Guidelines for the Presentation and Visualisation of LifeLog Content

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ABSTRACT
Lifelogs offer rich voluminous sources of personal and social data for which visualisation is ideally suited to providing access, overview, and navigation. We explore through examples of our visualisation work within the domain of lifelogging the major axes on which lifelogs operate, and therefore, on which their visualisations should be contingent. We also explore the concept of 'events' as a way to significantly reduce the complexity of the lifelog for presentation and make it more human-oriented. Finally we present some guidelines and goals which should be considered when designing presentation modes for lifelog content

INTRODUCTION

Originally envisioned by Bush in 1945 [6], lifelogging or the recording of personal life experiences by us using digital technology is a concept we are becoming increasingly familiar with. Our music players remember the music we listen to frequently, our web activity is stored in a browser's 'History' and we capture our important life experiences regularly through photos and videos. Bush's vision, however, would see this life recording taken a great deal further and we are now moving towards fulfilling his vision of a world where digital memory can supplement the shortcomings and fallibility of human memory, and where memories, experiences and life content such as diaries, data and encyclopedias can be accessed from a digital repository with ease and efficiency. Bush has inspired the creation of tools like MyLifeBits [15], which enable the logging of our desktop computer interaction. Additionally, Microsoft Research has built a small wearable prototype device, known as the SenseCam (see Fig 1.) designed to passively capture life experiences as a series of photographs with associated sensor values [14].

By coupling these recording devices with sensing technologies and consequently providing access to rich sources of social context data, extremely powerful collections are created. For example, Bluetooth sensors can be used to gather social presence information [18] and GPS sensors which can provide a geographic location for the activities captured within the lifelog [8]. Combining this information together in a collection allows a lifelog to rapidly gather not only a wealth of information on a person's day-to-day activities and experiences, but also the social interactions and networks which bind them. The power of social context data in lifelogging has been highlighted through the Reality Mining Project, which uses mobile phone activity information in the exploration a person's daily activities [12]. We have similarly examined the usefulness of Bluetooth and GPS information [8] in retrieval of life memories.

In this paper we present our work in the visualization of lifelog social data, along with our insights. Our experiences show that lifelog data should be visualized through a limited number of axes and should be aggregated into events when presenting to users.

Figure 1 The Microsoft SenseCam. Inset As Worn

CHALLENGES OF LIFELOGS

With the SenseCam taking approximately 3000 images per day, very quickly large and rich photo collections for a user's activities can be built. The other sources of data further add to the richness and utility of such collections. The benefits of capturing such life experience content are numerous and include: the ability for a user to easily record events without having to sacrifice their participation, aiding memory and recall; and providing insight into a person's life and activities [14]. While the benefits and applications of the SenseCam technology are numerous, it is not without its drawbacks.

Lifelogging records much more data on a daily basis than traditional datasets would record over an extended period. For example, within just one year of use, passive photo capture using the Microsoft SenseCam [14] can easily accumulate over a million photographs. This far exceeds the expected size of traditional photo collections. The combination of and recording of multiple sources of contextual information (sensors, desktop activity, mobile phone activity, passive photo capture or personal video capture) further compounds this as a challenge, resulting in a personal collection where it is difficult to gain a point of entry, navigate or gain an overview to the data. Appropriate presentation of the collections content through visualisation therefore becomes extremely important in this domain as it provides solutions to overcoming many of these challenges. Through novel presentation and visualisations specifically designed for the unique challenges presented by lifelog collections, we can offer more effective means to overview, relate, view and navigate our personal digital memories, experiences and the social networks which bind them.

Furthermore, human memory is fallible and unstructured. We all to easily forget activities and events we have been involved in recently; have difficult in recalling the details of, people present at and times for events; and can recall events out of sequence temporally. This presents a distinct difficulty for users trying to locate or retrieve content of relevance to them. We must consider this when designing the means in which users browse and access the content within such voluminous, ever-growing collections.

