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SENSTER: REACTIVATION OF A CYBERNETIC SCULPTURE

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Abstract

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

What determines the lifespan of a complex autonomous system? We expect that objects of this kind, which can be viewed as testaments of contemporary culture, will survive into the future. However, observations on the instability of such assemblies suggest that their most distinctive features including interaction, performance or movement, are impossible to maintain due to the ephemerality and unpredictability of electronic and digital matter. Nevertheless, after a few decades of experimenting with data processing and control system engineering, the knowledge of the media ecology gradually points us towards the methods that promise to overcome these obstacles. Objects and scripts are being emulated, recorded and transferred into meaningful datasets. This strategy favors specific qualities of the original item such as computability, logical coherence, or compliance with current documentation practice, such as filmmaking or 3D scanning. The characteristics and potential of these qualities are discussed below in reference to *Senster*, a specific example of a hardware-based autonomous

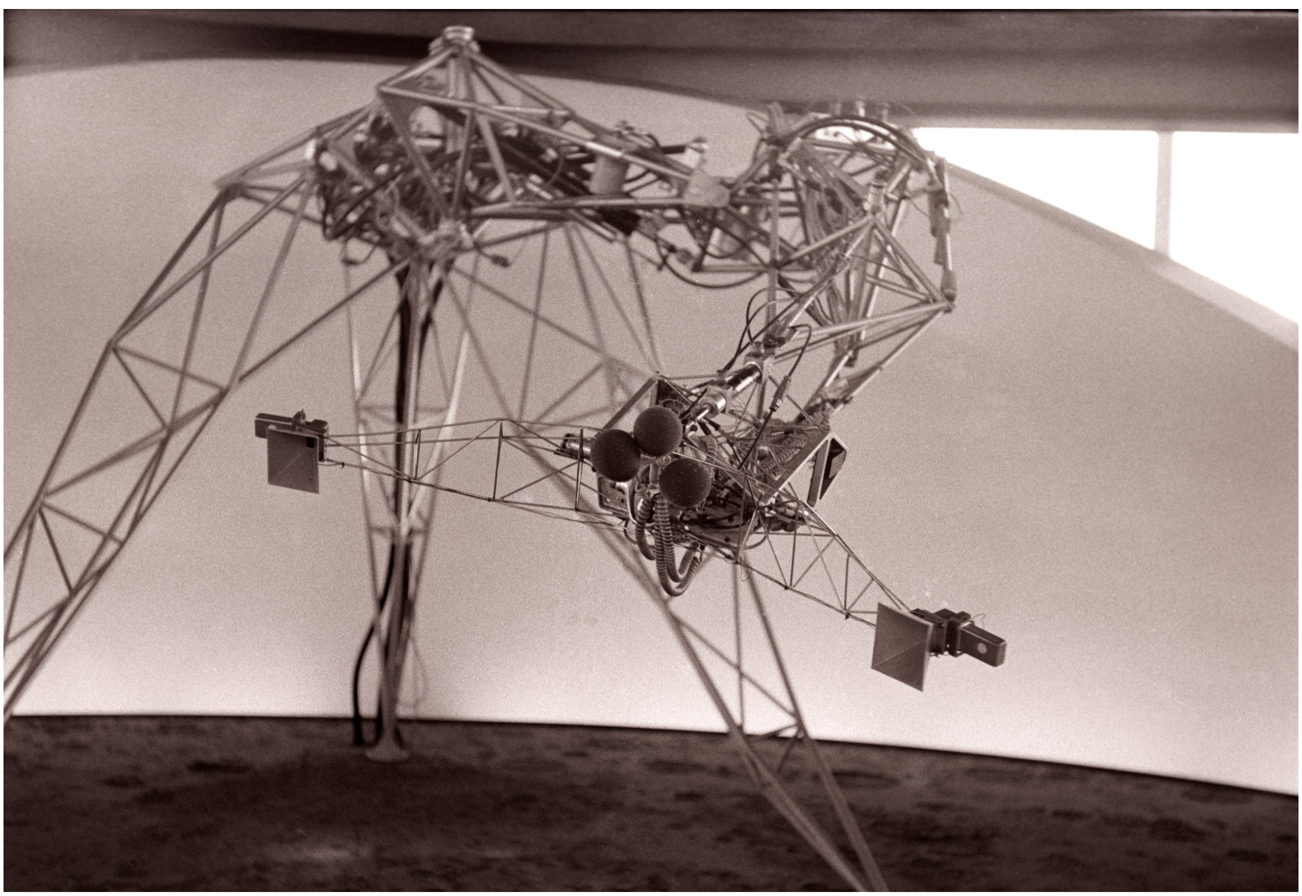

Fig. 1 Edward Ihnatowicz, *Senster*, 1970, Evoluon Eindhoven (© James Gardner Archive, University of Brighton Design Archives)

system.

Re:Senster

The *Senster* merges the concept of kinetic sculpture with the principles of cybernetics. The large scale work created by London based artist Edward Ihnatowicz c. 1970 has been recognized as one of the pioneering and classic examples of media art. However, until recently the piece was known exclusively via three minutes of footage and a few archival photos [1]. Designed by an artist and built with the help of the engineers, the work was initially installed at its commissioner's newly opened exhibition hall – the Philip’s Evoluon in Eindhoven. However, despite its significance, *Senster* was dismatled in the mid-1970s as the company decided to cease its involvement in this costly and demanding endeavor. Taken out of the public view, the piece had retreated to the cultural margins along with many other icons of a short-lived fascination with cybernetics.

