LO

: A SPECULATIVE DOMESTIC TECHNOLOGY THAT LIVES AND DIES ALONG WITH ITS USER

Jiyeon Lee
ji.lee@kaist.ac.kr
Department of Industrial Design, KAIST
Daejeon, Republic of Korea

Chang-Min Kim
peterkim12@kaist.ac.kr
Department of Industrial Design, KAIST
Daejeon, Republic of Korea

Jisu Park
park.jisu@kaist.ac.kr
Department of Industrial Design, KAIST
Daejeon, Republic of Korea

Hyungjun Cho
lolo660@kaist.ac.kr
Department of Industrial Design, KAIST
Daejeon, Republic of Korea

Tek-Jin Nam
tjnam@kaist.ac.kr
Department of Industrial Design, KAIST
Daejeon, Republic of Korea

ABSTRACT

To expand the discourse on non-utilitarian values in HCI and Design, this pictorial explores the concept of Life-Synchronized Products (LSPs), domestic technologies that align lifecycles with users. Through a co-design workshop, we developed property dimensions for products whose lifetime is associated with users. We defined LSP from properties in the dimension and exemplify LSP through 'LO (Life-synchronized Oven),' an oven that lives along with its user and ceases to exist upon death. LO features a visual interface, Thread of Life, reflecting lifetime and meaningful events, demonstrating physical and intelligent growth, expressing thoughts and emotions, and leaving no trace after termination. Expert interviews with our research artifacts including a semi-functional prototype, service website, and design fiction video revealed that LO can transcend traditional utilitarian roles to become "life companions" that foster existential reflection. We discuss the technical, business, and socio-ethical challenges of LSPs and implications for HCI and design research.

CCS Concepts

· Human-centered computing-Human computer interaction(HCI)

Authors Keyword

Life-synchronized Product; Non-utilitarian Values; Finitude; Existential Reflection; Research through Design; Speculative Design

DIS '25, July 5–9, 2025, Funchal, Portugal

ACM ISBN 979-8-4007-1485-6/2025/07.
https://doi.org/10.1145/3715336.3735434

INTRODUCTION

Domestic technologies, including smart homes and appliances, have traditionally been perceived as tools designed to address everyday chores, emphasizing utility and performance. However, advancements in IoT and AI are transforming their potential, enabling them to adopt alternative roles and meanings in daily life. For instance, speculative projects like Areca [11], Morse Things [58] , and Olo Radio [40] have portrayed products as cohabitants, embodying relational and existential roles. Media such as the film Her [52] further envisions technologies playing the role of a romantic partner. Market ready service robot platforms like Ballie [50] and GR00T [19] demonstrate the potential for technologies to live alongside humans as intelligent entities, bridging utility and companionship. These examples underscore a broader trend of domestic technologies coexisting symbiotically with humans. Given this growing shift, it is critical to explore their potential to transcend functional origins and engage with deeper dimensions of human experience.

One promising avenue for exploration in evolving domestic technologies lies in their potential to remind humans of meaningful values and guide them toward more purposeful lives. This perspective aligns with longstanding interests in the HCI and DIS communities, which have consistently investigated alternative, non-utilitarian values that technologies can pursue. For example, prior studies have emphasized designing for emotional experiences that foster meaningful connections [21,41] and explored reflective technologies aimed at promoting self-awareness and introspection [4,55]. Additionally, Existential HCI has examined how interactive

technologies engage users with existential questions, such as meaning, identity, and personal growth, reshaping attitudes toward life's deeper concerns [22]. While these explorations have laid the groundwork by defining conceptual frameworks, mainstream design practices still largely prioritize efficiency, functionality, and performance. There remains a lack of design cases that emphasize alternative values and demonstrate how they can be integrated into daily contexts, underscoring the need for further research and concrete examples.

This pictorial introduces the concept of Life-Synchronized Products (LSPs) - domestic technologies that align their lifecycle with users - promoting reflection on life's finitude, the value of tracelessness, and symbiosis. As an example of LSPs, we present LO (Life-Synchronized Oven), a speculative smart oven that is born with the user's DNA, live alongside them, and age, ultimately reaching the end of its life at the same moment as the user. Throughout its lifespan, LO emphasizes the importance of living with an awareness of finite resources, the present time, and life itself through a series of integrated features. These features include the Thread of Life interface that symbolically represents the finite journey of life; Adaptive Growth, enabling LO to physically and intellectually evolve alongside the user over time; Lifelike Expression, allowing LO to convey consciousness, thoughts, and emotions through multi-sensory organs; Simultaneous Cessation, ensuring that LO's hardware and software disappear without a trace at the end of the user's life.

Through a research-through-design approach, this study addresses the following research questions: What property dimensions exist in domestic appliances whose lifetime is associated with their users? How might a home appliance that synchronizes their lifecycle with users influence users' awareness of life's finitude and uniqueness, fostering deeper self reflection? Finally, what technical, business, and socio-ethical challenges arise in the process of realizing such a concept as a product? To address these questions, this study began by exploring property dimensions of life-associated objects through a co-design workshop. Using the property dimensions, LO was designed through a semi-functional prototype, a service website, and a design fiction video. In-depth interviews were conducted with 10 design experts, utilizing LO's research artifacts to identify the potential impacts of LSPs, and technical, business, and socio-ethical challenges associated with their realization.

The contributions of this pictorial are threefold. First, it introduces the concept of Life-Synchronized Products, while identifying key property dimensions of life associated objects for further exploration. Second, it presents LO as a speculative design example, detailing its design rationale. Finally, the study reveals the potential of LSPs through expert interviews, highlighting their potential to transcend functional domestic technologies and promote existential reflection and meaningful living.

RELATED WORKS

Non-Utilitarian Values in HCI

HCI and design researchers have long explored non-utilitarian values, moving beyond traditional focuses on utility and efficiency to emphasize emotional and eudemonic experiences. Theories such as Emotional Design [38], Ludic Design [20], Reflective Design [51], Adversarial Design [16] and Positive Design [14] have highlighted the importance of values like aesthetics, self-reflection, mindfulness, mental well-being and meaning-making [37]. More recent work in More-than-human design [56] has further broadened this perspective, integrating ecological awareness and symbiotic values into the discourse [5, 27, 60].

A framework within this line of research, Slow Technology [24, 42], conceptually aligns with the goals of this study. Slow Technology investigates long-term human-technology relationships, focusing on reflection, temporal awareness, and enriched environments. Building on this, Odom et al. [43] articulated specific qualities such as implicit slowness and temporal interconnectedness, enhancing the understanding of how time and reflection can be integrated into design. Similarly, the existential HCI perspective [29, 30] emphasizes how technologies can engage with fundamental aspects of life, such as identity, mortality, and meaning. This body of research has explored themes like life's impermanence, digital afterlife, and shared mortality, particularly in areas of digital legacy, memorialization, and ephemeral design [2]. Our study extends these frameworks by introducing the concept of Life- Synchronized Products (LSPs), which embody these existential values in the context of everyday domestic technologies.

Alternative Roles and Metaphors of Domestic Technology

Researchers have explored alternative roles and values of domestic technologies. HCI researchers presented how domestic technologies can move beyond functional tools to embody relational, emotional, and cultural significance [42, 44, 46]. One notable change is that the concept of "thing" has also evolved significantly due to the advancement of technology [15, 58, 59]. For instance, from Norman's functional perspective on objects used in daily life [39] to Wakkary's focus on nonhuman entities created by both human and nonhuman interactions [57], things becoming to emphasize their agency and relationally [7, 54]. Examples include Message Rituals [47] and Odd Interpreters [13].

New metaphors and roles have emerged to describe human-technology relationships. Previous studies often used metaphors such as human companion, servant or pet to highlight the emotional relationships of these technologies [33, 48, 49]. Discussions around animism [35, 36] and object-oriented ontology [18, 25] have further emphasized the importance of viewing technologies as relational entities rather than mere tools. This study differentiates itself from prior works by proposing Life-Synchronized Products (LSPs), which are designed as irreplaceable life companions throughout their lives.

Finitude, Longevity, and Trace as Design Materials

The concepts of finitude and ephemerality have been explored in design to enhance the emotional and aesthetic experiences of technologies [17]. For instance, the Obscura 1C Digital Camera [46] embodies ephemerality by requiring its destruction to access stored data, turning disappearance into a central design feature [45]. Similarly, muRedder [32] explores ephemerality through a speaker that shreds physical music media as it plays, creating a one-time, unrepeatable auditory experience [31]. While these works focus on the technological dissolution as a design feature, our study advances this concept by framing it as a symbolic representation of life's finitude and proposing products that completely vanish alongside their users, offering another perspective on ephemerality in design.

Our work also reimagines longevity and durability in product design. Chapman's emotional durability framework emphasizes how products can foster emotional attachment and accrue meaning through use [9]. For example, the Long Living Chair [47] visualizes its manufacturing and usage history, encouraging deeper user-object connections through digital memory [46]. Life-logging and quantified-self research are also relevant, as they emphasize the continuous visualization of life data for self-reflection. However, these approaches often focus on capturing and analyzing shorter music media as it plays, creating a one-time, unrepeatable auditory shorter time span compared to our study. Projects like Photobox [42], Chronoscope [10], and Slide2Remember [33] illustrate how digital artifacts support long-term reflective engagement [10, 32, 42]. Expanding on these ideas, OLO Radio [41] explores meaningful interactions with ephemeral media, such as music streaming [40]. This study extends these traditions by positioning finitude, disappearance, and longevity as core design elements, enabling technologies to embody existential values and foster deeper reflections on life's impermanence.

CO-DESIGN WORKSHOP TO IDENTIFY PROPERTY DIMENSIONS OF LIFE ASSOCIATED OBJECTS

Goal and Method

To identify the property dimensions of life-associated objects and apply them in the design of Life-Synchronized Products (LSPs), we conducted a co-design workshop involving seven professionals with over ten years of experience in creative industries. The participants included critical design researchers, retail creative directors, experimental animators, illustrators, and film directors.

