STARTS Residency Public Report
Residency name

Biobot is a hybrid organism, a robot with intertwined biological and technological parts. With the help of biotechnological protocols Zoran Srdić Janežič is developing live neurons to harvest an electrical signal, which would move the Biobot. To accomodate, observe and work with the living tissue the Kambič company introduced an industrial innovation and developed the incubator for artistic purposes. The Biobot team includes various scientists and experts for developing custom made biosensing electronics and the mechanical moving part of the body. While they were working on Biobot, Kambič in parallel constructed the incubator with camera inside. This challenge presented a learning curve for the engineers and will be used in their future work. The artwork gained a standardized industrial piece of equipment, which enables further work with neurons. Biobot is a result of a multilayered art and science collaborations, including biotechnology, engineering, biosensing hardware and software development, and more. In the future the team will bring the quality of a neural signal to a higher degree and include live muscle engineering into the Biobot's movement.

***Index Terms*— biological robot, hybrid organism, biotechnology, industrial innovation, tissue engineering**

I. INTRODUCTION

In a body of the Biobot we can find live neurons, growing on a plate with electrodes. The electrodes conduct electrical signal, which we convert from analogue to digital, amplify and use for the manipulation of Biobot's movement. At the same time, we are trying to engineer live muscle in a lab as a part of the kinesthetic mechanism.

II. ARTWORK

Moving mechanisms and live materials

In the last decade Zoran Srdić Janežič has been intensively engaged with the construction of mechanisms in connection with using the organic materials (Corpus Indeterminata) or live organisms (Horsepower, FlaNeuron, Biobot 1.1 & 1.2, Biobot / Insider). The artist has always been interested in moving mechanisms, which are parts of a more monumental sculptural works: animal statues with built-in mechanisms and moving pillars, communicating with lights. At the same time live organic and changing materials were also intriguing. Statue, made of lard and the technological system that sustained it were the beginning of a more 'biological' line of works, starting with bioreactors with horse meat, connected to the mechanism of a horse. A more complex art with live cells followed, supported with scientific work in a laboratory, where some experts – scientists, biotechnologists, biohackers, but also programmers and engineers were of a great help. The biological work collided with moving mechanisms in Horsepower and FlaNeuron. The artworks advanced towards (dis)functional movement and designing a living organism was just self-evidently complemented with technology. A year of working on FlaNeuron, resulted in a responsive neural network, which he in/corporated into a mechanical apparatus.

Information loop from the bot's movement to neurons

In Biobot 1.1 & 1.2 the team designed the mechanical part for the biobot in different shapes and finally with a possible information loop from the movement of bot's body that could serve as the information input for the neurons. In the future they will be able to retrieve this information, modified by neurons, back to the technological body.

Technological and biological intertwined

In the next step the combination of technological and biological in the Biobot will be intertwined: the 'artificial' moving mechanism will no longer be separated from the 'natural' tissue. (Every movement, in Srdić Janežič's opinion, can previously be found in nature, while tissue can obviously be designed.)

Different energy paradigm

Conceptually the project is fueled by one of the major leaps in scientific and technological development in human history: as in the 19th century, when the electric current was transformed into motion, which allowed for a different energy paradigm to result in previously unthinkable autonomous systems, such as computers, now the living cell tissue, by becoming the part of a mechanical device enables different responsiveness, adaptability, and alteration. A new paradigm opens, introducing a different motor and energy transfer, and with this a different kind of relationships. Biobot is a small step towards new possibilities for different kinds of movement and the use of energy, and in consequence towards new ways in art.

Appropriating science

Biobot incorporates a concept of employing not only new materials, but also new processes in artistic practices and from that emerges the new artistic language. The project uses scientific and technological development in a non-scientific way for a poetic composition of biological and technological parts. This releases us from scientific thinking and brings up art thinking for interacting with the future world.

Industrial innovation

Biobot is a small robot, moved by a live muscle, created in a laboratory for tissue engineering. The leading partners in the project are Kersnikova Institute with its BioTehna Laboratory and Educell professional laboratories for developing tissues from stem cells. Kambič Laboratory Equipment developed an incubator, inside which the team can observe the neural network and have the right living conditions for neurons, which produce a signal input for the Biobot's movement. INSIDER incubator is Kambič's innovation in the field of industry, brought up by the needs of the Biobot project, and will be used for testing the signals and the movement of Biobot.

