all the excavation activities, and specifically, by way of turning all possibly critical or even mistaken situations into a positive learning experiences where the acquisition of knowledge was achieved by both sides. In fact, according to the experimental mood of the team, questions, critiques and innovations were welcomed and stimulated. Consequently, the observer was immediately accepted and perceived as just another kind of “strange young archaeologist” who had to learn something about their work. In this positive relationship, when a particular behavior was observed, the observer could ask the archaeologists for clarifications and motivations, irrespective of their level of experience and role in the excavation activities: the resulting interaction showed a high degree of mutual empathy. All this information was carefully annotated and constituted a precious source of data. The archaeological work is characterized by time slots where a lot of activities “chaotically” occur (typically in the morning when they have to organize their work or when something unexpected happens) followed by quite periods where the often prevalent manual work allows for relaxed conversations among archaeologists, and what is important in our study, between them and the observer.

The observer shared the living experience with the archaeologists in an almost isolated and not very comfortable location where the archaeologist lived (beside the very pleasant experience to enjoy the Mediterranean Sea): this full time presence was very important to observe archaeologist’s activities and conversations because their work very often continues after the organized work periods, such as the morning activities at the excavation site before the temperature becomes to hot and at the laboratory in the afternoon. In fact, they also work in the evening and in many cases till late night, to perform activities that they cannot do or do not have time to do during the day: in particular they prepare all the necessary material for the day after, e.g. the new photomosaic. This situation made the apparently short stay at Mursia a very demanding experience and favored rich data collection.

At the time of our study in 2008 the team was composed of 16 persons, playing the following roles (some persons play more than one role): one field director; four area managers; one topographer; one laboratory manager; 11 junior archaeologists (students and graduates).



**Fig. 3** Some uses of the photomosaic. An archaeologist and the field director (*left*); a group of archaeologists (*center*); two archaeologists working both with the digital and the printed photo-mosaic (*right*)

As alluded earlier, the environmental conditions at the excavation site were very critical. The hot temperature and especially the dust produced by the excavation activities and the wind in an area close to the sea, together with the lack of communication coverage, made it difficult to really use ICT technologies to their full potential. Data transfer was made manually by using different devices. The hardware equipment used at Mursia was composed of:

- An Electronic Total Station to take geo-referenced coordinates in the field
- Two digital cameras endowed with remote control to take pictures both of the excavation site and of the most relevant finds
- A USB hard disk on which both the source photos and the resulting photomosaics are downloaded
- Four notebook pcs where the photos were elaborated
- A color inkjet printer to printout the photomosaics (Fig. 3)

The two digital cameras were also jointly used to take stereo photographs to build 3D models of the excavation site; in fact, during the 2008 campaign in Mursia, archaeologists evaluated on one hand, the efficiency and effectiveness of the 3D-creation process (from taking pictures to 3D model creation) and on the other hand, if and how the obtained 3D model might be useful for the documentation and the study of the excavation findings. However this was only a potential innovation at that time and was not exploited in a meaningful way for our study.

## The Collaboration Surrounding Photographs

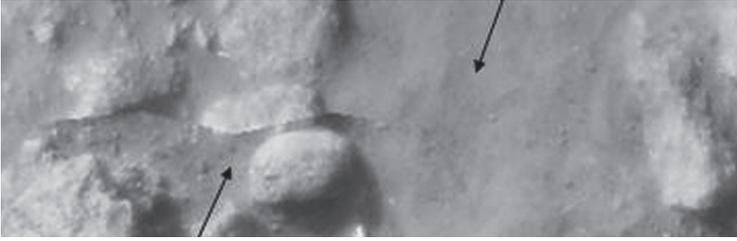
Collaboration and coordination around photographs were affected by both environmental constraints and some needs intrinsic to their usage and management. The difficult environmental conditions (recall, hot temperature, dust and lack of stable network connections) reduced the availability of typical ICT supports that would have been taken for granted in other application domains. For example, at

the excavation site there was a single PC available that was not easily reachable by the people performing the excavation, since it had to be positioned in a very protected location. It was used only exceptionally to upload data, collected using other less delicate instruments (like the Electronic Total Station) or photos when the memory of the camera was accidentally full; or to access some information that was not available on paper (e.g., if it had been forgotten in the laboratory or not printed at all by mistake). The uniqueness of another resource used in the laboratory, namely the USB hard disk, was due to the need to avoid distributed collection of the basic information to be organized in the official documentation of the excavation campaign. The lack of stable connections made this device a shared physical object that had to be used in competition with other team members. This overhead of coordination was preferred rather than the possibility to lose or obtain unaligned information if it had been retrieved from the various PCs. Consequently, especially in the second case where the usage in the laboratory was continuous, a lot of conversations were about the most appropriate way to guarantee optimal access for all members in order to allow them to download the data on the PCs and to solve emergent information needs when the device was owned by one person.