Finally, a large proportion of the data collected will be relatively mundane. Often a large portion of our days can be spent doing uninteresting things. However, the lifelog will continue to amass information on such activities. For example, the SenseCam will capture images from every activity in our day, irrespective of its interestingness. The likelihood then is that a large proportion of the multimodal collection will be uninteresting even to its owner. The high frequency of capture is particularly problematic during the capture of uninteresting events. During uninteresting or mundane activities in our day, very little can change in the environment around us. For example, when working on writing a report, you will sit in front of the computer for perhaps several hours. The SenseCam will collect an image every 40 seconds and the vast majority of these images will capture the Screen displaying a Word document. The collection then becomes clogged with potentially hundreds of extremely visually similar photos. This creates problems for the user browsing the archive as they must navigate through these large volumes of uninteresting content to get to the material of relevance, interest and engagement.

The sheer volume of data collected, the rate at which a collection can grow and the limitations in human memory which preventing effective search of the set are significant challenges presented by the human digital memory (or lifelog) collections. The overwhelming amount of data, often highly similar, to be presented to the user must be resolved or constrained in some fashion, in order to allow quick and effective exploration of the photoset.

AXES OF A LIFELOG

While a lifelog data collection can have large volumes of data from a range of sources and sensors, there are just three main axes on which lifelog information is contingent: people; places; and times. Each sensor reading or device recording within a lifelog belongs to one or more of these. For example, the SenseCam [14] records an array of information about a person's activities, capturing a rich source of information about a wearer's day-to-day and social activities. See Table 1 for a full description. SenseCam can be augmented with GPS and Bluetooth sensing to provide additional sources of context data on the location and people co-present with the wearer.

These axes may also help to disambiguate the constituent components of a lifelog e.g. does a temperature belong to a person or a location? It is our expectation that by considering these axes when designing for lifelogs, more appropriate and effective visualisations will be achieved. We suggest the lifelog visualisation should seek to incorporate as many of the axes as are available (depending on the collection all three may not have been captured). While often a visualisation will be oriented towards one of the axes in particular (i.e. it accesses and presents visual information on this axis), it should also seek to offer means to filter and manipulate the information via the remaining axes.

Source	Description
Ambient temperature	the temperature of a *place* that a *person* is in at a given *time;*
Passive Infrared	indicating presence of a *person* in front of (*place*) of the wearer (*person*);
Accelerometer	indicating movement of the wearer (*person*) in x,y,z directions;
Photos	capturing the view in front of the wearer (*person*) in a given *location* at a given *time.*

Table 1 Information recorded by a SenseCam and the axes on which they operate.

EXAMPLE 1: PEOPLE-ORIENTED BLUETOOTH

Bluetooth is a short-range wireless protocol which provides users with a convenient and effective mechanism for exchanging information over short distances with other enabled devices. It is increasingly included in a wide variety of devices from home computers to portable laptops, mobile phones, PDAs, key-boards, mice and headphones. Today there are over 1 billion Bluetooth equipped devices in use and it is expected that this number will double by 2009 [4]. As such Bluetooth offers enormous potential for ubiquitous networked applications. Bluetooth activity information can also be used to record co-present devices, and by implication persons and this has real utility in the domain of lifelogging to provide social context to the collection [8]. Such social content can be recorded via Bluetooth logging with tools such as University of Helsinki's ContextPhone [23]. Furthermore simple calculations can be used to infer the relationships and social networks between the individuals encountered.

One such method, and one with we employ, is the concept of familiarity for devices within the Bluetooth space. popularized by Nicolai [20,21]. He suggests that there are 3 main types of devices that are encountered: those that are well known, regularly encountered and familiar to you; those that are somewhat known, encountered at semi-regular intervals (known as a familiar stranger) and those which are infrequently encountered and generally unknown (known as strangers.) His work demonstrated that social context could be drawn from general encounters with devices. In [18], we extended Nicolai's work and examined a more robust mechanism for calculating a measure of familiarity for an encountered device. Our mechanism provides a cumulative score based on a device's presence relative to the others by dividing each day into intervals at which presence and duration of presence is examined.

Below we present a means by which a user can gain a detailed understanding and an at–a-glance overview of the complex relationships contained within day-to-day Bluetooth interactions. The size of the diagram also provides an immediate visual cue to the amount of the data and the number of devices that it represents.

Figure 2 A Bluetooth Visualisation displaying 10 days data for one device.

