The Weather Harp

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Fig. 1. The Weather Harp with surrounding fans and sound-making objects, January 2026.

1 Program Notes

The Weather Harp is an instrument and sonic environment played by the wind. The central instrument is a bass drum frame with four tuned brass strings coupled to a top membrane via a wooden bridge. The strings are excited with novel, custom-made Lorentz force sustainer circuits. The central instrument is surrounded by four fans which move air across small sound-making objects. The sounds of these objects are captured by contact microphones and routed to transducers on the central instrument. North, east, south, and west winds each reveal different sonic characters. The sustained strings on the central Weather Harp, as well as the fan-driven sound-making objects, are activated by real-time wind speed and direction data streamed from an outdoor weather station. The sonic environment is subtly interactive; human presence in the space gently influences the gusts and eddies of air. Similarly, the viewers are subject to sounds and sensations in the space. This interaction is a mediated mirroring of our relationship with the weather outdoors, which we feel as an agential force but which is profoundly influenced on both local and global scales by collective human activity.

2 Project Description

The Weather Harp is an instrument and sonic environment played by the wind. It was first fully realized as the installation described here in January 2026. The Weather Harp emulates the sound of the acoustic weather harp with a novel Lorentz force and data-driven electroacoustic system that re-presents our complex and intimate agential relationship with the weather. The sonic environment was designed to subtly highlight the felt impact of weather on the listeners and vice versa. The central instrument is a circular, wooden-bodied instrument partially constructed from a bass drum frame, with four

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tuned brass strings coupled to a top membrane via a wooden bridge. The strings are excited with novel, custom-made actuation circuits based on the Lorentz force. The interior of the central instrument contains the actuation circuits, an audio amplifier, and two tactile transducers affixed to the underside of the membrane, so that all of the digital audio included in the piece emanates from the central instrument. Fixed magnets on the top surface of the membrane exert lateral forces on the strings, inducing sustained vibrations when an oscillating signal of appropriate frequency is applied to the ends of strings [9, 11]. See Figure 2 for a system diagram.