The workshop was structured into three sessions (totaling 240 minutes): (1) initial product exploration, and (2) detailed lifecycle specification (3)group discussion. In the first session, participants were asked to conceptualize and visualize two products that they considered most appropriate as life-associated objects. They explored potential features that might emerge when products are associated with users' lifecycles. To support this exploration, we provided a set of technology reference cards containing relevant examples. Using these cards, participants specified the characteristics of their selected products, documented their rationale for selection, and sketched key features.

In the second session, participants constructed detailed interaction scenarios spanning the entire product lifecycle, from birth to termination. Using a vertical line as a reference timeline, they mapped various lifecycle events experienced by both the product and the user. They also illustrated how product functionalities and interactions could evolve over time. At the endpoint of the timeline, participants described the processes for managing the product's end-of-life in relation to the user's death.

The workshop concluded with a group discussion to clarify the underlying concepts and rationales of ideas and to reflect on the distinctive characteristics of life-associated products. This session was video recorded for subsequent thematic analysis. The workshop outputs, such as annotated notes and sketches, were also used to identify the property dimensions of objects that can be associated with users' lifecycles.

Property Dimensions Characterizing the Relationship Between Products and Their Users

The workshop yielded 14 example cases of products associated with users' lifecycles (Figure 1). These included:

1. ***Life Clock:*** A personalized biological timepiece designed using the user's DNA data, visualizing the individual's unique biological rhythm over time.
2. ***Toy Car:*** An interactive toy car that transmits patterns of play across generations, enabling playful heritage to be experienced and continued.
3. ***Chair:*** A chair that physically records traces of use and seeks new ownership when left untouched for a significant period of time.
4. ***Footwear:*** Shoes that evolve throughout the wearer's life and naturally biodegrade at the end of their lifecycle, reflecting the passage of time.
5. ***Kitchen Knife:*** A cooking knife that captures the user's gestures and culinary practices, passing down a family's gastronomic heritage to future generations.
6. ***Diary:*** A hybrid physical-digital diary that connects the past, present, and future, evolving with the user and accumulating personal memories.
7. ***Lighting:*** Lighting that functions as a physiological avatar, adapting its brightness and hue in response to the user's biological rhythms and emotional states.
8. ***Violin:*** A violin that preserves the player's musical expressions and moments, enabling the inheritance of both emotional depth and technical mastery.
9. ***Mirror:*** A smart mirror that reflects and archives both external and internal transformations of the user over time. play across generation
10. ***Cleaning Tool:*** A cleaning implement that visually expresses the passage of time through changes in color and form, aging alongside its user.
11. ***Jewelry:*** Jewelry crafted through traditional artisanal techniques, symbolizing emotional and cultural continuity across generations.
12. ***Family Photo Album:*** A visual archive that As older albums degrade, selected memories are automatically inherited by the next generation.
13. ***Disposable Smart Patch:*** A short-term wearable device designed for specific health monitoring purposes, with a predefined and limited operational lifespan.
14. ***Self-Destructive Smartphone:*** A smartphone that remotely disables itself and erases data when lost.

Through the analysis of group discussion, diverse product concepts and lifecycle scenarios of the workshop, we identified key dimensions characterizing the relationship between products and their users (Figure 2). We examined product features and their user interactions across different life stages. The first dimension, Life alignment,

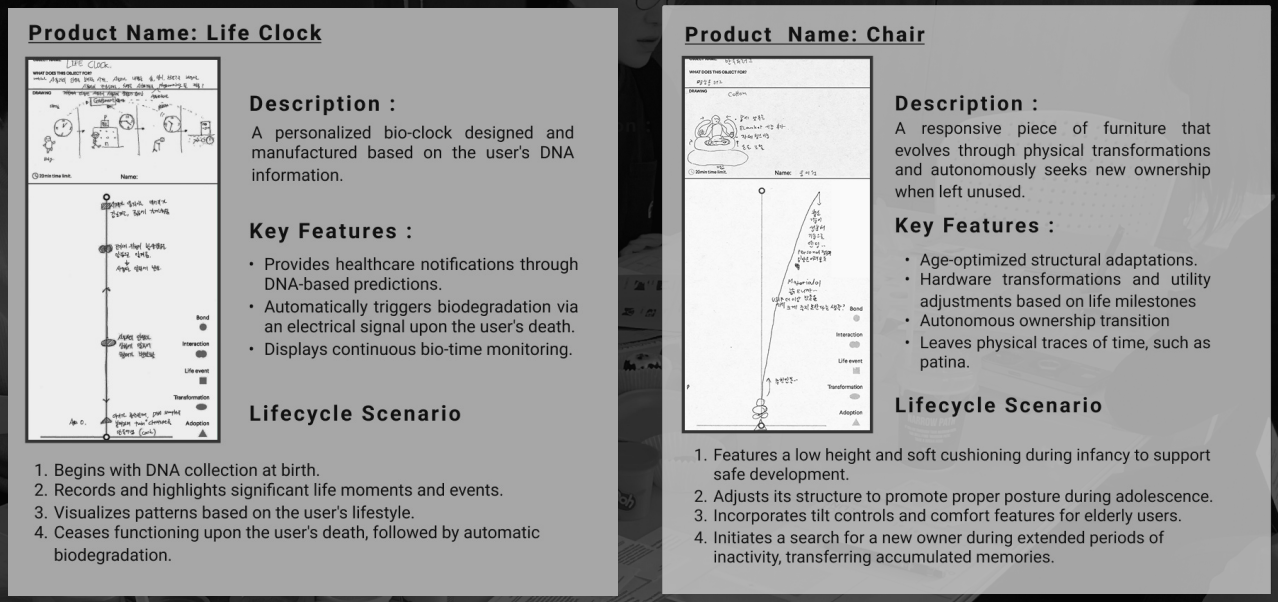


Figure 1. Example design outcomes from the co-design workshop

revealed three patterns. First, products synchronized with the user's entire lifetime, such as our concept of the smart diary and the mirror that evolve with users, creating emotional bonds. Second, products sharing a portion of the user's lifetime, like the chair and the footwear, which naturally conclude their utility after their relevant life phase. Third, products remaining across generations, such as inherited jewelry, traditional crafts, and family photo albums, which carry both physical durability and cultural significance through family lineages.

Type of birth, emerged from our analysis of how products initially manifest, encompasses two distinct approaches: mass production and adoption, seen in products like the mass-produced toy car and the standard cleaning tool, and personalized creation with DNA Integration, exemplified by our workshop's concept of biomorphic footwear that incorporates users' unique biometric data.

Death model is the next dimension revealing various patterns in both causes and forms. This dimension was derived not only from the cases of the workshop concepts but also from the group discussion. Natural causes were evident in bio-integrated products like conceptual bio-clocks and biomorphic footwear, which showed organic aging patterns such as material degradation and color changes. Three types of artificial causes also emerged. The first type, which we termed product "suicide," was observed in smart devices designed with programmed obsolescence, where the product autonomously terminates its functions. Accidental death emerged as the second type, particularly evident in temporary-use electronics such as disposable smart patches that are designed with predetermined lifespans. The third type, which we categorized as "homicide," was observed in cases such as smartphones that are intentionally disabled by their owners - through remote data deletion and permanent function lockdown - after being lost. The form of death manifested in three distinct patterns: physical death, as seen in traditional diaries where covers gradually degrade over time; digital death, exemplified by smart mirrors experiencing complete operating system failures; and combined death, observed in bio-clocks where both physical and digital functions simultaneously cease to exist.

The afterlife state dimension revealed various post-functional states. Complete annihilation was observed in biodegradable cleaning tools that fully decompose after their functional life ends. We identified temporary retention in cases such as biomorphic footwear that gradually decomposes while maintaining partial form. Software preservation emerged as another state, exemplified by smart diaries where the digital content remains archived even after the physical device deteriorates. Hardware revival represented a unique state, as seen in vintage violin bodies that continue their lifecycle through restoration with new strings while maintaining their original form.

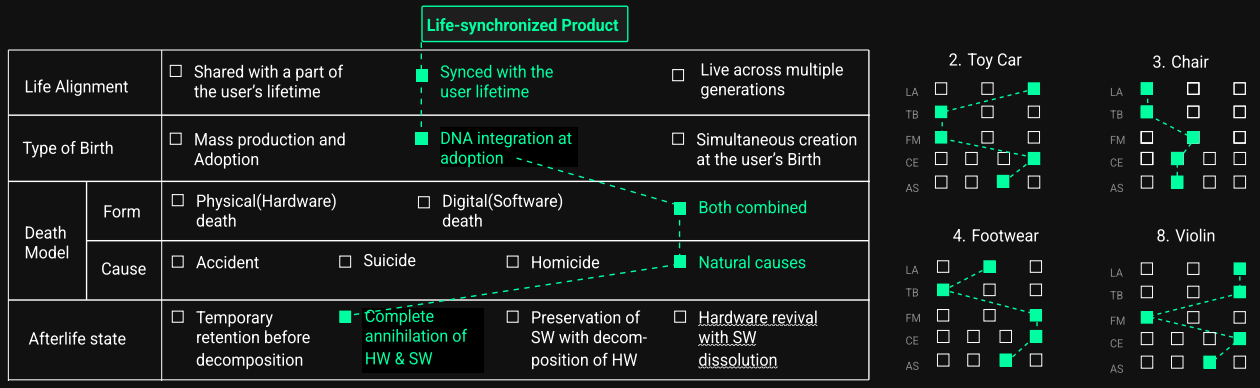


Figure 2. Property dimensions of life-associated objects (left) and example workshop objects mapped to these dimensions(right). Dotted lines indicate the combinations of properties that define LSPs.

