

# Pearl: living media enabled by interactive photo projection

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**Abstract** People capture more and more photographs leading to large personal photo collections that require much time and effort to organize. A lack of organization can have a negative effect on photo retrieval and photo sharing. In this user-centred design case study, we have explored new possibilities for organizing and sharing photographs. To organize photographs, the concept living media was created; automatic positive selection based on which photographs are viewed more often and viewed for a longer time. These photographs are apparently more interesting, and therefore, they will keep their appearance; less popular photographs will slowly fade to black over time. To share living media away from the computer, the device Pearl was designed. Pearl has an integrated pico projector that projects an interactive collage of living media in a living room. Interaction with the collage, such as deleting unwanted photographs from the collage, gives input to the selection procedure of living media. Placing Pearl at a distance creates a larger projection size, suitable for sharing photographs with a group of people. Our design

is evaluated in two small-user studies, where we found benefits and challenges of using a combination of positive selection and pico projectors for photowork and photo sharing.

**Keywords** Digital photo sharing · Photowork · Positive selection · Pico projectors · Everyday remembering · Interaction design

## 1 Introduction

Imagine you have just come back from a one-month holiday to Indonesia, with 1,206 photos, 60 movies and 11 audio recordings. How do you organize, archive and share such a large collection of media? This real-world example from the life of the first author points to a growing problem that people have with their exponentially growing media collections. The aim of the following investigation was to understand and address these difficulties through a combination of user research and design envisionment.

An overload of media has emerged since the introduction of the digital camera and the integration of camera sensors in mobile phones. The large amount of captured photographs creates more work on, for example, organization of photos. This inconvenient task is crucial to be able to find specific photographs at a later moment. Still the majority of people are reluctant to organize their photographs, because of the complexity of the task and the time it takes to organize such a large amount of data [21].

The digitization of photographs has also changed the way photographs can be shared, for example, via e-mail and online photo albums. Although there are several possibilities for sharing photographs online, sharing offline has been problematic [26]. Digital applications for co-present sharing

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of photographs lack social affordances in comparison with analogue applications like slide projectors and photo albums. People organized photo sharing evenings with slide projectors, and photo albums can be shared comfortably on a couch. This rich form of social interaction, also called phototalk [14], does not occur with online photo sharing. There is therefore a need for a convincing co-present photo sharing application that facilitates phototalk. In this paper, the term sharing is used for the collaboration around photos and not the (online) distribution of photographs. A study was done investigating how co-present sharing with digital photographs can be improved. This resulted in the design and evaluation of the concept Pearl.

We will give an overview of related work on photographs (Sect. 2), from capturing to sharing. Furthermore, we will introduce our iterative design research process (Sect. 3). Sections 4 to 5 describe the research and design activities and explain the process underlying the design of Pearl (Sect. 5). This design is evaluated in two user studies (Sect. 6). The results of these two studies form the base for our discussion (Sect. 7), followed by our conclusions (Sect. 8).

## 2 Related work

The process around photographs can be divided in three phases: capturing photographs, photowork and photo sharing.

Photographs are subjective visual statements and not copies of reality, according to Chalfen [7]. Some events are unthinkable without *capturing photographs*, for example, weddings and holidays. Especially tourists use their camera a lot more than in an everyday situation. Capturing photos can help tourists to get more control over an unfamiliar place and gives them something to do [34]. Sontag [35] even suggests that tourism has become a strategy to collect photographs. Tourists take such vast amount of pictures, because they experience the world around them with amazement. This experience is what Urry calls the tourists gaze [37]. When tourists see a couple kissing in Paris, they will see “timeless romantic Paris”. As a visitor, they are looking for typical Frenchness. Tourist photography can be seen as documentation of the tourist gaze. Bærenholdt et al. [3] investigated tourist photography and concluded that not all tourists have the same gaze and have different strategies to practise photography during their holiday. The most common strategy is to go to a tourist attraction and take a photo of that attraction among the tourist crowds, which is considered the collective gaze. Some tourists prefer to frame their family or loved ones in front of that tourist attraction. This family oriented holiday photography is called the family gaze. Other tourists prefer to leave the busy tourist crowds and put a lot of effort to portray the

tourist attraction perfectly. This is what Bærenholdt et al. call the “romantic gaze”.

The capturing phase is followed up by the *photowork* phase. Photowork is the term for possible actions after capturing and before sharing, for example, the selection, annotation or the visual editing of photographs [21]. Photowork can occur on the camera, at the moment of downloading or in advance of sharing photographs. Most of the photowork for amateur photographers is in the organization of their photographs; however, it takes much time and effort. A lack of organization has a negative effect on long-term retrieval of photographs. People fail to find almost 40 % of the photos older than a year [38]. Reasons contributing to this poor retrieval were the large amount of photos, distributed storage of photographs and no hierarchy in the collection. A way to bring hierarchy into the collection is positive selection, which is the identification of favourite pictures. Positive selection is implemented in several photo software packages, for example, with the star-rating tool [2, 29]. With this tool, users can rate 0–5 stars to photos according to how much they like them. The user can later filter a set of photos by a number of stars to find the positive-selected photographs. Positive selection enlarges the visibility and availability of favourite photos and is therefore promising to implement in an organization tool [38]. The opposite is negative selection, which is selecting unwanted or poorly focused pictures. An application of negative selection without deleting is GrayArea [5]. Users can drag unimportant files to a grey area at the bottom of their file folders. This way these unimportant files do not compete for attention.

Digital photographs can contain metadata. Metadata is additional information about, for example, the time and location that the photograph was taken or people that are on the photograph. Photographs can be clustered according to parameters in the metadata and could help in finding photographs [8, 9, 24]. Another approach to retrieve photographs is with the help of physical souvenirs that are associated to photos [16, 28, 36]. The souvenirs already have a meaningful connection to the media files and are therefore logical access points to the digital collection. Furthermore, souvenirs facilitate the remembering process [17]. However, these methods do not decrease the amount of photographs and do not decrease the media overload.

