Normative roboticists: the visions and values of technical robotics papers

Martim Brandão

***Abstract*— Visions have an important role in guiding and legitimizing technical research, as well as contributing to expectations of the general public towards technologies. In this paper we analyze technical robotics papers published between 1998 and 2019 to identify themes, trends and issues with the visions and values promoted by robotics research. In particular, we identify the themes of robotics visions and implicitly normative visions; and we quantify the relative presence of a variety of values and applications within technical papers. We conclude with a discussion of the language of robotics visions, marginalized visions and values, and possible paths forward for the robotics community to better align practice with societal interest. We also discuss implications and future work suggestions for Responsible Robotics and HRI research.**

I. Introduction

Robotics research and development has grown considerably in recent years. The flagship robotics conference IEEE International Conference in Robotics and Automation (ICRA) has grown from 155 papers in 1998, to 1024 in 2019; the number of global industrial robot installations has grown 19% per year on average between 2013 and 2018 [1]; and service robot sales between 2017-2018 increased 61% [1]. Robotics companies are also formed each year, many of which are spin-offs of university research. At the same time, research has shown how science-fiction [2] and the social background of typical roboticists and AI researchers [3], [4] influences technical research. Much of robotics research, as science and technological research in general [5], is guided by visions of potential futures [6]. These visions serve to attract attention, secure research spaces, and to discover new research problems [5], [7]. However, a large body of research shows that such technology and its visions also shape society [8], [3].

Given the important role of visions in guiding and legitimizing research, and the recent uptake of robotics research and development, it is then important to understand what the promoted visions are in robotics research, as well as their normative nature and the values that are represented. We argue this analysis is important in order for us in the robotics community to critically analyze and potentially change the visions and values in our research, to in turn better align research with society's needs.

In this paper we are guided by the following research questions:

1) What are the visions and expectations guiding robotics research?
2) What is their normative force?—In particular, what does the language used implicitly say about what is assumed robots and society *should* be like?
3) What applications and values are most and least represented in robotics research?

We answer these questions by a mix of quantitative and qualitative analysis of research papers published between 1998 and 2019. Our contributions are the following: (1) We identify several *themes* of robotics visions, deterministic visions, and implicitly normative statements in research papers (Section III-B and III-C); (2) We quantify the relative presence of a broad set of values and applications in research papers (Section III-D and III-E); (3) We discuss the results in light of other research in Science and Technology Studies and HRI, reflecting on the community's use of language, its marginalized visions and values, and possible paths forward (Section IV).

*Martim Brandão is with King's College London, UK.

II. Related work

A. Studies of scientific writing

Our paper is related to several general studies of scientific writing. These studies have characterized the genre of scientific writing to be self-promotional [9], [10], and based on self-fulfilling prophecies and emotional character [11]. Self-fulfilling prophecies are fueled by the way expectations and technological progress are discussed in scientific discourse [12], and their promotion has also been identified specifically in roboticists' discourse [3]. Scientific writing is additionally characterized by a large number of subjective vocabulary, through the use of such words as "persuasive", "important", "promising", and others, even in abstracts which are commonly assumed to be most objective [13]. Scientific papers have dimensions common to marketing and advertising [14], since authors try to make papers attractive to readers and capture their (scarce) attention through engaging writing [14].

B. Studies of expectations and visions

Expectations studies within the field of Science and Technology Studies have identified multiple characteristics of visions and expectations in science and technology [7]. Expectations are usually technologically deterministic and rely on broader expectations for protection (e.g. the expectation of technological progress) [12]. Expectations are also set high to attract attention and have the appearance of authority [7]. van Lente [12] identifies technological progress specifically as a well-embedded concept that mobilizes support for technology research, even though it represents an ill-defined normative goal [15]. Technological optimism in roboticists, identified by Šabanović [3], also relates to such widespread belief in progress. Expectations are intricately related to research visions. The work of Berkhout [5] comprehensively explores the topic of visions in science and technology: it argues that they work as "bids" on potential futures that are socially

distributed and typically moralized. Visions also serve to map a "possibility space" and serve as a heuristic to identify problems that need to be solved [5]. Visions have ideological and utopian dimensions [16], and in practice do not realize as planned [17]. Bell and Dourish [17] argue that visions can be persistent in a scientific community for long periods of time, even after they seem unlikely.

