Emerging Tools & Techniques Of Digital Media: history log and multiple futures

Slavko Milekic, The University of the Arts, USA

Abstract

The introduction and acceptance of any new technology by the general public goes through a stage during which the capabilities of the new technology are tested and measured against traditional procedures. During this process the new technology is often used in a manner similar to and with the constraints characteristic of the traditional procedures, even if the new technology is not bound by them. It takes time and experimentation for the new technology to be adopted and exploited to its full potential. Today, we find ourselves in a similar situation in respect to the introduction of the digital medium. Initially, the interactions that took place in this medium mimicked the ones we were used to conducting in other media. Thus, the first electronic exchanges were conceptualized as "e-mail" although they differ from traditional mail in almost every respect: the exchange is almost instantaneous and is not affected by geographic distance, the "mail" can stay forever in one's "mail box" and now one can even use the same procedure to "mail" voice messages, pictures and movie clips. With increasing familiarity with the medium, the uses specific to the new medium emerge: tele-presence, e-commerce, digital paging, collaborative document creation, etc. In this paper I will use the example of documenting the art creation process to explore the implications of the history logging potential of the digital medium for creative processes in general.

Introduction

The emergence of any new technology is followed by a period in which its potential uses and applications are largely unknown. This is the period during which the 'early adopters' of the new technology are trying it out and testing its boundaries. A similar situation exists in relation to the emergence of a new medium. If the new medium is sufficiently different from the ones that precede it, the 'discovery' of its uses has an explosive character and gives rise to new ways of expression almost instantaneously. However, if the new medium can mimic the effects of the preceding one(s), there is always a period during which the new medium is used in a manner and following the constraints of the more traditional one. An example of the former is the relationship between the radio and the first movies, where there was hardly any overlap (especially during the era of silent movies). The latter is exemplified by the relationship between the movies and the television. In the first days of television its main use was considered to be the broadcasting of movies and it was even thought that the appearance of television signaled the end of movies. It took years, if not decades, until the specific characteristics of the medium were recognized, giving rise to unique new genres: TV movies, soap operas, talk shows, video spots, etc.

Today, we find ourselves in a similar situation in respect to the introduction of the digital medium. The problem is even greater than before because this powerful new medium is capable of mimicking *any* of the previously existing ones. The ease with which it is possible to transfer works from other media to digital form is tempting. With a press of a button I can create an electronic version of my book, drawing or a sculpture. However, re-producing the works or techniques from other media also reproduced the constraints characteristic of the original medium. Thus, an electronic book also reproduced the linear, sequential character of a real book and the digital video clips came (and still do!) with a set of VCR-like controls. However, with increased familiarity with the medium, the uses and techniques specific to the new medium start to emerge. Although we are very far from understanding the full potential of this medium, we can have a glimpse of some of its future uses by analyzing the development of the procedures rooted in the unique properties of the digital medium. These unique properties are, for the most part, corollaries of the shift from material to immaterial (binary data) representational mechanisms. In this paper I will examine the implications of the history logging potential of the digital medium on creative processes and social interactions occurring in this medium.

Digitization and the evolution of the document

Documenting events, discoveries and manifestations of the real is a uniquely human characteristic that allowed humankind to extend its evolution

beyond the biological one. In this context, by documenting I mean translating some aspect of reality into a form that allows it to be preserved and shared among humans regardless of its material fate. Both the history of an individual and the history of humankind can become a part of the general knowledge through the process of documentation. Thus, an oral epic is a document as well as a story, a dance, a ritual or a carving. The emergence of writing systems brought the idea of documentation closer to the one we have today. It also made documenting practices more common, although the 'sampling' of real life events that were considered worthy of documentation was pretty sparse. It included only the most significant events in lives of individuals (births, deaths and marriages) or the most precious collective knowledge of nations (rituals, laws, myths). As technological advancements made documenting procedures more accessible, the number of documented events also increased.

