Journal of
Professional Communication jpc

Iterative emergence of art/science hybrids

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Article Info

Article Type:
Editorial

Article History:
Received: *2013-09-09*
Revised: *2014-04-09*
Accepted: *2014-04-15*

Keywords:
Digital Art
Live Performance
Interactive Installation
Software Engineering

Abstract

This paper highlights and analyses the realization of three examples of Art/Science hybrids that resulted from close collaboration of artists, scientists and engineers: First, the Scheinwerfer Live Visuals project was accompanied by the development of the media-processing software *Soundium*. Second, the Digital Marionette was based on Soundium, and extended with real-time speech recognition and facial animation. Finally, the *Procedural City* installation used a fingerprint scanner and a generative urban modeling tool to create personalized 3D cities. The examples started from uncertainty in terms of technology, design and anticipated result. A common denominator was the interaction between artistic process, scientific research and engineering: Artistic ideas often were beyond the capabilities of available technology, thus triggering research and development. New solutions then returned in a generalized form, spawning new artistic demands. This paper identifies processes and strategies involved, and argues that a close iterative interplay between domain experts is a key ingredient for rapid emergence from uncertainty to a final work.

"The further art advances the closer it approaches science, the further science advances the closer it approaches art."
Buckminster Fuller quoting Leonardo da Vinci (Fuller, 1938).

Since Aristotle, subject areas have been divided in categories and since then many have attempted to come up with clear criteria that define and distinguish those areas. In the case of the arts and sciences many criteria exist, but today there seems no universal consensus on what divides them (Mumford, 2012). Maybe for this reason, Alan Kay's viewpoint that:

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> Today, science (a concern with what is real) is mixed with mathematics (a concern with what is true) is mixed with engineering (a concern with how something can be made). Each worker in each of these fields also partly works in the other two. (Kay, 2001)

can be applied in the art-science context as well. Furthermore transdisciplinary approaches go a step further and demand that workers need to obtain expert knowledge in more than one field (Gibson, 2008). Ultimately, this may lead us to ignore the division, as Kay further states: "I did not distinguish between 'art' and 'science' and still don't." (Sasha & Lazere, 1998).

This paper will not examine the divide between art and science, but will explore what happens when scientists and artists work together, or when they become deeply engaged in both art and science. In particular, we will explore the workflows that accompany the evolution of works. Thus, when looking at *art-science* (or *science-art*) *hybrids*, how do workflows in either domain relate with respect to evolving works? Will either scientific or artistic approaches become dominant? Or will they remain separate in their domains and proceed independently? If so, how will they influence each other? To answer these questions, this paper looks at three hybrid works in the domain of digital art and explores the processes that took place during their development, starting with the premises that initiated the hybridization, continuing onto the workflows that took place during the development of the works and finally highlighting some of the effects that took place after completion of the works.

Our exploration shows that the general direction of workflows involved in each domain remained relatively unchanged, mainly due to the fact that the timelines of the realized artworks were constrained by external factors, such as completion of other projects. At the same time, strong bonds between different workflows quickly developed, and works mainly emerged iteratively, where requirements and preliminary results were passed back and forth, bringing the work closer to the desired result. Finally, engineering played an important role building and maintaining the bonds, as it served as a communication channel and the practical tool between different domains – this may have been due to the strong technical foundation present in all works. Thus, we may also see engineering as the mediator between scientific reasoning and artistic decision. On one hand engineering operates systematically, but on the other, it includes design decisions that are based on available choices.

The Works

The Art/Science hybrids explored in this paper were realized in a period from 2002 to 2009. They are all based on a considerable amount of software engineering, focusing on real-time graphics and audio processing and user interface design. While this paper does not go into details of the conceptual or aesthetic aspects, in this section we briefly highlight the history and basic properties of each work.

Scheinwerfer is a live visuals project that emerged out of several PhD projects and developed into an independent research project. One characteristic of the project is that it was based on custom software: *Soundium* (Schubiger & Müller, 2003) – a real-time media-processing framework that was originally developed to synchronize animated musical gestures to audio. Originally, it served as a software tool for validating research in mathematical music theory (Mazzola, 2002) and was then re-used as a live visuals performance tool in the electronic music scene, resulting in a generalization of the approach.

