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Exploring the Ambient in Relation to Urban Life and AI

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Abstract: The purpose of this paper is to explore the nature of the ambient in an era of artificial intelligence (AI), focusing on the urban context. As such, this paper explores evolving understandings of the ambient in everyday life encompassing a range of elements such as awareness, computing, experiences, information, and intelligence in relation to rapidly evolving and emerging applications of AI and generative AI in urban environments. A review of the research and practice literature for the ambient in relation to urban AI is provided in this paper enabling formulation of a conceptual framework to guide the exploration. A poll conducted online using the Whova platform during a hybrid (e.g., virtual and in person) conference event provides insight into the awareness element in the context of AI from the perspective of researchers, students, practitioners, and other conference participants and attendees (e.g., government business, etc.). Implications for urban life, smart cities, learning cities, and future cities are discussed, giving rise to challenges and opportunities for research and practice going forward. This work is significant in that a range of perspectives across a variety of domains emerge for the ambient in relation to everyday life and AI and to urban AI.

Keywords: ambient awareness; ambient information; ambient computing; ambient engineering; ambient experiences; artificial intelligence; awareness; generative AI; learning cities; smart cities

1. Introduction

With the purpose of exploring the nature of the ambient in an era of artificial intelligence (AI), this paper focuses on the urban context encompassing AI urbanism, ambient AI, and urban AI. Gams, Gu, Härmä, Muñoz, and Tam (2019) [1] refer to the strong interconnection between ambient intelligence (AmI) and artificial intelligence (AI), where AmI is said to be "AI in the environment". AI is described by Gams et al. (2019) [1] as "the intelligence demonstrated by machines", as in, machine intelligence (MI), which is distinct from "natural intelligence (NI)" as "displayed by humans and other animals". Gams et al. (2019) [1] claim that any demonstration of intelligence "by machines in the surrounding environment" denotes AmI. Further, AmI is said to have interdisciplinary applications in areas such as smart cities, intelligent homes, intelligent workplaces, smart public spaces, smart schools and playgrounds, and ambient care and safety (Gams et al., 2019) [1]. AI implementations include capabilities associated with "human cognitive functions" such as "perceiving, processing information from the environment, and learning" (Gams et al., 2019) [1]. While AmI systems pertain to "electronic environments that are sensitive and responsive to the presence of people" where key properties can be found, such as embedded, context-aware, personalized, adaptive, anticipatory, unobtrusive, and non-invasive, AmI is also described as "an experience of the user with respect to the service provided" by AI technologies (Gams et al., 2019) [1].

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Challenges abound with emerging technologies and among the seven human–computer interaction (HCI) grand challenges identified by Stephanidis et al. (2019) [2] for living and thriving in "technology-augmented environments" is that of "human–environment interactions" and, also of "human–technology symbiosis" giving rise to a series of research challenges and opportunities pertaining to a rethinking of many elements including attention, interaction design, leveraging intelligent infrastructure, and enhancing human skills, to name a few. More recently, Garibay et al. (2023) [3] address six grand challenges pertaining to human-centered artificial intelligence (HCAI), where human-centered refers to "ethical, fair, and enhance the human condition". Among these grand challenges are responsible design, human well-being, and human–AI interaction (Garibay et al., 2023) [3], giving rise to research challenges and opportunities pertaining to a rethinking of policy guidelines, social media platform impacts, and methods and frameworks.

Caprotti, Cugurullo, Cook, Karvonen, Marvin, McGuirk, and Valdez (2024) [4] explore the importance of urban AI for urban studies research, opening areas for exploration pertaining to challenges and opportunities for urban governance. For Caprotti et al. (2024) [4] the emergent nature of urban AI gives rise to many challenges involving autonomy, intelligence, and even the need for a common vocabulary in urban contexts, while also providing opportunities "to produce a range of urban futures", a key concern for AI urbanism. Cugurullo, Caprotti, Cook, Karvonen, McGuirk, and Marvin (2024) [5] describe AI urbanism as "urbanism influenced by AI" as distinct from smart urbanism in theory and practice, giving rise to many questions pertaining to autonomy, human–machine relations, sustainability, and urban futures, to name a few.

In exploring the ambient in relation to urban life and artificial intelligence (AI) it is worth noting that Barns (2024) [6] proposes the notion of an 'ambient commons', drawing on the work of McCullough (2013) [7], as a way of framing the debate pertaining to "the exploitation of shared civic spaces by private technology platforms". Focusing on ambient computing infused with, or enabled by AI, Barns (2024) [6] is concerned with "the valuing of urban public spaces" and the "rich forms of data generated in these domains" based on "citizens acting freely together, as strangers, in public".

As such, this rapidly evolving space of ambient AI development and use gives rise to the research question for this paper, as follows:

RQ: What is the nature of the ambient in relation to urban life and AI?

This work is important in that the evolving of the ambient, across many sectors, surfaces key elements such as attention, awareness, and sensibility, involving computing, information generation, and experiences while giving rise to concerns with a range of factors such as accuracy and privacy in smart environments, contributing to an emergent space with many challenges and opportunities going forward. Principal conclusions include the need for ongoing scrutiny and evaluation in addressing evolving ambient AI challenges; opportunities for rethinking AI in relation to AmI (Andre, 2024) [8] and the possible emergence of super-AmI (SAmI) (Gams et al., 2019) [1]; and the evolving of perspectives on the ambient and urban AI, contributing to human–AI interaction potentials.

2. Background

In terms of background, definitions for key terms used in this work are provided in Section 2.1 and the primary objectives of the paper are identified in Section 2.2.

2.1. Definitions

Key terms used in this paper are defined below based on the research and practice literature.

The Ambient: McCullough (2013) [7] describes the ambient in a range of ways including "that which surround but does not distract" and "a continuum of awareness and an awareness of continuum".
Ambient Intelligence (AmI): Andre (2024) [8] describes ambient intelligence as a "transformative concept" and "a vision where environments are responsive, adaptive, and aware of human needs and preferences, making technology an intuitive extension of our daily activities".
Ambient Perspective: McKenna (2023) [9] describes the notion of an ambient perspective as "views that take into consideration the dynamic awareness capabilities of people and the dynamic aware-enabling capabilities of technologies and the interactive potentials of the two".
Urban AI: According to Luusua, Ylipulli, Foth, and Aurigi (2023) [10], urban AI refers to "the integrating of AI technologies into cities" while defining the urban AI concept as "the study of the relationship between artificial intelligence systems and urban contexts, including the built environment, infrastructure, places, people, and their practices".

2.2. Objectives

The primary objectives of this paper are to provide an overview of the research and practice literature for the ambient in an era of urban AI; formulate a conceptual framework for the ambient, urban life, and urban AI; and explore challenges and opportunities associated with the ambient and urban AI.

What follows is the development of a theoretical perspective for the ambient and urban AI, an overview of the exploratory approach used in this paper, findings pertaining to the exploration of challenges and opportunities associated with the ambient and urban AI, limitations of this work, future directions, and the conclusion.

3. Theoretical Perspective

A theoretical perspective is developed in Section 3.1 based on an exploration of the research and practice literature focusing on the ambient in the context of urban environments and the evolving of AI while being attentive to emerging challenges and opportunities. In Section 3.2 the implications of ambient AI and the emergence of AI urbanism are explored. In Section 3.3 key challenges and opportunities are further explored and a conceptual framework for the ambient, urban life, and urban AI is then formulated in Section 3.4 to guide explorations in this work and beyond.

