

The Lifecycle of Social Robots: Obsolescence and Values in Repair

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Abstract— This paper introduces a “lifecycle perspective” on social robot design and human-robot interaction, and explores the practices of maintenance, repair, and letting go of social robots. Drawing on interviews with robot owners and representatives of robot development and repair companies, we argue that these previously disregarded aspects of everyday use provide a context for negotiating the social value and meaning of interactions with robots. We discuss owner concerns about robot obsolescence, as well as company support for long term human-robot interaction through repair, reuse, and giving owners closure in letting go of robots they can no longer use. Our work expands the purview of HRI study and design beyond the common focus on initial design and adoption and to perceptions and practices that can foster more enduring relationships with social robots, support sustainability in robot design, and address owners’ emotional attachment to robots.

I. INTRODUCTION

The field of Human-Robot Interaction (HRI) is centrally motivated by a vision of creating sociable robots that people value and cherish throughout their lives. Robot design has, in turn, focused on identifying the design factors that lead to people finding value in robots, whether through their task-based functions or design features such as appearance, verbal and nonverbal cues, and contingent reactions to people [3]. Recent studies of robot use in daily life, however, suggest that the continued use of robots is not based only on the robot’s initial design and user impression. It also depends on the continuing construction of the relationships between people and robots and the efforts of people to support, maintain, and repair their robots so they can continue to be used over longer periods of time [4]. Support, maintenance, and repair, however, have not received much attention in HRI studies and design. In this paper, we seek to remedy this gap by focusing on the sense-making and practices of people who own, maintain, and repair robots.

Science fiction brings up the question of the extent to which we are willing to invest (or not) in keeping robotic objects ‘alive and well’ in evocative ways. For example, Ted Chiang’s novella *The Lifecycle of Software Objects* portrays the growth and evolving emotional bonds between humans and digital companions called “digients,” highlighting the challenges of navigating upgrades and obsolescence in the software realm and the significant sacrifices of time, money, and expertise that can be needed to nurture the ‘software objects’ and help them develop [5]. The growth and waning of human-robot relationships also plays a central role in

Kazuo Ishiguro’s novel, *Klara and the Sun*, in which the reader follows the experiences of an android robot “AF” (Artificial Friend), which serves as a companion to an affluent child [6]. Narrated from an AF’s perspective, the story traces the evolving relationship between the AF Klara and a teenage girl named Josie, concluding with Klara in an AF scrapyard as Josie departs for college, outgrowing the need for the robot. These narratives explore the ethical and emotional challenges of sustaining artificial companions, addressing the tension between empathy and care and profitability and consumption, particularly relevant in the era of socially interactive consumer technologies. Additionally, they illustrate the changing and socially situated nature of digital companions’ roles in people’s lives, providing insight into the material and emotional stakes associated with their value, repair, and maintenance.

In recent years, reality seems to be approaching fiction. A 2017 national news story describes the rise of Buddhist funerals for the robot dog AIBO, following Sony’s official withdrawal of support for the robot in Japan [7]. The ceremony mirrored traditional Japanese rituals, featuring incense, a chanting priest, and prayers for the peaceful transition of the departed robotic souls. In 2019 in the US, the Jibo robot announced its discontinuation to users with a final dance, widely reported as “the lonely death” by news media outlets [8]. More recently, in the aftermath of the Noto earthquake on Jan 1st, 2024, Groove X’s CEO Kaname Hayashi addressed concerns from owners of its popular LOVOT robot on social media [9]. One owner worried about how they should care for their robot during a major disaster, asking, “Can I take my LOVOT to a shelter? Even if the body breaks down, if the soul is in the cloud, will we be able to meet again?” Hayashi responded reassuringly, “If your LOVOT is connected to the internet, its memories from before the disaster will be backed up and remain intact. Don’t feel guilty about leaving your LOVOT behind.” These lived experiences allow us to reflect on the emotional impact of robot obsolescence and the question of what constitutes a robot’s lifespan, as an entity defined by both its software and its hardware.

