A Wearable Architecture for Zero-Friction Civic Micro-Participation

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Abstract. *Citizen participation plays an important role in strengthening public management and can be enhanced through digital technologies. However, many existing solutions depend on active interactions, limiting continuous engagement. This work proposes a citizen-sourcing system based on contextual and low-effort interaction, where citizens evaluate urban spaces according to their geographic location using mobile and wearable devices, such as smartwatches. The solution adopts a client-server architecture composed of an API and two Flutter applications (smartphone and wearable). An exploratory user study was conducted using questionnaires based on TAM, SUS, trust, and public value constructs. The results indicate high acceptance regarding usefulness, ease of use, and usability, demonstrating the potential of the approach to reduce participation barriers. However, institutional trust presented greater variability, suggesting that adoption depends not only on technological quality but also on confidence in how public management uses the collected information. The main contributions include a contextual citizen participation model supported by wearable devices and evidence on factors influencing the adoption of citizen-sourcing solutions in urban environments.*

1. Introduction

Citizen participation plays a fundamental role in strengthening public management, contributing to greater transparency, social control, and improved service delivery [Bouzguenda et al. 2019]. With the advancement of digital technologies, new forms of interaction between government and society have emerged, highlighting the use of digital platforms for collecting opinions, monitoring services, and fostering social engagement [Zahn et al. 2024].

In this context, crowdsourcing-based approaches have shown to be promising, as they allow citizens to actively contribute information about urban issues, the evaluation of public works, and the quality of public services [Estellés-Arolas and González-Ladrón-de Guevara 2012, Saralioglu and Gungor 2020]. These solutions expand the monitoring capacity of public administration and promote greater inclusion in decision-making processes.

However, most existing solutions rely on active user interaction, requiring deliberate access to the application, the completion of forms, or navigation through more complex interfaces. This model may limit continuous engagement, especially in everyday scenarios where participation competes with other user attention demands.

In addition, the effectiveness of these platforms is directly related to factors such as ease of use, perceived usefulness, usability, and, especially, trust in the system and in the institutions responsible for using the collected information [Zahn et al. 2021]. The absence of visible feedback or perceived impact tends to reduce engagement over time, compromising the sustainability of these initiatives.

In this context, this work proposes a citizen-sourcing system—defined as the application of crowdsourcing concepts in the public sector—based on contextual and low-effort interaction, in which citizens are invited to evaluate urban locations according to their geographic position. The solution leverages mobile and wearable devices, allowing evaluation requests to be automatically presented when users are near points of interest, and enabling responses directly through smartwatches.

This approach reduces the need for active interaction and brings the system closer to the ubiquitous computing paradigm, in which technology is more naturally integrated into the user's daily life. Furthermore, the use of simple questions, with limited response options and intuitive visual elements, aims to minimize cognitive effort and enhance participation potential.

To evaluate the proposed solution, an exploratory study with users was conducted, using a structured questionnaire based on well-established models in the literature, including the Technology Acceptance Model (TAM), the System Usability Scale (SUS), as well as constructs related to trust in e-government and perceived public value.

The objective of this work is to analyze user acceptance and experience regarding the developed system, considering dimensions such as perceived usefulness, ease of use, usability, trust, perceived public value, and intention to use in the future.

The main contributions of this work are: (i) the development of a citizen-sourcing solution based on contextual interaction and wearable devices; (ii) the proposal of a low-effort citizen participation model aligned with the concept of ubiquitous computing; and (iii) initial empirical evidence on factors influencing the adoption of this type of solution, with particular emphasis on the role of institutional trust.

The remainder of this paper is organized as follows: Section 2 presents the theoretical background; Section 3 describes the research methodology; Section 4 presents the obtained results; and, finally, Section 5 presents the conclusions and future work.

2. Theoretical Background and Related Work

This section presents the theoretical concepts that underpin the proposed architecture and reviews the current literature at the intersection of municipal citizen-sourcing and wearable computing, highlighting the contrast between traditional digital participation and our zero-friction approach.