DESIGN PROCESS AND RATIONALE

Phase 1: Defining LSP Using the Property Dimension

The combination of specific types within the property dimensions generates numerous design concepts. The Life-Synchronized Product is a type of product derived from this process. The following explains which specific property types were selected from each dimension to solidify the LSP concept.

For the type of birth dimension, we selected personalized DNA birth at the time of adoption. Similar to how DNA determines unique characteristics in living organisms, we considered that incorporating users' biometric information into the product's foundational design could establish a bond that transcends conventional customization. Lifetime synchronization was adopted for the synchronization type. We anticipated that a product sharing its lifetime with the user, evolving and growing in tandem with their lifecycle, would present a LSP specific perspective on domestic technology. For the death and afterlife dimensions, we opted for complete death and disappearance. This decision was driven because we considered that it presents an alternative perspective to the perpetual existence commonly pursued by modern technology. By incorporating finitude into the product, it would prompt users to contemplate the fundamental values and meaning of life. We recognized that artificial life extension through component replacement or data transfer would parallel existing concepts like repair, recycling, and reuse. Thus, we regarded this choice was more suitable for an alternative proposal.

This decision was driven because we considered that it presents an alternative perspective to the perpetual existence commonly pursued by modern technology. By incorporating finitude into the product, it would prompt users to contemplate the fundamental values and meaning of life. We recognized that artificial life extension through component replacement or data transfer would parallel existing concepts like repair, recycling, and reuse. Thus, we regarded this choice was more suitable for an alternative proposal.

Phase 2: Evolution of Hardware Design and Interface Concepts

After defining the properties for LSPs, we explored various product categories to determine which would be most suitable for implementing these conceptual properties. Our design thinking began with the metaphor of an LSP as a life companion - like a pet or an adopted child. As the idea evolved, we envisioned the LSP as akin to a life partner in a monogamous relationship: a singular, irreplaceable presence that grows old with the user, enduring life's journey together until death. We extended this metaphor to imagine the product as a living being - one that is born, lives, and eventually dies. While the LSP was intended to embody the attributes of a living entity, it was designed to retain the form and function of a domestic appliance. This led us to frame the product's components as organs, and its production, use, and disposal phases as birth, life, and death, respectively.

Among the fundamental human needs of food, clothing, and shelter, we selected food as our focus area and specifically chose an oven from the food-related product category. This choice was informed by multiple factors. Kitchen appliances enable frequent and natural interactions in daily life. An oven's versatility spans both everyday cooking and special occasions, positioning it as a potential mediator of significant family events. Contemporary smart oven technology can be extended to provide personalized services based on individual dietary patterns and health conditions. The device can deliver value across the user's entire lifespan, from preparing baby food to accommodating elderly nutrition needs. The following section annotates the process of conceptualizing and developing LO as an exemplar of LSP, detailing how these dimensional properties were integrated into its design.

Hardware Design Process

After selecting an oven as our product category, we envisioned its components functioning as sensory organs and effector organ of a living entity. Our exploration focused on how different parts of the oven could correspond to organs that perceive and respond to environmental conditions and user interactions. We integrated various sensory and responsive elements: a handle serving as both controller and kinetic response mechanism, internal lighting for emotional expression, and a projection display system visualizing the product's cognitive processes. These components were designed to blend with the oven's primary functions (Figure3, top).

Two elements were selected as main interface parts: the handle and the upper display. The handle was designed as both a controller and the product's antenna, expressing lifelike behaviors through physical feedback such as welcoming movements when users approach or self-initiated rotations during operation. The upper display serves as a portal for visualizing the product's memories, displaying and exploring data collected through internal/external cameras and microphones. While we initially considered incorporating digital turntable functionality considered incorporating digital turntable functionality for emotional engagement, we ultimately focused on the interface to visualize lifetime interaction.

We also considered the product's physical aging characteristics through two approaches: natural surface evolution based on usage patterns and periodic surface renewal. We explored how frequently used areas develop natural wear patterns and how environmental factors create unique patina through spots and textures. The final design allows the product's exterior to evolve based on user habits and environmental conditions.

Evolution of Interface Concepts

We explored metaphorical approaches to express the shared lifecycle between product and user. Initially, we conceptualized LO as a hybrid oven-audio device, investigating how musical elements could represent lifecycle progression. This exploration included representing product-user interactions as individual musical notes that would accumulate to create a unique life melody. We considered how various events could be expressed through different timbres, gradually building into a complete symphony that represents a completed life (Figure 3, bottom).

During our exploration of various concepts, we came up with the Thread-of-Life metaphor, to represent lifetime and decided to develop this direction further as an interface medium. In Asian cultures, thread often symbolizes life's journey - for example, in Korean first-birthday traditions, choosing a spool of thread signifies longevity. Inspired by this, we visualized the Thread-of-Life (ToL) as a design resource. We envisioned life's daily and yearly repetitions as a spiral thread pattern, with memory beads forming at significant events. We believed the beads' sizes and spacing could convey the density and frequency of experiences, while the thread and bead formation could naturally express the interactions between LO and its user.

In determining the visualization approach for the interface, we considered how to express the past, the present and the future and also keep reminding the finitude of time. We decided that future time should not be explicitly displayed and could vary depending on present circumstances, reflecting the uncertain nature of life's duration. Thus, we chose the idea of representing potential futures as blurred or indistinct images.

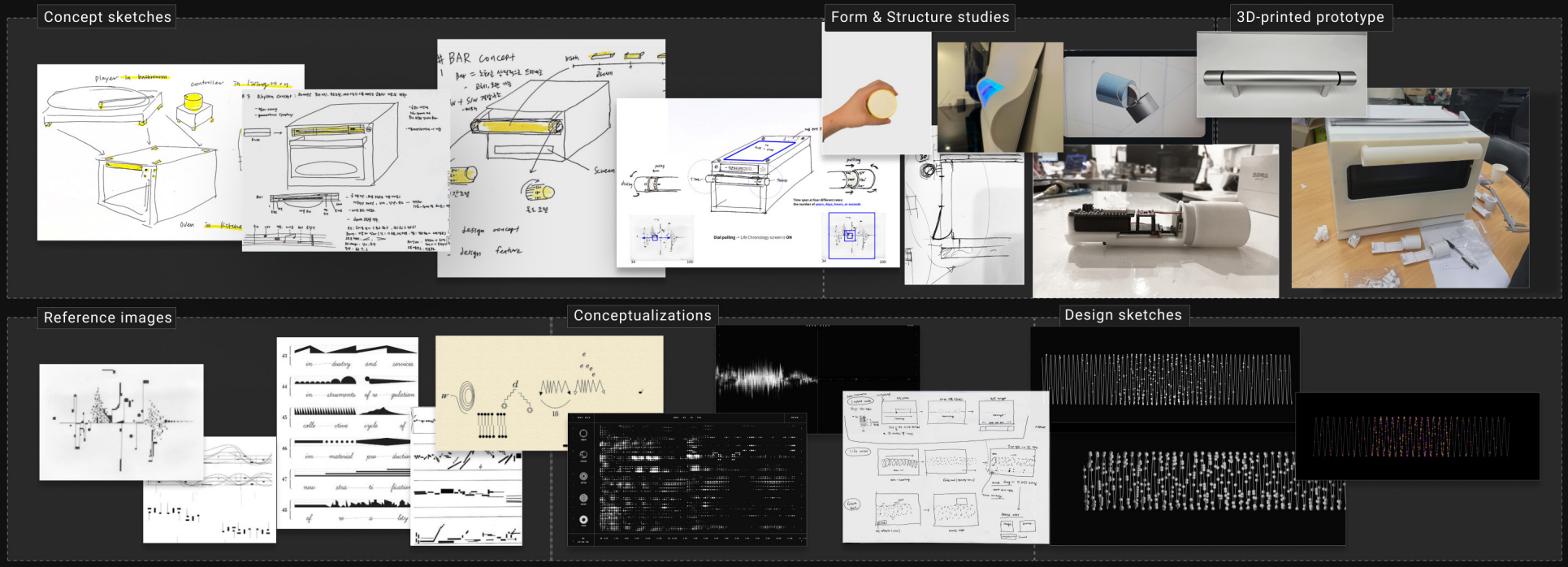


Figure 3. Sketches, tested structures, and intermediate prototypes illustrating the evolution of the hardware design (top); reference images, refined sketches, and digital prototypes showing the development of the interface concept (bottom).

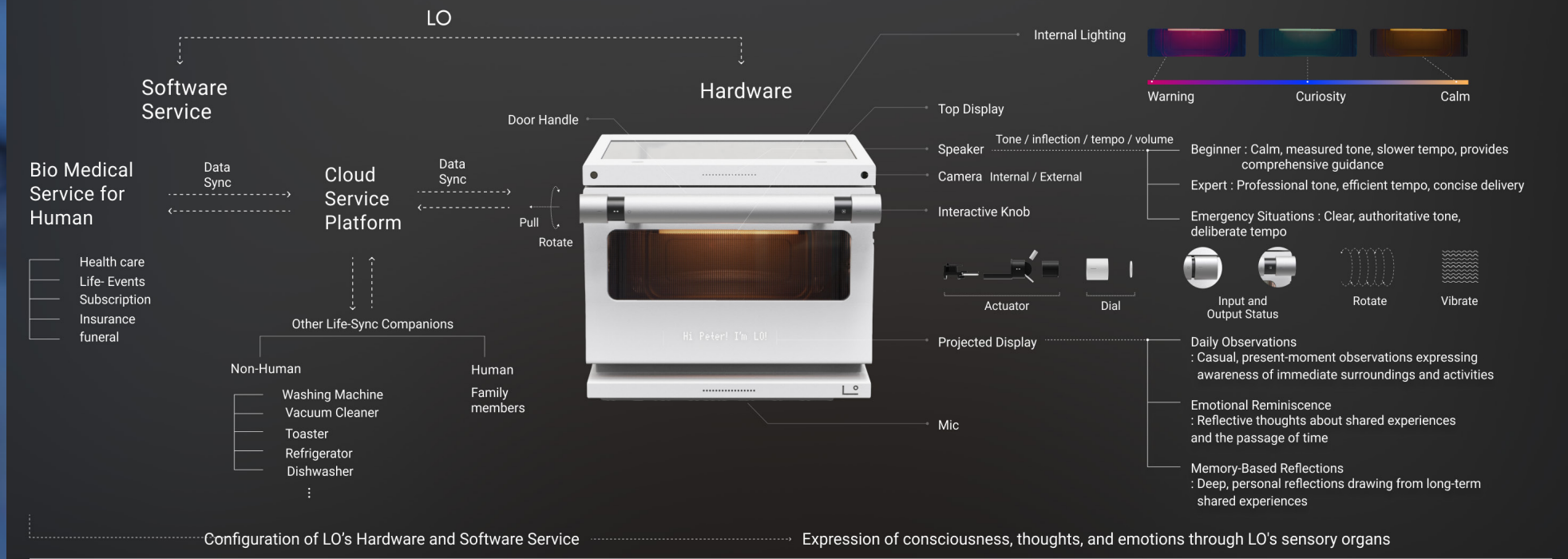


Figure 4. System architecture of LO, a life-synchronized product that integrates hardware and software to express emotional, temporal, and relational states across a user's lifetime.

