AN INNOVATIVE NOISE MANAGEMENT PLATFORM

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As urbanization takes place, noise from construction activities adversely affects the quality of life of those living in the vicinity of the activities and poses a challenge to government regulatory agencies. This paper describes an innovative noise management platform that has been developed to (i) manage and monitor noise due to construction activities remotely, (ii) diagnose the cause of noise even under a multiple-site condition, and (iii) inform the public in an understandable manner to build trust and demonstrate transparency when necessary. The design, hardware, and software of the platform are introduced. An illustrative case is used to demonstrate the application and use of this platform.

1. Introduction

As human population grows and urbanization increases globally, more people are living in cities [1, 2]. Cities in Asia are particularly under pressure because of the relatively high urbanization rates comparing to the rest of the world. In China’s cities such as Hong Kong SAR, Macao SAR, Guangzhou, Tianjin, Shanghai, and Beijing, construction activities have increased substantially in the past ten years due to the demolition of old buildings, construction of new commercial and residential buildings, new facilities such as schools, hospitals, government buildings, and mass transit systems including metro and inter-city links. Unavoidably, people living in the vicinity of construction sites are adversely affected by the pollutants discharged/emitted from the sites. Dust, particulate matter, construction waste water, noise, etc, are some of the pollutants. In Hong Kong, construction noise is one of top six environmental pollution complaints with 1,485 cases in 2012 [3].

The management and monitoring of noise is challenging. In urban planning and management, noise mapping has been recognized as a useful tool because policy makers and the public can visualize the effect of urban development such as new roads and more traffic on the noise levels in cities [4]. Researchers have developed transportation-related noise models for better predicting noise levels in the past decades [5-13]. Nevertheless, there are other noise issues in cities. They include community noise and noise from construction activities.

In this paper, we present an innovative noise management platform that has been developed based on the demand of the construction industry in Hong Kong SAR. The system can enable users to monitor noise levels at specific locations remotely and to identify the sources of noise using sound level meters and dedicated CCTV units. The interfaces include a wide range of terminals including smart phones, tablets, and notebook computers. In Section 2, we present the system configuration of the platform. A case showing how the platform was used in Hong Kong SAR is presented in Section 3. Section 4 presents the concluding remarks.
2. **System Configuration of Noise Management Platform**

Traditionally, the noise monitoring of a construction project is carried out by an environmental team. According to the Technical Memorandum on Environmental Impact Assessment Process (EIAO-TM) and other TMs in Hong Kong, noise monitoring shall be carried out at the designated monitoring locations to obtain one set of $L_{eq,30-min}$ noise measurements in dBA between 07:00 and 19:00 on normal weekdays. When the measured noise levels at the designated locations exceed the limit level at 75 dBA, the environmental team needs to carry out a detailed investigation to identify the source(s) and cause(s) of the noises and to notify the contractor(s) and all other concerned parties including independent environmental checker, independent consultant, and the Environmental Protection Department immediately. The contractor(s) shall take immediate action to mitigate the noise(s) while the environmental team needs to perform additional noise monitoring for checking the effectiveness of noise mitigation measures. Hence, it takes a lot of time and concerted effort to ensure that noise from construction activities is properly monitored and controlled. In addition, there can be cases that noise exceeds the permitted level but is not detected by the environmental team.

In order to carry out automatic noise monitoring without too much of human involvement, an innovative noise management platform was designed and deployed to a large-scale infrastructure construction project in Hong Kong SAR. As cloud computing is flexible, cost effective, and has the ability to scale applications on demand, it is utilized as the backbone of the platform [14].

According to Murugesan and Laplante [15], the advent of information technology (IT) changes our life and the way we perform our work and green IT refers to the design, manufacture, use, and disposal of IT products and systems in a more environment-friendly manner. Green IT also encompasses the use and integration of IT products to create resource-efficient, environmentally sound business practices, processes, and solutions, and to support environmental initiatives and create green awareness [15, 16]. Hence, we adopted a cloud platform as shown in Figure 1. Figure 1 shows that an innovative noise management platform has a secure site and a number of hardware including sound level meters and CCTV that will upload data to the platform continuously. The platform in fact is a noise management system that collects, processes, and stores raw and processed data. For users, they can access to raw data and processed data via mobile terminals such as smart phones, tablets, and notebook computers.