In order to understand the potential of these social interactions between collocated individuals, we previously developed a unique visualization [3] (see Figs 2, 3) which leveraged concepts from Wattenburg's Arc diagrams [27] and DocuBurst's radial space filling visualisation of WordNet lexicons [9] to visualise the complex and rich source of data that Bluetooth logging provides. The visualization, detailed in [7], operates on the person axis. By mapping a Bluetooth device to an individual person we can view the social interactions between device owners. The Bluetooth lifelog contains a wealth of social context data and through this visualisation we can interpret the person-person relationships present such as: the familiarity of those co-present Bluetooth-enabled devices [18]; indications of social networks [7]; and group cohesion [7].

Within the inner area of our radial diagram an arc will connect an encountered device to another if they have been encountered at some point at the same time, i.e. they were encountered proximal to one another. The more collocated encounters, the stronger the weight of the line and the less transparent the arc. Conversely if a device has only been collocated infrequently with another, it will be represented as a thin transparent line.

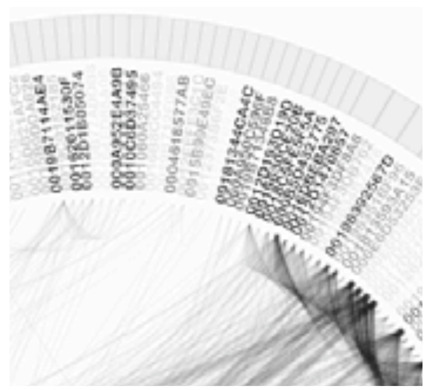

Figure 3 Zoomed segment of the Bluetooth visualisation.

TOWARDS EVENTS

While individual items of social data within a lifelog will belong to the axes previously described, they also belong to higher-level concepts. One such concept is a spatio-temporal unit of retrieval we define as an 'event', which results from the synthesis of these three axes (see Fig. 5). While each individual data element only represents a moment in time, an event consists of a series of closely temporally related items, which overview a unique occurrence or activity carried out by a person within their daily life. The aggregation of lifelog data elements into events allows for the collection to be greatly simplified in its complexity, and more closely mirrors how human memory operates. Tulving [26] indicates that our memories are organised as "episodes." 'Events' therefore are fundamental to the way in which we as humans perceive our experiences and extremely important to consider within the context of a lifelog. One of the major benefits of considering the three axes outlined in this paper is in the identification of these events. There is however a significant challenge posed in terms of aggregating and analysing the data from the range of sources available within a lifelog in order to adequately achieve this.

We have been using this concept extensively with the SenseCam and by using data analysis techniques we can segment temporally continuous elements within the lifelog into discrete events [10] with a reasonably high degree of accuracy. Using more sophisticated techniques, such as concept detection, we could potentially use the elements within an event to automatically describe and annotate it. Despite the overhead in data analysis, structuring lifelog information into events has proven extremely effective and we would recommend it as a standard approach to the presentation and management of lifelog collections.

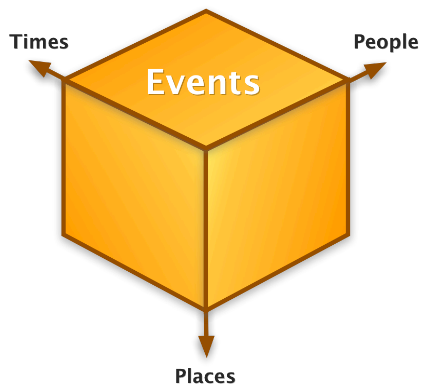

Figure 4 Representation of the three axes of a lifelog.

EXAMPLE 2: EVENT-ORIENTED SENSECAM

The SenseCam [14] is a small wearable device, that passively captures a person's day-to-day activities as a series of photographs. It is typically worn around the neck and, so is oriented towards the majority of activities which the user is engaged in. It contains a rich source of information about a wearer's day-to-day and social activities and As such it operates on both the time and person axis. Within just one week, over 20,000 images may be captured and over a year the lifelog photoset could grow to over one million images.

As mentioned previously, the rate at which a SenseCam photo collection can grow presents a significant challenge to both browsing and retrieving relevant images compared with traditional photo-sets, which typically only contain of the order of thousands of images at most. In order to reduce the complexity of the collection, we aggregate sets of related images into discrete events.

Our online SenseCam image management system [19] provides an automatically-structured visualisation of hundreds of thousands of SenseCam photos so that the owner can easily browse and search their collection. The visualisation affords the user a concise one-page overview of a given day's events (see Fig. 4). A small number of significant events for a day are automatically selected and a landmark image is presented. The size of the event is dependent on its novelty. Events with higher novelty appear larger and command more overt visual attention. The visualisation uses a packing algorithm similar to [5] to automatically compose a compact layout for the photos.

