A Social Media-Based Approach to Addressing Temporality in PPGIS: Enhancing Citizen Engagement and Participation

Mohammad Hasan Zali [1*], Mohammad Ghanbarei Baba Ahmadi [1], Meysam Argany [1], Mir Abolfazl Mostafavi [2,3]

[1] Faculty of Geography, University of Tehran, Iran, Iran, Islamic Republic of - mohammad.zali@ut.ac.ir, mghanbarei@ut.ac.ir, argany@ut.ac.ir

[2] Center for Interdisciplinary Research in Rehabilitation and Social Integration, Université Laval, Québec (Qc) G1V 0A6, Canada - mir-abolfazl.mostafavi@scg.ulaval.ca

[3] Center for Geospatial Data and Intelligence, Université Laval, Québec (Qc) G1V 0A6, Canada

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Abstract

Public Participation Geographic Information Systems (PPGIS) have become essential tools for engaging citizens in urban planning and decision-making. However, a significant challenge persists in the temporality of data collection, most PPGIS platforms rely on one-time surveys or questionnaires, leading to outdated and infrequent data updates. This research proposes an innovative social media-based PPGIS that fosters continuous engagement, ensuring real-time and dynamic citizen participation. Unlike conventional methods, this approach integrates a location-based social media platform that allows citizens to contribute data through posts, discussions, and feedback mechanisms. Additionally, a recommender system will be developed to enhance interaction by prioritizing user-generated content based on location, relevance, and engagement history. The research will employ a mixed-methods approach, combining system development, usability testing, and participatory evaluation. Expected outcomes include an improved engagement model, enhanced real-time data collection, and a sustainable participatory environment for urban governance. This study aims to revolutionize PPGIS frameworks by bridging the gap between spatial decision-making and social media engagement.

1. Introduction

Public Participation Geographic Information Systems (PPGIS) play a critical role in urban governance by enabling citizen engagement in spatial decision-making (Simon, 2024). These platforms allow individuals to contribute local knowledge, voice concerns, and provide valuable geospatial input that enhances urban planning and policy formulation (Pamungkas et al., 2023). By integrating geographic information systems (GIS) with participatory methods, they contribute to the achievement of Sustainable Development Goals (SDGs) by fostering inclusive and participatory urban governance processes (Esposito et al., 2024).

Governments and urban planners increasingly recognize the value of bottom-up approaches where citizens actively participate in shaping their cities (Özdamar and Önay, 2024). PPGIS serves as a bridge between authorities and the public, fostering collaboration in areas such as transportation planning, environmental monitoring, disaster response, and urban development. When successfully implemented, citizen engagement can promote value creation in urban development projects. Citizens play a central role as key stakeholders in urban development projects, and their empowerment ensures they have a direct voice in decision-making processes (Vuorinen et al., 2024).

Despite its advantages, a significant limitation of current PPGIS platforms is the issue of temporality, the inability to maintain continuous and up-to-date citizen participation (Laborgne and Klöcker, 2023). Traditional PPGIS platforms predominantly rely on surveys, questionnaires, and single-event participatory mapping sessions, where citizens provide spatial data at a specific point in time. This data collection method introduces several challenges:

- Static and Outdated Information: Since most citizens participate only once, the data quickly becomes obsolete, leading to inaccurate urban planning decisions (Santos et al., 2023).

* Corresponding author

- Low Retention and Engagement: Citizens often lose interest in platforms that do not provide immediate or sustained benefits, reducing their willingness to contribute (Yasuoka, 2023).

- Limited Interaction and Feedback: Traditional PPGIS platforms function one-way, where users submit data but receive minimal engagement or feedback from authorities or fellow citizens (Anugraha et al., 2022).

As a result, existing PPGIS systems fail to create a sustainable participatory ecosystem, limiting their long-term effectiveness. Several approaches have been proposed to enhance citizen engagement and address the temporality issue in PPGIS.

To sustain participation, some platforms have developed mobile apps that encourage users to contribute updated information (Fahsi and Kettani, 2024). While this improves retention to some extent, it does not foster organic engagement, as users often perceive these notifications as intrusive.

Some researchers have explored gamification techniques, such as rewarding users with points or rankings based on participation levels (Paraschivoiu and Layer-Wagner, 2021). While gamification can boost short-term engagement, its long-term effectiveness is uncertain, as users may disengage once the novelty fades.

