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Demo Abstract: A Spatio-Temporal System for Public Transit-Guided Volunteer Task Matching

Xuzhe Wang[1,2], Chen Gao[2], Weichen Zhang[1,3], Chengzhao Yu[1], Chenyu Zhao[2], Xinlei Chen[1,3,4†]
[1]Shenzhen International Graduate School, Tsinghua University;
[2]Tsinghua University, Beijing, China;
[3] Pengcheng Laboratory; [4] RISC-V International Open Source Laboratory; [†] Corresponding author.

ABSTRACT

Volunteer activity often undergoes unique transformations with the constant changes in society. The information behind volunteer data was created to enhance public welfare efficiently and boost governmental organization productivity. This research aims to utilize public transit systems for volunteer services, reducing inequality in volunteer service provision across different regions and improving overall service efficiency. We collected and processed large-scale data related to public transit and volunteer services, conducting in-depth analysis using data mining techniques and deep learning methods. Through LDA, we annotated a large amount of volunteer data, and via data analysis, discovered patterns related to population distribution, spatial distribution, and temporal distribution. Combining public transit data and the mined features, we propose a novel spatio-temporal embedding model based on the transformer architecture, which can effectively classify and predict the matching between volunteer service demands and public transit systems. Studying the coupling between volunteer services and transportation systems helps establish a new data-driven mindset, better utilize urban resources, and provide high-quality volunteer services to the public.

1 INTRODUCTION

Volunteer activities play a crucial role in building a harmonious society and promoting public welfare. However, with the continuous changes and development of society, volunteer activities have undergone unique transformations to cater to the ever-evolving needs of communities. The information behind volunteer data was created to enhance public welfare efficiently and boost governmental organization productivity[1].Volunteer services are essential in providing support and assistance to various sectors, including education, healthcare, environmental protection, and disaster relief. They not only alleviate the burden on governmental organizations but also foster a sense of social responsibility and community engagement among citizens.At the same time, volunteer services also foster social cohesion and the cultivation of a spirit of mutual assistance within the society.

However, the unequal distribution of volunteer resources across regions poses a significant challenge. Factors such as population density, socioeconomic status, transportation infrastructure, and cultural norms contribute to this disparity[2]. Areas with higher population densities and better transportation networks tend to attract more volunteers, while remote or underdeveloped regions often struggle to attract and retain volunteer support[3]. To ensure equitable access to volunteer services and maximize their societal impact, it is crucial to address this inequality and promote a more balanced distribution of volunteer resources.

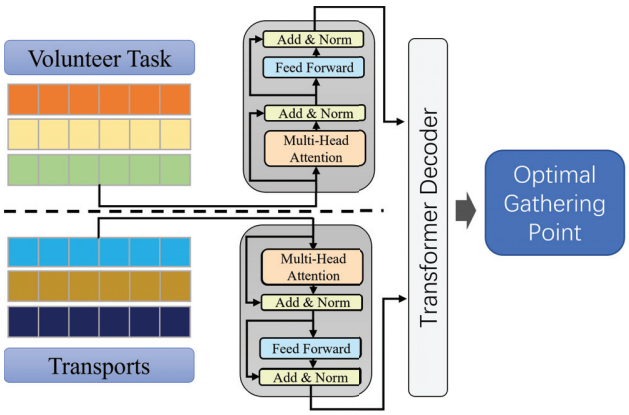

Figure 1: Model Overview

In this research, we aim to leverage public transit systems to guide and optimize volunteer allocation, reducing the inequality across different regions and improving efficiency. By collecting and processing large-scale data related to public transit and volunteer services, and conducting in-depth analysis using data mining techniques and deep learning methods, we seek to uncover patterns and correlations that can inform a more effective allocation of volunteer resources.Through techniques such as Latent Dirichlet Allocation (LDA)[4], we annotated a large amount of volunteer data and discovered patterns related to population distribution, spatial distribution, and temporal distribution. Allocating additional tasks through vehicle dispatch can also be utilized in volunteer assignments[5–7]. Combining these mined features with public transit data, we propose a novel spatio-temporal embedding model based on the transformer architecture[8]. This model is designed to effectively classify and predict the matching between volunteer service demands and public transit systems, enabling a more efficient and equitable allocation of volunteer resources across regions.

