A Noise Map of New York City

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**The paper was done when the first and third authors were interns in Microsoft Research under the supervision of the second author.*

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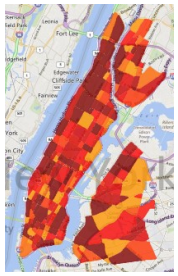
Abstract
This demonstration presents a noise map of New York City, based on four ubiquitous data sources: 311 complaint data, social media, road networks, and Point of Interests (POIs). The noise situation of any location in the city, consisting of a noise pollution indicator and a noise composition, is derived through a context-aware tensor decomposition approach we proposed in [5]. Our demo highlights two components: a) ranking locations based on inferred noise indicators in various settings, e.g., on weekdays (or weekends), at a time slot (or overall time), and in a noise category (or all categories); b) revealing the distribution of noises over different noise categories in a location.

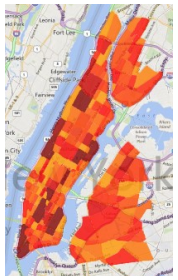
Author Keywords
Urban computing; urban noises; social media; big data

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

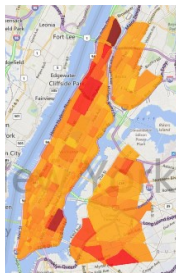
Introduction
Noise pollution becomes a major problem in modern city during the rapid progress of global urbanization [6]. In addition to compromising working efficiency and the quality of sleep, noises may impair people's physical and mental health, therefore attracting a wide range of attention [2][3]. People living in major cities, especially in NYC, are increasingly concerned with noise pollution, calling for technology that can diagnose the citywide noise pollution and the composition of noises.



(a)



(b)



(c)

Figure 1. The Noise Map of NYC: (a) weekday 'Load Music / Party' noise at 21:00, (b) weekday 'Construction' noise at 21:00, and (c) weekend 'Construction' noise at 21:00

However, inferring the noise map of a city is difficult, due to lack of sensors, data sparsity, and people's subjective feelings etc., let along analyzing the noise composition of a specific region in a time slot. To tackle these challenges, we use ubiquitous noise related data sources (e.g., 311 data, check-in data in location-based social networks, POIs, and road networks) which are proved to have correlations with urban noises [5], and integrate these datasets into a context-aware tensor decomposition model. The output of our model is a fine-grained noise pollution indicator of any region in any time slot and any noise category. By aggregating dimensions of the inferred tensor, we can diagnose citywide noise situation in various settings.

Based on the inference model we proposed and evaluated in [5], we implement a city-scale noise map of New York City with noise visualization and diagnosis [8]. Moreover, two highlighted components of our system are proposed as follows:

- Location ranking based on inferred noise indicators on the weekdays (or weekends), in a time slot (or overall time), and in a noise category (or all categories).
- Noise composition analysis of main noise categories and their distributions over time in a region.

User Interface Design

Our system is based on the tensor model described in our previous publication [5]. Here, we focus on the noise map of NYC, and two highlighted components: location ranking and noise composition analysis.

As in Figure 2, the user interface of our system consists of two major parts: the left one in the red frame is the control panel and the right one in the green frame is the noise map of NYC based on Bing Maps.

The control panel has three components as in Figure 2. a) Data and Time Panel, which controls the map on right to visualize noises in various setting in terms of weekday (weekend), time of day, and category, e.g., Figure 1(a) is the map at weekday 21:00 in 'Load Music/Party' category. By choosing 'Construction' in the dropdown list, the map refreshes to Figure 1(b). Also, the slider in the time panel can be dragged to show the noise situation in different time of day, while the buttons below are used to automatically play the city's noise situation in chronological order; b) Top 5 noisiest location list; and c) Noise composition analysis.

When selecting 'Overall Time' checkbox, as in upper left of Figure 2, time panel aggregates the data in different time of day and transforms to pie chart of citywide noise categories analysis in NYC.

In the noise map, we partition the city into disjointed regions using a map segmentation algorithm [4], assuming the noise situation in a region is uniform while that of different regions may be different. If having the 311 data, the noise indicator of a region is denoted by the number of 311 complaints. The noise map is overlaid on Bing Map which supports real-time scaling and moving. The darker a region's color is, the heavier noise pollution in it. Besides, when the mouse hovers over a region, a corresponding infobox with detail region information appears, as in Figure 2(d).

