Enhancing Urban Data Analysis through Large Language Models: A Case Study with NYC 311 Service Requests

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This paper demonstrates using large language models (LLMs) to extract insights from extensive urban data sets, demonstrated through a case study analyzing New York City's 35.4 million 311 service requests. While ChatGPT 4.0 generated multi-modal narratives from small data samples, limitations emerged in recognizing long-term patterns across the larger data set due to constrained context windows. Overcoming these LLM limitations on complex real-world data remains an open challenge to create effective interactive community engagement agents.

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1 INTRODUCTION

This research investigates how large language models (LLMs) can be used as conversational tools to encourage participatory storytelling and integrate personal narratives with institutional data. The aim is to increase civic engagement by providing formal channels for citizens to share their lived experiences, enabling communities to collaborate on data-driven actions tailored to local needs [2, 4]. By combining personal stories with administrative data, a more comprehensive understanding of factors affecting citizens' quality of life can be achieved, allowing individual voices to inform and shape policies that better serve the public interest [1].

To illustrate this vision, we present two example vignettes of human-system interactions. In the first vignette, a user approaches a bus stop in Harlem and asks the system when the next bus will arrive. The system provides the expected information about bus arrival times and additionally recognizes that the user has previously asked historical questions.

> *User*: When does the next bus arrive? *System*: The next bus is in 15 minutes. I noticed you've asked about Harlem's history before. Did you know this bus stop is near the famous Hotel Theresa, which hosts many famous African American celebrities and political figures? Would you like to know more?

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In the second vignette, a user who is moving to a new apartment asks the system about noise complaints in the neighborhood. Rather than simply stating the frequency of complaints, the system's response reflects an understanding of the community's values and provides context about the surrounding environment:

> *User*: What are the main complaints in this neighborhood? *System*: The noise complaints are related to the park construction project that has been going on for 6 months and is scheduled to finish in June 2024. The construction is part of a larger Green Initiative Project that began in 2020 and aims to provide more natural spaces to the community.

These vignettes demonstrate our vision of integrating community narratives and values into an LLM's responses to create more meaningful and contextualized interactions.

2 INITIAL RESULTS WITH CHATGPT-4.0

We investigated using large language models (LLMs) as a conversational interface for community engagement with the NYC 311 Service Requests dataset. This dataset contains over 35.4 million rows and 45 columns, spanning numerous data types from geographic coordinates to timestamps. In initial experiments, we provided ChatGPT-4 segments of this data to analyze trends and extract narratives. However, issues emerged when testing with a larger 17,000-row subset. Despite this file covering 311 complaints over the past 15 years already organized chronologically, ChatGPT-4 responded that there was insufficient data for trend analysis. This directly exhibited the "lost in the middle" problem from Liu et al.'s paper [3]. Due to LLMs' limited context windows, ChatGPT-4 only recognized the most recent complaints in the file.

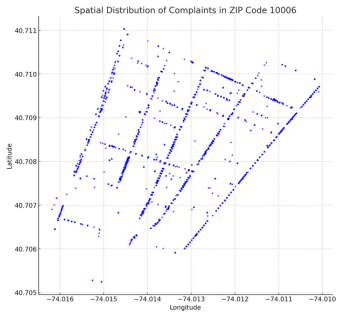

Fig. 1. The image shows a scatter plot of complaints in ZIP Code 10006. The points are concentrated in distinct lines, demonstrating that the complaints are aligned with streets within the ZIP code area.

Observations and Future Work: Our system's deployment underscores the necessity of incorporating several key components into the large-scale narrative formation framework. These components include a narrative structure component to guide the assembly of extracted data into coherent stories, a spatiotemporal indexing mechanism to organize and query data efficiently, and a vector database for optimized data representation and retrieval. Additionally, integrating a fact-checking agent and a logic agent is crucial for ensuring the accuracy of the narratives generated and for facilitating logical reasoning about the data.

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