Integrating Roboticist Values into a Value Sensitive Design Framework for Humanoid Robots

EunJeong Cheon and Norman Makoto Su
School of Informatics and Computing
Indiana University Bloomington
Bloomington IN 47408, USA
echeon@indiana.edu, normsu@indiana.edu

***Abstract*— A good body of work in HRI has investigated how to design humanoids to effectively serve users' needs. This user centered approach has proved fruitful, but there exists relatively little work examining the intent and values of the roboticists themselves. Furthermore, we know little of how the values of roboticists influence their own designs. Such knowledge could help designers better reflect on whether their designs effectively convey particular ethics to their users. In this study, we analyzed 27 interviews of pioneer humanoid roboticists, seeking to identify the values of such roboticists. Our results suggest that roboticists' values are shaped by a dominant engineering-based background that emphasizes robotics as a field of integration (especially humanoids). Roboticists also see robots as testbeds for learning about humans themselves. We advocate a VSD approach for humanoids that goes beyond engineering disciplines and forces values to the forefront of discussion.**

Keywords*— *HRI design; Critical HRI; Humanoid; Value-Sensitive Design (VSD); Roboticists

I. Introduction & Research Motivation

Human-like robots have increasingly entered our personal and social lives. As their technologies mature and become economically viable, humanoids have begun to play a diverse role as our co-workers [1], companions [2], trainers [3], and health care assistants [4]. A robot's human likeness has played a major role in allowing them to fulfill these new roles. These humanoid robots reflect the desire to create a robot nearly indistinguishable from humans in (partly) both outward design and interaction (e.g., through language and gestures). This desire to create beings like ourselves is perhaps an innate human trait, as shown by our creations of the past like dolls, puppets, and automata [5].

There now exist a large body of work in HRI on the design of humanoids. This important work has examined how people (users) respond to and perceive the form and behavior of humanoids (e.g., the experiments testing Mori's uncanny valley hypothesis). What end-users feel and how they interpret robots is vital to understanding how we can more smoothly and naturally incorporate humanoids into our everyday lives. For example, previous studies have shown that people respond more strongly to humanoids than to other non-human-like robots; humanoids were seen as having more moral accountability [6], expected to observe social norms [7], and as feedback for humanoids, people tended to give more formal expressions and less behaviors of touching than for non-human like robots [8].

However, work in HCI and science and technology studies (STS) have emphasized the intertwined nature of a designer's values and perspectives with the resultant design they create. In other words, a *roboticist's values and perspectives are inseparable from the robots they construct* [9]. Yet, how robot designers themselves perceive their humanoid robots has been rarely been discussed. There are some exceptions that discuss roboticists' visions of their robot projects. Such work is cross-cultural in nature, focusing on the different social preconditions in the US and Japan [10] or are ethnographic, revealing the personal stories behind roboticists' robotic works [10].

If we were able to bridge this disconnect—identifying the roboticist's views and unfolding their design process with humanoids, this transparency could make robots more trustworthy for users, ensuring that humanoid robots will be smoothly accepted by the general public.

Furthermore, a study on the roboticists' perception and thoughts will give us a holistic view on the value-embeded design process of roboticists. This perspecitve would go beyond the user-centered view that dominates much of HRI literature. When we can understand the perspectives of roboticists, we can begin to categorize the sorts of designs in robots that are out there and what particular set of roboticist values they encapsulate. For example, some roboticists believe that humanoids should be developed intellectually, behaviorally, and socially to the point that they are nearly indistinguishable from humans. However, there may be an opposite camp of roboticist that opposes blurring the line between human and humanoid. How are such values reflected in the designs of robots? And, can we generalize the strategies by which roboticist values are mapped to robot designs? We may ask whether, for the users' sake, should such values be transparently explicated and communicated in designs? How might this revelation of values effect a user's experience and attitude towards robots?

A. *Research Questions and Overview*

This paper details a study that unpacks roboticists' perspectives in designing humanoid robots and asks how we might integrate such values and perspectives explicitly when designing robots in general. Our project asks: (1) What motivated roboticists to be engaged in developing robots and what meaning does it have for them?; (2) How do they define and views on robots; (3) How are their perspectives, values, experiences, and personal philosophies inscribed in the design of their robots (i.e., their features and functions); and (4) How can we revise a Value Sensitive Design framework to allow roboticists to critically reflect on how their human values are reified in robotics?

We analyze a selection of data from roboticists interviews in the IEEE collection: "Robotics History: Narratives and Networks" [34]. We selected interviews of roboticists who have been involved in at least one humanoid robot project. In total we found 27 roboticists who met this criteria. Our analysis particularly scrutinized portions of the interview where the roboticist discussed the values and perceptions that shaped their life trajectory. Based on our analysis on the interview data, we suggest a design agenda that incorporates VSD with humanoid robot design.

We hope that our research can contribute to expanding the scope of knowledge in HRI research by merging design grounded in research on values and ethics with HRI. Our research seeks to contribute to a particular HRI conference theme this year, *Reflections on HRI.*

Our research reveals that pioneering roboticists actually talk remarkably very little about the values and ethics they have, and how such values should be realized in robot design. Instead, roboticists are often siloed into the disciplines from which they come from. The lack of a coherent "robotic" discipline in the past has lead to the dominant presence of engineering-based values (e.g., physical safety). Roboticists instead often emphasize the lack of a coherent definition of robots and the accidental nature of their research trajectory into robotics. They recognize that robotics is about "integration" of specializations, which makes robotics (and humanoids in particular) both an exciting challenge research-wise and a logistical challenge (bridging disciplines). Our proposed framework details what we imagine a humanoid-flavored version of VSD might look like and emphasize.