C. Discourse analysis and visions of robotics

Similarly to this paper, a few researchers have analyzed the discourse employed by roboticists and within robotics. Šabanović [3] analyzed interviews with roboticists, observing that they typically create robots as technological fixes to social problems, and that they are optimistic about the role robotics can have in pushing "society to a better, though consistently vague, future". Other authors such as Fernaeus et al. [18] argue even that current visions entertained by roboticists are unrealistic and risk "reinforcing unrealistic ideas of what robots can do", especially because of the way visions are taken up by media. Cheon and Su [19] also analyzed interviews with roboticists to identify their motivations for becoming roboticists and their views on the field, although they discuss the lack of explicit mention of values and ethics within those descriptions. Compared to [3], [19], in this paper we focus less on researchers' informal discourse about robotics and their experiences within the lab, and more on the visions and expectations *implicitly promoted within their written work*.

III. Literature analysis and findings

A. Data gathering

We collected all papers published between 1998–2019 in the proceedings of the robotics conference ICRA and all papers published in the years 2000–2003, 2006, 2008, 2016, 2018 at IROS[1]. We obtained all full papers in PDF format, thus excluding workshop papers and leading to a total of 21178 papers. We converted the files to text using the `pdftotext` tool, post-processed text to remove white space and hyphenation, and used `grep` commands in a Linux environment to find patterns of text within all papers. Specific search patterns are listed in the appropriate sections below.

B. Visions and expectations

To find examples of text referring to visions and expectations of robotics technology, we searched the papers for the following patterns: "...it is expected that XX robots..."; "...in the future, XX robots..."; "...the next generation of robots..."; "...[robots are / robotics is] expected to..."; "...robots will [one day / soon / be expected to / be part / become / be / play]..."; "...it is predicted that..."; "...of the future will...". The characters "XX" in these patterns represent the presence of zero to 20 characters, which we introduced to allow a qualification of robots (e.g. "humanoid robots", "force-controlled"). The search rendered 242 text sections. We used these text sections to identify the *themes* of explicit expectation statements in robotics. We later describe how we evaluate the (larger) implicit presence of visions related to these themes in Section III-B.3, and discuss the degree of vision dissemination in Section IV-A.

[1]IEEE/RSJ International conference on Intelligent Robots and Systems

TABLE I: Occurrence of expectations and visions

Theme	Explicit	Implicit
Robots in our daily lives	55 (0.26%)	3927 (18.54%)
Robots cooperating with humans	15 (0.07%)	324 (1.53%)
Robots replacing humans	7 (0.03%)	188 (0.89%)
Robots doing dangerous jobs	15 (0.07%)	295 (1.39%)
Robots tackling the aging society	8 (0.04%)	6506 (30.72%)
Robots becoming human-like	4 (0.02%)	3939 (18.60%)
Robots respecting & bridging cultures	2 (0.01%)	1160 (5.48%)

We manually filtered the text results so as to discard those that referred to expectations or procedures of an experiment (e.g. "the robots are expected to choose...", "objects mistaken for robots will be included...") and those that did not refer to expectations of robot technology (e.g. "We present a framework to support the next generation of robots", "parallel robots will be presented in our further study"). This process led to 103 statements of expectations—i.e. 0.5% of the papers in the whole dataset contained explicit statements of expectations using the patterns above. We–the author of this paper–then coded the results by identifying common themes and concepts. We used an inductive coding process: we started by openly assigning themes to each result, and then merging and refining the theme categories in multiple reading rounds. At the end of the procedure, each statement was assigned at least one theme.

We show the identified themes of robot visions and expectations in Table I, together with the presence of each theme ("explicit" column). Both the number of papers found and the percentage *with respect to all papers in the dataset* are shown. The most popular themes are of robots being integrated in our daily lives (55/103), cooperating with humans (15/103), and doing dangerous jobs (15/103).

1) Examples of research visions: Below we provide some example quotes from each of the identified themes.

Robots in our daily lives. The common expectation in this theme is that robots will be a part of our daily lives, co-existing with humans, whether at home:

> In the near future, robots will be sought to become an integral part of our daily life as, for instance, multi-purpose service assistants in our homes. (Flacco, ICRA2015)

Or at work and healthcare facilities:

> Humanoid Robots are expected to exist together with human beings in the everyday world such as hospitals, offices and homes. (Fukaya, IROS2000)

Robots cooperating with humans. In this vision, robots will be actively cooperating and collaborating with humans to jointly complete complex tasks. For example:

> In the near future, more service robots will be assisting and cooperating with humans in many dynamic and complex real-world environments. (Kim, ICRA2015)

Robots replacing humans. Other papers emphasize the role of robots in *replacing* humans in doing certain, often undesired, tasks:

> Robots are expected to substitute human in doing simple factory tasks (Adachi, IROS2018)

Robots doing dangerous jobs. This theme involves both replacement of human work:

> Future robots are expected to free human operators from difficult and dangerous tasks (Park, ICRA2007)

and cooperative or collaborative work:

