# Open Roboethics: Establishing an Online Community for Accelerated Policy and Design Change

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## 1. INTRODUCTION

In the past decade, we have witnessed rapid development and deployment of robots. In 2010 alone, over 139,000 industrial robots and 2.2 million service and domestic robots were sold around the world, and these numbers are estimated to increase in the years to come [1]. This seemingly unbridled growth of robotics has brought forth ethical and societal concerns amongst the public and designers, challenging the boundaries of currently existing policies [2–4].

With the birth of roboethics [5], philosophers, engineers, and policy makers have begun to discuss these issues in an attempt to put ethics in the forefront of the technological advancement. However, discussions within the interdisciplinary field have been limited by international, cultural, and disciplinary boundaries. Subsequently, policy changes/establishments still remain behind the technology.

We propose the Open Roboethics initiative to apply the internationally viral open-source paradigm as a driving mechanism for discussion of roboethics, policy and design. In this work, we discuss how the successes of already established open source initiatives can help address practical issues – including financial sustainability and community building – of establishing a centralised and open community for advancing roboethics.

The remainder of this paper is organized as following. In Section 2, we discuss existing standards in robotics and established communities in roboethics. In contrast to the existing roboethics initiatives that mainly consist of closed groups of experts, we introduce how other fields of applied ethics have employed a bottom-up approach to advance their ethics discussions. Then, we present a few of many successful online platforms that enable free and open sharing of designs and knowledge. Subsequently, in Section 3, we propose the concept of Open Roboethics as a synergy between bottom-up roboethics discussions and open sharing of robot designs that accelerates policy and design changes in robotics. In Section 4, we postulate on how three key practical issues of establishing Open Roboethics could be addressed. We conclude our paper in Section 5.

## 2. BACKGROUND

In the past, the majority of robots were found in industries. These robots were regulated under international and national standards organizations such as the International Standards Organization (ISO) and the American National Standards Institute (ANSI). However, current application of robotics extends beyond industries – including military, search and rescue, medical, and eldercare – while regulation and standardisation of service robot are only starting to take place (e.g., ISO 80601-2 and ISO 13482 are being developed as standards for medical and non-medical service robots, respectively).

With over 6000 military robots sold in 2010 and many more deployed on battlefields today, there has been active discussion surrounding policy and ethics of military robots [6], [7]. Although international Laws of War and Rules of Engagement (ROE) exist, many find these laws insufficient for regulating the use of drones and other military robots [7].

Literature also demonstrates that there is a need to develop guidelines for using eldercare robots [8]. For example, Paro, a therapy robot used in nursing homes, is classified in the United States as a Class 2 medical device. Although the interactive nature of the robot makes its role significantly different than devices in the same classification, such as powered wheelchairs, the robot falls under the same regulation under the U.S. Food & Drug Administration.

A few studies suggest guidelines for design and use of service robots. For example, the COGNIRON project, which produced a library of rules concerning a robot's prescriptive performance in the home environment [9] and guidelines on designing the appearance of a robot to maximize user acceptance [10]. A study by Young et al. provided a guideline for considering user acceptability in the design of domestic robots [11]. However, scientific findings from these studies have yet to be established as standardised design guidelines.

Developing successful robotic products in our ever-changing society necessitates timely reflection of society's needs and values in the design process. However, standardisation in robotics still remains behind the technological advances and emphasizes the need to accelerate discussions in roboethics. In the following section, we provide an overview of already established roboethics organizations and initiatives and outline the need for roboethics discussions to cross national, disciplinary, and organizational boundaries.

### 2.1 Roboethics Organizations & Initiatives

To date, a number of roboethics initiatives have taken place at international and national levels. In 2004, the First International Symposium of Roboethics took place in Italy. This was followed by the International Robot Fair Japan, where the participants (robot scientists and representatives

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from the Japanese robotic industry) signed the World Robot Declaration [12], the robotic version of the "Hippocratic Oath", to better facilitate the acceptance of robots into society.

