Pacific Belltower, a sculptural sound installation for live sonification of earthquake data

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ABSTRACT

Pacific Belltower *tolls for you… to remind of the fragility of the Earth's crust, and the reality faced by people around the Pacific Ocean exposed to the terrifying power of unpredictable earthquakes and volcanoes. The tower is installed at the centre of a public space, such as a lobby, using parametric 'beam' speakers and wall reflections to diffuse a surround soundscape consisting of virtual* bianzhong *bells, during one minute at every half hour. Each peal is unique, generated in real-time using Internet data about the most recently detected earthquake activity. The bell sounds are spatialised according to the geographical positions of events, and their pitch and harmonicity reflect the epicentre depth and magnitude.*

1. INTRODUCTION

Geological movements in Earth's crust are continuously monitored in globally connected sensor networks [3]. Movements might reveal themselves as earthquakes or volcanic outbursts. They are mostly imperceptible, but in certain regions on the planet they are noticeable on an almost daily basis, and occasionally they cause havoc and devastation. Despite tremendous efforts, and advances in measurement technology and time series analysis, reliable prediction of large events is not yet possible. Studying records of past events, historic or as they continuously occur, is essential to gain insights that may one day save lives.

Sonification offers a way to perceive and understand physical phenomena that might otherwise elude us, for example if they are widely distributed in time and space: too large to fathom, or evolving over long time spans [2, 13]. Phenomena that pertain to planetary systems such as weather, ocean currents, and seismological activity, can be studied if brought to a scale that human perception can handle. Our visual sense is highly accurate to identify scenes and resolve events spatially, within a focussed, frontal area of the environment. Our auditory sense is highly accurate to segment a flow into separate temporal events, and capable to detect events spatially within the entire surrounding environment [4].

The author has developed interactive sonification of earth data, i.e. meteorological records and predictions for large regions of the planet, in a series of artwork [5, 7-10]. Works of this kind might be considered 'aesthetic sonification', as argued by [15], or 'data-driven sound art'. As described in [4, 6], these works have involved multichannel spatialisation of data using various techniques, such as surround and frontal auditory displays with conventional loudspeakers, and *ad hoc* networks of audience members' smart-phones. The present work, *Pacific Belltower*, pursues the investigation of earth data sonification using another loudspeaker technology, namely parametric 'beam' speakers.

2. INSTALLATION DESIGN

Pacific Belltower is a sculptural sound installation for live sonification of earthquake data from the Internet. The design concept builds on the idea of a 'tower' with multiple bells, played as part of a religious ritual (e.g. Wat Rakang in Bangkok, Thailand), or a sculptural installations (e.g. Children's Bell Tower, Bodega Bay, USA). Virtual bells produced by audio synthesis are used instead of physical bells, and they are 'performed' automatically.

The physical installation, seen in Figure 1, is portable and suitable for temporary exhibition in a medium-sized public venue with acoustically reflective walls, such as a foyer. The support structure consists of a custom-made aluminium pole standing on a heavy cast-iron base plate. Four hyper-directional beam speakers [1] are mounted at a height of approximately 3 m above the floor. They are pointed outwards to the enclosing walls, so that the acoustic beam is reflected off the walls and returning back to the auditors from four directions. A custom-built black box with electronics (Mac mini, audio card, 4-channel amplifier, circuit protection) is fitted at the base of the pole. The flooring material is protected with a thin rubber mat.

