Ambient Intelligence Governance: Intergenerational Design of Ubiquitous AI Systems

Abstract

As AI systems increasingly permeate physical environments through ambient intelligence, traditional governance frameworks struggle to address their unique sociotechnical implications. This paper introduces "intergenerational design" as a novel governance approach for ambient AI systems that impact multiple generations of users concurrently. I present findings from a mixed-methods study examining how three generations of families (n=42) perceive, interact with, and attempt to govern ambient AI in shared living spaces. My analysis reveals significant governance gaps between generational mental models, technology literacy, and value systems. I propose a sociotechnical governance framework that bridges these divides through collaborative configuration interfaces, multi-literacy onboarding protocols, and value-translation mechanisms. This work reconceptualizes ambient AI governance as an intergenerational design challenge rather than a purely technical or regulatory one, with implications for domestic environments, public spaces, and institutional settings where multiple generations coexist with increasingly autonomous ambient systems.

1. Introduction

Ambient intelligence—AI systems embedded in physical environments that can sense, anticipate, and respond to human needs—represents a significant evolution beyond screen-based and voice-assistant AI [1, 2]. These systems, integrated into homes, workplaces, and public spaces, introduce novel governance challenges as they operate continuously, often invisibly, and impact multiple generations simultaneously. While substantial literature exists on AI governance frameworks [3, 4, 5], these approaches typically conceptualize users as a monolithic entity with uniform levels of technology comprehension, agency, and values [6, 7].

The reality is far more nuanced. In domestic spaces alone, ambient AI systems mediate the experiences of children, parents, and grandparents—stakeholders with dramatically different cognitive models, technological capabilities, and normative expectations [8, 9]. This intergenerational dimension has been largely overlooked in existing governance frameworks, creating significant blind spots in how ambient AI systems are designed, deployed, and regulated. While studies on digital divides have examined age-based disparities in technology access and use [10, 11], few have investigated how these differences specifically impact governance needs in ambient intelligence contexts.

This paper argues that effective governance of ambient intelligence requires an intergenerational design approach—one that explicitly accounts for how different generations perceive, interface with, and attempt to exert control over ambient systems. My research addresses a critical gap by asking: How do intergenerational differences shape the governance needs and capabilities of users interacting with ambient AI systems in shared spaces?

2. Methodology

I conducted a mixed-methods study combining ethnographic observations, semi-structured interviews, and co-design workshops with 14 three-generation family units (n=42) over six months. Participating families had at least one ambient AI system (smart speakers, thermostats, lighting, or security systems) installed in their homes for a minimum of three months.

My methodology consisted of three phases:

1. Home observations (3 hours per family) documenting natural interactions with ambient systems across generations
2. Individual interviews (45-60 minutes) exploring mental models, governance concerns, and control strategies
3. Family co-design workshops (90 minutes) where participants collaboratively developed governance mechanisms for their ambient systems

Data analysis employed grounded theory techniques [12], iteratively coding for governance challenges, intergenerational differences, and emergent coping strategies. I conducted member checking with participants to validate my interpretations.

3. Findings

3.1 Divergent Mental Models

My findings reveal stark differences in how generations conceptualize ambient AI systems:

- Older adults (65+) primarily understood ambient systems through mechanical metaphors (e.g., "it's like a thermostat with a memory") and tended to attribute simpler capabilities to the systems than actually existed.
- Middle-aged adults (35-55) employed computational metaphors (e.g., "it's processing our data to learn patterns") but often overestimated system intelligence and underestimated data collection extent.
- Young adults and teens (13-25) demonstrated the most technically accurate models but frequently anthropomorphized systems, attributing intentionality to algorithmic behaviors.

These divergent mental models created significant governance tensions, as family members made incompatible assumptions about system capabilities, appropriate use cases, and potential risks. This finding aligns with prior research on generational technology mental models [13, 14], but extends these insights specifically to ambient AI contexts.

3.2 Asymmetric Control Capabilities

Technical literacy disparities translated directly into governance power imbalances:

- Configuration interfaces overwhelmingly favored tech-savvy users, creating "governance gatekeepers" (typically younger adults) who mediated system access for others.
- Older adults expressed frustration at being "locked out" of meaningful control, often developing non-digital workarounds (e.g., covering sensors or disconnecting devices).
- Children and teens demonstrated sophisticated circumvention techniques to bypass parental controls, creating "shadow governance" systems unknown to adult stakeholders.

These findings extend previous work on digital literacy divides [15] by demonstrating how they specifically impact power dynamics in ambient AI governance.

3.3 Value Conflicts in System Behavior

Intergenerational value differences emerged as a primary governance challenge:

- Elders prioritized reliability, predictability, and explicit consent for system actions.
- Middle-aged adults valued efficiency, convenience, and family safety.
- Younger users emphasized personalization, adaptive learning, and minimal friction.