On the other hand, the handling of the photographs raised the need to collaborate and coordinate actions among the members, although each single operation could appear as executable by a single person. In the following the main involved activities are considered.

### *Creating the Digital Photomosaic*

The creation of the photomosaic, the most important artifact based on photographs, entails the selection of the source photos, their composition and the final archival in the hard-disk for shared usage. Each day a member of the team is in charge of this activity. Both for contingent reasons (like, the senior archaeologists are involved in another aspect) and pedagogical ones, the job can be assigned to junior archaeologists. In this case, the collaboration arises from the need to get advice and direction on how to do the job. However, collaboration is required also among more experienced members since the person in charge has a limited knowledge of each single photograph and of the conditions under which it was taken: for example, the time it was taken could affect the direction and intensity of the sunlight, the presence of a special configuration of the land could generate shadowed areas, the presence of strong wind could have made the zenithal photograph imprecise or somehow distorted, and the like. In fact, as said before, the typical division of labor is based on a regular partition of the excavation area in small squares that are each assigned to a single person every day. These areas can be quite far apart one from the other: so keeping awareness of others activities is not easy and not actually necessary for accomplishing one's own local activities. The selection of the photos from which the photomosaic will be built with the help of the specialized software requires the interpretation of their contents primarily on their borders since these



**Fig. 4** Photomosaic composed by two images

should properly match to obtain a faithful composition. To this aim sometimes the photos have to be manipulated to improve the match: typically the geometry of the border has to be modified or a photograph is only partially used to complete the coverage (Fig. 4).

To understand this aspect better here is part of a dialogue between a student and an area manager from two different areas of excavation.

Student: Sorry, can I ask you some advice?

Senior: Of course

Student: In your opinion is the area that I have delimited for the rectification all right?

Senior: well, here you could perhaps include the whole perimeter wall, rather than divide in half, while at this point I would pass the border over or under this stone instead whether of cutting it in two. Do you have to match other photos to this?

Student: Yes

Senior: Remember, it is better that the prominent elements are inclusive completely in one of the photos that composes the photomosaic because if you divide them, the border among two photos is particularly evident, while if you delimit the photos along the layers, the border among two photos is almost invisible.

As it is deduced by the dialogue and is clarified in Fig. 3, this activity, called rectification, has to be done carefully, so that the border between two or more photos is almost invisible, and at the same time, important details are not lost when the operator cuts the area of interest.

During this activity besides there have often been discussions related to the interpretation of the photos, particularly of the geometrical properties and sometimes of the “signs” contained in each photograph: e.g. is a dark shape the shadow of a stone or the sign of the presence of a relevant find? Here is another fragment of dialogue that illustrates what we described:

Senior1: But do these stones come from a fireplace?

Student: yes, we begun digging it this morning.

Senior1: look how well you can see the remains of ashes from the structure!

Student: What, this gray stain? But isn't a shadow?

Senior1: No, look how it follows the borders! And the shape of the deposit. It is clearly the remains of ashes from the fireplace. Remember to be careful when you outline it during the digitalizing! (he calls the other area manager).

Senior1: Senior2, come. Have you seen this beautiful stain of ashes?

Senior2: Yes, I noticed it while we were cleaning the area to take the photo. But in this photo it is better than what we can see here!

Naturally the experience supports the correct reading of the photographed elements, often allowing to observe particular that in the field are sometimes hardly visible, for many reasons like the different perspective, or the strong and direct light.

In the second case, some additional documents could solve the problem but usually there is no time to look for them and having a direct answer from someone who might know and help is easier and more effective. To sort out the problem some people gather around the computer reproducing the photograph and the discussions help them to reach a consensus and to socialize the direct experience acquired at the excavation site.

### *The Use of the Printed Photomosaic*

Once the digital photomosaic has been created, archaeologists use the information it contains during the excavation to support many activities, namely those devoted to organizing their work, to performing the excavation and to validating the completeness of the collected documentation.

