Acoustic Ecology Data Transmitter in Exclusion Zone, 10 km from Fukushima Daiichi Nuclear Power Plant

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Abstract

Acoustic ecology data have been used for various types of soundscape investigations. Counting sounds in the soundscape is considered an effective method in ecology studies and offers comparative data for human-caused impacts on the environment. The authors constructed an Acoustic Ecology Data Transmitter in Exclusion Zone (Namie, Fukushima, Japan), 10 km from Fukushima Daiichi Nuclear Power Plant. It aims to transmit and store a live stream of sound from an unmanned remote sensing station in the area. They expect this data to prove useful for studies on topics, which include radioecology and the emerging dialects for future observations.

Background and Summary

According to the Chernobyl nuclear disaster report of the International Atomic Energy Agency [1], it is academically and socially important to conduct ecological studies concerning the levels and effects of radiation exposure on wild animal populations over several generations. Although many studies and investigations were conducted around the Chernobyl nuclear power plant, there were few audio samples. Twenty years after the Chernobyl disaster, Peter Cusack made recordings in the exclusion zone in Ukraine [2]. To understand the effects of the nuclear accident, long-term and wide-range monitoring of the effects of nuclear radiation on animals is required [3]. Immediately following the Fukushima Daiichi Nuclear Power Plant disaster, whose remnants are shown in Fig. 1, Ken Ishida (a research collaborator at the University of Tokyo) started conducting regular ecological studies of wild animals in the northern Abukuma Mountains near the Fukushima Daiichi Nuclear Power Plant, where high levels of radiation were detected. Ishida reported that it is essential to place automatic recording devices (e.g. portable digital recorders) at over 500 locations to collect and analyze the vocalizations of target wild animals [4]. For monitoring such species, counting the recorded calls of animals is considered an effective method because acoustic communication is used by various animals, including mammals, birds, amphibians, fish and insects [5–7]. In addition to using visual counts, this method, in particular, is commonly used to investigate the habitat of birds and amphibians [8]. Furthermore, ecological studies of the environment near urban areas are being conducted using cell phones [9]. However, it is difficult to use such information devices in the exclusion zone, as these areas do not have infrastructure services. It is necessary to develop a monitoring system capable of operating over multiple years to ensure long-term stability under unmanned operating conditions.

We have previously researched and developed proprietary systems that deliver and record remote environmental sounds in real time for design and ecology studies [10]. Tele Echo Tube (TET) [11] is a speaking tube interface that acoustically interacts with a deep mountain echo through the slightly vibrating lampshade-like interface. TET allows users to interact with the mountain echo in real time through an augmented echo-sounding experience with vibration over a satellite data network. This novel interactive system can create an imaginable presence of the mythological in the undeveloped natural locations beyond our cultural and imaginable boundaries. The results indicate that users take the reflection of the sound as a cue that triggers the nonlinguistic believability in the form of the mythological metaphor of the mountain echo. This echo-like experience of believable interaction in an augmented reality between human and nature gave the users an imaginable presence of the mountain echo with a high degree of excitement. We have also demonstrated [12] that (a) the transmission of live sound from a remote woodland can be effectively used by researchers to monitor birds in a remote location; (b) the simultaneous involvement of several participants via Internet Relay Chat to listen to live sound transmissions can enhance the accuracy of census data collection; and (c) interaction via Twitter allowed public volunteers (e.g. citizen scientists) to engage with and help the remote monitoring of birds and experience the inaccessible nature using novel technologies. With these achievements, this project aims to collect, share and analyze the soundscape data at over 500 locations in the exclusion zone by performing the following activities: (1) Distributing these sound data in the exclusion zone to the public via the Internet, in order to make the live sounds in the area publicly available for listening in real time and (2) distributing these sound data to the public via the Internet (<http://radioactivelivesoundscape.net/>).

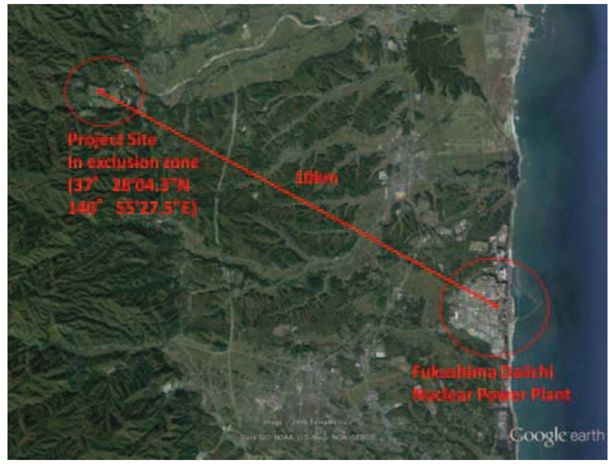

Fig. 1. Location of project site in exclusion zone (37° 28′ 04.3″ N, 140° 55′ 27.5″ E), 10 km from Fukushima Daiichi Nuclear Power Plant. Source: Geospatial Information Authority (GSI) of Japan website (<http://bit.ly/2jBBY0U>). Created by editing GSI Tiles. (© Hill Hiroki Kobayashi)