These competing values led to frequent reconfiguration conflicts and governance compromises that satisfied no one fully, supporting previous research on value tensions in multi-stakeholder technology contexts [16, 17].

3.4 Collaborative Governance Strategies

Despite these challenges, families developed innovative collaborative governance approaches:

- Translation rituals: Tech-savvy family members created simplified explanatory frameworks to help others understand system capabilities.
- Boundary objects: Physical artifacts (e.g., hand-drawn control maps) bridged generational divides by representing system functionalities in accessible ways.
- Negotiated territories: Families established space-based governance zones with different ambient AI configurations based on primary user needs.

These emergent strategies demonstrate how families attempt to overcome sociotechnical gaps through social negotiations around technical systems [18].

4. Framework: Intergenerational Ambient Intelligence Governance

Building on my findings, I propose a novel sociotechnical governance framework specifically addressing the intergenerational challenges of ambient AI systems. This framework is "sociotechnical" in that it explicitly recognizes and addresses the mutual constitution of social relationships and technical systems [19, 20]. Rather than treating governance as either purely technical (system settings and controls) or purely social (user education and norms), it acknowledges how ambient AI governance emerges from the interaction between technical affordances and social relationships across generations. The framework consists of three interconnected components, each directly tied to specific findings:

4.1 Multi-Literacy Interface Design

Directly addressing findings from Section 3.1 (Divergent Mental Models) and 3.2 (Asymmetric Control Capabilities)

Conventional approaches often treat technical literacy as binary (users either understand or don't), but my findings suggest the need for interfaces that accommodate multiple literacies simultaneously:

- Layered explanation systems that provide information at varying technical depths based on user preference
- Cross-generational configuration helpers that translate technical settings into value-based outcomes
- Metaphor selection systems allowing users to choose their preferred conceptual model for understanding system behavior

4.2 Collaborative Control Mechanisms

Directly addressing findings from Section 3.2 (Asymmetric Control Capabilities) and 3.4 (Collaborative Governance Strategies)

Rather than treating control as individual, I propose mechanisms for shared governance:

- Negotiation interfaces for resolving conflicting preferences
- Visibility of changes across user groups when settings are modified
- Collective override thresholds requiring multi-stakeholder agreement for significant system changes

4.3 Value Translation Protocols

Directly addressing findings from Section 3.3 (Value Conflicts in System Behavior)

To address fundamental value differences, my framework includes:

- Value-explicit configuration where users express desired outcomes rather than technical parameters
- Cross-generational impact visualization showing how changes affect different user groups
- Value-bridging algorithms that identify compromise configurations optimizing for diverse stakeholder needs

5. Discussion and Implications

Reconceptualizing ambient AI governance through an intergenerational lens has significant implications for research and practice:

For researchers: My findings highlight the need to move beyond individual user models in AI governance studies to accommodate multi-generational stakeholder dynamics [21]. Future work should investigate how these dynamics manifest across different cultural contexts and institutional settings beyond the home.

For designers: The proposed framework challenges conventional interface approaches that privilege technical expertise [22]. Designing for intergenerational governance requires fundamentally rethinking how users interact with complex AI systems through metaphors, visualizations, and collaborative controls.

For policymakers: Regulatory approaches must account for the power asymmetries created when ambient systems primarily accommodate certain generational perspectives [23]. Accessibility guidelines should expand beyond physical and sensory accommodations to include cognitive and generational dimensions.

6. Limitations and Future Work

My study focused on family units in domestic environments, potentially limiting generalizability to other contexts where generations interact with ambient AI (e.g., eldercare facilities, schools, public spaces). Additionally, my sample skewed toward middle-class households with broadband access. Future research should examine how socioeconomic factors intersect with generational differences in ambient AI governance.

I also recognize the need for longitudinal studies to understand how intergenerational governance practices evolve as ambient systems become more sophisticated and as younger users age into different roles within the governance ecosystem.

7. Conclusion

As ambient AI systems increasingly permeate shared physical environments, governance approaches must evolve beyond technical solutions to address the complex social dynamics of multi-generational use. My research reveals how mental models, technical capabilities, and values differ substantially across generations, creating unique governance challenges that current frameworks fail to address.

The intergenerational design approach I propose recognizes that effective governance of ambient AI requires accommodating diverse stakeholder perspectives rather than privileging technical expertise. By implementing multi-literacy interfaces, collaborative control mechanisms, and value translation protocols, ambient intelligence can better serve the needs of all generations sharing increasingly AI-mediated spaces.

References

[1] Cook, D. J., Augusto, J. C., & Jakkula, V. R. (2009). Ambient intelligence: Technologies, applications, and opportunities. Pervasive and Mobile Computing, 5(4), 277-298. https://doi.org/10.1016/j.pmcj.2009.04.001