

# The Lost Cosmonaut: An Interactive Narrative Environment on the Basis of Digitally Enhanced Paper

Axel Vogelsang<sup>1</sup> and Beat Signer<sup>2</sup>

<sup>1</sup> University of the Arts,  
Central Saint Martins College,  
Southampton Row, London

[a.vogelsang1@csm.arts.ac.uk](mailto:a.vogelsang1@csm.arts.ac.uk)

<http://www.incompatibility.net>

<sup>2</sup> Institute for Information Systems,  
ETH Zurich, CH-8092 Zurich, Switzerland  
[signer@inf.ethz.ch](mailto:signer@inf.ethz.ch)

**Abstract.** The Lost Cosmonaut is an interactive narrative based on digitally enhanced paper. This technology uses an electronic pen to mediate between paper and computer. Thus any actions of the pen on the paper can be captured and manipulated by a computer as well as we can map digitally controlled events onto paper. The story in this narrative environment reveals itself partially through written text and images on the paper surface just as any other printed story. However, additional information in form of digitally controlled outputs such as sound, light and projections can be accessed through interaction with pen and paper. Furthermore the audience is not only supposed to read and otherwise perceive information, we also want them to actively produce content for this environment by writing onto the paper. By doing so they also add content to the database containing the digital output at the same time. Hence we produce a complex multimedia environment that works on three levels: On paper, in a digitally controlled visual and acoustic environment and in the combination of both worlds. Last but not least this environment is an open system, which grows as a collaborative effort over time as each user adds his own entries to paper and database. We argue that using paper as an integrated part of a digital environment is a best-of-both-world approach that opens up new possibilities for producing and perceiving narrative.

## 1 Preliminary About the Nature of This Project

The Lost Cosmonaut is an art-science collaboration as part of the Artists-in-Labs program initiated by the HGKZ (University of Applied Sciences and Arts Zurich). The motivation was to develop a stand-alone artwork that showcases the possibilities of technologies developed by the Global Information Systems research group (GlobIS) in regards to interactive narrative. It was not in the

scope of the project to develop a general framework for narrative environments with digitally enhanced paper. The very restricted time frame of six months put some constraints on the functionality supported by a first prototype and did not allow for a proper series of user testing. There are some efforts made at the moment to further develop the project into a robust installation for general exhibition.

## 2 Introduction

Paper has been one of the most common media for storing and exchanging narratives for hundreds of years if not for two millennia. With the arrival of personal computing and notions of emergence and virtual environments the days of paper seemed to be running out. Experts reckoned that the arrival of the paperless office was just a question of time. But why has paper defied all these swan songs so far? And why should paper play a role in a digitally controlled environment in the first place? Research all across human sciences such as by the biologists Maturana and Varela [4] or the psychologist J. J. Gibson [2] has shown that human thinking and acting has developed through interaction with the physical and social environment in an intense process of structural coupling. We are not independent agents in a closed environment. We have developed in relationship to the environment while we have shaped it at the same time. Sellen and Harper [7] among others have looked at why paper still is a crucial media in working environments. According to them *“engagement with paper for the purpose of marking or reading is direct and local. In other words, the medium is immediately responsive to executed actions, and interaction depends on physical copresence.”* These and other properties relevant to humans are an expression of our existence in physical space and they have formed our relationship with information during the centuries. Thus Sellen and Harper conclude that *“paper tends to find its natural place in workplace activities that are point-of-use activities or that are the kinds of activities we normally think of as key to knowledge work. These are the activities that involve making judgments, solving problems, making sense of information, making plans, or forming mental pictures of information. In other words, these are the activities we have come to think of as getting to grips with information.”* As a lot of these mentioned activities do apply to story telling and reading, we conclude that paper as an integrated part of a digital environment can open new opportunities for interactive narrative as it combines the best of both worlds.

## 3 Background

The integration of paper and computers has been researched as early as the beginning of the 1990s when Pierre Wellner developed his DigitalDesk [9]. Here are some of the more recent projects dealing with computer-paper-integration and/or with embodied interactive story telling.

The *Listen Reader* [1] was mainly aimed at children and the interface consists of a book containing a printed story combined with a chair with integrated speakers. The user sits on the chair while reading the book. Electronic field sensors in the binding sense the proximity of the user's hand to the pages. While turning the pages or passing over the text the hand movements trigger the playback of music samples as well as they influence volume and pitch. Even though the user still has to read the story, the interaction with the book provokes a physical engagement while the relating sound environment adds an emotional layer to the narrative.