Recognizing the limitations of current approaches, this research proposes a novel social media-based PPGIS platform that enhances continuous citizen participation. Instead of relying on static surveys, the proposed system integrates social media elements where users actively engage in discussions, share geospatial data, and interact with location-based recommendations. By fostering an interactive and dynamic environment, the platform encourages sustained participation, ensuring that urban planners receive timely, relevant, and community-driven insights.

This study aims to develop and evaluate this new participatory model, addressing the temporality issue in PPGIS while enhancing the user experience, engagement, and overall impact of citizen-contributed data.

2. Literature Review

Simon (2024) explores the application of Public Participation Geographic Information Systems (PPGIS) in healthy urban planning. Simon highlights the growing use of PPGIS as a tool for integrating community input into decision-making, ensuring that urban planning aligns with the health needs and preferences of residents. The author emphasizes the need for further research to address these limitations and to explore innovative approaches for enhancing public engagement in urban planning (Simon, 2024).

Kajosaari et al. (2024) investigate the spatial dimensions of citizen engagement in digital participatory planning. The findings reveal challenges, such as uneven participation rates and the risk of excluding certain demographic groups due to varying access to digital tools and platforms. The authors emphasize the need for more inclusive and equitable digital planning practices that account for the diverse geographies of citizen engagement (Kajosaari et al., 2025).

Borchers et al. (2024) address the challenges of facilitating clear and meaningful citizen contributions on digital urban participation platforms in their study. The authors investigate how technological and design interventions can support citizens in articulating comprehensible and actionable input for urban planning processes. Through a combination of user studies and platform evaluations, the study identifies key barriers to effective participation, such as difficulties in formulating ideas, lack of clarity in communication, and limited understanding of planning contexts. The authors propose design strategies, including guided input forms, contextual feedback mechanisms, and interactive tutorials, to enhance the quality and usability of citizen contributions. Their findings underscore the importance of user-centered design in fostering more inclusive and productive digital participation (Borchers et al., 2024).

Berigüete et al. (2024) explore the role of emerging digital technologies in enhancing citizen engagement for urban and environmental management in their study. They highlight how technologies such as Geographic Information Systems (GIS), mobile applications, social media platforms, and Internet of Things (IoT) devices are transforming participatory processes by enabling more accessible, real-time, and data-driven interactions between citizens and decision-makers (Berigüete et al., 2024).

Horelli and Wallin (2024) examine the role of civic engagement in urban planning and development. The authors explore how participatory approaches can empower citizens to contribute meaningfully to the planning and development of urban spaces, fostering more inclusive and sustainable outcomes (Horelli and Wallin, 2024).

Bąkowska-Waldmann and Kaczmarek (2021) investigate the application of Public Participation Geographic Information Systems (PPGIS) in spatial planning, aiming to enhance meaningful public participation. They emphasized the importance of designing user-friendly and inclusive PPGIS platforms to ensure broader and more equitable engagement (Bąkowska-Waldmann and Kaczmarek, 2021).

Arvanitis et al. (2022) explore innovative approaches to fostering citizen engagement in sustainable urban planning through the integration of installation design and digital gamification. The research demonstrates how creative design strategies can enhance public involvement in sustainable planning initiatives (Arvanitis et al., 2023).

Knecht et al. (2019) propose a novel approach to citizen engagement in urban planning by integrating citizen knowledge with expert design through computational design space exploration. The study explores how computational tools can facilitate collaborative planning processes by enabling citizens and experts to co-create and evaluate urban design scenarios. The authors highlight the potential of this approach to bridge the gap between lay and professional knowledge, fostering more inclusive and innovative planning outcomes. The study demonstrates how interactive platforms and visualization tools can empower citizens to actively participate in decision-making while providing experts with valuable insights into local preferences and needs. Challenges, such as the complexity of computational tools and the need for effective communication between stakeholders, are also discussed (Knecht et al., 2019).

All of these studies emphasize the importance of exploring strategies to enhance citizen engagement, as increased participation plays a crucial role in addressing the challenges identified in existing research. One of the most significant issues in PPGIS is the problem of temporality, where outdated and infrequent data collection limits its effectiveness. By fostering sustained citizen engagement and continuous participation over time, we can overcome this limitation, ensuring that PPGIS remains dynamic, relevant, and responsive to evolving urban needs.