II. Related Work

We now turn to previous work in the fields of HRI design and technology design. Because we focus on examining the motivations behind roboticists who work with humanoids, their design processes, and how values might be integrated into humanoid design, our literature review focuses on past work that crosses into design. We examine studies researching the design of humanoid robots, work that mentions the role of the roboticists' values in their design process, and, more generally, how HCI has argued that values should be treated as first class objects in design.

A. Humanoid Robot Designs Studies

There now exist a number of studies focused on user responses to the design of more human-like appearances on robots. Studies have examined human-like faces [13], behaviors [14] and social and collaborative skills [14, 15]. Lab-based experiments and surveys have revealed participants' perceptions and affective states towards humanoid robots. For example, [16] shows that participants felt more positively toward a humanoid when playing a competitive game than when playing a co-operative game with the robot. Another study [17] found that whether or not older adults were willing to accept robots was influenced by the robot's social abilities. Most of these studies do not detail the robot designers' views. There are some exceptions. Some studies involve robot researchers' views by noticing their opinions as robot experts [18], evaluations of a robot prototype [19] or participation in design sessions [20].

Other work [15, 21] has directly asked users if they were able to discern the values inscribed in humanoids during their interaction with such robots. Values such as robots should be reliable, trustworthy, safe and responsible were identified [2, 21]. Although some research [22] have revealed a disconnect between the perceptions of users and roboticists, the roboticists values were not investigated further.

A study [24] explored the design methodologies behind affective robots and the design guidelines conducted in Japan, USA, and Europe. Drawing from social psychology, it was found that a robot's appearance and anthropomorphism were important design factors that contributed to person's successful interaction with robots. Sullins argued that since affective robots were meant to create bonds with humans (rather than work efficiently as some traditional robots do), a consideration of human values should be incorporated into their design. This argument resonates with the motivation for our study—to understand if humans values are incorporated.

B. Design and the Roboticists' Perspective and Values

Design that accounts for or reflects values and ethics have been increasingly emphasized [25]. In a study of roboticists at MIT lab, Richardson [11] found that "robot and robot scientist seemed to mirror each other in unusual ways" (p.20). In other words, what they think the purpose of robots should be may influence the form and function of their robots. [26] argues that "values can be realized in our technologies or these could rather embed and create the opposite (p.95)" depending on a designer's judgment among different design options. Studies in roboethics (e.g. [29]) do acknowledge that because there are no legal guidelines on the design of robots, roboticists have a moral responsibility to create ethically abiding robots. Nevertheless, in most HRI studies**,** the robot designer's responsibilities are merely a footnote, or left without elaboration. We lack any design frameworks or guidelines for responsible robot design.

C. *Value-Sensitive Design (VSD); design approaches to incorporate values in technologies*

VSD is a design approach in HCI devised to push against the dominant user centered approach to design. By arguing that particular core values need to be considered throughout the design process, VSD has brought the designers' ethical and moral responsibility to the forefront [27]. [28] proposed a tripartite method to VSD that comprises conceptual, empirical, and technical investigations, forming an iterative process towards design.

In a study similar to our own, [29] developed a design framework for integrating values and ethics into the actual design process for social robots. In this study, two parts of the

VSD tripartite methodology—the conceptual and technical—were used to integrate values into the design of care robots. “Attentiveness, responsibility, competence, and reciprocity” were core care values that were found to have emerged in during the care context when robots were used to the lift patients. [29]’s framework of values in the design of care robots offered a general outline for the design practices of roboticists. This framework was not developed further as a design requirement for the design process.

Other approaches to HCI share some commonalities with VSD—for example, Value Conscious Design and Value at Play [30, 31], Reflective Design [32], and Critical Technical Practice [33] etc. Among these methodologies, we adopt the tripartite methodology of Value Sensitive Design (VSD) which consists of conceptual, empirical, and technical investigations [28]. Each investigation is mapped to our research questions: what values do roboticists have (conceptual), how are those values are considered (prioritized or traded-off) in design practice (empirical), and how are these intended values realized into the final design (functions and features) of their robots (technical).

As past work attests, values are situated in a variety of places during the design process: stakeholders (users, designers and engineers), the intention behind research projects, external and internal regulations, codes of ethics, etc. [35]. We envision that a framework that accounts for values in robot design will need to take into account the multiple places in which values have a role during design.

III. Methodology

In this paper, we wished to examine to what extent do roboticists think about their own values/ethics in the design of their robots. While roboticists may not explicitly state their values, their motivations for becoming roboticists and their concerns of their discipline may provide a glimpse into their own values.

A. Data Collection

We examined the interviews from the IEEE Robotics and Automation Society (RAS) website. The interviews was conducted for a robotic history project entitled, “Robotics History: Narratives and Networks." Researchers interviewed over 90 pioneer roboticists of different specializations and countries. These interviews were not focused on their academic papers, but on their personal experiences and life stories. Questions were asked about roboticist’s youth, motivations to start robotics, challenges they faced in research, prospects for future robots, etc.

