

# Senster

## Reactivation of a Cybernetic Sculpture

ANNA OLSZEWSKA AND MAREK DŁUGOSZ

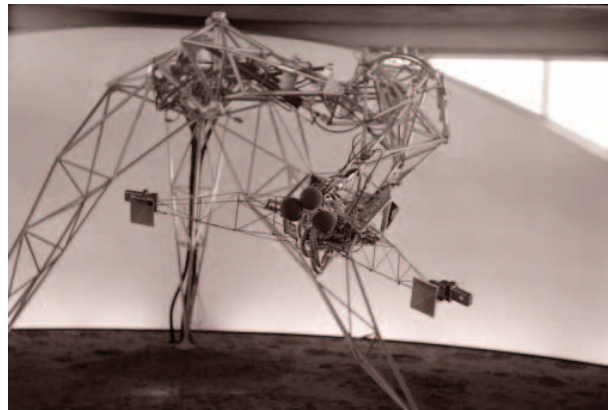
## ABSTRACT

The turbulent history of *Senster*, a large cybernetic sculpture designed by Edward Ihnatowicz c. 1970, is divided in two periods: its creation and prematurely canceled display (1968–1974) and its recent reactivation (2017–2018). This article presents a comprehensive narrative of *Senster's* reactivation. It explains how the formulation of the conservation philosophy and methodology employed in the process was instrumental in delivering the solutions. Based on these observations, the authors propose a detailed strategy for the maintenance and reactivation of interactive embodied systems.

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



**Fig. 1.** Edward Ihnatowicz, *Senster*, 2.5 m (tripod) × 3 m (arm), 1970, Evoluon Eindhoven. (© James Gardner Archive, University of Brighton Design Archives)

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 multi-disciplinary 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

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**Fig. 2.** Screenshot of the 3D scan, Colijnsplaat, 2014. (© WH AGH. Image: Marek Baścik.)

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 revived. 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 méta-mécanique 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 Lyé’s *Loop* (1964) and *Trilogy* (1977) [5]. In each case, the priority became the approximation of the piece’s function. Control systems were upgraded

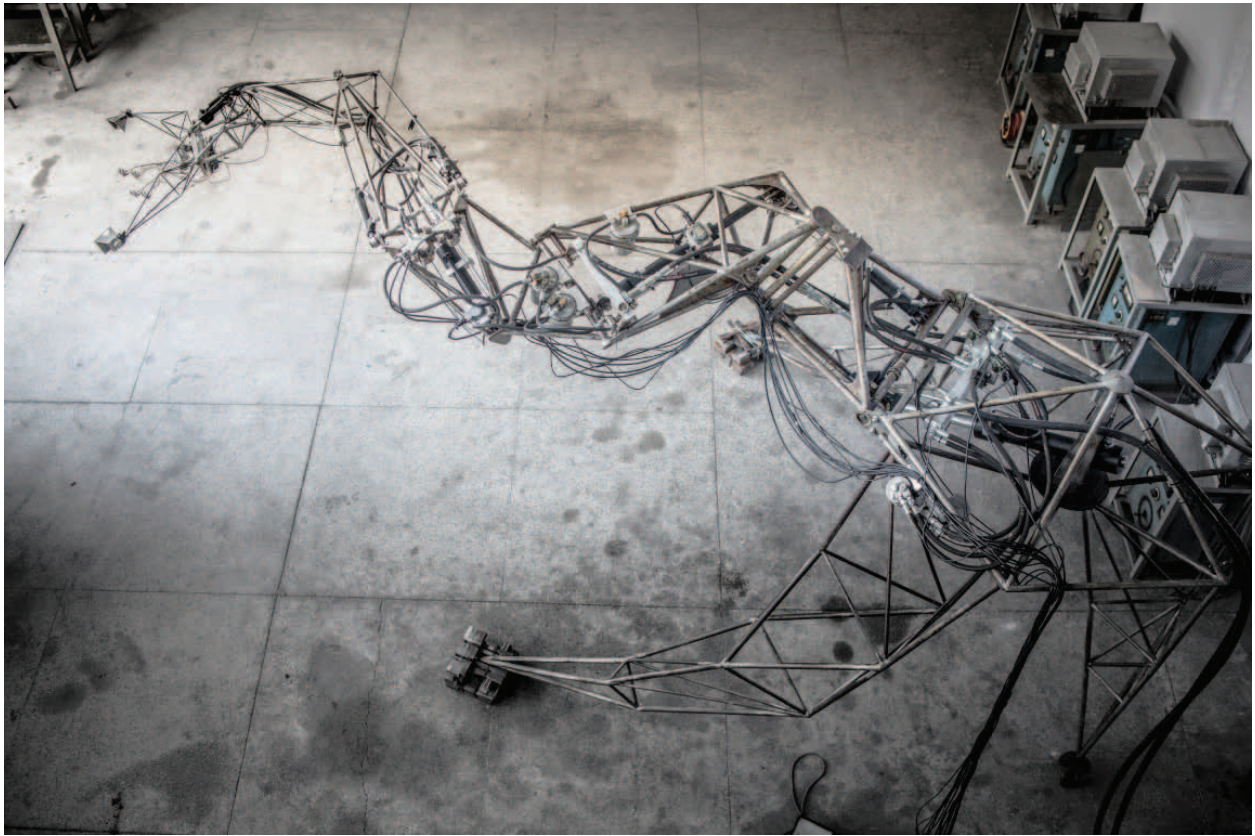
to modern programmable logic controller (PLC) units. Both *Senster*’s and *Loop*’s re-created performance relies on analysis of the historical footage rather than on the study of control switches or software.

