

Ethics in GIS: A Systematic Analysis focusing on Privacy and Surveillance

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Abstract

In the field of Geographic Information Systems (GIS), privacy and surveillance have emerged as critical ethical concerns, reflecting the growing tension between technological advancements and the protection of individual rights. This paper presents a review of the literature that investigates the ethical challenges associated with these issues, tracing their evolution and present significance. Drawing from scholarly discourse, we analyse how the capabilities of GIS have raised complex ethical dilemmas related to unauthorized data access, the construction of digital identities, and the increasing risk of pervasive surveillance. Our review reveals that while GIS offers considerable societal benefits, its unchecked potential for surveillance and infringement of privacy demands stronger ethical standards, regulatory frameworks and public awareness. We highlight the need for GIS professionals to adopt proactive measures, such as enhanced data security and informed consent protocols, to mitigate these risks. Furthermore, the study calls for ongoing scholarly inquiry into the ethical stewardship of GIS, emphasizing the importance of balancing innovation with the protection of individual freedoms. This research contributes to the broader dialogue on GIS ethics, advocating for responsible practices that prioritize privacy and limit the scope of surveillance, ultimately safeguarding personal autonomy in the digital age.

Keywords:

privacy, surveillance, ethics, Geographic Information Systems

1 Introduction

The rapid expansion of data generation, particularly through the widespread deployment of sensors and the Internet of Things, has significantly advanced the application of Geographic Information Systems (GIS). These systems now play a crucial role in decision-making processes across a wide range of sectors, including healthcare, environmental protection, disaster management and military operations (Tao, 2013). Esnard (1998) notes that GIS have become integral to municipal governments, particularly for managing natural resources and allocating social services. However, as digital technologies evolve, so too do ethical concerns surrounding their use, particularly in relation to privacy, surveillance and data security

(Fernholz et al., 2024). These concerns have grown as the collection and processing of geographic data increasingly involve sensitive personal information, sparking debates over the ethical responsibilities of GIS professionals. Since the 1990s, discussions around GIS ethics have intensified, particularly as the technology became more integrated into societal applications (Crampton, 1995). Ethical principles in GIS now focus on safeguarding privacy, ensuring data security, and maintaining transparency in data handling. As the amount of spatial data increases, so too does the potential for misuse, whether intentional or unintentional, raising concerns about the ethical management of this information (Lake, 1993). Early critics called for stricter control over GIS applications, particularly those related to national security, while opposing their use in warfare.

These early discussions laid the foundations for the development of ethical guidelines, including the first proposals for privacy firewalls and codes of conduct (Onsrud, 1997; Lake, 1993). Blakemore & Longhorn (2004) provide a broad overview of the ethical challenges inherent in working with geographic data, particularly in relation to intellectual property rights, data accessibility and the responsibility of governments to protect public information. These issues intersect with privacy concerns, as the ability to track individuals through geospatial analysis raises ethical questions about surveillance and the potential misuse of data. Crampton (1995) emphasizes the ethical implications of geodemographic data collection, critiquing how the private lives of individuals can be violated through the practice. These ongoing ethical challenges highlight the need for a balanced approach that protects individual privacy while enabling the beneficial use of GIS.

The aim of this paper is to examine the ethical concerns surrounding GIS, with a particular focus on privacy and surveillance as discussed in the scientific literature. Our guiding research question is: What ethical values are addressed in peer-reviewed literature concerning the use of GIS? By exploring the recurring ethical issues within GIS, this study seeks to contribute to the development of best practices for ethical decision-making in the field. Ultimately, our research aims to raise awareness of the ethical dilemmas in GIS and promote transparency in its application, ensuring that technological advancements align with ethical principles and protect individual rights, while it also acknowledges that ethics is a constantly evolving field where definitive resolutions are often elusive.

2 Literature Review Procedure

The literature review follows Petersen et al. (2008) (see Figure 1). The main outcome of the review is a systematic map of ethical concerns within the GIS research community (see Table 3). The literature used in this review was identified by using search strings in various scientific databases. The keywords were developed based on the works of Fernholz et al. (2024) and Jobin et al. (2019). The final list of keywords is as follows: GIS ethics, critical GIS, GIS responsibility, GIS privacy, GIS surveillance, GIS accuracy, GIS neutral (or objective), GIS justice, GIS transparency, GIS security. The keyword search also used “Geospatial Information System” and “Geospatial Data” in the place of “GIS”. Once the relevant search terms were identified, the search was performed using the following databases: Google Scholar, ScienceDirect, Taylor & Francis Online, JSTOR and IEEE.