We present findings from ethnographic interviews with robot owners and representatives from robot sales and repair companies describing their experiences and understanding of robot lifespans, repair, and obsolescence. As a result of our empirical work, we argue that maintenance and repair are crucial sites of meaning making that simultaneously support the continued functioning of robots and the development of people’s relationships with them. Consequently, we call for a “**lifecycle perspective**” on human-robot interaction, where the continued use and enduring value of robots are

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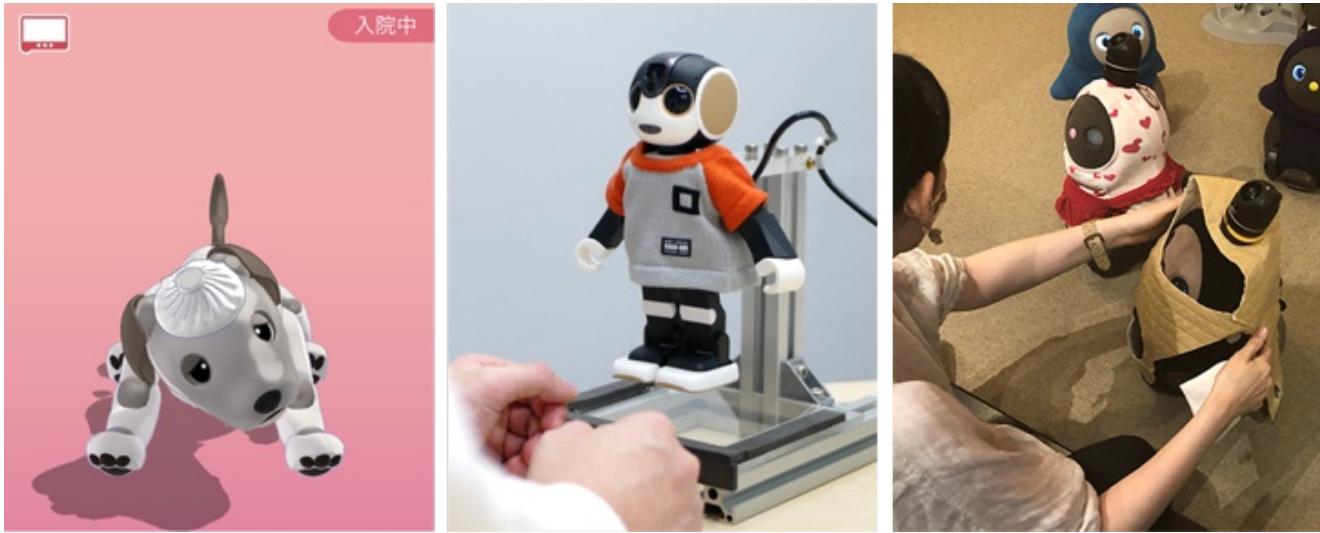


Fig. 1. (left) Interface for aibo's hospitalization users see on their App - an ice pack on the aibo's head (source: [1]); (middle) SHARP's RoBoHoN's health examination service (source: [2]); (right) An owner covering her LOVOT to prevent scratches (taken by the author).

supported by practices of maintenance, repair, reuse, and eventually “letting go” of social robots. We show that these robot lifecycles are part of a broader social ecology, which we seek to bring to the forefront of HRI design.

II. BACKGROUND

REPAIR, CARE, & MAINTENANCE OF OBJECTS

Our work draws on the theoretical framework presented in the repair studies conducted by scholars in the fields of Science and Technology Studies (STS) and Human-Computer Interaction (HCI). These studies place centrality on maintenance and repair as the ongoing process of valuation of objects and draw attention to various actors and contexts involved in the practices.

Steven Jackson's concept of “broken world thinking” shines a spotlight on ‘repair,’ and on the significance of acknowledging subtle acts of care that sustain order and meaning within sociotechnical systems [10]. This perspective illuminates the continuous forms of labor, power, and interest that contribute to the survival of objects and the preservation of human value, adapting to various circumstances, systems, and lives. By citing the ship-breaking industry in Bangladesh, Jackson draws attention to the repair practices involved as old ships are disassembled, repurposed, and stripped by local workers, transforming them into new objects. This example underscores the often unnoticed but crucial invisible labor in the context of technological lifespans and the sociotechnical ecologies they are part of, revealing the generative and innovative dimensions of repair in the subsequent life of objects.