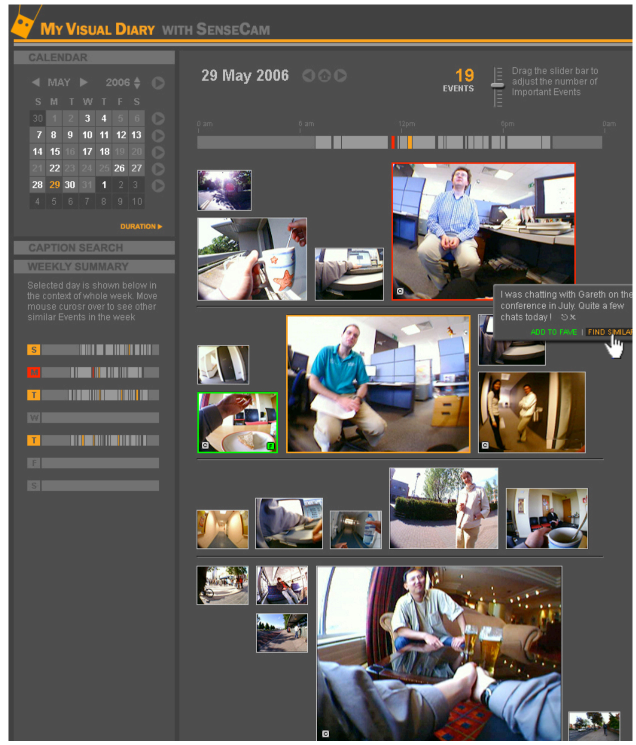

Figure 5 The SenseCam visualisation provides rapid cognition of a user's day-to-day activities

DESIGN GOALS

Further to the axes we have discussed for the visualisation of lifelog content we also now consider some more general design goals, which should be born in mind when presenting lifelog-based content. These design guidelines consider both the strengths and weaknesses of lifelog content, clear design goals for a visualisation of the photoset were established.

Simple & Intuitive Interface

Karvonen [17] defines simplicity as the removal of complexity and obstacles to functionality in order to provide a perception of ease of use and Nielsen [22] suggests that simplicity is core to usability for software. Simplicity can be considered no less important in the presentation and visualisation of lifelog content.

Lifelogs may be employed in a range of domains and for a range of applications these include: such as tourism [3,28], patient care [2,16], education [1,13] and accessibility within business [25]. As such, the potential users for lifelog-based presentations range widely across a diverse set of computer literacy, skills and experience. Consequently we assert it is extremely important that both simplicity and usability are major considerations in the design of any visualisation within this domain. The users of such a visualisation should be able to quickly and easily access, explore and navigate their photoset, and the navigation, display and arrangement of the collection's contents should be intuitive, logical and comprehensible - i.e. not require any support, guidance or training in order to use. By emphasising simplicity, the potential for the user becoming overwhelmed by the interface or volume of the lifelog collection should be greatly reduced.

Manage & Reduce the Large Data Set into Comprehensible Units

As discussed previously, a human digital memory archive is extremely voluminous and ever growing. Its volume of data presents a huge challenge for both visualisation and navigation. Unless constrained, the sheer mass of information that a user may need to deal with when browsing will most likely overwhelm them, by placing severe cognitive overheads on them. We previously outlined that in order to deal with this the volume of information within the set should be reduced into more comprehensible, intelligible chunks by grouping series of related images into "events." While each individual item only represents a moment in time, an event would consist of a series of closely temporally related items, which overview a unique activity. The aggregation of lifelog artifacts into events, allows for the collection to be greatly simplified in its complexity. Finally, given that not all of the items (and consequently events) contained within the archive will be of interest to the user, most likely as they capture mundane or humdrum activities, the collection can be further reduced, by seeking to rank or remove events based on interestingness. Achieving this, as in [11], also serves to give prominence to the most relevant, important, and interesting events.