> Robots are expected to aid rescue workers in dangerous rescue operations (Kurose, IROS2008)

Robots tackling the ageing society. Papers also envision robots with important roles in elderly care:

> Daily assistive robots are expected to play an important role in aging societies. (Nagahama, IROS2018)

Robots becoming human-like. This theme is common with humanoid robotics papers, although it is also mentioned with respect to general "robots" :

> ... future robots will be closer to human than current stage and their bodies should be much more compliant (Mizuuchi, ICRA2006)

Robots respecting and bridging cultures. Examples include robots having to adapt to local cultures:

> These robots will be able to adapt how they behave and speak to the culture, customs and manners of the person they assist. (Khaliq, IROS2018)

as well as bridging different cultures:

> In the future, robots might serve as mediators between cultures (Lugrin, IROS2018)

2) Deterministic visions: We identified a pattern of using the future tense to express expectations and visions of robotics, in a way that implies deterministic events:

> In the future, teams of robots will construct outposts on Mars and orbital structures in space. (Heger, ICRA2008)

> In a few short years, micro-robots will become the gold standard in a variety of industrial, medical, and academic applications. (Rogowski, ICRA2019)

> Robots will be ubiquitous with their complexity masked behind a user interface (Koh, ICRA2007)

> In the near future similar robots will be working side by side with humans in homes, offices, hospitals, and in outer space. (Stoytchev, ICRA2005)

Such visions, as we will discuss in IV-A, reflect a technologically deterministic stance on society—that a future with robots in certain roles is inescapable, and that technology will eventually pervade every aspect of society.

3) Implicit presence of visions: We measured the presence of each vision in the dataset of papers—not only explicitly as in the examples above, but also implicitly. We thus looked, for example, for statements regarding the (wish to) use robots in "daily life" even if these were not stated explicitly as expectations using the patterns above. To do this we searched the papers for words associated with each vision: 1) "daily", "home", "household", "everyday"; 2) "human-robot collaboration", "collaborate XX human", "human XX collaborate"; 3) "replace/substitute XX human", "free human", "instead of human"; 4) "dangerous XX environment/mission/task", "dangerous XX human", "human XX dangerous"; 5) "aging", "elder", "older adult"; 6) "human-like" and "humanoid"; 7) "culture/cultural". Table I shows the percentage of papers where the keywords above were found—i.e. where each vision was found implicitly through the keywords.

TABLE II: Occurrence of normative visions

Theme	Explicit matches
We want robots in our daily lives	21 (0.10%)
We want robots everywhere	10 (0.05%)
We want robots to replace humans	5 (0.02%)
We want robots to be friendly	2 (0.01%)
We want an efficient society	4 (0.02%)

Implicit presence of visions was orders of magnitude larger than explicit expectation statements—for example the "Robot in our daily lives" vision was implicitly present in 18% of papers, contrasting with 0.26% papers where it was explicit. Interestingly, the three last vision themes (i.e. aging/human-like/cultural) become more prominent, with aging-tackling and human-like robots becoming the most present implicitly, and culture-aware robots the 4th most present, after daily-life robots. This difference in prominence within explicit and implicit statements could be related to controversies regarding the desirability of the three visions [20], [21], [22].

C. Implicit normative statements

To find examples of text implying what robots *should* do, or that a certain use or application is *desirable*, we searched the papers for the following patterns: "...for XX robots to..." (e.g. for humanoid robots to be ubiquitous); "...if XX robots are to..."; "...robots have the potential to..."; "...robots should...". The reasoning behind the choice of such "in order for *Y* to be possible" patterns was that they assume *Y* to be desirable according to some criteria—and hence carry normative weight.

The search rendered 710 text sections. We manually filtered the results to focus on normative statements, in particular discarding those statements that did not specify a relationship between robots and humans, nor a target application for robotics (e.g. we discarded entries such as "robots should learn continuously" and "In order for the robots to be in sync"). This process led to 53 normative statements.

We then coded the results, from which we identified the themes shown in Table II. The most popular normative goal was integration into our daily lives (21/53), followed by ubiquity (10/53).

We want robots in our daily lives. This theme is similar to that in III-B, except for a difference in language—while in the previous section we identified *expectations* of robots being an integrated part of our day-to-day activities, here the authors implicitly *assume this integration is something we want*. For example:

> For robots to become life-long companions gathering information and generalizing them to learn new skills is important. (Park, ICRA2015)

assumes robots becoming life-long companions is a legitimate goal, that to be fulfilled requires learning skills. A large proportion of the normative statements were of this type. Other examples include:

> ... for these robots to ever be integrated into the human society, they must look, behave and even think like humans. (Ayaz, IROS2006)
>
> Robots should help people out of chairs. (Shomin, ICRA2015)

And many others such as: "For robots to co-exist with humans..."; "In order for robots to help humans in everyday tasks..."; "For humanoid robots to autonomously act in our daily environment...".