The reactivation project described here was proposed by Anna Olszewska in 2009 when fellows of the newly established Faculty of Humanities at AGH in Kraków considered involvement in art-related projects that would reflect the profile of the University as a technological academy which incorporates humanities in its curriculum. Re-creation of the historic autonomous system seemed to converge with the idea of networking academics designers and engineers networking as a multi-disciplinary team within the Academy.

From its inception, the project’s aim was to recreate the experience evoked by intertwining of the piece’s form and movement. However, the method of achieving this goal has reframed during its progress. The initial plan was to replicate the *Senster* based on archival records and 3d scans the team made after we located the original in Colijnsplaat (Zeeland). However, the 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 brought back to life. Despite the absence of control units and damage to hydraulic pipes, the erosion of oil filters, and the ‘head’ missing except for its mounting, the overall structure was still intact. The quality of the steel and the method of construction has 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. Hence, the research team decided to keep the remaining original parts of the piece rather than building a replica from scratch.

In the narrow context of the project’s history, the choice of a restoration strategy for *Senster* relied on the assessment of the state of the preservation of the sculpture. However, in the broader context, there is yet another factor to be noted. Trading radical preservation for functional restoration was possible due to the project being based within an institution. The science and technology university has estimated the potential risk of intervention as low. It is possible that this estimation reflected the stakeholder's professional experience and working practices [2]. Hence, the project described here did not follow either the idea of retirement, as in the case of Jean Tinguely’s *Sculpture meta-mecanique automobile,* or in the case of Ihnatowicz’s 2013 *SAM,* replication [3, 4]. Instead of displaying the immobilized original next to a functional replica, the remains of *Senster* were combined with replicated elements and activated.

Fig. 2. Screenshot of the 3d scan, Colijnsplaat 2014 (© WH AGH, by Marek Baścik)