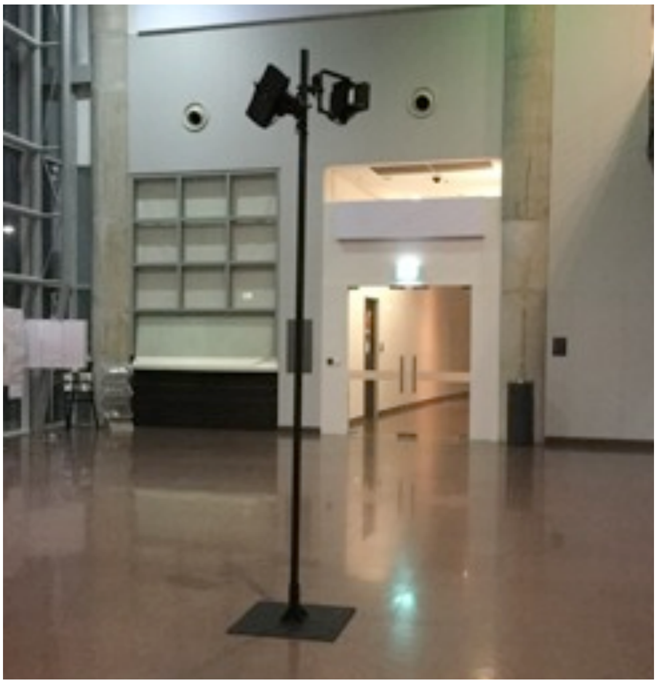
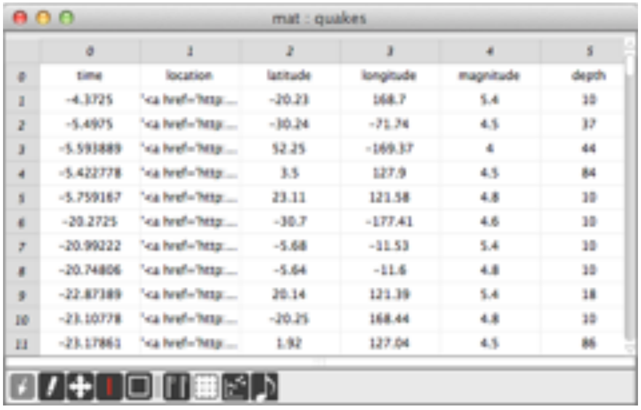


Figure 1. Setup of *Pacific Belltower.*

3. SONIFICATION METHOD

Twice every hour, *Pacific Belltower* generates a peal of bell sounds by sonifying seismological data retrieved from the Internet. The IRIS website [3] maintains a listing of earthquake and volcanic activity - geographic location, magnitude, and depth - from all over the planet (above a certain magnitude) for the past 72 hours, updated every 30 minutes. There are typically around 500 events listed at any time. For each peal, a program polls the website, parses the data, and performs sonification and spatialisation. The program is made in Max [11] extended with FTM and Modalys libraries [12]. Fig. 2 gives an example of what the parsed data looks like. The sonification method compresses time-ordered events to sixty seconds (it may therefore be called an audification [13]).


mat : quakes

	0	1	2	3	4	5
0	time	location	latitude	longitude	magnitude	depth
1	-4.3725	'<a href="http:...	-20.23	168.7	5.4	10
2	-5.4975	'<a href="http:...	-30.24	-71.74	4.5	37
3	-5.593889	'<a href="http:...	52.25	-169.37	4	44
4	-5.422778	'<a href="http:...	3.5	127.9	4.5	84
5	-5.759167	'<a href="http:...	23.11	121.58	4.8	10
6	-20.2725	'<a href="http:...	-30.7	-177.41	4.6	10
7	-20.99222	'<a href="http:...	-5.68	-11.53	5.4	10
8	-20.74806	'<a href="http:...	-5.64	-11.6	4.8	10
9	-22.87389	'<a href="http:...	20.14	121.39	5.4	18
10	-23.10778	'<a href="http:...	-20.25	168.44	4.8	10
11	-23.17861	'<a href="http:...	1.92	127.04	4.5	86

Figure 2. Earthquake data loaded into a FTM object in Max. The numerical entry in the top left data field indicates that the most recent earthquake had been registered approximately four hours previously.

