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Review of Ethics Codes for Environmental Robots

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Abstract. Like robo-fsh or conservation drones, environmental robots are those that can carry out jobs for environmental research, engineering, and protection. While the term "environmental robots" can branch into robots-in-ecology, robots-for-ecology, and ecobots, each with difering purposes and ethical concerns, their overall objective is directed towards protecting and enhancing the environmental health on Earth. Though there is a huge potential for the application of environmental robots, this concept itself is relatively new, and thus there is a lack of study done on the ethical aspects of environmental robots. In past literature, researchers often focused on 'specifc' types or products (e.g., robofsh, Treebot, etc.), but there were relatively few surveys of the overall category of environmental robots. Therefore, in recent years, scholars have pointed out the need to consider wider "ethical, practical and sociopolitical concerns" surrounding environmental robots. This paper has aimed to develop more reliable guidelines that are specifc to environmental robots, considering their unique roles and characteristics. First, this paper has identifed three main areas in which potential ethical issues may arise: the manufacturing of environmental robots, their operation abilities in nature and direct impact onsite, and expected or unexpected long-term consequences on ecosystems through their continued usage. Based on these three areas, the paper then built a broader guideline for the kinds of issues future ethics codes must address. Lastly, the paper systematically reviewed existing ethics codes for generic robots to suggest areas that have clear gaps or areas that are already sufcient to be applied for environmental robots. Human modifcation of ecosystems has been a key factor for the rapid population growth during the recent millennia, and environmental robots are growing to become the next key for this growth. However, we must proceed with attention to the design, construction, operation, and maintenance of these robots, as their positive potential for the environment may backfre and cause grave ethical concerns. Therefore, this research seeks to ultimately provide a reliable set of guidelines for future developers and manufacturers of robots associated with service in the environment.

Keywords. Environmental robots, ethics code, environmental health

1. Introduction

Robot technology is an ever-developing subject, especially in the current digital era. Many robot prototypes have been created targeting surveillance, house work, urban infrastructure management, environmental contributions, and much more. It is only true that robot technology will play a significant role in modern society; thus it is important to understand the advantages and limitations of such technology.

[8] This thought grounds the concept of robot ethics, or roboethics, a branch of study covering methods to design and assess robots based on moral criteria (Tzafestas, 2018). These criteria concern both the effect on society and on the environment, thereby promoting robots' ethical behaviour.

Environmental robots, as the name suggests, are robots placed in the environment. These robots can be differentiated into three broad categories; robots-for-ecology, robots-in-ecology, and ecorobots. The differences will be explained later on in this paper, but the difference lies in their impact on the environment. The way robots impact the environment is significant, as humankind is interfering with nature, a non-artificial part of our lives which has a unique characteristic. Nature has complex interactions within itself between different organisms and their environment; these relationships can also reach humans. Thus, it can be said that the way we utilize environmental robots directly impacts not only nature, but also humankind. It only makes sense that we regulate and assess these robots to make sure they work in an ethical manner.

The status quo lacks such regulation; the only statement regarding nature in the current ethical guidelines from the European Union reads: "AI systems promise to help tackle some of the most pressing societal concerns, yet it must be ensured that this occurs in the most environmentally friendly way possible. The system's development, deployment and use process, as well as its entire supply chain, should be assessed in this regard, e.g. via a critical examination of the resource usage and energy consumption during training, opting for less harmful choices. [10] Measures securing the environmental friendliness of AI systems' entire supply chain should be encouraged." (Weiser, 2019, pg. 19) This statement only covers the production methods for robots, which is a rather small part of the impacts robots can have when deployed in the environment.

Thus, this gap in literature shows the lack of attention paid to environmental robots. The aim of this paper is to establish certain ethical guidelines for environmental robots. This issue is urgent since many environmental robots are already in production; I will discuss some examples below. The paper will not offer a comprehensive overview, but instead focus on two particular issues that are considered most relevant: 1) the fragility of ecosystems and the environment; and 2) the definition of nature and the intrusiveness of robots. The first problem refers to the fact that ecosystems are likely to become dependent upon environmental robots, which decreases their independent subsistence. The second problem refers to the fact that environmental robots by their very nature diminish the intrinsic value of the environment.

In both cases, the rapid development of environmental robots and irresponsible release into the environment may pose huge consequences for humankind. Limitations to technology and robot's capabilities of influence must be set to counteract these problems. I will propose two guidelines to be included in any future ethical codes for environmental robots:

- Fragility: limit the capabilities of robots to prevent them from having a high ecological significance; or if that is impossible, limit the robot's autonomy to ensure human supervision;
- Intrusiveness: reduce the intrusiveness of environmental robots as much as is possible, sometimes at the cost of their effectiveness.