3.1. The Ambient in Relation to Urban Environments and the Evolving of AI

The ambient is explored by McCullough (2013) [7] who refers to the notion of the ambient commons, where attention and information seem to matter, as "quiet enough but seldom silent" affording "more notice of the world". For McCullough (2013) [7] the ambient is characterized by sensibility and accommodates data formation, embedding, participation, thematic layering, slowness, camouflage, and locality. From a practice and everyday life perspective, McKendrick (2023) [11] claims that ambient AI, as in, ambient artificial intelligence, is already here operating in mobile apps and search engines and that we are, for the most part, unaware of such developments. Andre (2024) [8] provides an overview of ambient intelligence (AmI), claiming the overarching goal "is to improve the quality of human life through technology that understands and anticipates our needs" as distinct from AI which "aims to achieve or replicate human intelligence for a variety of purposes, not always directly related to enhancing user experience". Arm (2024) [12] points to ambient technology experiences, said to be "powered by AI" involving ambient computing that is described as "seamless digital experiences tailored to individual preferences, needs, and

surroundings" so as to be "effortlessly integrating into our daily lives" necessitating the addressing of privacy and computing complexity issues. Augmedix (2024) [13], producer of ambient AI medical documentation using generative AI, recently released Augmedix Go for the noisy environment of emergency departments (EDs) where the tool is designed to "accommodate complex conversations and a plurality of recordings capturing multiple, non-sequential interactions with a single patient" in "documenting medical decision making, re-evaluations, and progress updates" while garnering the trust of clinicians.

Blum (2024) [14] speaks in terms of "ambient clinical listening" where adoption is ongoing although limitations are identified in AI scribe summaries requiring careful review by clinicians. DMG productions (2024) [15] draws attention to work by Ambient Enterprises on data privacy and protection using the Ambient ProtectTM application, said to have "the ability to securely manage, protect, and monetize data assets with unparalleled control, accuracy, and transparency, paving the way for people to interact equitably and securely in a digital society. (Pines 2024) [16] describes ambient AI in a healthcare context as "a new technology that listens to your conversation and processes information" using the example of "ambient AI scribing" which "listens" and "then writes a clinical note summarizing your visit". Such notes are said to be "used to communicate diagnostic and treatment plans within electronic health records" while serving "as a basis to generate your bill". Among the benefits of tools such as ambient AI scribes are said to be "more meaningful interactions and reductions in after-hours note writing" leading possibly to greater efficiency and more complete note-taking (Pines, 2024) [16]. Patients are also said to enjoy benefits of the ambient AI scribe tool, describing "physicians as more attentive" and less distracted by note taking (Pines, 2024) [16]. And yet, privacy challenges surround such technologies, as well as the need for checking the note-taking to ensure accuracy (Pines, 2024) [16]. Of interest perhaps in these accounts from the healthcare space is reference to the "experience" aspect of the ambient in various implementations (Andre, 2024; Arm, 2024) [8,12].

From a research perspective, Thibaud (2020) [17] explores the notion of an ambient ecology characterized perhaps by sensitivity and attention in urban environments focusing on "flows, atmospheres, envelops, and weather" in a "fluid, porous and diffuse space, in continual movement, formation and transformation". McKenna (2021) [18], in advancing ambient theory for smart cities, claims that "awareness, sensing, and meaningful involvement denote conditions indicative of when and where ambient theory will hold in the context of smart cities, environments, and regions". Sun and De Florio (2021) [19] focus on ambient assisted living (AAL) systems, said to be "the result of a complex interplay" involving "both human and technological", in accommodating "a wide spectrum of services" designed to "effectively support the elderly" so that they may "live independently at home". In this way, AAL is advanced by Sun and De Florio (2021) [19] to "build a safe environment around people in need" in the form of "descriptive, predictive, and prescriptive intelligences". Andre (2024) [8] identifies the key characteristics of ambient intelligence (AmI) in the context of AI as ubiquitous presence (e.g., homes, offices, public spaces), context awareness (e.g., location, time, emotion), adaptability (e.g., flexibility, learning, evolving), proactive and reactive functions (e.g., anticipatory and acting autonomously), seamless interaction (e.g., use of voice or gestures), and personalization (e.g., individual preferences and requirements). For Andre (2024) [8], key challenges for AmI include data security, ethical (e.g., autonomy and consent), privacy (e.g., personal information and behavior), responsible AI integration (e.g., systems designed in the "best interests of users and society"), and transparency and control.

Chou (2024) [20] looks at healthcare and ambient AI solutions noting the growing "marketplace for ambient listening tools" focusing on clinical documentation and summarization; AI integration for patient care; and clinical decision support, to name a few.

Hirokawa, Tsuji, and Fujinami (2024) [21] explore evolving understandings of ambient displays, proposing the Eyebient display involving "gaze guidance" using a smartphone and everyday objects, said to be a method characterized by "creativity and effectiveness". Rickert (2024) [22] addresses the notion of ambient engineering in an AI context claiming that "algorithms and AI are producing a transformation in the economics of attention" where "emerging AI-driven techniques of hyper-nudging and hyper-relevance address themselves to our senses of nearness and farness" through anticipation and inference that influence noticing, engagement, and the like.

Spenser (2024) [23] articulates the notion of 'ambient stories' that are "rooted in place and accessed using a smartphone". As such, according to Spenser (2024) [23], ambient stories "are not only told through the authored words that are presented to a reader through text on the screen of a smartphone or through elements of audio listened to through headphone but also the language found in the world around them" as in, "the physical landscape" or "architectural features of the city street, elements of the natural world or other people passing by". Elements associated with ambient stories, according to Spenser (2024) [23] include "situated reading experiences" that are said to be "embodied, authored, and often unpredictable, shared through text, audio, and sensor-based delivery". As such, ambient stories offer to the reader "an encounter with place that is mediated by ubiquitous, familiar technology" as well as "a lens through which to examine our relationship with technology and the world around us" (Spenser, 2024) [23].

In summary, as shown in Table 1, key perspectives by author and year on the nature of the ambient in relation to urban life and AI focus on the ambient commons; urban AI and AI urbanism; ambient ecologies; ambient assisted living (AAL) systems for the elderly and those in need, based on descriptive, predictive, and prescriptive capabilities; ambient theory; ambient data; ambient clinical listening; healthcare ambient AI solutions; AI urbanism and concerns with autonomy, human–machine relations, and sustainability, to name a few; ambient displays; AI and other emerging technologies for listening, processing and summarizing; ambient engineering; and ambient stories.

Table 1. Perspective on the Ambient and Urban AI.