Each seismological event is represented with a strike on a virtual bell, a physical model of *bianzhong*, an ancient Chinese instrument. Event depth (epicentre of the event, i.e. number of kilometers below surface) is mapped to bell pitch (fundamental frequency and a size parameter), so that more shallow events are represented with deeper, larger bells. This choice was made considering that for earthquakes with a shallow epicentre, more of the energy reaches the earth surface at a relatively small area, potentially causing more havoc. As is well known in music cognition and perception research (discussed in [4]), a deep sound can engage a (mild) threat response as it is innately understood to be caused by a larger physical event. Event magnitude is mapped to bell harmonicity (material parameters of the physical model, distortion, and filtering), so that more energetic events are represented with more inharmonic and distorted bells, independently of their depth. As discussed in [4], a distorted sound can attract attention and be understood as a signal of distress, thus indicating danger.

The bell synthesis uses a physical model made with Modalys [12] for Max [11]. The bells are spatialised according to the geographical location (epicentre) of the corresponding earthquakes. Because of the design concept of the installation, i.e. the pole and the audience area around it, there is a 'subjective listener position' which is selected to be the geographical position of the installation. For example, for a site-specific installation at ICMC the longitude and latitude of Shanghai gives the listener position. Given the locations the seismological events in the live data, the bearing (angle) and distance relative to the listener position are calculated using the haversine geodesic formulae [16]. A screenshot of the Max patcher is shown in Figure 3.

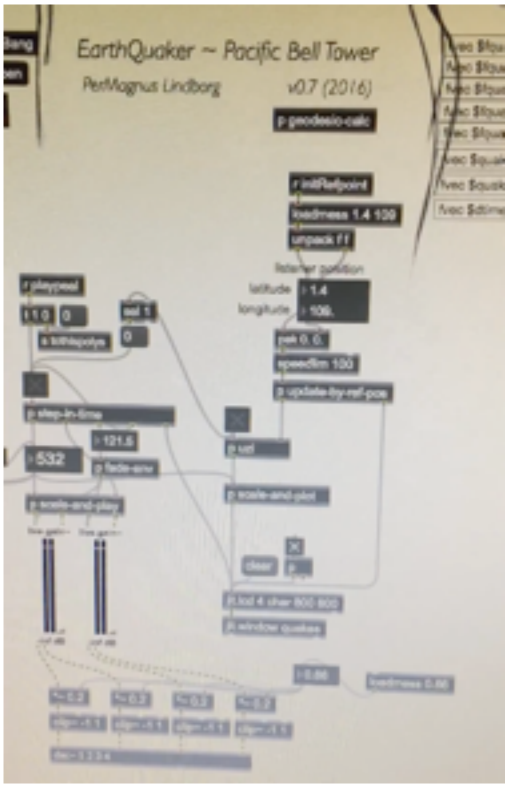


Figure 3. *Screenshot of the Max patcher (work-in-progress version). Note that 'listener position' is set to the latitude and longitude of the location of the installation, in this case, Singapore.*

4. CONCLUSION

If "a sonification that works is… the successful struggle to create a message that points beyond the medium." [15], then "Pacific Belltower" is an aesthetic sonification (or data-driven artwork) based on a premise with real-life urgency, that creates music out of potential disaster. It is not to be taken lightly the fact that the installation, running in real-time in the safety of an art gallery or public lobby, might come to herald deadly forces elsewhere on the planet. The author therefore aims both to increase the general awareness of earthquakes and stimulate the specialist debate on aesthetic and utilitarian purposes for sonification of earth data.

Work-in-progress versions of the installation have been displayed in Singapore (Yale-NUS College) and Finland (*Volume 2 Symposium*, Aalto) in late 2016 using a setup with regular loudspeakers placed closely together and directed outwards (as in Figure 4). Documentation and further information is available at http://permagnus.org > artwork > Pacific Belltower.

Figure 4. *Snapshot from the preview installation of Pacific Belltower at Volume 2 Symposium, Aalto University, Finland, November 2016.*

5. REFERENCES

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