Location Ranking Based on Inferred Noise Indicators

Noisiest region list is used to rank the top 5 noisiest regions in a specific setting, as in Figure 2(b). Please note that both the noisiest region list and the noise map on right can reflect the location ranking based on inferred noise indicators in our system.

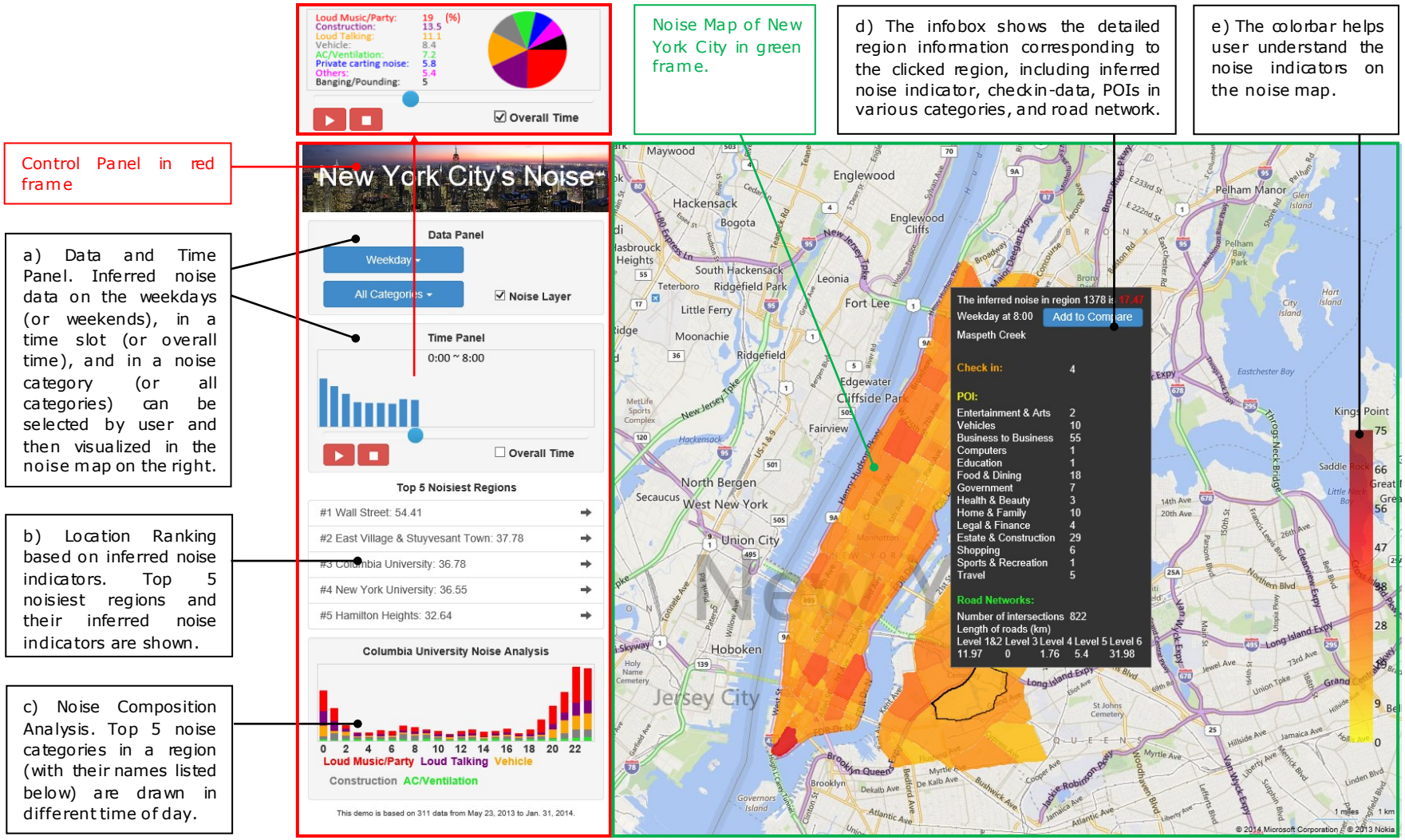


Figure 2. Screenshot of our noise map system.