First of all, the photomosaic was used to do a very practical operation: the setting of the physical grid on the excavation area. In fact, a grid was printed on the photomosaic to support the identification of the square areas at the excavation site. Archaeologists set up a physical grid based on the one printed with the photomosaic to organize their work: in fact, every day square areas were occupied by a single archaeologist who could change area the day after. Moreover, due to the highly distributed work organized in small areas, archaeologists preferred to bring several printed versions of the digital photomosaic constructed the day before to the excavation site. Depending on individual preferences, they printed the photomosaic on a single A4 page or as a poster. Whichever the format of the printed photomosaic is, the switch from the digital to the printed version of this artifact makes it easier for the team to use it. In fact, on the one hand each individual or small groups of people digging could have her own version and manage it as they like. This artifact guided the excavation performed on the current day since the director, or a senior archaeologist on his behalf, indicating where to start the new dig in each small square assigned to the various juniors on the basis of the situation at the end of the day before it is recorded in the photomosaic. For this reason each individual copy of this artifact supports the “visual” memorization of the sequence of subareas to be considered within the square and also the motivations behind this digging strategy. When a relevant find is identified during the excavation, e.g., a piece of ceramics,

an indication of the next underlying level or of a new architectural evidence, etc., the archaeological practice requires that the pertinent area is marked with a thick pencil and annotated with some codified information that will allow them to identify the entity during future interpretation. The action of surrounding the relevant find was usually followed by the check of the presence of a sufficiently complete documentation of this find, especially when it had to be removed (typically, a tool, or a pot or even larger objects like a millstone) to proceed with the excavation. During the excavation, collaboration and coordination mainly occurred when the dig involved the borders of the individual digging area: in this case, the work going on in the close areas had to be suspended to allow the taking of photographs of the find, so that no dust was generated in the meantime, or to coordinate and agree upon a uniform inscription concerning the same find in all the involved copies of the photomosaic. Moreover, if the find is of special interest or relevance or it is difficult to evaluate its nature and value, then the digger calls the attention of more expert archaeologists and discusses what to do with it.

The graphic survey is created at the excavation site because only direct observation allows archaeologists to perceive different materials (in particular ceramic) and annotate their location in the graphic survey. During this activity we observed the occurrence of serendipitous collaboration and coordination with the topographer if very precise spatial coordinates were needed to localize relevant finds. On the other hand, the pressure to proceed with the excavation often forced the diggers to make rough highlights and annotations on the photomosaic. This partial information was completed in the afternoon work at the laboratory when the same data were reported, very carefully, on the digital photomosaic in order to obtain the digital graphic survey and derive the excavation map from it that organizes the findings according to each single excavation layer, as shown in Fig. 1 on the right.

### *Creating the Digital Graphic Survey*

Once archaeologists are back to the laboratory with the graphic survey created at the excavation, they redraw the same survey over the digital photomosaic by means of the ArcGIS software application. In many cases during this activity archaeologists drew new graphic surveys that they deliberately left out at the excavation due to time constraints.

This activity is necessary because the digital graphic survey is used both to create the excavation map and to study the stratigraphic evolution. In particular, the last is made easier by the digital graphic survey because the ArcGIS software application allows one to superimpose different graphic surveys and select the entities belonging to the same stratigraphic layer.

There was one person, possibly different each day, in charge of the digital graphic survey: the appointed archaeologist collected the printed graphic surveys made at the excavation site and transferred the annotated information by using the graphic interface of the software application.

During the creation of the digital graphic survey, when all team members shared the same physical space in the laboratory, they discussed and commented what happened at the excavation site. Hence, this activity was by no means a mere transcription: on the contrary, it is when the richest exchange of information and awareness of all aspects of the excavation activities took place. Regarding this issue a dialogue took place among people digging in the same area.

Student1: I'm not sure, do you think the border that I drew is correct?

Senior: Yes, it's pretty good. Have you seen from the photo how clear the alignment that constitutes the partition wall is? (he calls the other students of his area). Look how well you can see the partition wall.

Student2: Yes, you're right, now I can see it well too. Then the hut was divided in two zones?

Senior: Probably, it would not be the first time that we find a structure with internal divisions.

Student1: But did the zones communicate through a door?

Senior: We cannot know with certainty. Look here (he shows the paper photomosaic of another area): in this hut we have found some large stones like for a doorstep from a side of the partition wall, for which it is presumed that there was an opening between the two rooms, but in other cases it is difficult to be certain. Tomorrow we will try to make a test along the wall to see if we can also identify a sort of doorstep.

