ABSTRACT

What determines the life span of a complex autonomous system? We expect that objects of this kind, which some view as testaments of contemporary culture, will survive into the future. After a few decades of experimentation with data processing and control system engineering, experts in media art conservation have gradually identified methods that promise to overcome these obstacles. Museums and art galleries developed sophisticated procedures to emulate, record or digitize collected objects. The procedures in question create the basis for allographic—inscription-based—presentations of ephemeral media artworks. As a matter of course, the inscription-oriented procedures favor specific qualities of the original item, such as computability, logical coherence or compliance with current documentation practice, such as filmmaking or 3D scanning. We discuss below the characteristics and potential of these qualities in reference to Senster, a specific example of a hardware-based autonomous system.

RE:SENSTER

Senster merges the concept of kinetic sculpture with the principles of cybernetics (Fig. 1). The large-scale work, created by London-based artist Edward Ihnatowicz, c. 1970, is a classic early example of media art. However, until recently the piece was known exclusively via three minutes of footage and a few archival photos [1]. The work was initially installed at its commissioner’s newly opened exhibition hall, the Philips Evoluon, in Eindhoven. Despite its significance, Senster was dismantled in the mid-1970s as the company decided to cease its involvement in this costly and demanding endeavor. Taken out of public view, the piece retreated to the cultural margins, along with many other icons of a short-lived fascination with cybernetics.

In 2009, author Olszewska proposed the reactivation project described here, called Re:Senster, as fellows of the newly established Faculty of Humanities at AGH University of Science and Technology in Kraków considered art-related projects appropriate to a technological academy incorporating humanities in its curriculum. Re-creation of the historic autonomous system seemed to converge with the idea of networking academics, designers and engineers as a multidisciplinary team within the academy.

From its inception, the project’s aim was to re-create the experience evoked by an intertwining of the piece’s form and movement. The initial plan was to replicate Senster based
on archival records and 3D scans the team made after we located the original in Colijnsplaat (Zeeland, the Netherlands) (Fig. 2). However, detailed inspection of the piece in 2017 showed that substantial parts of the skeleton and solid elements of the mechanical system were stable enough to be revivified. Despite the absence of control units, damage to hydraulic pipes, erosion of oil filters and disappearance of the “head” except for its mounting, the overall structure was still intact. The quality of the steel and the construction have made the skeleton resistant to deformation and strain. It is a mechanical system composed of solid hydraulic pistons and heavy-duty servo valves, designed according to aircraft industry and military standards. The research team therefore decided to keep the remaining original parts of the piece rather than build a replica from scratch.

In the narrow context of the project’s history, the choice of a restoration strategy for Senster relied on assessing the state of the preservation of the sculpture. In the broader context, there is yet another factor to note. It was possible to trade radical preservation for functional restoration due to the project’s siting within an institution. The university estimated the potential risk of intervention as acceptable. This estimation possibly reflected the stakeholder’s professional experience and performance-oriented working practices [2]. Hence, the project described here did not follow the model of retirement, as in the case of Jean Tinguely’s Sculpture métamécanique automobile or Ihnatowicz’s 2013 SAM replication [3,4]. Instead of displaying the immobilized original next to a functional replica, we combined and reactivated the remains of Senster with replicated elements (Figs 3–5).

In terms of contemporary restoration practice, the restoration process reported here corresponds with reactivation strategies described by Paul Brobbel and Simon Rees in reference to the restoration of Len Lye’s Loop (1964) and Trilogy (1977) [5]. In each case, the priority became the approximation of the piece’s function. Control systems were upgraded to modern programmable logic controller (PLC) units. Both Senster’s and Loop’s re-created performance relies on analysis of the historical footage rather than on the study of control switches or software.

What characterizes the Re:Senster strategy in the context of the material obsolescence treatment is that we treated the traces of wear visible in the structure of Ihnatowicz’s sculpture as aesthetically significant. Hence, we retained scratches, traces of rust and old layers of paint covering the truss structure and secured them using an anticorrosion coating. Our decision to keep some parts of the original mechanics (Fig. 4) has also influenced the installation’s performance. Due to minor leakages in the restored pistons and servo valves, the movements may become less precise, regulated by the control offset. In order to secure obsolete parts, the program does not allow the mechanical system to run at full speed.