3. Methodology

The proposed research aims to develop and implement a Public Participation Geographic Information System (PPGIS) platform that integrates social media functionalities with data-driven services to enhance citizen engagement and provide valuable insights for city planners.

The first component involves creating a dedicated social media platform tailored to facilitate active citizen participation. Unlike conventional PPGIS platforms that rely on traditional surveys and questionnaires, this platform leverages social media to encourage continuous and dynamic interaction among citizens.

The second component focuses on developing services that utilize data generated from the social media platform. These services are designed to offer practical benefits to citizens and actionable insights for city planners. These services are based on the data that produced by citizens, and they are one of the final users of the data that they produce and it may cause their sustainable participation.

3.1 System Architecture Overview

The architecture of the PPGIS platform is designed to ensure scalability, efficiency, and robust handling of spatial data. The system integrates multiple technologies, each contributing to different layers of the platform's functionality, from data storage to user interface.

3.2 Database Layer

At the core of the platform's data management is PostgreSQL, a highly reliable and powerful relational database management system (RDBMS). PostgreSQL is chosen for its advanced capabilities in handling complex queries and large datasets efficiently.

PostGIS Extension is used to enhance the spatial capabilities of PostgreSQL. PostGIS adds support for geographic objects, enabling the platform to perform spatial queries and manage GIS data effectively. This is crucial for storing, querying, and analyzing the geographic information submitted by users.

3.3 Backend Layer

The backend of the platform is built using Django, a robust Python web framework known for its rapid development and clean design.

GeoDjango for GIS-specific functionalities, GeoDjango is integrated within the Django framework. GeoDjango provides tools for geographic data manipulation and spatial queries, making it an ideal choice for GIS applications.

The backend follows the Model-View-Template (MVT) architecture pattern. This design promotes clear separation of concerns, making the codebase more maintainable and scalable. Models manage the data, views handle the logic, and templates control the presentation layer.

3.4 Frontend Layer

The frontend is developed with a focus on simplicity and user-friendliness, using: HTML for structuring web content. CSS for styling the user interface. Bootstrap for responsive design and consistent layout.

These technologies are chosen for their ease of use and quick development cycle, ensuring that the platform remains accessible and functional without requiring extensive frontend development expertise.

3.5 Data Engineering and Workflow Management

Data processing and pipeline management are handled using Apache Airflow. Apache Airflow As a Workflow Management System (WMS), Apache Airflow allows for the scheduling, monitoring, and automation of data pipelines. It integrates seamlessly with Python, enabling the creation of complex data workflows necessary for manipulating and analyzing user-generated data.

4. Result

This platform consists of several essential pages, each serving a specific function. Below is a brief overview of the key components of the platform.

The first page as shown in Figure 1 is sign-in anyone who wishes to access this platform or send a message must first be authorized by signing in. This requirement addresses privacy concerns for both the city and its citizens, ensuring a secure environment. Additionally, it encourages users to create an account before engaging with the platform.

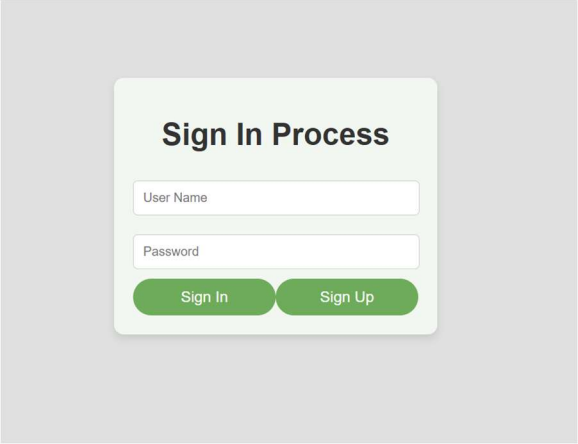

Figure 1. Sign In page

Second page as represented in Figure 2 is sign-up during the sign-up process, users will be required to provide information such as their National ID, phone number, address, and postal code. This ensures that only verified citizens of the city can access the platform, preventing participation from individuals with fake accounts.