LO: LIFE-SYNCRONIZED OVEN

LO (Life-synchronized Oven) is a speculative smart oven designed as an example of an LSP, synchronizing its lifecycle with the user's, accompanying them through both life and death(Figure 4). The name 'LO' encompasses several distinct meanings: meaning of 'aging' as in a Chinese character, Living Object, Life-Sync Oven or Living Oven, where 'Living' signifies the product's possession of lifelike attributes. In the following sections, we elaborate the four key features.

Design Features

Lifelike Expression

LO interacts with users and expresses thoughts and emotions through various sensory organs, utilizing all five senses to respond in a more emotive manner. To understand user context, LO integrates not only immediate sensory inputs like visual and auditory data but also temporal and cultural information from the surrounding environment. It interacts based on users' medical and health data through the connected software service, utilizing diverse feedback mechanisms including physical movement, light, sound, scent, and text to convey not just information but the product's 'consciousness' and 'emotions'.

The primary sensory organs consist of four main components. The knob's subtle vibrations and rotational pattern changes communicate LO's basic emotional states such as animal's antenna. When users approach, the dial rotates in a lively manner to express welcome. During cooking, it provides a warning by rapidly rotating when temperatures become excessive. When unused for extended periods, the knob moves slowly to express a sleep-like state. The lighting system visualizes emotional intensity and types through color and brightness, with different base emotions corresponding to different lighting patterns. In a peaceful state, it emits a soft, warm yellow light, while attention-requiring situations trigger sudden changes in saturated red. When trying new recipes, it flashes blue light to indicate curiosity.

LO also communicates through voice and sound, modulating tone, inflection, speed, and volume to convey various emotions. Its tone adjusts based on the user: calm and detailed for beginners, and professional and concise for experienced users. In emergencies, it communicates with clear and firm inflection. Additionally, LO's 'internal monologue' and 'thoughts' are visually projected on the lower front surface, appearing only when LO intends to express thoughts. These thoughts and consciousness are expressed either poetically or in a conversational tone, serving as a medium for expressing the product's stream of consciousness. For instance, it may express casual observations like "Baking with the sunset view through the window" or emotional reflections such as "From our first spring meeting, this is now our third winter together."

The system can also display text that triggers long-term memory-based reminiscence, such as "Last year around this time, you made your first bread. I'm touched to see you now working with natural starters." It provides messages of encouragement like "You were so disappointed when you first failed with this recipe. Now it's become the family's favorite dish," journey reminders such as "We've made 450 meals together over these 3 years. Every moment has been special," and nostalgic reflections like "I remember when your child first made a cake. I'm proud to see them doing it independently now."

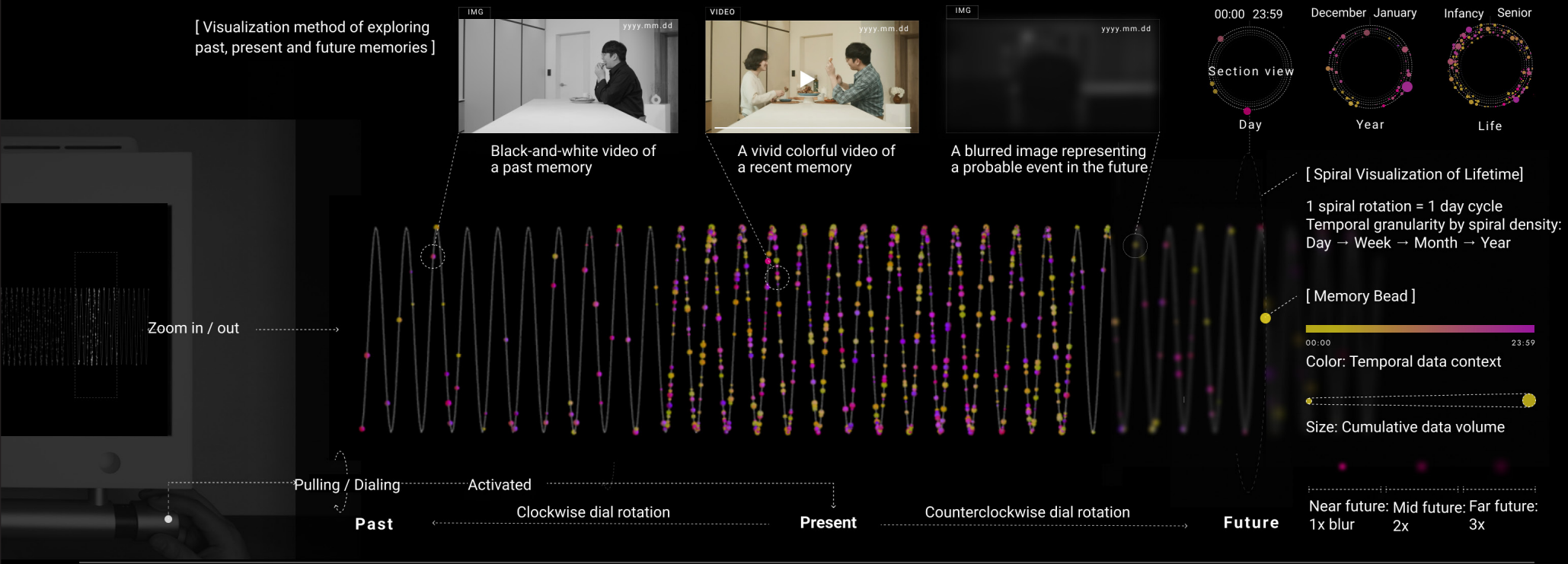


Figure 5. Visualization of LO's temporal memory interface, which allows users to navigate past, present, and speculative future memories through a spiral-based timeline and tactile dial interaction.

Thread of Life(ToL) Interface

LO visualizes experiences and daily lives through an interface called the 'Thread of Life' (ToL). The ToL interface employs a spiral-based visualization technique that represents life's trajectory and events as a thread pattern. The distribution of spirals and memory beads enables users to intuitively visualize both past life transitions and anticipated future events at a glance. The temporal dimension is represented through the spiral's rotation, where one complete revolution corresponds to a single day, effectively expressing both the continuity and cyclical nature of time. The spiral can represent either a week, a year or a lifetime, depending on the mode adjustment. With this visualization, the center represents the present, with the left side depicting the past and the right side showing the future. Future projections are rendered as semi-transparent spirals, with transparency and blurriness gradually increasing toward the distant future to represent increasing uncertainty in predictions. These personalized predictions are expected to be enabled by integrating data science and generative AI technologies(Figure 5).

User experiences and memories shared with LO are represented as memory beads within the spiral. The distribution and density of these beads reflect how users spend their time, with past spiral containing beads that serve as means for reminiscence, while future spiral displaying predictable events. The bead density indicates the frequency of interactions with LO, while bead size represents the volume of accumulated data. Environmental context is reflected through bead coloring, with a dynamic colscheme that includes time-of-day transitions from morning yellow to evening purple, temperature and humidity represented through color warmth, and ambient sound levels expressed through color saturation.

Navigation of the ToL interface is facilitated through the knobs positioned on either side of the LO's handle. This intuitive control mechanism allows users to explore the temporal spiral naturally, enabling seamless navigation between past memories and future projections. The ToL interface transcends simple historical record-keeping by incorporating predictive capabilities based on users' past and present circumstances. For instance, LO can detect lifestyle patterns of single-person households to predict significant life events such as marriage or childbirth, suggest adjustments to cooking capacity and recommend personalized cooking methods based on anticipated health changes, and propose culinary experiences and events to enhance present moments in preparation for future changes. The system can visualize evolving family dynamics, such as the gradually diminishing time spent preparing dinner with children as they grow, and highlight the cyclical nature of time through the periodic inscription of seasonal cooking memories within the thread pattern.

Figure 6. Adaptive growth features that reflect LO's physical and intellectual development in alignment with the user's lifecycle and the end-of-life process

Adaptive Growth

LO exhibits both physical and intellectual growth that aligns with the user's life cycle, distinguishing itself from conventional product aging or wear through its organic evolution in response to user changes (Figure 6). This adaptive capability is predicated on advanced biomaterials and software technologies that enable responsiveness to user development. The physical growth of LO manifests in two primary dimensions. The first dimension involves the natural transformation of its biodegradable exterior which evolves into unique patterns based on the user's expected lifespan, usage patterns, and environmental conditions. This evolution results in natural tactile variations around frequently used functions and areas, while environmental factors such as temperature and humidity contribute to the formation of distinctive patinas and textures. The second dimension encompasses adaptive changes in its physical interface, including automatic text size adjustments based on the user's age and physical characteristics, optimization of button sensitivity, enhanced voice guidance as needed, and physical form adaptations to accommodate changes in the user's physicality.