Interventions into the skeleton were minor. We repaired some parts of the mechanical system, including three pistons and four out of six servo valves. We documented and stored replaced elements. We completed linear position potentiometers, Doppler sensors and the characteristic horn antennas according to the types used in the original setup. We substituted other electronic elements with a modern PLC and microcontrollers (Figs 4–6) [6].

As work progressed, we formulated the maintenance regime for the piece by testing any initial assumptions on the question of which parts might have been designed for their artistic merit and which were engineered according to their function. During the months spent with Senster, we realized that these two complementary design principles would dictate a different approach and degree of complexity to the restoration tasks. It was much more challenging to convey the spirit of the artistic elements, while the restoration of components such as pistons or filters (verified only gradually during the project due to previously acquired knowledge of tested applications of engineering procedures) has proven
Fig. 3. Senster at AGH, September 2018. (© WH AGH. Photo: Adam Żądło.)

Fig. 4. Interventions made during the restoration process; repaired elements (left) and replaced elements (right). (© WH AGH. Photo: Adam Żądło. Design: A.O.)

Fig. 5. (left) The original “head,” c. 1970. (© James Gardner Archive, University of Brighton Design Archives.) (right) Its replica, 2018. (© WH AGH. Photo: Adam Żądło.)
much quicker and straightforward. Therefore, we based a restoration methodology on the distinction between those calculated and freely designed components. The sections below explain the procedure's development.

**REACTIVATION PHASE ONE: RESTORATION OF THE PHYSICAL COMPONENTS**

Restoration of the physical components began with the piece's transportation to Kraków in April 2017 and continued until October 2018. We treated the skeleton and the mechanical system and then reconstructed the head. Work on the sensors and wiring concluded the process.

Initially, we viewed a material part of the piece as if it had been a work of sculpture rather than of calculation and programming. Similarly, we thought that only the engineering principia rather than the artistic values were relevant to the control and mechanical systems. Our views on the division between engineered and freely designed elements changed gradually during the project. Mechanical engineering standards proved to be key to the restoration of the skeleton. Grzegorz Biliński and Marek Chołoniewski first argued in favor of applying these standards as we considered ways to disassemble the sculpture during the feasibility stage. During subsequent phases of the project, the rules of applied mechanics provided the principal point of reference for the mechanical system designers. Jerzy Stojek, Jarosław Mamcarczyk, Kamil Sikora and Jerzy Hawryluk reverse-calculated the parameters of missing actuators and servo valves and the hydraulic pump.

As the construction of the skeleton and mechanical system followed an engineering blueprint, it was easy to predict interventions into the original structure. For the same reason, we were able to re-create missing or destroyed parts of the sensor system. Familiarity with technical specifications of the original parts ensured that the replacements would conform in size and proportion with the originals. For example, we were able to correctly reconstruct the shape of the missing horn-like antennas attached to the head because their form was derived from the waveguide resonance frequency of the original Gunn diodes.

The degree of complexity in the restoration of freely designed components became apparent during re-creation of the head. Although the mechanical sections of the skeleton were easy to reconfigure, for those parts where the artist departed from the clear-cut truss-like structure in favor of soft molded shapes filled with micro pistons, rebuilding was more challenging. The pair of vertebrae-like forms moving independently in XY directions was installed on top of the arm. They supported a cluster of microphones designed to detect the presence of viewers. This original part was missing in 2017. Largely because of this, the reconstruction of the head by Jacek Żakowski proved to be much more challenging than the work on the rest of the skeleton. We 3D-printed three mock-ups of the head before we could agree on its final shape. We formed the core in the final stages of the project, after a trial period that allowed accurate estimation and capture of the proportions fitting the movement patterns, as well as the detail and configuration of its mounting (Fig. 7).