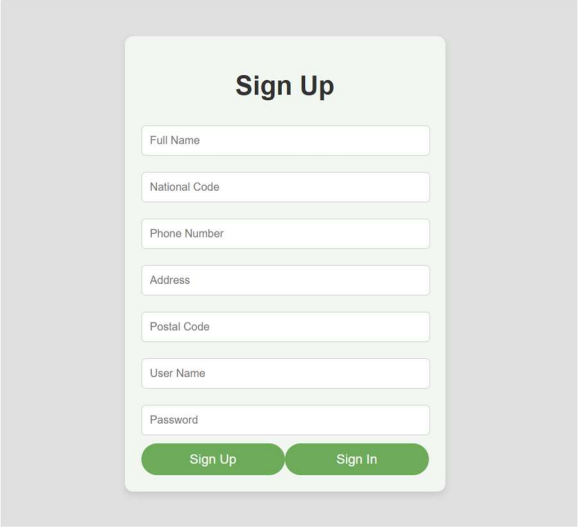

Figure 2. Sign Up page

Welcome page as represented in Figure 3 will outline our mission, explain how the platform operates, and highlight the added value it offers to users. At the bottom of this page, there will be two buttons: one directing citizens to the services we provide and the other linking users to our social media platforms.

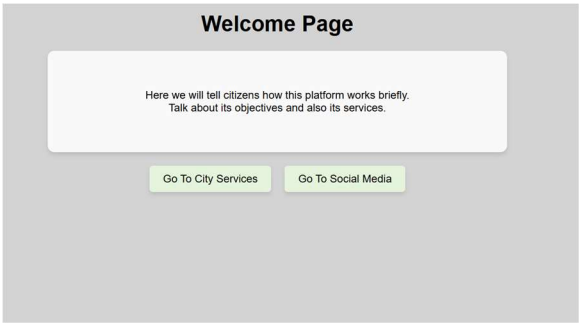

Figure 3. Welcome Page

Service page as illustrated in Figure 4 a list of services built using the data collected from this platform. These services are designed to encourage citizen participation and provide a reason for citizens to engage with the platform regularly. By offering solutions to citizens' daily needs, this approach addresses the temporality problem of PPGIS and ensures sustained user involvement. An example of this type of service is depicted in Figure 5, where citizens use a routing system powered by the data they themselves generate, allowing them to directly experience the impact of their contributions in everyday life.

Figure 4. List of city services

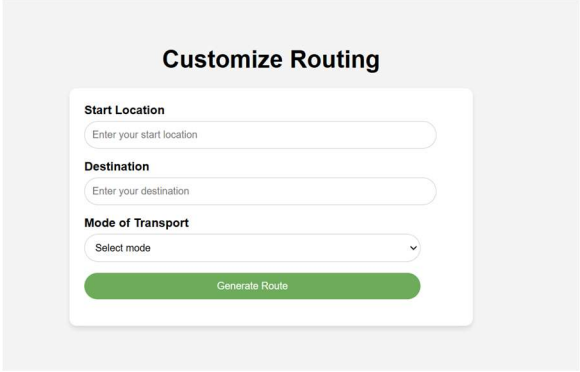

Figure 5. Example of services

Social media page serves as the core of our platform, where messages from other citizens are displayed for users to view , as demonstrated in Figure 6. The importance of our recommender

system, a key feature distinguishing our platform, is highlighted here. The system prioritizes messages based on their geographical proximity to the user. Additionally, users can filter messages by city areas, enabling them to stay informed about their neighborhoods.

Other factors influencing the recommender system include:

1. Timeliness: Messages are displayed to highlight current issues.
2. User Preferences: Content is prioritized based on categories the user interacts with most.
3. User Credit: A unique parameter we developed, which evaluates the user's engagement with the platform. It is calculated based on how frequently the user participates and the impact of their contributions and also their expert in specific domain.

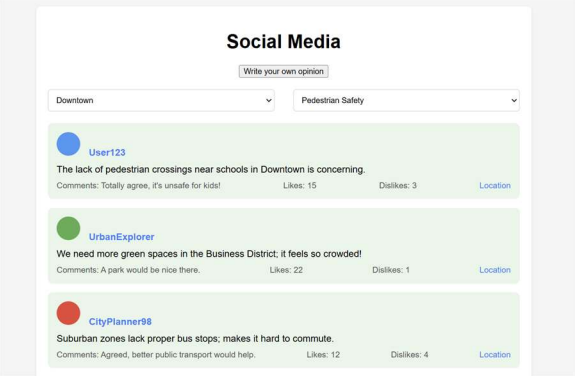

Figure 6. Social media page

For writing messages, the platform will extract the category, address, and location directly from the text submitted by users. This approach provides the most convenient and efficient way for users to send their messages. An example of the message composition page is presented in Figure 7.