The structure of the rest of the paper is as follows. In Section 2, I will introduce three different types of environmental robot. In Section 3, I will discuss the fragility problem in more detail. I will propose that the activities of environmental robots should be limited to prevent the ecosystem from becoming strongly dependent upon them. In Section 4, I will discuss the intrusiveness problem. Here, I will suggest that efforts should be made to limit the negative effect of environmental robots on the intrinsic value of nature. Section 5 concludes the paper.

2. Three Types of Environmental Robots

[9] In this section I will introduce three different types of environmental robots, following Donhauser (2018).

2.1 Robots-For-Ecology

Robots-for-ecology are service robots in the environment used to carry out complex tasks such as research and monitoring to collect data or regulate the environment. [7] An example of this is the COTSBot developed by Queensland University of Technology, an aquatic robot that helps regulate the balance of carrying capacities[1] of apex predators in underwater ecosystems (QUT Centre for Robotics, n.d.). [5] Another good example of a robot designed to do a specialized task is the Treebot, developed by researchers Lam and Xu. It is developed to efficiently and autonomously climb trees for "tree inspection, maintenance, pest control, and monitoring arboreal environments for ecological research" (Lam and Xu, 2012).

2.2 Robots-In-Ecology

Robots-in-ecology denote service robots targeting data collection and monitoring as more efficient and accurate alternatives for human environment inspectors. Such robots-in-ecology include drones, UAVs, rovers, or any other unmanned vehicles. These types of robots have less complicated objectives than robots-for-ecology and ecobots, and thus require less capabilities such as intelligent decision-making or actions with high-intrusiveness (the concept of intrusiveness will be dealt with later again) .

[4] The autonomous characteristics of robots-in-ecology used, for example, for monitoring the environment, return "more effective research with better results: eg. research shows that approaches by AGVs (autonomous ground vehicles) produce a significantly lower stress response (e.g. elevated heart rate) than approaches by human researchers" (Grémillet et al., 2012, p. 49–57).

2.3 Ecorobots

[9] Ecobots are 'ecologically functional robots' (van Wynsberghe and Donhauser, 2018, p. 12). Ecobots can be used for research, and can include robots-in-ecology that also provide ecological functionality. Ecobots can provide service to ecosystems by "playing some functional ecological role (e.g. serving as a proxy predator) or by augmenting ecological functioning (e.g. enhancing ecosystem services) via autonomous behaviors or controls of key environmental variables" (van Wynsberghe and Donhauser, 2018, p. 8).

Ecorobots often include a characteristic of bio-mimicking in both their appearance and mobility. [1] A good example of this is Aquaai, a biomimetic robotic fish used for monitoring temperature, dissolved oxygen, water quality and pH at different depths (Aquaai, n.d.). Aquaai's effectiveness and accuracy in collecting data contributes to aquatic farmers' efforts in fishing different species at sustainable and predictable rates. Aquaai's robotic monitoring platform can also be used to locate subsurface ocean plastic for removal before it breaks down, find sources of pollution, agricultural runoff, and check waterways after flooding and storms. Aquaai serves

[1] The maximum capacity of species an environment can hold with regard to the number of other species as well, thus maintaining a balance of prey and predator

as a good example of ecobots monitoring and contributing to both the environment and human activity (e.g. farmers). The ethical concerns of even such serviceable robots will be explained further on in the paper.

3. Issue 1: Dependency

In this section, I will discuss the issue of dependency that is typical to environmental robots. In 3.1, I will explain in more detail what this dependency entails. 3.2 concludes with the recommendation that environmental robots should avoid such dependencies.

3.1 Fragility of the Environment

Robots-for-ecology left in service within an ecosystem for a substantial period of time will establish a significant position in it, upon which parts of the ecosystem will rely for their continued survival. Thus, the ecosystem will become fragile, surviving on a slippery slope thinly sustained due to the robot's service. The higher the capabilities and effectiveness of the robot, the higher the "ecological significance" of the robot in any given ecosystem. Any manner of elimination of the robot, whether it being an unexpected removal or a malfunctioning of the robot, will cause unpredictable chains of detrimental effects in and out of the ecosystem. For example, COTSBot maintains the carrying capacity of predators in an ecosystem. When it is removed from that ecosystem, this can lead to an explosion of the number of predators, which can have disastrous effects on other species and the ecosystem as a whole. Any type of robot with an exceptionally high ecological significance may even impact humankind, as it has intervened and removed itself from the complex interdependencies between all of the organisms within an ecosystem.

3.2 Recommendations

[6] To prevent the initial cause of the dependency and fragility problem, environmental robots must be designed such that eventual failure or removal will not have any wide scale consequences for the ecosystem the robot is present in (Loh, 2019).