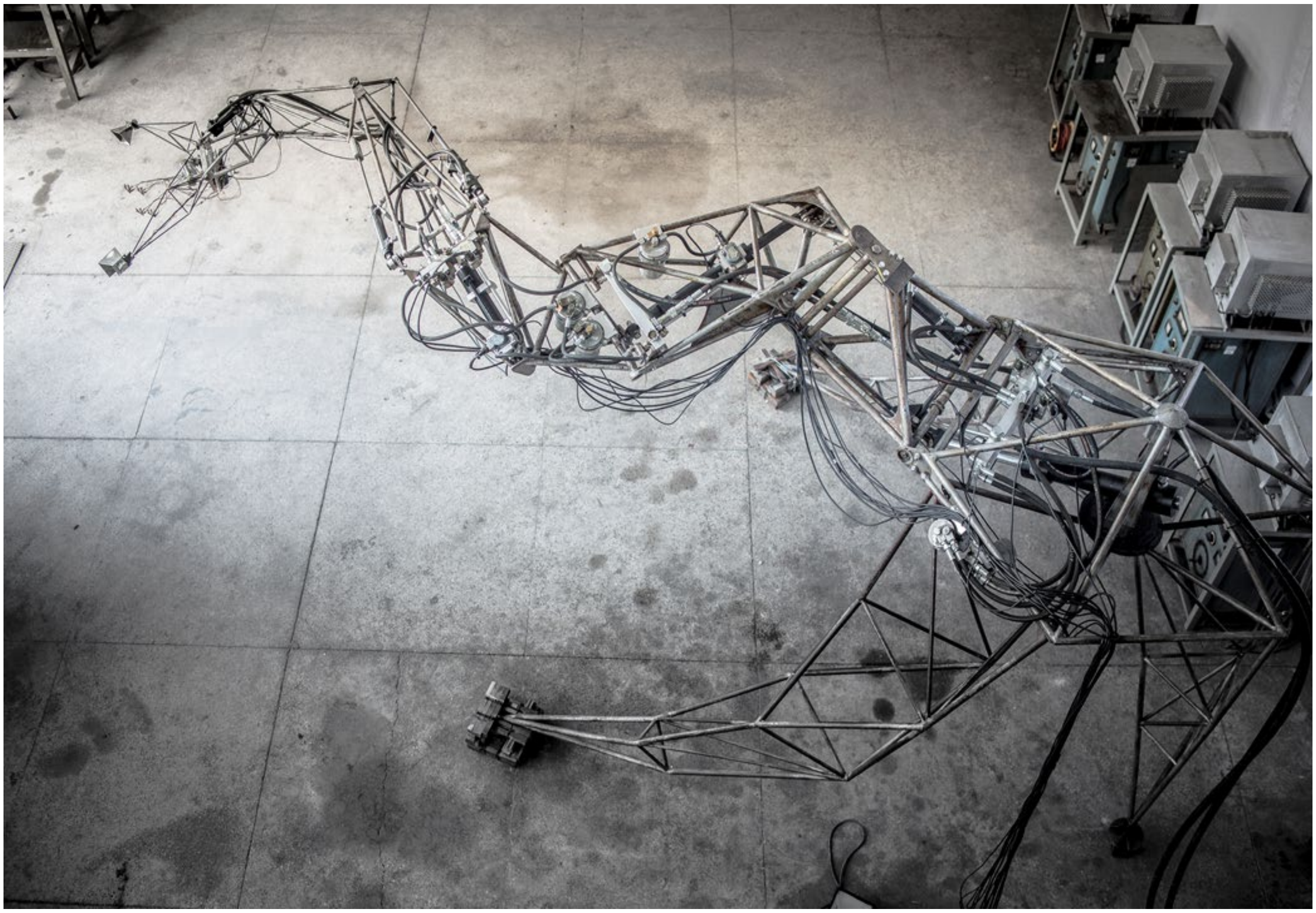

Fig. 3. ***Senster*** **at AGH, September 2018 (© WH AGH, photo: Adam Żądło)**

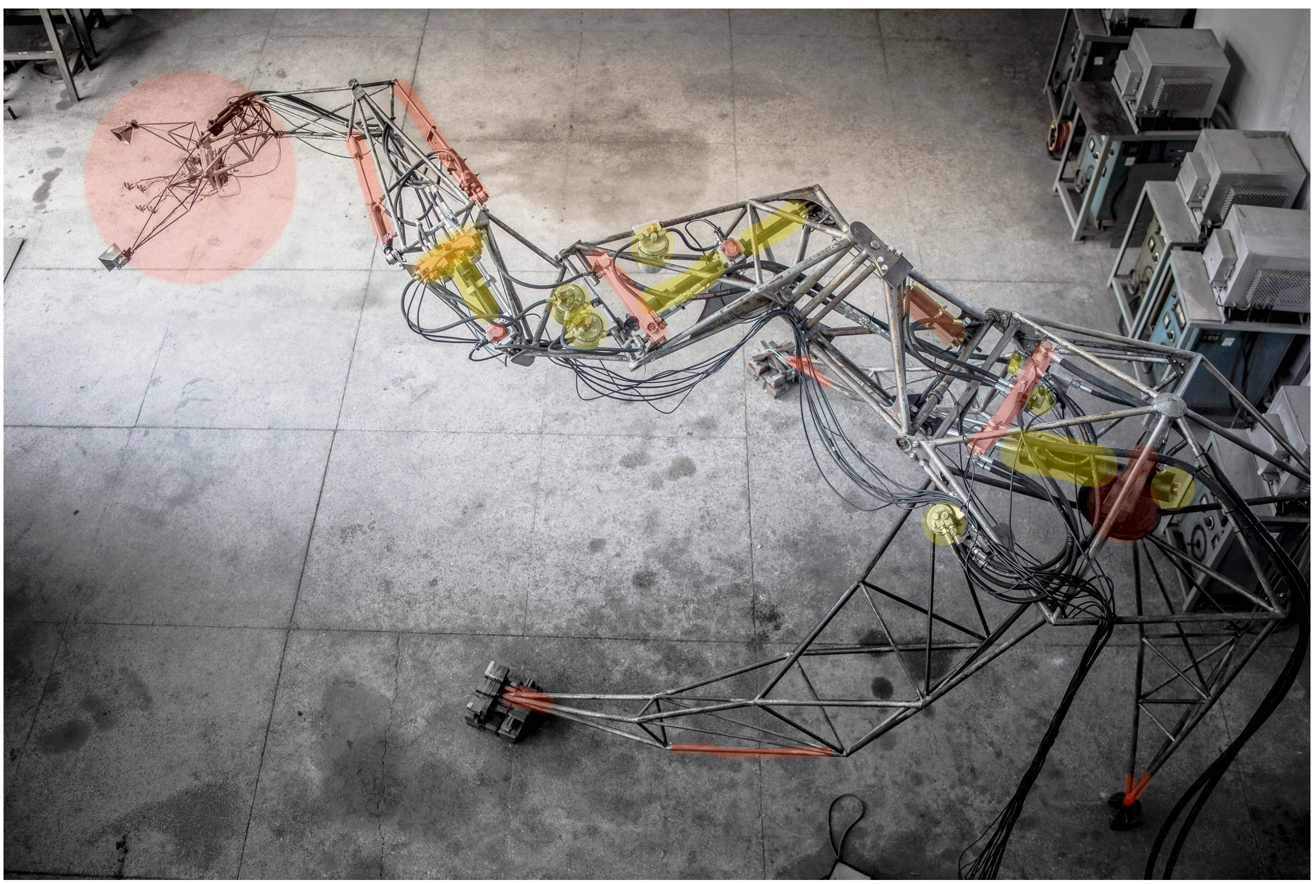

Fig. 4. Interventions made during the restoration process: replaced elements are marked in red (except for hydraulic pipes and wiring), repaired elements are marked in yellow (© WH AGH, photo: Adam Żądło)

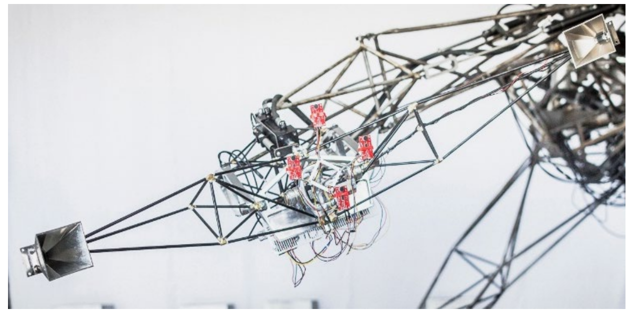

Fig. 5. The original 'head' c. 1970 and its replica in 2018 (© James Gardner Archive, University of Brighton Design Archives, © WH AGH, photo: Adam Żądło)

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) [4]. In each case reproducing the piece's function became a priority. In each case, control systems were upgraded to modern PLC units. Both *Senster's* and the *Loop's* recreated performance relies relies on analysis of the historical footage rather than the study of control switches or software.