After the photowork phase comes the actual *sharing* of photographs [21]. New technologies for sharing digital photos are called photoware [14]. The digitization of photographs created new possibilities for sharing photographs asynchronously, such as via social network sites or distribution of photos by means of e-mail. Co-present photo sharing still includes printed photographs but increasingly involves phones and other mobile devices. Sharing photos on a desktop computer screen is less convenient, because

computers often have unsuitable locations and too small [14, 26]. New developments now focus on interactive digital photo frames, tablet computers and smart phones as new sites for photo display [4, 11, 12, 20]. An additional technology for displaying photographs is projection. Pocket-sized pico projectors can be integrated into devices such as smart phones [15, 39, 40]. These projector phones create new possibilities for mobile photo sharing, but could also have an interesting function for photo sharing at home. In the following sections, we will explore the properties of pico projectors for supporting photowork and the sharing of digital photos in a home environment.

### 3 Design research process

This section explains the design research process used to arrive at our final design and conclusions. An iterative design research process was applied [19]. This involves a series of small-scale user studies and design envisionments intended to explore a design space in a user-driven way. The aim of the process can be the creation of understanding about the domain in a form of “design-oriented research” or the evolution of an evidence-based design proposal in a form of “research-oriented design” [13]. In this study, we prioritised the design outcome through research-oriented design.

The design research process consisted of three small iterations in preparation of a final large iteration (Fig. 1). Each loop in the figure represents an iteration that consists of a user study and a concept design. At the end of an iteration, we reflected on our results to determine the focus and activities of the following iteration. In the first iteration, tourists were interviewed about their capturing experiences and several concepts were created. The second iteration included a focus group session with exchange students. In the third iteration, we defined four personas, describing target groups based on research from the first two iterations. In the fourth iteration, a final design is proposed, that is, elaborated in a scenario of use and a prototype. We evaluated the concept with scenarios and a prototype in two small-user studies. This process leads to smaller-user studies than a usual user-centred design approach, but to more idea generation.

### 4 First design iterations

In the first three iterations of our work, an interview study and a focus group study were conducted, and personas were created to gather input for a final concept design. We design these briefly here, before outlining the design and evaluation of a photo-projection system called Pearl.

#### 4.1 Interview study

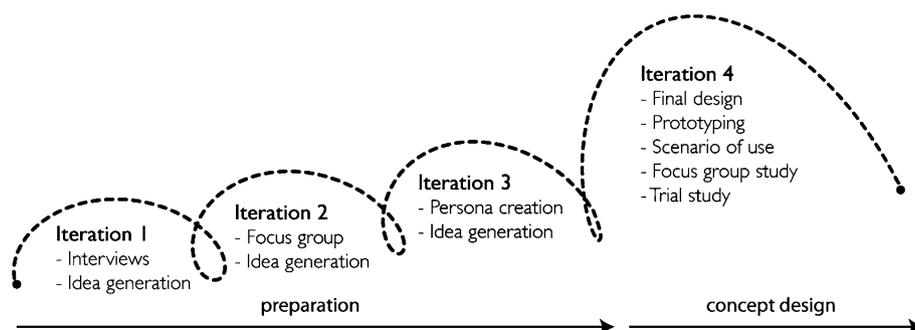
The aim of the first iteration was to get a broad understanding of the domestic photography domain, and work out some ideas that could improve the use of large volumes of photographs. One activity that leads to intensive capture and sharing of photographs is tourism, as in our opening example. Hence, interviews were conducted with tourists to feed the design process with rich and qualitative data. The goal of the interviews is to gather insights about how tourists experience the capturing, organizing and sharing of photographs. The interviews were semi-structured to be able to react on the participants’ answers. Furthermore, the participants were asked to share a copy of the photographs on their camera to get an impression of their capturing behaviour. The interviews were done with five tourists aged 21–38, coming from the Netherlands, Spain and Brazil. All participants were informed about the study and signed consent forms. The interviews were conducted in London, in the area of Green Park, Buckingham Palace and Hyde Park.

The participants explained that they captured photographs to document their holiday experiences and to remember them for the rest of their lives. Although most participants did not consider themselves as good photographers, they did enjoy photography. Some participants explained that they enjoyed the search for nice photo opportunities, but also that posing for the camera could lead to fun moments.

All participants produced a high amount of photos; several participants mentioned they took around 1,000 photos during one holiday week. One participant, who arrived in England only five hours earlier, had already taken 113 photos. The collected photographs show that most of them were taken at the changing of the guards at Buckingham Palace. Certain tourist events of this kind seem to have an iconic value and are captured simultaneously by any crowd of tourists (see Fig. 2). Furthermore our participant showed us multiple pictures from the same event. She explained that this allowed her to select the best photos that represented her experience.

After their holiday, all participants would upload all their created photos to their computer. This is because a computer screen is able to give a better representation of the quality of the photo. Some participants were very structured in the organization of their photographs; others were more reluctant. The main reason for organizing photographs is that it is much easier to find the pictures you are looking for. Two participants were very persistent in keeping their photo database up to date every week by deleting unwanted pictures and naming the files correctly. One participant organized his photo collection poorly, because he did not have the time for it. The result is a

**Fig. 1** The design research process



**Fig. 2** Hundreds of tourists taking photographs and videos at Buckingham Palace (participants' photo)



messy collection of over 20,000 pictures. This participant felt guilty for not taking the time to do it, but still had the dream to do it one day. He furthermore talked about the difference between his photographs for work and the ones he takes during holidays. He said he would have the same approach with taking work-related pictures, but he would keep more personal photographs (“even the rubbish ones”), because of their value as personal memory triggers.

One participant had made three collages of printed photographs that she frequently updated with new pictures. From this London trip, she would probably use three photos (out of the estimated 1,000). This shows the difference in the amount of photos taken and the photos that are apparently valuable enough to print and use. This participant coped with that problem by carefully selecting three photos to print.

In conclusion, tourists shoot a large amount of pictures, especially during an iconic event like the changing of the guard. This may also relate to the pressure that tourists can feel to take photos when other tourists capture photographs [34]. On the other hand, participants explained they simply enjoyed the activity of capturing photographs. The large amount of captured photographs puts pressure on the organization of photographs that is required to optimally enjoy their photos. Still not all participants reported doing this, because it was considered time-consuming and boring. Therefore, a tool that helps people with their organization would be useful.