In the same year, the IEEE Robotics and Automation Society constituted a Technical Committee (TC) on Roboethics. This was to promote the discussion between researchers and moral philosophers regarding ethical implications of robotics research, and the creation of a shared mechanism to handle related ethical issues.

While a majority of the initiatives share the common goal of promoting discussions within the field, many of the initiatives have been limited to expert groups, or by national and disciplinary boundaries. For example, the first Roboethics Roadmap presented at ICRA 2007 was produced as a result of the Roboethics Atelier Project, which was coordinated by the Scuola di Robotica, and funded by the European Commission Robotics Network (EURON). The members were only comprised of experts in the field. The Korean Government established the Korean Roboethics Charter project in 2007, members of which consist of experts in Korea. Similarly, Japan's Ministry of Economy, Trade and Industry (METI) also started to work on the "Japanese Roboethics Charter". Within Europe, the European Commission funded a Coordination Action for Robotics in Europe (CARE) in 2006. Its objective was to identify research priorities and to define a Strategic Research Agenda (SRA) for robotics in Europe to be developed by European Robotics Platform (EUROP). An important Work Programme was devoted to Ethical, Legal and Societal (ELS) Issues in Advanced Robotics.

However, robotics is the study of a pervasive technology that crosses national and disciplinary boundaries, and robotic products affect not only the experts but also lay users of the technology. Hence, roboethics discussions need to cross these boundaries. In the following section, we discuss how other fields of ethics apply bottom-up approaches to foster ethics discussions and policy making processes that are more inclusive of different stakeholder groups.

## 2.2 Bottom-up Approach

Bottom-up approaches are among the most inclusive approaches to issues in Applied Ethics (e.g., bioethics, information ethics) [13]. These approaches typically aim to understand the opinions and values of the public or larger stakeholder groups, and are managed and supported by the "experts committee."

Numerous studies support the bottom-up approach to applied ethics. In particular, a report by Jasanoff et al. demonstrates that disaffection with science and technology is often correlated with the lack of institutional capacity to deliberate and resolve normative questions regarding their advancement. They emphasize that "*socially distributed, autonomous, and diverse collective forms of enterprise*" are necessary to appropriately and effectively address public concerns regarding science and scientific products [14].

In the case of bioethics, information ethics, and ethics of genetically modified products we are witnessing a global bottom-up movement that promotes discussion and refinement of science policy [15]. Realizing the need to discuss the ELS implications of genetics research, Francis Collins – who led the Human Genome Project – spurred the idea of involving the public in a structured dialogue process about genetic policy.

Robotics, especially service robotics, is a rapidly developing field. However, we have yet to see established standards defining ethical, legal, and social issues in service robots. The increased need for policy making and the interdisciplinary nature of the field necessitate a mechanism that facilitates such bottom-up approach. We believe the power of mass collaboration demonstrated in open source paradigms can help address this need and bring forth accelerated policy and design changes within robotics. We discuss examples of open source paradigms in the following section.

## 2.3 THE OPEN SOURCE PARADIGM

Today, many widely accepted and trusted software packages are products of open source projects. Sociologist Eric Von Hippel [16] points out that open source software is a new model for innovation approaches, in which a community-based innovation blurs the distinction between developers and users to form user-induced innovations. Open-source platforms, as products of mass collaboration, have inherent advantages of being widely accepted [17]. By allowing anyone to access and modify the source code, the open-source paradigm has created open access software and hardware that are transparent, accountable, and functionally comparable to commercial examples.

### *2.3.1 Design Sharing*

Instead of holding a patent for a particular system or software, platforms that share designs or source code encourage developers to distribute their knowledge with the worldwide community.

Linux, a computer operating system inspired by Unix, was designed on a free and open-source software development and distribution concept. This system contains voluntary contributions from over 1000 developers [18]. Having such freedom to develop the system in collaboration with many others has elicited rapid improvement of the source itself; new versions of Linux systems with improved capabilities are released every 2-3 months on average [18]. Today, many available open-source software products are built on top of Linux.