What characterizes the *Re:Senster* strategy in the context of the material obsolescence treatment is that the traces of wear visible in the structure of Ihnatowicz's sculpture have been treated as aesthetically significant. Hence, scratches, traces of rust, and old layers of paint covering the truss structure were retained and secured by the anticorrosion coating.

Interventions into the skeleton were minor. Some parts of the mechanical system, including three pistons and four out of six servo valves, have been repaired. Replaced elements were documented and stored. Linear position potentiometers, Doppler sensors, and the characteristic horn antennas were completed according to the types used in the original setup. Other electronic elements were substituted by a modern PLC and microcontrollers. [fig. 4-6] [5].

The maintenance regime for the cybernetic piece in question was formulated as works progressed, by testing any initial assumptions on the question of which parts of the original piece might have been designed for their artistic merit and which were carefully engineered. During the months spent with the *Senster,* we realized that these two complementary design principles would dictate a different approach and degree of complexity to the restoration tasks. Gradually, it became evident that 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 proved much faster and straightforward. Therefore, a restoration methodology based on the distinction between those carefully calculated and freely designed components has been formulated. The following paragraphs explain how the procedure developed.

Fig. 6. *Senster*, detail of the arm 2018 (© WH AGH, photo: Adam Żądło)

Reactivation Phase One: Restoration of the Physical Components

Restoration of the physical components began with the piece's transportation to Krakow in April 2017 and continued until October 2018. Treatment of the skeleton and the mechanical system was followed by the reconstruction of the head. Work on the sensors and wiring concluded the process.

Initially, we viewed 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 have changed gradually during the project.

Mechanical engineering standards were key to the restoration of the skeleton. It was Grzegorz Biliński and Marek Chołoniewski who first argued in favor of this approach when we were considering ways to disassemble the sculpture during the feasibility stage. During the 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, 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. The Familiarity with technical specifications of the original parts ensured that the replacements would comply 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 moulded shapes filled with the 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 moving around 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 time consuming and challenging than the work on the rest of the skeleton. Three mockups of the head were 3D printed before its final shape could be agreed. The core was formed 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.