Alongside the user interviews, several design concepts were created. Among the ideas were a digital touch screen scrapbook and a tool to add Twitter messages created during a holiday to photographs of that holiday. Another concept was a necklace with integrated sound recording device and GPS sensor to record sonic souvenirs [10] and their location to be able to find them later. Also the concept Iconize resulted from this idea generation phase. This is shown in Fig. 3 and described below.

Iconize is positive selection at the moment of capturing. Cameras with a similar functionality to Iconize are already commercially available [25, 33]. These cameras support on-camera tagging or audio annotation, but the functionality is hidden inside a complex menu structure and not as easily accessible as the “thumbs up”-interaction. Furthermore, we question whether the relatively small screen of a photo camera is sufficient to be able to judge whether a photo is good or not. Participants from the interview study explained that they wished to select photographs at home, when they can view their photos on a larger screen. Therefore, we decided to design how these “icon photographs” can be organized and shared at home.

#### 4.2 Focus group study

Through a focus group study, we wanted to collect qualitative data of current photowork and photo sharing practices. In the focus group session, the differences between photowork and photo sharing experiences with

**Fig. 3** Iconize concept

Iconize is a function on a camera to rate the photo just taken as an icon photo. To make it an icon photo, just push the image up with your thumb (thumbs up!). Iconize implements positive selection right after the moment of taking a picture. It can help people to get an overview of the good photos that might be used for sharing, printing or online publishing.

prints and digital photographs were discussed. Five exchange students (two male and three female) participated in the discussion, aged 21–25 years old and came from Finland, Germany, Italy and the Netherlands. They were active photographers and active sharers to keep their loved ones back home up to date during their stay abroad. The conversation was recorded and transcribed afterwards. Affinity diagrams were used to analyse and cluster user statements.

During the conversation differences in enthusiasm towards photographs was found. Photo fanatic IP (participants initials are used for privacy reasons) named all the photos correctly and visually edited blurred or dark photos with Photoshop. AL was less organized and just downloaded her photos to a folder on their computer. Except for AL, all participants created a selection of their best photos. Although almost all participants used positive selection, only two participants reported the use of negative selection. Still, they would not delete these photos without a backup. This could be caused by the increase in digital storage capacity that allows people to keep more photographs. Furthermore, the participants might find it hard to delete photos permanently, because they represent personal memories they do not wish to lose.

Although a larger amount of photographs increases the time for organization of the photos and has a negative effect on long-term retrieval, some participants explained the benefits of more photographs. They simply enjoyed viewing the whole set of photographs which triggered their memories. For example, FL said: “The computer allows me to have more pictures than with printed pictures, because you don’t print every picture. And that’s the reason why I never delete a picture, because when I browse through them all... I rebuild the moment in my mind”. Also, the participants liked that computers are able to show photos at a larger scale, which can give more detail about the captured moment.

Despite the benefits of the computer, all participants still preferred prints. FL said: “Maybe paper pictures are just more fascinating than a screen. And I like to hang them on my wall or just store them, because hard discs crash”. Prints are seen as more special, also because the

participants could do something with them, like hanging them in their room or placing them in a photo album.

We also asked participants about their experiences with co-present digital photo sharing, both as a storyteller and as a listener. All participants found digital photo sharing boring.

MW: “I only show them to my parents... I don’t want to bore other people with that.”

AL: “Maybe the nice ones, but I’m really quite bored of people showing me their pictures... I’ll always know there’s going to be a next one and a next one and a next one... It is nice for ten pictures...”

FL: “Not for thousands no.”

This indicates that a large amount of photographs is less suitable for sharing.

A strict selection is needed to keep the listener interested. Also, participants explained that they have nice memories with the photographs as a storyteller, but they are unable to transfer their feeling to the listeners. Because co-present photo sharing was considered boring, most participants used social networking sites like Facebook for sharing their photos asynchronously. Friends that are interested can decide for themselves to view the photos on a moment that suits them and in their own pace. The participants found this a less forced way of photo sharing; however, it does not facilitate phototalk.

The focus group discussion showed different behaviours towards photography, especially a difference in interest and enthusiasm. We have clustered them into target groups described by personas to give an overview of their different needs (see Sect. 4.3). Furthermore, the difference in printed and digital photographs was discussed. Prints go through a tougher selection than digital photographs. People do not have the need to do a strict selection with digital photographs. The large amount of digital photographs supports reminiscing, because more photographs can give more details. However, co-present sharing with digital photographs is considered boring, because of this large amount.

In response to the focus group findings, a concept called MemoryLamp was developed to display iconic (positively

selected) media (see Fig. 4). MemoryLamp increases visibility and accessibility of personal media in the home, which could lead to more frequent exploration of the media collection. MemoryLamp uses projection to create a display on a wall or table. The projector enables people to vary the screen size by increasing the distance between the projector and the projection surface. This could be useful for sharing photographs with a large group of people. At this point, pico projectors grasped our attention and seemed like an appropriate technology for photo sharing.

Taken together, our first two user studies have led to a design idea called iconic media. Iconic media in this context are photographs that stand out from the rest and are more important to people. MemoryLamp is a product to share iconic media. However, MemoryLamp lacks a way to manipulate and organize iconic media. In the third iteration, we intended to create a product concept that elaborates this principle.

### 4.3 Persona creation

From the interviews and focus group session, we concluded that people have different behaviours towards tourist photography. Therefore, personas were created to portray these different behaviours. Personas are descriptions of persons that show behaviours and motivations that are typical for a broader range of users. Creating personas can function as a bridge between data and design [27] and inspire the final concept design. We based our personas on the data from our two user studies from the first two iterations and literature about tourist gazes [3].

The following four personas were created: Snapshooting Sam, Travelling Tina, Fanatic Fred and Caring Carla (see Table 1). They each differ in their enthusiasm about photography and the amount of effort they spend in capturing and organizing their photo collection.

Fanatic Fred and Travelling Tina are personas that enjoy photography and spend a lot of effort in organizing and presentation of their photographs. Snapshooting Sam and

Caring Carla represent people who have difficulties organizing their collection properly. This group of people would like to enjoy their collection optimally, but do not want to spend too much effort in organizing them or do not know how. Our primary focus will be on users that resemble the Snapshooting Sam and Caring Carla persona, because they have a large need for a better way to use their photographs. Therefore, the concept living media was created.