2.1. Electronic Participation and Citizen-Sourcing

Digital technologies play a pivotal role in advancing smart sustainable cities and enhancing democratic governance through electronic participation [Bouzguenda et al. 2019, Bastos et al. 2022]. Within this domain, citizen-sourcing emerges as the application of crowdsourcing principles [Howe et al. 2006, Estellés-Arolas and González-Ladrón-de Guevara 2012] to the public sector. It enables governments to collect data, ideas, and feedback directly from citizens, effectively transforming them into distributed sensors capable of monitoring urban environments [Nam 2012, Monteiro et al. 2021]. In municipal administration, this dynamic is frequently operationalized through ombudsman systems, which channel citizen reports regarding urban infrastructure and public services [Santos et al. 2019, Zahn et al. 2025].

Currently, the main technological channels for such civic contributions are web portals and smartphone applications. Although smartphones provide essential hardware components, such as GPS and cameras, they also introduce significant interaction friction that can limit continuous user engagement [Vasconcelos et al. 2024]. Submitting a report typically requires the user to interrupt their current activity, retrieve the device, unlock it, locate the specific application, navigate through the interface, and manually input text or images. This multi-step process demands conscious cognitive and physical effort, which reduces the frequency of spontaneous, on-the-go contributions and creates a barrier to widespread civic micro-participation.

2.2. Wearable Computing and Glanceable Interfaces

To mitigate the engagement barriers inherent in smartphone-based participation, wearable devices—especially smartwatches—offer continuous physical contact with the user and immediate accessibility. A defining characteristic of interaction on smartwatches is the concept of "glanceable interfaces": interfaces designed to present information and receive input within a few seconds, typically referred to as microinteractions.

Unlike smartphones, which are designed for prolonged use and macro-tasks, smartwatches prioritize brief and contextual interactions. By leveraging physical buttons, simple touch inputs, or localized haptic feedback, these devices enable users to perform actions without significantly diverting their visual or cognitive attention from the physical environment.

In the context of the architecture proposed in this work, the transition from active smartphone reporting to contextual smartwatch notifications involves reducing data dimensionality (e.g., replacing textual descriptions with simplified evaluation options) in exchange for faster input and lower interaction friction. By shifting the participation trigger from the user's active memory to an automated proximity alert (GPS-based geofencing), our system aligns with the ubiquitous computing paradigm. This theoretical foundation supports our zero-friction model, where civic evaluation is integrated naturally into the citizen's daily displacement, demanding minimal effort to generate valuable public data.

3. Research Methodology

The adopted method consists of the design, implementation, and initial evaluation of a computational system for distributed urban data collection through direct interaction with citizens. The study follows an artifact-oriented approach, in which a technological solution is proposed and evaluated in terms of its acceptance, usability, and perceived value in the context of public management.

3.1. Artifact Proposal

The proposal of this work consists of the development of a citizen-sourcing system in which citizens contribute data about urban spaces through their interaction with mobile and wearable devices.

The system is composed of two main roles: (i) the public manager and (ii) the citizen. The manager is responsible for registering questions associated with specific geographic points in the city, representing locations of interest for evaluation, such as public works, services, or public spaces. These questions are designed to be objective, containing simplified response options (e.g., two or three alternatives), with the aim of reducing cognitive effort and encouraging participation.

On the citizen side, the system uses location data (GPS) to identify the user's proximity to registered points. Upon entering an area of interest, the user automatically receives an evaluation request. Unlike traditional applications, the proposed interaction is minimally intrusive and does not require complex registrations or active navigation within the system.

As a distinguishing feature, the system integrates wearable devices, such as smartwatches, allowing questions to be presented directly on these devices via Bluetooth connection. In this way, users can respond to questions quickly and contextually, without the need to access their smartphones.

The collected responses are consolidated into a management module, in which managers have access to analytical dashboards with indicators on citizens' perceptions, enabling the identification of patterns, recurring issues, and priority areas for intervention.

