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Composer's Note

SOUNDS OUTSIDE: DESIGNING AN APPLICATION WHICH CREATES MUSIC FROM REAL-TIME USER SPECIFIC WEATHER DATA
外の音：利用者の現地の天気を使用、音楽を作るアプリ

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ABSTRACT

This paper describes an application which produces real-time ambient music generated from the weather conditions in the user's location. The music continues to change dynamically according to varying conditions. The challenge was to create an algorithmic composition which changes dynamically with the weather conditions while also aesthetically fitting the mood of the weather. Too many random elements had to be avoided so that the sound could be audibly linked to the weather states that generated them. Furthermore, as an ambient composition, it was necessary to ensure this audible variability could accommodate all kinds of weather and lengths of time. I developed the application with the location services feature of iOS devices in mind and used the algorithmic composition language RTcmix. The project was completed as a solo endeavor independent of institutions, with all programming and compositional decisions made by the author. I will begin by explaining the explicit aesthetic goals of the project and follow with a description of the design process and the techniques used to realize these goals.

1. AESTHETIC GOALS

> "I saw art not as something that consisted of a communication from the artist to an audience but rather as an activity of sounds in which the artist found a way to let the sounds be themselves. And, in being themselves, to open the minds of people who made them or listened to them to other possibilities than they had previously considered" – John Cage

> "Nevertheless, we must bring about a music which is like furniture-a music, that is, which will be part of the noises of the environment, will take them into consideration" – Erik Satie

Weather Music began from a line of thinking about the purpose of ambient music and its relationship to the environment. Ambient music often goes on for long periods without being truly noticed or attended by the listener, serving more to convey a mood. The prevalence of generally pleasing and calming ambient music serves as evidence that it is most frequently used to transform an environment in a positive direction. However, much as headphones provide music while obscuring any incidental or environmental noise, positive ambient music cuts off the listener from real conditions in the world. Thus it obscures appreciation of everyday surroundings and isolates the listener into the abstraction of pure musical experience.

Weather Music is an attempt to make ambient music which goes against this trend. It attempts to open the listener to other sounds and greater environmental awareness by using the appeal of ambient music which so often works against this. With this application[1] serving largely as background accompaniment to everyday tasks, I hope to train the listener in this way and occasionally refocus their attention as well.

The weather was chosen as a basis for sonifying the environment because it is an important feature of everyday life which an increasingly industrialized lifestyle encourages us to ignore. The weather is also the source of many sounds often considered beautiful in many aesthetic traditions, such as the wind blowing or rain falling. I wanted to draw on this tradition and redirect contemporary listening.

The application directly relates to its environment through the weather conditions at the present location of the user. It aspires to make the listener more conscious of the conditions and behavior of the weather in an otherwise closed-off environment. In addition, it aims to encourage more careful reflection on the sounds of the actual weather, and appreciation for and coexistence with already existing ambient sound.

2. TECHNICAL PLANNING AND IMPLEMENTATION

The aesthetic goals of this project required a technical platform which would allow for appropriate use and generation of sound. To create the appropriate relationship with the listener, the application must be generated in real time, use live data from their present location, and be accessible enough to be distributed and usable within a home or work space. Within these constraints, I decided that

[1] The multimedia nature of the work is crucial to achieving its aesthetic goals for reasons explained below. I will refer to it as a composition only when dealing with the specifically sound-producing elements.

concert and installation techniques would not be usable for such an application.

A synthesis and signal processing language developed primarily at Columbia University, RTcmix, has recently been used as an audio engine for several applications on personal computers and mobile devices. While not as popular as visual applications such as Max/MSP and PureData, the language is intended to be used for algorithmic composition and can be written entirely in typed code. This makes sonification processes which involve feeding in numeric variables from other sources very easy.