This data is particularly useful for our study which aims to unpack roboticist’s perspectives and reflections since the data is “revealing how individual values and actions have shaped robotics” and “how particular past experiences are shaping present-day actions and values” [34]. Another advantage of examining seasoned roboticists is that they may have a more nuanced viewpoint of the design process of robots as well as a broader perspective on the direction of robotics as a field. Such roboticists also play a powerful role in shaping how robots are designed by their students.

B. Sampling Methodology

We selected 27 of the interviews to qualitatively analyze roboticists whose research have intersected with humanoid robots development. Humanoid robots arguably require more consideration of ethical and value related issue compared to other types of robots. They must often interact with people and in relatively unrestricted environments with people. Design decisions must be made in terms of their human-likeness such as appearance or communication methods. For brevity’s sake, each of our 27 humanoid roboticists are identified with an ID number (e.g., R13 = Roboticist 13th from the RAS data set).

IV. Data Analysis & Findings

We closely looked at the roboticists’ academic journey from their youth to their current position—particularly what made them become interested in robotics, how they got into the robotics field, and how their robotic research interests have evolved. This allowed us to explore how a roboticist’s perceptions and values have formed throughout their life trajectory. Richardson [11] points out that a roboticist’s personal stories and experiences tend to feed into the development of robot designs. She notes that “robotic scientists were often unaware that the models they used for their machines were connected with their own personal difficulties—robots are intertwined with their makers in psycho-physical terms” (p.109). Niu et al [36] also notes that constantly defining and redefining the relationship between humans and artifacts depends on “the imagination and ingeniousness of robot designers” (p.53).

Thematic analysis [37] was conducted to generate themes revolving around values from the interview data. In order to analyze the data rigorously, each researcher individually coded the data first, and then throughout several discussions and comparisons of initial codings, both researchers generated coherent themes together. Our analysis focused on how roboticists responded to values related questions such as their motivation to do robot research and what robots meant to them. Our first roughly categorized themes dealt with themes such as a roboticist’s perceptions of robots and research interests. These themes were then refined into more focused, deep subthemes. For example, codes under the theme of ‘perception on robots’ were divided into specific themes such as ‘perception of humanoids’, ‘the definition of robots,’ and ‘perception gap between roboticists and the public’. Most of our values related themes (e.g., ‘reliability’, ‘safety’, ‘transparency’, ‘ethics’ and ‘human dignity’) were refined this way into subthemes.

A. Motivation & Pathways to Becoming a Roboticist

1) Roboticists from outside Robotics

Most of the roboticists had an engineering background but not all of them were only involved in engineering since ther undergraduate studies. For instance, some of the roboticists pursued pure science such as chemistry, mathematics or physics, and then got started with engineering studies by chance. One roboticist mentioned that he was encouraged by a famous robotic researcher at that time and eventually he decided to study computer science first before entering into robotics. *"…he said okay the only possibility then we are working in robotics, robotics is such and such…you have no graduation in robotics and so on…But first you try to get the graduation in computer science… after two years I succeeded in getting graduation in computer science." (R14)* [38]

Roboticists often have a narrowly defined specialty that has been achieved throughout their academic pathways in engineering. Their specialized areas that were mentioned in our interviews are broadly bioengineering, automation, image processing, artificial intelligence, and mechatronics. These specialties served as a foundation for roboticists to contribute to robotics by advancing a robot's sensors, pattern recognition, real-time controls, arm, fingers, and movements. Surprisingly, for nearly all of our interviewees, robotics only happened in the latter part of their academic career while only two of them entered robotics relatively early on by receiving a doctoral degree in robotics. Also, in terms of their research in robotics, most roboticists were invited to join newly-launched robotic projects to utilize their specialty to support key parts of a robot's functions or features.

2) The "Serendipitous" Roboticist

We found that more than a half (N=17) of our 27 roboticists stumbled into robotics. Robotics was not something these researchers sought to study: 10 of them were accidental roboticists and 7 of them were gradually becoming roboticists by expanding on their research interests. A roboticist is not necessarily a person who always has dreamed about developing robots since their childhood which is often described in fiction and movies.

Ten of our roboticists entered into robotics by chance – influenced by people they met, following their advisor's new research projects, joining new labs, or being encouraged from their colleagues in robotics. For example, R2 [39] said that "*I like to call myself a "serendipitous roboticist." I kind of stumbled into it for – in an odd way...I've had a passion for science from my youth, but not for – specifically for robotics.* (R2)". Similarly, R5 [40] says, "*It's by circumstances because you meet people. ... it just happened to be that he had the European research project in robotics starting around that time for which he was looking for people. And that's how you roll into a certain domain that you had no idea, or no ambition for before or during your studies, so by accident.* (R5)"

For seven roboticists, they gradually expanded their research agenda to finally arrive at robotics. For these roboticists, robotics was the right area to expand to at the time. Interviews with R7 [41] notes that the time was ripe to leverage new technologies in a new robot: "*So how to collaborate with a sensor networks and cyber network on cyberspace informations? That means the Internet, not only the standalone visible robot. So after that we just proposed to the government the combination of the visible type robot and the sensor network and the Internet information. And so after that we just proposed the concept of the networked robot. (R7)*