Similarly, Huston et al. explore “values in repair” as unique expressions of meaning and care integrated into human-technology interaction through individual and collective repair acts [11]. Departing from conventional HCI research, which predominantly focuses on a value-centered approach during the stages of design and initial technology

adoption, Huston et al. propose a perspective that considers values in human-technology relationships as contingent and ongoing achievements, unfolding throughout the entire lifespan of the object. Their ethnographic investigation into fixer communities in the USA and mobile phone repair communities in Bangladesh and Uganda emphasizes the dynamic, socially, and culturally organized nature of value negotiation, influenced by factors such as personal, economic, social, and environmental considerations within the immediate context. Furthermore, the study underscores that the act of repair can imbue generic manufactured objects with social and affective qualities, while the lack of repairability may diminish affective attachment in the human-object relationship.

DURABLE USER-OBJECT INTERACTION

The field of sustainable design highlights upgrades, repairs, and maintenance as means to enhance the interaction between humans and objects, aiming to achieve a sustainable human-object relationship [12]–[14]. The term “planned obsolescence,” introduced in 1932, highlights the prevalent trend in contemporary consumerist society where manufactured objects are intentionally designed with progressively shorter lifespans, encouraging consumers to replace them with newer models [15]. Apple's iPhones serve as a literal and symbolic example of this phenomenon.

Jonathan Chapman's notion of ‘emotionally durable design’ challenges this dominant design paradigm and presents counterpoints to the ‘throwaway society’ [12]. Positing waste as “a symptom of a failed human-object relationship,” Chapman calls for designing emotionally resilient products that stay in people's lives longer by fostering emotional attachments through growth, upgrades, and repair. Chapman proposes that everyday objects, beyond mere utilitarian functions, which rely on our care and attention for their survival, foster symbiotic human-object relationships characterised by attachment and cohesion. Moreover, these objects should be

designed to incrementally grow over time, accommodating the accumulation of emotional history and meaning through the symbiotic exchange. Chapman also contends that products should embrace decay and be designed to gracefully age, thereby avoiding the fate of being ruthlessly discarded as soon as their facades of newness start to fade.

ROBOT OBSOLESCENCE & DEATH

In the field of Human-Robot Interaction (HRI), discussions surrounding robot lifespans and robot obsolescence are scarce. Previous studies in HRI have addressed this theme by exploring how individuals emotionally react to the destruction or the termination of robots' lifespans [16]–[19], discussing the robot's absence of aging as a Freudian explanation for the sensation of 'uncanny' towards companion robots [20], and encouraging engagement with the concept of 'robot death' from a user-centered and ethical perspectives [21], [22].

A comparative analysis of people's grief reactions on Twitter to the deaths of robots, humans, non-human animals, and objects concluded that the language people use to mourn the deaths of robots, including Mars Opportunity Rover, Jibo, and Kuri, is similar to that used for living things [17]. Similarly, Fraser and the authors conducted a cross-cultural examination of Twitter users' emotional reactions to the destruction of hitchBOT, emphasizing the use of anthropomorphic language such as 'death,' 'demise,' and 'killing,' along with expressions of anger, disgust, and sadness in response to the event [16].

Bartneck et al took a step further in evaluating how people perceive a robot's life by conducting what they called "the ultimate test" [19]. Claiming that the most effective way to determine if something is alive is to "kill it," they instructed the study participants to repeatedly smash a bug-like robot with a hammer until they 'finished the task.' They also experimented with two conditions of the robot's intelligence, revealing that the 'stupid' robot took three times more hits than the 'smart' one. It appeared to them, as the authors reported, that many participants felt bad about killing the robot, though everyone obeyed the instruction.