Author	Year	Focus
McCullough	2013/24	Ambient commons
Caprotti et al.	2019	Urban AI & AI urbanism
Thibaud	2020	Ambient ecology
Sun & De Florio	2021	AAL systems–descriptive, predictive & prescriptive intelligences
McKenna	2021	Ambient theory–awareness, sensing & meaningful involvement
Andre	2024	Ambient intelligence (AmI) in contrast with AI
Barns	2024	Valuing ambient data in urban public spaces
Blum	2024	Ambient clinical listening
Chou	2024	Healthcare ambient AI solutions
Cugurullo et al.	2024	AI urbanism & autonomy, human–machine relations, sustainability
Hirokawa et al.	2024	Evolving ambient displays to *eyebient*
Pines	2024	Technologies for listening, processing & summarizing
Rickert	2024	Ambient engineering influencing attention
Spenser	2025	Ambient stories, lens to examine our relationships with technology

Depicted graphically in Figure 1, key perspectives on the nature of the ambient in relation to urban life and AI pertaining to AI urbanism, ambient commons in urban environments, ambient data, ambient ecology, ambient engineering, the evolving of ambient displays, ambient theory, and technologies for listening, processing and summarizing.

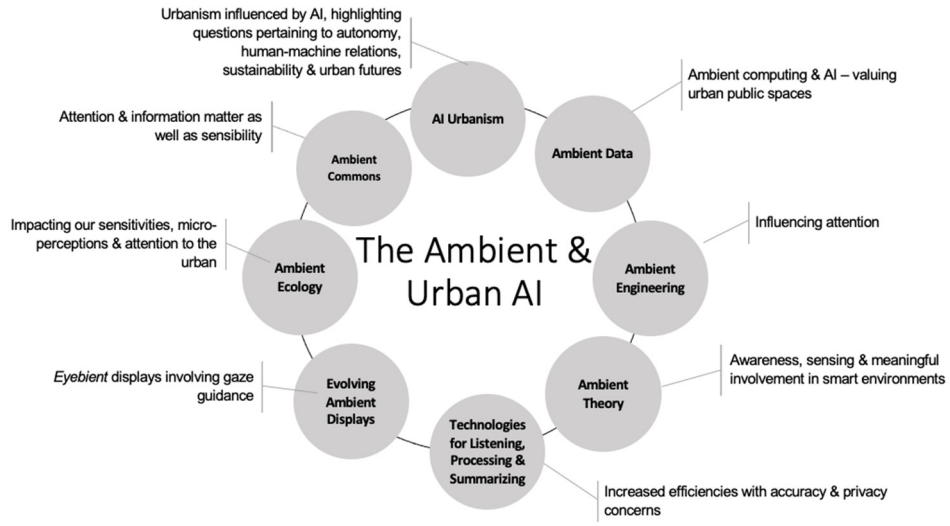

Figure 1. Perspectives on the ambient, urban life, and urban AI.

Next, implications of ambient AI are considered in relation to the emergence of AI urbanism in Section 3.2.

3.2. Implications of Ambient AI and the Emergence of AI Urbanism

Based on the literature review, implications of ambient AI and the emergence of AI urbanism are considered, spanning the years 2019 to 2024, as shown in Table 2.

Table 2. Implications of Ambient AI and the Emergence of AI Urbanism.

Author	Year	Implications of Ambient AI & AI Urbanism
Gams et al.	2019	SuperAmI emerging sooner than Superintelligence
Li et al.	2022	Eye tracking for vigilance assessment in traffic services
Cugurullo et al.	2023	Cultural dimensions & landscape of AI
Daruwala & Oberst	2023	SHT uptake–compatibility & perceived usefulness
McKenna	2023	Culture, economy & mobility–Pattern & relationships
Barns	2024	Data flow ownership & use in ambient environments
Caprotti et al.	2024	More-than-human capacities–Sensemaking, etc.
Hornos & Zamudio-Rodríguez	2024	AI systems for sensing & decision-making in real-time

As such, the research work of a range of authors provides a glimpse of the cultural, economic, and social implications of ambient AI and the emergence of AI urbanism, contributing to a more comprehensive foundation for understanding the ambient in the context of AI and urban life. For example, Gams et al. (2019) [1] argue that super-AmI (SAmI) enabled "through embodiment, embedding and interactions with humans" may emerge sooner than superintelligence (SI) which is said to involve the achieving or surpassing of human intelligence.

Li, Chen, Lee, and Feng (2022) [24] describe a study to explore an AI-enabled, non-intrusive vigilance assessment method involving eye tracking and the analysis of gaze patterns, designed to reduce human error for traffic controllers in transportation (e.g., air traffic management, vessel traffic service, and high-speed trains) associated with the monitoring of traffic conditions and the noting of potential hazards.

Cultural aspects and a cultural perspective figure strongly in the AI urbanism work of Cugurullo et al. (2023) [5] where it is said that "AI has become part of the cultural landscape of the 21st century".

Concerned with the "relatively low" uptake of smart home devices, Daruwala and Oberst (2023) [25] provide a systematic review of automated domestic appliances in the category of smart home technology (SHT) where the technology acceptance model is found to be the most used in research studies while the variables of compatibility and perceived usefulness emerge as most used in the measuring of acceptance.

McKenna (2023) [9] explores urban life from an ambient perspective focusing on culture, economy, and mobility, finding a range of patterns and potential relationships as well as a series of issues, controversies, and problems. Further, Barns (2024) [6] raises a number of questions such as "[w]ho gets to own and exploit the data flows existing within these ambient environments?" According to Caprotti et al. (2024) [4], urban AI consists of several sets of entwined "more-than-human capacities" in the form of sensemaking in urban environments; robotization of tasks in urban spaces that may be too high risk or monotonous for humans; and the ongoing evolving of urban AI capabilities in augmenting, enhancing, controlling, and the like, of urban functions.

In terms of how the intelligence from AI systems is harvested and put to use, consideration is given to whether the technology is being used to merely scrape data on human behaviors on the one hand, and on the other hand, to develop applications able to serve the health and well-being of those in the public realm. For example, Hornos and Zamudio-Rodríguez (2024) [26] introduce a thematic issue on the development and integrating of next generation technologies for sensing and decision-making in support of economic impacts focusing on the areas of intelligent environments, smart cities, Industry 4.0, and advanced healthcare systems. As such, Hornos and Zamudio-Rodríguez (2024) [26] seek to show how such technologies "are shaping the future of intelligent environments and driving societal transformation". Sensing technologies include wearable devices and mobile sensors that are "increasingly used in enhanced living environments and healthcare applications to improve safety and efficiency" and particularly "[t]he ability to process sensor data in real-time" enhancing functionality while providing "new opportunities for personalization and adaptability". Such systems are said to have implications for accuracy, analysis, learning, adaptability, innovation, optimization of services, productivity, and sustainability (Hornos and Zamudio-Rodríguez, 2024) [26]. As such, spaces are opening for the consideration of technology as an ambient force, capable perhaps of transforming urban life as we know it.

Depicted graphically, Figure 2 provides an overview of implications of ambient AI and the emergence of AI urbanism focusing on cultural landscapes; culture, economy, and mobility; data flows; eye-tracking vigilance assessment; more-than-human capacities; sensing and decision-making; smart home technologies and uptake; and superAmI in advance of superintelligence.

Next, challenges and opportunities of the ambient in relation to the evolving of urban AI are considered in Section 3.3.