In fact, we observed the usage of guiding people and speaking aloud to attract the attention of other potentially interested people as observed in [9].

## ***Management of Photos***

In archaeological work documentation, and specifically photographs, plays a fundamental role since it constitutes the unique memory of what is progressively, layer after layer, destroyed by the excavation. Actually, we observed all the three modes of recording reported in [10]. In fact, the photos might contain cues that allowed the archaeologists to remember or recollect past events: for example, the photo of a special find (an almost undamaged little amphora) was the trigger of a detailed narrative of where and how it was found and by whom during the past campaign, as well as all the actions that followed this rare event (its restoration and exhibition in the museum close to the laboratory). This narrative let the archaeologists not involved in this event know about it and hope to have a chance to experience the same emotion. Unlike the experiments described in [10], remembering of past situation triggered by the photos were a collective action and the narrative was the collage of each participants' small piece of experience. The same thing happened in less emotional situations where the cues were contained in the photomosaics: here the memory was more about the procedures used to manage the excavation of the specific represented layer and the problems that had to be dealt with in this professional activity.

Photographical documentation is quite complex, since it concerns synthetic information like the digital photomosaic instances and analytic information like the

reproduction of a single find. To manage the photographical documentation archaeologists organized photos in directories, one directory for each day, and renamed photos' filenames to the date of the current day followed by an incremental number and stored all the photos in the *unique* USB hard disk. In addition, they stored some meta information (e.g., the excavation area, the stratigraphic layer) related to the photos and a link to the photo's files in a database that was created for future use (e.g., when they will study the excavation outcomes once back in their offices at the university) but it was not used during the campaign.

From the point of view of the sharing practices the availability of a unique USB hard disk caused the following main drawbacks: not more than one person could access the shared photos simultaneously, unless they were replicated to the laptop of each interested person; and more importantly from the cooperation point of view, it was not easy to know who was doing what with these photos.

On the other hand, photos-sharing did not require the concurrent elaboration of the same photos: in fact, photowork activities were well organized and coordinated in a way that avoided the concurrent elaboration of the same photos.

## **Related Work and New Findings**

In this section we discuss the results of the analysis of the data we collected in the field and in subsequent meetings with some senior archaeologists who were particularly interested in the definition of innovative, at least for them, (technological) supports to make their work easier and to promote their "excavation school" and practices within a broader community of archaeologists.

### ***Home Versus Professional Usage of Photographs***

As anticipated in the introduction, in the literature empirical observations and design implications concerning photograph usage are mainly focused on home photography, where three main actions have been identified: photo-talk, photo-work and end-use. These terms support an analytical distinction between conversations and elaborations that might imply photograph manipulation or a simple action on them (e.g., display), respectively. On the contrary, this paper takes the point of view of professional usage, specifically within the archaeological domain: this fact allows one to identify both similarities and differences in the two distinct kinds of usages. In home settings [11, 12], practices surrounding photograph management entail many photo-work activities that can be both solitary and collaborative. The same holds for the case of archaeologists where the interplay of solitary and collaborative photo-work is a prevailing common practice. Frohlich et al. [12] identified collaborative photo-work by observing the emergence of photo-talk during photo-work activities. The practices that we observed in our field study confirm what has been observed at

home: for example, when archaeologists work at the rectification of a photomosaic, their talks are focused on it, as we described in Section “Creating the Digital Photomosaic”.

On the other hand, going deeper in to the analysis of the dialogues, we recognized that when people talk about the photo they are elaborating, they used lexical cues and voice intonation to separate the discussion about the photo’s properties/ characteristics from the discussion about the photo’s content, i.e. what is depicted by the photo. For example, when two archaeologists work at the rectification of a photomosaic, they talk about how much to rotate/translate the photos constituting the mosaic, i.e. how to change a property of the photo, in relation to the represented excavation area as a whole, and in the general case not about its detailed contents. Photograph content, instead, is the unique topic of conversations following the strict elaboration phase (photo-work), when for example the goal is to plan the next day’s activities (end-use).