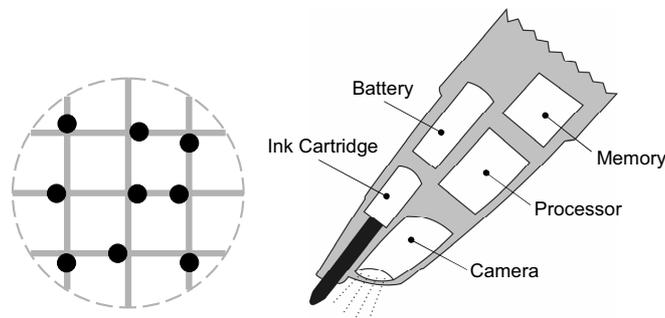
*Tangible Viewpoints* [5] is a multiple viewpoint narrative that allows the use of physical pawns as "handle on the character viewpoints" in an interactive narrative. One or more users can experience a story from different viewpoints by moving the pawns on a sensitive field. As narrative outputs for this environment serve multiple media such as audio, image, video and text that react on the movements of the pawns. It is a very media-rich environment which engages with space and offers physical embodiment of individual story characters. Thereby it claims to heighten the engagement with the story and the identification with the story characters.

The *EdFest* system [6] is an ongoing research project by the GlobIS group aimed at developing a knowledge sharing environment for the Edinburgh festival based on paper-computer integration. It is supposed not only to provide access to information about venues and events, but also to allow tourists to enter and share reviews of events and information about restaurants and bars discovered during their visit. Tourists are provided with a specially designed digitally augmented map and brochure, a digital pen, an earpiece that serves as an audio channel and a wearable computer. A user can access information by moving the pen over the brochure as well as generate additional input by writing onto it. Moreover these comments will be shared with other users, which also has a strong element of narrative to it.

The Lost Cosmonaut aims at combining a lot of the above-mentioned features: It wants to draw from the strengths of pen and paper as traditional and simple tools for reading and writing stories. It will use the inherent appeal of tactile sensation and spatial movement. It wants to enrich the user experience by a layer of digitally controlled outputs in form of audio, video, image and text. It will produce additional involvement by engaging the user into a collaborative process of narration.

## 4 Interactive Paper

While several projects in the past have sought to bridge the paper and digital divide, recent technological developments make this a realistic option and a number of commercial products are now available using Anoto technology. The technology is based on an almost invisible pattern of infrared-absorbing dots printed on paper and special digital pens which have a camera situated alongside the writing stylus as shown in Fig. 1.



**Fig. 1.** Anoto technology

The pattern of dots encodes x and y positions in a vast virtual document address space. Camera images are recorded and processed to give up to 100 x and y positions per second and enable a good representation of handwriting to be captured. Several pages of handwriting can be stored in the pen before being transmitted to a PC. Commercial products based on this technology include Nokia's Digital Pen and Logitech's io Personal Digital.

Currently, the focus of commercial products is on information capture for enhanced writing. A number of research projects have also investigated technologies for enhanced reading based on some means of creating links to digital materials within printed documents. Many systems use printed visible marks on paper such as standard barcodes or specially printed patterns. While visible encodings have the advantage of making links obvious to users, they can also be extremely disruptive to reading, especially if many links are present.

The GlobIS research group developed iServer, a cross-media information platform that allows any form of media to be integrated through a resource plug-in mechanism [8]. So far plug-ins for interactive paper (iPaper), HTML documents, movies, sounds and still images have been developed. These allow not only entire resources to be linked, but also elements within resources as specified through appropriate selector mechanisms. In the case of interactive paper, selectors are defined as active areas within physical document pages.

In the Lost Cosmonaut installation, the pen is used as a writing and interaction device, thereby combining the approaches of enhanced writing and enhanced reading. Since iServer is independent of any specific technology for interactive paper, we are able to use Anoto functionality both for the capture of handwriting and the activation of links within a page. However, it is important to stress that in order to do this, we use pens specially modified by Anoto rather than an off-the-shelf product.

## 5 The Story

We decided against a linear or a forked path that would lead to a closed story. Instead we produced a database of smallest narrative units. The audience is

provided with a theme rather than with a coherent story in order to keep the environment open for individual imagination and user contribution.

The theme is based on stories surrounding cosmonauts being either secretly used as guinea-pigs or otherwise lost in space. The emotional and narrative potential was more important to us than the facts behind the stories. There is an element of mystery, which leaves sufficient gaps for the audience to fill in. Space travel has been a generator of fantasy and speculation for a long time. The stars themselves have a long history as an oracle of human future, personal success and love issues. The cosmonaut theme is laden with symbolism and metaphors, waiting to be exploited. It also relates to the time when digital technology slowly started to take over, which together with the nostalgia surrounding the early days of space travel did fit nicely into our idea of combining a very old interface with latest technology.