By studying the coupling between volunteer services and transportation systems, we aim to establish a new data-driven mindset that can better utilize urban resources and provide high-quality volunteer services to the public. This research not only addresses the pressing issue of regional inequality in volunteer service provision but also contributes to the development of innovative data analysis techniques and models for optimizing resource allocation in the context of public services.

2 METHOD

We propose a novel spatio-temporal embedding model based on the Transformer architecture to tackle the volunteer task prediction

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and gathering point selection problems. The model consists of an encoder-decoder structure, where the encoder learns the spatio-temporal representations from the input data, and the decoder generates the predictions for future task locations and types.

Input Representation: The input features x_i are preprocessed and encoded into a sequence of embeddings. Specifically, we employ the following encodings:

- **Location Encoding**: The task location is represented using geographic coordinates or a grid-based system, which are then mapped to a learnable embedding space.
- **Category Encoding**: The task type is encoded using one-hot or learnable embedding vectors.
- **Temporal Encoding**: The task time is decomposed into various temporal features, such as hour, day of the week, and holidays, which are then embedded into a continuous space.
- **Public Transit Encoding**: The public transit data, including routes, station locations, and timetables, passenger flow, are encoded into embeddings and integrated into the input sequence.

Encoder: The encoder component of the Transformer model is responsible for capturing spatio-temporal dependencies and contextual information of the input embedding. We designed two different encoders to cope with volunteer data and public transport data

Decoder: The decoder component generates predictions of task location and type based on the encoded representation of the encoder. Similar to the encoder, the decoder consists of N_d identical layers, each containing a multi-head attention sublayer, an encoder-decoder attention sublayer, and a position feedforward sublayer. The decoder receives data from both encoders simultaneously and fuses the two data to generate predictions

Gathering Point Selection: Given the predicted task location, we search for nearby public transit stations within a specified radius. For each candidate station, we compute a score that considers the following factors:

(1) **Distance to the task location**: Stations closer to the task site are preferred.
(2) **Accessibility from populated areas**: Stations with higher accessibility from densely populated regions are favored.
(3) **Safety constraints**: Stations located in safe neighborhoods with adequate facilities are prioritized.

The score for each station is calculated as a weighted sum of the aforementioned factors, and the station with the highest score is selected as the gathering point for volunteers.

3 CONCLUSION & FUTURE WORK

Figure 2 offers a glimpse into the preliminary results of our intricate model, one that revolutionizes the allocation of volunteer tasks. At its core, the model meticulously distributes unequal tasks to optimal aggregation points, leveraging extracted task features as the guiding compass. This approach is not just a technical exercise; it addresses a critical social issue – the inequality in volunteer tasks. By streamlining this allocation process, we aim to facilitate the efficient completion of tasks, ensuring that each volunteer's efforts are maximized and their contributions are recognized. The emergence of this model represents a significant step forward in addressing

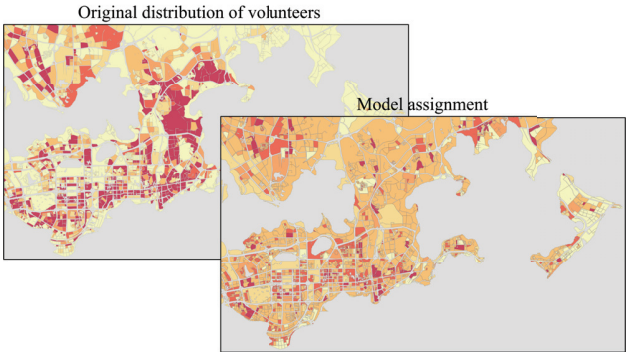

Figure 2: Smoother and more efficient volunteer assignments based on model assignments

our volunteer task assignment challenges. It not only improves the efficiency and effectiveness of the volunteer workforce, but also promotes the overall well-being and satisfaction of volunteers. Additionally, we are also committed to exploring solutions for on-site monitoring of volunteer tasks[9]. As we continue to refine and optimize the model, we are confident that it will play an increasingly important role in the future development of volunteer work.

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