Figure 1 presents the overall architecture of the solution, while Figure 2 illustrates the main system interfaces, including authentication screens, question registration, geographic visualization of points, and interaction via wearable devices.

Figure 1. Solution architecture

3.2. Development

The system was developed based on a client-server architecture. The back-end was implemented in Node.js [OpenJS Foundation 2024b] using the Express [OpenJS Foundation 2024a] framework to provide an HTTP/JSON API, while data persistence is managed through an SQLite [Hipp 2024] database. This central server is responsible for storing essential entities, such as registered devices, geographic locations of interest (including activation radii and coordinates), active evaluation rules, and the synchronized responses. On the client side, two interconnected applications were developed using the Flutter[1] framework: a mobile application intended for smartphones and a companion app designed for wearable devices.

Regarding the data model, the SQLite database is structured around essential entities designed to support the contextual interaction. The main entities include: (i) *Devices* (storing identifiers, last known city, coordinates, and synchronization status); (ii) *Locations* (containing name, city, coordinates, and activation radius); (iii) *Questions* and *Activation Rules* (defining the text, valid periods, available alternatives, priority, and linkages to specific locations); and (iv) *Responses* (recording the device, answered question, chosen alternative, and location context). Furthermore, the database manages activity events and synchronization tasks to ensure data consistency across the distributed architecture.

The information flow follows an efficient synchronization strategy designed for low friction. The central server acts as the primary repository. Initially, the mobile application queries the server to download and locally cache locations and questions that match the user's current geographic position. When a citizen is prompted and provides an evaluation, the data flows locally from the smartwatch to the smartphone via Bluetooth Low Energy. Finally, the mobile application transmits the collected responses back to the server API, where they are persisted and made available in the analytical dashboard for public managers.

To ensure user privacy and data protection, the system architecture was designed following the principles of data minimization and *privacy by design* [Schaar 2010]. Participation is strictly voluntary, requiring explicit user consent within the mobile application to access background geographic location (GPS) and Bluetooth services. The collected data is pseudo-anonymized; the device identifiers stored in the database are randomly generated tokens, ensuring that the submitted evaluations cannot be directly traced back to the citizen's personal identity.

Location data is processed locally by the smartphone via background GPS. When a user remains within a registered location's radius for at least 10 seconds, the system triggers a contextual question. To ensure privacy and battery efficiency, continuous tracking paths are never sent to the server; only the specific location context linked to a submitted response is transmitted.

The API acts as the central layer of the solution, being responsible for managing the questions registered by managers, receiving responses submitted by users, and providing data for analytical visualization. On the client side, the smartphone application includes functionalities for authentication, registration, and management of georeferenced questions, as well as the visualization of these questions on a map. The questions are associated with specific geographic coordinates, allowing their activation based on the user's location.

The application for wearable devices was designed with a focus on quick interactions and low cognitive effort, displaying directly on the watch the questions associated with the user's location. Communication between the smartphone and the smartwatch is carried out via Bluetooth, enabling the delivery of notifications and the collection of responses in a seamless and continuous manner.

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[1] Flutter: https://flutter.dev

The system's operating logic is based on monitoring the user's geographic position through GPS. Upon detecting proximity to a previously registered point, the system automatically triggers an evaluation request, which can be answered directly on the wearable device. The responses consist of simplified options (e.g., two or three alternatives), with the aim of reducing interaction time and encouraging participation.

Figure 2 presents the main system interfaces, including: (A) login screen, (B) question registration by the manager, (C) visualization of questions positioned on the map, (D) connection process with the wearable device, and (E) display of the question for evaluation directly on the smartwatch.