Imagine that photo files that are used more often behave differently than less popular photographs (Fig. 5). Living media is positive selection of photographs based on the viewing history of photographs. This implementation is simple and can give an overview of positively selected photographs without looking chaotic. The concept of living media can be applied to computer software; however, reminiscing and storytelling can have more value when it happens away from the computer [14]. The presentation of living media might be done on a home computer screen, but we believe it will be more effective as a large wall projection in a shared recreational area of the home. Therefore, the product Pearl was designed for use in a living room and is oriented to sharing.

## 5 Design of Pearl

The aim of this iteration is to design a product that facilitates viewing and sharing of living media. The main purpose of the design of the product is to increase the visibility of photographs in the home and share them with others.

### 5.1 Pearl

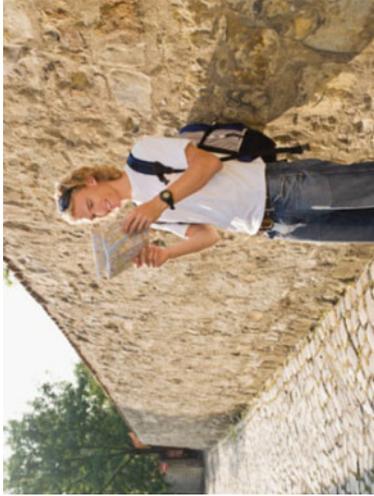
Pearl is a device with an integrated projector that can be placed on a sideboard and projects an interactive photo collage on the wall (Fig. 6).

Pearl consists of two functionalities: an interactive photo collage and a full-screen chronological photo browser. The

**Fig. 4** MemoryLamp concept



MemoryLamp is a lamp with an integrated projector and speakers. It projects a digital map to find photos, videos, sounds and GPS-tracks of travels. The user can interact with the map and media with a touch interface. The display of iconic media or all media is coupled to the zoom-function of the map. Iconic media will be shown when the map is zoomed out. When the user zooms in to a certain location, more detail of this location will be given. This means that more detailed and non-iconic media will become available.

**Table 1** Tourist photographer personas*Snapshotting Sam*

“Hi, I’m Sam, a 21-year-old International Marketing student and currently I’m doing an exchange in Italy for 5 months. I made a lot of international friends here and we travel a lot together. On these trips I always bring my digital compact camera. When I’m taking photographs I am not very interested in all the camera settings; I just shoot some photos and hope some will turn out nicely. So I’m not an expert at all, I just like the activity of shooting photos. I intended to write a blog about my adventures abroad (like some of my friends did), but so far I have been too busy. I sometimes post a selection of my photos on Facebook to update my friends and family at home, but also to share with my newly made friends. I actually never share my photos face-to-face, except with my family. I don’t want to bore other people with that. Besides, my collection is a total mess. All my pictures are titled something like 0536859.jpg”.

*Fanatic Fred*

“My name is Fred and I’m a 32-year-old IT consultant and photography is my biggest passion. The best way for me to practice it is to travel to exotic places in the world together with my wife. We want to see as much of the world as possible before we start a family. We both own a digital SLR with multiple lenses and bring them everywhere we travel. During a holiday I am constantly looking for photo opportunities. It makes me more aware of my surroundings and photography is the way to express that. When I take a photo I spend some time to find the right location, composition and settings. I keep shooting until I think I’ve captured the moment as beautifully as possible. I love it when I’m able to create something visually appealing with a complex piece of technology. At home I immediately make a backup and use Lightroom to organize, rate and edit my photos. I also made a nice website together with my wife about our travels showing our most beautiful photos”.

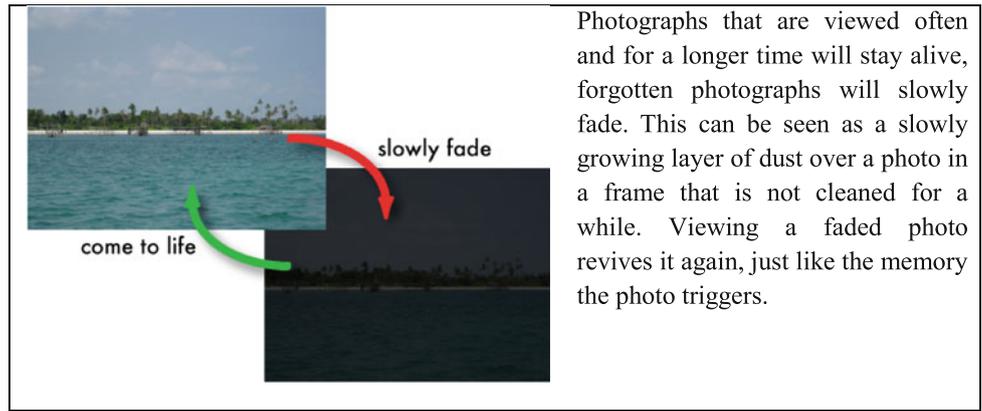
**Table 1** continued*Travelling Tina*

"I'm a 29-year-old lawyer and an active traveller. I just love to get a taste of different cultures. I like to travel alone, because this gives me more opportunity to interact with the other culture and I can go wherever I want to. Photographs help me to remember how it was like to be there. Therefore I take photographs of buildings, landscapes, local people and things that are typical about a certain culture. I have backpacked through parts of South America and Asia, but also visited big European and American cities. When I come home I upload my photos on my computer and create a backup of all photos on CD or DVD. Afterwards I delete the bad ones and create a selection of the best photos to put on my Facebook. I always make photo albums with detailed annotations, but I still need to finish the album of my last trip".

*Caring Carla*

"I'm a happily married 42-year-old mother of three children. I'm a French teacher and guess where I like to go on holiday. My husband shoots most photos, but sometimes I ask whether I can take some. He only makes photos of the tourist attraction itself, while I want some of my husband and the kids. Photos of just buildings or landscapes have no meaning for me without the people I love. I also hate it when he snaps photos all the time. I rather enjoy the moment itself instead of being busy taking photos. However sometimes I find myself snapping photos and remind myself to actively look around instead of looking at the camera screen. When we're at home my husband puts the photos on the computer. If I want to look at them, I need to ask him to find them for me. Sometimes I wish we just had an analogue camera with a film that is printed. Unfortunately we almost never print photos anymore".