Re-creating the world

In the last two centuries technological advancements played a major role in the development of new media – new ways of re-producing and re-creating the world. The digital medium offers the same possibility, but the way this function is carried out is qualitatively different when compared to the historically younger media. Analog sound recordings, photography, film and video re-created segments of reality by physically manipulating magnetized particles in a tape, by controlling the oxidation of silver in photographic gel, or by coordinating the emission of electrons in the cathode ray tube (CRT). Thus, re-created reality in a new medium was as physical as the real world. In contrast, the process of digitization translates the real world into immaterial information space. The binary encoding can reveal itself in a variety of other media (currently most often on a computer screen), but *it is not bound by them*. It is this property of the digital medium that gives rise to many of its unique characteristics which, at the most general level, can be labeled as:

- reproducibility
- transferability
- pervasiveness
- manipulability

Reproducibility is a pervasive characteristic of the digital medium. In a certain sense, all of the digital world is a reproduction. Since digital artifacts exist only in immaterial data spaces, every time they are made available to our senses, they are, in essence, reproduced. This is also true for the 'original' code. Every time the code is used to make a digital artifact manifest in the real world, the code itself is being reproduced, for example, in the memory of a computer executing the code. However, since the reproduced code is indistinguishable from the original in its abstract, essential form, the reproduction of digital code can be described as the creation of multiple originals.

Transferability. Every execution of the digital code involves its reproduction. This is usually achieved by transferring the code from a permanent storage space (hard drive, CD ROM, diskette) to a reproduction space (volatile computer memory). Since the storage space and the execution (reproduction) space of the digital code can be (and in the case of World Wide Web are) geographically distant, transferability of the digital code becomes a global phenomenon and will, in the near future, lead to the *pervasiveness* of the digital medium.

Manipulability. Manipulability of the digital artifacts is also the consequence of the shift from material to immaterial representation. As Weibel notes:

> ... Once recorded, visual information is irreversible. The individual image is unmoving, frozen, static. Any movement is, at best, illusion. The digital image represents the exact opposite. Here each component of the image is variable and adaptable. Not only can the image be controlled and manipulated in its entirety, but, far more significantly, locally at each individual point. In the digital media all the parameters of information are instantly variable... (Weibel, 1996)

With digital re-production becoming increasingly finer grained, a certain point is reached when it, as far as the human senses are concerned, can replace the original. The best example is the development of digital audio recordings – once the technology allowed very fine sampling rates, the digital music CD was born. Paradoxically, the quality of the digitized sound, which is just a sampling of the infinitely richer analog signal, is considered to be truer to the original, and became a quality standard in the recording industry. We are witnessing the same trend in the realm of digital imaging and digital video. Currently, digital images have reached the level of quality (again, measured against human senses) where they are hardly distinguishable from the originals. Digital video is on its way to reaching the same level, although its real-time pro-

cessing demands make it more dependent on technological advancements.

History logging and art creation/ exploration

One of the unique properties of the digital medium is the potential for precise logging (documenting) of all interactions that occur in it. So far, this potential has been used mostly for the preservation of identity in electronic correspondence or commerce (Figure 1.) Paradoxically, this potential feature of the digital medium was rarely used even in circumstances where it would have contributed greatly to the functionality of different applications. For example, it took literally years for software designers of digital graphic and design programs to implement a multiple 'undo' feature in their programs which allowed the users to 'step back in time' and access earlier stages of their designs. The great-

```
from hamp.hampshire.edu (root@hamp.hampshire.edu [192.33.12.137])
by spinit.pgh.net (8.8.7/8.8.7/PGH.NET-02) with ESMTP id QAA05834;
Tue, 16 Feb 1999 16:52:53 -0500 (EST)
Received: from smCCS ([192.101.188.190]) by hamp.hampshire.edu (8.8.8/
8.7.3) with SMTP id QAA06369; Tue, 16 Feb 1999 16:58:17 -0500 (EST)
Message-Id: <4.1.19990216164017.00a0a160@hamp.hampshire.edu>
X-Sender: smCCS@hamp.hampshire.edu
X-Mailer: QUALCOMM Windows Eudora Pro Version 4.1
Date: Tue, 16 Feb 1999 16:50:37 -0500
To: ichim99@archimuse.com
From: Slavko Milekic <smCCS@hamp.hampshire.edu>
Subject: ICHIM'99 paper summary
Cc: dbear@archimuse.com, jtrant@archimuse.com
Mime-Version: 1.0
Content-Type: text/plain; charset="us-ascii"
```

Figure 1. A typical header from an email message. Note that both the sender and the receiver are identified.

est benefit of this feature was freedom from consequences of mistakes or experimental actions. This definitely supported the desire for creative explorations in the medium and had an impact on the quality of the end products.