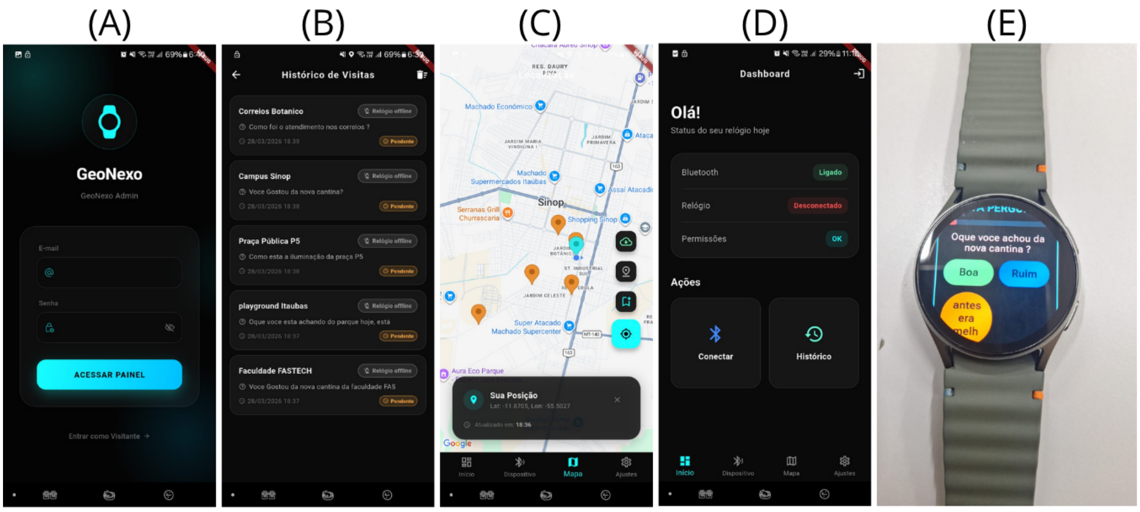

Figure 2. Main Interfaces

The management module, accessed through the client application, enables the analysis of collected data through aggregated visualizations, including the geographic distribution of responses, evaluation metrics, and indicators of citizens' perceptions.

3.3. Initial Evaluation

The initial evaluation of the system was conducted through a structured questionnaire, applied to potential users of the solution, with the aim of analyzing acceptance, usability, and perceived value of the proposed system.

The data collection instrument was based on well-established models in the literature, including the Technology Acceptance Model (TAM) [Venkatesh and Bala 2008], the System Usability Scale (SUS) [Brooke et al. 1996], as well as constructs related to trust in e-government systems [Carter and Bélanger 2005] and perceived public value [Moore 1997].

The questionnaire was organized into six main dimensions: (i) perceived usefulness, (ii) ease of use, (iii) usability, (iv) trust, (v) perceived public value, and (vi) intention to use in the future. The questions were designed using a five-point Likert scale, ranging from "strongly disagree" to "strongly agree". Data collection was conducted using the Google Forms platform. Participation by respondents was voluntary and anonymous.

4. Results and Discussion

The evaluation included the participation of 17 respondents, who used the application and smartwatch in a university environment to evaluate a proposal for a new university cafeteria. Considering the exploratory nature of this stage, the results were analyzed from a predominantly qualitative perspective, using percentages to support data interpretation.

Overall, a positive perception of the system can be observed among participants. Most responses are concentrated in the categories "strongly agree" and "partially agree", indicating good acceptance of the proposed approach.

The results suggest that the solution was well understood, particularly regarding its ease of use and potential application in public management. On the other hand, dimensions related to institutional trust and practical impact showed greater dispersion in the responses.

4.1. Perceived Usefulness

Regarding the perceived usefulness questions, the responses showed very positive evaluations. For the question "The system is useful for expressing my opinion about public works and places", 88.2% of participants agreed, with 58.8% indicating strong agreement.

For the question "The system facilitates my participation in public management", unanimous agreement (100%) was observed, indicating strong alignment with the citizensourcing approach. Regarding the question "Using the system can contribute to improving public services", 88.3% of respondents evaluated it as agreed, while 5.9% evaluated it as partially disagree.

Additionally, for the question "The system helps communicate problems or perceptions about the city.", 70.6% of respondents indicated strong agreement, reinforcing the potential of the solution as a channel for interaction between citizens and public managers. Figure 3 presents the percentages of the responses.