Robotics became a promising place for previous non-roboticists to realize their intellectual curiosity or an alternative way to solve their research questions. For example, building a robot was a way of solving research problems to R15 [42] as he said that "*so I thought instead of an analytic approach to understanding intelligence a more synthetic approach would be warranted, which then got me into actually starting to think about building robots. … I joined the GRASP Lab there and started really doing hard-core research in robotics.(R15)"* Sometimes a robot was considered as a tool for testing their own research tasks. R4 [43] 's comments clearly demonstrated this "*I thought that it was a good way of testing your algorithms, … I mean, the robotics gives you a very good testing of your sensory processing, so that's what I focused on.*(R4)"

The rest of our interviewees (N=10) pursued robotics on their own volition while researching other fields. Some wanted to try something new and it led them into robotics. According to R8 [44], he said that "*I studied mechanical engineering. Of course it was very interesting, but most of that is a little bit classical. So I want to do something new, and at that time I found robot can be a very interesting research topic."(R8)*

3) An Epiphany: I am a Roboticist

In our findings, roboticists often realized only later that what they have been doing all the time could be labeled as "doing" robotics. In this way, some roboticists said that they haven't thought that what they developed would become a component of robots or a robot itself. R21 [45] confessed that he didn't be conscious of what he made but could notice later that it became suddenly a robot: "*So before I building my first robot in the year 2002 my most interest was to realize the control in the real field; I try to implement all my theory into real thing. So naturally I did research related on robots but not essentially robots, for instance servo controls and sensing eventually became a robot. (R21)"* Having an experience in a leading robotics laboratory and interacting with other roboticists often inspired researchers to expand their research area into robotics.

4) Humanoids as a Lens into Humanity

Roboticists do not necessarily create or study humanoids because they have an underlying fascination with robots themselves. Many roboticists see humanoids as a pathway to help answer fundamental questions of humankind itself. R13 [49] summarizes this viewpoint, "*There is always this idea that robotics is about robots. Actually robotics is…this body of science that we are developing…with models…to explore articulated body systems, high-dimensional spaces…insight[s] coming from the physical world."* Humanoids give roboticists the excuse to study fundamentals of human physical motion, language (R22 [54]), intelligence (R17 [55], R23 [52]), emotion (R23). R15 [42] further summarizes that robotics is not merely a solution to a task (e.g., to go from point A to point B) but about the "*fundamental science*" behind it.

More concretely, humanoids provide an opportunity to observe, theorize, and test fundamental models of human body and mind. R4 [43] considers humans as "*very nice mechanical, dynamical systems*" with which one can build models upon. Humanoids push us to observe ourselves—e.g., how our fingers move and how we walk—to create models.

Roboticists are attracted to the discipline because it offers a testbed or experimental playground in which to test fundamentals of human nature (e.g., concepts and theories of mind and body). As R23 [52] philosophically states, building a humanoid is a quest to discover the "*origin of living things, or the origin of…intelligence*."

B. Definition of Robots

There were few central or standardized themes or concepts found in defining a robot. The definition of robot was unclear even among roboticists who have worked in robotics for years. Some followed "famous" definitions of robots, for example, by Bekey or Wolfram. According to R16 [46] , he said that "*The definition Dr. Bekey used today and his talk was rather good, I think, a machine that senses, processes information, and acts – acts physically within the environment, interacts with the physical world. That's good enough. (R16)*"

Even though their definition may be flexible, a few roboticists did seem to have their own concrete definition of robots. When these interviewees described robots, some consistent themes appeared: for example, 'complex' (R5) and 'integration of important studies" (R11), and 'special' or 'new' (R21). According to R21 [45], autonomy, control, and mobility were also aspects of a robot's definition. For examples, R21 [45] said that *"…the combination of those stuff would be a robot because robot is a new creation to do special things…Robot doesn't need to be a specific shape or function; it's just any, any motion with certain level autonomy, certain level of control.. and a communication form there and mobility. That's it. (R21)".* Interestingly, among those roboticists who articulated what a robot is, none of them were "serendipitous" roboticists. They were all people who started robotics by on their own- through strong interest.

C. Robotics: A Science of Integration

R5 [40] calls robotics a "*science of integration*" that "*requires you to have expertise in other sub domains before you start applying in robots*." As shown in Section 4.1, roboticists, especially those from an engineering background, have specializations (e.g., creating the "eyes" of the humanoid through computer vision, the "fingers" of humanoids through grippers via mechanical engineering). The humanoid most represents the ultimate integration of these specializations—it is a "*good source to integrate everything—the visions system, and manipulation, mobility, leg, and intelligence, and communication interface"*(R10) [48]. The discipline of robotics will remain stagnant unless "we really bring that understanding between people in computer science and electrical engineering, mechanical engineering, to really understand what are the issues and the problems (R13)." [49]

Our roboticists found this integration invigorating (sometimes more than their original research field). R2 [39] clearly referred to this point, "*And it's always been extremely fruitful for me to work with folks in other domains, and now that has been more recently extended to lawyers and philosophers, and others, as well, too. That's the thing I find most exciting about the field, is the ability to grow in new dimensions. … Robotics is.. a wide-open frontier."(R2).*

Integration, however, represents an incredibly difficult problem that is trivialized by popular discourse around robotics. College students simply want to "become" roboticists. In a number of interviews, roboticists believed that you first needed a fundamental education and then you could delve into robotics—"*You're an electrical engineer first. Then you're in robotics. You're not a robotics engineer and then become familiar with electricity.*"