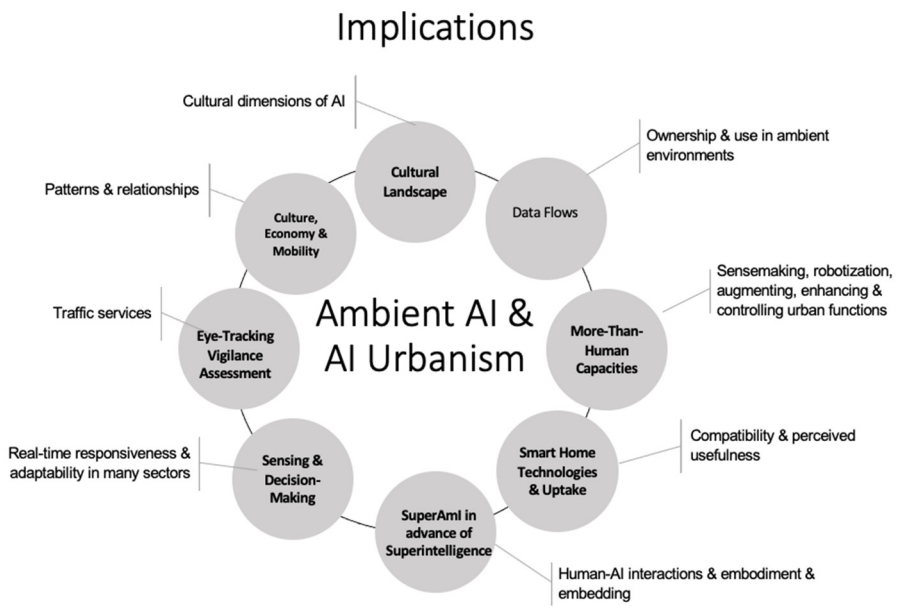

Figure 2. Implications of ambient AI and the emergence of AI urbanism.

3.3. Challenges and Opportunities of the Ambient in Relation to the Evolving of Urban AI

Based on the literature review of the ambient in relation to the evolving of AI in urban contexts, a range of challenges and opportunities emerge, spanning the years 2019 to 2024, as shown in Table 3, pertaining to HCI grand challenges, AI grand challenges, accuracy, attention (impacting engagement, etc.), autonomy, awareness, bias, privacy and security, transparency (algorithmic), and trust.

Table 3. Challenges and Opportunities for the Ambient and Urban AI.

Author	Year	Challenges & Opportunities for the Ambient & Urban AI
Stephanidis et al.	2019	HCI grand challenges
Dahlin	2023	Autonomy
Duncan et al.	2023	Awareness
Gagné	2023	Privacy & Security
Garibay et al.	2023	AI grand challenges
Nahar & Kachnowski	2023	Transparency (algorithmic)
ACM	2024	Trust
Balloch et al.	2024	Accuracy
Onque	2024	Bias
Rickert	2024	Attention, impacting engagement

For accuracy, in a healthcare context, Balloch, Sridharan, Oldham, Wray, Gough, Robinson, Sebire, Khalil, Asgari, Tan, Taylor, and Pimenta (2024) [27] report on phase two of a simulation trial of a multi-phase study on the use of an ambient AI tool to improve the quality of clinical documentation, finding that "the use of ambient technology has the potential to significantly improve letter and note quality beyond standard EHR capability" as in, electronic health records. It is perhaps worth noting that Nelson (2024) [28] reports that "[a]bout half of clinicians using an ambient AI documentation tool in a clinical trial reported positive outcomes, but some found no time-saving benefits or improved EHR experience". Concerns were said to focus on "the accuracy of information generated by the AI tool, related to occasional additions or omissions of information and resulting inaccuracies in the

notes and letters" giving rise to the recommendation that "the accuracy of notes and letters should be further evaluated across a wide range of consultation types and complexities" (Balloch et al., 2024) [27]. As such, despite the potential "to formulate diagnoses or to recommend treatments and management strategies", Balloch et al. (2024) [27] argue that such "functionality should not be incorporated into clinical practice without extensive scrutiny and detailed evaluation for accuracy, relevance and avoidance of bias".

For attention, Thomson Reuters (2024) [29] point to "ambient assistants" in the AI landscape in everyday life where "boring AI" is said to be "reframed as 'ambient AI', a more sophisticated label that captures the essence of AI working quietly in the background, delivering insights, and managing systems without requiring constant user engagement". In this reframing, "the goal is to make AI an unobtrusive companion, enhancing experiences without demanding user close the quotation, as follows, attention (Thomson Reuters, 2024) [29], using the example of "AI assistants" in the legal profession in the workplace while extending beyond such spaces and "affecting our daily interactions and experiences" integrating into our lives and "subtly influencing how we operate without drawing attention to its presence".

For autonomy, Dahlin (2023) [30] explores the concept in AI–human relations where "autonomy is a double-edged sword" with an analysis "showing that humans not only coordinate their perception of autonomy but also switch between registers by sometimes ascribing certain autonomous features to the AI system and in other situations denying the system such features". As such, human–AI relations are said "to be not so much determined by any ostensive delegation of tasks as by the way in which AI and humans engage with each other in practice" using "a theory of relationality that redirects focus away from questions of agency towards questions of what it means to be in relations" and where autonomy is "multifaceted" and human–AI interactions are "complicated".

For awareness, DeepScribe (2024) [31] focus on ambient awareness in a healthcare context using ambient intelligence where "innovators and healthcare specialists are imaging the future of care" with "advanced environmental devices that permeate the physical world and provide state of the art care–both reactive and proactive" as in "context aware, personalized, anticipatory, adaptive, ubiquitous, and transparent" within or beyond the examination room. By contrast, Duncan, Miller, and Borghetti (2023) [32] focus on ambient awareness in a defense intelligence context in addressing data overload issues while enhancing the breadth and depth of searching.

For bias, Onque (2024) [33] focuses on the healthcare domain, quoting comments by Dr. LaTasha Seliby Perkins, a family physician at Georgetown University who, based on training experience with AI use, is concerned about "not only the opportunity, but risks that might be associated" as in "any biases that might be introduced or exacerbated". Seliby Perkins (Onque, 2024) [33] cautions that while "AI can help with some of the generalized things, to mitigate bias, we still have to keep in mind that there are going to be equity, inclusion and diversity issues that we have to remain mindful of when we're using artificial intelligence, because of the way it collects information".

For privacy and security, Gagné (2023) [34] focuses on the invisible nature of ambient computing, claiming that this confluence of AI, Internet of Things (IoT), natural language processing (NLP), and machine learning (ML) forms a "context-aware and responsive computing environment" that "encompasses the integration of technology into our surroundings with utmost seamlessness". According to Gagné (2023) [34], this environment does not "rely on direct user engagement" contributing to "an intuitive and immersive technological ecosystem that adapts to our needs without requiring explicit user commands or interactions" and as such, has implications for privacy and security.

For transparency, from a digital health perspective, challenges associated with current and potential applications of ambient AI are considered by Nahar and Kachnowski (2023) [35] who describe a range of issues in a healthcare context including bias; explainability in terms of "the ability of the ambient AI systems to clearly explain to the end users its prediction and decision-making process" as in, algorithmic transparency; data privacy and security; and legal and ethical matters.

For trust, it is perhaps worth noting the emerging themes of an upcoming ACM (Association for Computing Machinery) Web Science Conference 2025 (2024) [36] focusing on "maintaining a human-centric web in the era of generative AI" with concerns for "trust and community" such that contributions to the conference are invited pertaining to "investigating how humans are reconfiguring their Web-based content engagements in the presence of artificial intelligence".

Depicted graphically, Figure 3 shows further exploration of the challenges and opportunities pertaining to the ambient and urban AI focusing on accuracy, attention, autonomy, awareness, bias, privacy and security, transparency, and trust.