**Fig. 5** Living media concept



dynamic collage is the standard functionality and the full-screen browser allows users to chronologically browse through photos of a certain event one by one.

### 5.2 Interaction with Pearl

The collage has several interaction possibilities. Interacting with photographs through either the photo collage or the photo browser affects their status as living media.

#### 5.2.1 Collage

The collage consists of six photos. This amount was chosen because this is just enough to create a collage without reducing the visibility of the photos. One photo is positioned in the middle and is slightly bigger than the others. Every day the collage refreshes with different photos, except for the central photo. This central piece functions as a specially selected photo that is displayed for a longer period. The user can place a photo in the middle to keep it for a longer time. This is similar to a printed photo in a photo frame but with a lower threshold to change the photo. Next to centralizing a photo there are three other

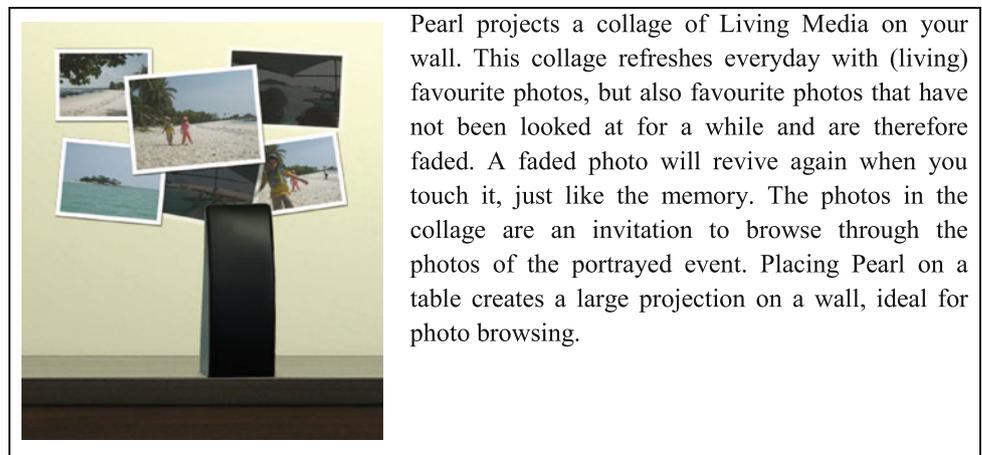
interaction possibilities with the collage: touching and removing a photo and refreshing the whole collage (Table 2).

The user can play with the collage to change it until he or she is satisfied with the collage. All interactions with the collage have an influence on the selection procedure of living media. For example, the user can give extra value to a photo by centralizing it. In everyday use, the collage persuades the user to shortly interact with living media and say something about the value of the displayed photos. In other words, the interface triggers the user to interact with media and hereby support the selection procedure.

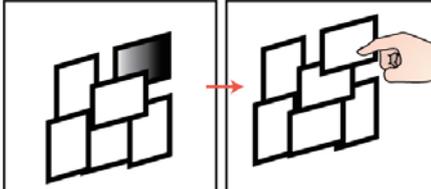
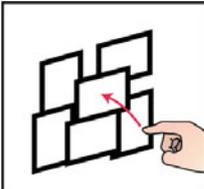
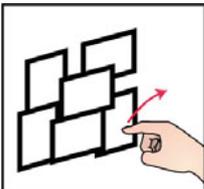
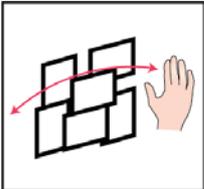
#### 5.2.2 Browser

The browser can be used to browse through photos of an event or through events itself in a thumbnail matrix or full-screen view. Users can decide whether or not they wish to browse through all of the photos or only through the positively selected photos. Because the browser functionality is similar to browsing on a computer, the choice was made to focus on the design and elaboration of the interactive collage.

**Fig. 6** Pearl concept



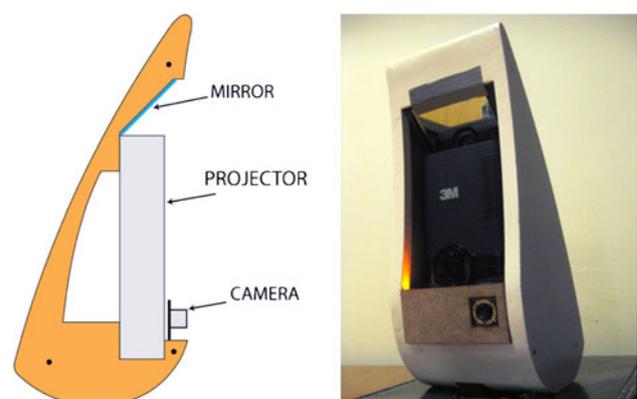
**Table 2** Interactions with the collage of Pearl

	<p><u>Touch a photo</u></p> <p>The central photo is displayed on the foreground. Touching a photo enlarges it and brings it to the foreground. Touch a faded photo to let it light up and unveil the content.</p>
	<p><u>Centralize a photo</u></p> <p>When a user sees a photo he/she enjoys, it can be dragged to the middle to swap it with the middle photo and ensure that it is still there tomorrow.</p>
	<p><u>Remove a photo</u></p> <p>When a photo is inappropriate or unwanted, the user can remove that photo by dragging it out of the projection area. A new photo will appear on the place of the removed photo.</p>
	<p><u>Refresh the collage</u></p> <p>Interrupt the projection beam by waving in front of the object and it will show a new collage.</p>

### 5.3 Implementing Pearl

A prototype was created for a user test. The prototype consisted of a 3M mpro120 projector [1] with a light intensity of 12 lumens and a Logitech QuickCam Pro 9000 webcam [23]. The pico projector, webcam and a mirror were integrated in a model created out of laser cut sections from MDF fibreboard (Fig. 7). The software for the photo collage functionality (Sect. 5.2.1) was developed in Processing [31]. This software ran on a laptop connected to the projector and camera.