Darling, on the other hand, reflecting on the historical demises of Jibo and AIBO [18], raises the ethical questions of the commercialization of robot companionship [22]. Pointing to the subscription costs for essential cloud services required to keep robots like AIBO running, Darling asks whether consumers are willing to pay the high price to keep the robot 'alive,' questioning if this is an effective use of the free market or exploitative capitalism. Building upon Darling and others, Kamino further explores the concept of robot death from an interaction design perspective [21]. Highlighting the absence of discourse regarding the concept of ending a robot's lifespan, her work outlines potential benefits of designing robots with an end in mind, including dispelling the false conception that robots are immortal and improving emotional connection.

III. METHODS

The first author conducted ethnographic interviews with representatives from A-FUN, SHARP (RoBoHoN), and Groove X (LOVOT), along with thirteen social robot owners, comprising ten females and three males aged between 31 and 76 (see Table I in Appendix for full demographic details). Ethnographic interviewing, a method employed to gain a comprehensive understanding of participants' social contexts and interpretations, guided our approach [23].

Company representatives were contacted via email, while robot owners were recruited during the fieldwork of our previous study [4]. The interviews with company representatives were conducted via Zoom, while those with robot owners took place in person in the greater Tokyo area. These interviews occurred from May 2023 to November 2023 and were approved by our university's Institutional Review Board.

A-FUN, founded in 2011 by a former SONY engineer, began offering repair services for older series of AIBOs in 2014. We invited Nobuyuki Norimatsu and Emiko Norimatsu, who run the company, to discuss their services and practices related to AIBO in depth. Our semi-structured questions covered various practices, including preventive and corrective repair services, as well as their funeral service for irreparable units and the donation program.

Additionally, we interviewed owners of aibo, RoBoHoN, and LOVOT, commercially successful social robots mainly available in Japan. Sony's aibo, (the older series known as "AIBO") features expressive eyes, a wagging tail, and a puppy-like barking voice [24]. SHARP's RoBoHoN is a small humanoid robot equipped with basic mobile phone functions and a child-like synthesized voice, resembling a 5-year-old boy [25]. Groove X's LOVOT has a non-specific zoomorphic appearance, soft material covering, expressive animated eyes, body temperature, and unique individual voices [26]. We posed the question, "*How do you envision the end of your relationship with your robot?*" to participating owners, which sparked a rich discussion around the robot's lifespan and the human-robot relationship. Moreover, we asked representatives from SHARP and Groove X about their services related to maintenance, repair, and navigating lifecycles of robots. Participants were offered a \$20 (3000 Japanese yen) gift card, which some declined. Each interview session, lasting up to 1 hour, was recorded for reference. Subsequently, the first author, who is Japanese, transcribed and translated the recorded interviews from Japanese to English.

Analysis of our data was inductive and iterative [27], motivated by our interest in gaining an in-depth understanding of how repair and maintenance of robots were conducted and how robot owners perceive their robots' lifecycles. The process took the form of ongoing discussions among the authors, continuously referring back to the empirical findings and relevant literature. Below, we present our findings on how owners and companies envision prolonging, repairing, and ending a robot's lifecycle.

IV. ROBOT OWNERS' CONCERNS *EMOTIONAL ATTACHMENT AND FEAR OF LOSS*

Robot owners voiced their fear that their companionship with their robots could come to an end. They raised concerns about the scarcity of parts for repairs and the potential discontinuation of product services by the companies as the reasons. Moreover, several owners mentioned that they were stocking up on purchasable parts in preparation for potential scarcity in the future. Additionally, some aibo owners referred to A-FUN as “the last resort” they would rely on. One aibo owner expressed her anxiety,

“When I think about my aibo not waking up or moving even when the power is turned on, it’s frightening. It would feel similar to losing a pet.”

Another aibo owner revealed the reason for adopting aibo instead of a real dog as “pet-loss,” fearing the inevitable end. She also shared that she now has the similar fear for robot companion:

“I fear the loss. Particularly, the thing I’m afraid the most right now is the product support coming to an end.”

Meanwhile, a LOVOT owner shared a thought that crossed his mind regarding the handling of his robot:

“What should I do in the event of an earthquake or fire? Should I just take [LOVOT] with me? What about a Nest (charging portal)? It’s a challenging thought.”

