Ethical Tissues

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1 Introduction

Artificial Intelligence (AI) is moving into the material world and creating new challenges and opportunities for many disciplines in the technological as well as the humanistic sciences. Seen from the perspective of ethics, there has been an ongoing discussion continuously informed by novel scientific attempts. Reversely, the discussions regarding what forms of machines or what forms of intelligence computer scientists ought to create is in dialogue with these advances in ethics.

The realization of advanced AI depends on this mutual development and maturing of the technological and the social aspects. Currently, the Norwegian University of Science and Technology (NTNU), in collaboration with Oslo Metropolitan University (OsloMet), aims at creating an organically based AI that can control mechanical bodies in a project called NTNU Cyborg where the researchers investigate how to make an interface between neural tissues and robotics [1]. A high degree of media and popular interest in NTNU Cyborg has sparked internal discussions about how the researchers should or want to communicate in public settings [2]; these discussions, in turn, are the focus of the separate research project *Embodied Engagement*, an investigation into research communication and the socio-ethical dimensions of the endeavor.[1] As part of this project, the authors have interviewed the main researchers, students, resource persons and central staff in order to understand how they understand the communicative and ethical dimensions of the research. In this paper, we present the results from the investigations into the ethical aspects as these emerged through a series of interviews.

[1] Research Council of Norway project 276211: Å gi formidlingen en kropp - en casestudie av NTNUs kyborgprosjekt, Embodied engagement - A case study of the NTNU Cyborg project

2 Background

In order to understand the findings from the interviews, it is necessary to describe more in full the NTNU Cyborg and to address what are the ethical discussions in the participating disciplines.

2.1 The NTNU Cyborg

The Cyborg project is a multidisciplinary lighthouse initiative at NTNU that aims at developing a cybernetic organism, i.e., a cyborg. The cyborg in this case consists of a robotic body interfaced to and controlled by a living biological neural network, where the neural network functions as an AI. Therefore, one the main goals is to enable the communication between living neural tissue (grown in a petri-dish in a laboratory) and the mechatronic components of a robot. Such project is a truly multidisciplinary effort, as it includes (i) the in-vitro cultivation of biological neuronal cultures over multi-electrode arrays (MEA), i.e., tiny chips with electrodes to which the neural tissue is connected to in order to record neural signals and stimulate the neural substrate with electrical signals; (ii) the interpretation and processing of the electrical signals resulting from the neural network processing (spikes) and the modeling of algorithms for stimulation of the neural networks to learn the target behavior; (iii) the development and integration of a robotic artifact with sensory feedback that allows the creation of a closed-loop robotic-neuro system. Therefore, the different disciplines (neuroscience, computer science, cybernetics) merge their own research questions (RQ) towards the broader goals of creating a cyborg. The combination of RQs from different domains and their individual ethical implications result in new ethical considerations that go beyond those of the single scientific disciplines, in terms of technological developments and use cases, as well as their communication.

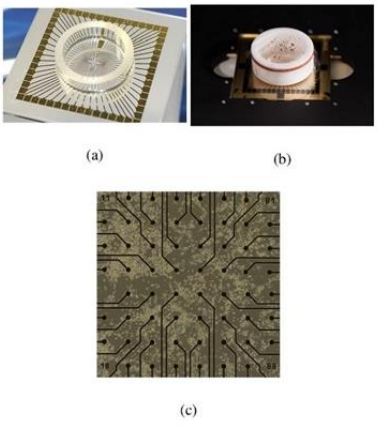

Fig. 1. (a) A generic MEA. (b) A MEA with a neuronal culture. (c) Microscopic image of culture with visible neuronal structure formation.

2.2 Ethics

A project combining neuroscience, computer science, and cybernetics engineering needs to consider the main ethical discussions within these areas as well as how they intersect. Consequently, the findings in this paper are discussed with relation to the central issues in neuro ethics, AI ethics and ethical discussions concerning human enhancement [3-8].