At the same time, the multidisciplinary nature of robotics makes it daunting for newcomers (R13). Humanoids especially require integration of sometimes disparate fields—making it an attractive thing to build and study because of its inherent challenges but perhaps out of reach for newcomers.
Challenges and task driven goals are one way to force integration to succeed. Some of the roboticists mentioned the DARPA grand challenges as well as Robocup: (R15): "*The question in robotics is what is that kind of big problem that we're going after…that's what the DARPA Grand Challenges have been, right, let's define an actual task"* (R20) [50]. Challenges create a robot that equally weighs disciplines

Yet, many of the interviewees related stories in which integration did not succeed or was a hassle. R21 [45] notes the problem with integrating specialists: "*There's no tangible robot yet. So actuator is important, combination, intelligence…we have to do everything at the same time…[A]ll the specialists say that they 'My part is most important.' <laughs>…So they cannot make decisions.*" R23 [52] remarked on trying to work with psychologists but failing to find common ground in their goals. R9 [53] similarly talks of the divide between AI and mechatronics: "*We have to do logistics and AI. And then the robot community, those who were working on the real robots, were frustrated and said 'Well, the AI people are promising too much.'…We need both areas, the mechatronic one and the software and intelligence and cognition one. Only if they both cooperate in an optimal way we will get out the robots which we'll need in the future"*.

V. Discussion

Perhaps our key finding is what, despite our best efforts, we did *not* find, Although interview questions in our dataset probed the definitions of robots, motivations behind becoming roboticists, and the future of humanoids, we found very little mention of values or ethics. We acknowledge part of this may be due to the nature of the interviews that were meant to capture an oral history of robotics as a field—such oral histories may gloss over personal motivations or philosophies on robots. However, as we will discuss later, we found that roboticists did discuss safety—so they are not completely dismissing values.

Our findings do show, however, that the motivations and pathways of roboticists are often narrowly focused and heavily influenced by their backgrounds (e.g., engineering). Yet, roboticists recognize that there is a "big picture"—that disparate, specialized parts combine together to form a humanoid. Roboticists are fascinated by humanoids precisely because they represent a "hard" problem/challenge (sometimes a very specific problem) to solve and may reveal fundamentals about human nature itself. Yet, integration, whether by a definition of robots or through the collaboration of different disciplines is not something roboticists seem to think much about in their daily lives.

In this section, we propose an agenda for incorporating value into humanoid design. This design framework builds upon VSD, creating a robotic specific design process that integrates value into conceptual, empirical, and technological investigations. This framework can help to give roboticists a value centric perspective into design, uncover values that are ignored in robotic design today, and a way to integrate and see the "big picture" of robot design—an issue that roboticists often describe in their interviews.

A. For Conceptual Investigations: Going Beyond Engineering-focused Values

Research has shown that interviewing the creators of their products themselves can be a fruitful exercise (e.g., in examining how designs created by software developers reflect their values [56]). In the roboticists' interviews, we did find some values they were concerned with: safety, reliability, transparency, and human dignity (ethics). By far, safety—an engineering-focused value—was discussed the most. Consequently other possible ethical values (e.g., trust) were ignored. The pathways and motivations of our roboticists may explain this engineering grounded value system.

In VSD, the conceptual investigation is where possible values are identified and redefined as a new concept appropriate to the target context. Depending on contexts and agents, the same value could have diverse meanings. For example, 'safety' may be conceptualized differently in the context of designing a user interface and of designing a robot. Also it could be a safety toward humans such as users or designers (in an experiment) or safety toward the robots themselves. Such multi-dimensions (e.g., whose value, what contexts, the types of robots) to be considered in value often make creating a value-related agenda or guideline tricky to deal with. Which dimension should be focused on the most is not easy to decide.

According to the roboticists in the interviews, safety had a quite straightforward meaning to roboticists. To many roboticists, safety oriented "users" and "physical safety" in the context of interactions with a robot. For example, R23 [52] exemplifies the concern with safety many roboticists had: "*In my case, the safety means safe human robot interaction. So the robot works around the human. The robot has safety functions. So the industrial robot, there are many kinds of robot. There are some say, isolate by the fence or something….The safe robot means that a robot can have the physical interaction with human. That means safe. Safety." (R23)*

If we understood how roboticists interpreted other values (non engineering-focused values) such as dignity and trust, we might have a better design framework based on their perceptions by identifying which value is lack of and complementing such values.

B. For Empirical Investigations: Cultural and Spiritual Aspects of Values should be Accepted in the Definition of Robots

The second phase of VSD as empirical investigation is to assess values imbued in technologies. In order to evaluate appropriately whether an intended value is realized in a robot's design, we might start by having a united definition of robots. Such a definition is important given that how we define a robot is not separable from how we perceive it. For example, P5 [40] also pointed out this. "*Perception is a very important thing. And people put a lot of perception in the system, in the machine, depending on how it looks like, or how it is called. So calling something a humanoid robot, that gives a lot more expectation, perception in the humans than calling the same device a tree-structured robot, and it's a valid name. (P5)*" Despite the diversity in a robot's definition, common themes did arise when roboticists defined robot. Nearly all of them were about technical aspects of robots such as autonomy, control and mobility. This implies that roboticists often perceive a robot as a machine, which may make it hard to incorporate human values into robot design.