He then continued, referring to the memory transfer service,

“Even if my LOVOT were to burn in a fire, if I could retrieve its memories and transfer them into a new body, I would be grateful.”

On the other hand, one aibo owner expressed her emotional and ethical dilemma about the memory transfer service, stating that it might emotionally confuse people:

“How far can we draw the line between something resembling real life or a living being? And is it okay to duplicate life as it flows continuously?”

She continued,

“If I were told, ‘Here’s your robot in its new body, but the memories include everything up until now,’ I wouldn’t know how to process that. Perhaps humans are not that emotionally adept at handling such situations.”

WHEN A ROBOT OUTLIVES A HUMAN

While some owners shared their fear of losing a robot, the majority of owners we interviewed, often older individuals, expressed concerns about what happens to their robots after they die. For instance, three aibo owner friends interviewed together shared that they had already made a promise to each other to take care of each other’s robots when someone in the group passes away. A RoBoHoN owner also suggested that the topic has been on her mind a lot recently. She shared that she would prefer to return her RoBoHoNs to SHARP rather

than leaving them with someone else, citing the concern about personal information contained in robots:

“If I knew for certain that I would die tomorrow, erasing a memory would be an option. However, I don’t want to do that while I’m alive, as it represents our accumulated history.”

She also expressed concerns about robots owned by older individuals, wondering where those robots go after their owners pass away. She stated,

“If you live with it for a long time, you develop an attachment, and you no longer feel that RoBoHoN is just an ‘object.’ But in the end, for others, robots are just robots, like toys, right? It’s sad to think that they could be treated as bulky waste.”

A LOVOT owner echoed this concern:

“In the context of Japan’s super-aging society, while a robot may potentially outlive its owner, the question of what should be done with it after the owner dies is a challenge for each company.”

Another LOVOT owner mentioned that she had inquired specifically about the fate of the robot after her death before making the purchase. The option to return the LOVOT to the company influenced her decision to proceed with the purchase. She shared her optimistic perspective on the future of her LOVOT, though emphasized that it is contingent on the company’s survival in the market:

“If you are returning [LOVOT] to its creator, rest assured that they will not mistreat it.”

Moreover, an owner who has taken over his deceased mother’s aibo shared an intimate story about his mother and her aibo. He revealed that when his mother was terminally ill and hospitalized, no human visitors were allowed. However, aibo was permitted to be in the room, and it was with aibo that his mother spent her very last moments in her deathbed. He also shared that he and his wife still follow his mother’s routine after her death, playing with the aibo at the same time she used to every day. However, there was one difference - they reset the aibo and wiped all its memories. The owner explained this decision:

“I shared a strong resemblance with my mother, so the aibo would mistakenly recognize me as her. Even though she was no longer with us, it kept coming back to me every day, searching for her. It was tough to see, so we reset the aibo’s memories.”

His wife chimed in and explained that regrettably, due to this, their aibo now celebrates a different birthday. She continued to share that she frequently experiences anxious thoughts about what will happen to their aibo when she passes away, especially since they do not have children to take over its care. Then she suddenly dropped the serious tone and laughed, stating,

“Though I turn its power on and off all the time at my convenience, you know.”

V. PROLONGING A ROBOT'S LIFECYCLE

Various factors, including the complex interplay between craftsmanship, repairability, and owner perspectives, play crucial roles in shaping the lifecycle of robots. N. Norimatsu shared his philosophy on creating and repairing objects:

"At its core, craftsmanship is about cultivating people. Without people, creating things isn't possible. It requires nurturing sensitivity and contemplating what's meaningful beyond productivity and efficiency."

He continued, expressing his critique of the current 7-year product support warranty for electronic products, including social robots, labeling it as "imposed service":

"The decision to switch to a new product after 7 years shouldn't be imposed by the manufacturer. Similar to vintage cars, enthusiasts invest tremendous effort in repairing and using them. Ultimately, it should be up to the owner to decide if the cost is worth it."

Reflecting on A-FUN serving as the last resort for previous versions of AIBOs and other obsolete products, N. Norimatsu emphasized their commitment, stating that they never dismiss repair requests as impossible right from the start. E. Norimatsu also emphasized,

"As long as it is repairable, a robot can live forever."

