

More Than Meets the Eye: An Exploratory Study of Context Photography

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ABSTRACT

In *context photography*, sensors gather real-time context information, which visually affects a photograph as it is taken. We have implemented a prototype running on standard camera phones. It uses sound and movement as context information and a set of custom-made computer graphics effects which affect images in real time. To investigate how people would receive the concept, we conducted an exploratory user study with seven participants using context cameras for a six-week period. The study provided insights into how such a camera is perceived and used, revealing the emergence of new goals, expectations, aesthetics and practice in taking pictures.

Author Keywords

Digital photography, context photography, ubiquitous computing, user study, camera phones.

ACM Classification Keywords

H.5.2. Information Systems – Information interfaces and presentation (e.g., HCI). Evaluation/methodology. **I.3.8 Computing Methodologies** – Computer Graphics: Applications.

INTRODUCTION

Digital cameras are rapidly becoming a pervasive presence in people's everyday life, either as self-contained devices or integrated in camera phones. The digitalisation of photography has given birth to a new visual culture and enabled new types of practices, such as digital post-manipulation of photographs, direct image sharing using MMS (Multimedia Messaging Service), or web communities such as Flickr (www.flickr.com).

However, in terms of actually taking a picture, not much has happened since the days of the analogue camera. The photographer still points and clicks to capture an image that



Figure 1. The context photography application visually captures sound and movement in a still picture.

originates from the light reaching the camera lens. The only real evolution in the picture-taking moment has consisted of automating the adjustment of sharpness, shutter speed and aperture, and more recently the possibility of seeing a preview image on the camera display. While these changes have simplified the act of taking a picture, they still rely on preconceptions of what a camera can achieve; preconceptions that have their origin in the optical and mechanical constraints of analogue cameras. What would happen to the picture-taking moment – and to the creative practice of photography in general – if we took advantage of digital technology to break from these preconceptions and introduce entirely new photographic parameters to the user?

In order to explore alternative means of creating pictures and to make use of the new opportunities of digital technology, we have developed a novel concept for digital cameras: *context photography* (see Figure 1). Context photography consists of taking photos that capture not only incoming light but also some of the additional context surrounding the scene. Information such as temperature, sound, pollution, the presence of other users or their activity is gathered from sensors and used to visually affect pictures in real time, as they are taken. For example, loud music at a party could be represented by coarseness in the image that would give an amplified sense of 'being there', or the chill

in the air on a mountain could be made visible as a bluish tint evocative of low temperatures.

Using input from focus groups of dedicated amateur photographers, we have developed a series of context camera prototypes [8,10,13]. Our current prototype is an application running on standard camera phones that uses contextual information about sound and movement. Here, we report on a user study where participants used our prototype to take context pictures in their everyday life during a period of six weeks. This study helped us to understand how people would use a context camera in everyday settings, and the implications of augmenting the action of taking pictures with new digital parameters.

RELATED WORK

Exploring alternative means of creating pictures with digital technology, we are using a new approach to context information that could enable a new type of everyday photography with aesthetic purposes.

Creating Aesthetic Images with Camera Phones

As camera phones are becoming increasingly popular, new motivations for taking digital photographs are emerging. One category of pictures of particular interest to our project is the spontaneous, everyday, aesthetic pictures categorised by van House et al. as images for “self-expression” [17]. The authors argue that an increase in photographic self-expression is to be expected as a consequence of the pervasiveness of camera phones. A similar taxonomy of reasons for capturing images with camera phones was presented by Kindberg et al. [9]: although not explicitly using the notion of ‘aesthetic’ or ‘creative’ images, this taxonomy also showed the existence and importance of these kinds of images.

So far digital cameras and camera phones have only supported such aesthetic motivations by providing users with built-in visual manipulation programmes such as frames, filters, or colour settings (e.g. sepia, black-and-white). Although they let users affect pictures on the fly, these image renderings are static and self-contained. Therefore, context photography could provide a new dimension to the practice of taking creative pictures by adding the dynamic and situated dimension of context.

Context and Photography

Context is an important aspect of the field of ubiquitous computing [15]. Dey defines it as “any information that can be used to characterise the situation for an entity (place, person or object)” [3]. Such context information is typically derived from sensor data about the user and the environment, and is either used in real time or stored for later use. Context information is mostly utilized to support a task or practice by providing relevant information or services depending on the user’s goals, for example providing tourist information to someone based on her position and orientation [1].

When applied to photography, context is usually referred to as metadata: contextual or picture related information, such

as shutter speed or ISO number, saved along the photograph when it is taken. Such metadata has been used for a variety of purposes, all enriching the photographic experience.

Supporting the Practice of Photography

Most cameras already possess a distance sensor to adapt sharpness, and some also have an optical image stabiliser that compensates for the photographers movements in order to optimise the picture sharpness. This use of sensors was taken a step further with the context-aware camera by Holleis et al [7], where metadata could be used as a means of supporting the practice of taking a picture. The camera gathered context information (e.g. the photograph’s movements) to help people take better pictures. Based on how the user photographed with the camera, the user was provided with feedback or personal settings.