Our conclusions regarding the varying degree of complexity in approaching the restoration of elements of a differing nature are in line with the precepts of Nelson Goodman's notation theory. They confirm his famous reflections on the differences between systems organized as is a musical score, based on notations, and those systems such as painting, which he describes as dense, continuous and nonreducible to a score-like framework of principles. Goodman asked why people consider a painted image to validly exist only in a single, original version, with every other version remaining only a copy (or a forgery), while with a musical piece, each performance can be treated as preserving its authenticity [7]. As we worked with Senster, we realized that the parts based on the engineered calculations are comparable to the "score"-based...
pieces. They can be reconstructed without significant loss of their authenticity. According to the notation theory, every new version would be equal, like a musical performance based on the orchestral score. However, reconstruction of the artistic elements would be more problematic. Since there is no score underlying these elements, they manifest in dense, irreducible and nonreplicable structures similar to those of a painting. During the restoration we learned that both the continuous and script-based components are embedded throughout: starting from the skeleton through the mechanical system, sensors and circuits to the control program.

**REACTIVATION PHASE TWO: CONTROL SYSTEM DESIGN**

The second phase of restoration focused on the restoration of movement and interaction functions (June–October 2018). In this context, we assessed the efforts in the original control program implementation to be less significant compared to the goal of performative feature maintenance. Therefore, initially our work with movement functions was informed by reference to the short footage showing public interplay with Senster at Evoluon.

This phase was particularly demanding due to the disjointed nature of the archival resources. Documentation on Senster is incomplete, particularly in relation to the analog electronic components. As a result, there were two options for the straightforward re-creation of the performance functions. We could have used a version of the original program compiled by Peter Lundahl and Ihnatowicz in December 1970 [8]. However, this scenario, relying on an archived version of assembly code, was potentially less feasible. Therefore, the project team—author Długosz, assisted by Rafał Bieszczad and Piotr Madej—realized that in designing the new control system, in order to correctly implement the code, it was necessary to replicate all the control and signal processing units composing the original system: a missing predictor that smoothed the movements, an acceleration splitter that synchronized the speed of the movement and the computer that processed the subroutines. Physical reconstruction of these parts would make Senster’s electronics evocative of its technological history. The replication of such a control system surpassed the project’s scope and was deferred for future consideration.

The team decided that the original code would be sacrificed for the benefit of achieving the original performance functions. Consequently, the starting point was a formal analysis of the movement. This involved collating fragmentary descriptions of Senster’s behavior with the visual sources. It was essential to bear in mind that the piece could perform two modes of movement: tracking and retreat. Ihnatowicz himself declared that the tracking reaction of the system would not be proportional to the input signals and “sudden movements or loud noise would make it shy away” [9]. Curator James Gardner confirmed this in his 1988 report, acknowledging that the tracking would have been performed up to the point when noise or movements of the viewers became so intense that it would overload the control system. The curator noted: “As instructions were being shouted at Senster non-stop the computer was stretched to its limits, and so when the public got too excited, we programmed it to hold its head in the air—as if to say ’Enough‘” [10]. Thus, Senster’s alarm mode was a safety valve for the relatively slow data processing system, and the noted “shyness” of Senster’s behavior was a creative response to the limitations of contemporary technology rather than reflecting any dramatic intention. By the same token, the artist probably did not decide what level of noise would be sufficiently high to alarm the system. Once again, just as in the case of the restoration of the physical skeleton, enumeration of engineering-calculated solutions provided a systematic framework for the rest of the work.

These conclusions are verified by an analysis of short foot-
The process described here was limited to a single case study. One can find comparative material for evaluation of the proposed strategy in studies on kinetic and media art restoration. We can only hope that our conclusions contribute to the advancement of maintenance methods, with reference to the issues of sequencing works on the partially preserved structures. We also hope that readers will find our experience of interest and accept it as a valid contribution to the ongoing debate on the principal merits of autonomous systems.
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References and Notes
1 For further details concerning the history of the piece, the reactivation project’s origins and members of the team, please see this article’s online supplementary material.
6 Documentation of the project is preserved in the AGH Faculty of Humanities archives. Reports on the current state of mechanics, control system and skeleton are being prepared for publication at www.senster.agh.edu.pl/reports.

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