The different nature of the talk contents has been already identified in [2], in particular with regard to storytelling and reminiscing. However, the proposed definition of photo-talk does not explicitly take into account the talks about the properties of the photos, which instead characterizes professional collaborative photo-work, since it often requires their digital composition. Since conversations about the properties of the photos are important during collaborative photowork, and in particular in archaeological work, this is important for its implication in design, as we shall see in Section “Implications for Design”; we would adapt the proposed photo-talk definition accordingly: photo-talk is the “naturally occurring conversations *about either the properties or the content of the photograph* in which photograph sharing takes place”.

Here we notice that talking about photograph properties has the goal to better organize and articulate the ongoing collaborative photowork. In fact, the latter involves not only technical aspects, but also a form of creativity to identify the better manipulation strategy for the given situation: therefore, collaborative photowork cannot be based only on predefined steps but has to be articulated and negotiated to be both efficient and effective. Instead, talking about photograph content entails the articulation of future activities that belong to the workflow, organizing a broader process: of course, this process incorporates photograph elaboration as one specific activity, but it is oriented to the true goal of the archaeological work, that is, the collection and interpretation of the archaeological findings and their dissemination within the archaeological community.

## ***Two Forms of Socialization***

Archaeological work, in general and specifically the implied usage of photographs, is both collaborative and knowledge intensive. For this reason, “socialization of archaeological issues”, as they call a relevant part of their work, assumes two distinct connotations, accordingly. These aspects were discussed with the archaeologists during both the field work and in subsequent meetings organized during our long term joint project. Our interlocutors used the term “socialization” after an early meeting where we discussed the various facets of knowledge work and mentioned

the model proposed in [13]. Their use of this term was not fully coherent with its original definition, but we did not force any change of terminology since their interpretation, being based on the central role of experience, was altogether compatible with the model itself. Actually, the model associates socialization primarily with learning by doing/imitation, a concept that is closer to the phenomena that will be described in the next paragraph.

From the collaborative point of view, socialization was interpreted by archaeologists as the need to become more aware of what is going on during the excavation campaign. The desired awareness concerns the perception of how the produced documentation is growing, as a consequence of the ongoing excavation and the activities that are performed at the excavation site and in the laboratory by groups that are distributed in time and in space. The core artifacts gluing all these activities are the photomosaics and some predefined forms containing information about the excavation layers and their alignment according to what they call time phases. All actions refer to, and all discussions speak about, these artifacts and their connections. The current documentation is very fragmented and the connections between the artifacts constituting it are in the heads of the archaeologists, although these connections carry a very well defined and shared semantics. This fragmentation makes it difficult to share the experiential knowledge about time, space and context that governs their collaboration and is implicitly incorporated in the documentation beyond the pure data it contains.

From the point of view of the knowledge dimension, socialization was interpreted by archaeologists as the need to share and access excavation experiences and outcomes. This domain lacks from the predominant view of sharing and accessing knowledge as the availability of huge data sets where findings are collected and cataloged: they liked to describe this as “creating electronic dust instead of the real thing”. The new archaeology school (to which our interlocutors belong to) tries to go beyond this narrow view (that is unfortunately common to many approaches to knowledge management) and looks for new forms of data aggregation and presentation that for the considerations made in the previous sections, cannot avoid being rooted in work practices and thus considers photographs and the results of their elaborations as a starting point.

Archaeological work showed socialization practices surrounding photographs similar to the ones that have been observed in home photography [2]: namely storytelling and reminiscing of what was going on at the time the picture was taken. Beside this, a similar form of socialization happened inside situations. Excavation teams, in general, are mainly constituted of young people since the excavation work is demanding in terms of physical effort: this was obviously the case of the observed team. According to young people’s habits, the team took a lot of pictures of people at the excavation site or in the place where they lived together, by using their private cameras. They shared these pictures (sometimes through the facilities by which they elaborated the official excavation photographs), they kept them from one campaign to another, they showed and shared them with the newcomers and told a lot of (funny) stories around these photographs in order to receive them in the community or to recall meaningful or simply amusing situations with old friends. Although this aspect was foreseen, its relevance became more substantial than expected: actually, this specific kind and usage of photographs was in the heads of the observed archaeologists,

a relevant part of the documentation of the excavation campaign itself. The above practices were socially very relevant. In fact, they were not only tolerated but also promoted by the senior archaeologists, since they naturally helped to build the social ties that make the hard and tiring archaeological work tolerable and less prone to the rise of conflicting behaviors in front of breakdowns.