Tagging Pictures to Facilitate Image Searching

Metadata has also been used to tag pictures and facilitate browsing through image or video databases. For instance, LAFCam [11] detected laughter to index video recording with points of interest such as scene involving fun, and simplify video editing. StartleCam [6] used a skin conductivity sensor to measure excitement, which triggered the camera to start recording without a direct action of the photographer. Position data can be used to annotate pictures for later retrieval, for instance to create a trip diary as in GTWeb [16]. Finally, Web communities such as Flickr (www.flickr.com) allow users to manually tag their own and others’ pictures for easier searching.

Enriching Photographs with New Dimensions

Metadata can also be used to provide context as a new dimension to pictures. In Audiophotography [4], recorded audio snippets were associated with photographs, giving viewers a sense of the sound surrounding the moment when the picture was taken. Audio as context information was also used in RAW [2], where a digital camera equipped with audio recording features captured a minute of sound before and after a picture was taken, providing a rich and novel means of documenting one’s everyday life. Other ways of enriching pictures by contextualising them with metadata include adding location information, a feature now available in some commercial camera phones (e.g. Samsung SGH-E760). Using GPS information, a picture is automatically linked to the specific geographical location in which it was taken.

Context as Visual Aspect of an Image

In context photography, context information is used in a novel way: it becomes a visual parameter that is reflected in the resulting pictures. This approach is related to Sonic City [5], where sensor information from the urban environment is gathered as the user is walking about in a city, and used in real time to create electronic music. In both Sonic City and in context photography, context becomes a vivid part of the outcome.

CONTEXT CAMERA PROTOTYPE

A context camera senses information about the surrounding physical context and captures this information visually in still pictures, in real time. The context information is gathered from sensors, and visual modifications are applied to the image using computer graphics effects. Using an iterative process, we have implemented a series of prototypes on handheld [8] and tablet computers [10], finally arriving the current version that runs on a standard camera phone [13].

Design Process

During our design process, we were inspired by Lomography (www.lomography.com), an amateur photography practice that makes use of old Russian analogue cameras with optical defects to take images with a particular aesthetic. Lomographic picture-taking is spontaneous and explorative, and often implies “shooting from the hip”, i.e. not looking through the view-finder while taking a picture. We benefited early on from the input of a panel of lomographers and other amateur photographers, including a design workshop where the panel reflected on our concept [8], and two evaluation workshops where they tested a working version of the context camera prototype in specific settings [10]. This feedback was used to modify the effects, and we also added a calibration feature to allow users to affect the level of influence of the sensors, giving the photographers more control over the outcome.

Throughout the project, we have been working with an experienced visual artist to design effects and mappings. We investigated how sensor input can be mapped to effects and represented, with for example distortion, layers and traces, in order to make interesting and visually appealing pictures. The effects and mappings, as well as the input processing, were refined and modified iteratively during the process to best respond to the feedback obtained during the workshops.

Implementation

Our current context camera prototype is an application running on camera phones [13]. It uses sound and movement as context information. The application currently runs on two standard camera phone models, the Nokia 6600 and 6630. It utilizes the device’s own hardware (microphone and lens) as sensors: the microphone is used to sense sound level and spectral distribution, and the image stream from the camera itself is used to identify instances of movements as a vector field in the picture. The application was programmed in C++ using the graphics library GapiDraw [14], a multi-platform computer graphics library available for various handheld devices, as well as optimised algorithms from the image processing programme Optica [12] developed by the visual artist we worked with.

To explore a variety of ways in which context can be represented, we implemented four visual effects that each combines “movement” and “sound” differently. Different types of mappings of sensor input to visual effects are used:

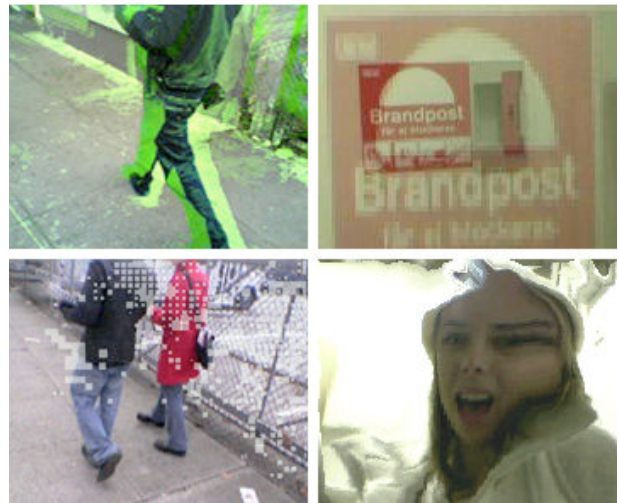


Figure 2. Examples of context pictures : a) man walking; b) fire hydrant sign; c) people in motion; d) girl smiling.

orthogonal mappings where sound and movement influence separate types of effects (for example sound affecting the overall colour, and movements leaving traces on the picture), as well as mappings where the impact of these two inputs are correlated (for example visual traces caused by movement getting a specific tint depending on the sound frequency).