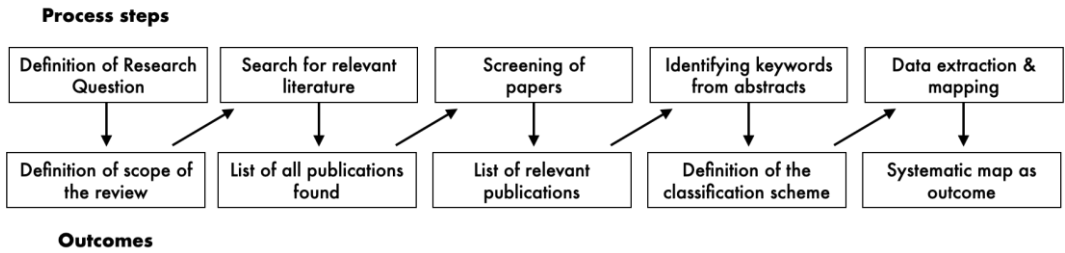


Figure 1: The Systematic Mapping Process according to Petersen et al. (2008)

The search was limited to the first 20 results in each database to keep the analysis within manageable limits. When possible, only titles and abstracts were searched for keywords to ensure that the papers were closely related to the research question. When no abstract was available, either the introduction or the entire paper was searched. A spreadsheet was created to catalogue the studies and record information. The data included the author's name, the publication year, and the publication type. After this, the papers were screened more thoroughly using an exclusion and inclusion scheme.

The inclusion criterion is that the abstract, and if not applicable the introduction, should mention at least one of the search terms listed above. In some rare cases where neither an abstract nor an introduction was available, the entire paper was reviewed. The exclusion criteria are entire studies not being accessible, and studies lying outside the context of GIS ethics. After screening the literature, the process of Petersen et al. (2008) was extended by conducting a backward and forward search. In the forward search, the list of references in the selected papers was screened. In the backward search, other papers that cite the selected papers were searched. connectedpapers.com was used to conduct the backward and forward searches automatically for each selected paper. This procedure identified studies that were probably connected to our research interests but that were not found in the initial literature search. The literature screening and the backward and forward searches were repeated until no more viable papers were found. Table 1 presents the papers selected.

Table 1: The literature selected for analysis

No.	Authors	Year	Title
1	Andrienko	2012	Privacy issues in geospatial visual analytics
2	Armstrong & Ruggles	2005	Geographic information technologies and personal privacy
3	Babinski	2021	GIS&T for equity and social justice
4	Bertino et al.	2008	<i>Security and Privacy for Geospatial Data: Concepts and Research Directions</i>
5	Blakemore & Langhorn	2004	Ethics and GIS: the practitioner's dilemma
6	Blatt	2012	Ethics and privacy issues in the use of GIS
7	Chen & Yang	2005	Legal issues on public access to remote sensing data in Taiwan

8	Cinnamon	2020	Data inequalities and why they matter for development
9	Craig	1993	A GIS code of ethics: What can we learn from other organizations?
10	Crampton	1995	The ethics of GIS
11	Crampton et al.	2017	Societal impacts and ethics of GIS
12	Curry	1997a	The digital individual and the private realm
13	Curry	1997b	Digital people, digital places: Rethinking privacy in a world of geographic information
14	DiBiase et al.	2012	The GIS professional ethics project: Practical ethics for GIS professionals
15	Elwood & Wilson	2017	Critical GIS pedagogies beyond "Week 10: Ethics"
16	Esnard	1998	Cities, GIS, and ethics
17	Goss	1995	"We know who you are and we know where you live": The instrumental rationality of geodemographic systems
18	Graeff & Loui	2008	Ethical implications of technical limitations in GIS
19	Haque	2003	Information technology, GIS and democratic values: Ethical implications for IT professionals in public service
20	Harvey	2014	Values, choices, responsibilities: Thinking beyond the scholarly place of ethics for the GIScience and technology profession and GIScience
21	Hernon & Dugan	1997	GIS and privacy
22	Huff	2014	From meaning well to doing well: Ethical expertise in the GIS domain
23	Klinkenberg	2007	Geospatial technologies and the geographies of hope and fear
24	Lake	1993	Planning and applied geography: Positivism, ethics, and geographic information systems
25	McKenzie et al.	2019	Geospatial privacy and security
26	McLafferty	2004	The socialization of GIS
27	Nelson et al.	2022	Accelerating ethics, empathy, and equity in geographic information science
28	Obermeyer	1998	Professional responsibility and ethics in the spatial sciences
29	Onsrud et al.	1994	Protecting personal privacy in using geographic information systems
30	O'Sullivan	2006	Geographical information science: Critical GIS
31	Power & Trope	2005	Acting responsibly with geospatial data
32	Rajpoot & Patel	2014	A comparative study on various aspects of security of geospatial data
33	Schuurman	2000	Critical GIS: Theorizing an emerging science
34	Scull et al.	2015	Privacy and ethics in undergraduate GIS curricula
35	Sheppard	2005	Knowledge production through critical GIS: Genealogy and prospects