We want robots everywhere. Ubiquity-themed visions assume that robots should be everywhere, for example:

> If robots are to become ubiquitous in personal spaces... (Böhlen, IROS2002)
>
> For robots to be truly ubiquitous... (Kress-Gazit, ICRA2010)
>
> For robots to become widely used... (Gadre, ICRA2019)

We want robots to replace humans. In this theme, robots should replace human action:

> In order for robots to perform actions in place of human hands... (Teshigawara, ICRA2009)

We want robots to be friendly. Here it is assumed that friendliness is a desirable feature of robots, e.g.:

> For robots to be more interactive and friendly to humans... (Kim, ICRA2018)

We want an efficient society. These are statements that express a desire for a more efficient society, that improves "service in terms of accuracy and efficiency" (Che, ICRA2018).

D. Values

We then measured the representation of different values within all the research papers in the dataset. We started by elaborating a comprehensive list of values based on surveys of ethical principles [23], [24]—accountability, beneficence, dignity, fairness, freedom, privacy, robustness, safety, security, solidarity, sustainability, transparency, trust—and expanded the list with other values gathered from an informal survey of robotics papers—accuracy, efficiency, friendliness, reliability, simplicity, usability and usefulness. Then, we chose a list of search keywords that would point to that value being embedded in research[2]. For each value, we refined the keywords until value-unrelated search results were discarded. For example, "explain" is a keyword for "explainability" but leads to many search results on "we will now explain..."—in this case we had to refine the search term to "explain their", as in "robots explain their actions" or "robots should be able to explain their beliefs".

Figure 1 shows the ratio of papers where each value is represented (i.e. the ratio of papers where at least one keyword associated with a value is present). The most consistently

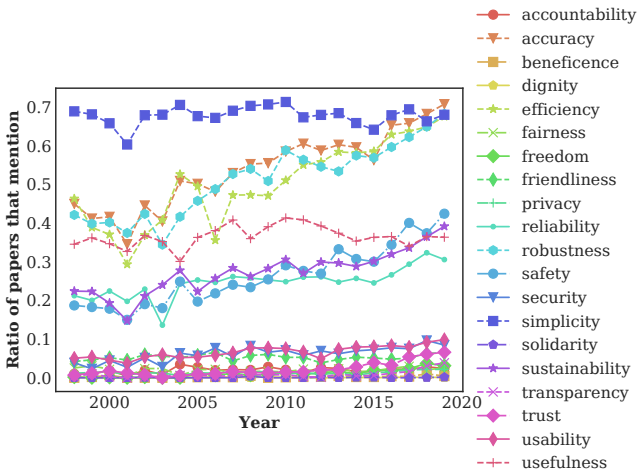

Fig. 1: Values in robotics research.

well-represented value is simplicity—every year, around 70% of the papers mention simplicity-related words. This is related to a focus on creating a "simple model", a "simple framework", or mentioning related work that is "simple". The representation of accuracy, efficiency and robustness has been equally increasing from around 45% in 1998 to 65-70% in 2019. The focus on usefulness is stable at 35%, while safety and sustainability has been increasing from 20% in 1998 to around 40% in 2019. Reliability is stable at 20-25%, while usability has recently reached 10%, security 8% and trust 7%. The rest of values are below 5% per year.

Some values are used with multiple meanings: for example "fairness" (<3%) most often refers to experiments being fair *in their comparison to other technical methods*, while other times it refers to the technical conception or model of fairness (e.g. "path fairness", "network fairness").

E. Applications

Within the research papers, we measured the ratio of papers mentioning each of a set of applications of robotics. Since we count mentions of applications *anywhere* within the papers, these could be both the specific applications considered in the paper's methods and experiments, or applications mentioned in the introduction as potential targets for robot technology or the proposed methods. We started by elaborating a list

[2]*accountability*: accountability, accountable, liability, liable, integrity; *accuracy*: accuracy, accurate; *beneficence*: beneficence, well-being, wellbeing, peace, social good, common good; *dignity*: dignity; *efficiency*: efficiency, efficient; *fairness*: fairness, equity, justice, discriminatory, accessibility, human rights; *freedom*: consent, self-determination, liberty, empowerment; *friendliness*: friendly, friendliness, friend, companion; *privacy*: privacy, private, personal information; *reliability*: reliable, reliability; *robustness*: robust, robustness; *safety*: safe, safety, unsafe; *security*: secure, security; *simplicity*: simple, simplicity; *solidarity*: solidarity, social security; *sustainability*: sustainability, sustainable, nature, natural resources; *transparency*: explainability, explainable AI, explainable robot, be explainable, produces an explanation, explain their, interpretability, interpretable, understandability; *trust*: trust, trustworthy, trustworthiness, trusted; *usability*: usable, usability, user-friendly, user-friendliness, easy to use, ease of use; *usefulness*: useful, usefulness.

of applications and search keywords for each application[3], and then computed the ratio of papers where at least one keyword associated with an application is present. The results are shown in Figure 2.