The effects are the following:

1. *Colour shadows*: Traces of coloured shadows follow movement; the colour of the shadows is affected by the frequency of the surrounding sounds (Figure 2.a – correlated mapping)
2. *Zoom*: The part of the picture with most movement is zoomed in, and rendered as a transparent layer on top of the rest of the image; the amount of transparency is determined by surrounding sound level (Figure 2.b – correlated mapping)
3. *Pixel*: Small white dots follow movement as a decaying trace; the size of the pixels in the picture is proportional to the surrounding sound level (Figure 2.c – orthogonal mapping)
4. *Wave*: Movement creates waves in the image, making it look like a dense liquid. As in 3, the size of the pixels in the picture is proportional to the surrounding sound level (Figure 2.d – orthogonal mapping)

Interface

The interface allows the user to capture images, see the resulting photographs, save them, browse through the pictures and delete them in the same way as with a regular camera phone. The user can choose among the four graphical effects and calibrate the sensitivity of the sound and motion sensing. The sensitivity of the sensors can be calibrated individually; one effect might be strongly affected by the sound level, whereas another one might not

User	Age	Gender	Country	Occupation
Erik	23	M	Sweden	student
Sigvard	49	M	Norway	senior lecturer
Camilla	40	F	Norway	professor, artist
Jane	33	F	England	researcher
Tobias	27	M	Sweden	IT-support
Jonas	30	M	Sweden	interaction designer
Anthony	27	M	Australia	PhD student

Table 1. Participants overview.

be affected at all. Each picture is named after time and date of capture for logging purposes, and is saved together with a copy of the image without effects.

USER STUDY

We conducted an exploratory user study to investigate how people would use and perceive the context camera as a new photographic device. The study comprised seven people with a general interest in photography, who were instructed to take context pictures during a six-week period, using either their own phone or one they borrowed from us.

Users were recruited through a call for participation published on our project website and sent out to a variety of blogs and mailing lists in topics such as photography, art and technology. This gave us access to a diverse user group with different ages and occupations spread over four different countries (see Table 1). After reporting their interest and agreeing with the terms and conditions of participation, people received the context photography application. Local participants who did not own a camera phone borrowed devices from us with the application pre-installed. All participants were provided with documentation on how to install the programme as well as a brief user guide to the interface and the visual effects, including example images. This user guide only gave technical guidance, and did not give instructions on *what* to take pictures of or *how* exactly, in order to avoid affecting their use of the camera. Technical support was provided throughout the study.

We requested that the participants made their context photographs available to us throughout the study and asked them to upload their pictures on Flickr (www.flickr.com). On this popular photoblog website, pictures can be easily uploaded, tagged and commented by the original uploader as well as other Flickr members. The participants also had the option of e-mailing pictures directly to us if they did not want to have pictures on-line.

After the first three weeks of the study, we sent out a mid-study questionnaire to get more background information about the participants: we asked the subjects to describe their interest in photography, what motivates them to take pictures and what they think makes a good and a bad digital

photograph. We also asked them to describe their experiences with context photography so far.

After the six weeks of the study were over, we sent out a final post-study questionnaire that went more into details about context photography and their experience of it. We asked questions such as what context photography is for them, what role context played in their picture taking, and how the fact that the visual effects were rendered in real time affected their experience. The questions also covered topics such as frequency and situations of use, physical interaction, preferences in visual effects and aesthetic qualities of context pictures (e.g. what is a good and a bad context photograph). In several questions we asked the participants to refer to and comment on some of their own context pictures: ones they thought represented context photography well, ones that did not, etc. Participants located in our city were interviewed at the end of the study. They were asked the same questions as in the distributed questionnaires and were encouraged to talk about their context pictures.

We collected a total of 303 context pictures during the study. More pictures had been taken but some were deleted or never uploaded, for instance due to privacy concerns or aesthetic considerations. Table 2 summarises the number of pictures provided by each participant, as well as the distribution of the various effects. The 54 pictures that are categorised as unidentified (marked with a '?') are images where we could not identify which effect had been used, mainly because no effect was visible. This could depend on calibration settings being set very low, or on the fact that there might have not been enough sound or movement to capture at these moments.

User	Colour	Zoom	Pixel	Wave	?	Total
Erik	67	23	10	19	0	119
Sigvard	5	4	11	11	19	50
Camilla	15	3	7	8	9	42
Jane	1	1	4	4	1	11
Tobias	12	4	2	6	6	30
Jonas	7	3	8	4	8	30
Anthony	1	1	1	7	11	21
Total	108	39	59	43	54	303

Table 2. Pictures taken by each user, according to effects.

USER CASES

To emphasise the participants' individual experiences of context photography, we chose to analyse each user's qualitative data separately as a user case, along with corresponding pictures. In the following we present each person's use, perception and experiences of context photography in the form of summarised user cases.



Figure 3. A sample of the pictures taken by Erik (a-d).

Erik

Erik is interested in photography on an amateur level, and he takes photos to remember special occasions or just for the fun of taking pictures that “look nice”.