Numerous open robotics projects, open source projects on software/hardware, already exist, and the advantages of open robotics have been well documented [19]. Although open robotics systems can complicate liability problems, contributions to open robotics continue to grow.

In particular, the Robot Operating System (ROS), developed by Willow Garage (Menlo Park, CA), has demonstrated the power of the open robotics. Since its initial distribution release in 2009, ROS has become the fastest growing operating system for robots. This freely available centralised system has enabled over 60 research labs and corporations, and numerous students and hobbyists, to collaborate on developing robotics applications [20].

Open-source hardware platforms also exist. For instance, Arduino, an open-source microcontroller developer, allows users to access hardware design specifications, software sources, and all documentation of the product for free. The business model of Arduino relies on commercializing advanced solutions of the open access hardware design.

### 2.3.2 *Knowledge Sharing*

Sharing knowledge on any particular topic is greatly facilitated by today's Internet-based servers. Unlike hard copy encyclopaedias, Wikipedia is an open-access, web-based knowledge platform to which over 100,000 people from all countries have contributed in more than 250 different languages.

Other examples of open-access initiatives include the Public Library of Science (PLoS) [21], for which authors pay a fee to journals to publish manuscripts that are provided to readers for free, and the Public Knowledge Project [22], which allows authors to publish peer-reviewed articles and readers to access knowledge for free. Recent studies indicate that open-access journals have impact factors comparable to that of traditional journals [23].

Outside of academia, there are successful examples of knowledge sharing, such as the open-source learning initiative by Richard Baraniuk (Connexion), which over 2 million people from 196 countries use every month [24].

All of the abovementioned initiatives have a hierarchical mechanism to moderate new content, which is produced by authors who are experts in particular fields.

## 3. OPEN ROBOETHICS

Noting the obvious successes of these projects, can the field of roboethics leverage the power of the Internet and mass collaboration?

We propose a centralised, open-access online space, which we refer to as Open Roboethics, dedicated to hosting roboethics discussions and relevant design-sharing that crosses cultural, geographical, national, and disciplinary bounds. We envision Open Roboethics to be a dynamic online platform that connects various stakeholders of robotics technology by synergizing design sharing (technical contents) and knowledge sharing (non-technical content). Figure 1 presents a graphical overview of the Open Roboethics concept.

Design sharing would include open source code and hardware designs. We envision Open Roboethics to host open source robotics projects, or open robotics, on high-level decision-making codes that reflect ROE for military applications, design of robot motions that have ethics-based design components, and programmed culture and context-based behaviour standards for robots.

Non-technical contents would include research findings, existing standards/regulations, reports and articles from the media, collections of data openly accessible for analysis, as well as on-going discussions on roboethics topics. For

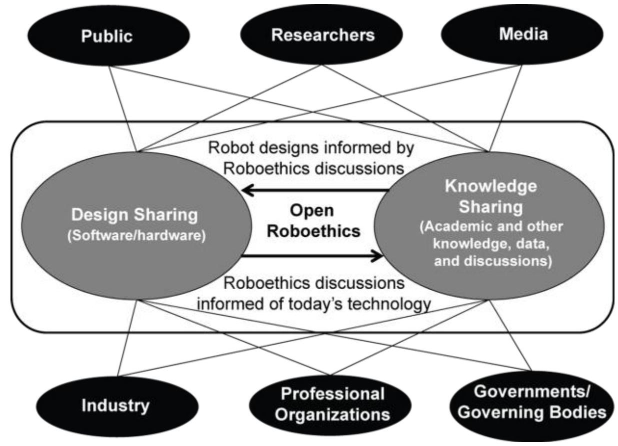


**Figure 1. Overview of the Open Roboethics concept.**

example, Open Roboethics could host open-access behavioural data collected from various human-robot interaction scenarios, such that the data can be analyzed and studied by any interested parties.

In the following sections, we outline how Open Roboethics could accelerate policy and design change to better reflect current states and trends of society as the technology and social norms evolve.