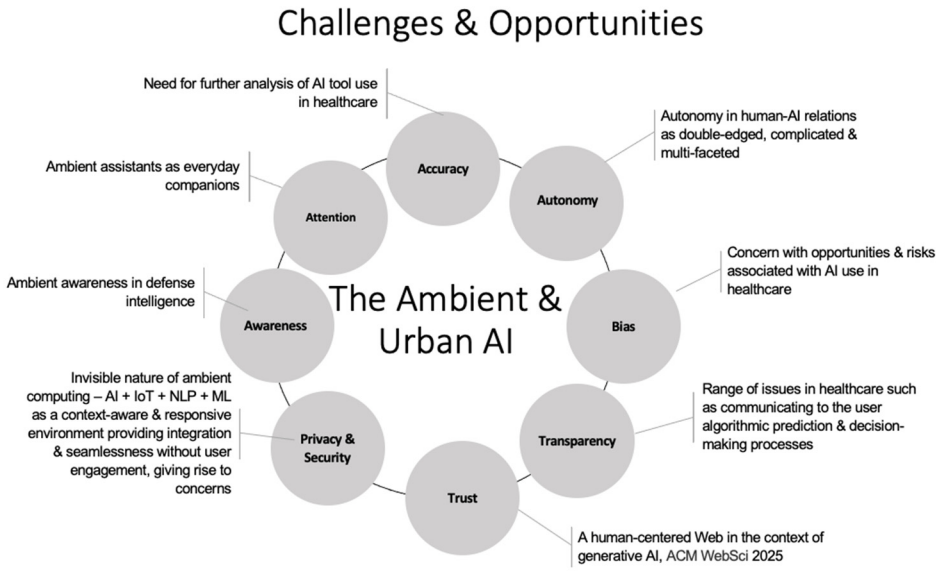

Figure 3. Challenges and opportunities for the ambient and urban AI.

Further, the ambient intelligence perspective is said to provide "the cornerstone for developing smart environments and cities that are not only intelligent and efficient but also inclusive and human-centric" (Hung, Yen, and Massetto, 2024) [37]. Hung et al. (2024) [37] note the presence of AmI applications across sectors such as healthcare, library systems, social media, urban planning, and cybersecurity, that afford capabilities associated with safety and efficiency where challenges in waste management are highlighted.

A conceptual framework for the ambient in relation to urban AI, based on the research and practice literature, is provided to guide explorations, as discussed in Section 3.4.

3.4. Conceptual Framework for the Ambient in Relation to the Evolving of Urban AI in Urban Life

This review of the research and practice literature focusing on challenges and opportunities for the ambient, urban life, and urban AI enables formulation of a conceptual framework as shown in Figure 4. This framework also builds upon and extends the "conceptual framework for artificial intelligence in urban life and the ambient in smart cities" (McKenna, 2023) [9] through placing an emphasis on human–AI interactions and ambient environments. This conceptual framework features the human–AI interactive components

of attention, analysis, awareness, experiences, learning, and sensitivities in support of adaptability, innovation, responsible and ethical design and use, and sustainability.

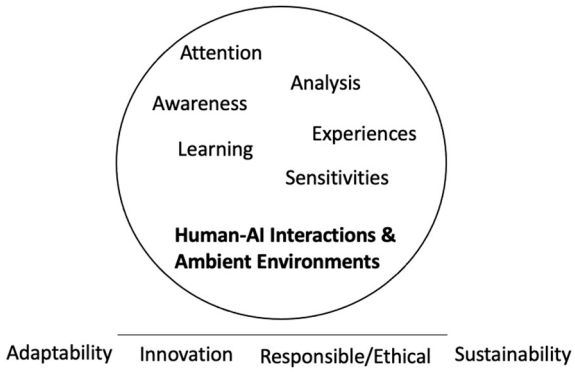

Figure 4. Conceptual framework for the ambient, urban life, and urban AI.

4. Methodology

The methodology used in this work involves an exploratory case study approach, given the contemporary nature of the inquiry (Yin, 2018) [38], combined with a complementary explanatory correlational design (Yin, 2018) [38]. As such, an online webspace was used to describe the study and invite people to participate and interest emerged from individuals in multiple cities across a range of countries (Canada, United States, Greece, Ireland, Israel, etc.) spanning several continents (North America, Europe, and the Middle East). Demographic data were also gathered from individuals during sign up for the study, including age range, gender, and city. Additionally, people could self-identify in one or more categories (e.g., business, community member, student, educator, etc.). A survey instrument, pre-tested prior to use, was used in this study and contained closed and open-ended questions. Survey questions pertained to a range of items related to smart cities and AI. Survey respondents were also invited to participate in an in-depth interview which was guided by an interview protocol pre-tested prior to study use. Additionally, data were gathered systematically through group and individual discussions, conducted in parallel with this study, with individuals from many sectors (e.g., students, faculty, and staff in higher education, business, community members and leaders, and city staff and leaders) in Canadian cities (e.g., Toronto, Vancouver, Victoria). Overall, an analysis was conducted for n = 79 consisting of 42% females and 58% males for people ranging in age from their 20 s to their 70 s.

Further, this work involving a review of the research and practice literature, leverages the surfacing of challenges and opportunities in Section 3.1 and explored in Section 3.3 through further probing in Section 5. The use of probes (Babbie, 2020) [39] and indeed civic probes (Johnson and Vlachokyriakos, 2024) [40] is advanced in this work as a way of more carefully exploring the challenges and opportunities identified in this work. While the methodology of this paper may not seem to be particularly novel, it is perhaps the use of probes in the form of conference polling in real-time during a conference event that may contribute a sense of the ambient and possibly an emergent novel approach. Also of note, is the diverse engagement across sectors and age ranges to questions pertaining to the urban and to smart cities in an era of AI.

The research question from Section 1 is reformulated here as a challenge proposition and also as an opportunity proposition for exploration in this work, as follows:

CP: The nature of the ambient in relation to urban life and AI contributes to a range of challenges pertaining to accuracy, attention, awareness, and privacy and security

OP: The nature of the ambient in relation to urban life and AI contributes to opportunities associated with human–AI interactions

An exploration of these propositions is provided in Section 5 where findings are revealed and discussed.

5. Explorations of Challenges and Opportunities for the Ambient and Urban AI

The research question identified in Section 1 and reformulated in the development of a challenge proposition and an opportunity proposition is explored here in terms of practice and research for the ambient and urban AI, in Sections 5.1 and 5.2, respectively. Case study findings and discussion are presented in Section 5.3 followed by conference poll and question findings and discussed in Section 5.4.

5.1. Challenges for the Ambient and Urban AI

Probing further, challenges for the ambient and urban AI in a world increasingly permeated with AI are categorized for consideration in Table 4 in relation to the ambient, urban life, and AI. Content in Table 4 is described while being attentive to the challenge proposition for this paper, as follows:

CP: The nature of the ambient in relation to urban life and AI contributes to a range of challenges pertaining to accuracy, attention, awareness, and privacy and security

Table 4. Challenges by Category for the Ambient and Urban AI.

Challenges	The Ambient	Urban Life	AI
Accuracy	Relevance	Avoidance of bias	Further scrutiny & improvements
Attention	Listening	Healthcare	Documenting
Awareness	Sensibility	Participation	Embedding
Privacy & Security	Seamlessness	Technology experiences	Individual preferences, needs, etc.