Erik uploaded a total of 119 pictures. For him, an interesting context photograph involved action. In order to find context to capture, he took pictures of traffic and movement, for example a car passing by, or when he was in movement himself. This was something which he would not have done “if it hadn’t been for the effects that the application gives.” He enjoyed pictures that both looked aesthetically pleasing and represented the context well. One picture that was taken of his bike while riding it (Figure 3.a) captured the movement and the annoying squeaking of the pedals. In another one (Figure 3.b), coloured shadows clearly reflected the movement of a flower that was being swirled between two fingers. However, representing a situation well is not enough to make a good context photograph. If for example a scene is too quiet to give visible effects (Figure 3.c), then “it is a boring way to use the application. Therefore also a bad context photograph.”

Erik plans and takes his context pictures differently than he does with a regular camera, as “There is a whole new dimension, sound and movement to experiment with”. According to him, you “sometimes experiment with different movements and settings to get the effects you want”, even becoming more physical with the camera than usual: “You move yourself or the camera more. Spin it etc. just to try to get a fun effect.” He would also sometimes involve others, for example by asking someone to scream (Figure 3.d). For Erik, manipulating images in real time “feels more real” than doing it afterwards, as it reflects “how it WAS...” The fact that sound and movement affect the pictures can make it more difficult to control the result, “but much of the fun with context photography is that you feel you are not entirely in control over how the picture will turn out.”

Jane

Jane has a background in design and is knowledgeable in both analogue SLR (single-lens reflex) and digital photography. She says that she enjoys taking pictures of abstract, odd or surreal things.

Jane provided us with 11 context pictures. She mostly took pictures of things or “banal objects”, sometimes in motion. She enjoyed the distortion and abstraction that the context camera can cause, as in Figure 4.a that to her was “reminiscent of a painting”, and in Figure 4.b that had a “sense of rhythm and complexity”. However, when the distortion became too intense, she thought that pictures became too simple and lacked “reference to the original object” (Figure 4.c).

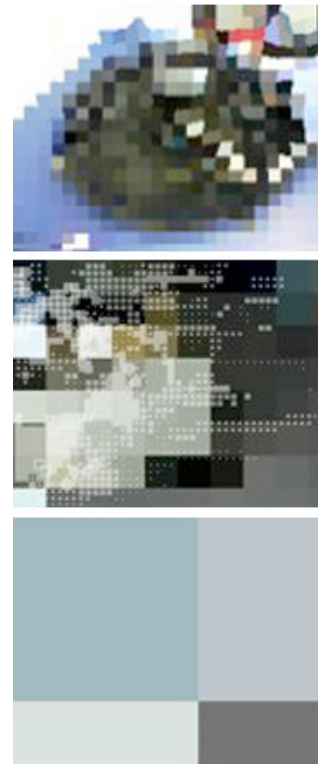


Figure 4. A sample of the pictures taken by Jane (a-c).

Jane started understanding how the camera works when she used it in a “very noisy workshop”. She then continued using it in noisy environments, mostly when on her own. She frequently used the calibration function to adjust the sensitivity of sound and movement sensing and sometimes physically moved the context camera to obtain movement effects, but she was not sure of what the outcome would look like or how much the usual parameters affected pictures, perceiving that “although [the camera] is capable of [creating] ‘creative’ images this seems like a fluke rather than any creativity on the photographers part.”

Tobias

Tobias is an amateur analogue photographer and devoted lomographer who takes many pictures in his everyday life. He also uses a digital camera. A good composition is less important to him than having something happening in the picture.

Tobias uploaded 30 context pictures, but deleted several because he thought they showed “too much [visual effects]”. Before taking context pictures, Tobias thought first about what effect would suit a particular subject: “[I] wanted that [picture] and sought out a filter that would work” (Figure 5.a). He often used the calibration mode to get a preview of how the picture would turn out, see what needed to be changed and thereby learn how the camera works. However, after 10 years as a lomographer he still did not look at the display much when actually taking a



Figure 5. Some pictures taken by Tobias (a-b).

picture. To obtain effects and learn how the camera works, he would produce sound as well, by for example hitting the camera phone's microphone.

For him, affecting images with effects “*mustn't be just a way to 'space-out' [i.e. distort] the picture.*” The most fundamental thing when taking pictures – whether context or regular picture – is to “*add something*” to an image, to augment it and make it more interesting, instead of just showing how things were. He thus liked Figure 5.a and Figure 5.b, and commented on the first one that “*it looks like you were sitting in an amplifier*”. He saw context photography either as a way of getting “*cool pictures*”, or as a visual representation of the actual context but personally opted for simply seeing it as pictures looking in a certain way in certain situations. For him, it was the real-time manipulation that made context photography special: “*Here and now is important. Otherwise the whole thing loses its point.*”

Sigvard

Sigvard has a background in photojournalism, media studies and photography. He uses his camera phone to depict and share everyday occurrences with friends. He also captures dramatic events such as fires and storms that he provides to newspapers.