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.

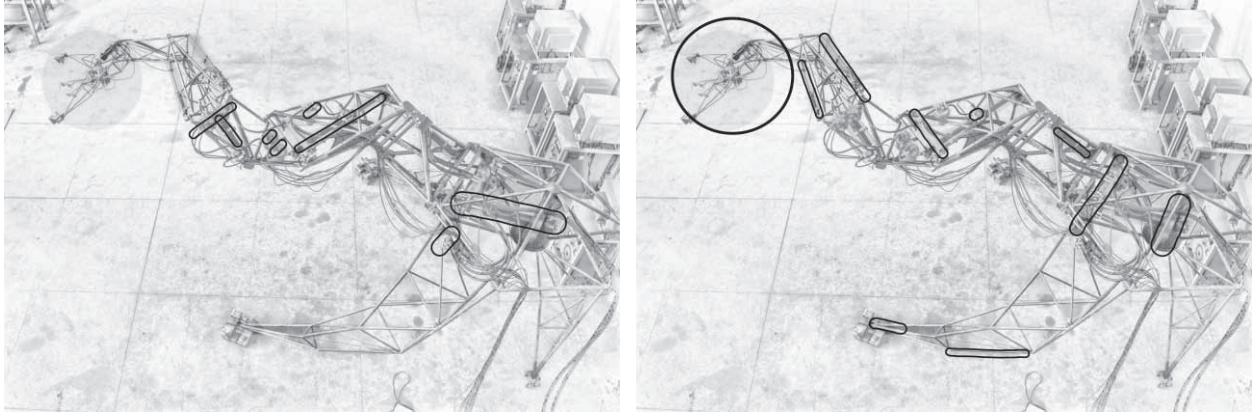
Interventions into the skeleton were minor. We repaired some parts of the mechanical system, including three pistons and four out of six servo valves. We documented and stored replaced elements. We completed linear position potentiometers, Doppler sensors and the characteristic horn antennas according 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