## 6 The Setup

The basic setup for The Lost Cosmonaut is a desk on which one user at a given time interacts with objects made of digitally enhanced paper using an electronic pen as shown in Fig. 2. These objects contain pre-produced texts and/or images. Besides reading and looking at those information the user is supposed to point his pen at text and pictures in order to trigger digitally controlled outputs. Those outputs manifest as audio from surrounding speakers as well as video, animation, image, text, projected onto a screen in front of the user.

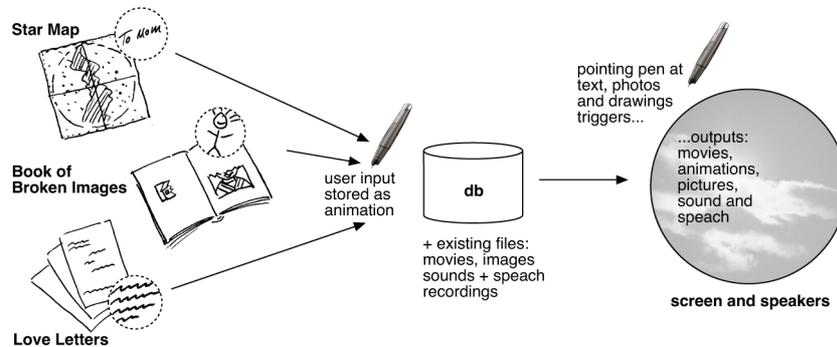
### 6.1 Database Content

For the content we gathered film footage and images surrounding space travel. Additionally we used sounds and short speech recordings. These are our smallest narrative units that provide the user with a backdrop for his own personal interpretation of the story while he interacts with our installation.

Another part of content is provided by the audience itself who is invited to write and draw on the interactive objects as we will explain in detail later. These



Fig. 2. The Lost Cosmonaut setup



**Fig. 3.** Content structure

acts of writing and drawing will obviously change the content of the physical object. And in addition this user input will be captured as an animation and will enter the database. Triggered by user interaction these animations will be replayed on the screen at a later time in combination with sounds and speech. So the user's input will reappear as output in a different context.

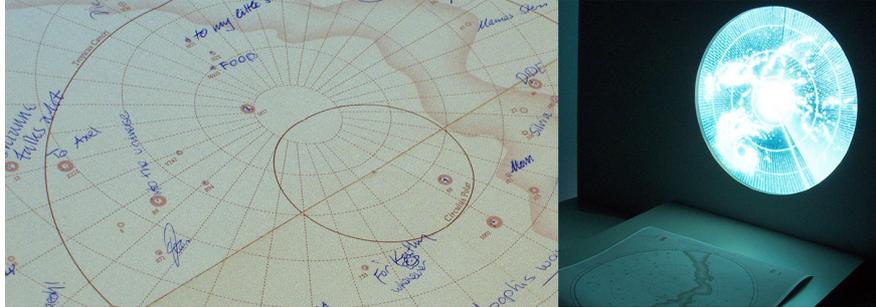
It is also very important that the whole system, physical objects and database that is, grow over the time of an exhibition. There is no reset of the database neither do we intend to give every user fresh paper objects. Thereby the content builds up over multiple user sessions and the narrative turns into a collaborative effort as outlined in Fig. 3.

## 6.2 The Paper Objects

*The Book of Broken Images:* The first object is a photo album presented in Fig. 4. There are photos of people, houses, a party, a starry night, a man in uniform, etc. It could be somebody's family album. The mysterious thing though is that



**Fig. 4.** The Book of Broken Images



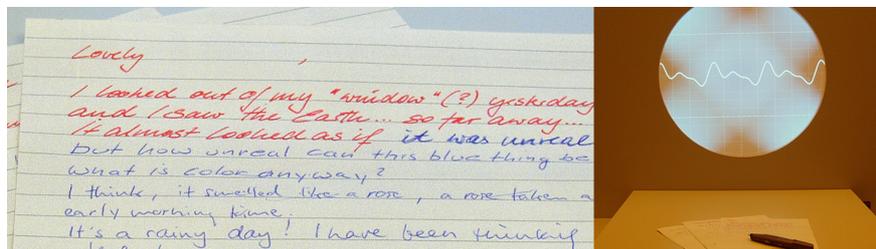
**Fig. 5.** The Star Map and relating mood

one half of each image is torn off. Those half images are printed on digitally enhanced paper. When the user points with the pen at them, the screen shows different images or films: a camera walking through empty rooms, a desert, the moon surface, all supported by relating sounds.