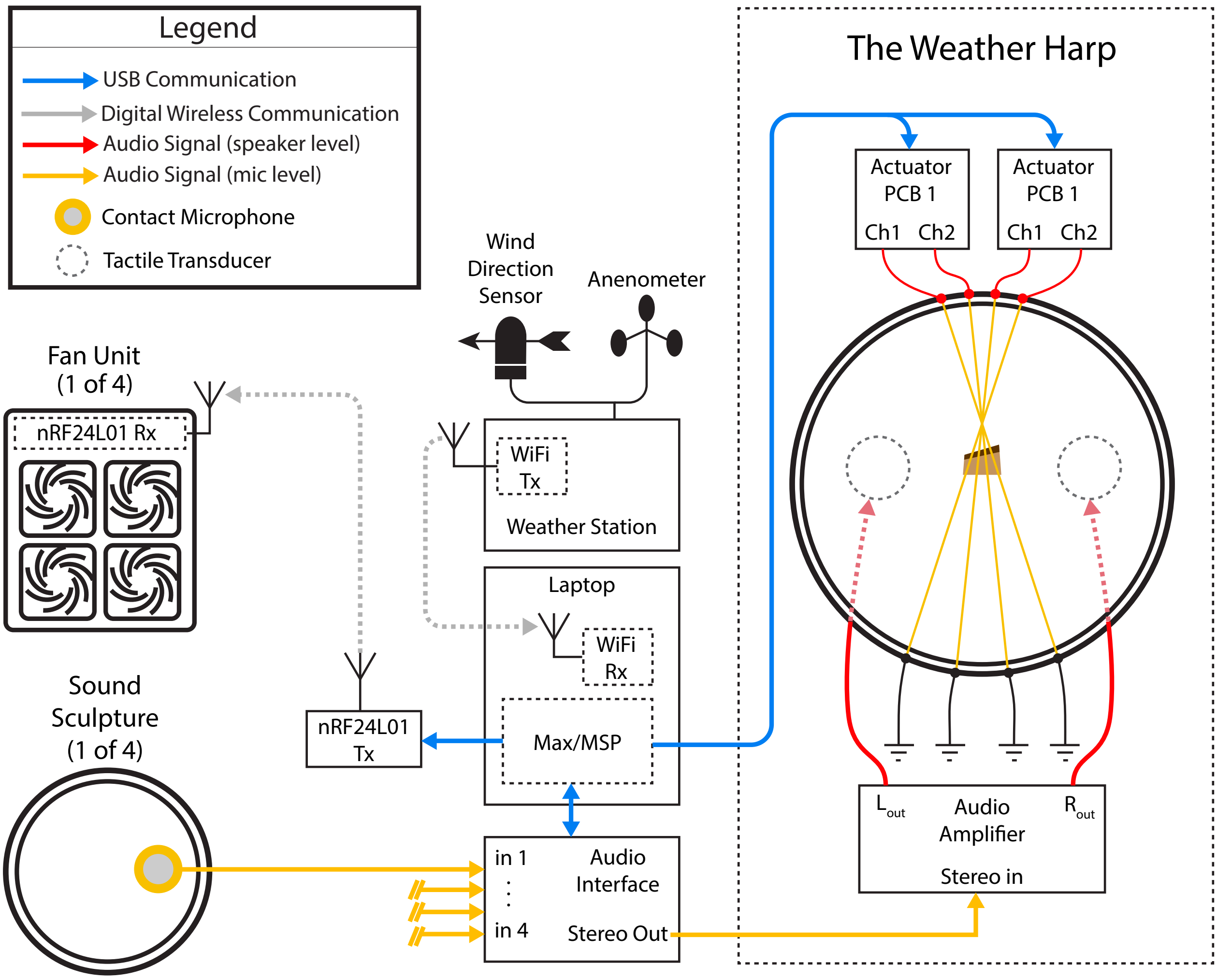


Fig. 2. System diagram of the full Weather Harp installation

The central instrument is surrounded by four fans suspended from the ceiling, which activate small sculptural sound-making objects affixed to the heads of drums. The fans and sound-making objects are positioned within the space to align with the four cardinal directions. The north fan creates sound with an evergreen branch tracing through seed beads; the east wind vibrates a mass of paper loops; the south fan blows a fine metal plectrum across embossed metal strips; and the west fan creates a bell-like ringing sound with a paper sail and a jar. The sounds of these objects are captured by contact microphones attached to each of the four drum heads, amplified, and routed to the transducers inside the central instrument.

Structured improvisations commissioned from two collaborating instrumentalists—Mark Kirschenmann (extended trumpet) and Emily Rach Beisel (bass clarinet)—are occasionally triggered and played back through the transducers as well. Each of the instrumentalists was provided with eight text scores for improvisations focused on specific pitches, textures, and extended techniques. Their recordings were collaged by the authors to support the soundscapes associated with each cardinal direction.

The sustained strings on the central instrument, as well as the fan-driven sound-making objects, are activated by real-time wind speed and direction data streamed from an outdoor weather station. A cup anemometer measures wind speed, while an eight-direction wind vane measures wind direction. This wind data is streamed via WiFi-enabled microcontrollers, so that the central instrument and fans inside the installation space reflect the wind direction, speed, and variability outside the space.

The Weather Harp was preceded by a series of projects inspired by the authors' experiences of physiological response to weather. An early version of the central instrument, an acoustic circular weather harp with temperature and humidity sensors, was constructed and displayed in spring 2024 at the Atlantic Center for the Arts. An audiovisual installation entitled Whether Station, presented in fall 2024 at the art space *Leisure.*, sonified and visualized temperature, humidity, barometric pressure, wind speed, and precipitation data as well as errors in site-specific weather prediction models running on ArduTFLite. These prior experiments led to a decrease in the number of weather parameters displayed with the Weather Harp. Rather than the maximalist, complex soundscape of Whether Station or a literal approach to data sonification, the Weather Harp presents a slowly-evolving sonic environment drawing on just two weather parameters, wind speed and direction. Conversations with aeolian harp builder Michael Krzyzaniak, the creator of the electronic Fulgorian Harp [3, 4], and percussion builders and players Olivia Cirisan, Ancel Neeley, and Dr. Matthew Jordan also influenced the final design of the Weather Harp.