We argue that cultural and spiritual values (e.g., mind, emotions) are should be acknowledged as one of components in the definition of robot. This may facilitate not only the development of a standardized definition among the same culture but also an understanding of robots in different cultures. In this regard, roboticists actually recognized how robot's definition can be diverse according to different cultural values. This is articulated well through R23 [52]'s comments. *"Many Japanese or most of Japanese accept to consider the mind and kokoro in the robot artificial of things. But in America and Europe, it is very difficult to introduce such kind of philosophy or concept because.... We are easily sympathize with such kind of dolls or the artificial things, but resemble to the animal or the humans. Robot is for it's come from the difference of the culture or the religion.. That's a big difference, difference with the culture and concept (R23)"*

Given this, it may be challenging to devise a centered definition of robot. However, roboticists might be made aware of important values in design process if the desired values and concepts, according to cultural differences, were explicitly articulated in the definitions of robots. This may clarify which value should be prioritized during the empirical investigations of robot design.

C. For Empirical & Technical investigations: Participatory Design (PD) Workshops with Non-traditional Stakeholders.

The empirical and technical phases in VSD allows us to evaluate how conceptualized values are identified throughout one's interaction with the technology. Participatory Design (PD) is a design method in HCI that by makes users an active and equal participant of the technology design process. Throughout the user's participation in design decisions, PD is proposed to not only empower users with knowledge of technology but to also produce insightful design implications. While PD in HRI has not been a common method, it has successfully brought critical views and discussions into the design and meaning of robots. [57]

Regarding this, PD would be one of possible methods to conduct empirical or technical investigations of VSD in robotic design. For example, how participants discover and interpret intended values can be observed throughout PD. In particular, inviting non-traditional stakeholders to the robot design workshop would be one of routes to allow roboticists to explore different interpretations on robot design. P23's interview about how children's approaches were different from adults illustrates this very well: *"[W]hen the robot's safe then you suddenly realize the children playing with it are adapting to the robot. They're finding the lowest common denominator and playing. The adults playing with it are trying to figure out how to make the robot break. They're trying to demonstrate that they're better than the robot, and the robot is incompetent at some level of performance. And the children, in fact, as soon as they discover some way that the robot is incompetent cleverly and quickly learn how to avoid that particular stage of interaction…And so it can actually interact within a more sophisticated way. (R20)"*. As pointed out, inviting users together with their children in the design workshop and observing children's "genuine" (or unbiased) interaction may allow us to access value-embedded design. Other possibilities of non-traditional stakeholders include lawyers and judge, as hinted by R16 [46]: "*It's lawyers who work with juries and judges to determine liability for injuries or death of human beings as a consequence of the function of machinery. I don't see robots as being much different in that regard, except for the ability of robots to act more pervasively and more autonomously*."

VI. Conclusion

We have just described a Value Sensitive Design framework to helping roboticists reflect on their values and intentions during their design processes. This framework drew from our attempt to unpack roboticists' perceptions and views. These perceptions were themselves extrapolated from our roboticists' life trajectories and their robotics research stories. Their accidental, unplanned, fragmentary pathway to robotics has helped to inform suggestions on how values might be integrated into the stages of investigation in VSD.

Our contributions include a closer view onto what motivates roboticists to do what they do, and what concerns do they have about their own discipline. We found that roboticists talk very little about values and ethics, but instead relish how robots provide a research playground to investigate fundamentals of humans as well as technical aspects of their specific expertise (e.g., vision). This emphasis on a narrow range of ethics/values suggests that a VSD process for humanoids needs to expand its scope beyond engineering-like values, emphasize a united definition of robots that includes cultural and spiritual aspects, and the involvement of non-traditional stakeholders in design to precisely bring/force such values to the forefront.

Our research is a first step to creating a more holistic viewpoint on robot design that encompasses both the user's and robotistic's values. It is also an attempt to bridge the good work that has been done in STS, roboethics, and sociology with HRI design. By not taking morals and values as a secondary foci in humanoid design, we can hope to create transparency between users and designers, allow designers to reflect on both concious and unconcious mappings of values to their creations, and ultimately create humanoids that support the well-being of both humans and robots themselves.

References

[1] A.Sauppé and B. Mutlu. "The Social Impact of a Robot Co-Worker in Industrial Settings." In *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems*, pp. 3613-3622. ACM, 2015.

[2] M.Salem and K. Dautenhahn. "Evaluating Trust and Safety in HRI: Practical Issues and Ethical Challenges." in Emerging Policy and Ethics of Human-Robot Interaction : A Workshop at 10th ACM/IEEE Int Conf on Human-Robot Interaction (HRI 2015) .

[3] B. Robins, K. Dautenhahn, R. Te Boekhorst, and A. Billard. "Robotic assistants in therapy and education of children with autism: can a small humanoid robot help encourage social interaction skills?." *Universal Access in the Information Society* 4, no. 2 (2005): 105-120.

[4] E. Broadbent, R. Stafford, and B. MacDonald. "Acceptance of healthcare robots for the older population: Review and future directions." *International Journal of Social Robotics* 1, no. 4 (2009): 319-330.

[5] E.G. Wilson. The melancholy android: on the psychology of sacred machines. SUNY Press, 2012.

