Interactive digital art

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ABSTRACT
In this paper, we present DNArt in general, our work in DNArt’s lab including a detailed presentation of the first artwork that has come out of our lab in September 2011, entitled “ENCOUNTERS #3”, and the use of DNArt for digital art conservation. Research into the use of DNArt for digital art conservation is currently conducted by the Netherlands Institute for Media art (Nederlands Instituut voor Mediakunst, NIMk). The paper describes this research and presents preliminary results. At the end, it will offer the reader the possibility to participate in DNArt’s development.

Keywords
DNArt, living system, new media art concept, digital art conservation

INTRODUCTION
DNArt is defined as a work of art that by concept will grow and change in time. Where traditionally a work of art is an object, DNArt will behave much more as a subject that interacts with and learns from its surroundings.

Characteristics of DNArt
DNArt presents a model for computer-based works of art. DNArt’s mission is the creation of art that:
• is capable to maintain and develop itself;
• can easily interconnect with people, social networks, and similar works of art across the globe;
• can learn from and by its interactions;
• will have relations with people, institutions, and businesses;
• behaves like a living system;
• will become legally independent (as a foundation) and will be able to manage its own resources.

In short, art that will behave much more as a subject rather than an object.

Development of DNArt
DNArt was initiated by Bill Spinhoven van Oosten and in order to let DNArt reach out more easily to potential co-developers, a cooperation with the Pervasive Systems research group at the University of Twente was initiated in November 2010. As a result of this cooperation DNArt uses the Smart eXperience (SmartXp) research lab1 of the Faculty of Electrical Engineering, Mathematics and Computer Science at the University. SmartXp is a living lab, which aims to provide an interactive environment for researchers, user groups, artists, and social scientists to work together on the creation and evaluation of the next generation of ubiquitous systems and their impacts. Some parts of the development of DNArt have been integrated as projects in the curriculum of the University in the form of student assignments. Within these assignments students will look at, for example, creation of real-time 3D reconstruction of activities captured by Kinect motion sensing input devices as well as creation of interactive digital art.

In the following, we present one of our interactive digital art works created using DNArt.

ENCOUNTERS #3
The digital art work entitled “Encounters #3” is the third work in the “Encounter” series, in which the viewers can see themselves on a screen on the wall in the exhibition space. The screen shows the footage of a video camera that is hanging against the ceiling looking down at the exhibition space. The live image is delayed by five seconds and virtual visitors are added to the image. As a result the viewers can see themselves together with virtual visitors within the exhibition space. The key idea from the visitors’ view is that by entering the space, one starts interacting with these virtual visitors.

Technique
The virtual visitors are selected from a list of prerecorded movies. The selection is done in a way that assures that the spots at which the virtual visitors appear are not at the same time occupied by a live visitor. The five-second delay gives the system some pre-knowledge about the behaviour and position of the visitors. The list of movies to choose from is categorized according to themes giving the

1 http://smartxp.ewi.utwente.nl
installation the option to behave differently on different occasions or at different events. For the creation of the movies we asked for public participation and all of the virtual visitors were created with the assistance of people present at the exhibition space.

**Software**

In order to make the process of the creation of the movies as easy as possible, a special program was created, see Figures 1 and 2. The ease of the program gave us the possibility to focus on the interaction with the actors.

The length of each recorded movie is only 10 seconds and this practically removes any hurdle to participate as an actor for the movies.

The fact that the final result can be viewed immediately before the next recording gives the whole process of recording a feeling of interactivity. Feedback can be used directly for the next recording. The program also generates a masked movie clip with data about the position of the virtual visitor. The clips contain additional data about their length, resolution and some other items, but one property we would like to mention in particular has to do with the ability of clips to loop at some point. This loop (which can be as short as a single frame) is typically used to make clips longer.

The following example scenario illustrates this process.
A virtual visitor enters the room and stands still.
The virtual visitor’s movie enters a loop of one single frame effectively freezing the movie and making the virtual visitor stand still.
The virtual visitor maintains this position until some real visitor comes too close (or the maximum allowed duration of the loop has passed).
The virtual visitor leaves the room.
The real person moves to the place where the virtual visitor was before.

Because of an introduced delay of five seconds, we know where our real visitors are going to be in five seconds, so it is relatively easy to check if a visitor will get too close.

Presentation Framework
The prerecorded movies combined with the live camera input are used by a second program whose output is shown on the screen in the exhibition space, see Figure 3. They are used as textures on the floors of a three-dimensional (3D) model. The model itself can be created by any 3D modelling program as long as it is saved as a platform-independent 3D Data Interchange Technology (FBX) object [2]. For our program we have chosen Microsoft’s XNA 4.0 [12] as the 3D framework. The only reason for this choice was the fact that our lead programmer had some experience with this framework.