2.1 Aeolian Harp

The Weather Harp is inspired by the aeolian harp, a wind-played acoustic instrument of the 16th century. The aeolian harp consists of a long, wooden acoustic body fitted with strings and placed in an open window, where steady winds excite upper harmonics of the strings [8]. Because aeolian harps are decorative objects as well as instruments, there is not one standard form, but a typical aeolian harp is rectangular and at least one meter long so that the upper harmonics of the strings are audible. The aeolian harp introduces an ethereal, sustained chordal sound to an interior space without intervention from a human player. Named for Aeolus, the mythological Greek shepherd of the winds, the aeolian harp experienced popularity and cultural currency in Europe for much of the 18th and 19th centuries [7]. Drawing inspiration from the aeolian harp, the design of the Weather Harp evokes its immersiveness, ethereality, and non-humanness while engaging novel techniques for string actuation, real-time data streaming, and data display. The sound of the Weather Harp reflects the wind's variability and intensity in the current place and time. The fans, sound-making sculptural objects, and structured improvisations connect the outdoor conditions with the sonic environment inside the installation space.

2.2 Sonic Environment

The sound of the central Weather Harp consists of ethereal sustained vibrations of the four brass strings. As in acoustic aeolian harps, each string's fundamental frequency is seldom heard [8]. Rather, the upper partials of the strings (sometimes as high as the 7th harmonic) are excited. Spontaneously varying constructive and destructive interference between harmonics on different strings, loosely coupled through the instrument's bridge and membrane (see Figure 3), create dynamic and emergent sonic textures that are out of our control. This chaotic behavior audibly shifts with even subtle changes in wind direction, and multiple actuation modes allow for variations in the system's behavior to promote sustained musical interest during both periods of frequent wind change and periods of static or no wind.

Four peripheral sculptural instruments surround the central weather harp at locations marking the cardinal directions. Each of these stations includes a bespoke fan enclosure, suspended from the ceiling. Near each fan at each location is a unique sound-making sculpture, hand crafted from simple materials. Each incorporates a drum and a contact microphone for capturing and amplifying the sound. The amplified sounds of the peripheral instruments are routed back through the central weather harp via a transducer mounted on the underside of the membrane. As the wind outside shifts direction and varies in speed, the fan-driven instruments and the strings are simultaneously activated to present a shifting sonic environment immediately reflecting the activity of the wind in the present time and place.

2.2.1 North. The north fan blows a suspended evergreen branch whose needles dangle in a bed of glass seed beads. The beads are placed directly on the drum head, retained by a bespoke ring. When blown by the wind, the evergreen needles occasionally trace tracks through the beads, evoking the sound of crackling ice or footsteps in snow. This is the quietest and most subtle of the instruments, requiring a particular confluence of conditions for sonic activation. See Figure 4a.

2.2.2 East. A mass of paper loops that are affixed directly to the drum head are set into vibration by the east fan. The papers visibly and audibly rustle and tremble in the wind and collectively activate a subtle drone-like sound by vibrating the drum head. This is the only station where the sound-making elements are actuated directly by the wind, without additional mechanical mediation. The sound is noisy and chattering, fairly constant when the fan is activated, in contrast to the other stations that are activated by swinging actuators. See Figure 4b.

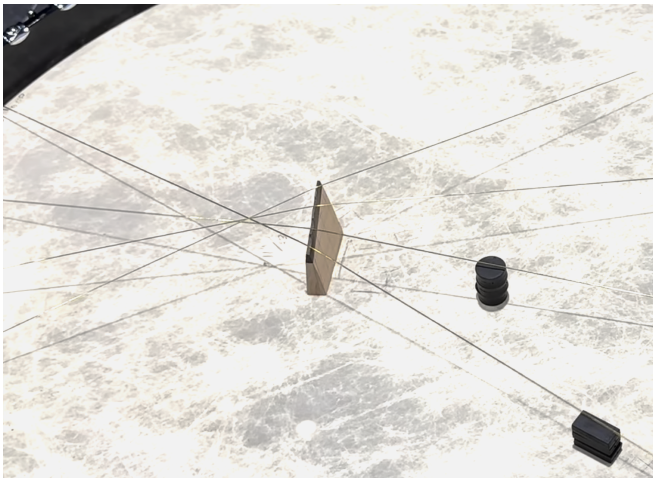


Fig. 3. The brass strings and bridge of the central Weather Harp instrument. Magnets placed within the electromagnetic fields of the strings cause the strings to vibrate.

