Designing a Noise Mapping System based on the Citizen Scientists' Smartphone Sensor Data

Eunyoung Shim[1], Youngtae Cho[1]*, Hyekyung Woo[1]*, Dohyeong Kim[2]

[1] Center for Smart Technology and Public Health, Seoul National University

[2] The University of Texas at Dallas

* Corresponding author (youngtae@snu.ac.kr)

Introduction

Over the last three decades, the academic interest in daily exposure to noise has rapidly increased. Noise is one of the serious environmental problems for urban dwellers. Long-term exposure to noise at certain decibel can increase the risk of blood pressure, ischemic heart disease, and hypertension and sleep disturbance. To aware the loudness of one's daily ambient environment may promote her or his health by allowing the chance to avoid the noise. A number of metropolitan cities run numerous noise monitoring stations and provide the information to their citizens. However, the practical value of the information has not been high enough, since the geographic coverage of monitoring stations is hardly robust and the presentation of noise level utilizing the administrative boundaries often provides information unmatched with one's actual location.

The increase of smartphone penetration rate in many countries is amazing. To take South Korea as an example, over 80% of cell phone users use smartphone in 2013. A smartphone is equipped with numerous embedded sensors. Although variable by makers and models, most smartphones basically furnish GPS (global positioning system), WPS (wifi-based positioning system), light, gyro, accelerometer, sound, and/or magnetic sensors. These two facts associated with smartphones, the penetration rate is enormously high and sound and geographic sensors are basically inserted, allow us to creatively envision the possibility of monitoring daily ambient noise levels utilizing citizens' smartphones and of producing practically valuable live information of noise that can cover a wide range of city area.

The purpose of this research is to design and explore the practical possibility of the noise mapping system by applying the concept of citizen scientists. First, unanimous smartphone users provide their information on location and ambient noise sporadically monitored by their own smartphones. Then this information is graphically presented on a map that can be accessed by the public.

Data Collection

We collected geographic sensor monitored data (GPS and WPS) from Seoul residents aged 20 to 49 who use smartphones daily. We limited age groups from the 20s to the 40s for the participant selection, since the smartphone penetration is the highest in these age groups. Participant selection was carried out by the Gallup Korea, the largest social survey company

in Korea. Selection of participants was limited to those used Samsung Galaxy S3, Galaxy Note 1, Galaxy Note 2 models to minimize the possible errors caused by technical differences across different smartphone brands. Initially 360 participants were collected, but finally 336 participated in the study. Since the participant selection was conducted by the social research company, those participants statistically represented Seoul residents aged 20-49. However, we did not pay attention to statistical process of population estimation since the purpose of our exploratory study did not include population estimation from the sample.

Participants were requested to download and install an application called “Smart Census” to their smartphones. The “Smart Census” application was developed by authors only for the use of the current study. When the application was installed and first opened, users were informed about this study and the details of data collection procedures. Participants could choose to proceed or leave. The application ran automatically to gather GPS and WPS information once in every five-minute and sound information in every 10-minute for seven days. Therefore a total of 1,008 times (7days*24hours*6times) of sound sensor data could be collected, although there were variations across samples due to uncontrollable mechanical or technical problems. We designed the "Smart Census" application to store all collected GPS/ WPS data and sound data in the participants’ own smartphones. When 7 days of data collection was completed, the application automatically showed a pop-up message to the participants informing the end of participating in Smart Census and asked if they agreed to send all sensor data collected by and stored in their smartphones to the study server which was secured and protected by the Statistics Korea. Thus, informed consent to take part in this study were taken twice from the study participants, just after the installing the application and right before the submission of collected data, and the entire study design and procedure was reviewed for its ethical issues by the IRB committee of the School of Public Health, Seoul National University.