Challenges include accuracy, attention, awareness, and privacy and security in relation to the ambient, urban life, and AI. Accuracy challenges pertain to relevance, avoidance of bias, and the need for further scrutiny and improvements before application to diagnosis and treatment recommendations in healthcare settings. Attention challenges pertain to listening, health and well-being in relation to healthcare, and documenting. Awareness challenges pertain to sensibility, participation, and embedding. Privacy and security challenges pertain to seamlessness, technology experiences, and the identification of individual preferences, needs, and the like.

In summary, these challenges emerging from the research and practice literature pertain to a range of concerns being addressed through AmI (Andre, 2024) [8] in seeking to improve the quality of life aided by technology.

In the spirit of further probing, possible challenge questions for educators, researchers, and students to consider include the following three questions:

Qc1. What would you say is missing from this exploration of challenges for the ambient and urban AI? And what would your key question or questions be?
Qc2. How would you describe challenges associated with the ambient and urban AI in your city or region?

Qc3. Is the influencing of our attention, noticing, and engagement by ambient engineering important for cities and regions to consider in an era of AI? Please explain briefly why or why not.

5.2. Opportunities for the Ambient and Urban AI

Probing further, opportunities for the ambient and urban AI in a world increasingly permeated with AI, are categorized for consideration in Table 5 in relation to the ambient, urban life, and AI. Content in Table 5 is described, attentive to the opportunity proposition for this paper, as follows:

OP: The nature of the ambient in relation to urban life and AI contributes to opportunities associated with human–AI interactions

Table 5. Opportunities by Category for the Ambient and Urban AI.

Opportunities	The Ambient	Urban Life	AI
Human–AI Interactions	Seamlessness	More meaningful interactions	Integrating AI, affecting experiences

Human–AI interaction opportunities in relation to the ambient, urban life, and AI pertain to seamlessness, highlighting the importance of awareness capabilities; more meaningful interactions, whether through engagement, participation, or the like; and the integrating of AI more creatively (Hirokawa, et al., 2024) [21] so as to better affect the experiences of everyday life.

In the spirit of further probing, possible opportunity questions for educators, researchers, and students to consider include the following three questions:

Qo1. What would you say is missing from this exploration of opportunities for the ambient and urban AI? And what would your key question or questions be?
Qo2. How would you describe opportunities associated with the ambient and urban AI in your city or region?
Qo3. Are human–AI interactions evident in your city and regions? Please explain briefly why or why not.

5.3. Case Study Findings for the Ambient and Urban AI

Looking to the case study survey findings relevant to human–AI interactions in ambient environments, based on elements associated with challenges and opportunities (Tables 4 and 5), assessment results are provided in Table 6. For example, in response to the question of whether city-focused social media and other aware technologies give rise to many possibilities, assessments are presented for attention and sensibility, as proxies for attuning to urban spaces and heightening urban sensibilities, respectively. For attention, on a 7-point Likert-type scale, where 1 = Not at all and 7 = Absolutely, 17% of respondents selected the neutral position of 4, 33% responded toward the upper end of the scale at position 6 (Sure), and 50% responded at the upper end of the scale at 7. For sensibility, 33% of respondents selected position 5 (Sort of), 17% responded at position 6 on the scale, and 50% responded at the upper end of the scale at 7.

Table 6. Assessments for Attention and Sensibility in Ambient Urban AI.

Items	Aware Technologies & Possibilities	Correlation
Attention	17% (4); 33% (6); 50% (7)	.26
Sensibility	33% (5); 17% (6); 50% (7)	

The Real Statistics add-in for Microsoft Excel (Zaiontz, 2022) [41] was used to calculate the Spearman correlation for ordinal data on the assessment results of the two items in Table 6, showing a correlation of .26. Creswell (2018) [42] advises that for correlations in the .20 to .35 range "there is only a slight relationship" such that findings "may be valuable to explore the interconnection of variables but of little value in prediction studies". This finding is important in that it would seem to point to the challenge dimension of attention identified in Table 4 as well as that of sensibility in relation to the ambient.

It is also worth noting that, qualitatively, in response to an open-ended survey question on whether "social media and other aware technologies are affecting your experience of the city", an individual identifying as a city executive commented as follows: "greatly but not enough in terms of governance" which would seem to support the calls by Caprotti et al. (2024) [4] for research and practice opportunities around urban governance.

5.4. Findings Extending to Conference Polls and Questions

During an HCII2024 hybrid (virtual and in person) event where a paper was being presented (McKenna, 2024) [43], an online conference poll was conducted using the Whova platform made available in the virtual space. When asked: What are some of the key issues for urban life in a world infused with AI? respondents were provided with a series of checkbox options where one or more items could be checked. As shown in Table 7, a total of 50 individuals responded to the poll [n = 50]. The first option, being aware and keeping informed of when and where AI is being used, garnered a 58% response rate, second highest of the range of options to choose from. As such, the awareness element, key to the ambient concept, emerges strongly in an urban life and AI context, second only to the privacy issue at 66%.

Table 7. What are some of the key issues for urban life in a world infused with AI? (n = 50).

#	Options	%
1	Being aware & keeping informed of when & where AI is being used	58%
2	Whether AI will shape urban life OR whether urban life will shape AI	20%
3	Feeling a sense of autonomy in urban life with AI	20%
4	Privacy & urban life with AI	66%
5	Transparency in urban life with AI	32%
6	Evolving of everyday practices for urban life in a world with AI	26%

Also of note is the transparency issue receiving a 32% response rate and the evolving of everyday practices with a 26% response rate pointing possibly to the shaping capabilities outlined by Hornos and Zamudio-Rodríguez (2024) [26] contributing to the notion of an ambient force. The autonomy issue is somewhat lower at 20% perhaps indicative of the

"double-edged sword" description of the concept by Dahlin (2023) [30]. Concerns with the shaping issue at 20% are perhaps indicative of urban futures as part of urban AI (Caprotti et al., 2024) [4] and AI urbanism (Cugurullo et al., 2024) [5].

The following question was also posed in the online Conference space:

To the extent that AI seems to be all around us, all the time, is it now possible to speak of "ambient AI"? If yes, in your view, what are the benefits and risks of ambient AI?

No response was received to this question, perhaps indicating a preference for poll type questions with options to choose from. If this is the case, then explorations going forward could include survey or poll questions with checkbox options guided by the conceptual framework formulated in this paper (Section 3.4). That a response was not received to this question may also be indicative of the need for further explorations in this area and it is hoped that this paper will contribute to greater awareness and understanding of the ambient AI urban space.

Also of note qualitatively, is a question posed in Chapter 4 (Awareness and Seeing: People and Data in Smart Cities) of a book by McKenna (2021) [44] where now, some three years later (December 2024) with the most recent response, the question remains relevant. Specifically, an individual, self-identified as a student in the age range of 30–39, responded to the question, "How would you describe awareness in a smart city or region?" with the following comment: "knowledge about data and using of them". This interactive response was enabled through use of an active link to a Google Docs survey form containing three questions at the end of each chapter in the book. This response further serves to highlight the importance of the "awareness" element in relation to urban AI and indeed AI urbanism, evolving through and beyond earlier understandings of smart cities.