Sigvard uploaded a total of 50 context pictures. He focused a lot on sound and movement and was often “*searching for movements and noise to succeed*”, which “*rendered a new*



Figure 6. A sample of Sigvard's pictures (a-d).

and interesting experience and results.” One example of a picture he enjoyed is Figure 6a, taken of street musicians. Context was sometimes hard to capture. Some objects were too fast for the camera: “*I experience that movement of cars were too fast for the contextphoto, making strange photos.*” In other cases, input was too low and he would have to amplify movement and sound with the calibration in order to obtain effects. He thought that pictures sometimes got too much effect (Figure 6.b) or too little (Figure 6.c).

Taking context pictures was thrilling, but he thought that the results could just as well have been obtained by manipulating the photos afterwards. He could however sometimes recall the sound and movement as he experienced it, for example in one with girls jumping on a trampoline, where “*The contextphoto reflect[s] what I wanted to picture*” (Figure 6.d).

Camilla

Camilla has a background as a photographer, and she uses her camera phone to take pictures as notes or small souvenirs.

Camilla uploaded 42 photos and used the context camera whenever she “*had a peaceful moment and time to play with camera; in metro, on beach, by swimmingpool, in cafe, etc*” (Figure 7.a and 7.b). Camilla saw herself “*getting more practiced to see when to use it and to get what I am after.*” Although she considered her interaction with the context camera to be mainly the same as with a regular one, this interaction also involved new practices such as “*making noise or asking someone to scream ;-).*” Camilla found it difficult to see how the effects worked together and also considered the calibration to have too many adjustment options.

For Camilla, nice and interesting context pictures had something “*different*” as well as “*a strong feeling of sound / movement.*” An example of this is Figure 7c, where “*one can imagine the sound of screaming.*” She considered that the concept of affecting images in real time was fundamentally different from manipulating them afterwards, but that the resulting pictures can look similar for someone who



Figure 7. Some pictures taken by Camilla (a-c).

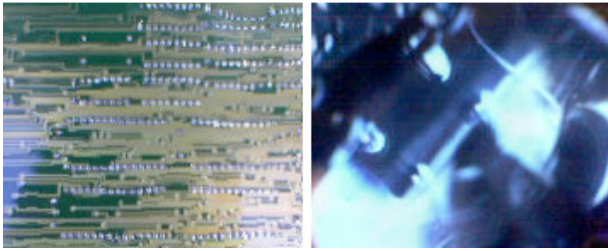


Figure 8. A sample of Anthony's pictures (a-b).

would not know they had been taken with a context camera.

Anthony

Anthony owns a small digital camera that he takes with him everywhere, most often taking art, travel or party pictures. He also sometimes uses a camera phone. Aesthetic qualities of pictures are important to him.

Anthony provided a total of 21 pictures of various objects, details and textures (Figure 8.a). He deleted some pictures *“that didn't significantly change after the filter”*. Anthony thought that context photography *“didn't really capture the context” of the original situation* and thought that pictures were just receiving visual alterations based on algorithms. Although he thought that context photography could *“theoretically provide a new lens on the original situation”*, he considered that the subject of the photography was actually lost. This was not necessarily a problem, as he said in reference to Figure 8.b: *“I like this one because it isn't at all clear what is being photographed”*. Anthony did not use the calibration function, as he did not feel it impacted the pictures. He mostly used the wave effect to get *“a stronger blurring effect”*. Anthony thought that the quality of a context photo *“has less to do with the subject matter and more with the graphic effect that can be applied to it”*. As he considered the effects to be *“quite limited”*, he thought that applying effects to images afterwards *“provides a lot more flexibility”* than in real time. He did however think that *“some of the [context] pictures appeared more artistic after alteration”*.

Jonas

Jonas usually takes pictures during trips to document moments and experiences that he would like to share with others. He uses a SRL camera as well as a digital one. He values pictures with aesthetical qualities.

Jonas uploaded a total of 30 pictures, mostly taken during sailing holidays (Figure 9.a). His girlfriend occasionally borrowed the camera from him. When taking context pictures, Jonas aimed to capture a certain context and/or get a certain effect in a picture – as opposed to documenting a moment or an experience. His choice of effects depended on how he wanted the picture to look visually, rather than on how suitable they would be to depict certain situations. Sometimes Jonas got too much or too little effects in his pictures and could not figure out why. For instance, he could not capture the sound of seagulls that he felt was very

present – probably because the sound was too weak or too sporadic for the camera. He would sometimes switch off movement sensing and focus on capturing sound only, because sound was more straightforward to grasp and control.

For Jonas, context pictures need to have clearly visible effects, which implied that *“you are forced to be creative to get pictures”*. *“If you don't do anything then it's like a regular camera”*. He also considered that affecting a picture in real time is important if *“if you're after capturing something”*. One picture was particularly successful in representing context, as it emphasised the sound of the motor on his boat (Figure 9.b). However, successful and aesthetically pleasing are not necessarily the same thing for him. Jonas appreciated the aesthetic qualities and evocative power of a picture where he could *“see”* the wind blowing although in reality it was not blowing at all (Figure 9.c); much more than being reminded of how bad the motor sounded.