Each object implies a specific interaction. With the photo album the idea is that the audience should start to imagine the other part of the photo and to fill in the gaps by drawing with the pen. And each drawing itself turns into a sensitive field that is connected with objects in the database. If the user moves the pen onto them he will again be presented with audio or video output. And as we've mentioned before, everything that is drawn is captured and stored in the database.

*The Star Map:* The second object, shown in Fig. 5, resembles an ancient star map. When the user ticks the pen onto one of the stars, the environment reacts with various outputs coming from the database, which also contains animated versions of the drawings that the users have left in the book of broken images.

Also the user is intended to dedicate a star to somebody. And as with the book of broken images, the dedications added by the users are captured and added to the database while their physical manifestations on the paper turn into active areas, which trigger an output whenever the pen touches.



**Fig. 6.** The Love Letters and relating mood

*The Love Letters:* They are actually not more than fragments of letters, started but never finished as indicated in Fig. 6. Similar to the other two objects the user interacts: He points the pen at written texts and the system reacts with outputs. He fills in gaps in the letters and thereby produces more content for the database as well as more active areas on the paper which themselves can be used to trigger audio and visuals.

Each of the three objects is additionally supported by a basic theme composed of sound, visual and lighting, which we call mood. This mood is constantly playing/showing as a background when there is no user activity but it is also giving direct feedback on whatever inputs. Part of the mood of the Love Letters is a pulsating heartbeat on an oscilloscope. When the user writes, this heartbeat accelerates. RFID tag stickers on the back of each object in combination with an RFID reader on the middle of the table activate those moods.

## 7 Technical Infrastructure

The interactive paper platform (iPaper) supports enhanced reading as well as enhanced writing. Based on a set of abstract interfaces, the interactive paper platform is very flexible in supporting various forms of input devices. For the Lost Cosmonaut interactive narrative, a Nokia Digital Pen was the primary input device next to some other sensors, such as Radio Frequency Identifier (RFID) tags, which were used for document tracking. A system overview of the Lost Cosmonaut architecture is given in Fig. 7. It is based on a client-server infrastructure with iServer and OMSwe, a publishing framework, on the server side. The two server components manage all relevant information, whereas the client-side components provide the user interface.

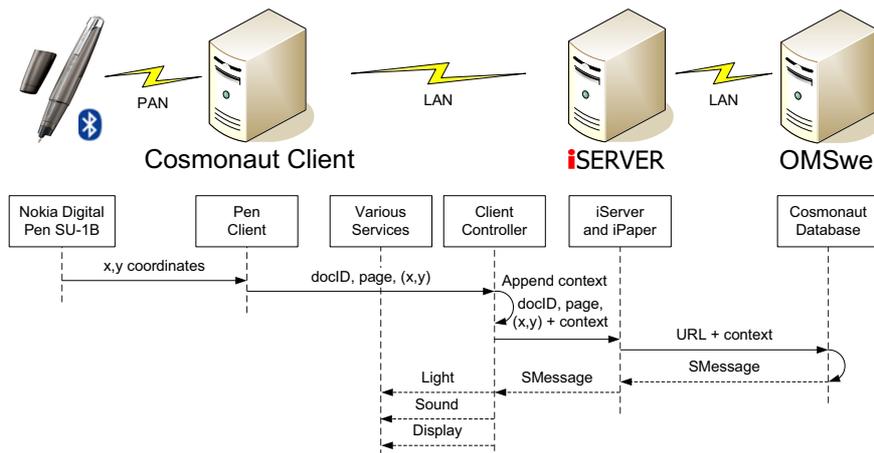


Fig. 7. Lost Cosmonaut architecture

As the user writes or points somewhere in one of the three documents with the Digital Pen, the **Pen Client** sends a request to iServer. The iPaper plugin resolves the positional information and retrieves the appropriate object that is linked to the selected position. However, all application-specific information is stored in a separate OMSwe database and iServer only handles references to these applications objects in the form of OMSwe active components. The OMSwe database contains pre-authored information or data that has been added by previous visitors and returns the result as an XML Service Message (**SMessage**).

All requests from the client device to iServer are redirected over a **Client Controller** component. The **Client Controller** is responsible for dispatching the Service Message returned from iServer to the appropriate output channel. An important detail of the Lost Cosmonaut installation is that a Service Message may address multiple output channels. For example, if a new document is placed on the table, a request is sent to iServer and a Service Message containing information for all mood channels, i.e. the light control, the ambient sound system and the video display service, is returned. The architecture is flexible in supporting new output channels since only a new Service Message has to be defined and registered with the **Client Controller**.