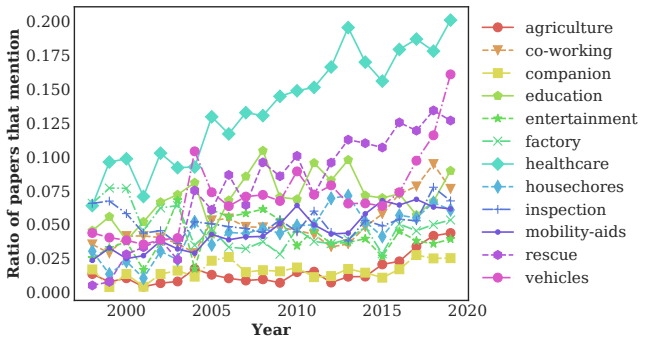

Fig. 2: Applications in robotics research.

Healthcare is consistently the highest-mentioned application of robotics (20%), which is consistent with the prominence of the "robots in our daily lives" and "aging society" visions. Recently, vehicles have surged as the second-most mentioned application, due to an increased interest in autonomous vehicles. Also increasing is rescue robotics, from <1% in 1998 to 12% in 2019. The rest of the applications have been relatively stable at under 10%.

Another thing to notice is the overall increase in application mentions themselves. Computing the ratio of papers mentioning *any* of the previously stated applications shows an increase from around 33% in 1998 to 65% in 2019. This trend suggests a shift in the technical robotics community to application-focused research.

IV. Discussion and Paths Forward

A. Language strategies for promoting visions

One recurring feature of the expectation statements in III-B is the use of the proximate future—the "near future" that is just around the corner. This linguistic choice expresses technological optimism: not only about the problems that robotics can solve [3], but also the ease with which robotics visions can materialize. The use of the proximal future further resembles the pattern of self-fulling prophecies [12], [11], and matches claims that expectations in technology are initially set high to attract attention and build protected spaces for researchers [7]. However, such expectations also carry an appearance of authority and certainty [7], which could be harmful in the sense of transmitting wrong expectations to press, policy-makers, and the general public. An appearance of certainty is also given by the deterministic statements found in Section III-B.2, and the use of an "anonymous predictor"—for example "Robots are expected to play an important role" begs the question: expected by whom? Such use of language hides away subjectivity but is, nonetheless, not rigorous without proper proof of argument.

Finally, in this paper we identified both explicit and implicit vision dissemination. While we found explicit statements were present in only 0.5% of the papers (Section III-B), we expect the real value to be larger than this due to linguistic flexibility—i.e. our search patterns only capture a limited set of statements and robot types. However, our results do show that implicit vision dissemination is widespread—reaching 30% presence in some themes. The intuition for this is that states-of-affairs are often used as a motivation for research: for example, "the use of personal robots is rising" and similar statements are often used to imply they will keep rising, thus also aligning with expectations of ubiquity and integration.

Path forward: Although roboticists typically defend robotics as rigorous science, the use of the proximate future, anonymous predictions, and determinism to provide guiding visions of research partly undermines this stance. Funding priorities and research evaluation metrics are partly responsible for putting pressure on scientists to produce (or promise) novelty fast, and to argue for the urgency and transformative nature of their research—perhaps in an exaggerated way [25]. As a path forward, we believe that the study of scientific discourse and its underlying normative influences [5] should be part of academic training. Relatedly, the focus of responsible academic writing courses should be placed not only on plagiarism and falsification but also on the careful promotion of visions, expectations, and values. The high degree of implicit vision dissemination also raises the question of whether researchers are aware of such dissemination in their writing. We believe we as a community should promote self-reflection and promote a critical attitude towards our promoted visions. We believe that consciously thinking through the research visions and expectations that guide our research in robotics would both benefit our community's trajectory and the calibration of expectations by the press, policy-makers and the general public. Two extreme approaches could be used to tackle this issue: 1) the conscious moderation of promoted visions and value-laden speech; and 2) the explicit though rigorous discussion of guiding visions through argument and/or citation to promote the critique and robustification of visions.