The 3D framework also allows us to use the camera as a tool for expressions: just like in a regular movie we can move the camera to emphasize certain parts of the image. Furthermore, by using a 3D framework we can give visitors from separate geographical locations the illusion of being within the same building or object. This illusion can be created by using the combined movies as textures for floors in a 3D model.

The program has no regular graphical user control because the output of the program is shown on the presentation screen, thus that would be unpractical. Instead of a graphical user interface (GUI) the program can be controlled through Open Sound Control (OSC) [13]; this allows us to view and set debug parameters and variables at a remote location. This interface can also be used by other remote programs to interact with the presentation.

Living System
Since “Encounters #3” is a living work of art, it wants to learn and explore its wealth of possibilities. It does so by actively seeking participation from the audience and all other people and institutions it interacts with. This participation can be on a technical level, like for instance helping to make “Encounters #3” detect the visitors and their actions better, or on an more artistic level, like exploring the cinematographical possibilities of this new world.

The “Encounter” series explores the concept of interaction with the viewer and as such forms a phase in a development towards something like interactive cinema.

Figure 4 shows the first work in this series, which is titled “Encounters #1”. The current work, “Encounters #3” can connect two geographical separated locations in such a way that visitors are able to interact with each other.

DNART’S DNA: ENABLING TECHNOLOGIES
DNArt’s software consists of virtual machines that can communicate with sensors and actuators as well as with each other by standardized methods. These methods include Open Sound Control [13] and IEEE 1722.1 [9] and have been chosen for their use of time stamps. This way, actions can be synchronized and sensor data can be integrated more easily.

Sensor and Actuator Networks
Use of sensor and actuator networks is a well-known concept in the field of digital media art, in which creation of dynamic installations is the main focus. The concept behind these installations is rooted in creating a dynamic experience for the visitors by reacting to their presence and/or interactions through sound and gesture. While sensors and actuators have been used in the process of creating digital media art, use of sensor and actuator
networks instead of individual sensors and actuators has received little or no attention. To this end, sensor and actuator networks can offer fine-grained spatial and temporal situation awareness on art works which enables in-situ monitoring of environmental conditions around the art installation and analysis of their impacts on its presentation and performance.

The situation awareness offered by the sensor and actuator networks not only includes monitoring and analysis of the art installation itself but also offers a new possibility to observe the visitors and their interaction with the installation in a privacy-aware manner. To this end, the visitors and not the art work are object of observation. In contrary to the common concept of filming the visitors, sensor and actuator networks can offer an unobtrusive manner of online detection of visitors’ activities through online feature extraction and pattern recognition in which activities rather than each individual form the focal points.

Open Sound Control
The method we currently use most for communication between virtual machines, sensors, and actuators, is Open Sound Control (OSC). This is an open, transport-independent, message-based protocol developed for communication among computers and other multimedia devices [13]. OSC uses a network port for its communication. We combine the use of OSC with a zero configuration service [16] to publish information like the port address to other devices and services.

Zero configuration networking allows devices such as computers and sensors to connect to a network automatically without the need to configure each computer’s network settings manually. There are several ways to implement zero configuration and we have used Apple’s Bonjour.

Audio/Video Bridging
Although OSC is very useful for most of our needs it lacks standardization for dealing with queries. This has led to many ad hoc solutions, one for each out of many implementations. Our approach is to follow and combine the methods proposed by Koftinoff [11] and the methods used by Jamoma2 [14] as closely as possible. Although AVDECC was chosen over AVBC as the way to go for Audio/Video Bridging (AVB), many of the proposed implementations, like the OSC<>JSON conversion, are suitable for DNArt. Another problem with OSC is the fact that it does not lend itself well for streaming large amounts of data. This is why we intend to use the following IEEE 802.1 Audio/Video Bridging protocols and standards in the near future:

- IEEE 802.1 AS — Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks (LANs), a precision time synchronization protocol [5];

2 http://jamoma.org/

Figure 4. “Encounters #1”
IEEE 802.1 BA — Audio/Video Bridging (AVB)

IEEE 802.1 Qat — Stream Reservation Protocol (SRP); an end-to-end bandwidth reservation protocol within a bridged LAN [7]; and

IEEE 802.1 Qav — Forwarding and Queuing for Time-Sensitive Streams: A/V traffic scheduling enhancements for mainstream Ethernet and other network switches [8].

Utilizing AVB, the transmission of audio and video streams can be synchronized within a microsecond, with low delay, and minimal data loss caused by network congestion. The range of delay and amount of lost data depends on the particular network technologies (e.g., Ethernet, wireless) on the stream path. For example, in the case of a full-duplex switched 100 Mb/s Ethernet network that implements AVB, any two endpoints that establish a stream reservation have less than 2 milliseconds (ms) packet delivery delay, less than 1 microsecond (μs) synchronization error, zero long-term wander, low jitter and zero data loss due to congestion.