## 8 Observations

We set up a demonstrator of the installation at the ETH Zurich for a week as a showcase of our work-in-progress from which we gained the following insights.

*Pen handling:* The usage of the pen as an interactive reading tool as such was not so easy to comprehend without introduction. We are considering to start each user session with a playful theme related introduction, including a hands-on guide to the usage of the pen itself.

*Feedback and Reward:* The audience was not always aware of the feedback for writing interaction such as the speeding up of the heartbeat. The reason is probably an inconsistency in how feedback is given. Consistent feedback appears crucial though as the user needs reassurance. Also the system only gives feedback when the user points at areas that contain some kind of visual content. Pointing at other areas doesn't trigger any reactions. We are considering some basic sound feedback for empty areas as a general reassurance.

*Interaction with the Content:* Some users tried out unexpected interaction patterns which proves disruptive at times. We will have to look closer at differing usage patterns in order to understand how they influence the experience.

Many users received the outputs of the system as rather randomly. This will be worth looking at because the more the user understands the consequences of his actions, the more likely he will engage himself with the installation

*Narrative:* This installation is setting up an environment with a specific theme, which emotionally involves and stimulates the user in order to fill the gaps with his own imagination. This works very well in some parts but the randomness of some of the output seems to be a bit disruptive in regards to the narrative.

## 9 Conclusion

The Lost Cosmonaut shows that digitally enhanced paper can offer a very interesting approach for developing interactive and nonlinear narrative. It opens up many possibilities for providing rich experience and involvement and it also supports imagination as well as user creativity. Our project combines the positive aspects of paper and pen providing a tactile embodied experience and relates those properties to a complex multimedia environment.

As to the narrative aspects of this installation: According to Kuitenbrower there are three main categories of interactive relations between user and system [3]: A “functional relation” where the system does exactly what it is told. On the contrary side of this experience there is “no relation” where the system seems to take no notice of the user but has its own life. Between these two extremes there is an “interesting relation” where “the system reacts to us with some kind of flavor of its own”. This middle ground is where we position the Lost Cosmonaut. We will work further on providing more consistent feedback while sustaining an element of mystery and imagination. We are aware that the narrative structure we use, hardly supports a classical dramatic progression nor does it have dramatic closure. But this is the price that non-linear storytelling has to pay for exploring new areas. However we can easily imagine how the infrastructure could be used to provide a more linear or even game-like experience.

We would like to thank Andrea Lioy for his work on conceptualising and writing, Kurt Schlegel for sound composing and engineering as well as Rudi Belotti, Corsin Decurtins, Ljiljana Vukelja, Nadir Weibel for vital contributions.

## References

1. M. Back, J. Cohen, R. Gold, S. Harrison, and S. Minneman. Listen Reader: An Electronically Augmented Paper-Based Book. In *Proceedings of ACM CHI 2001, Conference on Human Factors in Computing Systems*, Seattle, USA, March 2001.
2. J. J. Gibson. *The Senses Considered as Perceptual Systems*. Houghton Mifflin, Boston, 1966.
3. K. Kuitenbrower, Emergent Narrative, [www.mediamatic.net/article-200.9160.html](http://www.mediamatic.net/article-200.9160.html).
4. H. R. Maturana and F. J. Varela. *Der Baum der Erkenntnis – Die biologischen Wurzeln des menschlichen Erkennens*. Goldmann-Verlag, 1987.
5. A. Mazalek, G. Davenport, and H. Ishii. Tangible Viewpoints: A Physical Approach to Multimedia Stories. In *Proc. of 10th ACM Intl. Conference on Multimedia*, Juanles-Pins, France, December 2002.
6. M. C. Norrie and B. Signer. Overlaying Paper Maps with Digital Information Services for Tourists. In *Proc. of ENTER 2005, 12th Intl. Conference on Information Technology and Travel & Tourism*, Innsbruck, Austria, January 2005.
7. A. J. Sellen and R. Harper. *The Myth of the Paperless Office*. MIT Press, 2001.
8. B. Signer and M. C. Norrie. A Framework for Cross-media Information Management. In *Proc. of EuroIMSA 2005, Intl. Conference on Internet and Multimedia Systems and Applications*, Grindelwald, Switzerland, February 2005.
9. P. Wellner. The DigitalDesk Calculator: Tangible Manipulation on a Desk Top Display. In *Proc. of ACM UIST'91, 4th Annual Symposium on User Interface Software and Technology*, November 1991.