The interaction with the collage is based on finger tracking with the help of a camera [40]. However, this was too complex to implement in a relatively short time. Therefore, the Reactivision software [32] was used, which is able to track the location and orientation of so-called fiducial markers with a camera. These fiducial markers were printed on cardboard cards. Keeping a card in front of a photo in the collage (Fig. 8) executed one of the following



**Fig. 7** Side view from a technical drawing (left) and a photo of the final prototype (right)

actions: touching a photo, removing a photo from the collage, centralizing a photo, refreshing the collage with new photographs and full screen view. Different cards were held over selected photographs to execute each action.



**Fig. 8** Participant using the Pearl prototype

## 6 Exploratory user studies

To evaluate living media and Pearl, two small-scale user studies were done: a focus group and a trial with the prototype described in Sect. 5.3.

### 6.1 Focus group

A focus group discussion was organized [22] to collect multiple viewpoints on photo organization and photo sharing with the concepts living media and Pearl. Scenarios were created to describe the concepts (Appendix) and used as input for the discussion.

#### 6.1.1 Methodology

The value of living media and Pearl in contrast to existing methods of photo organization and sharing was discussed with the help of two scenarios (Appendix). A scenario is an “informal narrative description” [6] that describes human activities or tasks. Scenarios can explain existing work situations as well as proposed solutions [30]. We created two scenarios that described the activities of the personas Snapshooting Sam and Caring Carla after they come back from their holiday with a lot of photographs. The first scenario shows how Sam and Carla organize and share their photographs after their holiday using existing tools. Their organization consists of deleting unwanted photographs and sharing with friends on a home PC. The second scenario illustrates the selection method of living media and the interaction possibilities with Pearl. After each scenario was shown, a discussion was started about the situation in the scenario.

Four participants were recruited to enable an in-depth discussion from multiple viewpoints. The participants should resemble the Snapshooting Sam and Caring Carla personas. The participants were three Dutch students and one Spanish student (three male, one female), aged 23–28.

All found the situation described in the first scenario a familiar situation; this made them suitable participants for this study. After the first scenario was shown, the participants were asked whether they could identify themselves with the personas to verify whether they belong to the target group of this study. The discussion took place in the living room of one of the participants. This created a pleasant atmosphere for the discussion.

#### 6.1.2 Results

Participants RB and GG explained that they were too lazy to put much effort into the organization of photographs. They would only copy their photographs to a folder on their computer and not do a lot with them afterwards. IP explained that he recently created a slideshow to share photographs with his parents. MS said that physical photo albums are the best way to archive her photographs. However, she does not make them anymore because it takes too much time. Now she makes a selection and posts this selection on Facebook. She bases the selection on what could be interesting for others. Telling nice anecdotes with photos is not possible with online sharing. She misses this, because she found this the fun part of sharing photographs.

After seeing the second scenario, the participants were very curious about whether the selection method, based on amount of views and duration of views, would actually work. MS explained that she actually already used a similar approach to view photographs in online albums.

If I view photos from people’s photo albums on Hyves (Social Network website), I look at how many times the photos are viewed and I view only the ones that are viewed often. Those are apparently more interesting photos.

The participants liked the metaphor of living media files and agreed that the faded unpopular images help to give a good overview of favourite photographs. Also they would be triggered to delete “dead” files that are never watched, at least more than in the current situation. The interviewees said that they wanted to have final control in the selection process and the ability to overrule the automatic selection procedure if necessary. GG also feared that the system would end up in a loop, as only the favourite photographs would stand out.

For further discussion, the participants were asked to assume that the positive selection method would work perfectly. MS noticed that this system could help with keeping the important photographs together over time. For example, she explained that a photo of a beautiful hill could be very interesting right after a certain holiday. But seven holidays later with similar photos of other hills, that same photo might not be that interesting any more.

The living media selection does not happen only right after a photographed event, but occurs continuously. All participants acknowledged that the positively selected photos were most likely the ones they wished to share with others. Using living media in the collage of Pearl was considered logical and convenient.

MS: “The collage gives a nice overview of your collection and is like a public photo album. It is a pleasant way of sharing your photos, without the effort required to create a physical photo album.”

The several functions like removing a photograph from the collage, touching a photo and centralizing a photograph were discussed. Removal was considered simple and necessary, especially for poor or highly private images. Centralizing was seen as a nice functionality as it allows putting extra emphasis on a nice photograph. Touching a photo was an intuitive way to select a photo. The participants did not like the faded photographs in the collage. They understood the trigger, but found it confusing because the collage should only show living media. People should interact with a photo they find important, not just to make it clear again. Furthermore, they asked themselves whether they would use this functionality after a while. Therefore, the participants wanted only clear photos to appear in the collage.

The projector was another point of discussion. Some participants liked the fact that the projection is on a wall and that a bit of texture of the wall can be seen through the pictures. However, not all participants liked this effect. Participant RB thought that Pearl would enable convenient photo sharing with multiple people: “The atmosphere of viewing photographs is different. You can just grab this one (the Pearl), while you often have to go to a desktop computer”. MS reacted that a laptop is also not convenient to view photos with more than two people. The large screen that Pearl is able to produce made it more practical for sharing photographs, because everyone is able to see it well. For browsing photographs alone, the participants did not see any difference between browsing photographs with a computer and with Pearl and would probably use a computer.

## 6.2 Trial study

The interactive collage and the selection method living media are new functionalities. Through a trial of the prototype, we wanted to gather further insights about the experience of using these new functionalities in a real-life context [18].

### 6.2.1 Methodology

In this trial study, the Pearl prototype (Sect. 5.3) was placed and used in participants’ homes for four days. A

qualitative approach was used to understand what features the participants valued and what living media and its implementation in the photo collage meant for them. The four-day period was chosen to let the participants experience what it would be like to use the Pearl and living media in their daily lives. Three Dutch couples that had not participated in earlier stages of the study, participated in the user evaluations.

After the trial period of four days, each participant filled in a form with seven open questions. The questions addressed topics, such as, participants’ responses to the device, usability issues with different features and recommendations for improvement. The responses to the questions were discussed with each couple to get more in-depth information about the participants’ experiences with the Pearl prototype.

The prototyped photo collage showed different photographs every hour instead of every day to trigger the participants to interact with the collage and simulate a longer period of use. The photo collage was the only functionality tested, because the prototype was difficult to move due to the attached laptop and power adapter. The projector was also not bright enough to project at a distance without a darkened room. Therefore, the browsing functionality was not evaluated in this study.