There are also two draft standards that rely on IEEE 802.1 AVB to provide professional quality Audio/Video:

IEEE 1722 — Layer 2 Transport Protocol for Time-Sensitive Streams, which allows easier porting of applications, currently IEEE 1394 (FireWire®) to AVB [9]; and

IEEE 1733 — which extends RTCP for RTP streaming over AVB-supported networks [10].

There are several methods proposed within the IEEE 1722.1 standard as the way in which an Ethernet AVB controller could discover the capabilities of devices on an Ethernet AVB network:

ZeroConf (Apple’s Bonjour);

IEEE 1722.1 AVDECC;

IEEE 1722.1 AVBWEB; and

IEEE 1722.1 microsupport, a minimal protocol for simple and fast connection management and control of AVB devices.

The Use of Timetags and Timing Mechanisms in DNArt
Timing is a precarious topic in relation to virtual computers [15]. However, we need precise timing when we combine data from several sensors or creating simultaneous events in different nodes on a network. Because of this, special care has been given, with the choice of our communication protocols, to the standard implementation of so-called timetags. Both AVBDECC and OSC have the ability to add information about timing. They also contain methods to synchronize clocks (for OSC there are several proposals how to do this). AVB was specially developed to solve the timing and synchronization issues inherent in AV over Ethernet. So it will be no surprise that one of its most important tasks is to provide precise timing.

Generally one AVB device supplies a clock value and all other devices in the network follow the clock. This method is specified in a separate IEEE standard, 802.1AS [5]. The device supplying the clock is called the Grand Master Clock and can be automatically chosen. This facilitates auto configuration. If needed the clocking device can be synchronized to other system clocks. Timetags can also be used to ensure commands will be executed simultaneously at some time in the future (by giving them a future timetag). This concept can also be used for bundling a sequence of commands as a method to significantly reduce network traffic in comparison to sending them one by one. To solve the problem of varying speed with regard to program execution on different virtual computers, the concept of a master clock was applied here as well. Often the refresh rate of a sensor (i.e., camera) was used when no other master clock was connected to the system.

COMPUTER ART CONSERVATION
DNArt is a living work of art; its structure was specifically chosen to be long lasting. These robust features of DNArt’s DNA seems to provide an ideal model for the conservation of media art.

Figure 5. “I/Eye” (1993)
DNArt will also provide additional tools for conservators to gather information about user interaction and monitor the functionality of the work.

**Virtualization as a Preservation Strategy for Digital Art**
To enable easy and meaningful interaction with digital art works on the one hand, and correct conservation of the digital arts on the other hand, one needs to find proper methods and tools. To this end, a fundamental question to be answered is whether virtualization is an adequate method to enable an audience to experience computer-based installations in times when the hardware and software formats used in the artwork have become obsolete and whether it offers an option for their preservation for the future.

**Case Study**
In order to explore this we conducted an empirical study into the installation “I/Eye” (1993) by Bill Spinhoven van Oosten using the structure DNArt. The results of this study were positive. During the symposium “To transfer or to transform” (on the 24th of February 2011 at NIMk in Amsterdam) an emulated and virtualized clone of “I/Eye” was presented side-by-side with the original “I/Eye”. Although the original (see Figure 5) was running on a computer from 1993 that used a completely different processor architecture, no noticeable difference could be detected by a professional audience.

The website http://conservation.DNArt.me provides some preliminary documentation on this case study conducted for the NIMk. The proceedings of this research are extensively discussed by Hölling in [3] and [4].

**CONCLUSIONS**
The use of virtual computers as used by DNArt has proven to be very useful for media art conservation in general.

The start of our first implementation of DNArt has generated a lot of support, publicity and interest into DNArt.

We actively seek further cooperation with all interested parties. We have ported our software to Github Social Coding3, though we have to keep the software in a closed repository for now. This is due to uncertainty about the licenses of software components. Nevertheless, anyone interested in co-developing parts of DNArt is very welcome to contact us.

**Lessons Learned**
We encountered a number of limitations in the use of the Kinect; most were due to the fact that the version of the Software Developer’s Kit (SDK) we are using is still a beta version. Through discussions on forums we found out that most issues we encountered will be resolved before the official release of the SDK. These issues are: no gain and brightness control for the colour camera, limited-depth data (the maximum depth value is 4 meter) and lack of support for virtual computers.

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3 http://github.com

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Kinect is a registered trademark of Microsoft Corporation.

Bonjour is a registered trademark of Apple Inc.

**REFERENCES**