Responses to online conference polls and questions in this work provide a glimpse of real-world interactions with researchers and practitioners across many sectors and countries to urban ambient AI issues, possibly contributing to the notion of ambient inquiry (McKenna, 2021) [45].

6. Limitations and Future Directions

Limitations of this paper pertain to the literature review which is intended to provide an overview rather than comprehensive coverage of the ambient and urban AI. As such, opportunity is provided for the conducting of a systematic review going forward. Caution is encouraged regarding interpretation of findings from the poll discussed in Section 5.4, given the relatively small sample size. Additionally, conference poll participants may have been motivated by the garnering of leaderboard points although it should be noted that they did choose to respond to this particular poll, among the many other polls to choose from during the conference event.

Future directions might include explorations of the ambient engineering notion (Rickert, 2024) [22] in terms of the impact on attention, engagement, noticing, and other emergent elements. Opportunities pertain to further exploration of the awareness element in relation to the ambient and urban AI in view of the importance of "being aware and keeping informed" as indicated by conference poll respondents (Section 5.4). Challenges pertain to further exploration of understandings of autonomy (Dahlin, 2023) [30] in the context of the ambient and urban AI and human–AI interactions.

7. Conclusions

This paper is significant in that it brings together a range of perspectives on the ambient in relation to urban life in an era of AI and evolving understandings of smart cities. This work is also significant in that it contributes the ambient perspective to the urban AI and AI urbanism research and practice literature. While a strong relationship was not

found between the variables of attention and sensibility when assessed in terms of aware technologies and possibilities, with a Spearman correlation of .26 (Section 5.3), this may point to the need for addressing the challenges and opportunities highlighted in Figure 3 (e.g., awareness, transparency, trust, and so on) in support of learning cities, smarter cities, and future cities. That 58% of conference poll respondents indicated the importance of "being aware and keeping informed of when and where AI is being used" as a key issue for urban life in a world infused with AI (Section 5.4) gives rise to the significance and role of the ambient, characterized as it is by elements such as awareness. Indeed, the use of online polling in real-time during a conference event may support the notion of ambient inquiry (McKenna, 2021) [45] in research and other contexts. The conceptual framework for the ambient, urban life, and AI formulated in this work (Section 3.4) is designed to guide explorations in this paper, research beyond this work, and practice initiatives concerned with human–AI interactions and urban environments.

As an interdisciplinary and international work, the audience for this paper will be specialists in a wide range of fields such as architecture, computer science, human geography, information science, public policy, and urban planning. Interest is also expected from a broad range of educators, researchers, and practitioners looking for guidance on engaging with AI in relation to urban life from perspectives that include the ambient. As such, in Section 5.1 challenge questions, and in Section 5.2 opportunity questions are included that are designed for educators, students, and community leaders and members.

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References

1. Gams, M.; Gu, I.Y.-H.; Härmä, A.; Muñoz, A.; Tam, V. Artificial intelligence and ambient intelligence. *J. Ambient. Intell. Smart Environ.* **2019**, *11*, 71–86. [CrossRef]
2. Stephanidis, C.; Salvendy, G.; Antona, M.; Chen JY, C.; Dong, J.; Duffy, V.G.; Fang, X.; Fidopiastis, C.; Fragomeni, G.; Fu, L.P.; et al. Seven HCI grand challenges. *Int. J. Hum. Comput. Interact.* **2019**, *35*, 1229–1269. [CrossRef]
3. Garibay, O.O.; Winslow, B.; Andolina, S.; Antona, M.; Bodenschatz, A.; Coursaris, C.; Falco, G.; Fiore, S.M.; Garibay, I.; Grieman, K.; et al. Six human-centered artificial intelligence grand challenges. *Int. J. Human Comput. Interact.* **2023**, *39*, 391–437. [CrossRef]
4. Caprotti, F.; Cugurullo, F.; Cook, M.; Karvonen, A.; Marvin, S.; McGuirk, P.; Valdez, A.M. Why does urban Artificial Intelligence (AI) matter for urban studies? Developing research directions in urban AI research. *Urban Geogr.* **2024**, *45*, 883–894. [CrossRef]
5. Cugurullo, F.; Caprotti, F.; Cook, M.; Karvonen, A.; McGuirk, P.; Marvin, S. The rise of AI urbanism in post-smart cities: A critical commentary on urban artificial intelligence. *Urban Stud.* **2024**, *61*, 1168–1182. [CrossRef]
6. Barns, S. Ambient commons? In *Artificial Intelligence and the City: Urbanistic Perspectives on AI*; Valuing urban public spaces in an era of AI-enabled ambient computing; Cugurullo, F., Caprotti, F., Cook, M., Karvonen, A., McGuirk, P., Marvin, S., Eds.; Routledge: Abingdon, UK, 2024; pp. 189–204. [CrossRef]
7. McCullough, M. *Ambient Commons: Attention in the Age of Embodied Information*; MIT Press: Cambridge, MA, USA, 2013.
8. Andre, D. What is Ambient Intelligence? *AAA (All About AI)*. 24 September. Available online: https://www.allaboutai.com/ai-glossary/ambient-intelligence/ (accessed on 17 November 2024).
9. McKenna, H.P. *Urban Life and the Ambient in Smart Cities, Learning Cities, and Future Cities*; IGI Global: Hershey, PA, USA, 2023.
10. Luusua, A.; Ylipulli, J.; Foth, M.; Aurigi, A. Urban AI: Understanding the emerging role of artificial intelligence in smart cities. *AI Soc.* **2023**, *38*, 1039–1044. [CrossRef]
11. McKendrick, J. Ambient AI Is Here, and We Are Blissfully Unaware of It. *Forbes*. 29 December 2023. Available online: https://www.forbes.com/sites/joemckendrick/2023/12/29/ambient-ai-is-here-and-we-are-blissfully-unaware-of-it/ (accessed on 21 June 2024).
12. Arm. The Rise of Ambient Technology Experiences, Powered by AI. *eeNews*. 26 February 2024. Available online: https://www.eenewseurope.com/en/content_sponsorship/the-rise-of-ambient-technology-experiences-powered-by-ai-2/ (accessed on 7 March 2024).