Another powerful, but also fairly recent, use of logging potential of the digital medium is exemplified by the option to 'record actions' in a number of graphics and 3D rendering programs. This option is similar to a 'macro recording' function of modern word-processing programs in allowing the user to define a sequence of actions which can be recalled at a later date with a press of a button. For example, in a graphics rendering program one could create an action sequence which produces a 'cutout' effect of any well-defined object image by executing the following sequence of actions: ...select background (of the original image)... cut the selection... create new image... 'fill-in' with dark color... paste the previously cut portion of the original... Although by using the action recording function one could document and play back the making of a digital rendering (and there are examples of such use in some programs like MetaCreation's "Painter"), I still have not seen a digital application in which the logging of creation history would be integrated into the environment itself and executed automatically. In the next section I will use the example of history logging of digital works of art as a starting point for the discussion of its uses within and beyond the digital medium.

Creation history

The creation history of an art artifact is usually not evident and, even with the aid of modern technology, is hard to reconstruct. By creation history, I don't mean the historical context that gave rise to a certain work of art as exemplified by the commissioning of certain paintings or sculptures by upper classes. The creation history that I am referring to is the sequence of actual production stages that led to the creation of an artifact. Making it possible to provide this additional dimension to an artifact can be beneficial both for the creative process and for the aesthetic appreciation of the finished product. Following are some of the possible benefits that can be linked to the existence of creation history:

- better understanding of the creative process;
- a new layer for artistic expression – the history of an artifact creation can become yet another parameter that can be manipulated by the artist in order to achieve a certain effect;
- allows re-creation of different stages in artifact production and using them as starting points for exploration of different creation paths, ultimately leading to the creation of a 'family' of artifacts that share a part of the creation process;
- makes possible creation of new pedagogical tools for art education. For example, students can try to anticipate the next stage in artifact creation by creating it themselves and then comparing it to the original process;
- creation history would add yet another element to the recognition of a particular artist's style by allowing examination of the unique spatial and time patterns typical for an individual artist;

To illustrate some of the above points we can start with an illustration, in this case a portrait drawing (Figure 2). The drawing itself is similar to the many drawings of the same kind but is unique in that it has the digitally recorded history of its own creation (samples of which are illustrated in Figure 3).

The creation history becomes a part of the artifact that adds a new dimension to it. In its digital form, the drawing allows the viewer to adopt a more active role in a relationship with the artifact. One can explore different stages of the creation history, or let it unfold automatically (see on-line reference materials for URL). In the digital medium the image becomes interactive.

The creation history can be explored on many levels, from purely aesthetic to the physical and perceptual. Figure 3 provides a sampling of different stages in the creation history of the portrait. Looking at this sequence it is evident that the artist strictly followed left-to-right and top-to-bottom directions in creating the drawing. This observation

Figure 2. Portrait of the author of this paper by artist/designer Ellen Rooney Copyright, 1999 Ellen Rooney, (reproduced with permission).

can provide a variety of different clues: it may indicate that the artist was right-handed or it can be the consequence of the lighting conditions during drawing, etc.

Creation history of an artifact can also become a part of the creation process itself. For this one needs to provide an unobtrusive interface mechanism, which would let an artist move easily back and forth between different stages of the creation. An interface design suggestion and examples of possible manipulations are provided in Figure 4. The only visible interface element during the drawing would be the timeline represented by the red band with arrows pointing in either direction. The creation history can be described in the following manner: The upper row of drawings in Figure 4 (series A, drawings 1-4) corresponds to the first, uninterrupted, stage of creation. The end product of this stage is a dragon with wings, and clean, unscaled

Figure 3. Several stages of the creation history of the portrait from Figure 2. Even cursory analysis reveals information that cannot be inferred from the finished drawing. For example, it is evident that the artist strictly followed top-to-bottom and left-to-right directions in creating the drawing Copyright, 1999 Ellen Rooney, (reproduced with permission).

body. The artist then decided that she would like to redo some of the details and, sliding the 'buckle' on the timeline band (from position II to position I) chose an earlier stage of the creation history (series B, drawing 5). She started adding details to this stage until she finally produced a dragon of the original shape, but without wings, with scales covering his body, and fire coming out of his mouth (series B, drawing 7). Following the logic that 'more is better' she finally decided to combine all of the details, and achieved this by moving the 'buckle' on the timeline from position II to position III (Figure 4). This final step is depicted with more clarity in Figure 5.