B. Visions are utopian

We identified multiple themes of visions for robotics: robots in our daily (personal) lives, robots cooperating with humans, replacing humans, etc. All these visions were utopian: in an ideal world, robots would be solving many social and technical problems that need to be solved in society. Many of them were also moralized, in the sense that robots are expected to "do good", free humans from harm, etc. Moralization is a typical feature of visions and is used to increase their force and persuasive power [5], so as to

[3] *agriculture*: agriculture, farming; *companion*: companion, robot partner, lonely, loneliness; *co-working*: co-worker, collaboration, teaming; *education*: education; *entertainment*: entertainment, music, musical instrument, musical, sing, comedy, laugh, laughter; *factory*: factory, factories, assembly line, assembly lines, production lines, production line; *healthcare*: healthcare, medicine, medical; *housechores*: housechores, house chores, laundry, cooking, gardening, mopping, cleaning, tidying, kitchen; *inspection*: inspection robot, inspection robots, remote inspection, nuclear, offshore, oil and gas, powerplant, turbine, vessel; *mobility-aids*: wheelchair, disabilities, walking assist, walking assistance, exoskeleton; *rescue*: disaster, rescue; *vehicles*: self-driving, autonomous car, autonomous cars, autonomous vehicle, autonomous vehicles.

in turn secure protected academic space and power [7]. Some of the identified visions (e.g. replacement, aging) are arguably naive by potentially ignoring social components of complex problems of human work [26] and care [20]. This suggests a solutionist [27] approach to robotics that promotes technological fixes to socio-technical problems. However, part of the solutionism in robotics is related to funding incentives: policy makers also look for quick solutions to deep societal problems, and researchers take advantage of this in grant proposal [25].

Path forward: Regarding the realism of current visions, more scrutiny is necessary in evaluating grant proposals to make sure they are realistic, and that they do not take a purely technological approach to complex social problems. Fernaeus et al. [18] argues that visions should go through "reality checks" that investigate whether they can be realized. Current robotics visions are also limited in a different sense—in the lack of variety and responsibility-centered visions, such as dystopian visions. Dystopian visions [5], [6], [28] of lying robots, unexplainable robot behavior, enslaving robots, dehumanizing robots, etc., can be used as undesirable states of affairs that research focuses on preventing. For example, it is the dystopian vision of unexplainable and unaccountable AI that is leading to the recent trend on explainable and transparent AI. Similarly in robotics, we need to more critically think through the potential negative scenarios that could emerge from deploying robots, and use those scenarios to guide research. A similar call for identifying and addressing potential unintended consequences of robot capabilities has been put forward in the Responsible Robotics literature [29], which describes this as forward-looking responsibility of robotics teams.

C. Marginalized values

This paper shows a strong focus of technical research on a set of 4 core values—accuracy, efficiency, simplicity and robustness. Equally noticeable is a set of *marginalized values*: accountability, beneficence, dignity, fairness, freedom, friendliness, privacy, security, solidarity, transparency, trust and usability.

Path forward: While considerable efforts have been made by sub-communities of robotics to increase the discussion on such marginalized values, such as HRI, ROMAN, RoboPhilosophy, ICRES and conference workshops, the fact is that these communities are currently disconnected from technical conferences such as ICRA/IROS. However, if robotics research is to evolve responsibly, critical voices and value-centered robotics also need to reach "purely technical" conferences and researchers. This could be done through separate "social good" and "responsible robotics" submission tracks at technical conferences, but also through ambassador programs and co-location schemes that foster exchange with ethics and HRI venues. One potential barrier to widening the values of robotics research is that the 4 core values are also of high interest to the industry—and therefore to funding agencies who are looking to improve industry competitiveness. Whether or not the diversification of the value-landscape of robotics research will happen will therefore also depend on whether funding agencies decide to privilege responsible innovation—and on researchers' civic participation to help this happen.

D. Implications for Responsible Robotics and HRI

The research community of "Responsible Robotics" (RR) has so far put forth different critiques and frameworks focused on the responsible *development* and *deployment* of robots by designers and other stakeholders [30], [31], [29]. While these are clearly crucial aspects of responsibility, our paper showcases another important aspect of responsible research in the area of robotics—language. In our view, the forward-looking responsibility of roboticists discussed in RR should not only be that of preventing harm from happening due to *design factors and capability-related harms* [29], but also preventing harm resulting from the *promotion of hype, normative visions and unrealistic expectations* in scientific communication [32], [33]. Current frameworks and principles of RR should thus be extended with considerations of language use and implicit promotion of values and visions by researchers, marketeers, other stakeholders, as well as operation manuals and interfaces. Furthermore, insights from this paper could be used to form "objectivity" and "responsible writing" checklists or guidelines for robotics groups, researchers, and other stakeholders to use in their writing.