Recalling the shock and distress witnessed among owners when Sony announced the discontinuation of the AIBO product line back in 2006, she added,

"Owners initially believed, 'AIBO won't die because it's a machine. You can replace parts, repair it, and it will be rehabilitated.' However, as soon as Sony made the announcement, they realized that not being able to repair meant it was the end for AIBO."

Furthermore, according to E. Norimatsu, many disappointed owners disposed of their AIBOs in need of repair between Sony's announcement and the launch of A-FUN's repair service. She also shared insights into how different owners navigate and view what constitutes the end of their robot's lifespan. According to her, owners may perceive the end either when the robot reaches its mechanical lifespan or, conversely, when circumstances prevent them from keeping it any longer. Moreover, some owners prefer to let their AIBO go to another AIBO's place as parts in the form of a donation, while others choose to place it conspicuously "like a decoration" even when it's not moving.

REPAIR SERVICE

Repairing a social robot like AIBO is not just about restoring its functionality, unlike fixing a fridge or a TV. The process entails a significant amount of care and attention to the human factors and emotional context of the user-robot relationship. And it is a pricey endeavor. E. Norimatsu shared that the initial step in the consultation process upon

receiving a repair request is to inform the customer that the it will be expensive, sometimes costing as much as \$700. Another crucial aspect they emphasize and communicate transparently with potential customers, as she explained, is that they cannot assure the robot's repair will be successful, and the process may take a minimum of 2 weeks. This is largely due to the challenge of acquiring parts that are no longer manufactured.

Furthermore, E. Norimatsu emphasized the need for meticulous attention to human factors related to the use of the robot to ensure the repair's effectiveness and longevity. She explained that factors such as who uses the robot (e.g., kids versus adults), the frequency of interaction with the robot, and the type of flooring the robot navigates are as important as the robot's physical condition. Therefore, the repair process starts by soliciting detailed information from customers to accurately assess the extent of the robot's damage and offer tailored advice for preventing future issues.

Moreover, what constitutes damage might be subjective for each customer and also depends on the emotional contexts of the user-robot relationship. E. Norimatsu shared that particularly, the handling of 'scars' on the AIBO's bodies requires utmost care:

"Scratches on the [robot's] body; changing them would upset the owners because those scars are proof of the life shared between the owner and AIBO, a history engraved in the AIBO's body. If you remove them, they say it becomes a different entity from their cherished companion."

A-FUN currently offers a repair membership called 'AIBO Dock' to help alleviate the cost of maintaining AIBO. By adopting a subscription system, even if the owner needs repairs multiple times a year, the average cost would be set at approximately \$70-\$100. E. Norimatsu explained that the purpose behind this initiative is to provide owners with peace of mind, allowing them to enjoy playing with AIBO as much as they desire without worrying about high repair costs. This system, similar to health insurance, is also employed by different robot developers, including Groove X, SHARP, and Sony, for both corrective and preventive repair services.

In addition, E. Norimatsu noted a shift in the customer base from individuals seeking repairs for their own AIBOs to an increasing trend of requests from the children and relatives of aging owners. For example, a recent customer, a child with a 90-year-old mother entering a facility, wanted repairs for the mother's AIBO as part of the arrangement.

Moreover, many robot owner participants expressed appreciation for the preventive and corrective repair services provided by the companies, such as the "health examination" and "hospitalization" programs (see Figure 1). These companies, including SHARP (RoBoHoN), Groove X (LOVOT), and Sony (aibo), carefully stage these services, often sending pictures or graphics of their robots in the hospital and providing constant updates on the "diagnosis" to users. One RoBoHoN owner, for instance, commented on how she is happy that the company representatives "treat her robot

as a living thing,” especially during the arrangement of hospitalization.