RTcmix has been released as dynamic libraries for use on several platforms, including apple computers, iOS, Open Frameworks, android, as well as several others. I chose to build for iOS devices because the iPhone and iPad are convenient devices often carried around by the user which is nevertheless present in the home and at rest. In addition, iOS provides easy access to important information crucial to such an application, such as geographic location and local time. In order to be unobtrusive and appropriately real-time, an application requiring the user to manually enter such information would not have been ideal. iRTcmix, the iOS release of the language, allows RTcmix programs to be embedded within iOS applications, which provides very easy transfer and sharing of variables, as well as direct control of different components.

iOS does not natively allow a developer to get information related to weather, so an external API, OpenWeatherMap, was chosen. OpenWeatherMap can be easily integrated into a basic iOS project. Using a generated key linked to a developer account, any user's device can fetch data on weather by geographic location (longitude and latitude) or city name. The weather data is then returned as JSON data. The use of OpenWeatherMap is priced based on number of calls per minute. The operational budget for this project was very small, so reducing the frequency of calls in the app was a practical concern throughout the design process. Fortunately, as weather conditions do not usually change second to second, this was not a major obstruction to the realization of the app.

3. BASIC DESIGN OF COMPOSITION

With weather data and a dynamic synthesis engine in place, the project then became a question of designing the actual music. Many algorithmic composition methods rely on temporal evolution; Weather Music was intended to be played in the background for any variable length of time, with any changes determined by the external state being sonified rather than an imposed temporal structure. I decided not to have a defined structure and instead rely on several simultaneous systems. Because the goal was to have the initial conditions of the algorithm understandable from the sonic output, I avoided highly complex generative techniques such as Cellular automata or equations from Chaos Theory. However, a simple conditional (i.e. a certain type of music plays for rain) would be simplistic and fail to engage the listener beyond an initial curiosity. The final application uses several different simultaneous sound generation functions, which are dynamically determined by enough independent variables to avoid this problem.

The application's sonic elements are generated by a single algorithmic script (called a "score file" in the case of RTcmix) which repeats itself every 45 seconds. There are five instruments, each of which has properties generated via several different equations, including the properties of the sounds they output (and whether they output them at all). Properties changed include amplitude, pitch, duration, envelope, and more. These variables were each generated either from a numerical piece of data (i.e. temperature in Celsius) or assigned a value based on a conditional (i.e. if there is a thunderstorm, play 4 note chords). A detailed example of one instrument will follow in the next section.

A significant inspiration for this application was Professor Brad Garton's "Loocher." "Loocher" is an early ambient real-time algorithmic composition which has been produced and reproduced on a variety of platforms including RTcmix, which Garton is one of the chief architects of. "Loocher" centers on long drone sounds generated randomly from a fixed pitch class. This has led to pleasant results which continue to be novel for hours. "Loocher" has been used by many listeners for the sort of ambient background accompanying other tasks which Weather Music was intended to be. With this background, I created the primary drone sound using similar techniques. Garton was instrumental in this project also for providing some examples of instrument source code from which to borrow.

"Loocher" is primarily driven by randomness, whereas Weather Music is intended to reflect real-time conditions and therefore needs to be audibly driven by these external variables. Randomness, where it interferes with listener identification between sound and external state, needed to be avoided if possible. However, as weather conditions change rather slowly and the basic loop was short due to not having temporal structure, this presented a major design challenge. If every single note and element were determined by the weather conditions, this would require constant and focused listener attention to be understandable, against the purpose of ambient music. Rather than eschew randomness altogether, the application is structured based on the idea of states.

Weather conditions produce various states of the application, which thereafter randomly generate sounds within the newly defined bounds. Each state can be distinguished audibly, even if random elements prevent the same state from producing exactly identical results. For example, two states may feature a drone played for 8 seconds with a randomly generated gap of 3-5 seconds in between each note. The listener can hear that there is no stable rhythm, but cannot distinguish very easily between a 4.5 second and 5 second gap. However, the drones use two different pitch classes (determined by temperature) with a large separation in frequency. This frequency difference is distinct enough (high notes vs low notes) that the listener can tell the difference easily without necessarily focusing on each note. As states are produced through a combination of many different independent variables, the number of states is effectively infinite. Yet there are enough state-determined audibly distinct elements that the user is likely to be presented with several different recognizable elements during their usage of the application.