Functionality

The first small muscle with a simple moving mechanism was created in Japanese laboratories in May 2018 (https://www.youtube.com/watch?v=2tloliBmj-k). Educell, where they develop bone and skin tissues, is helping with the development of muscle fibers that can be used as the Biobot engine. This will be a miniature motion mechanism, designed to enable the life of tiny muscles, its metabolism inside a cell medium - a chamber that will be a part of the mechanism. The mere integration of living tissue into a technological mechanism will be a success in the artistic as well as scientific world. In the next step the artist wants to create a hybrid moving mechanism, driven by muscle and neuron cells. This will be accomplished through a closed environment with a nutrient medium for the maintenance of cells, attached to a broader base that serves as a body. This will make a larger movement of this surface possible - similar to the muscle in the body which by shrinking and stretching causes movement. Muscle cells will grow on a matrix, made of synthesized polymers, developed at the National Institute for Chemistry and at the Jožef Stefan Institute in Ljubljana. The main idea is to enable the muscle to move the body from inside. Most biohybrid robots move in the transparent liquid containers, filled with cell culture media. The project is among others inspired by some famous hybrid robots like Stem ray biohybrid robot (MIT, 2016). Zoran Srdić Janežič wants to create a mechanism and environment for a larger moving body, which the spectator could actually observe. The movement of muscle cells is relatively slow and with a larger body the deviation of movement in time is larger.

Inspiration

Information technologies together with biotechnologies are nowadays connecting humanity with all living environment. The artist sees this connection in creating live biohybrid forms. Growing living tissue inside a mechanism also means a contemplation on the beauty and complexity of already existing movements as they are seen through different scopes of technological and scientific advances. Biobot is a small-scale living entity with its own intelligence and its own rights to exist as a life form.

III. METHODOLOGY

The 4 interconnected methodologies in this art process were: 1. the biotechnological protocols for growing neurons, 2. developing hardware and software biosensing apparatus for harvesting signal from neurons, 3. developing Biobot's mechanical shell or an exoskeleton, which still needs time for consideration about the best final form of the bot, 4. engineering an incubator with a camera inside, a visible working surface and a display of microscopic image for the viewers.

1. Biotechnological part began with extracting chicken neurons from fertilized eggs, preparing them in growth media and growing them on MEA. In the future artist will be also using clean neural cell lines, which are normally used for the laboratory work, due the convenience of storing, transport and on-the-spot growing for the exhibition. The protocol needs to be highly optimized and reliably repeatable.

2. The set of amplifiers, converter, Arduinos and PCBs were all custom made for the MEA setup and need to be further developed. The signal itself is attained in a form of data noise and needs to be further analyzed and purposefully used as a trigger for the moving parts of a Biobot and eventually the muscles.

3. Several forms of the Biobot's shell were considered and developed, from soft baggy shape, to a firmer tube with a caterpillar movement. Special engineering was made for small rectangular 3D printed mechanisms, triggered by electricity and designed for the tiny movement of the muscle.

4. Industrial innovation with the incubator was done by brainstorming of the artist's team and Kambič's engineers on the needs of the artwork, the new ideas on the functionality and form. After the first meetings the drawings and plans were made and the prototyping began. The 3D renders, engineering hardware, programming software and testing the incubator were executed before the final product has been made.

IV. CO-CREATION PROCESS

The development of project at the residency was carried out at different levels and locations simultaneously:

1. At Kersnikova institute and its BioTehna laboratory the artist with biotechnologist extracted and developed neurons on MEA. The first trials on growing muscle cells were conducted at Educell laboratories by dr. Ariana Barlič.

2. At Kersnikova also the hardware and software for interpreting the neural signal were made. The construction of the Biobot's shell was developed partly at the artist's studio and partly at Kersnikova.

3. The Kambič company planed the incubator according to the needs of the Biobot in parallel. Artist made several trips with biotechnologist and producer to the factory to consult and observe the process.