### ***Managing Control During the Usage of Photographs***

During the collaborative usage of photographs we observed situations where the archaeologists had to manage the control of the related actions performed both at the excavation when the graphic survey is involved (Section “The use of the Printed Photomosaic”) and at the laboratory in all the elaborations of the photomosaics (Sections “Creating the Digital Photomosaic” and “Creating the Digital Graphic Survey”). The first situation is more about photograph sharing and is similar to the case discussed [7] where they investigated the effects of equality of control in photograph sharing: in this case, participants enjoyed equality of control because they “found photograph sharing to be more fun, less constrained and more natural” and that “roles were more flexible, that everyone was involved more, and that the conversation flowed better”.

In the situation at the laboratory it is important to note that the control device (in this case, the mouse plugged into the laptop) was acquired not only to get control over the photo display, but also to get control over its elaboration. Although the observed group was not based on a hierarchical structure, we noticed some asymmetry in the behavior of the archaeologists engaged in the collaborative elaboration of the photos. Actually, when a junior archaeologist interacted with a more skilled one, it was not easy for her to take back the control of the mouse when the other archaeologist got it. This switch happened usually only when the latter had completed her photowork activity. Although this practice did not raise great conflicts due to the learning nature of the setting, however, in some cases the less skilled archaeologists told us that they would like to show how they had liked to do the same activity, maybe in a different way.

We discussed issue of equality of control with the senior archaeologists in relation to the possibility to stimulate autonomous if not original ways of solving problems, a necessary aspect also in professional excavation. To find a way to facilitate equality of control was appreciated as a possible approach to support learning by doing; in particular, it may be a way to support learning by imitation, i.e. when actors re-do the same actions that more skilled colleagues have done [13].

### **Implications for Design**

From the practices we have observed and from the previous considerations, we can derive implications for the design of a photoware that at least can support the archaeological work rooted in photograph management. In so doing, we are well

aware that the introduction of even a very light technology in domains like archaeology may have deep and sometimes unanticipated effects, as in fact, happened with the introduction of digital photography. However, the following with implications for design received a preliminary consensus from the archaeologists observed when we identified them during our joint discussions: this consensus was combined with the strong requirement that whatever the resulting functionalities could be, they should be easy to use by not only technology experts but especially by laymen, since information technology is not yet appropriated by the professionals working in the archaeology domain.

A first set of functionalities strictly concerns photowork. For example, the technology should support the management of the duplication of a photograph, the various (partial) elaborations performed on the copies and then their possible reconciliation in a single photograph to be stored for future use. At the same time, an easy way to manage the link of a photograph with its elaborations (without reconciliation) would also be appreciated. Moreover, additional functionalities could support the recording of the sequences of actions that led to high quality results when constructing photomosaics. As already mentioned, this is a creative activity that requires the solution of unanticipated problems: e.g., depending on the nature of the soil, the presence of geologic configurations, the low quality of some photographs, and so on. This kind of photo-work is often based on a try and error approach that would be more productive if the technology could help in handling the sequence of the performed actions and their outcomes, e.g., by supporting backtracking and the recording of productive sequences. The latter could be organized to become a more reactive and useful support by pointing to best practices and appropriate warnings in specific phases of the elaboration. Finally, in agreement with the experimental nature of archaeological collaborative photowork and in support of learning by doing/imitation, the issues about equality of control discussed in Section “Management of Photos” suggest the opportunity of multiple accesses to the instruments (i.e., multiple controllers) used to elaborate, specifically, the photomosaic and the digital graphic survey. In the case of the technological setting like the current one in Pantelleria this means installing two (or possibly more) mice plugged into the same laptop in order to put both archaeologists on equal footing, allowing multi-pointer interactions such as in (and possibly by means of) MPX [14]. This way the skilled archaeologist could draw the digital graphic survey of a problematic area of the photomosaic and the student archaeologist could replicate the same drawing, or draw the graphic survey in his own way, and then compare the results.

By taking into consideration the socialization involving collaboration that we described in Section “Related Work and New Findings”, the technology should provide a framework where photographs can be easily associated to other artifacts constituting the documentation of the excavation campaign. This way this documentation can be seen as “a web of artifacts” having photomosaics as privileged nodes (archaeologists liked this metaphor that we borrowed from the healthcare domain [15, 16]): in fact, the web evokes both strength and scalability, and at the same time, flexibility of the connections among the artifacts that the web makes explicit. On this web, awareness of new events (like, updates, completion of tasks, the creation

of new nodes and connections, and so on) could be propagated according to disparate criteria (semantic proximity, role played by the user, etc.) by using different notification and awareness models [17]. This proactive behavior was considered as an adequate way to convey awareness of activities distributed in time and space that in archaeology (like in healthcare [18]) leave traces on the collected data in multiple ways.