The 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

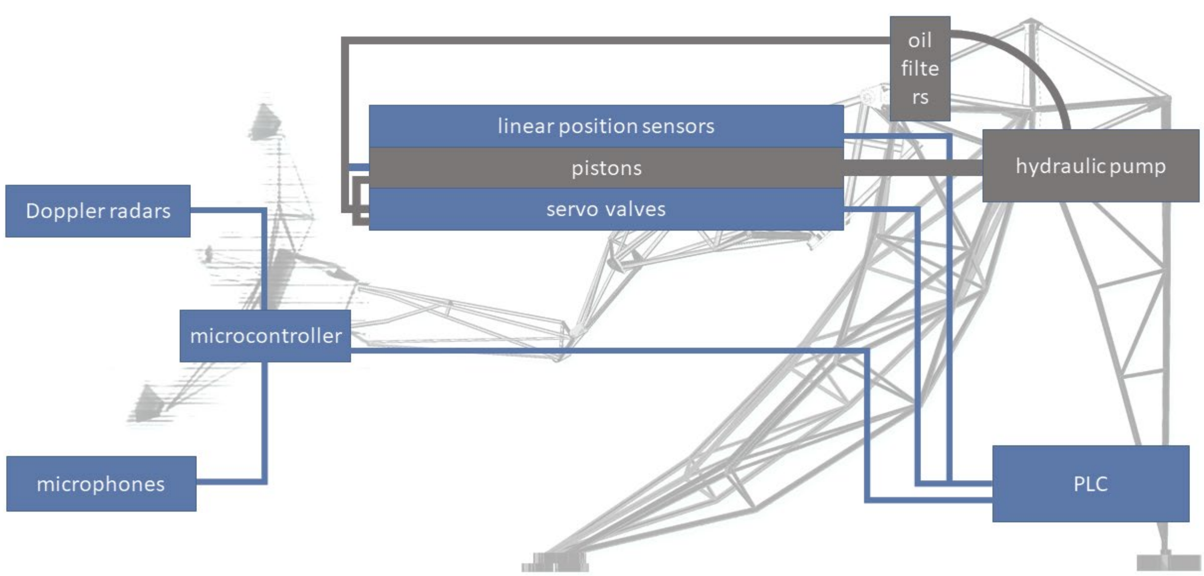

Fig. 7 ***Senster*****, installation block diagram: electronics (blue), hydraulics (gray).**

in the same way as a musical score based on notations and those systems like painting, which he describes as dense, continuous, and non-reducible to a score-like framework of principles. Goodman began with a provocative question on why it is considered that a painted image can only validly exist in a single, original version and every other version will only remain a copy (or a forgery), while with a musical piece, each performance can be treated as preserving its authenticity [6]. Working 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 non-replicable structures similar to those of a painting. During the restoration we have 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, the value of the original control program implementation has been assessed as less significant compared to the goal of the performative features maintenance. Therefore, the work with movement functions was informed by references to the principles of control theory, while the interaction pattern was approximated based on the rudiments of information theory.

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 recreation of the performance functions. We could have used a version of the original program compiled by Lundahl and Ihnatowicz in December 1970 [7]. However, this scenario, relying on old software, was potentially less accurate. Considering this, the project team comprising Marek Długosz, assisted by Rafał Bieszczad, Anna Olszewska and Piotr Madej realized, that in designing the new control system, and in order to correctly implement the code, it was necessary to replicate all the control and signal processing units comprising 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 the *Senster's* electronics evocative from the technology history point of view. The efforts involved in replication of such a control system surpassed the project's scope and were deferred for future consideration.

It was 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 tracking reaction of the system would not be proportional to the input signals and "sudden movements or loud noise would make it shy away" [8]. 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'" [9]. Thus, *Senster's* alarm mode was a safety valve for the relatively slow data processing system, and the famous "shyness" in *Senster's* behavior was a creative response to the limitations of contemporary technology rather than any intention to add dramatic effects. 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, separation of engineeringly calculated solutions provided a systematic framework for the rest of the work.

These conclusions are verified by an analysis of short footage showing *Senster* interacting with the public on three occasions [10]. The film, when watched in slow motion, exposes the performance patterns. It shows the arm in constant motion alternating between the vertical and horizontal. Whenever a human interactor approached, the pre-programmed 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. 6 m) 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 which could produce a highly simplified interactive mode. This recreates the original performance by linking it to the rudiments of the information theory.

The programming was based 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 was to do with the external signals, which were treated as a series of stochastic events that can engage a value 0 or 1 for every swipe of the arm.

The whole sequence has been designed as follows. During the first stage, the movement covers the whole, six-meter range in front of the sculpture. Simultaneously the vertical pair of microphones register 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. The mode is more interpretative then reconstructive. It was designed based on the assumption that sinusoid is the most common movement pattern in nature. For this reason, Marek 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 have been showcased, it transpired that each method resonates 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 when confronted with only a few viewers.

Conclusions: Script-to-Design Maintenance Strategy

In conclusion, regarding the experience gained during works on the *Re:Senster* project, we propose the 'script to design' method of restoration of interactive pieces. A meticulous assessment of both the engineered and freely designed components should form 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. Only based on the knowledge gained through such an assessment should the reconstruction, conservation and repair works proceed. At this stage, work with the engineered parts should take precedence, before works on the free designed components can commence. This means that all the reverse-engineering should be done during this phase, no matter 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.