At the final stage the Biobot in development was exhibited at the Start's Residencies Days at Centquatre Paris, on the 29th of February till 1st of March 2020.

Artistic team was in constant dialogue with the engineers at Kambič factory, for example, engineers did not know much about the requirements for observing the live tissue, so the biotechnologist from artistic team was in constant touch with them about choosing the right visual equipment and creating the right atmosphere in an incubator for keeping the tissue alive. The artist himself was contemplating to put the art installation inside the incubator and later outside of it, so he needed inputs and outputs from the installation into the incubator. He was explaining this to the engineers. Also, the design of the incubator needed to be appropriate for the exhibition, in a way like an exhibition vitrine, but also with a space below the petri dish for camera, so that the viewer could observe the microscopic image on a display outside. This was never done before at Kambič, so the artistic team needed to build the whole new idea of the incubator. Besides the visual and functional part, there was a dialogue about the software possibilities and electronics among the art team and engineers. They were literally complementing each other: artistic team also includes people who deal with electronics, same as at Kambič, and biotechnologist, who advised Kambič on the biotechnological aspects. The design, shape, functionality were in the hands of Kambič, Srdić Janežič and producers. There were no problems with the language and technical expressions, since everyone in artistic team is interested in electronics, mechanics, biology, software etc., at least to the extent that they can understand each other. All the more specific issues with the construction and problems faced were explained by Kambič and engineers in understandable manner. Perfect solutions were not possible because of the limited time or financial support, but they did the best they could according to the means. Also, the final product is a prototype and usually the industrial pieces undergo a lot more testing and improving. This cooperation is one in the line of expert collaborations in Biobot project, so Kambič was with the artist one part of the journey. Nevertheless, the final product can also be used for scientific research.

V. IMPACT

Throughout the Starts residency Zoran Srdić Janežič was able to develop Biobot by a large degree: he researched various movements for the bot and developed two prototypes of the Biobot's body; with the help of biotechnologists and the laboratories he engineered the neural and began the engineering of muscle tissue; and at the end he gained the adjusted incubator for live tissue as the environment, where the neurons can grow and be tested for the signal.

Important outcome of the residency will follow with showing the incubator at the industrial fairs and applying with this product for the local award for innovation (https://www.gzdbk.si/si/aktualno/novice/?id=3869&l=2020), but also at any future chance to show the results of this art and industry collaboration.

A. Research Impact

The Kambič company made an innovation in the form of not just reshaped incubator, but designed in completely new fashion with nine modules inside, enabling the tissue development in 9 different phases at one time and close monitoring through in-build microscopic camera. The company will use the new hardware and software in their next products.

B. Artistic Impact

Zoran Srdić Janežič now has the right environment for further tissue engineering of neurons and muscles. The new incubator enables direct view of the tissue and makes the testing of neurons possible, while they remain in the right atmosphere.

VI. ART-SCIENCE INTER-RELATIONSHIPS

In the project Biobot artistic team uses the industrial capacities for designing an industrial innovation, which supports the artistic project. This innovation is not using art as design or as a promotion of science, but rather employs industry for artistic goals. The artist takes advantage of the possibilities that the cutting-edge science can offer in the form of tissue engineering to build partly biological and partly technological being and with it raise the inevitable ethical questions that rise with designing life.

The Biobot project brings art thinking into industry and bends the science for the artistic, non-scientific use.

VII. FUTURE DIRECTION AND ACTIONS

Biobot is at the present developed towards its advanced form in a shape of autonomous body, which will incorporate muscle movement and the use of neural information in a combination with the technological body. INSIDER incubator will assist it on its way and at the same time have its own life as a product on fairs and exhibitions and maybe enable the support of new innovations.

VIII. CONCLUSION

A. Concluding Remarks

The Starts Residency was an important landmark not only for the Biobot project itself, but it also enabled a true industrial innovation and deepened the collaboration between industrial, scientific partners and artist. We are glad to notice the enthusiasm of all involved scientific partners and Kambič to be a part of the future art projects.

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Muscle engineering:
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