## 3.1 Transparency & Accountability

Understanding and reflecting the values and interests of the public is crucial if a policy is to be established or changed for the betterment of society, and if a design is successfully accepted by its users. We believe that, with a much larger number and variety of people contributing roboethics content, the centralised roboethics knowledge base will provide a lean and transparent means to communicate society's values and needs to policy makers and designers.

The proposed Open Roboethics bottom-up process of issue identification and policy-making will allow us to track the rational steps taken to implement high-level software designs that will define robot behaviour and codify morality. This will become the most socially accepted international mechanism to assure accountability for all types of automated systems: military robots that follow the ROE in war [25], autonomous vehicles that follow the rules of the road, and the many other robots of the future employed in personal, medical and service applications.

## 3.2 Roboethics without Borders

We believe that our proposed approach can help eliminate some of the barriers facing roboethics discussions today. As a web-based tool, Open Roboethics closes geographical gaps between stakeholders of different continents and countries.

It will also help address cultural and language barriers. Given the fact that the three most automated countries are Japan, the Republic of Korea, and Germany [1], language barriers are a key concern when considering international discussion on roboethics issues. We posit that, with a platform that encourages authors to access and contribute content in any language, information written in foreign languages may be translated at an accelerated pace with voluntary contributions by bilingual authors. Such translated information can enable other people to easily understand the cross-cultural perspectives on various roboethics issues.

In addition, Open Roboethics can be a centralised space to foster discussions among individuals in different disciplines and stakeholder groups. This will help close the disciplinary gap – especially between roboticists and social scientists – that currently exists in roboethics today.

## 3.3 Potential Deliverables

Open Roboethics, when established, could provide several useful services and deliverables to industry to help make informed design decisions and to governing bodies to help make informed policy changes.

First, Open Roboethics can provide access to a database of robot related incidents, such that more timely technical improvements and/or policy changes can be made to prevent future incidents. Further, contributors with technical background could provide technical solutions to prevent particular types of future incidents and accelerate the design change process. The opinions from the lay public regarding the incidents could also inform what kinds of design/policy changes are desired by the public, and also inform interested professionals in fields outside of robotics.

Second, Open Roboethics can serve as a valuable means for the industry and governing bodies to access a large pool of stakeholders. Through Open Roboethics, industry and governing bodies could collect crowd-sourced answers to critical questions that affect their design/policy decisions.

Third, as a space where roboethics-related knowledge and discussions will be dynamically collected as digitized data, the public's opinions about particular topics/concerns can be organized in ways that are meaningful to the stakeholders. The qualitative stakeholder opinions to roboethics issues can be quantitatively categorized – or 'tagged' – by the contributors, such that empirically grounded quantitative summaries can be produced to better inform the field. As the Open Roboethics community grows over time, the trend of the public's opinion on various roboethics issues could also be collected and analysed in this way.

Fourth, Open Roboethics could host standardised simulation scenarios to test the performance of a robot's high-level decision-making codes. For example, an accident scenario could be simulated to help identify causes of an incident or potential flaws from a prototype.

# 4. PRACTICAL CHALLENGES

How would the Open Roboethics platform work and sustain itself? This section addresses three practical challenges that face the establishment and development of Open Roboethics: moderating shared content, building a community of contributors and financial sustainability.

## 4.1 Financial Sustainability

Sustainability of the open source organizations heavily depends on continuous financial support. Most of the open source initiatives have been founded by companies and have depended on the contributions of the public to keep their services running. For example, Willow Garage founded, financed and provided technical support to ROS [26], which is currently being widely used by research communities, as well as some industries. Also, the Linux Kernel development team is being supported, to a large extent, by companies such as IBM [27]. The rationale behind company-driven sustainability is that it is a win-win game for both parties. For instance, IBM uses Linux Kernel in their system operations in return for provision of financial support that allows the open source communities to survive and sustain their projects.