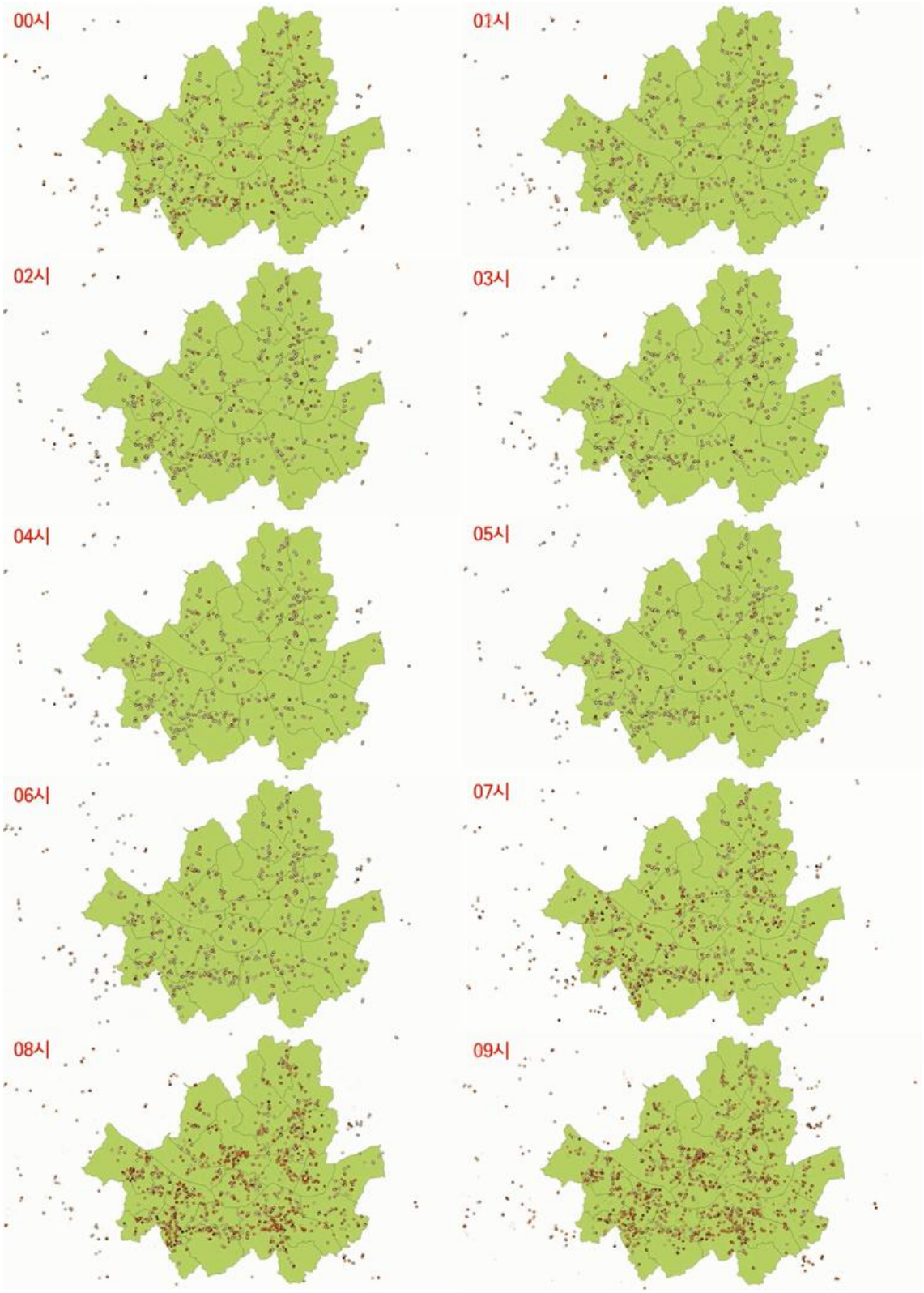
Participants could join the *Smart Census* any time during March 11-17, 2013. Data submission from the last participant was done on March 22, 2013. Since the "Smart Census" application was developed only for those participants, we sent a text message with a link that they can download the application rather, than to have them use general application stores for Android phones. When GPS and WPS data were submitted from all participants to the secured server, Statistics Korea reviewed and cleaned them first to remove any types or kinds of information that could violate the Personal Information Protection Act of Korean Law.