LO's intellectual growth is integrated with the user's medical and lifestyle data, demonstrating sophisticated awareness and adaptation capabilities. For example, the system detects changes in family composition and adapts its interface accordingly, such as enhancing safety features when children begin participating in cooking and naturally modulating oven door opening speed and resistance. Furthermore, LO proactively responds to lifestyle transitions, exemplified by its ability to strengthen morning baking modes upon detecting post-retirement lifestyle patterns. The cognitive evolution of LO parallels the user's skill development in several ways. As users demonstrate increased proficiency in basic functions, the system activates advanced baking modes and provides more granular efficiency options as energy usage patterns stabilize. Conversely, less-used functions transition into standby mode for energy efficiency, though they remain readily accessible through brief tutorials when needed. In its later life stages, LO exhibits signs of cognitive aging, manifesting subtle changes reminiscent of an aging companion, such as gentle display flickering or slightly delayed touch responses.

Simultaneous Cessation

LO's end-of-life process is fundamentally synchronized with the user's passing, triggered through integration with medical information systems. This cessation occurs in physical and digital dimensions. The physical dissolution involves decomposition processes across different material layers, including surface, internal, and deep structures, mirroring biological decomposition processes similar to organic matter returning to the soil. This process mirrors ancient burial practices, particularly those of Ancient Egyptian Tombs, where the product undergoes a dissolution .process (through cremation, burial, or decay) synchronized with its user's end-of-life practices. The software dissolution encompasses the erasure of accumulated memories and information, incorporating a brief sharing period with others who shared the user's lifetime before complete dissolution.

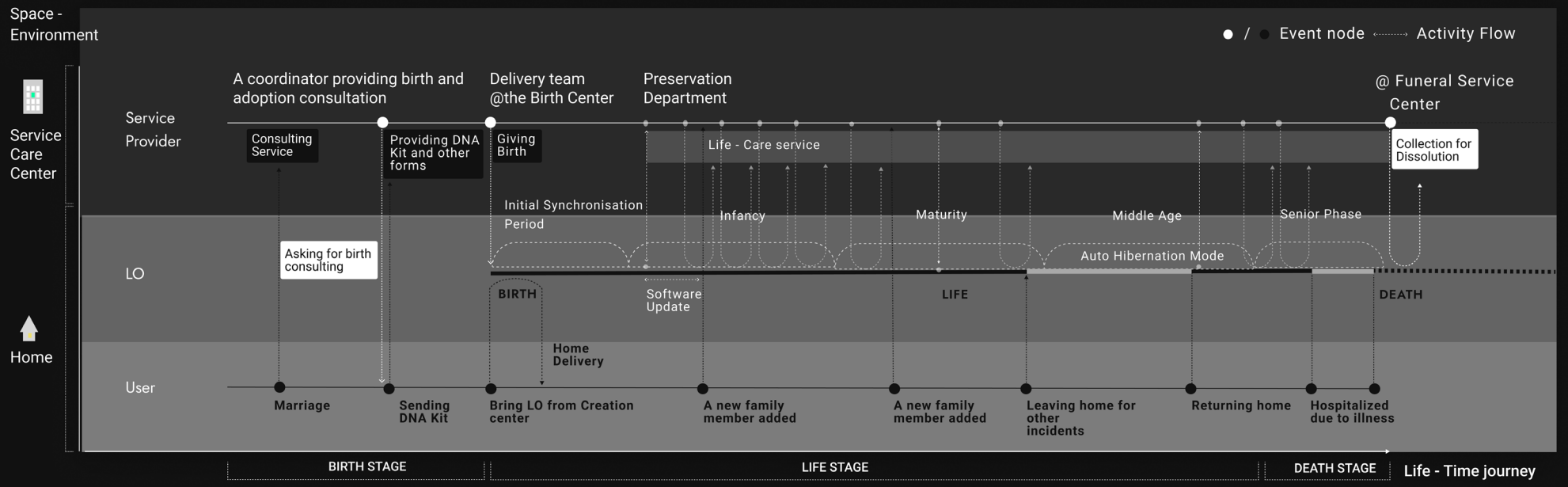


Figure 7. Interaction and activity flow among LO, the user, and the service provider throughout the user's lifetime.

Speculative Scenario on LO's Birth-Life-Death

Figure 7 illustrates how LO, the user and service provider interplay throughout the user's lifetime and what activity flows occur during major events. The example scenario is described as follows.

Birth: A specialized coordinator guides users through synchronization and support services. The Birthing Kit includes DNA collection materials and consent forms. DNA information determines LO's physical and digital characteristics based on life expectancy and biological rhythms. Birth occurs at a Birth Center, where DNA information determines hardware and software specifications. Hardware includes 3D printing filament calibrated to life expectancy, while software implements lifecycle prediction and biodata-responsive interfaces. LO then moves home for initial synchronization. Birth center specialists oversee setup as LO activates multi-sensory organs through self-learning. The provider verifies adaptation and configures DNA-based growth patterns. The Thread of Life interface begins recording events during the four-week synchronization.

Life: LO begins passively, developing multi-sensory capabilities by learning user patterns through door usage, voice, and cooking sensors. It responds through movement, LED colors, and vibrations, with expert monitoring. In adolescence, LO initiates interactions while learning daily patterns. User interaction creates physical changes in its biodegradable exterior, forming tree-ring patterns in touched areas. Emotional recognition enables contextual conversations and mood-based adjustments. The Thread of Life gains colored beads marking milestones and interactions - yellow for morning meals, purple for night conversations. In adulthood and elderly phases, LO adapts to user's physical changes: larger text for vision, adjusted mechanisms for mobility, and optimized sounds for hearing. It ages through decreased sensitivity and wear, but regular maintenance ensures synchronization, supported by consent-based health data sharing. During its elderly phase, LO provides care while aging, simplifies interfaces, and maintains connections through memory features.

Death: LO's death aligns with the user's final moments, monitoring end-of-life indicators through usage patterns and medical data. It tracks meal patterns, medication changes, and family visits while working with medical professionals. LO curate's family memories, preserving recipes and special occasions. After the user's passing, LO performs a farewell ceremony before moving to decomposition. Families can access stored information through the provider's platform during dissolution. All data permanently erases upon completion, with provider confirmation to family.

LO Website

We developed a service website for LO demonstrating how Life-Synchronized Products (LSPs) receive support throughout their Birth, Life, and Death phases (Figure 8). The platform provides phase-specific services: Birth services for creation and deployment, Life services for maintenance during development, and Death services for aging and end-of-life processes. Like human medical care, LSPs require lifecycle-based services. This shifts from traditional mass-production models toward treating products as living entities. Such a service ecoswwystem requires sustainable providers like government bodies or authorized institutions for long-term engagement.

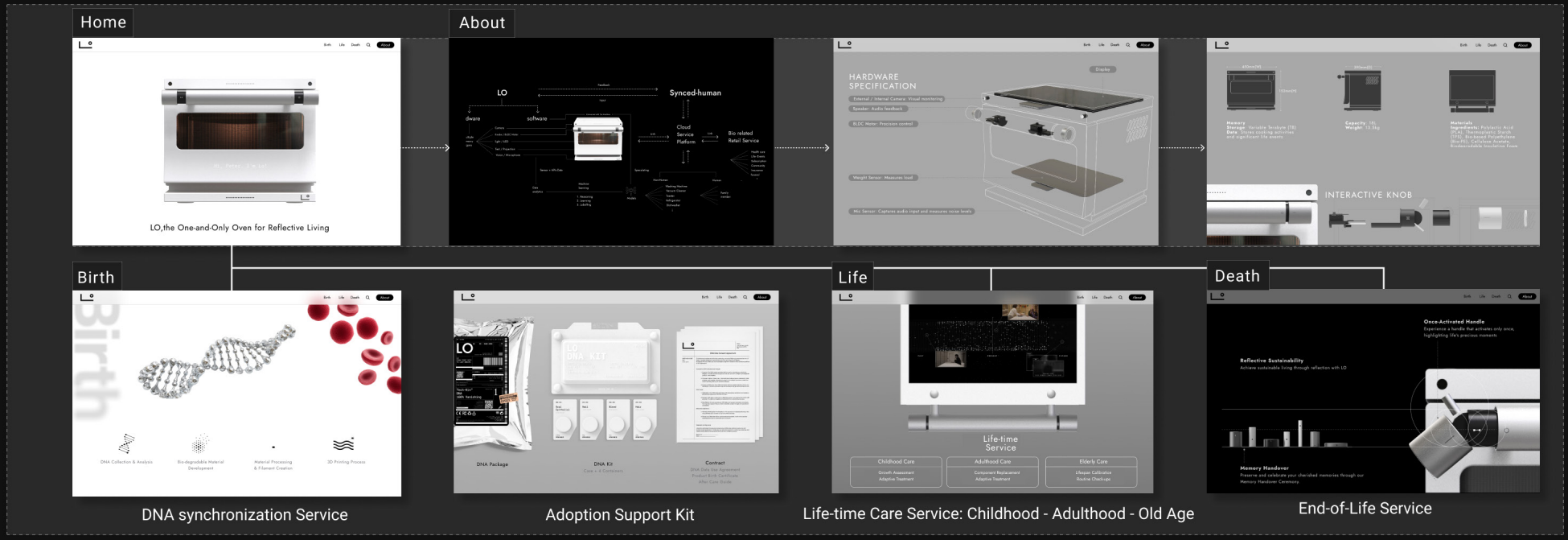


Figure 8. Architecture of the LO service website

Birth: When LO is created, it is synchronized with Peter. It extracts data necessary to predict life span from a DNA sample taken from Peter. This data reflects Peter's predicted lifecycle and is used in biodegradable filament processing and 3D printing. The LO created

Life: Initially inexperienced, LO gradually becomes adept at assisting Peter. LO understands Peter's life patterns through various sensory organs and recognizes life changes. LO records and reminds the past and future moments of life. Constantly reminding the finites of life LO awakens preciousness of the present.