36	Sheppard & Cizek	2009	The ethics of Google Earth: Crossing thresholds from spatial data to landscape visualisation
37	Tullis & Kar	2020	Where is the provenance? Ethical replicability and reproducibility in GIScience and its critical applications
38	Verrax	2017	Beyond professional ethics: GIS, codes of ethics, and emerging challenges
39	Wilson	2015	On the criticality of mapping practices: Geodesign as critical GIS?
40	Wilson & Poore	2009	Theory, practice, and history in critical GIS: Reports on an AAG panel session
41	Wong & Wu	1996	Spatial metadata and GIS for decision support
42	Zhu et al.	2009	Ethical concerns of online geoinformation services

The classification scheme was created in an iterative process, starting with reading the papers and reviewing the topics discussed. Metadata was collected during the process. The classification scheme used four different criteria relating to the metadata of the literature: the publication year, the research type (following Wieringa et al. (2006)), the publication type, and the field of study. It also used content-specific criteria, i.e. ethical principles based on Fernholz et al. (2024) and Jobin et al. (2019): privacy, surveillance, accuracy, (social and environmental) justice, security, transparency and neutrality (see Table 2).

Table 2: Classification Scheme

Literature Criteria	Publication Year	1993-2022
	Research Type	Validation Research, Evaluation Research, Solution Proposal, Philosophical Paper, Opinion Paper, Experience Paper
	Publication Type	Journal, Book, Blog, Workshop
	Field of Study	Information Systems, Philosophy
Content Criteria	Ethical Concerns	Privacy, Surveillance, Accuracy, Justice, Security, Neutrality, Transparency

3 Results of the Literature Review

To answer the guiding research question, the focus was on examining ethical concerns discussed in peer-reviewed publications within the context of GIS. Figure 2 shows the number of mentions per ethical concern in the selected papers. Privacy is mentioned in the vast majority of them, and the number of mentions dwarfs those of the other concerns. The second most-mentioned concern is surveillance, which is not particularly surprising considering that surveillance and privacy are closely related topics. Next come accuracy, justice and security. Neutrality and transparency were mentioned the least frequently (in just three and two papers respectively). This result came as a surprise, as neutrality and transparency were expected to be more important. Value neutrality had already been discussed in map-making prior to the emergence of GIS, for example in Harley (1988), leading to the expectation of finding greater resonance in the GIS literature as well.

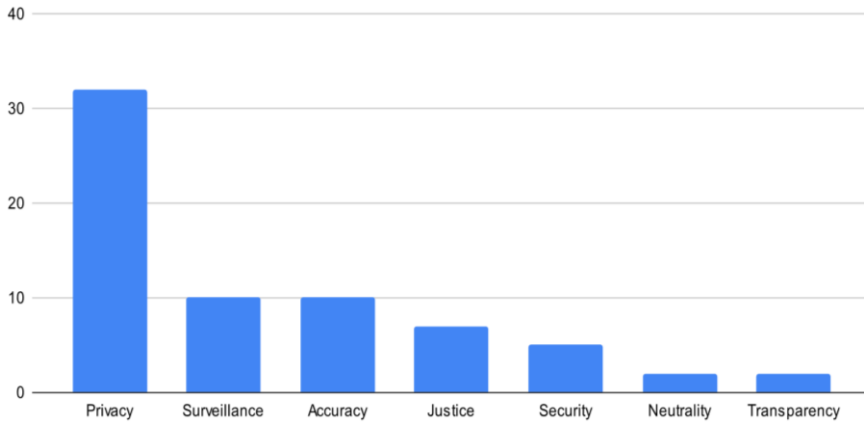


Figure 2: Number of Mentions per Ethical Concern

Table 3 shows the resulting map of the literature, differentiating between the seven ethical concerns outlined in the classification scheme (Table 2). Due to length restrictions, the focus of this paper is on privacy and surveillance as ethical concerns.