2.2.3 South. The south fan blows a suspended sail made from paper and an embroidery hoop. A fine metal plectrum suspended by thread from the sail scrapes across embossed metal strips on the drum head as the sail moves. The construction of the sail creates a double-pendulum effect, resulting in chaotic movements of the plectrum when the fan is activated. The plectrum frequently flies beyond the limits of the embossed strips, creating a sense of suspense and unpredictability that is manifested in the soundscape. See Figure 4c.

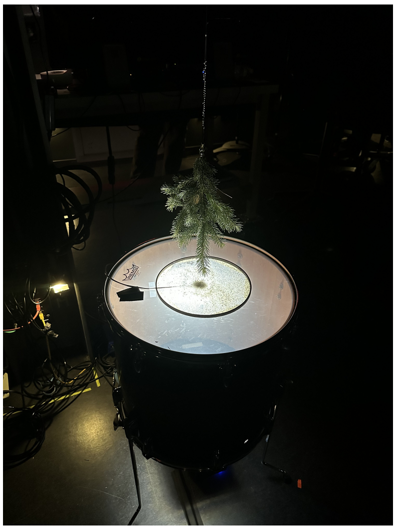
2.2.4 West. The west assemblage also features a double pendulum, in this case with a pleated paper sail based on the shape of a folding paper fan. A nail suspended from the sail hangs into the opening of a glass jar that rests on the drum head. The sail's motion in the wind causes the nail to tap the sides of the jar, creating a sharp, glassy bell-like ringing sound. See Figure 4d.

2.3 String Vibration Sustainers

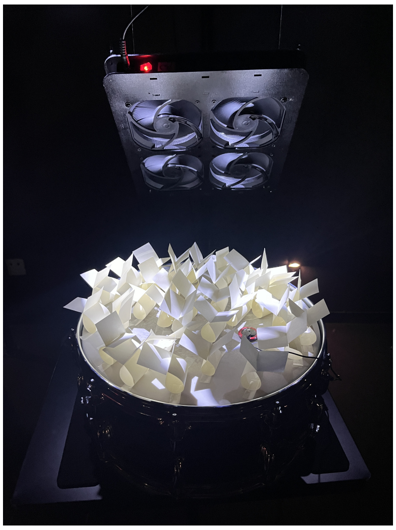
A pair of recently-developed custom printed circuit boards (PCBs) initiate and sustain vibrations on the Weather Harp's strings [10]. When a string controller is activated, an amplified audio signal runs through the string and generates a small alternating magnetic field corresponding to the audio signal. Permanent magnets in close proximity to a string provide strong, fixed magnetic fields that the string's small alternating magnetic field interacts with. Physical vibrations are induced in the string depending on the location of permanent magnets and string's tension. This is known as Lorentz force actuation, and its application for musical effect was first pioneered by Alvin Lucier in Music on a Long Thin Wire [5] and has been recently explored within the NIME community [9, 11]. This is the same fundamental concept as a dynamic coil loudspeaker but deconstructed and rearranged—each string can be thought of as a voice coil that has been unwound, stretched out, and tensioned across the Weather Harp. However, just as a speaker can be treated as a microphone and vice versa depending on the circuit they are connected to, these new electronic controllers use the bilateral nature of electromagnetism to not only actuate a string (like a speaker), but also simultaneously measure the string's movement (like a microphone). When the circuit is activated, it feeds the string's sensed vibration signal from the sensing portion of the controller into the actuation portion of the controller, closing a feedback loop that sustains vibrations indefinitely. Different magnet placements and polarities were explored experimentally and iteratively to target the upper harmonics of the strings. Some qualities of the feedback are controlled via serial communication to Max/MSP corresponding to the incoming wind data.