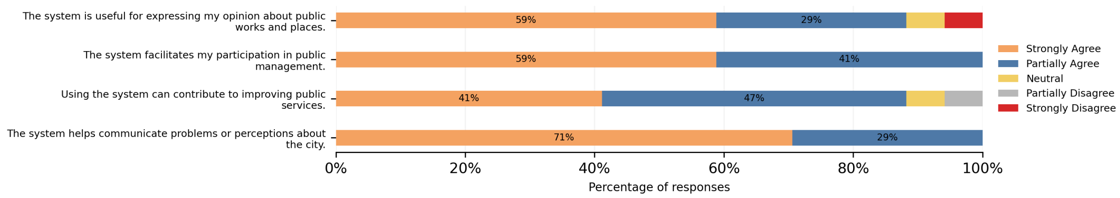

Figure 3. Perceived Usefulness

4.2. Ease of Use

Ease of use was one of the most highly rated aspects. For the question "It was easy to learn how to use the system", 88.2% of participants agreed, with 70.6% indicating strong agreement.

Consistently, for the question "Submitting an evaluation was simple", 94.1% of respondents agreed, while for the statements The evaluation format is clear and easy to understand" and "The system is intuitive to use", total agreement (100%) was observed. Figure 4 presents the results.

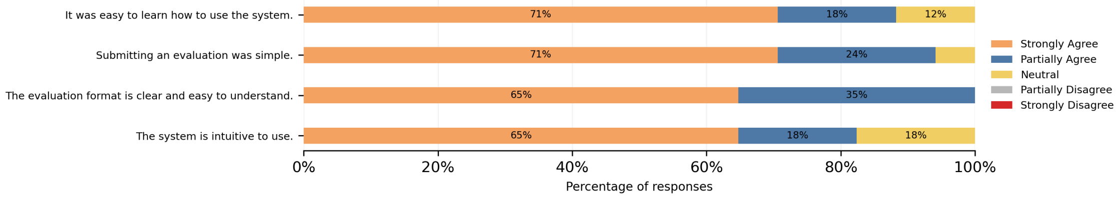

Figure 4. Ease of Use

4.3. Usability

Regarding usability, the results are also positive. For the negatively phrased question "The system is confusing to use", 64.7% of participants strongly disagreed. Similarly, for the statement "I found the system unnecessarily complex", 70.6% disagreed, indicating a low perceived level of difficulty.

Additionally, for the statement "I needed help to use the system", 52.9% of respondents strongly disagreed, suggesting that most users were able to use the application independently. These results indicate that the proposed simplified interaction, based on quick responses and visual elements, contributes positively to the user experience.

On the other hand, for the positive questions "The system is easy to use" and "I felt confident while using the system", 100% agreement was observed. However, regarding the question "I would use this system frequently", 70.6% of respondents agreed, while 11.8% selected the option partially disagree and 5.9% selected strong disagree. This indicates that, despite the simplicity of the application, some users still prefer not to use it frequently. Figure 5 presents the complete usability evaluation results.

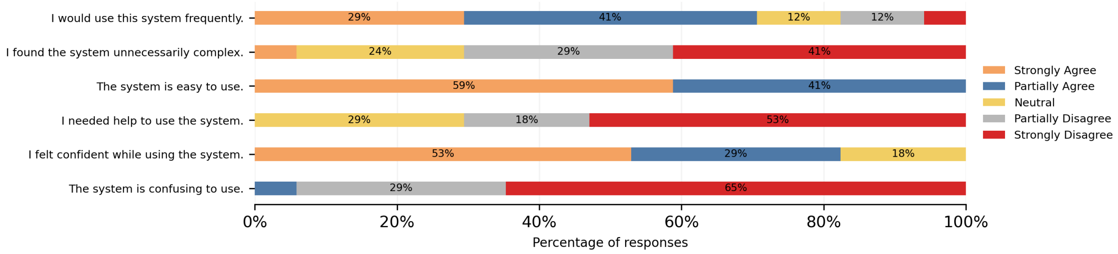

Figure 5. Usability

4.4. Trust

The analysis of trust reveals differences between the perception of the system and that of public management. For the statement "I trust that my evaluations are correctly recorded", 82.3% of participants agreed. Similarly, the question "I believe the system is secure and reliable" obtained 64.7% agreement.