A final element added to the composition was time based variables. While most weather data services deliver independent elements i.e. temperature or precipitation, the human experience of weather is often determined by the time of day in addition to these conditions. Afternoon rain is a different experience than midnight rain, and many examples from literature and other art forms attest to this. The common expression "afternoon showers" as used in weather forecasts is more evidence of this. As has been discussed above, the application also needs to present itself as sufficiently variable over extended periods of listening. Therefore, some elements are based on the time of day in the user's location. Several points were chosen based more on common experience than mathematical neatness, and the application interpolates the current value of these variables based on the current time's position between the two closest points. For example, if a duration variable has a value of 5 at noon and 8 at 4pm, at 2pm the value will be 6.5. These changes remain slow enough that an extended mood can be captured, but changes enough that listening at different times of day will produce audibly difference results without obvious strong break points in the musical output.

4. CASE STUDY

In this section, I will examine several factors which go into the generation of the drone instrument, discussed above. This will hopefully give a sense of the variety of hybrid techniques used to sonify the weather data. The drone instrument is the most complex and uses several different generation techniques to produce the final sound.

The first step with creating the drone instrument is generating its pitch class. A base frequency is determined by the current temperature in Celsius, using this equation:

$$Frequency = 600 - T * 16 \tag{1}$$

Where T is equal to the temperature. Therefore, hotter temperatures will produce lower starting frequencies.

From here, the number of pitches in the pitch class is selected by the type of weather. Snowy weather has a very small pitch set of three, whereas a partly cloudy day has six pitches. From the base frequency, the other pitches are generated a whole step above the preceding note, generated from the following equation:

$$Frequency = B * a^{(n*2)} \tag{2}$$

Where B is the base frequency, n is the number in the pitch class, and a is the 12^{th} root of 2.

Each time the program runs, it selects a note randomly from this pitch class. Duration and additional voices are determined, like the number of pitches, by the type of weather at the present moment. The selected duration may also be extended based on the influence of humidity. More humid weather increases the duration, but also modifies the envelope so that the notes take longer to fade out completely and notes are more likely to melt together.

These conditional variables were all chosen based on the mood of the weather, so snowy weather receives sparser shorter notes, and will likely featuring shriller higher notes due to temperature as well. Strange combinations of weather are likely to produce appropriately strange results. Because the scope of the composition is so wide, it is impossible on an authorship basis to account for all possibilities. However, each individual element was chosen with great care and consideration for the appropriate mood. All this was done in the hopes that the unpredictable combination of these elements can provide even greater insight than each individually.

5. IMITATION

Several instruments were created with the idea of musical imitation as a goal. For example, the noise instrument is intended to evoke the sound of wind, the actual speed of which is what determines the output volume of the sound. This was partially to encourage the user to question the nature of musical imitation within the context of environmental noise. It would not be hard to replace these imitative instruments with actual samples, however the level of abstraction makes the musical sounds evocative rather than an exact copy. Most importantly though, it causes users to question the difference between the actual, live sounds of the weather and the synthetic sounds generated by the application. A momentary confusion between heavy rain or howling wind and the similar but distinct sounds of the application is precisely the situation this application seeks to create. This furthers the aesthetic goal of the project by causing reflection and careful listening to the environment around the listener.

6. USER INTERFACE

The User Interface of the application was kept sufficiently minimal in order to encourage a focus on the sonic aspect of the experience. The only interaction is stopping and starting the audio. However, there is still a display of the basic data: temperature, humidity, wind speed, and weather status. This is to explicitly encourage the user to associate what they are hearing with the state of the weather. Often when an application actually succeeds in getting the user's full attention, it is through a strange or unexpected sound, or perhaps just a particularly pleasant combination. The immediate reaction to this is often to actually look at the application which has caused this, which then presents the conditions responsible, leading to a stronger association between the sounds and the conditions.

7. CONCLUSION

At the time of writing, the application has been finished and released as a free download on the Apple Appstore. The intention is for the work to be as accessible and usable as possible. If it receives positive response, ports to other platforms such as desktop or Android devices will be considered. Hopefully the sonfication techniques and technological platform can serve as a basis for future works with similar aspirations. Whether it has achieved its aesthetic goals is in the hands of the users.

8. AUTHOR'S PROFILE

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Ethan Edwards is a programmer, new media artist, filmmaker, and researcher currently based in Tokyo. He studied Philosophy and Computer Music at Columbia University, graduating in 2015. He received a grant from the Columbia University Scholars Program in 2014 to make an experimental documentary film in Japan. His recent works focus on bringing classical aesthetic thought into dialogue with new mediums of expression.