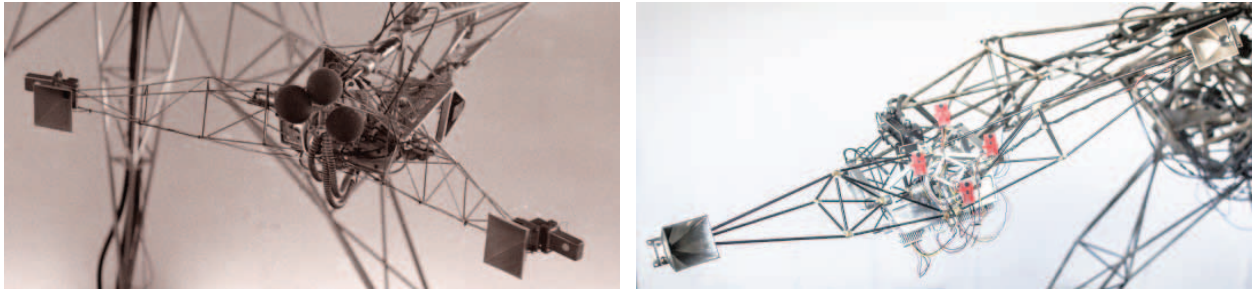




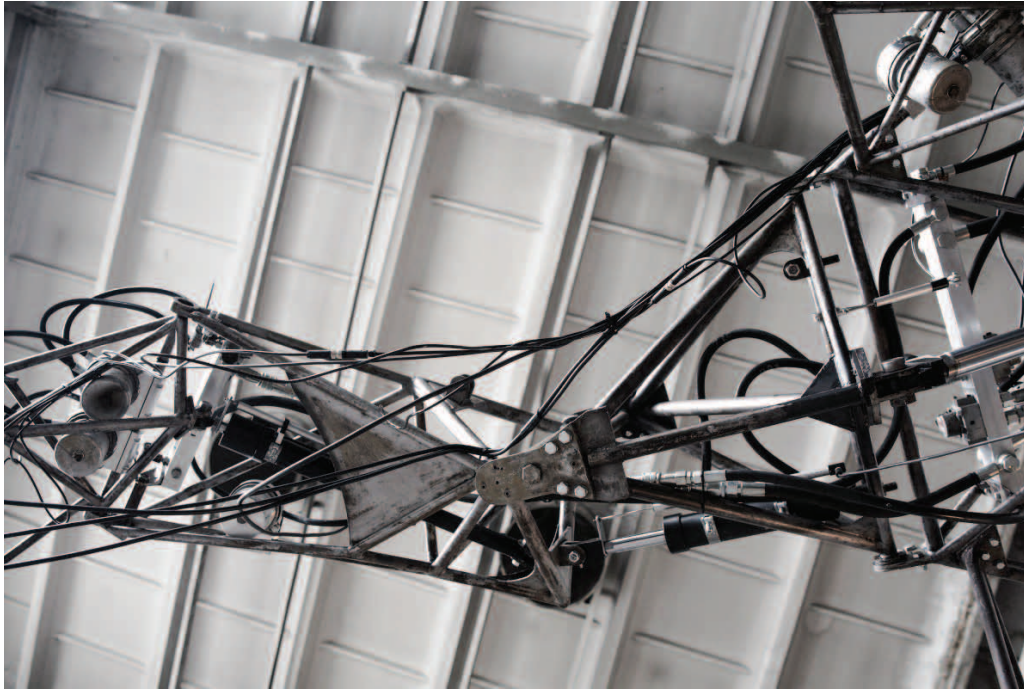
**Fig. 3.** *Senster* at AGH, September 2018. (© WH AGH. Photo: Adam Żądło.)



**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.)



**Fig. 6.** *Senster*, detail of the arm, 2018. © WH AGH. Photo: Adam Źądło.)

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 Mamarczyk, Kamil Sikora and Jerzy Hawryluk reverse-calculated the parameters of missing actuators and servo valves and the hydraulic pump.

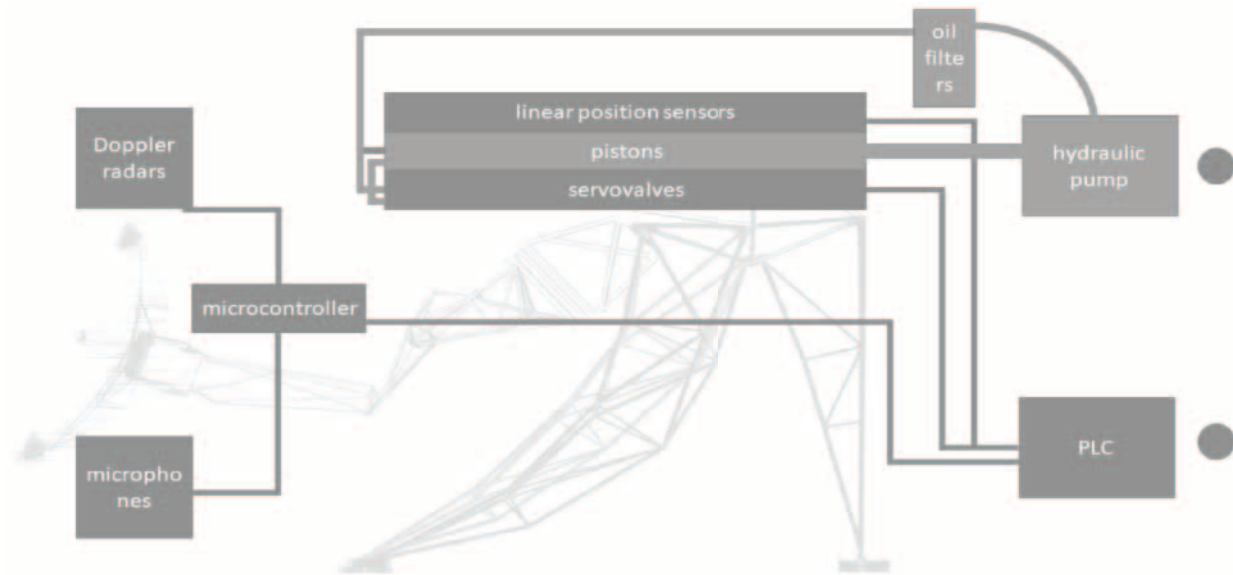
As the construction of the skeleton and mechanical system followed an engineering blueprint, it was easy to predict interventions into the original structure. For the same reason, we were able to re-create missing or destroyed parts of the sensor system. Familiarity with technical specifications of the 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 Źakowski 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





**Fig. 7.** *Senster*, installation block diagram: electronics (dark), hydraulics (light). (© Anna Olszewska)

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 Bieszcza 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-

age showing *Senster* interacting with the public on three occasions [11]. The film, when watched in slow motion, exposes the performance patterns. It shows the arm in constant motion, alternating between vertical and horizontal. Whenever a human approached, the preprogrammed path of movement changed. Initially the arm scanned a wide area in front of the sculpture and, subsequently, this was limited to just a portion of the range. The artist's decision as to how to structure the sequence of movements probably resulted from the location of the highest audio signal amplitude detected during each previous step. Considering the scale of the sculpture (c. 3-m-long arm), the maximum range of the movement (c. 120°) and the average space occupied by a human spectator, this simple method could have led to moving *Senster's* head in front of the viewer within a reasonably short time.