The Digital Marionette (Figure 1), exhibited in 2004 at Museum Bellerive in Zurich and at the Ars Electronica Centre in Linz from 2006 until 2008 (Mueller, Müller, Schubiger & Specht, 2006), was an installation that allowed the audience to use a traditional puppet interface and speech input to control a virtual marionette. This was a result of continued work on Soundium that integrated research prototypes for speech recognition and facial animation.

Figure 1: The Digital Marionette, exhibited at Museum Bellerive, Zurich in 2004.

Procedural City, exhibited at the Ars Electronica Centre from 2009 to 2012 (Schubiger, Mueller & Müller, 2009) at the Academy of Fine Arts, Xi'an (2010) and at the Maison D'Ailleurs, Yverdon-les-Bains (2012) was an interactive installation that used a fingerprint scanner and CityEngine, a generative urban modeling tool, to create an urban environment whose morphology was unique to a visitor's biometric fingerprint. In contrast to the previous examples, the installation was realized within a corporate environment. The *ETH Zurich* spin-off company *Procedural Inc.* carried out the project. Its development was tightly integrated in the agile development cycles of the CityEngine.

In order to explore the evolution of the three works, Figures 2 and 3 show timelines with the slanted lines depicting interactions between the main pieces, the involved projects and museums or curators. The types of interactions cover a rather large range, from commissioning of works, to knowledge transfer and communication, and to software exchange. Relevant events and observations are indicated by the numbered bullets and discussed below.

Emergence of Scheinwerfer and the Digital Marionette

Figure 2 shows the timeline and interactions of both Scheinwerfer and the Digital Marionette, as the latter was based on the same software and the two works were very closely entangled. A first overall observation is that both works emerged almost coincidentally when different research results – notable for having been developed almost simultaneously at different universities – were combined: Soundium's code base had its origins in mathematical music theory and real-time media processing, and was mainly used to validate research results, rather than as a live performance instrument. However, when one of the researchers was asked to do a spontaneous VJ gig at a dance music event, a first prototype version was written and used within one week (Figure 2, bullet 1). While this "going public" of academic research was unexpected, it triggered a rapid and systematic development of Soundium, which was followed by more than 100 performances to date and which in turn allowed a feedback into the original domains (Bullets 2 & 3). The access to a self-developed framework, combined with on-going research and repeated performances, led to a productive, iterative process resulting in a rapid emergence of Scheinwerfer's live visuals both in terms of expression and aesthetic.

The development of Soundium laid the foundations for the Digital

Marionette, when research on facial expression and animation was integrated into the software for rapid prototyping of demos (Bullet 4). This point also indicates an increasing entanglement of the involved areas, with Soundium emerging as a central hybrid spine, supporting the commissioning of the Digital Marionette (Bullet 5), and serving as a coordination instrument for the first (Bullet 6) and second (Bullet 7) exhibitions of the piece. In between, results (mainly in form of code) were fed back into the Soundium development (Bullets 8 & 9).

To summarize, in the case of Scheinwerfer and the Digital Marionette, scientific and artistic approaches became closely interwoven, with an intense interaction between the two domains. The open academic environment constituted a fruitful playground, where other scientists without a priori interests in artistic works contributed results that were valued by the dissemination of their work through different channels from the traditional scientific ones. These contributions also allowed for fast advancement of the works. Software engineering played an important factor as it grounded scientific results and made them available for artistic exploration. In turn, the realization of the artworks was typically constrained by limitations of already available scientific results, triggering new scientific problems that were fed back to on-going research projects.

Figure 2: Timeline of the evolutions and interactions of Scheinwerfer and the Digital Marionette.