2.4 Outdoor Wind Sensor Station

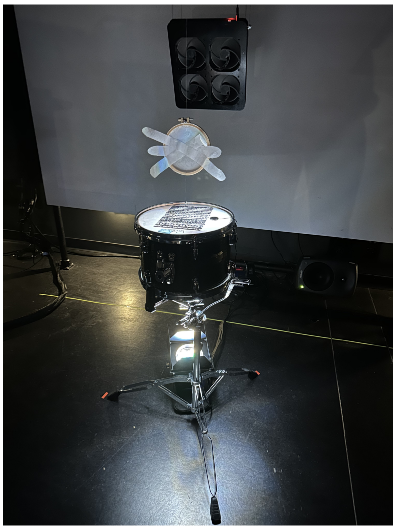
Outside the building housing the installation space, a custom battery-powered weather station streams live data to the instrument inside. A cup anemometer and digital eight-direction wind vane measure wind speed and direction every 200 ms. These data are streamed wirelessly via a WiFi-capable microcontroller connected to a local WiFi network. The weather station is placed in a conspicuous location outside the building, aiming to attract interest and intrigue. A webcam and ambient microphones in the indoor installation space are livestreamed to a web server. A QR code posted near the outdoor



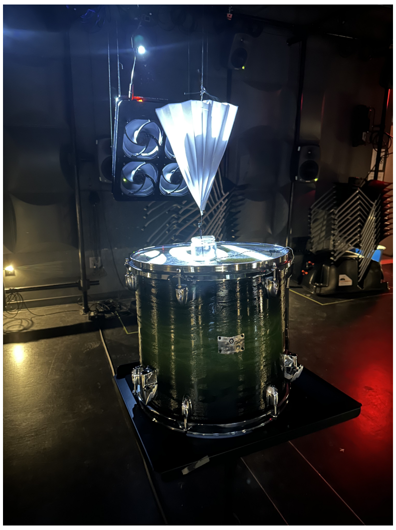
(a) North wind activates a branch tracing through glass seed beads.



(b) East wind vibrates a mass of paper loops.



(c) South wind scrapes a piece of metal across an embossed surface.



(d) West wind blows a nail into the side of a glass jar.

Fig. 4. The four wind-blown sound-making objects corresponding with the four cardinal directions.

weather station takes visitors to the livestream on their phones. Collectively, these interventions aim to foster a sense of connection and continuity between the indoor and outdoor elements of the installation, but also highlight its disjunct, mediated nature.

2.5 Experience

Visitors are free to explore the installation space, weaving among the peripheral drums and central Weather Harp as desired. The experience is multisensory and immersive. The mediated nature of the central Weather Harp’s energy source makes it imperceptible—it isn’t acoustically excited by the wind itself, rather by an electronic circuit driven by data from the wind—giving it a magical quality [6], as if manifesting an invisible agency. The string sustainer circuits are on the underside of the instrument; the only visible components of the excitation system are the magnets and the strings themselves. Although it is an acoustic instrument, it lacks pronounced mechanical or physical movement; it is a strictly sonic manifestation of the wind, which cannot otherwise be felt at the central location.

But the Weather Harp also acts as the loudspeaker projecting the amplified sounds of peripheral fan-driven sound objects, creating a sonic connection to those elements of the environment. In contrast with the central Weather Harp, the fan-driven instruments provide a mechanical and visceral experience of the wind that is concurrent with their sound, as in the acoustic aeolian harp. Even if an acoustic aeolian harp has no obvious moving parts, we can feel the wind that drives its sound, and see other visual artifacts of the wind—hair, clothing, plants, or trees provide visual traces of the instrument's activating force. In our installation visitors can similarly feel the wind from the fans on their skin and see the visual effect of the wind as the fan-driven sonic elements are blown around, which in turn are activated by the measured force of the actual wind outdoors.

2.6 Weather, Agency, and Interactivity

The Weather Harp serves not as a literal auditory display of wind data but as an interpretation of the changes in sensation and experience brought about by changes in weather. Weather affects our bodies, our buildings, our energy levels, and our beings, and it is omnipresent and constant, but we do not always pay attention to it. We have also made the weather easy to ignore in the isolated comfort of climate-controlled buildings. The Weather Harp re-presents the weather, prompting consideration of non-human agency in the creation of human sensations and experiences. By extension, the instrument evokes ongoing conversations in the NIME community about non-human agency in human-computer musical ecosystems [1, 2]. Like the aeolian harp, the Weather Harp brings traces of the outdoor weather's agency to interior spaces.