Thus, there are two solutions:

- limit the capabilities of service robots to prevent them from having a high ecological significance and thus decrease the risk of ecological fragility after elimination, for example by letting robots only monitor the environment rather than act on it; or
- add a strict checks-and-balances system, or safety net, to limit the amount of autonomy the robot is capable of; this may be achieved by direct monitoring of the robot, confirmation requests to human workers before commencing high-risk activities, etc.

At the end of the day, both solutions will lead to safe utilization of robots with complex tasks and high ecological significance.

One may oppose that these regulations will limit the effectiveness of such robots, as the essential reason they have a high ecological significance is because they are capable of providing significant benefits to the ecosystem. One may add that limiting the capabilities, thus, is counterintuitive regarding the purpose of the robots, and that the harms mitigated from limiting the capabilities will be larger than when the robot malfunctions. However, it should be clearly noted that environmental robots and deep implementations is a rather new topic which presents risks unknown. The scale of impact of this risk is too large to the extent that it only makes sense to prevent any possibilities of it. Sometimes you want to choose the less efficient option if it is the safest one (for example with speed limits).

4. Issue 2: Intrusiveness

In this section, I will discuss the issue of intrusiveness laid upon environments due to high levels of influence that robots may have. In 4.1, I will describe the definition of nature and the impact of robots on it. In 4.2, I will explain what intrusiveness is, how it is problematic, and leave recommendations to mitigate the issue.

4.1 Definition of Nature / Necessity of Differentiation

Nature inherently is a self-sustaining system withholding organisms in a healthy manner. Humankind, as an external factor inherently unincluded from such self-sustaining systems, must limit the amount of influence it lays upon such systems in order to preserve the intrinsic value of nature. Too much influence will blur the boundaries between humankind and nature; it destroys the character of nature as part of the world untouched by human/technological intervention. Thus there is a need for appropriate amounts of regulation for human influence, in this case, through the medium of robotics. [3] This is especially important in the case of environmental robots, which are often designed to directly interact with nature (Ducarme and Couvet, 2020).

4.2 Definition of Intrusiveness

By intrusiveness we mean the degree to which the environment is modified by the introduction of foreign factors. Ecobots stand at the core of this issue. The definition of “nature” derived from its Latin roots is the following:

[11]‘things that happen by themselves, "naturally", without "interference" from human deliberation, divine intervention, or anything outside what is considered normal for the natural things being considered.’ (Wikipedia Contributors, 2019)

Many ecobots take on the role of an alternative for real organisms, like the biomimetic fish Aquaai. Simply put, if the nature to artificial alternative ratio reaches a certain extent, then whether nature is really natural becomes a blurry distinction, not to mention the increased severity of fragility for the respective ecosystem. For example, biomimicry ecobots may accidentally trick infant organisms that it is their parent: in this case for fish, young fish may follow the aquatic robot to research labs or any other abnormal location and be extracted from normal routines. This issue may introduce a new concept of a “hybrid ecosystem”, where what was originally real nature must now be considered man-made and man-sustained.

Another issue arising from this interpretation is the disturbance of the intrinsic aesthetic value of nature, an issue that will inevitably occur with the introduction of ecobots. At the end of the day, we may end up terraforming our own planet, which may irreversibly harm nature as it is defined: a space uninfluenced by human actions.

Opposing factors may claim that high intrusiveness often is a necessary factor for the higher-level performance of robots, and thus enables a greater positive impact on the environment. Such opposers may additionally claim that humans themselves leave an even greater level of intrusiveness and harm on a daily basis, with common examples being deforestation, raw material production, pollution emission, etc.

In response to this objection, firstly it is acknowledged that human influence can also harm nature. But this means that the same approach must be applied both to human and robotic interaction with nature: minimize the intrusiveness. Secondly, while it is possible in principle to completely minimize human influence on nature, for example with a carbon-neutral policy, this is not possible for environmental robots. By their very nature, environmental robots introduce a foreign element into nature, thereby harming its intrinsic value. We must therefore be extra careful in employing environmental robots.

5. Conclusion

5.1 Careful Approach

One core message this paper wants to leave is that humans must keep the environment as it is as much as possible, thus preventing the dilution of nature in order to preserve its intrinsic value. As a clarification, this paper does not condemn technological developments nor the implementation of service robots for the environment and humankind. However, this paper does advocate a careful approach to the development of robots and usage of capabilities through incorporating roboethics in line with the issues described above.

5.2 Further thought

For the future, there is one further interesting issue we can and should consider. The issue that may arise if robots were to escape their limitations of rudimentary decision-making capabilities is the issue of “human-robot purpose alignment”. Simply put, this concept describes a situation where a robot may decide to act in a way it has decided is beneficial to the environment, but may be the opposite for humankind; here, the dilemma whether to put humans over nature or vice versa appears. However, this paper is not meant to address this issue, and therefore will end here.

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