Our system automatically names regions according to their titles and addresses of POIs and road networks inside. As shown in Figure 2(b), with Top 5 noisiest region list, we understand that Wall Street is the noisiest region of NYC at weekday 8:00 in all noise categories with a noise indicator of 54.41.

Noise Composition Analysis

Noise composition analysis is used to dig in the noise composition in a region and understand the main noise categories and their distribution changing over time. A click on the noise map or noisiest region list can activate the analysis of that region. In Figure 2(c), an

analysis of Columbia University is shown. While the horizontal axis denotes the time of day and the vertical axis represents the 5 categories combined noise indicator, the histogram in Figure 2(c) shows the top 5 categories as well as the noise trend of the region.

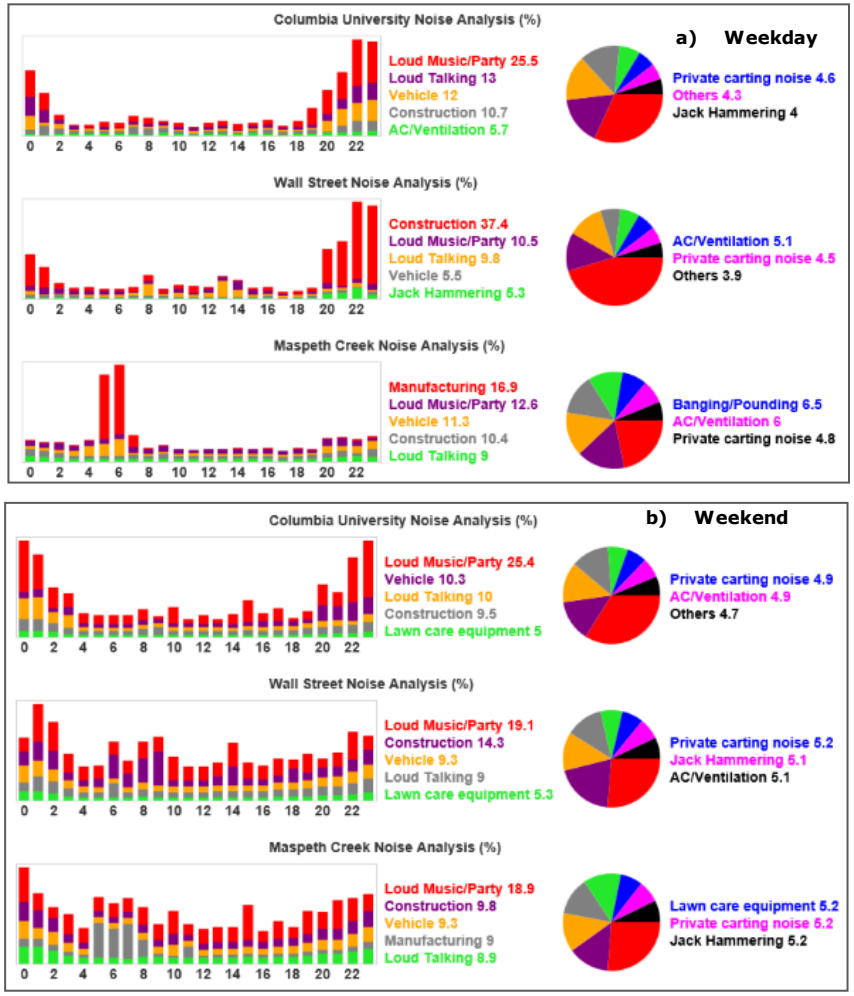


Figure 3. Noise Comparison of three regions between weekdays and weekends

Clicking 'Add to Compare' button in the infobox of a region can add the region to the noise comparison. The comparison component provides noise composition analysis of the compared regions and the pie chart of top 8 categories with their names and percentages. As shown in Figure 3(a), the dominated noise categories in three regions on weekday are 'Load Music/Party', 'Construction', and 'Manufacturing'. However, in Figure 3(b), as people tend to enjoy their lives on weekend, 'Load Music/Party' dominates the noise pollution.

Conclusion

This demo presents a Noise Map of NYC that can help diagnose noise pollutions, with two major components: location ranking and noise composition analysis. The demo site is publicly available at [8]; the model has been published in [5]; the data can be obtained at [7].

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