RESULTS

The user cases brought to light specificities of context photography and of the new photographic experience it provides, as well as corresponding challenges. Issues discussed below encompass roles of context in the picture-taking, the impact of real-time image manipulation, the visual qualities of context photographs, and the process of taking pictures.

Roles of Context

A fundamental aspect of context photography is that instead of providing support to the act of taking a picture (as context would typically be used in ubicomp applications), the context *visually affects* images *as they are taken*. This new approach implied that users developed new goals of and motivations for taking pictures.

User feedback suggests two different ways in which contextual information can be approached when taking context pictures, in terms of how it visually affects pictures. In the first, the user tries to *capture* the context of a particular situation and explicitly represent it in a picture, as

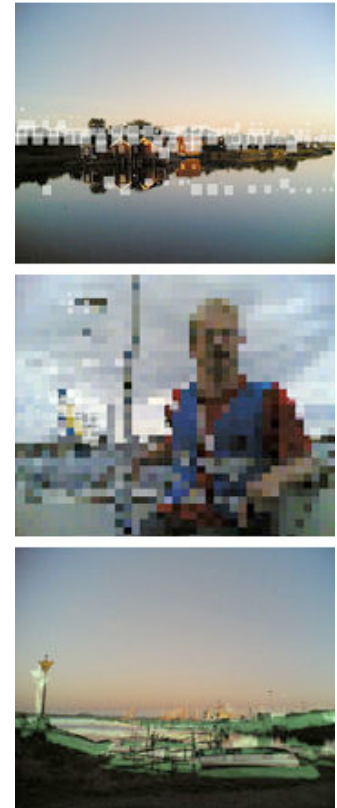


Figure 9. A sample of Jonas' pictures (a-c).

Jonas does when he tries to capture sounds surrounding his boat. In the second, sound and movement are used as new camera *parameters* in order to obtain certain visual qualities in pictures: the context can be seen as an active ‘contributor’ to the picture. As Erik says: “*The situation will determine this [how the picture will turn out]*”. Two new roles of context thus emerged from the study: context as something to capture and represent, and as something to use as a visual parameter.

A challenge with trying to capture context in photographs is the potential disparity between what the user *experiences* and what the camera *registers*. The user might perceive a sound to be louder than what the camera does, or feel that temperature during a hot summer day is the prominent aspect of context, even though it will not be registered by the camera at all as it senses other parameters. This challenge also relates to the issue of subjectivity in representing context. Because of differences in how a user perceives context or the intensity of an effect, or in how the camera is calibrated, users might not interpret images in the same way. As shown in previous user workshops [10], representing and interpreting context could become a shared language to learn, or a language that some users might want to create for themselves individually. However, as Tobias expressed, one can also bypass this issue by simply choosing to look at context photography as being about taking pictures that get various visual qualities depending on *where* you take them, as opposed to trying to capture how you perceive the situation: “*you have to see it like depending on where you are, the picture turns out cool. [...] You probably shouldn’t see it like it shows what you feel [in a certain environment].*”

Real-Time Image Manipulation

Photographs are affected by context in real time, which results in new types of connection between the user, the subject of the photograph and the time and place of the picture-taking.

The real-time aspect of image manipulation in context photography “*immediately shows an alternative visual perception of the experienced environment*” (Anthony). Experiencing how the visual qualities of images directly result from the situation also creates a strong connection to the original place and time in which the picture is taken: “*In some way it feels more real. I did not manipulate this picture afterwards, this is how it WAS...*” (Erik). This makes it fundamentally different from the usual post-image processing: “*Here and now is important. Otherwise the whole thing loses its point*” (Tobias).

While some users highly valued the real-time manipulation, some users considered that the immediacy and connection to the situation it provided was sometimes impaired by limitations of the effects design. Comparing context photography to post-editing, Camilla reflected that: “[The] *concept is completely different. Currently [the] results look quite similar*”. She also argued: “*when I look at the images*

–and if I would have no idea that they are taken w [with the] [...] -program- I would easily just assume that they are done by using filters or other image manipulation”, pointing out that the link between an image and its original situation might not hold for other viewers. Sometimes connection to the photographic subject might even be lost. As Anthony put it: “*[it] did change the original perspective from what was initially viewed, to what was shown in the altered image, which could theoretically provide a new lens on the original situation [...] in practice [...] it did more to obscure it, as it often isn’t clear what is being photographed.*”

Visual Qualities of Context Photographs

Affecting photographs with context information brings with it new aesthetic considerations and expectations in terms of how a picture should look and depict a subject. A picture that might normally be considered as satisfactory, might not be anymore as context picture.

Satisfactory context pictures should have clearly visible effects. As Jonas commented: “*if you’re using a context camera, you do want to get an effect, that something happens that is more than just the picture*”. However, as Tobias reflected, it is crucial that the concept of context photography is more than playing around with different graphical effects. The visual altering “*mustn’t be just a way to ‘space-out’ the picture. It has to add something*”. As Camilla also commented about her context pictures: “*Good one[s] makes a nice/interesting image [that] has something “different” in it*”.