### 6.2.2 Results

Three Dutch couples (4 men, 2 women) with an average age of 42 participated in the trial. A few days before the trial took place, the participants’ digital photo collections were picked up. We noticed that finding the photographs cost some effort. Some photographs were only stored on CD’s or external hard drives that were located on the attic or at their work. Participants HV and RF were embarrassed about the way they had organized their photo collection because they were not able to find a large part of their digital photo collection. All three couples provided only a part of their photo collection, but this resulted in more than 1,000 photographs per couple, which was considered sufficient for this trial.

After preparation of the prototype with the photo collection of the participants, the prototype was installed in the home of the participants (see Fig. 8). The concept of living media and Pearl was explained and the interaction with the prototype was demonstrated. The participants were asked to switch on the prototype whenever they were at home and awake.

To begin with, all participants were enthusiastic about participating in the evaluation, because they acknowledged that they did not see their photos very often, especially older digital photographs. The participants indicated that using the collage gave them a better overview of their

photo collection. This was also acknowledged in the open questions, the participants enjoyed seeing a selection of their photos in the collage. For example, IB wrote: “it’s a pleasant and fun way to view your photos and nice to walk into some old ones. I normally don’t view them, because they are on the computer”. The participants explained that the changing compilation of photos in the collage provided a surprising element, because sometimes they did not even remember that they had these pictures.

Two of the three couples used the collage actively by putting favourite photographs in the middle and removing unwanted photographs from the collage. The other couple used the collage more passively; they did not feel the need to remove photos and just enjoyed watching them.

Participants also indicated in the questionnaire that they found organizing their collection with the Pearl more fun. The interaction with the collage (such as deleting, centralizing and touching) “invited [them] to play”. Deleting photographs was used most often; the participants liked to have a nice collage and therefore deleted unwanted photographs from the collage. The function of the central photo as a “keeper” was also used during the trial because these were appreciated more as other photographs.

Before the trial, the participants indicated that they did not delete many photographs. However, the collage gave them an urge to discard photographs that were not special or ugly and hereby clean up their collection. Most participants found this interaction with the collage to organize photographs very enjoyable. Only one participant did not like this, because she would like to manually select her favourite photographs. She also explained that sometimes she would dwell on a nice photograph that was not necessarily a favourite. This might indicate that she is more like the persona Fanatic Fred and actually does not belong within the intended target group of Pearl.

Both positive and negative feedback was given to the functionality of faded images in the collage. For example, IB commented the following on faded images: “sometimes it made me curious, but sometimes I just enjoyed watching the clear ones”. Although the faded photographs were found mysterious, most participants did not touch the faded images after a few days of using the Pearl.

The appearance of the collage was found to be too small and the participants requested a larger one including more than six photographs. They also wanted the central photo to be displayed significantly bigger than the others. The photos in the prototype were organized neatly and a collage can have a more spontaneous appearance when photos are rotated slightly and when their size is varied. The participants also suggested the functionality of saving a nice collage to use it later. Also the automatic creation of a

collage around a theme or seeded by a particular photograph was proposed as a possible improvement.

The pico projector technology was new to all participants, but the use of projection to display photographs was known from (traditional) slide projectors and was seen as “nostalgic”. One participant explained that she would like to use the Pearl to organize photo sharing evenings just like she did with her old slide projector. There were some remarks about the brightness of the projection. The brightness was not sufficient to view photographs in broad daylight. One couple even blinded their windows to be able to view the photographs during the day. AH mentioned that darker photographs were not displayed clearly. He deleted these from the collage for this reason. On the other hand, the dimness of the projector also had a positive effect as several participants explained that it brought a nice atmosphere in their living room: IB: “The projection is pleasant, because it is less bright and it integrates into your home” and “It sets a pleasant mood”.

The interaction with the prototype with the help of the fiducial cards was experienced as straightforward but not effective. The participants had to search for the card with the functionality they wanted to use and this seemed like a hassle. In addition, the device did not always recognize the cards immediately and this delay had a negative impact on the experience of using the Pearl. The participants could imagine that the use of gestures for interaction with the Pearl could be more intuitive than the fiducial cards. Overall, the participants enjoyed having Pearl in their living room to display a compilation of their photo collection.

## 7 Discussion

To enjoy and share media, people must be able to find it. According to Whittaker et al. [38], almost 40 % of digital photographs older than a year cannot be found. The poor retrieval is caused by the large amount of photos, distributed storage of photographs, no hierarchy in the collection and a lack of maintenance. Throughout our study, we found further clues that people have difficulties with handling and maintaining their large personal media collection. For example, the participants in our trial study did not store their collection in one place and needed to search throughout the house for their photographs. An obvious solution is to store photographs in one place, for example, on a network-attached hard drive. Negative selection and positive selection are methods to address the large amount of photographs and a lack of hierarchy. Negative selection is the deletion of unwanted photographs and positive selection is the identification of favourite photographs [14, 21]. Negative selection decreases the amount of files;

however, we found that people like to keep their photographs. Our first focus group study (Sect. 4.2) indicates that the large amounts of photographs helps the reminiscing process, but is not suitable for sharing. Therefore, we focused on positive selection, which emphasizes the favourite photographs without deleting any photographs.

Current photo software packages [2, 29] use several positive selection methods: rating photographs with 0–5 stars, flagging photographs and colour labelling. However, most people do not spend the time and effort to manually select their photographs. For this group of people, we introduced the living media concept, which is automatic positive selection of photographs based on their usage. Photographs that are viewed longer and more often are considered favourite media files and keep their appearance, while photographs that are not viewed will slowly fade to black unless they are used again. This creates a hierarchy between photographs that are more interesting and photographs that are less interesting. The created hierarchy increases visibility and accessibility of popular photographs and could improve the long-term use of photographs [38]. Participants in our studies explained that these popular photographs were the ones they would like to see after a long time. Positive selection as implemented in living media organizes photographs without spending much time and effort. It merges the photowork phase [21] and the photo sharing phase [14] and leads to the continuous maintenance of people's photo collection.