For the time being most of the described characteristics and benefits of history logging apply only to the creations & interactions carried out in the digital medium. However, with the spreading of digitization as a preferred method of documentation, even real-world artifacts will have their digital counterparts, with preserved creation histories. In fact, the portrait from Figure 2 was created in a traditional way, but the progress was digitized using a scanner every couple of minutes. Needless to say, such a procedure can be very disruptive of the creation process, but one already has much less intrusive ways of digitizing real-world works. For example, a relatively cheap digital camera connected to a computer can be set up in such a way to automatically take snapshots of an artist's canvas at regular intervals.

Beyond creation history

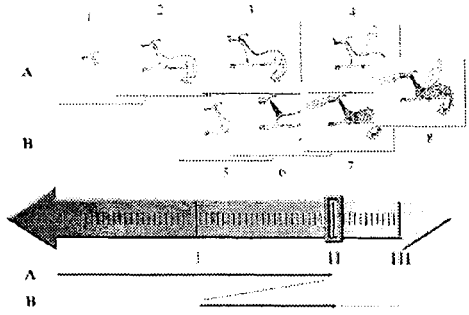

Figure 4. Illustration of the creation history with a timeline interface mechanism (red band with arrows and a 'buckle'). The short notches on the timeband indicate the relative density of the recorded stages. The long notches indicate the instances when the user manipulated the timeline, using the stages of creation history in the creation process. Detailed explanation of actions is in text.

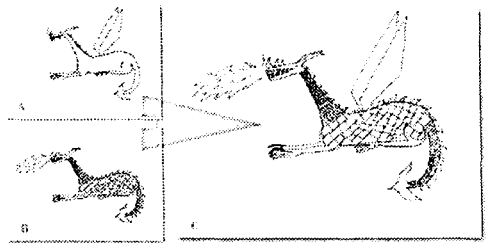

Figure 5. Dragon with wings and no scales (A) and dragon with no wings, with scales and fire coming out of his mouth (B) are two different drawings with a common part of creation history (illustrated by drawings 1 & 2 in Figure 4). Dragon in the drawing (C) combines the features of the other two and was created by their merging using the timeline interface handle depicted in Figure 4. (Dragon drawings by Nadja Milekic, 12 years)

In the following sections I would like to expand the concept of digital logging beyond the creation history aspect which was described in some detail in the preceding part of this paper. Many of these 'logging applications' can be viewed as future tools and techniques specific to the digital medium, which will allow us to achieve better understanding of humans and the way they relate to, use and exchange information. For most of the described tools the existing technology is more than adequate for their implementation (in the same way a computer on a desk of a typical user is more than adequate for word-processing, which is still the task personal computers are most often used for). For the following brief descriptions of the different logging tools, a focus of their tracking activity was used as a distinctive criterion.

Interaction logging (focus on process): In this kind of logging the focus is on what the users actually do with an application. Although many other kinds of digital tracking can be described as logging of user/application interactions, I use this term in a more narrow sense to describe any kind of logging of raw data provided by the application input devices. Easy to implement, this kind of logging often reveals surprising facts about the use of an application. In a recent study (Lee & Heller, 1997) a simple keystroke log file of an elaborate interactive setup revealed that the most expensive part of the application, the digital film and video resources, are hardly being accessed by the users.

Providing a mechanism for individual user recognition interaction logging can become a powerful mechanism for gaining insight into user's preferences, goals and abilities. Figure 6 provides visual representation of an interaction log file for a program which is being developed for neuropsychological testing of young children.*History logging* (focus on period, stage, epoch, community): History logging is tailor made to capture historical events. It is often long term and focusing on a specific community or particular time period. It is designed to capture community interaction patterns and their change over time.

Experience logging (focus on user's experience of content): Experience logging differs from straightforward interaction logging in that it takes into account the number of times the user was exposed to a certain content and often has a built-in model of typical user reactions. Experience logging allows an application to appropriately modify the content which is frequently displayed to a user. For example, if a certain operation requires a number of steps to be performed before it can be executed, the first several times the user initiates this operation detailed instructions would appear on the screen. However, with the subsequent initiating of the operation and anticipated user learning, the instructions can be progressively reduced to a condensed reminder.

Creation history (focus on product of interaction, an artifact): Possible uses and advantages of having a creation history of digital artifacts were discussed in detail earlier.