Analysis

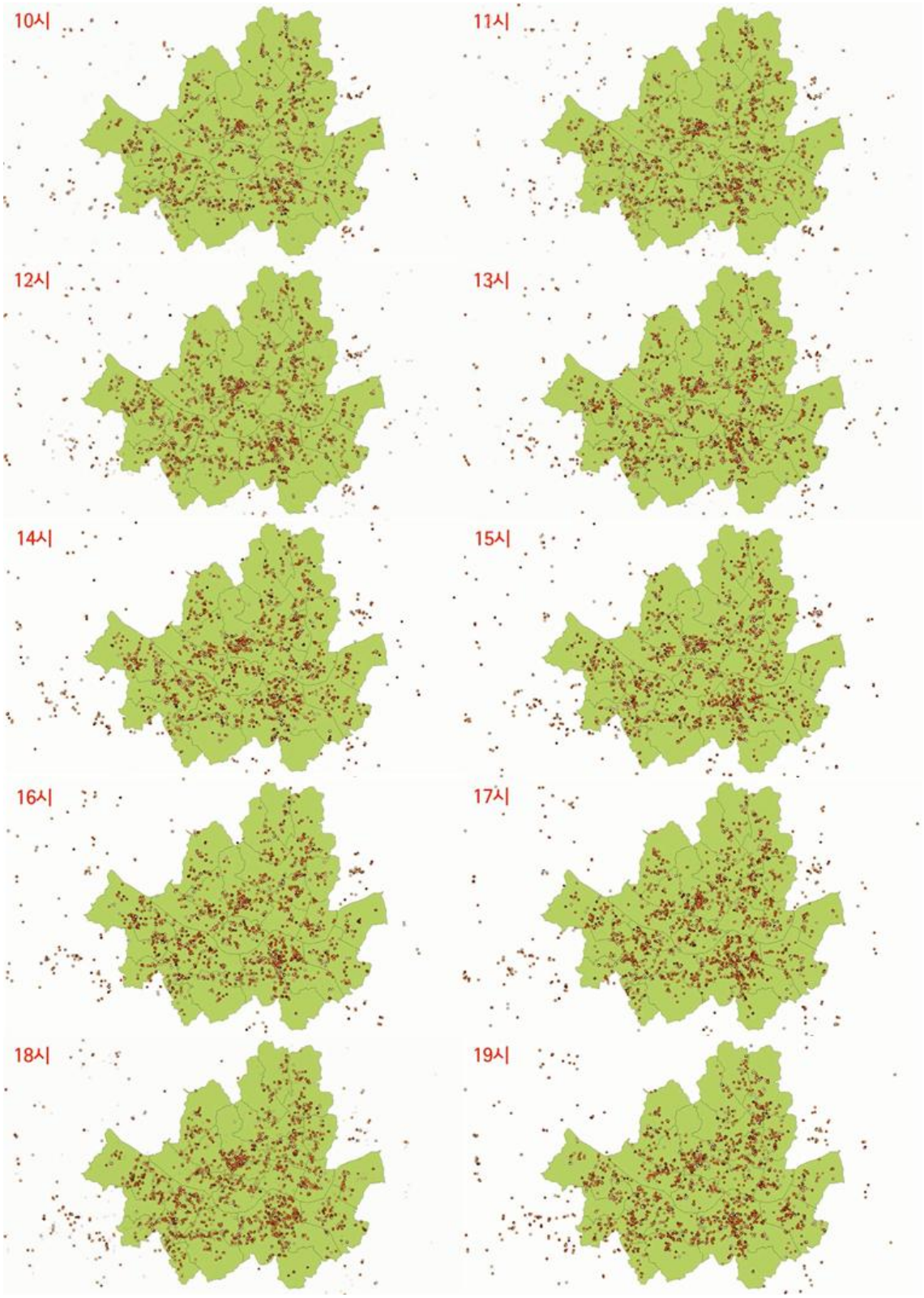
We employed the QGIS software to graphically present the noise map, and WPS data were used to identify whether the sound information was collected indoor or outdoor. First, the sound level, measured in decibel, was spotted on the map (example shown below). Then the ESDA (Exploratory Spatial Data Analysis) method was applied to construct an interpolation map.

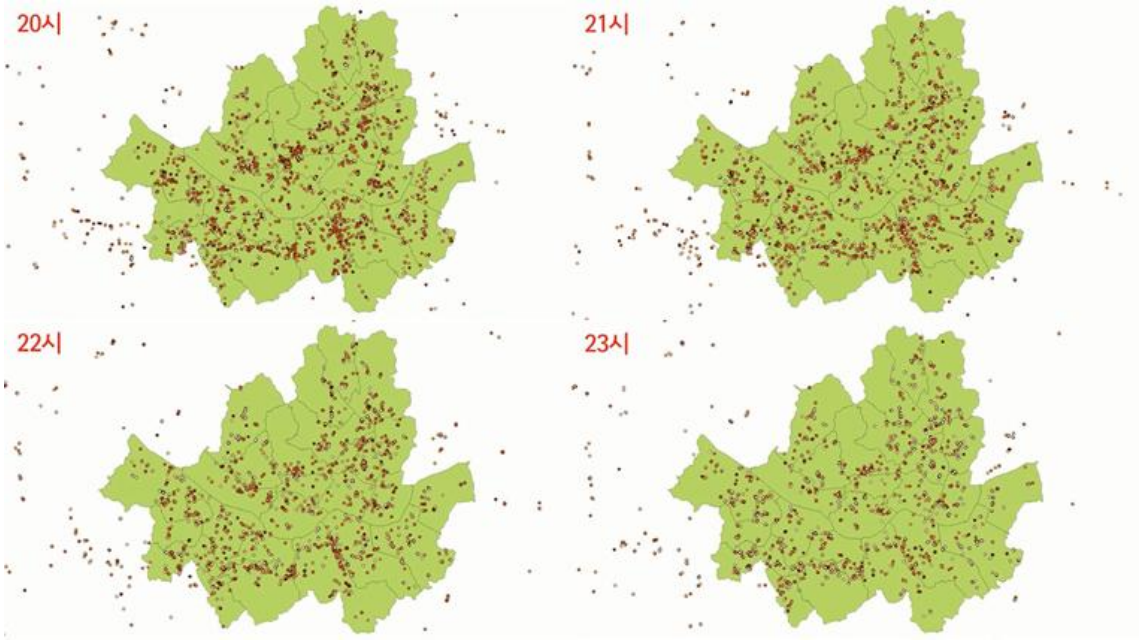
Results and Implications

The number of study participants was only 336. But interestingly, their sensor data, collected in every 10-minute, covered most space of Seoul as shown below. The results show that if at least 300 citizens participate in this kind of project as citizen scientists, it is very plausible to monitor the noise levels with the robust and continuous coverage capability and generate a real-time noise map that can be valuable for entire citizens.



<Noise map by hour>


10시
11시
12시
13시
14시
15시
16시
17시
18시
19시


20시
21시
22시
23시