Frohlich et al. [14] noted that the current means of face-to-face sharing of digital media lack the social affordances needed for a sharing situation. This was also acknowledged in our second focus group; participants felt that sharing photographs on the computer was not ideal. In our fourth concept design iteration, we aimed to design a device that is able to share living media and takes these social affordances into account. Pearl was the outcome of this iteration, a projection device with an ambient mode and a proactive sharing mode.

The evaluation was split in two studies. The ambient mode of Pearl was worked out in a prototype and evaluated in a trial study. The overall concept of living media and Pearl was visualized in a scenario and discussed in a focus group. Participants of both studies indicated that they would want to use Pearl with living media functionality for sharing purposes. The collage gave the participants a peek in their own photo collection and they were often surprised by the content of their own collections. The participants would like to have final control over the selection and wanted to be able to set certain photographs as private. Most participants in the trial were triggered to interact with the collage, also after a few days. They mentioned that they wanted a nice collage, so they kept removing unwanted pictures from the collages. The simple interaction with the

collage encourages people to play and say something about their photos. Remarks were given about the appearance of the collage: a higher amount of photographs in the collage and a larger size for the middle photo were preferred. Furthermore, the participants mentioned that they did not select faded images after a few days. The participants also mentioned that the collage should only show selected images and not faded images. This indicates that the random faded image function in the collage might not be appreciated. This suggests that further research should be done on browsing behaviour and positive selection of media. This might explore alternative ways to indicate favourite media, for example, by scaling the photographs according to their relevance or using existing methods as such as the star-rating tool.

The projection display was also evaluated. Participants indicated that the projection integrated the media nicely into their living room as part of their interior. The projection set a pleasant mood, which could stimulate the reminiscing process. Also the projection was perceived as less invasive than a screen. Projection is indirect lighting and has no borders and thus focuses on the image of the photographs. In this way, the technology is in the background and the photographs itself in the foreground. The projector also enables a small screen size for ambient mode and big screen size for sharing mode united in one device. The integration of both functionalities in a single device could make the transition between triggers in ambient mode to active sharing easier and thus lowers the threshold to share. A tablet computer in combination with a TV could also facilitate the ambient and sharing mode [16]. However, these screen-based displays would not benefit from the soft qualities of projection as mentioned above.

A longer trial period and a larger sample would allow for more robust conclusions about the effects of Pearl and living media. Furthermore, the interaction with the prototype could be improved by incorporating full gestural control. Also, a projector with a higher resolution and increased brightness is required to be able to view the photographs better during daylight.

Overall, the results of our current investigation have given a lot of insights about difficulties with enjoying and sharing large media collections. The feedback of the participants on the proposed solutions living media and Pearl was mainly positive and validates the approach for further development.

## 8 Conclusion

Despite the importance of digital photographs in people's lives, our research has shown that the difficulty and effort of organizing photographs inhibits people from viewing

and sharing them effectively. In response to this finding, we have developed two potential solutions: automatic positive selection for organizing photographs through the living media concept and pico projection of a photo collage for browsing and sharing photos in the home. Both solutions are combined in our final design of an interactive photo-projection device called Pearl. Despite some usability problems related to faded images and the lack of full gestural control over the photographs, Pearl was seen as a fun way of organizing photographs by just sharing or interacting with them. This suggests that the living media approach is a promising way of giving

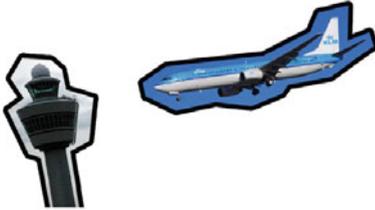
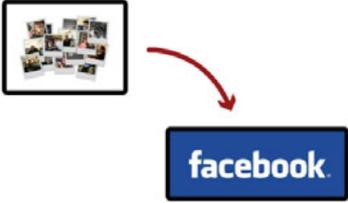
precious photographs the special treatment they deserve and may ultimately allow people to enjoy their many photographs more often and for a longer time.

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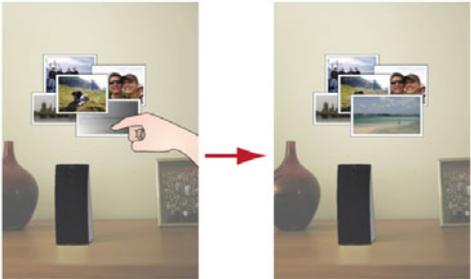
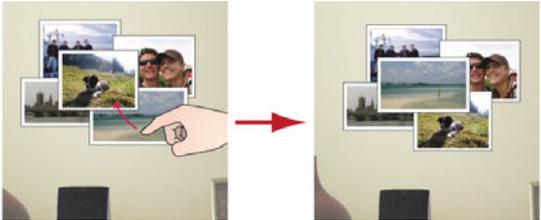
**Appendix: Scenarios**

See Tables 3 and 4.

**Table 3** Scenario 1

<p>Sam and Carla arrive back in Holland from their holiday to Peru.</p> 	<p>The moment Sam gets home he uploads all the photos to his computer.</p> 
<p>He deletes all the blurred and ugly photographs...</p> 	<p>And posts a selection on his Facebook profile.</p> 
<p>Carla wants to see the photographs too and asks Sam to show the photographs.</p> 	<p>A few days later their friends come over. Carla wants to share the holiday photographs and asks Sam to show them on the computer.</p> 

**Table 4** Scenario 2

<p>Sam and Carla come back from their holiday to Peru. Sam uploads the photographs and deletes a few ugly ones while viewing them.</p> 	<p>Afterwards the photos that have been viewed less long and less times slowly fade away. The popular photographs stay bright and alive. This principle is called living media.</p> 
<p>Pearl is a kind of digital photo frame that projects a collage of living media on your wall. Carla sees that one photo has faded.</p> 	<p>She touches this photo and it lights up and comes forward. She sees it is a photo of their holiday to Thailand 7 years ago.</p> 
<p>Carla puts Pearl on the table and asks Sam to join and view the photos of their Thailand trip.</p> 	<p>After viewing all the photos Carla puts Pearl back on the sideboard. She really enjoyed this photo and drags it to the centre.</p> 
<p>The next day the collage shows new photos, except the centre photo has stayed the same. Sam drags an inappropriate photo out of the collage to remove it.</p> 	

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