[6] P.H. Kahn Jr, T. Kanda, H. Ishiguro, N.G. Freier, R. L. Severson, B.T. Gill, J.H. Ruckert, and S. Shen. "“Robovie, you'll have to go into the closet now”: Children's social and moral relationships with a humanoid robot." *Developmental psychology* 48, no. 2 (2012): 303.

[7] D.S. Syrdal, K. Dautenhahn, M.L. Walters, and K.L. Koay. "Sharing Spaces with Robots in a Home Scenario-Anthropomorphic Attributions and their Effect on Proxemic Expectations and Evaluations in a Live HRI Trial." In *AAAI Fall Symposium: AI in Eldercare: New Solutions to Old Problems*, pp. 116-123. 2008.

[8] A. Austermann, S. Yamada, K. Funakoshi, and M. Nakano. "How do users interact with a pet-robot and a humanoid." In *CHI'10 Extended Abstracts on Human Factors in Computing Systems*, pp. 3727-3732. ACM, 2010.

[9] W. Wallach and C. Allen. *Moral machines: Teaching robots right from wrong*. Oxford University Press, 2008. pp.39

[10] G. Shaw-Garlock. "Looking forward to sociable robots." *International Journal of Social Robotics* 1, no. 3 (2009): 249-260.

[11] K. Richardson. An Anthropology of Robots and AI: Annihilation Anxiety and Machines. Routledge, 2015.

[12] B. Friedman, P.H. Kahn Jr, A. Borning, and A. Huldtgren. "Value sensitive design and information systems." In *Early engagement and new technologies: Opening up the laboratory*, pp. 55-95. Springer Netherlands, 2013.

[13] C.F.DiSalvo, F. Gemperle, J. Forlizzi, and S. Kiesler. "All robots are not created equal: the design and perception of humanoid robot heads." In *Proceedings of the 4th conference on Designing interactive systems: processes, practices, methods, and techniques*, pp. 321-326. ACM, 2002.

[14] C. Breazeal, A. Edsinger, P. Fitzpatrick, and B. Scassellati. "Active vision for sociable robots." *Systems, Man and Cybernetics, Part A: Systems and Humans, IEEE Transactions on* 31, no. 5 (2001): 443-453.

[15] P. J. Hinds, T. L. Roberts, and H. Jones. "Whose job is it anyway? A study of human-robot interaction in a collaborative task." *Human-Computer Interaction* 19, no. 1 (2004): 151-181.

[16] B. Mutlu, S. Osman, J. Forlizzi, J. Hodgins, and S. Kiesler. "Perceptions of ASIMO: an exploration on co-operation and competition with humans and humanoid robots." In *Proceedings of the 1st ACM SIGCHI/SIGART conference on Human-robot interaction*, pp. 351-352. ACM, 2006.

[17] M. Heerink, B. Kröse, B. Wielinga, and V. Evers. "Enjoyment intention to use and actual use of a conversational robot by elderly people." In *Proceedings of the 3rd ACM/IEEE international conference on Human robot interaction*, pp. 113-120. ACM, 2008.

[18] D.C. Scherer. "Movie Magic Makes Better Social Robots: The Overlap of Special Effects and Character Robot Engineering." *Journal of Human-Robot Interaction* 3, no. 1 (2014): 123-141.

[19] A. Sauppé and B. Mutlu. "Design patterns for exploring and prototyping human-robot interactions." In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pp. 1439-1448. ACM, 2014.

[20] H.R. Lee, S. Šabanovic, and E. Stolterman. "Stay on the boundary: artifact analysis exploring researcher and user framing of robot design." In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pp. 1471-1474. ACM, 2014.

[21] M.Salem and K. Dautenhahn. "Evaluating Trust and Safety in HRI: Practical Issues and Ethical Challenges." in Emerging Policy and Ethics of Human-Robot Interaction : A Workshop at 10th ACM/IEEE Int Conf on Human-Robot Interaction (HRI 2015) .

[22] A.Weiss, J. Igelsböck, D. Wurhofer, and M. Tscheligi. "Looking forward to a “robotic society”?." International Journal of Social Robotics 3, no. 2 (2011): 111-123.

[23] B.R. Duffy. "Anthropomorphism and the social robot." Robotics and autonomous systems 42, no. 3 (2003): 177-190.

[24] J.P. Sullins. "Friends by design: A design philosophy for personal robotics technology." In Philosophy and Design, pp. 143-157. Springer Netherlands, 2008.

[25] L.E. Holmquist and J. Forlizzi. "Introduction to Journal of Human-Robot Interaction Special Issue on Design." *Journal of Human-Robot Interaction* 3, no. 1 (2014): 1-3.

[26] I. Oosterlaken. "Design for development: A capability approach." *Design Issues* 25, no. 4 (2009): 91-102.

[27] D. Fallman. "The new good: exploring the potential of philosophy of technology to contribute to human-computer interaction." In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 1051-1060. ACM, 2011.

[28] B. Friedman and P.H. Kahn Jr. "Human values, ethics, and design." In The human-computer interaction handbook, pp. 1177-1201. L. Erlbaum Associates Inc., 2002.

[29] A. van Wynsberghe. "Designing robots for care: Care centered value-sensitive design." Science and engineering ethics 19, no. 2 (2013): 407-433.

[30] M. Flanagan, D.C. Howe, and H. Nissenbaum. "Embodying values in technology: Theory and practice." Information technology and moral philosophy (2008): 322-353.