![Figure 1. Cloud-based Noise Management Platform.](image-url)
2.1 Noise data management

In Hong Kong, construction noise is monitored using the A-weighted equivalent continuous sound pressure level i.e. $L_{eq}$. As stated earlier, $L_{eq,30-min}$ is used as the monitoring parameter for the time period between 07:00 and 19:00 on normal weekdays. For all other time periods, $L_{eq,5-min}$ is used so that the measured noise level can be compared with the criteria set by the Noise Control Ordinance. Hence, sound level meters shall be set to measure $L_{eq}$, $L_{10}$, $L_{90}$, $L_{min}$, and $L_{max}$ at the 5-min intervals and data are transmitted to the platform. Concurrently, wind data based on 5-min averages and visual data from the CCTV unit are transmitted to the platform as well. At the moment, the maximum uploading speed of Hong Kong’s 3G system is 384 kbps and that of 4G system is 35 Mbps. Data are collected by the secure noise monitoring platform EAS. The EAS is a Green Cloud that was developed to perform a wide range of environmental monitoring services and noise is one of key environmental parameters. Noise data are collected, processed, and stored at the EAS.

Authorized users can remotely access the EAS by using smart phones or tablets. As suggested by To et al. [14], the cloud performs data analysis while phones and pads can serve as terminals (paaT/PaaT i.e. phone/Pad as a Terminal). The data transmission rate depends on the available bandwidth subscribed by the users. In Hong Kong, 3G mobile system has the maximum download speed at 2Mbps while 4G mobile system has the maximum download speed at 100 Mbps. Hence, noise spectra and the associated CCTV images can be downloaded readily for problem identification and trouble-shooting.

3. A Case in Hong Kong

The platform core technology was utilized as an integrated noise monitoring system for environmental noise and monitoring of a major infrastructure project in Hong Kong SAR. The aim of the project was to build a 26-km railway line from South-West Kowloon to the border of Hong Kong SAR near Huang Gang and to connect Hong Kong’s rail system to high-speed rail networks in mainland China. As a number of civil engineering contractors were involved in this project and some residential buildings could be adversely affected by construction noises from multiple sites of this mega project, sound level meters and CCTVs were installed at the perimeters of sites and automatic noise monitoring was performed. The system automatically compared the analyzed noise data with the limit levels. When any one of the measured noise levels exceeded the limit level, the system sent alert signals to the concerned parties to trigger further investigation and follow-up actions. Figure 2 shows the sample screen shots of the system.

Figure 2. Noise monitoring and investigation by using the EAS platform and some of its displays.
3.1 Trouble-shooting using a sound focusing device

The platform was extremely powerful to identify when and where the measured noise levels exceeded the limit levels. Associated with the CCTV images, the environmental team and other concerned parties had successfully identified the sources of noise and developed appropriate mitigation measures to alleviate the construction noise problems quite effectively. However, at certain time, the exact location of noise source could not be identified due to multiple sources located close to each other. The ways to deal with such a situation included (i) alternatively switching on and off noise sources, (ii) carrying out sound power measurements using sound intensity probes (but very time consuming), and/or (iii) adopting a beam-forming approach for mapping the noise radiated from source(s) [17-19].

More recently, sound measuring equipment suppliers have successfully developed handy acoustic cameras (see Figure 3) that can be employed to identify the dominant noise source easily [20, 21].

![Figure 3. Source identification and location using an acoustic camera.](image)

4. Concluding Remarks

Noise monitoring and auditing is a complicated and involved task. Fortunately, with the advent of IT and broadband mobile network, an innovative noise management platform was designed and tested in a mega-infrastructure project in Hong Kong SAR. The cloud-based noise management platform offers an unmatched capability in handling a large number of noise data and the associated images from sound level meters, meteorological sensors, and CCTVs. The platform performs intelligent noise problem diagnosis by comparing the measured noise levels with the criteria set by the Noise Control Ordinance. When any one of the measured noise levels exceeds the limit level, the platform will automatically send alert signals to all concerned parties and record the raw sound automatically for further investigation. More importantly, with images from CCTVs, the concerned parties can spot some noise problems remotely and initiate noise mitigation measures immediately. However, it should be noted that there were incidents that in-situ examinations and sound power measurements were carried out to identify the dominant noise sources. The development team of this platform is currently working on algorithm to deal with multiple sources located close to each other. In addition, utilizing acoustic cameras seem to be one of the feasible solutions.
REFERENCES