Table 3: Map of the Relevant Literature

Ethical concerns:	Privacy	Surveillance	Accuracy	Neutrality	Justice	Transparency	Security
Andrienko	✓						
Armstrong & Ruggles	✓	✓					
Babinski					✓		
Bertino et al.	✓						✓
Blakemore & Langhorn	✓						
Blatt	✓		✓				
Chen & Yang	✓						
Cinnamon	✓	✓			✓		
Craig	✓		✓				
Crampton	✓	✓					
Crampton et al.	✓	✓			✓	✓	
Curry (a)	✓	✓					
Curry (b)	✓						
DiBiase et al.	✓	✓					
Elwood & Wilson					✓		
Esnard	✓						
Goss	✓						
Graeff & Loui	✓		✓				

Haque	✓		✓				
Harvey					✓		
Hernon & Dugan	✓						
Huff	✓						
Klinkenberg	✓	✓			✓		
Lake				✓			
McKenzie et al.							✓
McLafferty							
Nelson et al.		✓			✓		
Obermeyer			✓				
Onsrud et al.			✓				
O'Sullivan	✓						
Power & Trope							✓
Rajpoot & Patel							✓
Schuurman		✓			✓		
Scull et al.	✓						
Sheppard	✓						
Sheppard & Cizek			✓	✓		✓	
Tullis & Kar		✓					
Verrax			✓				
Wilson				✓			
Wilson & Poore		✓					
Wong & Wu			✓				
Zhu et al.	✓						

4 Discussion

In this section, privacy and surveillance are discussed in more detail in relation to each of the 42 publications analysed. The focus is on how these two ethical concerns have changed over time within the context of GIS.

4.1 Privacy

Privacy emerges as one of the principal concerns within the GIS literature. It is underscored by Lake (1993), who highlights the dual imperative of leveraging GIS technology for societal benefit while ensuring robust protection against intrusion into privacy. This foundational stance sets the stage for a discourse on ethical considerations, proposing a code of conduct for GIS professionals that addresses system security, access and privacy. The narrative extends

into geodemographics: Crampton (1995) and Goss (1995) both critique the risk of evolving into a “surveillance society” through the unauthorized usage of consumer data; both emphasize the crucial need for consent and the ethical quandaries posed by the construction of consumer identity without permission. Here, we define privacy as the protection of individuals' location-based information against unauthorized access and misuse, focusing on safeguarding sensitive data, ensuring informed consent, and maintaining location privacy (Elwood & Leszczynski, 2011).

The historical arc of privacy rights, traced by Curry (1997b), reveals a burgeoning concern over the unregulated availability of data and the invasive potential of data profiling. The concept of "digital individuals" (Curry, 1997b) complicates privacy by linking personal data to maps, whose interpretative variability heightens privacy risks. Legislative lag in response to GIS developments poses significant privacy protection challenges, as noted by Hernon & Dugan (1997) and Obermeyer (1998). The capabilities of GIS to merge and sift through vast datasets necessitate urgent regulatory updates to safeguard individual privacy. In response to these challenges, Obermeyer (1998) outlines a series of privacy protection guidelines for the GIS community, advocating for the judicious collection and use of personal data, complemented by stringent data security measures. The ethics codes of various GIS organizations, reviewed by Blakemore & Longhorn (2004), uniformly emphasize individual privacy. Meanwhile, McLafferty (2004) explores practical solutions such as geographic masking and data dissemination strategies to mitigate privacy risks without compromising the use of GIS for social applications.

The discourse extends into the realm of satellite surveillance (Armstrong & Ruggles, 2005) and mobile tracking (O'Sullivan, 2006), highlighting the profound privacy implications of emerging technologies. The need for ethical standards and privacy regulations becomes ever more evident amidst the potential for pervasive surveillance. Bertino et al. (2008) delve into the specific challenges of maintaining privacy within GIS data repositories, advocating for nuanced access controls and privacy-aware data management practices. This is echoed in the calls for educational efforts and analytical vigilance by Zhu et al. (2009) and Andrienko (2012) which aim to pre-empt privacy breaches through informed awareness and proactive data handling strategies.