[31] M. Flanagan, D. C. Howe, and H. Nissenbaum. "Values at play: Design tradeoffs in socially-oriented game design." In Proceedings of the SIGCHI conference on human factors in computing systems, pp. 751-760. ACM, 2005.

[32] P.Sengers, K. Boehner, S. David, and JJ. Kaye. "Reflective design." In Proceedings of the 4th decennial conference on Critical computing: between sense and sensibility, pp. 49-58. ACM, 2005.

[33] P. Agre. "Toward a critical technical practice: Lessons learned in trying to reform AI." Bridging the Great Divide: Social Science, Technical Systems, and Cooperative Work, Mahwah, NJ: Erlbaum (1997): 131-157.

[34] S.Sabanovic, S. Milojevic, P. Asaro, and M. Francisco. "Robotics Narratives and Networks [History]." *Robotics & Automation Magazine, IEEE* 22, no. 1 (2015): 137-146. & Online EEE History Center archive: [Online]. Available: http://www.ieeeghn.org/ wiki/index.php/Oral-History:Robotics_History:_ Narratives_and_Networks

[35] I.Van de Poel. "Values in engineering design." (2009). In Anthonie W. M. Meijers (ed.), Handbook of the Philosophy of Science. 973-1

[36] S.D. Niu, S. McCrickard, and S. Harrison. "Exploring humanoid factors of robots through transparent and reflective interactions." In Collaboration Technologies and Systems (CTS), 2015 International Conference on, pp. 47-54. IEEE, 2015.

[37] V. Braun and V. Clarke. "Using thematic analysis in psychology." *Qualitative research in psychology* 3, no. 2 (2006): 77-101.

[38] Jean-Paul Laumond, an oral history conducted in 2011 by Selma Šabanović with Matthew R. Francisco, Indiana University, Bloomington Indiana, for Indiana University and the IEEE.

[39] Ronald Arkin, an oral history conducted in 2014 by Peter Asaro, Indiana University, Bloomington Indiana, for Indiana University and the IEEE.

[40] Herman Bruyninckx, an oral history conducted in 2011 by Peter Asaro, Indiana University, Bloomington Indiana, for Indiana University and the IEEE.

[41] Norihiro Hagita, an oral history conducted in 2013 by Peter Asaro, Indiana University, Bloomington Indiana, for Indiana University and the IEEE.

[42] Daniel Lee, an oral history conducted in 2014 by Peter Asaro, Indiana University, Bloomington Indiana, for Indiana University and the IEEE

[43] Ruzena Bajcsy, an oral history conducted in 2010 by Peter Asaro with Selma Šabanović, Indiana University, Bloomington Indiana, for Indiana University and the IEEE.

[44] Shigeo Hirose, an oral history conducted in 2011 by Selma Šabanovic with Matthew R. Francisco, Indiana University, Bloomington Indiana, for Indiana University and the IEEE.

[45] Jun Ho Oh, an oral history conducted in 2012 by Peter Asaro and Selma Sabanovic, Indiana University, Bloomington Indiana, for Indiana University and the IEEE.

[46] Bob McGhee, an oral history conducted in 2010 by Peter Asaro with Selma Šabanovic, Indiana University, Bloomington Indiana, for Indiana University and the IEEE.

[47] Hiroshi Ishiguro, an oral history conducted in 2012 by Peter Asaro and Selma Sabanovic, Indiana University, Bloomington Indiana, for Indiana University and the IEEE.

[48] Hirochika Inoue, an oral history conducted in 2011 by Selma Šabanovic with Matthew R. Francisco, Indiana University, Bloomington Indiana, for Indiana University and the IEEE.

[49] Oussama Khatib, an oral history conducted in 2013 by Peter Asaro, Indiana University, Bloomington Indiana, for Indiana University and the IEEE.

[50] Illah Nourbakhsh, an oral history conducted in 2010 by Peter Asaro with Selma Sabanovic, Indiana University, Bloomington Indiana, for Indiana University and the IEEE.

[51] Norm Caplan, an oral history conducted in 2012 by Peter Asaro with Selma Šabanovic, Indiana University, Bloomington Indiana, for Indiana University and the IEEE.

[52] Shigeki Sugano, an oral history conducted in 2014 by Peter Asaro, Indiana University, Bloomington Indiana, for Indiana University and the IEEE.

[53] Gerd Hirzinger, an oral history conducted in 2011 by Peter Asaro, Indiana University, Bloomington Indiana, for Indiana University and the IEEE.

[54] Luc Steels, an oral history conducted in 2011 by Peter Asaro, Indiana University, Bloomington Indiana, for Indiana University and the IEEE.

[55] Francesco Mondada, an oral history conducted in 2011 by Peter Asaro, Indiana University, Bloomington Indiana, for Indiana University and the IEEE.

[56] K. Shilton, J. A. Koepfler, and K. R. Fleischmann. "How to see values in social computing: methods for studying values dimensions." In *Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing*, pp. 426-435. ACM, 2014. pp.430

[57] S.Šabanović, WL. Chang, C.C. Bennett, J.A. Piatt, and D. Hakken. "A robot of my own: participatory design of socially assistive robots for independently living older adults diagnosed with depression." In Human Aspects of IT for the Aged Population. Design for Aging, pp. 104-114. Springer International Publishing, 2015.