This work also has important implications for human-robot interaction. First, the widespread implicit promotion of certain normative visions in technical research raises the question of whether and how the (typically more critical) HRI community also disseminates such visions, especially in social and collaboratory applications of robotics so popular within the community. Secondly, our research relates to recent HRI research on robotics and trust [34]. Our insights suggest a need to investigate the kind of influence that technical speech (in robot manuals, instructions, interfaces and HRI experiment setups) has on user expectations and trust, depending on the use of implicit and/or explicit vision promotion. Controlled experiments manipulating the implicitness and degree of normativity of visions in such media could bring forward new perspectives and an important piece of the puzzle of user expectations and trust.

V. Conclusion

In this paper we analyzed the visions, expectations, normative assumptions, values, and applications that are represented in the full text of research papers in technical robotics conferences from 1998 to 2019. We identified multiple visions used by robotics researchers in their work: robots in our daily (personal) lives, robots cooperating with humans, replacing humans, doing dangerous jobs, assisting the elderly, becoming human-like, and respecting culture. We also identified the use of the proximate future (e.g. "in the near future, robots are expected to...") and deterministic future (e.g. "robots *will be* ubiquitous") as common forms of vision expression. We showed that the language used also often assumes certain normative stances—that we *want* robots to be in our homes, to take care of older adults, etc. We then identified four core

values reflected in technical research: accuracy, efficiency, simplicity and robustness. We suggested that marginalized values should be further explored, such as those relating to how robots will be interacting with humans—fairness, privacy, social acceptance, etc.

We finally proposed some possible paths forward. As a community, we argued there is a need to explore currently marginalized visions and values, and a need to study the nature of expectation and vision promotion in academic writing. We further argued for the moderation of our disseminated visions, in order to better calibrate the expectations of the general public; and the need of a shift in technical conferences towards promoting the explicit discussion of robotics visions as part of the main venue. We also discussed some possible research directions following this paper, such as investigating the use of dystopian visions as guides to robotics research that avoids undesired impact, efforts to improve Responsible Robotics frameworks to account for communication, and HRI experiments to understand the influence of implicit vision dissemination in user expectations and trust.

Limitations of our analysis include the use of simple text-pattern searching for identifying visions and values, and the focus on large technical robotics conferences (while excluding, for example, social robotics, humanoid robotics, and HRI conferences). This work could thus also be extended by more advanced NLP-based approaches and studies with a larger and more varied set of datasets and coders for thematic analysis.

ACKNOWLEDGEMENTS

We would like to thank Alan Winfield, Gerard Canal and Masoumeh Mansouri for their valuable feedback, and Alexandre Bernardino for his help with data collection.

REFERENCES

[1] I. F. of Robotics, *World Robotics 2019*. VDMA Services GmbH, 2019.

[2] K. Richardson, *An anthropology of robots and AI: Annihilation anxiety and machines*. Routledge, 2015.

[3] S. Šabanović, "Robots in society, society in robots," *International Journal of Social Robotics*, vol. 2, no. 4, pp. 439–450, 2010.

[4] D. Forsythe, *Studying those who study us: An anthropologist in the world of artificial intelligence*. Stanford University Press, 2001.

[5] F. Berkhout, "Normative expectations in systems innovation," *Technology Analysis & Strategic Management*, vol. 18, no. 3-4, pp. 299–311, 2006.

[6] N. M. Su, L. S. Liu, and A. Lazar, "Mundanely miraculous: the robot in healthcare," in *Proceedings of the 8th nordic conference on human-computer interaction: fun, fast, foundational*, 2014, pp. 391–400.

[7] M. Borup, N. Brown, K. Konrad, and H. Van Lente, "The sociology of expectations in science and technology," *Technology analysis & strategic management*, vol. 18, no. 3-4, pp. 285–298, 2006.

[8] S. Jasanoff, "Future imperfect: Science, technology, and the imaginations of modernity," *Dreamscapes of modernity: Sociotechnical imaginaries and the fabrication of power*, pp. 1–33, 2015.

[9] C. Berkenkotter and T. N. Huckin, *Genre knowledge in disciplinary communication: Cognition/culture/power*. Routledge, 2016.

[10] M. J. Luzón Marco, "The construction of novelty in computer science papers," *Revista alicantina de estudios ingleses, No. 13 (Nov. 2000); pp. 123-140*, 2000.

[11] J. Guice, "Designing the future: the culture of new trends in science and technology," *Research Policy*, vol. 28, no. 1, pp. 81–98, 1999.