Successful context photographs in terms of representing a situation are not necessarily satisfactory ones. If for example nothing is happening and thus no visual effects are visible, a picture is not considered as satisfactory even if it faithfully depicts context. Erik commented when describing a picture of a quiet scene: “*It [the picture] does indeed reflect the reality. It was calm and quiet. But it is a boring way to use the application. Therefore [it is] also a bad context photograph.*”

Aesthetic qualities of pictures are higher-valued than just representing context. They partially depend on the amount of effects and of how they worked visually with the photographic subject: although taste varies from one individual to another, most users considered that effects needed to be balanced in order to look good. For Sigvard, “*A good contextphoto is obviously a picture that has movement, but not too[o] much and not too[o] little.*” For Camilla, it was important not to overwrite what was taken a picture of, and described a good context photograph as “*An image which has a strong feeling of sound / movement, but does not overwrite the image itself.*” Jane considered that pictures could lose “*reference to the original object*” if the effects were too extreme, but did enjoy some distortion because it brought a “*sense of rhythm and complexity*”.

Designing effects for a context camera thus implies more than reaching an adequate representation of contextual

dimensions such as sound and movement. It is also a matter of meeting the user's new aesthetic expectations as well as not letting effects overwrite the subject of the photograph. Moreover, having four different effects available in the context camera prototype revealed differences between the users in terms of expectations and aesthetic taste, and in terms of how they motivate them. Camilla for example preferred subtle effects leaving traces in the images because they *"don't overload the image"* and are instead *"enhancing some features of the image"*. Jonas on the other hand enjoyed the pixel effect, but only due to a personal weakness for pixel aesthetics in general. Several users even had difficulties giving an explicit reason to why they preferred a certain effect more than another. Therefore, designing effects to suit a high number and wide range of users becomes a challenging task.

Taking Context Pictures

The context camera gives *"a whole new dimension, sound and movement to experiment with"* (Erik). To get interesting context pictures, the participants sought or created dynamic situations involving movement and sound. Dealing with the dynamic nature of sound and movement also implied not being entirely in control of the outcome, something that turned out to be both a challenging and fun experience.

The context camera made people strive for taking pictures in dynamic situations and look for action. While regular photography might sometimes involve taking pictures of dynamic things, looking for action was an essential part of the context camera experience: *"Context photo made me after a while search for movements and noise to succeed [...] And this rendered a new and interesting experience and results"* (Sigvard). This search resulted in pictures taken in amusement parks, of people jumping, dancing, in traffic or when being on the move: *"I snap many pictures from my bike or when I'm in a car/bus/tram :)"* (Erik). It also made users take pictures of new subjects: *"I would probably never have spontaneously taken a picture for example of a car passing by if it hadn't been for the effects that the application gives"* (Erik).

The context camera was designed to capture sound and movement but input from subjects were sometimes out of reach, or at least difficult to capture in a satisfying way. Movement could be too quick, as for Sigvard: *"I experience that movement of cars were to[o] fast for the contextphoto, making strange photos"*. Sound could also for example be too low or too sporadic to be sensed successfully, as when Jonas tried to capture the sound of seagulls.

In situations where the surroundings did not itself provide enough dynamic input, the users experimented with various means of obtaining effects. Some acted more physically: *"You move yourself or the camera more. Spin it etc. just to try to get a fun effect"* (Erik). Similarly, Camilla created sound input by for example *"making noise or asking someone to scream ;-)"*. Tobias sometimes "faked" audio input by tapping on the microphone: *"I had to cheat a little.*

Had to make some sounds. Sometimes it happens you try to achieve [visual] effects." The calibration was also used to increase or decrease the sensitivity of the camera and thereby the amount of effects, the way Jonas did by switching off the movement sensing to focus on sound. As he pointed out, with context camera *"you are forced to be creative to get pictures"*. *"If you don't do anything then it's like a regular camera"*, meaning that you might not otherwise get satisfying effects in the pictures.

Still, even when actively searching and creating sound and movement, succeeding in getting effects was not guaranteed. As input were dynamic and hard to control and to capture in the static medium of still images, participants were not entirely in control of the visual outcome. Jane felt that creative context images seemed more like a *"fluke"* than anything she felt responsible for as she did not feel in control of the results in spite of using the calibration: *"I control the sensitivity and in some way the measure of it by the amount I move it but I don't feel at all in control of the outcome."*

However, some users were actually only moderately interested in being in control. Tobias only used the calibration in order to learn how input and effects were connected, and foresaw that he may in the future lock the calibration on a *"specific sensitivity"*, once *"you have found your calibration [settings]"*. Erik as well happily gave up part of his control. For him, not having complete control was new and exciting: *"much of the fun with context photography is that you feel you are not entirely in control over how the picture will turn out. The situation will determine this..."*

CONCLUSIONS

We have presented our exploratory user study of context photography and resulting user experiences. By adding a new dimension of context to photography, context photography gave rise to new picture-taking experiences and implied new types of goals, expectations, aesthetic considerations and practice of taking pictures.