The importance of privacy in health and public records is underscored by Blatt (2012), who emphasizes the ethical obligations of researchers in handling sensitive data. The findings of Scull et al. (2015) reveal a broad consensus on the criticality of privacy and ethics education among GIS professionals, despite existing curricular gaps. Verrax (2017) and McKenzie et al. (2019) reflect on the contemporary challenges of digital privacy, contemplating the balance between open data access and the safeguarding of personal privacy. The advent of location-based technologies further complicates this landscape, as discussed by Tullis & Kar (2020) and Nelson et al. (2022), who highlight the ongoing struggle to establish ethical norms and regulatory frameworks capable of protecting individual privacy in the digital age.

By looking at the evolution of privacy in the context of GIS over time, we found that in the 1990s, early discussions, such as those by Curry (1997b), focused on how digital geographic data could infringe personal privacy. These discussions emphasized the need to reconsider privacy in the face of emerging GIS technologies. By the mid-2000s, the focus expanded to

integrate privacy with data security, as highlighted by Armstrong & Ruggles (2005) and Bertino et al. (2008), whose works underscored the dual challenge of safeguarding geospatial data while protecting individual privacy. In more recent years, the discussion has become increasingly specialized, with privacy being addressed alongside broader ethical considerations. McKenzie et al. (2019) revisit privacy within the context of modern GIS technologies, while Scull et al. (2015) highlight the importance of teaching the ethics of privacy in GIS education.

4.2 Surveillance

A further concern within the field of GIS that is closely related to privacy is surveillance. Surveillance can be described as a practice of following and monitoring subjects or events across different locations and at different times, related to the systematic collection, analysis and utilization of personal spatial data. The practice has the effect of facilitating technological advancements (Lyon, 2001) and raises concerns about privacy, ethics and power imbalances (Leszczynski, 2016). This capability, highlighted by Crampton (1995), extends from government use to corporate applications, notably in targeted marketing strategies that rely on geospatial data for consumer profiling. Such practices, while boosting business efficiency, raise significant privacy and ethical questions, as the complex identities of individuals are reduced to mere geographic data points. Goss (1995) further examines GIS's pivotal role in enhancing surveillance capabilities, enabling precise individual and behavioural profiling by corporations and governments. This technological leap forward offers vast analytical opportunities but also harbours risks for privacy and the potential for information misuse.

The narrative of surveillance's societal impact, as critiqued by Curry (1997b), underscores the shift towards intensified monitoring facilitated by rapid technological advancements in the absence of robust regulatory frameworks. Curry proposes a novel approach that uses GIS to create virtual counterparts to real individuals, allowing for an observational layer that could potentially mitigate direct invasions of privacy by focusing surveillance on digital proxies rather than real persons. Curry (*ibid.*) notes further the judicial system's inertia in addressing the growing pervasiveness of surveillance. This failure to adapt legal responses to technological progress underpins a broader societal transformation towards a surveillance-intensive paradigm that is unmitigated by adequate legal safeguards. Modern thoughts on surveillance are historically rooted in the 19th century, but its evolution has seen a significant uptick since 9/11, which Klinkenberg (2007) identifies as a turning point towards heightened security measures justified by national security concerns. The years since 9/11 have been marked by a deliberate move towards restricting access to information as a countermeasure against perceived threats, thereby entrenching surveillance as a societal norm.

Wilson & Poore (2009) broaden the discourse to encapsulate the use of surveillance in both corporate and governmental spheres, emphasizing the need for a paradigm shift away from surveillance-driven objectives towards GIS applications that prioritize social justice and minimize harm. Cinnamon (2020) delves into the geopolitical implications of surveillance, particularly in the context of military operations and the so-called "war on terror". The concept of "dataveillance" emerged in the 2010s as a critique of the massive collection and retention of location-based data. While ostensibly aimed at enhancing security, the practice raises

profound concerns over discrimination, social injustice and the erosion of democratic freedoms.