The installation challenges expectations of interactivity and agency. These are indeed 'NIMEs', but direct interventions are discouraged; visitors are asked not to touch the instruments. Visitors' presence and activity in the installation space influence the system's behaviors by generating and disrupting air currents and affecting the heat and humidity of the environment. This mirrors our relationship with the weather, which is locally and globally impacted by human activity. Human-caused climate change is creating dramatic variations in weather patterns, but on a hyperlocal scale, land use and the built environment alter wind patterns. The wind's behavior sensed outdoors is therefore as much a product of the entanglement of human and planetary agencies as is the indoor sound installation, even without direct interventions or manipulations.

3 Technical Notes

3.1 Space Requirements

This piece requires both an indoor space and an outdoor site to put the wind sensors. The ideal footprint of the indoor installation is approximately 6m x 6m. As some of the sounds are fairly subtle and there is no conventional sound reinforcement through speakers, the indoor location should be fairly isolated from other sound sources and from large crowds. A gallery space or small room is optimal. The space would ideally offer the possibility for the fans and actuators of the peripheral instruments to be suspended from the ceiling. This could be via ceiling-mounted hooks, truss or lighting/speaker grid, or structural supports of a drop ceiling. The objects to be suspended are quite lightweight, with a maximum weight of 1.5kg. If suspension from the ceiling is not possible, we would require 4 sturdy boom microphone stands.

The outdoor site should allow a tripod to be set up with no obstructions in a radius of about 1m surrounding the weather station. The outdoor location should be visible to attendees in some way, possibly as they enter the building. Optimally, the outdoor location might be visible through a window in the gallery, obviating the need for the livestream.

During featured hours, we anticipate an attendant (one of the authors) periodically circulating through the indoor and outdoor spaces in case of unanticipated issues like WiFi disruptions.