- *Goals*: Context photography brings innovative ways of associating context to photography by enabling at least two different new aspirations in taking context pictures: to represent a specific context, or to consider context as a parameter to create interesting pictures with.
- *Expectations*: Users expected to get visual effects in the pictures. If a picture does not include effects and looks like a regular picture, even if it has a good composition, it will not be a satisfactory context photograph. This changes the view of what could previously be considered as a good photograph. How the camera registers contextual input can also differ from the user's perception of them, which can lead to a new type of mismatch between perception and representation.

- *Aesthetics*: Context photography has brought a new type of aesthetics. We found that preferred aesthetics of context pictures were highly subjective and very much a matter of personal taste. Two separate visual effects may have different appeal for various people in representing the same context. However, for all users, images need to reach a balance in the amount of visual effects in order to possess an aesthetic value.
- *Practice*: Several new aspects have emerged in the picture-taking practice. Even though obtaining effects with post-editing would be more flexible, context photographers appreciated the real time aspect of the picture-taking. They tried to obtain effects by using the context camera as an 'action camera', actively seeking or creating sound and movement to achieve interesting effects. Interesting subjects to take a picture of in regular photography may no longer be interesting in context photography, unless they involved sound and movement. Not being always in control because of the dynamic nature of the input also proved to be both a challenging and fun experience.

With context photography, we have shown a novel way of using digital technologies in photography that breaks from the preconceptions originating from the limitations of analogue cameras. Besides enabling new ways of taking creative pictures in everyday settings, context photography broadened the possibilities of using context as a resource in aesthetic practices; taking into account the qualities of the creative medium as well as the resources provided by new technologies.

FUTURE WORK

As future work, a deeper analysis of context pictures could be performed. This analysis could for instance investigate possible evolution of a visual language specific to context photography or the potential emergence of personal expression. More generally, much remains to be explored within the practice of taking digital photographs: trying out other sensors with context cameras themselves and even other types of sensor-based photographic devices, as well as exploring entirely different new possibilities of digital photography.

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REFERENCES

1. Abowd, G. D., Atkeson, C.G., Hong, J., Long, S., Kooper, R. and Pinkerton, M. Cyberguide: a Mobile

- Context-Aware Tour Guide. *Wireless Networks*, 3(5):421-433, 1997.
2. Bitton, J., and Agamanolis, S. RAW: Conveying Minimally-Mediated Impressions of Everyday Life with an Audio-Photographic Tool. *Proc. of CHI'04*, ACM Press, 2004.
3. Dey, A. K. Understanding and Using Context. *Personal and Ubiquitous Computing*, Vol 5(1), p.p. 4-7, 2001.
4. Frohlich, D. and Tallyn, E. Audiophotography: Practice and Prospects. *Proc. of CHI'99*, ACM Press, 1999.
5. Gaye, L., Mazé, R., and Holmquist, L.E. Sonic City: The Urban Environment as a Musical Interface. *Proc. of NIME '03*, McGill University, Montréal, Canada, 2003.
6. Healey, J. and Picard, R. W. StartleCam. A Cybernetic Wearable Camera. *Proc. of ISWC'98*, Perceptual Computing Technical Report nr. 468, 1998.
7. Holleis, P., Krantz, M., Gall, M., and Schmidt, A. Adding Context Information to Digital Photos. 5th IWSAWC, *Proc. of IEEE ICDCS*, 2005.
8. Håkansson, M., Ljungblad, S. and Holmquist L. E. Capturing the Invisible: Designing Context-Aware Photography. *Proc. of DUX'03*, ACM/AIGA, 2003.
9. Kindberg, T., Spasojevic, M., Fleck, R., and Sellen, A. The Ubiquitous Camera: An In-Depth Study of Camera Phone Use. *IEEE Perv Comp*, Vol. 4, Num. 2, 2005.
10. Ljungblad, S., Håkansson, M., Gaye, L. and Holmquist, L. E. Context Photography: Modifying the Digital Camera Into a New Creative Tool. *In Extended Abstracts of CHI'04*, 2004.
11. Lockerd, A. and Mueller, F. LAFCam. Leveraging Affective Feedback Camcorder. *Proc. of CHI '02*, ACM Press, 2002.
12. Optica www.id.gu.se/arttech/projects/dots/optica.htm
13. Rost, M., Gaye, L., Håkansson, M., Ljungblad, S., and Holmquist, L.E. Context Photography on Camera Phones. *In Extended Abstracts of UbiComp'05*, 2005.
14. Sanneblad, J. and Holmquist, L. E. The GapiDraw Platform: High-Performance Cross-Platform Graphics on Mobile Devices. *Proc. of MUM'04*, ACM 2004.
15. Schmidt, A., Beigl, B. & Gellersen H-W. There is more to Context than Location. *Computers & Graphics Journal*, Elsevier, Volume 23, No.6, pp 893-902, 1999.
16. Spinellis, D. Position-annotated photographs: A geotemporal web. *IEEE Pervasive Computing*, 2(2):72-79, April-June 2003.
17. Van House, N., Davis, M., Ames, M., Finn, M., and Viswanathan, V. The Uses of Personal Networked Digital Imaging: An Empirical Study of Cameraphone Photos and Sharing. *Extended Abstracts of CHI'05*, 2005