The history of *Senster* shows that, despite the ephemerality of electronic matter, complex cybernetic objects can function in a historical framework. It confirms that the lifespan 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 the most optimal preservation of any such piece. Unlike digitally-conceived entities, a hardware-based physical structure such as *Senster* cannot be utterly transformed into a stream of data.

The project described here was limited to a single case study. The comparative material for evaluation of the proposed strategy can be found in studies on kinetic and media art restoration. We can only hope that our conclusions will 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.

Acknowledgments

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supplementary material

SENSTER: REACTIVATION OF A CYBERNETIC SCULPTURE

Senster: a history of making

For a couple of decades, Senster has been routinely cited in the writings on the origins of cybernetic art and in recent works on the early media art scene [1-8]. At the same time, the literature on Ihnatowicz' place in art history have highlighted the importance of the sculpture in the context of the development of the history of engineering [9-10]. These studies, together with the available archival material, give a good insight into the issues and challenges the artist and his creation faced in the late 1960s.

Edward Ihnatowicz, the creator of *Senster*, was a London-based artist, a sculptor working in cast metal. In the period preceding his Sound Activated Mobile (SAM) presentation at the Cybernetic Serendipity (1968), Ihnatowicz was invited by James Gardner, on behalf of the Philips technology company, to create a large-scale piece. The *Senster* contract was signed in April 1968 [11]. Subsequently, a ¼-scale model of the sculpture was prepared for evaluation in February 1969. After a six-month delay, work on the full-scale piece commenced in April of the same year [12]. In June 1970 the piece was shipped to the Netherlands to be installed at Evoluon, Eindhoven - Philips' newly opened science-technology exhibition hall. The official opening had been planned for September.

Designed by an artist, but built in collaboration with engineers, Senster merged cybernetics with the principles of kinetic sculpture. Investigation into its history shows that the sculpture emerged based on the conceptualization of fluent movement merged with the rigid structure of large steel joints. Thus, a skeleton capable of rising to over 6 meters was designed. The steel tripod base of *Senster* supported a movable arm with a sensor mounted on a link at its terminus. The skeleton was moved by seven actuators controlled by six servo valves (two actuators worked as a pair). Hydraulic actuators, responsible for elevating the elements, were controlled by a hybrid electronic system. The analog parts were controlled by servo valves, predictor and acceleration splitter [12]. These parts were responsible for smooth movement and orchestration of the joints in motion. Digital control procedures relied on a machine code processed by a P9201 prototype computer. These parts interlinked the joints positions with sensor input signals.

The studies exploring the history of *Senster's* origins highlight the importance of developing a formula which combined sculptural kinetics with a program-controlled interaction pattern. One of the principles of the piece was to correlate its movement with changes in its surroundings. Thus, the terminus link of the arm was equipped with a set of microphones and a pair of microwave radars using the Doppler Effect to detect sounds and motion. Tracking noise and movement around the sculpture, these made it move in a sequence of swift swipes. Since the full range of the half-length arm was 6 meters, and the size of the head had a range of approximately 1.5 meters, Senster could track the source of sound in between 3 and 6 moves. It is important to note that the interaction was designed as reversely proportional to the intensity of the signal. Edward Ihnatowicz is known to have said that loud sounds and sudden movements would repel *Senster*, while constant sound emission was instrumental for tracking of a sound source [13].

One of the challenges of the creation process was making the sculpture appealing to humans in the process of social interaction. The name *Senster* stands for SENsitive MonSTER - by equipping a massive quasi-robotic construction with swift interactive motion, Ihnatowicz aimed to give *Senster* an animal-like appearance. With golden horn antennas flanking the soft molded core of the head, *Senster* would have been easily perceived as a fantastic creature attracted by human presence. A zooid. This made it easy for the project's curator, James Gardner, to make this SENsitive MonSTER, into a crowd-pleasing piece for visitors at Evoluon [14].