There are also open community-driven non-profit organizations that use a sustainable open business model. For instance the annual budget of Wikimedia Foundation was around 4.6 million dollars in 2008 [28].

In order to maintain its financial sustainability, Wikimedia Foundation started a fundraising campaign, and raised approximately $2 million from the public. In this respect, we can categorize Wikipedia as a platform that depends on community support to sustain their projects. On the other hand, ROS and Linux Kernel open source initiatives were supported directly by companies.

A third approach to sustainability is to commercialize some of the services while providing the rest free of charge. For example, Ubuntu is an open-source operating system that provides free access to all users. At the same time, Ubuntu cloud services and some of the add-ons are made commercial, contributing to the financial sustainability of the platform [29].

## 4.2 Building a Community

Second, attracting and motivating participants to contribute content without tangible incentives can be a challenge.

The first step of attracting individual developers to become a part of the team is to have an already developed service to which they can contribute. In his speech on how to start an open source project, the founder of TiddlyWiki project, Jeremy Ruston, said making people wanting to participate is the key successfully building a critical mass of contributors [30].

A good example of this concept is given by the ROS community; ROS contributors started taking part in the conglomeration after the STAIR project at Stanford University had already created ROS and Willow Garage improved upon it [31]. The contributors did not start from the nascent stages of the community, but from where the two had left off.

Other than software development, Willow Garage provided 12 PR2 robots to some of the most reputable universities across the globe free of charge. This allowed the robots to be tested by different robotic researchers, and also led to the creation of a community that shares the same tools and software to conduct research.

But why do those contributors choose to be a part of this community in the first place? Previous studies have shown that the majority of the contributors to open-source projects are self-motivated [17]. They consider the act of sharing as part of their identity, as a means of building reputation, and also giving back to the community.

It is our hope that future contributors to Open Roboethics will see the value of sharing that can exceed individual gain.

### 4.3 Moderating Shared Content

Third, the question remains as to whether the hierarchical moderation approaches well-established in the existing open-source initiatives are appropriate for Open Roboethics.

In knowledge-sharing, a hierarchical system has been implemented. For example, Wikipedia has a group of editors that have a multi-level editorial hierarchy to better maintain the information flow [32]. Other than the group of editors, individual contributors can also edit the articles, which is a huge amount of contribution to the website by itself. Wikipedia foundations reported that 139.3 million edits were made to Wikipedia articles from July 2010 to June 2011. On average, 8,371 new articles are created per day. This shows the power of mass collaboration and the capabilities of individuals who work as a team, with minimum guidance.

Moderation of open source software employs a similar hierarchy-based moderation. The community of Linux Kernel developers is an example that illustrates the hierarchical moderation in an open-source initiative. Since 1991, Linux Kernel developers have already contributed more than 14 million lines of code [33] by organizing themselves mostly through an email list. Even though anyone can contribute to the open-source project, Linus Torvalds, the project manager, is the final decision-maker on all contributions [34].

However, unlike software, where the adverse effects of ill-developed codes typically do not have physical consequences, robotic systems can actually harm their users physically.

In order to prevent the occurrence of such a problem, the ROS community has a core team that is in charge of the regulation of contributions. They review the submitted code before including it in the next release of ROS.

## 5. CONCLUSION

In this work, we introduced Open Roboethics as a promising approach to inform and accelerate policy and design change in the fast-paced field of robotics. Given cultural, religious, and political differences present across the world, we do not claim that Open Roboethics will lead to a one-size-fits-all solution to robotics issues. Instead, we believe it will serve as a catalyst for discussions within and across nations and organisations, such that policies and design changes within the smaller communities can be grounded in transparent and accountable communication between the stakeholders of robotics technology deployment and use.

We also identified and postulated three key practical issues in establishing the centralised online space. As this initiative aims to positively affect all stakeholders of robotics technology, the process of creating Open Roboethics itself is an open and dynamic process. Hence, we welcome feedback from interested stakeholders on designing and building Open Roboethics.

## 6. ACKNOWLEDGMENTS

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