The form of socialization based on the knowledge dimension requires a support to search and browse that is driven by the documentation contents: specifically, searching by similarity was mentioned as a functionality that could support many of the practices described in Section “The Collaboration Surrounding Photographs”. This very simple and obvious requirement was, however, the source of a lively debate on its implications. In the experience of our interlocutors, the search based on keywords was too poor for their needs; on the other hand, the typical semantic search based on a predefined ontology was problematic. In fact, although the domain already generated models and languages for this, they are still unreconciled and too related to specific archaeological approaches: consequently, the definition of a really usable universal domain ontology was not deemed as realistic, and in any case too general purpose, to be used in specific situations. The alternative solution to maintain a locally defined ontology was deemed as an unsustainable effort. Moreover, as is often the case, the question to be answered by the search is not always well defined and often transforms the search in a browsing activity. This mixed functionality was described as a support of journeys that traverses the webs of artifacts that have been constructed in different campaigns: the same metaphor has been later proposed in [19]. In this uncertain process, similarity cannot also be defined on static and predefined parameters. From the archaeologist’s point of view, a typical path starts from a find and the photographs containing it, it reaches the documentation of similar finds, then passes through the forms that incorporate their interpretation, from which it reaches a photomosaic indicating the finds and soon. In this process, existing consolidated taxonomies (e.g., characterizing the shape of ceramic artifacts) and metadata capturing locally defined semantics can be reasonably used to proactively identify alternative next steps of the investigation, up to the point that they do not undermine the flexibility required by this qualitative mix of searching and browsing.

## **Conclusion and Future Work**

This paper described the setting and the outcomes of a field study aimed at identifying the practices surrounding the use and management of photographs as part of the archaeological work performed during an excavation campaign, both at the excavation site and in the laboratory where post excavation elaborations were performed. Beside practices that have been uncovered in home photography, professional usage of photographs shows additional practices that are motivated by the features and goals of the specific domain that make these artifacts a different kind in relation to forms and templates that have been considered up to now.

Since we will have the opportunity to continue this empirical research during the next campaigns, we are planning some short term activities to start the experimentation of initial technological solutions along with the ones mentioned in Section “Implications for Design”. We distinguish between technologies to be used at the excavation site and those that can be used in the laboratory.

For what concerns the first kind, we plan to provide the archaeologists with small devices (like e-paper based iLiad or palmtop) in order to let them directly produce the digital graphical survey, thus avoiding the necessary passage via the paper based version. This solution does not prevent having the printed version of the previous photomosaics and the related digital graphical survey available at the excavation site: it allows instead the combination of the two media in order to have a more readable version of the excavation area reproduction, and at the same time, to avoid useless duplication of effort to produce the next survey. Moreover, this solution would allow them to construct on the fly links to interesting information (photographs, interpretations, structure of the excavation layers): this is a first step toward the construction of the web of artifacts that constitutes the archaeological documentation. To this aim, we plan to integrate open source technologies that augment photographs with “hot spots” to which multimedia information can be flexibly and easily associated.

For what concerns the technology to be experimented in the laboratory, our effort is oriented to support the management of the photographs that are used to build the photomosaic. Currently this management is based on the different extensions of the files that are produced by the cameras and are required by the integration software (jpeg and bpm, respectively). This is clearly not enough to manage the multiple versions of each photomosaic and their rich semantic links as discussed in Section “Implications for Design. For what concerns the collaborative work on the same photomosaic, we plan to experiment technologies like Google-docs, to be specialized for the collaborative elaboration of the same version of the shared photograph. This solution is preferred by archaeologists more than duplication/reconciliation because they agree with the literature giving evidence that in cooperative work social control is a strong and by far more acceptable form of coordination than the one driven by sophisticated and possibly error prone computer (graphics, in our case) algorithms.

Our long term research agenda concerns the full development and implementation of a technology supporting the metaphor of the web of artifacts and the various forms of awareness that can be propagated through the related semantic links: this support was initially conceived for the healthcare domain but our investigations proved that it is applicable to the archaeological domain as well. In fact, the two domains show a similar mix of tacit and explicit conventions that govern collaboration in situations where wrong behaviors might produce unrecoverable outcomes.

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