Affect logging (focus on the emotional aspects of interaction): As Rosalind Picard states in the introduction for her book *Affective Computing*, for computers to be able to adapt to us "they will need the ability to recognize and express emotions, to have emotions, and to have what has come to be called 'emotional intelligence'" (Picard, 1997). Emotional 'dialogue' plays an important, if not crucial, role in human communication. We are often unaware of the importance affective signals (facial expressions and body language) play in everyday communication. On the most basic level these signals serve the purpose of indicating that communication has succeeded, that the message or intent 'came across'. Taking away these 'confirmation signals' can have disastrous effects both on human-to-human communication and human-computer interaction. Lack of acknowledgment that certain action has been registered has led many a computer user to repeat their actions in frustration and often lose valuable data in the process.

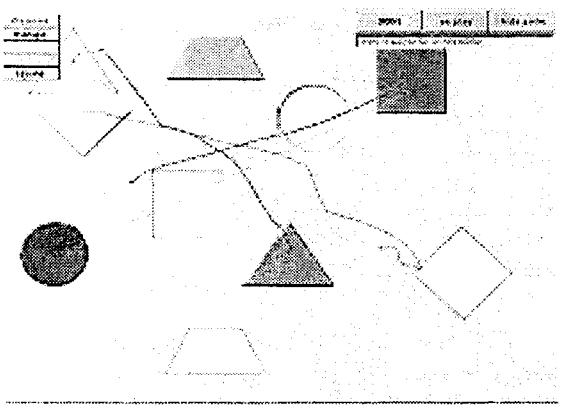

Figure 6. Visual representation of the interaction log file in a diagnostic application where children explore the environment consisting of a number of colored geometric shapes and corresponding cutouts (Milekic, 1998)

Currently there are a number of ongoing studies investigating the use of different channels for affect logging. They range from the detection of skin galvanic response ('lie detector' test), analysis of voice intonation patterns and heart rate variability (Rowe, Sibert, Irwin, 1998) to the registering of gaze direction (Velichkovsky & Hansen, 1996) and dilation of pupils. However, affective logging does not have to be tied to the use of sophisticated technology, a surprising amount of relevant information can be deduced even by analyzing more usual user interactions: the pattern of keystrokes entry as well as the frequency, speed and pattern of mouse movements.

Globalization of digitization

Some of the sophisticated digital tracking techniques exist already and are extensively used for marketing purposes. However, I would like to point out the limited usefulness of these techniques for anything besides their intended purpose. Their development was based on a user-as-consumer model. Although this is a legitimate model of the world, the focus of this paper is on models that are better described with user-as-explorer, user-as-creator or user-as-individual labels.

With digitization becoming a prevalent method for archiving and documentation and with the inherent tendency of the digital medium towards pervasiveness we can expect (in the not so distant future) the development of digital 'tracks' for an increasing number of real-life situations. We are witnessing a proliferation of portable, handheld, pocket, wearable and even implanted devices whose main purpose is to transfer some real-life data into digital form and make them more suitable for storing, manipulating and exchanging. This is nowhere more evident than in the realm of family snapshots and home videos that are increasingly created and exchanged digitally. A growing number of specialized devices are offering special digitizing functions, from business card scanners to digital voice recorders bundled with voice recognition software capable of transcribing recorded sessions into a word-processor document. In the area of personal use, it is still not clear whether the future will bring the development of a large number of small, highly specialized devices or a general purpose digitizer capable of recording voice, still images and digital video, but also with optic character recognition, digital data exchange and videophone capabilities. Some of the currently available PDAs (personal digital assistants) are already coming very close to this description.

In the realm of industrial/commercial use, the current trend is definitely towards the development of specialized 'digital enhancements' of tangible objects. It is exemplified by 'smart price tags' in supermarkets – tiny LCD displays showing the price of a product. The price can be adjusted almost instantaneously by receiving an appropriate message from the central computer. A more active approach, which allows multi-user multi-object interactions, is illustrated by 'TouchCounters' (Yarin and Ishii, 1998); storage containers with electronic labels that are capable of tracking and displaying the use of a particular container. A collection of containers of

this kind reveals not only the history of use of an individual container, but also more complex patterns of usage which are readily available through simple visual inspection.