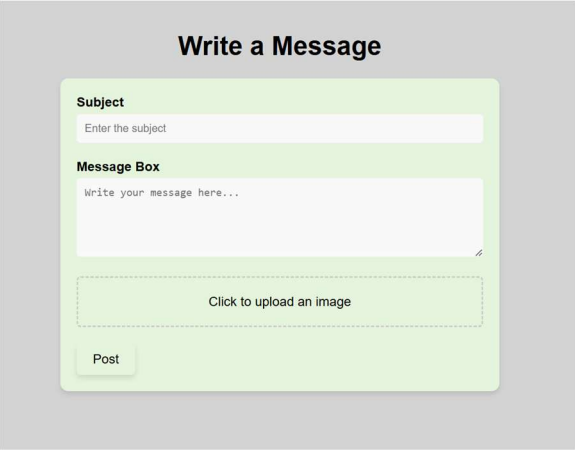

Figure 7. Writing Message page

If users click on a location in the message section, the message will be displayed on a map. Additionally, users can view all messages collectively on the map. This feature is designed to enhance user interaction and engagement with the platform. Figure 8 demonstrates how this data can be visualized on maps.

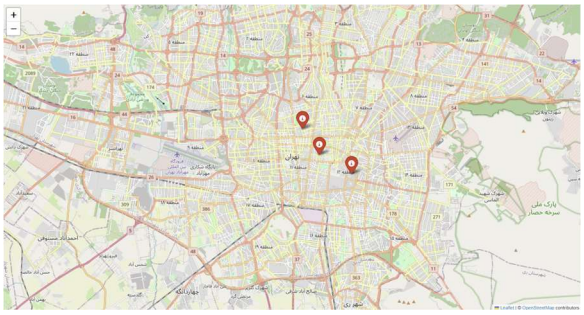

Figure 8. Showing data on map

User Profile section displays the user's profile and information, as shown in Figure 8. Users can highlight their responsibilities or expertise in specific domains. Based on the information they provide, their activities on the platform, and the reliability of the content they share, an activity score will be calculated. This score serves as their credit on the platform, influencing the visibility of their posts. Users with higher activity scores will have their posts prioritized in the social media feed, increasing their chances of gaining more engagement and views.

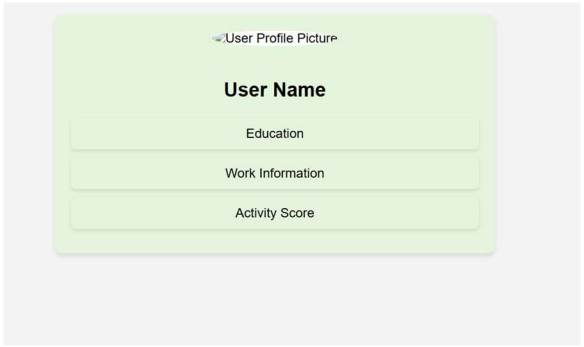

Figure 9. user profile page

5. Conclusion

This research proposes the development of an innovative Public Participation Geographic Information System (PPGIS) platform that integrates social media functionalities with data-driven services to enhance citizen engagement and urban planning. By leveraging modern technologies such as PostgreSQL with PostGIS, Django with GeoDjango, and Apache Airflow, the platform ensures efficient data management, spatial analysis, and workflow automation.

Unlike conventional PPGIS platforms, which often struggle with low participation rates and temporality issues, this approach fosters continuous user engagement by providing an intuitive

social media-based interaction model. The integration of a recommender system, location-based dashboards, and real-time feedback mechanisms will allow for the generation of more accurate and reliable spatial data.

The expected outcomes of this research include increased citizen participation, sustained engagement, enhanced collaboration between citizens and experts, and improved data reliability. By addressing key limitations of existing PPGIS platforms, this project aims to create a scalable, dynamic, and participatory urban management tool that benefits both city planners and residents.

Ultimately, this research contributes to the advancement of smart cities by promoting citizen-driven decision-making, fostering transparent governance, and enabling data-informed urban development. The findings and implementation strategies from this project can serve as a model for future participatory GIS applications worldwide.

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