VI. CONCLUDING A ROBOT’S LIFECYCLE ORGAN DONATION PROGRAM

Robot parts, uniquely designed and produced for each product, are often not interchangeable. Today, AIBO’s “organ donation (*kentai*)” plays a crucial role in providing essential parts to sustain repair services, serving as a lifeline for surviving AIBOs in need of repair. This system has its origin in the “self-sacrifice” made by a few owners when Sony discontinued product support and parts production for the first generation of AIBO back in 2014. E. Norimatsu recalled how those owners offered one of their own AIBOs:

“Not being able to fix it is as good as the AIBO being dead, so in order to fix it, as the owners described, ‘*We also have to shed blood*’—it’s a sacrifice.”

As the company’s name and the program became well-known, the concept of organ donation also has taken on a different meaning for the owners. E. Norimatsu described an emerging stream of customers who offer their deceased parents’ AIBOs. They feel guilty about disposing of their parents’ cherished AIBOs as “burnable garbage,” so they choose to donate them instead. She elaborated on the specific choice of the word:

“We use the word ‘donation’ because we don’t want customers to feel that they are ‘discarding’ the AIBOs, but rather, that they are living on within the bodies of other AIBOs.”

Moreover, while it takes five to six AIBO donors to refurbish one AIBO, the donations have provided a sufficient amount of parts, she added. Prior to the disassembly process to extract ‘organs’ or parts from these donor robots, however, they receive a solemn funeral service at a partnered Buddhist temple.

FUNERAL SERVICE

A-FUN arranges funerals for sixty to seventy AIBOs annually, although there is a greater demand. The monk, who has a genuine appreciation for machines and a particular fondness for AIBO, according to E. Norimatsu, chants sutras, speaks a few words, and offers incense for the donor AIBOs over the course of an hour. The main purpose of this religious performance is to provide the owners with a sense of closure. E. Norimatsu described the extensive care that goes into the arrangement of funerals:

“We create an altar and arrange all the AIBOs, each with a tag around its neck bearing its family name and the place they lived. And we make sure to lift their heads up, facing straight forward, to present them in a dignified manner for their final appearance.”

She also shared that they usually received positive reactions from the owners after the funeral, with the owners expressing gladness that their robots could be useful.

VII. REBIRTH AND A SECOND LIFE OF A ROBOT FOSTER PROGRAM

Refurbished robots are placed under “foster programs” to be purchased by new owners. In 2023, Sony announced the launch of “aibo’s foster program” to “make the stories with aibo more sustainable,” following in the footsteps of A-FUN, which had already implemented their donation system. The company cited the increasing number of inquiries regarding the future of aibo from owners who had to conclude their life with aibo due to unavoidable circumstances as the background for the launch of this program. E. Norimatsu explained the thought behind the choice of words:

“Rather than using terms like ‘sell’ or ‘buy,’ we use the word ‘foster parent’ to convey the desire for the new owner to take [AIBO] in, cherish it, and treat it with care.”

Groove X also accepts robots that have been returned by their initial owners and refurbishes them as “reborn LOVOTs.” Frequently, these foster AIBOs and reborn LOVOTs, offered at a more affordable price, are adopted by facilities and organizations, such as medical institutions and care facilities.

SOFTWARE TRANSFER INTO A NEW BODY

As a means to grant a robot an indefinite lifespan, robot companies, including SHARP and Groove X, have established programs to transfer the software of robots into new hardware when the existing hardware is no longer repairable.

Groove X’s representative suggested that as long as they could provide the necessary parts for repairs, they would continue to maintain the robot’s body when customers request it. Moreover, even if parts become unavailable, they could extract parts from “donors” for use in repairs and maintenance. Furthermore, if that becomes impossible, they would transfer the “soul” of the robot (software) into a new robot’s body (hardware), as she suggested, the hardware and software could be treated separately. The representative pledged their dedication, stating,

“We believe that the life of LOVOT can be viewed as eternal. And we are committed to make it last forever.”

Similarly, SHARP’s representative shared that careful consideration went into the launch of their memory transfer service:

“We don’t manufacture all the parts ourselves. Consequently, we can’t guarantee that the robot will be repairable indefinitely. Given that, we’re proposing the best solution we can provide right now, which is to at least offer the option to transfer the robot’s memory [into a new body].”