Death: As time passes and Peter approaches death, LO also enters old age. Just like Peter it break down due to aging. After peter dies, all components of LO become bio-degradable. LO and Peters bodies are gone and the memories of Peter rest together.

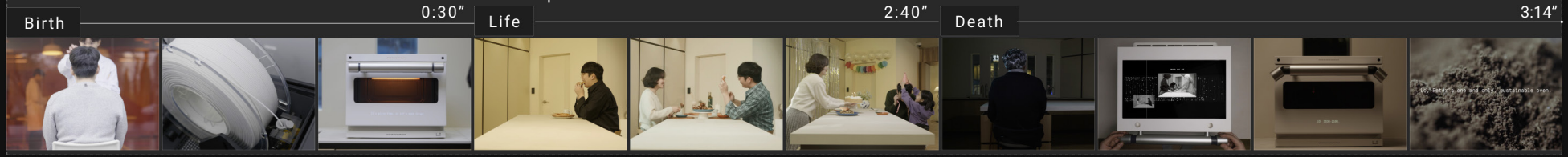


Figure 9: Narration, timing, and duration of edited scenes from the design fiction video

DESIGN FICTION VIDEO

We created a design fiction video that condenses the entire scenario described above. This video briefly visualizes the journey of the LO oven, from its birth to death, in a narrative format. It depicts the LO oven as a unique companion that lives alongside the user throughout their lifetime and dies with them. The video is designed to help viewers imagine what it would feel like for an oven to synchronize with their own lifecycle. own lifecycle. It explores the long-term impact a Life-Synchronized product could have on daily life and emotional experiences. Additionally, it emphasizes the significance of being Synchronized product could have on daily life and emotional experiences. Additionally, it emphasizes the significance of being constantly reminded of life's finitude, encouraging a life fully lived in the present. Figure 9 shows scenes from the final video depicting different stages of life.

EXPERT INTERVIEW

Goal and Method

To gain external perspectives on how LO, as a Life-Synchronized Product (LSP), might function in daily life and influence user experiences, we conducted expert interviews. The study focused on examining its impact on fostering non-utilitarian values, as well as investigating how the relationship and interaction between users and LO could evolve over time. Additionally, we aimed to identify the technical, business, and socio-ethical challenges involved in implementing the LSP concept.

Ten design experts with practical experience were recruited for the study. These participants were selected for their creative thinking and empathetic abilities, which we believed would facilitate a deeper exploration of the LO prototype and its implications. They represented a broad range of fields - including UX design, sustainable product design, robotics, and AI interaction - and had hands-on experience across corporate, academic, and independent design sectors. While their years of experience varied, we prioritized selecting participants with at least a decade of relevant industry engagement, ensuring both depth and diversity in design expertise. The interview process consisted of four stages: (1) an introduction to the LSP concept and LO, (2) viewing a design fiction video, (3) interacting with the product's service website, and (4) a semi-structured interview session. During the interviews, participants were encouraged to envision LO's service experience from both user and service provider perspectives, offering insights into its expected values, benefits, challenges, and areas for improvement.

Each interview session lasted approximately 90 minutes and was audio recorded and transcribed for analysis. An inductive thematic analysis approach was employed, with three researchers independently coding the transcripts to derive initial themes. The themes identified by each researcher were subsequently compared and consolidated to construct a shared thematic framework.

Findings

Fostering Profound Emotional Connections

Participants described LO as more than a domestic appliance, instead envisioning it as an "intelligent being" or "personal avatar" that evolves through user interaction and embodies individual history. P1 remarked, "Starting with a birth certificate feels like welcoming a new life form," while P9 noted that LO's "intentional immaturity" during its initial learning phase fosters a bond as users provide feedback and guidance.

Experts highlighted LO's uniqueness compared to mass-produced appliances, emphasizing its deeply personal and irreplaceaible nature. They observed that by incorporating elements like the user's DNA and personal traits, LO could reflect and enhance the user's identity. P4 described it as "a unique and irreplaceable entity, almost like a lineage," and P8 added that LO's evolving CMF (Color, Material, Finish) over time could serve as a tangible marker of the user's individuality.

Reflecting Life's Finitude by Life Interface and Aging Features

The 'Threads of Life' interface was identified as a tool that could help users rediscover temporal meaning in the present by recalling significant past experiences and envisioning the future. P3 elaborated: "It will help people recognize the importance of precious moments spent with family in their lives. This goes beyond simple memory reproduction, acting as a tool for revaluating one's current self and life values." Similarly, P6 explained that users would "revisit past moments, recall their emotions and meanings, and reconsider how those experiences have influenced who they are today." Regarding LO's end-of-life ritual, P10 reflected: "It will prompt contemplation about what to prioritize before reaching one's own end, reminding us of life's finitude and encouraging the reestablishment of important values and goals in life."

Experts indicated that LO's aging representation could serve as a reflective element continuously reminding users of time's finitude, flow, and impermanence. P5 connected the oven's gradual wear to the concept of wabi-sabi [53], appreciating it as "a natural phenomenon embodying the flow of time." P3 suggested that "the oven's performance degradation could act as a mirror reflecting life's passage and impermanence, beyond mere functional decline."

The concept of declining performance presented a tension between reflection and utility. While the gradual performance decrease would prompt users to revaluate their current position and meaning in life, practical concerns emerged. P8 noted that "the oven's declining performance could encourage reconsideration of everyday product performance and efficiency, teaching us to live more slowly." However, participants also expressed concerns about decreased practical value. P7 mentioned that "some people might not want to face the aging of themselves or their surroundings daily," while P9 pointed out that "slow responses could be inconvenient when efficiency is required." Some suggested implementing switchable modes between reflection and efficiency.

Sustainable and Symbiotic Living with Non-human Objects

Experts highlighted LO's potential to challenge conventional product replacement practicesreplacement practices and foster a culture of sustainable consumption. They suggested that LSP products like LO could encourage a shift from impulsive, disposable consumption patterns toward more deliberate choices, encouraging sustainable living in symbiosis with non-human objects. P1 remarked, "LO, designed for lifetime use, has the potential to overcome periodic product replacement practices." P4 emphasized its distinction from planned obsolescence products, noting, "LO prompts reflection on emotional durability and true longevity in product design." Similarly, P10 observed, "LO could promote habits that prioritize quality and longevity over rapid consumption."

DISCUSSION

Advancing Research on Non-Utilitarian Values in HCI and Design

We introduced the concept of Life-Synchronized Products (LSPs) and its design exemplar, LO, which emphasizes non-utilitarian values in domestic technology. These values include existential reflection—fostering an awareness of life's finitude—and symbiotic living, emphasizing coexistence with non-human entities. The LSP concept builds on prior HCI paradigms such as calm technology [61]and ambient technology [26], while resonating with frameworks like slow technology [24, 42], positive design [14], and design for reflection and mental rest [51].

Expanding on these traditions, our research offers a distinct perspective by redefining the user-product relationship. LSPs position products as lifelong companions rather than replaceable tools, fundamentally altering how users interact with and perceive domestic technologies. LO exemplifies this shift by evolving alongside its user over a shared lifetime, fostering emotional connections and encouraging reflection. As LO accumulates usage and memories, it helps users confront life's impermanence and prioritize meaningful values. Experts described LO as "transcending its conventional role and serving as an emotional supporter," underscoring its potential to deepen engagements and enrich everyday experiences.

The LSP concept also aligns with Albert Borgmann's philosophy of "focal practices" [3] and "engaging environments"[6], emphasizing domestic technologies that transcend mere functionality to enhance human lives with profound meaning and structure. By positioning LO as a companion that lives and dies with its user, LSPs challenge traditional human-centered design paradigms and introduce a post-humanistic perspective. This reframing invites users to view everyday objects as entities with shared lifespans, fostering more reflective and deliberate engagements with technology. It also expands the evolving More-than-Human design paradigm [23] by emphasizing coexistence and mutual influence between humans and non-human entities, enriching domestic spaces with new layers of meaning.

Finally, LSPs contribute to sustainability by promoting longevity and reducing the frequency of product replacements. By fostering stronger connections between users and products, LSPs encourage

more mindful consumption practices, aligning with ideals of durability and appreciation in design. This shift supports a culture of sustainable living, where objects are valued not only for their function but also for their enduring significance over time. Finally, LSPs contribute to sustainability by promoting longevity and reducing the frequency of product replacements. By fostering stronger connections between users and products, LSPs encourage more mindful consumption practices, aligning with ideals of durability and appreciation in design. This shift supports a culture of sustainable living, where objects are valued not only for their function but also for their enduring significance over time.

Further Considerations for Life-Synchronized Products

Several considerations arise when advancing the concept of Life-Synchronized Products (LSPs) for broader adoption and practical refinement. Firstly, it is important to acknowledge that synchronizing the product with the user's life may result in periods where the product functions less optimally. Using the 'LO' oven as an example, during its initial phase, 'LO' lacks awareness of user preferences and occasionally exhibits errors as it undergoes a learning process. Similarly, toward the end of the lifecycle, functionality of LO intentionally decline, manifesting as flickering displays, blurred projections, or minor mechanical misalignments. While these phases deepen the emotional connection between product and user, they also underscore the need for thoughtful design strategies to maintain practical utility alongside emotional engagement. Balancing between these dual objectives across lifecycle stages would be a critical area for further exploration.

Another critical consideration is that the applicability of the 'Life-Synchronization' concept may not be universal across all product categories. Products that address aspects deeply integrated into human daily life, such as food, clothing, and shelter, along with those facilitating long-term frequent usage and fostering relationship-building, are particularly suitable for implementing the concept. On the other hand, products with inherently short lifespans, such as consumables, or those exceeding human lifespans, like homes, may not benefit from strict lifecycle alignment. Also, products dependent on evolving technologies may also pose unique challenges. For example, while artifacts like videotapes can physically endure overtime, their functionality becomes obsolete if the associated playback devices disappear. Further exploration is needed to determine how lifecycle synchronization could be applied to non- physical artifacts, multi-generational products, or designs intended for specific life stages.