On the other hand, for the question "I trust that public management will use these evaluations responsibly", only 52.9% agreed, while 23.6% disagreed and 23.5% remained neutral. This result suggests that the main limitation is associated with institutional trust, rather than with the functioning of the technology. Figure 6 presents the complete results.

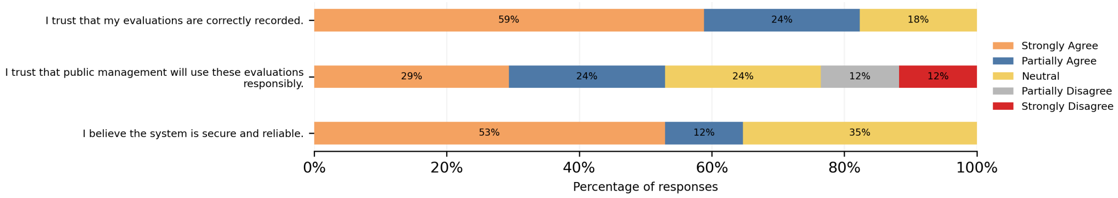

Figure 6. Trust

4.5. Perceived Public Value

Participants recognized the public value of the solution. For the statement "The system strengthens citizen participation", 94.1% agreed, representing one of the most expressive results. However, for the question "I feel that my participation can generate real impact", 64.7% agreed, while 35.3% showed neutrality or disagreement.

Similarly, for the statement "The system contributes to greater transparency in public administration", 76.5% agreed, indicating a positive perception, although still dependent on factors external to the technology. Figure 7 presents the results regarding the perceived public value questions.

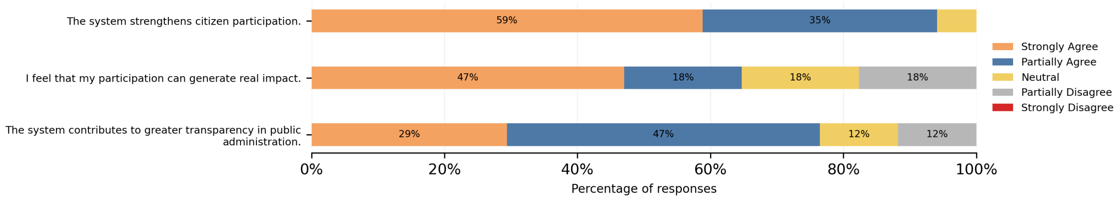

Figure 7. Perceived Public Value

4.6. Intention to Use in the Future

The intention to use the system in the future shows positive results. For the statement "I intend to use the system again", 70.6% of participants agreed. Additionally, for the question "I recommend the use of the system to other people", 82.3% of respondents agreed, indicating good acceptance of the proposed solution.

On the other hand, for the statement "I would use the system whenever I had the opportunity", a greater dispersion in responses is observed, with some participants indicating neutrality or disagreement, suggesting that frequency of use depends on the context of application. Figure 8 presents the results regarding the intention to use in the future questions.

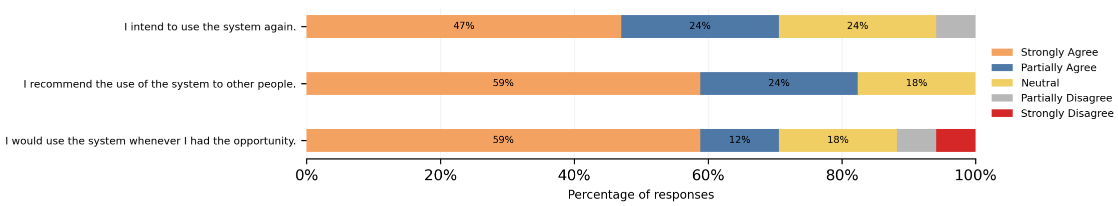

Figure 8. Intention to Use in the Future

4.7. Qualitative Analysis

The open-ended responses reinforce the findings, with participants highlighting simplicity, practicality, and ease of use as the main positive aspects of the system.