Aid Human Memory

Human memory is extremely error prone. Schacter et al. [24] define the "seven sin's of memory" as: transience or the decreasing ability to access memories that occurred some time ago, absent-mindedness or general forgetfulness; blocking or the temporary inability to retrieve information that we know; misattribution or incorrectly assigning a source to a memory; suggestibility or false memories; bias or the exertion of an affect on past memories by current knowledge and beliefs; persistence or the inability to forget unwanted memories.

A lifelog can definitely help overcome some of but not all of these memory issues. It can, for example, help to overcome absentmindedness by allowing the review of events to locate our missing keys and it can remove bias on past memories by providing a permanent unchanging record of it. The lifelog can act as an externalised memory store and has already proven to be effective in combating the "sin's of memory" [16]. With this in mind, we recommend visualisation should intend and be designed to capitalise upon the strengths of a lifelog's data in overcoming memory issues and in providing effective cues for the recall, remembrance and reminiscence of past experiences events. Furthermore, we advise the careful consideration for the task the user will be expected to carry out and how both the content and presentation can seek to achieve the user's goal e.g. are they attempting to find specific knowledge or to gain an overview of a previous activity?

Allow for Exploration and Comparison

While lifelog visualisation should also allow a user to quickly explore their collection, it should also allow them to compare items within the set. In order to achieve this, the relationships between items in the archive should be maintained, e.g. temporal or social, and a user should be able to visually interpret such aspects in order to allow for comparison between items. A common goal of lifelog visualisations is to provide an effective visual summary of a day that will allow for comparison between its events and across other days, for example as in [19]. In order to achieve this, it should provide effective and sensible navigation controls, which enable rapid exploration of a data set that can contain millions of artifacts across weeks, months or potentially years worth of content.

Enjoyable, rich and engaging but also meaningful!

It is worth noting that the content being presented through visualisation of or interfaces for lifelog content is inherently personal. The artifacts within such a collection are collected from the day-to-day activities of a person and in effect capture their life experiences digitally. We must bear this in mind when designing for such content. Given the highly experiential and affective components of the content, we recommend any visualisation of such content should attempt to be equally expressive. This may be achieved through affective design choices including the choice and use of colour, transition or animation. Furthermore, these artifacts have significant to their owner. Visualisation of lifelog content should strive to capture and communicate this meaning. In short, the lifelog content, and in particular its visual content, such as SenseCam photographs, is extremely meaningful to their owner and their review should be an enjoyable, engaging experience.

CONCLUSION

Lifelogs are collections of social and personal data from a given person's life. They contain overwhelmingly large amounts of data which necessitate the use of appropriate visualizations to reduce complexity and offer access to and overview of the information. Through our experience within the domain of lifelogging, we have identified the three major axes on which these visualizations should operate, namely; people, places and time (see Fig. 5). We suggest that lifelog visualisations should seek to access, present, manipulate, and filter information through these major axes. We also suggest that where appropriate the visualizations should attempt to aggregate lifelog information using these axes into more usable chunks. These chunks should take the form of discreet 'events' which map to one continuous activity within a person's (or persons') day. The information presented here can be used as a basic template or framework to inform the design of lifelog visualisations.