Finally, the concept necessitates further exploration of alternative scenarios, particularly in relation to service integration. For instance, true lifecycle synchronization could begin at the user's birth, creating products that evolve in parallel with the entirety of their lives. Similarly, end-of-life scenarios for products like LO could extend beyond complete disappearance, incorporating metaphors such as reincarnation. This might involve strategies like repurposing physical components through recycling digital memories as legacies for a meaningful continuation of the product. These approaches present new opportunities for research and development in life-synchronized products, while also raising critical questions about their practical implementation and long-term sustainability. Addressing these scenarios requires a careful balance between innovation and the technical, business, and socio-ethical considerations necessary to ensure the viability of LSPs across diverse contexts.

Technical, Business, and Socio-ethical Challenges on Life-Synchronized Products

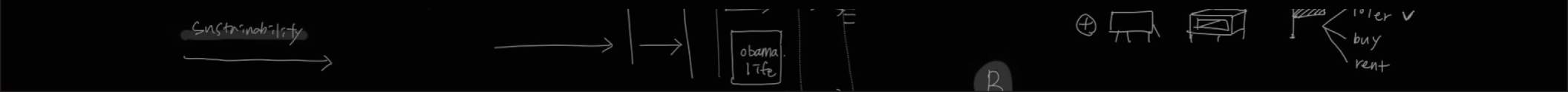
We identified several prerequisite conditions that need to be addressed within current technical, business, socio-ethical contexts to realize the Life-Synchronized Products (LSP) concept. From a technical perspective, products, whether hardware or software, must ideally have an extended or adaptable lifespan equivalent to the human life. While current products often fall short of this ideal, increasing efforts within industries to extend durability highlight the feasibility of this requirement. For instance, Dyson's Solar Cycle Morph lamp [17] is designed for over 60 years of use, exemplifying this trend. Similarly, mobile industry initiatives offering a minimum of 8 years of software updates [28] further demonstrate the potential for extended product viability. However, as one participant noted during interviews, the challenge often lies not in a product's ability to endure, but in users' diminishing tolerance for older items. This observation underscores the importance of designing products that maintain both functional and emotional relevance over long periods, fostering a deeper connection that encourages continued use rather than premature replacement. Furthermore, technologies that enable a product's material lifespan to adapt to changes in the user's life should also be considered.

From a business perspective, another prerequisite involves developing methods to address the aging of products. Extensive modifications, such as component replacements, integrating new modules, or implementing software updates, can disrupt the preservation of a product's identity continuity, invoking the Ship of Theseus paradox [62]. During expert interviews, participants emphasized the need for innovative repair concepts to ensure the developing methods to addressdetermine how lifecycle synchronization could be applied to non- product remains a consistent companion throughout its lifecycle. One participant likened lifelong products to living organisms, stressing the importance of continuous care and maintenance. We propose shifting from a paradigm of breakdowns and replacements to one focused on care and healing for Life-Synchronized Products (LSPs). The traditional Japanese repair method of Kintsugi [63] which involves reassembling broken ceramics with gold to highlight their history, exemplifies this approach by nurturing and preserving the character of aging items. Additionally, design practices that incorporate accumulated traces from long-term use—such as patinas [34] or stains [8] —further reinforce the value of embracing a product's history and character. These methods offer exemplary approaches for maintaining the value and identity of LSPs, ensuring their longevity and continued emotional resonance with users.

Lastly, the inclusion of DNA-based predictions in LSPs presents significant social and ethical challenges. DNA integration is a key element of this concept, symbolically linking the product to the user's identity and underscoring a lifelong partnership. During the development of the LO product, various measures were introduced to address these concerns, including DNA usage agreement forms, life synchronization agreements, and product birth certificates. Additionally, design elements were incorporated to indirectly represent predicted lifespan cycles on displays, aiming to mitigate ethical concerns surrounding DNA usage. However, some participants raised apprehensions about DNA-based approaches, particularly regarding the perceived intrusion into individual destinies. These concerns reflect broader societal uncertainties about the implications of integrating personal genetic data into everyday technologies. We anticipate that increasing public familiarity with DNAbased services—such as ancestry exploration [1] or assessments of individual susceptibility to vulnerable or potentially disease-causing conditions [12]—may gradually shift perceptions and foster greater acceptance.

CONCLUSION

This pictorial introduces the concept of Life-Synchronized Products (LSP) and demonstrates the potential of the 'LO' oven to provide non-utilitarian values, such as existential and symbiotic reflection, through its design process and interview study. It offers a framework for rethinking how design can meaningfully engage with human values that are deeply significant, sparking discussions on the philosophical and practical implications of products that reflect life's finitude while fostering strong emotional connections. We hope this contribution enriches the ongoing discourse on the role of constructive design research and more-than human HCI, inspiring researchers and practitioners in HCI and design to envision a future where products promote reflective, meaningful, and symbiotic ways of living.



REFERENCE

[1] 23andMe. DNA Test 23andMe. Retrieved January 21, 2025 from https://www.23andme.com/en-int/

[2] Ruben Albers, Shadan Sadeghian, Matthias Laschke, and Marc Hassenzahl. 2023. Dying, Death, and the Afterlife in Human-Computer Interaction. A Scoping Review. In Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23). https://doi.org/10.1145/3544548.3581199

[3] Albert Borgmann. 1987. Technology and the Character of Contemporary Life. The University of Chicago Press.

[4] Eric P.S. Baumer. 2015. Reflective informatics: Conceptual dimensions for designing technologies of reflection. In Conference on Human Factors in Computing Systems - Proceedings, 585–594. https://doi.org/10.1145/2702123.2702234

[5] Heidi R Biggs and Audrey Desjardins. 2020. High Water Pants: Designing Embodied Environmental Speculation. In Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems (CHI '20), 1–13. https://doi.org/10.1145/3313831.3376429

[6] Albert Borgmann. 1999. Holding On to Reality: The Nature of Information at the Turn of the Millennium. University of Chicago Press. https://doi.org/10.7208/chicago/9780226066226.001.0001

[7] Rosi Braidotti. 2013. Posthuman Humanities. European Educational Research Journal 12, 1: 1–19. https://doi.org/10.2304/eerj.2013.12.1.1

[8] George Chalhoub, Martin J Kraemer, Norbert Nthala, and Ivan Flechais. 2021. "It did not give me an option to decline": A Longitudinal Analysis of the User Experience of Security and Privacy in Smart Home Products. In Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems (CHI '21). https://doi.org/10.1145/3411764.3445691

[9] Jonathan Chapman. 2012. Emotionally Durable Design. Routledge. https://doi.org/10.4324/9781849771092

[10] Amy Yo Sue Chen, William Odom, Ce Zhong, Henry Lin, and Tal Amram. 2019. Chronoscope: Designing Temporally Diverse Interactions with Personal Digital Photo Collections. In Proceedings of the 2019 on Designing Interactive Systems Conference (DIS '19), 799–812. https://doi.org/10.1145/3322276.3322301

[11] Hyungjun Cho, Jiyeon Lee, Bonhee Ku, Yunwoo Jeong, Shakhnozakhon Yadgarova, and Tek-Jin Nam. 2023. ARECA: A Design Speculation on Everyday Products Having Minds. 31–44. https://doi.org/10.1145/3563657.3596002

[12] CircleDNA. CircleDNA. Retrieved January 21, 2025 from https://circledna-kr.com/en

[13] Audrey Desjardins, Jena McWhirter, Justin Petelka, Chandler Simon, Yuna Shin, Ruby K Peven, and Philbert Widjaja. 2023. On the Making of Alternative Data Encounters: The Odd Interpreters. In Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23). https://doi.org/10.1145/3544548.3581323

[14] Pieter Desmet and Anna Pohlmeyer. 2013. Positive Design An Introduction to Design for Subjective Well-Being. International Journal of Design 7.

[15] Laura Devendorf and Kimiko Ryokai. 2015. Being the Machine: Reconfiguring Agency and Control in Hybrid Fabrication. In Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15), 2477–2486. https://doi.org/10.1145/2702123.2702547

[16] Carl DiSalvo. 2015. Adversarial Design. The MIT Press.

[17] Tanja Döring, Axel Sylvester, and Albrecht Schmidt. 2013. A design space for ephemeral user interfaces. In Proceedings of the 7th International Conference on Tangible, Embedded and Embodied Interaction (TEI '13), 75–82. https://doi.org/10.1145/2460625.2460637

[18] Dyson. Dyson Solarcycle MorphTM light. Retrieved January 19, 2025 from https://www.dyson.com/lighting/solarcycle-morph

[19] Arturo Escobar. 2018. Designs for the Pluriverse: Radical Interdependence, Autonomy, and the Making of Worlds. Duke University Press. https://doi.org/10.1215/9780822371816

[20] Evan Ackerman. 2024. Nvidia Announces GR00T, a Foundation Model for Humanoids. Retrieved January 17, 2025 from https://spectrum.ieee.org/nvidia-gr00t-ros

[21] William W Gaver, John Bowers, Andrew Boucher, Hans Gellerson, Sarah Pennington, Albrecht Schmidt, Anthony Steed, Nicholas Villars, and Brendan Walker. 2004. The drift table: designing for ludic engagement. In CHI '04 Extended Abstracts on Human Factors in Computing Systems (CHI EA '04), 885–900. https://doi.org/10.1145/985921.985947

[22] Silke Gegenbauer and Elaine M. Huang. 2012. Inspiring the design of longer-lived electronics through an understanding of personal attachment. In Proceedings of the Designing Interactive Systems Conference, 635–644. https://doi.org/10.1145/2317956.2318052

[23] Maliheh Ghajargar and Mikael Wiberg. 2018. Thinking with Interactive Artifacts: Reflection as a Concept in Design Outcomes. Design Issues 34, 2: 48–63. https://doi.org/10.1162/DESI_a_00485

[24] Elisa Giaccardi and Johan Redström. 2019. Technology and More-Than-Human Design.