Methods

This project installed the first transmitter station in the exclusion zone area (10 km from the Fukushima Daiichi Nuclear Power Plant). A map of the exclusion zone in Fukushima is shown in Fig 1. The transmitter station (Fig. 2) is located in the town of Namie in the Oamaru district, Fukushima (37° 28′ 04.3″ N, 140° 55′ 27.5″ E). We chose this site in the exclusion zone because it is one of the most difficult areas for long-term and continuous investigations. First, this zone is the most radioactively polluted zone in Fukushima. Second, no remote-sensing method at the surface level is available due to the lack of power and information infrastructure. Third, field surveys are required; however, the amount of workable hours is extremely limited due to radiation exposure concerns. Further, frequently used portable recorders require regular replacement owing to memory and battery capacities, which is impractical for long-term, continuous investigations. Therefore, for the first location, we developed a “Live Sound System” and a

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"Streaming/Archiving System." The technical operational testing notes of the Live Sound System can be found in our previous study [13].

The Field Encoding System established in the remote forest includes the antenna depicted in our previous study [14]. This system comprises two blocks: an audio block and a transmission block. The microphones (omnidirectional SONY F-115B microphones) are individually connected to the amplifier (XENYX 802, Behringer) of the audio block, and their outputs serve as input to the audio encoder (instreamer100, Barix) to convert the microphone sounds into MP3, the format used for subsequent digital sound delivery. As there was no prior Internet connection at the exclusion zone site, we incorporated a satellite Internet service, which was provided by IPSTAR in April 2016. We subscribed to IPSTAR's "Dual" service plan, which provides the largest upload bandwidth of 2 mbps for approximately U.S. $125 per month. There is also a daily limit (2 GB) on data usage per customer. These characteristics of the service plan are important, because the research funds required to conduct a long-term ecological study are likely to fluctuate over time. The power supply to the Field Encoding System is provided by a local electric company via a special contract. Indeed, the company needed to reconstruct the infrastructure in the exclusion zone after the devastating damage caused by the earthquake. This reconstruction was important for the long-term continuity of the project. To continuously operate the system using solar panels or other independent power sources, frequent system maintenance at the site would be required.

The Streaming/Archiving System is located in the server room in our laboratory and has a normal bandwidth Internet connection, allowing simultaneous public access to transmissions. Two servers are used, one for streaming and the other for archiving. The servers were established in the laboratory due to technical difficulties (e.g. the previously mentioned problems with power supply and data download limits) involved in the setup and operation of such a server at the relevant site. The processed audio signal is sent from the microphone, encoded into an MP3 live stream in the Field Encoding System and transferred to the Streaming/Archiving System. The MP3 live stream can then be simultaneously played on MP3-based audio software worldwide. We use a standard single package of Linux Fedora 14 as the operating system and the Icecast 2 software as the sound delivery server. We have used Icecast 2 in our projects since the beginning and have experienced only minor problems, e.g. a slight delay (0.5 s) in the sound transmission. However, the signal strength of our system is affected by severe weather, such as heavy rain or snowstorms, and this could cause communication delays with the satellite network. To address this, we adjusted the amount of information that could be received by the network (via the Linux TCP Receive Window) to ensure that interruptions do not occur when transmitting sounds on the streaming server. Finally, to share the encoded live sound with listeners at high availability, the archiving server stores all the MP3 sound format files that are sent from the Field Encoding System through the Streaming Server. It is important to make live transmissions publicly available for listening purposes and have access to the archive to experience changes over a day as well as across all the seasons.

This project started with a year of literature search (2011), fundraising with government approval (2012–2014) and the installation of a transmitter station with satellite Internet (2015). Finally, based on official preparations and approvals, a local electric company agreed to sign a service contract with us in 2016 after an intensive feasibility survey of the transmission facilities at the location. The final construction was completed at the end of March 2016. This project aims to operate the system for 24 hours a day, 365 days a year. Prior to this project, we had experience operating a similar system for more than 10 years [15]. Therefore, it is possible to operate this project until approximately 2030. We believe this study is a unique contribution to soundscape [16] art.

Fig. 2. Construction of transmitter station at project site in exclusion zone. (© Hill Hiroki Kobayashi)

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