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REFERENCES

1. Barreau, D., Crystal, A., Greenberg, J., Sharma, A., Conway, M., Oberlin, J., Shoffner, M., and Seiberling, S. Augmenting Memory for Student Learning: Designing a Context-Aware Capture System for Biology Education, Proc. of the Am. Society for Information Science and Technology, 43(1) pp. 251–251, Oct 2007.
2. Berry, E., Kapur, N., Williams, L., Hodges, S., Watson, P., Smyth, G., Srinivasan, J., Smith, R., Wilson, B., and Wood, K. The use of a Wearable Camera, SenseCam, as a Pictorial Diary to Improve Autobiographical Memory in a Patient with Limbic Encephalitis. Special Issue of Neuropsychological Rehab. 2007, 17 (4/5), pp. 582-681.
3. Blighe, M., Sav, S., Lee, H., and O'Connor N. Mo Músaem Fíorúil: A Web-based Search and Information Service for Museum Visitors. In Proc. ICIAR 2008.
4. Bluetooth SIG. Bluetooth Technology in Hands of One Billion. www.bluetooth.com/Bluetooth/SIG/Billion.htm
5. Boreczky, J., Girgensohn, A., Golovchinsky, G., Uchihashi, S. An interactive comic book presentation for exploring video. In Proc. CHI '00, ACM Press.
6. Bush, V. As We May Think, In The Atlantic Monthly, 176 (1), pp.101-108, Jul 1945.
7. Byrne, D., Lavelle, B., Smeaton, A.F. and Jones, G.F.J. Visualising Bluetooth Interactions: Combining the Arc Diagram & DocuBurst Techniques, In Proc. HCI 2007.
8. Byrne D, Lavelle B, Doherty A.R, Jones G.J.F. and Smeaton A.F. Using Bluetooth and GPS Metadata to Measure Event Similarity in SenseCam Images. In Proc. of IMAI'07, July 2007.
9. Collins, C. DocuBurst: Document Content Visualization Using Language Structure. In Proc. IEEE Symposium on Info. Vis., Poster Session (2006).
10. Doherty A.R, Smeaton A.F, Lee K and Ellis D. Multimodal Segmentation of Lifelog Data. In Proc. of RIAO 2007, Pittsburgh, PA, USA, May 2007.
11. Doherty, A, Smeaton, A.F. Combining Face Detection and Novelty to Identify Important Events in a Visual Lifelog. In Proc. Workshop on Image- and Video-based Pattern Analysis and Applications, CIT 2008.
12. Eagle, N. and Pentland, A. Reality mining: sensing complex social systems. Personal Ubiquitous Computing 10, 4 (Mar. 2006), 255-268.
13. Fleck, R. and Fitzpatrick, G. Supporting Collaborative Reflection with Passive Image Capture, In Supplementary Proceedings of COOP'06, pp. 41-48.
14. Gemmell, J., Williams, L., Wood, K., Lueder, R., and Bell, G. Passive Capture and Ensuing Issues for a Personal Lifetime Store. In Proc. 1st ACM workshop on Continuous Archival and Retrieval of Personal Experiences, 2004, pp. 48-55.
15. Gemmell, J., Aris, A. and Lueder, R. Telling Stories with MyLifeBits, In Proc. ICME 2005.
16. Hodges, S., Williams, L., Berry, E., Izadi, S., Srinivasan, J., Butler, A., Smyth, G., Kapur, N., and Wood, K. SenseCam: a Retrospective Memory Aid. Proc. Ubicomp 2006, pp. 177 –193.
17. Karvonen, K. The Beauty of Simplicity, Proc. Universal Usability 2000, pp. 85-90
18. Lavelle, B., Byrne, D., Gurrin, C., Smeaton, A.F. and Jones, G.F.J., Bluetooth Familiarity: Methods of Calculation, Applications and Limitations, In Proc. MIRW 2007.
19. Lee, H., Smeaton, A.F., O'Connor, N.E. and Jones, G.F.J., Adaptive Visual Summary of LifeLog Photos for Personal Information Management, In Proc. AIR Workshop - 1st Intnl. Workshop on Adaptive Infor. Retrieval, (2006) 22-23.
20. Nicolai T., Behrens N., and Yoneki E. Wireless rope: Experiment in social proximity sensing with bluetooth. In Proc. PerCom 2006, Pisa, Ital.
21. Nicolai T., Yoneki E., Behrens N., and Kenn H. Exploring social context with the wireless rope. In Proc. MONET'06
22. Nielsen, J. Designing Web Usability. The Practice of Simplicity, New Riders Publishing, Indiana, 2000.
23. Raento M., Oulasvirta A., Petit R., and Toivonen H. Contextphone: a prototyping platform for context aware mobile applications. IEEE Pervasive Computing, 4(2) pp. 51-59, 2005.
24. Schacter, D.L., Chiao, J.Y. & Mitchell, J.P. The Seven Sins of Memory: Implications for Self, *Annals of the New York Academy of Sciences*, 1001(1), pp. 226–239.
25. Tjoa A., Andjomshoaa A., and Karim S. Exploiting SenseCam for Helping the Blind in Business Negotiations, Computers Helping People with Special Needs, Springer, pp. 1147 – 1154, 2006.
26. Tulving, E. Elements of Episodic Memory. Oxford University Press (1983).
27. Wattenberg, M. Arc Diagrams: Visualizing Structure in Strings. In Proc. InfoVis'02, IEEE Press, 110–116
28. Wood, K., Fleck, R. and Williams, L. Playing with SenseCam. In Proc. Playing with Sensors (W3) at UbiComp 2004, Nottingham, UK.