Among the suggested improvements, the following stand out: (i) inclusion of engagement mechanisms, such as rewards or incentives, (ii) the possibility of re-evaluating locations, (iii) greater discretion in interaction, and (iv) assurance of reliability and transparency in the use of information.

Regarding trust, participants suggest greater clarity about data usage and evidence of feedback from public management.

4.8. Results Synthesis

Overall, the results indicate high acceptance of the proposed approach, especially regarding ease of use and perceived usefulness, with a predominance of positive responses.

However, aspects related to institutional trust and the perception of real impact emerge as critical factors for the adoption and continued use of the system. These findings suggest that the success of the solution depends not only on its technological quality but also on the ability of public management to ensure transparency, credibility, and effective feedback to the population.

5. Conclusion

This work presented the design, development, and initial evaluation of a citizen-sourcing system aimed at citizen participation in public management, based on the collection of urban perceptions through mobile and wearable devices.

The proposed approach is distinguished by adopting a low-effort interaction model, in which evaluations are requested contextually based on the user's location and can be answered directly on wearable devices, such as smartwatches. This characteristic brings the system closer to the ubiquitous computing paradigm, reducing the need for active interaction and potentially increasing citizen engagement.

The results of the initial evaluation indicate a positive user perception, especially regarding perceived usefulness, ease of use, and usability. Participants recognized the system as a simple, accessible, and potentially effective tool for expressing opinions about urban spaces and contributing to public management.

The perception of public value was also evidenced, particularly with regard to strengthening citizen participation. However, aspects related to trust in how the information is used by public management showed greater variability, indicating that the adoption of this type of solution is strongly conditioned by institutional credibility and the perception of feedback from the contributions made.

These findings reinforce that, although the proposed technology is promising, the success of citizen participation systems depends on the integration between technological solutions and governance practices that ensure transparency, responsiveness, and effective use of the collected data.

The main contributions of this study are: (i) the development of an urban data collection system based on contextual interaction and wearable devices; (ii) the proposal of a low-effort citizen participation model aligned with the concept of ubiquitous computing; and (iii) initial evidence on factors that influence the acceptance and use of citizen-sourcing solutions.

As limitations, it is important to highlight, first, the small sample size, characterizing the evaluation as exploratory and limiting the generalization of the results. In addition, difficulties were observed in selecting participants who possessed wearable devices compatible with WearOS, especially those that allow the installation of applications (APKs), which restricted a broader experimentation of the solution in real-world usage contexts.

Another relevant limitation concerns the scope of the evaluation, which was conducted exclusively with academic participants in a university environment during the assessment of a proposed university cafeteria. Therefore, the findings may reflect the perceptions and experiences of a specific user profile and application context. Furthermore, the evaluation focused exclusively on the perspective of citizens (end users), not considering the analysis of the experience and perception of public managers, who are also key actors in the proposed ecosystem.

As future work, it is suggested to expand the sample, with greater diversity of participants, enabling more robust quantitative analyses and the use of inferential statistical metrics. It is also recommended to conduct studies with users who effectively use wearable devices on a larger scale, in order to validate the proposal under conditions closer to real-world use.

Additionally, future studies should include other stakeholder profiles, such as public managers and professionals involved in urban planning and public administration, enabling a more comprehensive analysis of the artifact from both operational and strategic perspectives. It is also recommended to evaluate the application in different environments and for other types of public works and urban interventions, broadening the understanding of its applicability and usability across different contexts.

Finally, future studies may investigate mechanisms to increase user trust, such as transparency strategies, feedback on actions taken based on the evaluations, and integration with digital governance initiatives, contributing to strengthening the citizen participation cycle.

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