[12] H. Van Lente, "Forceful futures: from promise to requirement," *Contested futures: A sociology of prospective techno-science*, pp. 43–64, 2000.

[13] H. Stotesbury, "Evaluation in research article abstracts in the narrative and hard sciences," *Journal of English for Academic Purposes*, vol. 2, no. 4, pp. 327–341, 2003.

[14] J. Law and R. J. Williams, "Putting facts together: A study of scientific persuasion," *Social studies of science*, vol. 12, no. 4, pp. 535–558, 1982.

[15] M. C. McGee, "The "ideograph": A link between rhetoric and ideology," *Quarterly journal of speech*, vol. 66, no. 1, pp. 1–16, 1980.

[16] D. Bodén, "On the pending robot revolution and the utopia of human agency," *Culture Unbound*, vol. 10, no. 2, pp. 208–225, 2018.

[17] G. Bell and P. Dourish, "Yesterday's tomorrows: notes on ubiquitous computing's dominant vision," *Personal and ubiquitous computing*, vol. 11, no. 2, pp. 133–143, 2007.

[18] Y. Fernaeus, M. Jacobsson, S. Ljungblad, and L. E. Holmquist, "Are we living in a robot cargo cult?" in *Proceedings of the 4th ACM/IEEE international conference on Human robot interaction*, 2009, pp. 279–280.

[19] E. Cheon and N. M. Su, "Integrating roboticist values into a value sensitive design framework for humanoid robots," in *2016 11th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*. IEEE, 2016, pp. 375–382.

[20] A. Sharkey and N. Sharkey, "Granny and the robots: ethical issues in robot care for the elderly," *Ethics and information technology*, vol. 14, no. 1, pp. 27–40, 2012.

[21] S. Šabanović, C. C. Bennett, and H. R. Lee, "Towards culturally robust robots: A critical social perspective on robotics and culture," in *HRI Workshop on Culture-Aware Robotics*, vol. 2014, 2014.

[22] F. Ferrari, M. P. Paladino, and J. Jetten, "Blurring human–machine distinctions: Anthropomorphic appearance in social robots as a threat to human distinctiveness," *International Journal of Social Robotics*, vol. 8, no. 2, pp. 287–302, 2016.

[23] A. Jobin, M. Ienca, and E. Vayena, "The global landscape of ai ethics guidelines," *Nature Machine Intelligence*, vol. 1, no. 9, pp. 389–399, 2019.

[24] A. HLEG, "High-level expert group on artificial intelligence," *Ethics Guidelines for Trustworthy AI*, 2019.

[25] A. Winfield, "A crisis of expectations," in *UK Robot Ethics workshop*, 2013. [Online]. Available: https://alanwinfield.blogspot.com/2013/03/a-crisis-of-expectations.html

[26] J. Smids, S. Nyholm, and H. Berkers, "Robots in the workplace: a threat to–or opportunity for–meaningful work?" *Philosophy & Technology*, vol. 33, no. 3, pp. 503–522, 2020.

[27] E. Morozov, *To save everything, click here: The folly of technological solutionism*. Public Affairs, 2013.

[28] T. Chakraborti and S. Kambhampati, "(when) can ai bots lie?" in *Proceedings of the 2019 AAAI/ACM Conference on AI, Ethics, and Society*, 2019, pp. 53–59.

[29] A. van Wynsberghe, *Responsible Robotics and Responsibility Attribution*. Cham: Springer International Publishing, 2021, pp. 239–249.

[30] R. Murphy and D. D. Woods, "Beyond asimov: the three laws of responsible robotics," *IEEE intelligent systems*, vol. 24, no. 4, pp. 14–20, 2009.

[31] M. Boden, J. Bryson, D. Caldwell, K. Dautenhahn, L. Edwards, S. Kember, P. Newman, V. Parry, G. Pegman, T. Rodden, *et al.*, "Principles of robotics: regulating robots in the real world," *Connection Science*, vol. 29, no. 2, pp. 124–129, 2017.

[32] C. Kueffer and B. M. Larson, "Responsible use of language in scientific writing and science communication," *BioScience*, vol. 64, no. 8, pp. 719–724, 2014.

[33] E. Simakova and C. Coenen, "Visions, hype, and expectations: a place for responsibility," *Responsible innovation: Managing the responsible emergence of science and innovation in society*, pp. 241–268, 2013.

[34] B. F. Malle and D. Ullman, "Chapter 1 - a multidimensional conception and measure of human-robot trust," in *Trust in Human-Robot Interaction*, C. S. Nam and J. B. Lyons, Eds. Academic Press, 2021, pp. 3–25.