Based on the outcomes of the performance analysis and the material structure of the piece, we have written a basic program that could produce a highly simplified interactive mode. This re-creates the original performance by linking it to the rudiments of the information theory. We based the programming on the assumption that the interactive sequence observed in the documentary film was characterized by some degree of redundancy. It should therefore be performed in a reasonably short, but not the shortest possible, sequence of movements. The other assumption concerned the external signals, which were treated as a series of stochastic events that could engage a value 0 or 1 for every swipe of the arm.

We designed the whole sequence as follows: During the first stage, the movement covers the whole 120° range in front of the sculpture. Simultaneously the vertical pair of microphones registers the level of sound amplitude. In this way, an array of data corresponding to the positions of the arm is created. This is then quantified into several packets imitating the data samples, reflecting the slow processing capacity of the original setup. The comparison of the sampled data determines the direction of the next movement. With each subsequent swipe, the range of movement is reduced by half until the head stops. If the predominant source of sound is stable, the head should end up in front of the viewer within three steps.

The second mode was meant to show that *Senster* is primarily a kinetic sculpture. This mode is more interpretative than reconstructive. It was designed based on the assumption that the sinusoid movement pattern is the most common in nature. For this reason, Długosz proposed that the sculpture's arm should move softly along a sinusoidal trajectory with low frequency. Whenever an external sound impulse was detected, the trajectory of the arm was modified, and *Senster* would start to track the sound source. The tracking was based on sound direction measurements acquired by implementing the binaural model of soundwave phase measurements. The time difference between a signal detected by the horizontal pair of microphones was recalculated into radians and sent to the main controller.

Once these two complementary modes were showcased,

we found each method to resonate with various display conditions. The basic interactive program works better in crowded and noisy surroundings, while the kinetic version is suitable for a quieter environment with only a few viewers. Interaction patterns remain open to further development, as in the case of reactions to movement enabled by the Gunn transceivers using the Doppler effect (here, we limited the restoration works exclusively to hardware implementation).

## **CONCLUSIONS: SCRIPT TO DESIGN MAINTENANCE STRATEGY**

Regarding the experience gained during works on the *Re:Senster* project, we propose a "script to design" strategy for restoration of interactive pieces. A meticulous assessment of both the engineered and freely designed components forms the core of the feasibility study. This should include all elements of the piece, including its program, sensors, power supply system, mechanics and physical parts. Reconstruction, conservation and repair works should only proceed based on the knowledge gained through such a holistic assessment. The next stages likewise do not have to follow a standard skeleton → mechanics → control system progression. Work with the engineered parts should take precedence over work on the freely designed components. All reverse engineering should therefore be done during this phase, whether it relates to the control system, mechanics or construction engineering. The engineering components are a priority in dictating the scope and sequence of the restoration project and a benchmark for the reconstruction of the freely designed elements. We expect that various configurations of these qualities would characterize a broader class of hardware-based interactive systems.

*Senster's* history shows that, despite the ephemerality of electronic matter, complex cybernetic objects will most probably function in a historical framework as constantly evolving entities. The case confirms that the life span of the complex system depends on qualities such as compliance with the predominant documentation practice, logical coherence and computability. However, these factors do not guarantee optimal preservation of any such piece. On the one hand, a hardware-based physical structure such as the one discussed above cannot be utterly transformed into a stream of data. On the other, the original codes do not seem sufficiently culturally valued yet to become the subject of time-consuming reimplementations that would adapt them into a renewed structure.

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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## Acknowledgments

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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.
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- 5 P. Brobbel and S. Rees, "'Pretty Good for the 21st Century': Restoration, Reconstruction, and Realization of Len Lye's 'Tangible Motion Sculpture,'" in Rivenc and Bek [3] pp. 120–131.
- 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](http://www.senster.agh.edu.pl/reports).
- 7 N. Goodman, *Languages of Art: An Approach to a Theory of Symbols* (Indianapolis: Hackett Publishing, 1968) pp. 115–122, 127–150.
- 8 The *Senster's* code manuscript (8 November 1970): [www.senster.com/ihnatoiwicz/senster/senstercomputer/index.htm](http://www.senster.com/ihnatoiwicz/senster/senstercomputer/index.htm) (accessed 17 October 2018).
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