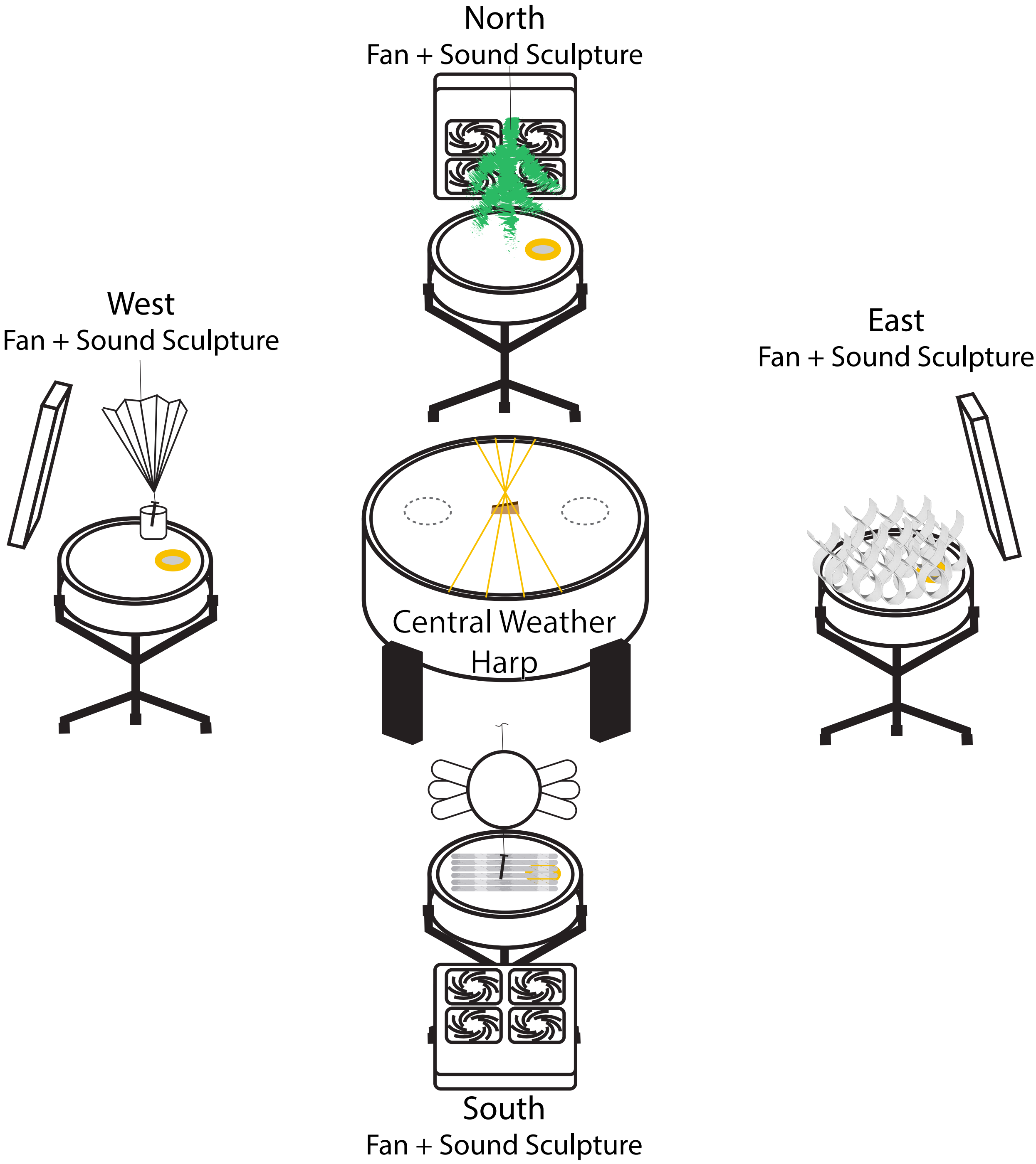


Fig. 5. Proposed layout of the installation

3.2 Material Requirements

Items We Will Supply	Items We *Require*
• Weather Harp central instrument + stand • Audio and Ethernet cables • 4 fans and wire to hang them • 4 drums • Sound-making objects • Laptop • Audio interface • Webcam for streaming • 4 contact microphones • WiFi router, if needed (see Network Requirements, below) • Arduinos, circuit boards, 2-channel amplifier • DIs • Outdoor weather station with WiFi transmitter	• 2 power strips with ≥ 4 outlets each • 4 XLR cables (approx. 25 ft) • Small table for laptop and audio interface • 4 laptop stands, drum stands, or drum tables • Tripod speaker stand or similar for wind sensors (outdoors) • Outdoor information board or music stand • Sandbags, if needed for outdoor stands • (optional) 4 small (1m x 1m) podia or risers for elevating the drum • 2 extension cords • Capacity to suspend fans from ceiling, or 4 heavy-duty boom microphone stands (see Space Requirements, above)

3.3 Network Requirements

The weather data from the outdoor weather station is streamed to the indoor installation location via a peer-to-peer UDP connection. This approach minimizes the latency between changes in the outdoor conditions and their effects being felt indoors, strengthening the conceptual connection between the two locations. There are several options for network infrastructure to support the installation. The option we ultimately select would depend on the proximity of the indoor and outdoor locations and any available wireless networks. This is a non-exhaustive list of possibilities, roughly in order of least to greatest complexity. We are confident that we can find an effective networking solution with sufficient advance consultation with the venue.

(1) If the indoor and outdoor locations are close enough to be within range of a standard personal-use WiFi router (approx. 30m apart), we would supply a router and connect the indoor and outdoor devices (wirelessly) to it. None of the devices would require Internet connections; this would be an isolated local network. We would require a relatively secure indoor location roughly midway between the weather station and the installation space, with a single power outlet for our WiFi router.
(2) As in (1), but with a direct wired ethernet connection between the router and the installation space.
(3) If available in both locations, we could use a dedicated IoT network that would allow UDP connections between the devices.
(4) Most university WiFi networks allow UDP connections between devices on the same subnet. Our needs could therefore be met by an available WiFi network with WPA / WEP / WPA-2 personal or WPA2-Enterprise connectivity (e.g., eduroam) in which both devices would be served IP addresses on the same subnet. However, the embedded computer in the outdoor weather station is headless, so we would need a network that doesn't require a web login to establish a connection.
(5) As in (2), but we could supply a 3-node WiFi mesh if the two locations are too far apart to be in range of a single router. This would require locations with power outlets to plug in the mesh nodes.

4 Media Links

- Video: The Weather Harp (https://vimeo.com/1164133536).

5 Ethical Standards

The piece and its supporting research adhere to ethical research guidelines. No human participants were involved in the development of the piece. The fixed media components of the piece were recorded by instrumentalists who were compensated for their work and aware of the final use of their recordings.

6 Acknowledgments

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