What does true globalization of digitization imply? In essence, it means that every object and individual will have a digital 'extension'. Creation histories, authorship and instruction manuals will become expected parts of objects. Prototypes of minute, unobtrusive electronic tags which can be embedded even into a piece of paper the size of a business card already exist (Want, Fishkin, Gujar, Harrison 1998). These tags are capable of 'calling' the more extensive information related to the object just by waving it in front of a (responsive) computer screen. Our professional and creative activities will be unobtrusively digitally encoded and stored, so we can later analyze, manipulate and exchange them. Because of the ease of communication in the digital medium and lack of geographic constraints our digital identities will play an increasingly important role in our everyday lives. And pretty soon, having a digital part of ones identity will become an expected commonality.

The future: 'digicreation'?

Most of this paper focused on the process of digitization because of the increasing use and availability of the digital medium. However, digitization does not have to be a one way process. For lack of better term, I shall call the process opposite to digitization 'digicreation'. In fact, a number of devices already exist which are converting digital encoding into a real-world form. In the realm of personal use, they are exemplified by humble printers. It is worth noting the current trend to make printers capable of accepting digital input directly (from a digital camera or 'memory stick') and doing the digital-real conversion without the aid of a computer. Thus, current printers can be viewed as a precursor of the future personal 'digicreation' machines.

In the area of rapid industrial prototyping there are already machines capable of producing accurate three-dimensional models of computer-generated designs. The models are small in size and fragile (made of colored cornstarch) but the production principle can be extended towards building of life-size models. Computer Aided Manufacturing (CAM) systems are capable of reproducing even very complex digital designs in hard materials, like metal or wood.

If the current trends of digitization continue one could imagine that in the world of art this would mean that any artifact would also have its digital equivalent (for classification, education and dissemination purposes). The artifacts will also routinely have their creation history available in digital form, and furthermore it would be possible to go back to any of the previous stages of the creation history and re-create the physical artifact at any stage of its production from its digital 'copy'. Meaning, if one sculpted something in marble, and the process was digitally recorded, it would be possible to reproduce (in marble) any of the previous stages of the sculpture.

Conclusion

A case has been made that most of the unique properties of the digital medium arise due to the shift from material to immaterial means of representation. These characteristics (reproducibility, transferability, pervasiveness and manipulability) allow the documenting (logging) of digital and digitized processes and artifacts with unprecedented ease. Furthermore, the logged information itself becomes easily accessible, reproducible and manipulable thus contributing in a qualitative way to the interactions involving the digital medium. With global expansion of the digital medium and the development of digitizing technology it is expected that most human activities and products will acquire a digital extension. Since the digital extension of a real-world artifact may contain essential information about its physical properties, further technological advancements could also make it possible to re-create an artifact (or any of the stages in its production) based solely on its digital extension.

References

Lee, S., Heller, R.S. Use of a Keystroke Log File to Evaluate an Interactive Computer System in a Museum Setting, *Computers in Education*, Vol. 29, 89-101, Elsevier Science, Ltd, 1997.

Milekic, S. CARE: Computer Aided Rehabilitation and Education, a touchscreen-based application prototype, 1998.

Picard, R. *Affective Computing*, MIT Press, Cambridge MA, 1997.

Rowe, D. W., Sibert, J., Irwin, D., "Heart Rate Variability: Indicator of User State as an Aid to Human-Computer Interaction", in *CHI-98: Human Factors in Computing Systems*, 480-487, ACM Press, NY, 1998.

Velichkovsky, B.M. & Hansen, J.P. "New technological windows into mind: There is more in eyes and brains for human-computer interaction", in *CHI-96: Human Factors in Computing Systems*, ACM Press, NY, 1996. (also available on line at http://rcswww.urz.tu-dresden.de/~cogsci/vlich/boris.html)

Want, R., Fishkin, K.,P., Gujar, A., Harrison, B.,L. "Bridging Physical and Virtual Worlds with Electronic Tags", in *CHI-99: Human Factors in Computing Systems*, 370-377, ACM Press, NY, 1999.

Weibel, P. "The World as Interface: Toward the Construction of Context-Controlled Event-Worlds", in Druckrey, T. (ed.) *Electronic Culture: Technology and Visual Representation*, 338-351, Aperture Foundation, NY, 1996.

Yarin, P., Ishii, H. "TouchCounters: Designing Interactive Electronic Labels for Physical Containers", in *CHI-99: Human Factors in Computing Systems*, 362-369, ACM Press, NY, 1998.