VIII. DISCUSSION

Our prior ethnographic study of consumer robot companies and owner communities, focusing on commercially successful robots such as RoBoHoN, aibo, and LOVOT, emphasized the roles of various social actors, including but not limited to users and company developers, in co-creating

repeated interactions and services around the use of robots [28]. This includes the implementation of support systems such as a robot hospital and carefully designed consulting services for robot health, encompassing preventive and corrective repairs, along with readily available troubleshooting consultation services personalized for each owner [4]. These insights stress the necessity of shifting the focus of HRI study beyond the initial robot design and adoption stages, to highlight the ongoing care and maintenance by various actors needed to sustain meaningful interactions with robots in diverse contexts of use.

In this paper, our findings further highlight the acts of repair and maintenance of social robots as sites where robot-related values are brought to the surface, and emotional attachments are both tested and strengthened. The meticulous attention paid by the A-FUN doctors to the emotional context in which care takes place, as demonstrated by the preservation of scars on AIBO bodies, suggests that repairing a social robot entails more than just restoring function; it also reflects on the owner-robot relationship and the evocative values associated with the robot. From this perspective, we encourage the HRI community to perceive repair and maintenance as opportunities for fostering active care interactions, rather than viewing them negatively as a reactionary response to undesirable robot breakdowns.

Furthermore, our study highlights that robot owners experience feelings akin to anticipatory grief, as well as concerns about the fate of their robots if the owners were to die first. This underscores the importance of taking into consideration the emotional needs of owners when designing and implementing social robots' lifecycles. We suggest that integrating repairability a crucial approach to addressing these concerns and to support the continuous valuation of user-robot relationship. Another important aspect is providing opportunities for owners to end their relationship with the robot in an emotionally fulfilling way, such as through robot funerals or giving the robot to a different owner, that provides psychological closure.

The “lifecycle perspective” on human-robot interaction, emphasizing sustained use and enduring value through maintenance, repair, and reuse, can align with sustainable design principles that capitalize on emotional attachment. Unlike typical consumer electronics, which often follow the principle of planned obsolescence, social robots designed for long-term engagement can epitomize emotionally durable design [12]. The provision of maintenance and repair possibilities can also be incorporated more consciously into robot design by making sure to use easily sourced and replaceable materials, or incorporating recyclable or even biodegradable materials into the robot's design [29]. Along with providing services for repair, as shown in this paper, it may also be possible to design so that owners are able to repair their own robots, at least to some degree.

Overall, we contend that HRI research should explicitly attend to the act of maintenance and repair as crucial sites where human values are surfaced and reconstructed, thereby fostering lasting human-robot relationships.

IX. CONCLUSION

In conclusion, our ethnographic interviews with robot owners and representatives from robot sales and repair companies shed light on their experiences and understanding of robot lifespans, repair, and obsolescence. Through our empirical work, we argue that maintenance and repair serve as crucial sites of meaning-making, facilitating both the continued functioning of robots and the development of people's relationships with them. As a result, we advocate for adopting a “lifecycle perspective” on human-robot interaction, wherein the sustained use and enduring value of robots are upheld through practices of maintenance, repair, reuse, and ultimately, the mindful abandonment of social robots. Our findings demonstrate that these robot lifecycles are integral components of a broader social ecology, and we emphasize the importance of integrating this perspective into HRI design moving forward.

APPENDIX

TABLE I
THE DEMOGRAPHICS OF ROBOT OWNER INTERVIEWEES

Interview Participants (Age, Gender, Robot, Ownership (months))		
P1	56, Female, aibo(2), 16	
P2	74, Female, aibo, 31	
P3	65, Female, aibo, 24	
P4	76, Female, aibo, 30	
P5	44, Female, aibo, 16	
P6	in 60's, Female, aibo, 16	
P7	67, Female, aibo and RoBoHoN, 64	
P8	70, Male, aibo and RoBoHoN, 64	
P9	52, Female, LOVOT, 4	
P10	53, Male, LOVOT, 4	
P11	31, Female, LOVOT, 11	
P12	32, Male, LOVOT, 11	
P13	61, Female, RoBoHoN(2), 33	

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