In 1970 *Senster* became one of the major art projects supported by the Philips company, following in the steps of Nicolas Schöffer's kinetic art sculpture "CYSP 1" (1956) and Le Corbusier, Iannis Xenakis and Edgard Varèse's "Poème électronique" pavilion and environment (1958). However, changing cultural trends lead to a sudden withdrawal of investment in such an expensive piece. Despite its significance, after the mid-1970s *Senster* was dismantled and taken out of public view. Meanwhile, Edward Ihnatowicz joined new professional networks while staying close to the engineering circles. He supervised graduate students at University College London. Eventually, he had to transform some of his later pieces into industrial machines [15, 16].

Senster: a history of a comeback

Fifty years after its creation, the importance of the sculpture was no longer validated by the patronage of a successful technology business. *Senster* had retreated to the cultural margins along with many other cybercultural icons. In the end, it was professionals from the field of art and humanities, with their awareness of symbolical values, who kept on referring to the piece in their studies providing the rationale for a reactivation project.

The new chapter in *Senster's* history began when, in April 2017, AGH University of Science and Technology in Krakow purchased the piece from its owners – the Delmeco Group Company based in Goes. The sculpture was moved to the Faculty of Humanities where work on its reactivation was carried out until October 2018 [17].

The idea that eventually became the *Re:Senster* project emerged in 2009 when fellows of the Humanities Faculty discussed art-related activities that would reflect the profile of the AGH as a technological academy which incorporates humanities in its curriculum. The choice of *Senste*r's reactivation seemed particularly fitting for this kind of academic institution as it would create an opportunity not only to provide a unique display piece but also for a collaborative project involving an interdisciplinary team. The inclusion of *Senster* was directly inspired by Eduardo Kac's article on early robotic art which coincidentally came to the author's attention at that time. The sculpture had been thought lost, except for occasional laconic information about its skeleton standing outdoors in the Dutch countryside – Colijnsplaat, the Netherlands. Given this, the initial idea was to replicate the sculpture starting with 3D modeling of the remains and drawing on archival photographs and film recordings.

Tracking *Senster's* post-Evoluon story started with visits to London and Brighton archives, meetings with Richard Ihnatowicz, the artist's son who participated in the sculpture's construction, as well as with Joanna Walewska and Alexandar Zivanovic who had published a corpus of archives connected with the artist's work [18, 19]. In the end, the remains of the skeleton were discovered accidentally, by spotting a geotagged photo published online by Richard Heijnen, a casual Panoramio user who had shared some views of Colijnsplaat (Zeeland) as a memoir of his weekend trip. After further investigation, it became apparent that the skeleton existed in relatively safe conditions thanks to the intervention of Piet Verbourgh, an inventor and electrical engineer who cooperated with Philips when the company decided to withdraw the piece from display in 1974 [20]. Verbourgh put the skeleton of *Senster* on his land in Zeeland. Inhabitants of Colijnsplaat remember him as an eccentric, who experimented with non-invasive electric fishing technologies. Standing in Colijnsplaat for some years *Senster* became an outdoor monument, part of the landscape, seen as a curiosity owned by a local potentate. In the end, it was the casual collecting and online amateur posting, together with academic inquiry and archival pursuits that determined the fate and secured the survival of this piece.

The project's network has evolved in its making. After a few open calls, fellows of both AGH and Fine Arts Academy in Krakow, have actively engaged with the project, joining trips to Colijnsplaat documenting the events (Marek Chołoniewski, Grzegorz Biliński), and exploring restoration strategies (Marek Długosz, Jerzy Stojek). Soon the team was joined by graduates of both universities, including Sonia Milewska, an art conservation graduate, Rafał Bieszczad and Kamil Sikora, students of engineering departments, as well as Monika Zielińska from the Faculty of Humanities. Invaluable support was provided by Jerzy Hawryluk, Jacek Żakowski and Jarosław Mamcarczyk, craftsmen and engineers working in the external workshops. Professor Anna Siwik, an historian and one of the university's rectors, became the main diplomatic force behind the project. The fact that the aims and objectives of this restoration project were founded in an interdisciplinary partnership of art, humanities, and engineering was pivotal to the final form of the reactivated sculpture.

The reactivated sculpture was first displayed at AGH in October-November 2018.

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