3 Theory

In order to analyze the occurrence of ethical issues, we apply an Ethical Matrix. The Ethical Matrix is a general ethical tool that has been used for normative and value systematization in fields such as radioactive waste, carbon capture and storage, assistive technologies, and genetically modified salmon [9-12]. The Ethical Matrix takes the systematization from medical ethics of value issues as being possible to classify as relating to well-being, dignity and fairness [13]. These issues are structured according to the relevant stakeholders, i.e. who is seen to be affected.

4 Methods

There are two sets of sources used in this article. The first set consists of interviews with ten scientists in the NTNU Cyborg from the field of computer science, cybernetics and neuroscience [14]. The second set of sources include interviews and focus group discussions conducted in connection with two workshops on ethical and societal dimensions of NTNU Cyborg, which were held by NTNU Cyborg researchers for groups of students in order to experiment with communicative theories and methods drawing on the field of responsible research and innovation [15, 16].

5 Main findings

Due to the interdisciplinary nature of the project, the interviewees discussed a broad set of ethical concerns. Some of the concerns were directly connected with applications of AI. Others were more indirectly related to AI. While they were the results of scientific progress enabled by the form of bio-inspired AI and computer science described here, they were not issues related to the application of AI as such. Overall, the main form of ethical impacts was those related to different dimensions of **well-being**. In particular, many informants emphasized the potential medical applications of outcomes from NTNU Cyborg. These impacts of well-being included increase in good health due to progress in understanding and correcting neural damages, such as in the case of Alzheimer's disease and Amyotrophic lateral sclerosis (ALS). A different aspect was the potential for improvements in prosthetics as a result of ameliorated understanding of neural signals to fore example mechanical limbs. The main examples regarding negative consequences were associated with military use of AI through automated weapon

systems. In addition, themes such as loss of jobs, costs and efficiency, risks in general, increased utility, and energy use were also raised. A notable example in the discussion on well-being was animal welfare, and the notion that increased understanding of neural activity in the lab could reduce the need for animal testing.

Quite a substantial discussion also occurred over different aspects of **dignity**. The most central theme here was the ability to control and account for the implementation of potential outcomes related to the NTNU Cyborg. Closely related to the discussion over control was a different element categorized under dignity, namely the ability for a combination of neurons to become sentient or to develop consciousness. Interestingly, also increased knowledge was seen as an ethical positive value, while bad science was its counterpoint. These relate to dignity as they increase to potential for good or virtuous actions. A different dimension discussed as negative was the effect of medical enhancement on human nature as well as on fairness.

Fairness was the least discussed theme among the informants. However, some informants questioned whether the medical benefits discussed above would extend beyond the realm of the rich and powerful. Likewise, enhancements might create disparities. In addition, there were a range of inter-scientific discussions over other dimensions of procedural fairness. Several informants discussed the importance of communicative precision as a prerequisite for fair access to research results as well as a duty to be transparent of the inputs, throughputs and outputs of the research process. Among the clearly negative potential impacts were issues concerning bias in AI, AI discrimination and uses affecting privacy or surveillance potentials,

Systematic attention to the stakeholders mentioned, show that the stakeholders to the ethical and communicative issues that are raised by the NTNU Cyborg researchers include both patients, researchers and research institutions, the public or society, animals and future generations.

6 Conclusion

The discussion concerning negative impacts on well-being stems from irresponsible implementations of AI without proper oversight, while the positive dimensions relate to neuro ethics. While under dignity, the discussions from neuro ethics mainly concern the negative dimensions – or moral dangers – of artificial consciousness and discussions over enhancement as unnatural and unfair. Also in the discussions over fairness, the negative dimensions are from AI ethics, but also from parts of the enhancement debate. None of the informants discuss how the outcomes of the NTNU Cyborg project might be used to enhance fairness in society- Fairness is mainly discussed as internal the scientific system when it comes to fair communication as an obligation of the researchers. We therefore recommend more discussion on the fairness dimension of complex novel technologies.

By displaying the ethical impacts related to well-being, dignity and fairness and explicitly connecting these impacts to stakeholders, we have here provided an overview of issues that the humanistic and the technological sciences could – or should –

investigate further in order to strengthen the socio-technical impacts of new technological paradigms.

7 Acknowledgements

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