The ongoing debate around surveillance reflects a critical examination of the role of GIS in surveillance and highlights the technological advances that enable unprecedented levels of monitoring and profiling. Despite efforts by regulatory bodies to introduce protective measures such as the General Data Protection Regulation (GDPR), global challenges persist in balancing technological innovation with fundamental rights to privacy and freedom, underscoring the need for vigilant, ethical considerations in the application of GIS technologies. The development of surveillance over time highlights this need. In the mid-1990s, foundational discussions, such as those initiated by Goss (1995), began to explore how GIS could be used to monitor and influence behaviour, raising early ethical concerns about its surveillance capabilities. By the 2000s, the focus on surveillance became more pronounced, particularly in the context of security and control. For example, Bertino et al. (2008) addressed how geospatial data could be used for surveillance, emphasizing the need for secure data practices to prevent misuse. In the 2010s and beyond, surveillance using GIS has been increasingly scrutinized within the broader context of social justice and ethics. Recent papers, such as Wilson (2009) and McKenzie et al. (2019), have examined critically how GIS technologies are employed for surveillance, and have highlighted concerns about power imbalances and the ethical implications of monitoring populations through spatial data. There has thus been a shift from viewing GIS as a neutral tool to recognizing its potential for surveillance, prompting ongoing ethical discussions about its use in society.

4.3 Summary

The exploration has unveiled privacy and surveillance as paramount and intricately linked concerns, pivotal for the integrity of personal freedom and autonomy. These concerns spotlight the tension between the benefits of technological advancements and the imperatives of ethical governance. Privacy, as our literature review underscores, emerges as a cornerstone of personal freedom, a bulwark against unwanted intrusion, yet it is continually challenged by the evolving capabilities of GIS. From the pioneering discussions by Lake (1993) to the nuanced analyses by McKenzie et al. (2019), the dialogue shifts from discussing the protective measures needed within the GIS community to broader societal implications, revealing a landscape where data privacy is perpetually at risk in the face of technological prowess and commercial interests. The emergence of “digital individuals” and the widespread use of geodemographic data, as critiqued by Curry (1997b) and others, exemplify the ongoing struggle to balance beneficial applications of GIS with the safeguarding of rights to privacy.

Surveillance, which is closely tied to the discourse on privacy, presents a double-edged sword. The literature traces its evolution from a necessary tool for governance and business efficiency, as noted by Crampton (1995) and Goss (1995), to a mechanism that potentially infringes individual privacy and fosters a surveillance society, as highlighted by Curry (1997a) and Cinnamon (2020). The critical examination of surveillance practices, from targeted marketing to wartime data collection, underscores the profound ethical dilemmas posed by the unchecked collection and utilization of personal spatial data.

A useful theoretical approach on privacy concerns in GIS is Nissenbaum's concept of contextual integrity. Nissenbaum (2020) emphasizes that privacy violations occur when information is moved from one context to another without adhering to the norms governing the original context. In the case of GIS, this issue is particularly relevant, as spatial data—which is often public in its original context, such as for navigational or urban planning purposes—may be repurposed for surveillance or commercial profiling without explicit consent. This re-contextualization of geographic data could lead to significant privacy breaches, especially when individuals believe they are only sharing limited information.

Future research could focus on developing clear ethical frameworks and legal criteria to distinguish between acceptable uses of public data in GIS and those that constitute privacy violations. This is particularly important as GIS technologies continue to evolve, pushing the boundaries of data collection and usage. As Nissenbaum (2020) pointed out, existing privacy theories offer considerable insight, but there remains a pressing need for further scholarly inquiry and judicial clarification to create robust guidelines. These efforts should aim to protect privacy rights in public spaces while ensuring GIS innovation is conducted responsibly. The development of these ethical standards will be crucial for ensuring that the balance between technological advancement and privacy protection remains intact in future GIS applications.

5 Conclusion

The investigation illuminates the need for a nuanced understanding of the ethical implications surrounding GIS. The recurring theme across the findings is the paramount need for a balanced approach that leverages GIS for societal good while fiercely guarding against privacy violations and intrusive surveillance. The scholarly discourse advocates for enhanced ethical standards, legal frameworks and public awareness to navigate the complex interplay between technological advancements and ethical responsibilities in GIS applications. The literature review not only underscores the critical ethical dimensions of privacy and surveillance in GIS but also calls for ongoing scholarly inquiry, policy innovation and ethical vigilance to ensure that the advances in GIS technology serve to enhance, rather than undermine, personal freedom and societal wellbeing. The state of the art in GIS ethics in the scientific literature presents a call for a balanced, ethical stewardship of technology that respects individual privacy and curtails unwarranted surveillance, thereby safeguarding the very fabric of our digital society.

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