13. Augmedix Inc. Augmedix Launches Industry's First Fully-Automated, GenAI-Powered, Medical Documentation Product for Emergency Departments. *GlobeNewswire*. 24 April 2024. Available online: https://www.globenewswire.com/news-release/2024/04/24/2868458/0/en/Augmedix-Launches-Industry-s-First-Fully-Automated-GenAI-Powered-Medical-Documentation-Product-for-Emergency-Departments.html (accessed on 24 April 2024).
14. Blum, K. All Ears: What to Know About Ambient Clinical Listening. In *Health Journalism Blog*; Association of Health Care Journalists (AHCJ), Center for Excellence in Health Care Journalism: Columbia, MO, USA, 18 March 2024. Available online: https://healthjournalism.org/blog/2024/03/all-ears-what-to-know-about-ambient-clinical-listening/ (accessed on 19 March 2024).
15. DMG Productions. Explore How Developments in Data Protection Are Providing Peace of Mind. *PRWeb*. 8 July 2024. Available online: https://www.prweb.com/releases/explore-how-developments-in-data-protection-are-providing-peace-of-mind-302188371.html (accessed on 8 July 2024).
16. Pines, J. Your Doctor's Office Might Be Bugged. Here's Why. *Forbes*. 4 March 2024. Available online: https://www.forbes.com/sites/jessepines/2024/03/04/your-doctors-office-might-be-bugged-heres-why/ (accessed on 5 March 2024).
17. Thibaud, J.-P. Towards an ambient ecology of the urban. In *Architecture, Subjectivity and Culture. Scenarios and Transversal Paths for Research*; Duarte, C.R., Pinheiro, E., Eds.; Proarq/Rio Books; 978-65-88335-03-1; halshs-02982219; HAL Open Science: Lyon, France, 2020.
18. McKenna, H.P. The importance of theory for understanding smart cities: Making a case for ambient theory. In *Distributed, Ambient and Pervasive Interactions, HCII 2021*; Streitz, S., Konomi, S., Eds.; Lecture Notes in Computer Science; Springer: Cham, Switzerland, 2021.
19. Sun, H.; De Florio, V. Perspectives and Solutions Towards Intelligent Ambient Assisted Living Systems. *arXiv* **2021**, arXiv:2102.13173.
20. Chou, D. Navigating the Growing Landscape of Healthcare Ambient AI Solutions. *Forbes*. 20 August 2024. Available online: https://www.forbes.com/sites/davidchou/2024/08/20/navigating-the-growing-landscape-of-healthcare-ambient-ai-solutions/ (accessed on 21 August 2024).
21. Hirokawa, T.; Tsuji, A.; Fujinami, K. Eyebient displays: Ambient displays by gaze guidance. In *Distributed, Ambient and Pervasive Interactions. HCII 2024*; Streitz, N.A., Konomi, S., Eds.; Lecture Notes in Computer Science; Springer: Cham, Switzerland, 2024; Volume 14719. [CrossRef]
22. Rickert, T. Ambient engineering: Hyper-nudging, hyper-relevance, and rhetorics of nearness and farness in a post-AI algorithmic world. *Rhetor. Soc. Q.* **2024**, *54*, 1–15. [CrossRef]
23. Spenser, A. *Ambient Stories in Practice and Research: Digital Writing in Place*; Bloomsbury Academic: New York, NY, USA, 2024.
24. Li, F.; Chen, C.-H.; Lee, C.-H.; Feng, S. Artificial intelligence-enabled non-intrusive vigilance assessment approach to reducing traffic controller's human errors. *Knowl. Based Syst.* **2022**, *239*, 108047. [CrossRef]
25. Daruwala, N.; Oberst, U. A systematic literature review of smart home technology acceptance. *J. Ambient. Intell. Smart Environ.* **2023**, *15*, 115–142. [CrossRef]
26. Hornos, M.J.; Zamudio-Rodríguez, V.M. Sensing, decision-making and economic impact for next-generation technologies. *J. Ambient. Intell. Smart Environ.* **2024**, *16*, 271–274. [CrossRef]
27. Balloch, J.; Sridharan, S.; Oldham, G.; Wray, J.; Gough, P.; Robinson, R.; Sebire, N.J.; Khalil, S.; Asgari, E.; Tan, C.; et al. Use of an ambient artificial intelligence tool to improve quality of clinical documentation. *Future Healthc. J.* **2024**, *11*, 100157. [CrossRef]
28. Nelson, H. Half of Clinicians Report Positive Ambient AI Experience. *TechTarget*. 3 September 2024. Available online: https://www.techtarget.com/searchhealthit/news/366610138/Half-of-clinicians-report-positive-ambient-AI-experience (accessed on 23 November 2024).
29. Thomson Reuters. Navigating the AI landscape: The evolution of ambient assistants. *Thomson Reuters Blog*. 26 January 2024. Available online: https://legal.thomsonreuters.com/blog/navigating-the-ai-landscape-the-evolution-of-ambient-assistants/ (accessed on 21 November 2024).
30. Dahlin, E. And say the AI responded? Dancing around 'autonomy' in AI/human encounters. *Soc. Stud. Sci.* **2023**, *54*, 59–77. [CrossRef]
31. DeepScribe. Ambient Intelligence in Healthcare: The Future is Near. DeepScribe. 2024. Available online: https://www.deepscribe.ai/resources/ambient-intelligence-in-healthcare-the-future-is-near (accessed on 25 November 2024).
32. Duncan, M.C.; Miller, M.E.; Borghetti, B.J. Analysis and requirement generation for defense intelligence search: Addressing data overload through human–AI agent system design for ambient awareness. *Systems* **2023**, *11*, 561. [CrossRef]
33. Onque, R. Ambient AI Might Be Listening in on Your Next Doctor's Appointment: What It Is, and What It Means for Patients. *CNBC Make It Blog*. 8 October 2024. Available online: https://www.cnbc.com/2024/10/08/ambient-ai-may-listen-in-on-your-next-doctors-visit-what-it-means.html (accessed on 23 November 2024).
34. Gagné, M.-R. Embracing the Invisible: Ambient Computing's Silent Takeover. *Irish Tech News*. 3 August. Available online: https://irishtechnews.ie/embracing-the-invisible-ambient-computings-silent-takeover/ (accessed on 31 October 2024).

35. Nahar, J.K.; Kachnowski, S. Current and potential applications of ambient artificial intelligence. *Mayo Clin. Proc. Digit. Health* **2023**, *1*, 241–246. [CrossRef]
36. ACM Web Science Conference Call for Papers. Available online: https://www.websci25.org/call-for-papers/ (accessed on 25 November 2024).
37. Hung, J.C.; Yen, N.Y.; Massetto, F.I. Editorial for ambient intelligence and applications for smart environment and smart city. *J. Ambient. Intell. Humaniz. Comput.* **2024**, *15*, 1799–1800. [CrossRef]
38. Yin, R. *Case Study Research and Applications: Design and Methods*, 6th ed.; Sage Publications: Washington, DC, USA, 2018.
39. Babbie, E.R. *The Practice of Social Research*; Wadsworth Publishing: Belmont, CA, USA, 2020.
40. Johnson, I.G.; Vlachokyriakos, V. Civic Probes: A Method That Embeds Questions of Civic Infrastructure and Participation. Interactions, XXXI.2. 2024. Available online: https://interactions.acm.org/archive/view/march-april-2024/civic-probes-a-method-that-embeds-questions-of-civic-infrastructure-and-participation (accessed on 31 March 2024).
41. Zaiontz, C. Real Statistics Using Excel. 2022. Available online: www.real-statistics.com (accessed on 14 January 2025).
42. Creswell, J.W. *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research*, 6th ed.; Pearson: London, UK, 2018.
43. McKenna, H.P. Conversing with our cars and the drive for more aware experiences, applying ambient theory to mobile design. In *Distributed, Ambient and Pervasive Interactions. HCII 2024*; Streitz, N.A., Konomi, S., Eds.; Lecture Notes in Computer Science; Springer: Cham, Switzerland, 2024; Volume 14718. [CrossRef]
44. McKenna, H.P. *Seeing Smart Cities Through a Multi-Dimensional Lens: Perspectives, Relationships, and Patterns for Success*; Springer: Cham, Switzerland, 2021. [CrossRef]
45. McKenna, H. *Visibilities and Invisibilities in Smart Cities: Emerging Research and Opportunities*; IGI Global: Hershey, PA, USA, 2021. [CrossRef]