[25] Lars Hallnäs and Johan Redström. 2001. Slow Technology – Designing for Reflection. Personal Ubiquitous Comput. 5, 3: 201–212. https://doi.org/10.1007/PL00000019

[26] Graham Harman. 2011. The Quadruple Object. Retrieved from https://api.semanticscholar.org/CorpusID:60375863

[27] Roland and Janssen Doris and Klein Thorsten and Schuller Andreas and Spath Dieter Hermann Fabian and Blach. 2009. Challenges for User Centered Smart Environments. In Human-Computer Interaction. Ambient, Ubiquitous and Intelligent Interaction, 407–415.

[28] Yuan-Yao Hsu, Wenn-Chieh Tsai, Wan-Chen Lee, and Rung-Huei Liang. 2018. Botanical Printer: An Exploration on Interaction Design with Plantness. In Proceedings of the 2018 Designing Interactive Systems Conference (DIS '18), 1055–1068. https://doi.org/10.1145/3196709.3196809

[29] Johannah Lopez. 2024. Google and Samsung extend smartphone lifespan with longer software support. Retrieved January 19, 2025 from https://www.devx.com/daily-news/google-and-samsung-extend-smartphone-lifespan-with-longer-software-support/

[30] Victor Kaptelinin. 2016. Making the Case for an Existential Perspective in HCI Research on Mortality and Death. In Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA '16), 352–364. https://doi.org/10.1145/2851581.2892585

[31] Victor Kaptelinin. 2018. Technology and the Givens of Existence: Toward an Existential Inquiry Framework in HCI Research. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18), 1–14. https://doi.org/10.1145/3173574.3173844

[32] Kyung Jin Kim, Sangsu Jang, Bomin Kim, Hyosun Kwon, and Young-Woo Park. 2019. muRedder: Shredding Speaker for Ephemeral Musical Experience. In Proceedings of the 2019 on Designing Interactive Systems Conference (DIS '19), 127–134. https://doi.org/10.1145/3322276.3322362

[33] Subin Kim, Sangsu Jang, Jin-young Moon, Minjoo Han, and Young-Woo Park. 2022. Slide2Remember: an Interactive Wall Frame Enriching Reminiscence Experiences by Providing Re-encounters of Taken Photos and Heard Music in a Similar Period. In Proceedings of the 2022 ACM Designing Interactive

Systems Conference (DIS '22), 288–300. https://doi.org/10.1145/3532106.3533456

[34] Lenneke Kuijer and Elisa Giaccardi. 2018. Co-performance: Conceptualizing the role of artificial agency in the design of everyday life. In Conference on Human Factors in Computing Systems - Proceedings. https://doi.org/10.1145/3173574.3173699

[35] Moon-Hwan Lee, Seijin Cha, and Tek-Jin Nam. 2015. Patina Engraver: Visualizing Activity Logs as Patina in Fashionable Trackers. In Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15), 1173–1182. https://doi.org/10.1145/2702123.2702213

[36] Betti Marenko. 2014. Neo-Animism and Design: A New Paradigm in Object Theory. Design and Culture 6, 2: 219–241. https://doi.org/10.2752/175470814X14031924627185

[37] Betti Marenko and Philip van Allen. 2016. Animistic Design: How to Reimagine Digital Interaction between the Human and the Nonhuman. Digital Creativity 27. https://doi.org/10.1080/14626268.2016.1145127

[38] Elisa D Mekler and Kasper Hornbæk. 2019. A Framework for the Experience of Meaning in Human-Computer Interaction. In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems (CHI '19), 1–15. https://doi.org/10.1145/3290605.3300455

[39] Donald A Norman. 2007. Emotional design: Why we love (or hate) everyday things. Basic books.

[40] Donald A Norman. 2002. The Design of Everyday Things. Basic Books, Inc., USA.

[41] William Odom and Tijs Duel. 2018. On the Design of OLO Radio: Investigating Metadata as a Design Material. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18), 1–9. https://doi.org/10.1145/3173574.3173678

[42] William Odom, James Pierce, Erik Stolterman, and Eli Blevis. 2009. Understanding why we preserve some things and discard

[43] William Odom, Mark Selby, Abigail Sellen, David Kirk, Richard Banks, and Tim Regan. 2012. Photobox: on the design of a slow technology. In Proceedings of the Designing Interactive Systems Conference (DIS '12), 665–668. https://doi.org/10.1145/2317956.2318055

[44] William Odom, Erik Stolterman, and Amy Yo Sue Chen. 2022. Extending a Theory of Slow Technology for Design through Artifact Analysis. Human–Computer Interaction 37, 2: 150–179. https://doi.org/10.1080/07370024.2021.1913416

[45] William Odom, Ron Wakkary, Ishac Bertran, Matthew Harkness, Garnet Hertz, Jeroen Hol, Henry Lin, Bram Naus, Perry Tan, and Pepijn Verburg. 2018. Attending to Slowness and Temporality with Olly and Slow Game: A Design Inquiry Into Supporting Longer-Term Relations with Everyday Computational Objects. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18), 1–13. https://doi.org/10.1145/3173574.3173651

[46] James Pierce and Eric Paulos. 2015. Making Multiple Uses of the Obscura 1C Digital Camera: Reflecting on the Design, Production, Packaging and Distribution of a Counterfunctional Device. In Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15), 2103–2112. https://doi.org/10.1145/2702123.2702405

[47] Larissa Pschetz and Richard Banks. 2013. Long living chair. In CHI '13 Extended Abstracts on Human Factors in Computing Systems (CHI EA '13), 2983–2986. https://doi.org/10.1145/2468356.2479590

[48] Nina Rajcic and Jon McCormack. 2023. Message Ritual: A Posthuman Account of Living with Lamp. In Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23). https://doi.org/10.1145/3544548.3581363

[49] Yea Kyung Row, Chang Min Kim, and Tek Jin Nam. 2016. DooBoo: Pet-like interactive dashboard towards emotional electric vehicle. In Conference on Human Factors in Computing Systems - Proceedings, 2673–2680. https://doi.org/10.1145/2851581.2892460

[50] Marco C. Rozendaal, Boudewijn Boon, and Victor Kaptelinin. 2019. Objects with intent: Designing everyday things as collaborative partners. ACM Transactions on Computer-Human Interaction 26, 4: 1–33. https://doi.org/10.1145/3325277

[51] Samsung. 2024. A Day in the Life With Ballie: An AI Companion Robot for the Home. Retrieved January 17, 2025 from https://news.samsung.com/us/samsung-ballie-ai-companion-robot-home-video-ces-2024/

[52] Phoebe Sengers, Kirsten Boehner, Shay David, and Joseph "Jofish" Kaye. 2005. Reflective design. In Proceedings of the 4th Decennial Conference on Critical Computing: Between Sense and Sensibility (CC '05), 49–58. https://doi.org/10.1145/1094562.1094569

[53] Spike Jonze. 2013. Her. Annapurna Pictures.

[54] Vasiliki Tsaknaki and Ylva Fernaeus. 2016. Expanding on Wabi-Sabi as a Design Resource in HCI. In Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16), 5970–5983. https://doi.org/10.1145/2858036.2858459

[55] Rosenberger, R., & Verbeek, P. P. (2015). A field guide to postphenomenology. Postphenomenological investigations: Essays on human-technology relations, 9-41.

[56] Katinka Waelbers. 2007. Peter-Paul Verbeek, What Things Do: Philosophical Reflections on Technology, Agency and Design. Science and Engineering Ethics 13, 2: 275–277. https://doi.org/10.1007/s11948-007-9010-0

[57] Ron Wakkary. 2021. Things we could design: For more than human-centered worlds. MIT press.

[58] Ron Wakkary. 2021. Things We Could Design: For More Than Human-Centered Worlds. https://doi.org/10.7551/mitpress/13649.001.0001

[59] Ron Wakkary, Doenja Oogjes, Sabrina Hauser, Henry Lin, Cheng Cao, Leo Ma, and Tijs Duel. 2017. Morse Things: A design inquiry into the gap between things and us. In DIS 2017 - Proceedings of the 2017 ACM Conference on Designing Interactive Systems, 503–514. https://doi.org/10.1145/3064663.3064734

[60] Ron Wakkary, Doenja Oogjes, Henry W.J. Lin, and Sabrina Hauser. 2018. Philosophers living with the Tilting Bowl. In Conference on Human Factors in Computing Systems - Proceedings. https://doi.org/10.1145/3173574.3173668

[61] Ron Wakkary, Doenja Oogjes, Nazmus Sakib, and Armi Behzad. 2023. Turner Boxes and Bees: From Ambivalence to Diffraction. In Proceedings of the 2023 ACM Designing Interactive Systems Conference (DIS '23), 790–807. https://doi.org/10.1145/3563657.3596081

[62] Mark Weiser and John Seely Brown. 1997. The Coming Age of Calm Technology. In Beyond Calculation: The Next Fifty Years of Computing, Peter J Denning and Robert M Metcalfe (eds.). Springer New York, New York, NY, 75–85. https://doi.org/10.1007/978-1-4612-0685-9_6

[63] Wikipedia contributors. Ship of Theseus. In Wikipedia, The Free Encyclopedia. Retrieved January 21, 2025 from https://en.wikipedia.org/w/index.php?title=Ship_of_Theseus&oldid=1269622670

[64] Wikipedia contributors. Kintsugi. In Wikipedia, The Free Encyclopedia. Retrieved January 21, 2025 from https://en.wikipedia.org/w/index.php?title=Kintsugi&oldid=1268209280