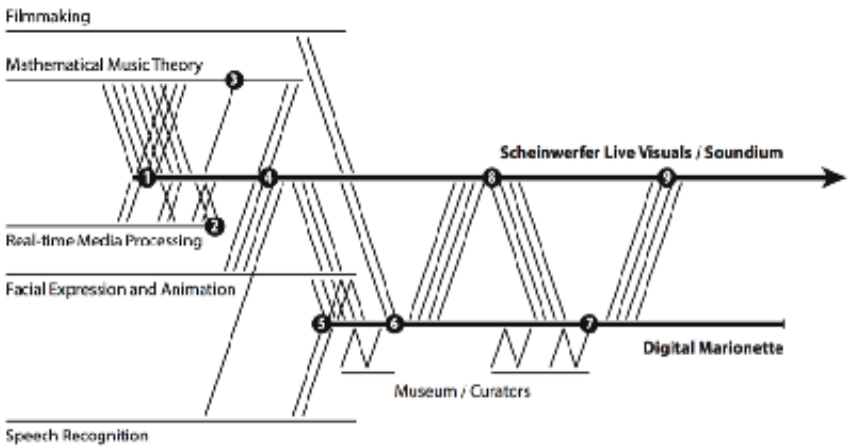
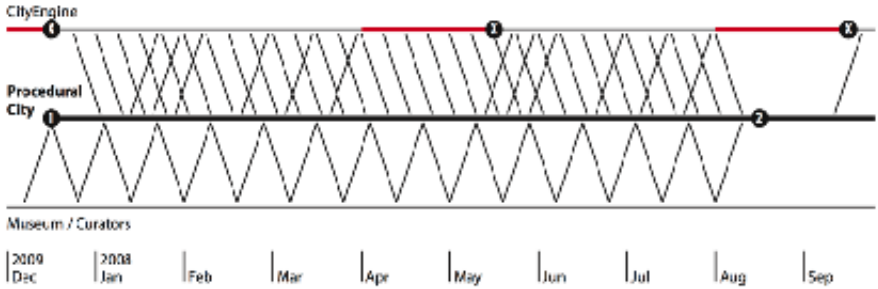


Figure 3: Timeline of the evolution and interactions of Procedural City



Evolution of the Procedural City

In contrast to Scheinwerfer and the Digital Marionette, Procedural City evolved in a research and development heavy, corporate spin-off environment. This situation had implications in the way the work was realized. As shown in Figure 3, there were mainly two strands of development: The main work on the CityEngine – the Procedural Inc.'s main product – and the commissioned work on the Procedural City installation. The timeline starting with the commissioning of the work (Bullet 1) until its installation at the Ars Electronica Centre (Bullet 2) was heavily constrained by the CityEngine development cycles with bi-annual releases indicated by the bullets labeled with an 'X'. As all researchers, developers and artists were involved in both projects, works on the installation were very limited during the time before the releases, which had absolute priority over any other activities. While these constraints resulted in a rather strict separation between art and science, there was still a close interaction between the two projects, and repeated effective development cycles of a small team allowed for rapid evolution on both sides. Figure 4 shows the main screen of the Procedural City installation at the Art Electronica Centre in 2009.

Figure 4: The main projector screen of Procedural City, at Ars Electronica in 2009

Conclusion

This paper highlighted timelines of three hybrid artworks: one performance-oriented and two interactive installations. As the presented works show, the workflows and interactions can be very different from case to case. Nevertheless, overall they can be split into the following three phases: incubation, iteration and consolidation.

The *incubation phase* provides a fertile ground that allows hybrid art-science works to be conceived and to grow. This phase may occur unexpectedly as in the case of Scheinwerfer or the Digital Marionette, or through a strong external impulse, such as the commissioning of the Procedural City. A common precondition, however, seems to be the degree of openness of involved stakeholders to allow unconventional, hybrid approaches that might not constitute major goals in the first place.

The *iteration phase* is the period in the workflow where strong interactions between origins and the emerging hybrid work happen. The involved fields, projects or teams shape the exact structure of the iteration. Iterations may work in nonbinding and irregular intervals, as was the case during the development of Soundium, or in a rather strict fashion that is bound to overarching business constraints in the case of the Procedural City.

Thirdly, the *consolidation phase* collects gained knowledge and output

and returns them to the origins that enabled the work. In addition, it reflects on the emerged work so its achievements can be used for the incubation of upcoming work, as it was shown by the re-use of Soundium for the development of the Digital Marionette.

With these considerations, the presented workflows and all of the interactions within, an additional question remains open: Where is the transition from a "pure" to a "hybrid" work? Where does science start to mix with engineering to mix with art? While we cannot not give a general answer, in the specific case of digital art, we know that it typically includes software development. We wish to conclude this paper with Donald Knuth's conclusion of his 1974 Turing Award lecture:

> We have seen that computer programming is an art, because it applies accumulated knowledge to the world, because it requires skill and ingenuity, and especially because it produces objects of beauty. A programmer who subconsciously views himself as an artist will enjoy what he does and will do it better. Therefore we can be glad that people who lecture at computer conferences speak about the *state of the Art*. (Knuth, 2007)

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