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LIGHTSOUND: ACCESSIBILITY AND AWARENESS FOR UPCOMING SOLAR ECLIPSES

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ABSTRACT

People from all over the United States (and abroad) flocked to the path of totality to witness the Great American Solar Eclipse in 2017. The sentiment was the same for the 2019 and 2020 South American eclipses that passed through Chile and Argentina. While a total solar eclipse is typically thought of as a striking visual phenomenon, it is not the only way to observe one, and for blind or low vision individuals, having an alternate medium to observe an eclipse is a necessity. LightSound is a low-cost, hand-held device that was originally developed for the 2017 North American eclipse. It has a very high-dynamic range sensor that converts light to sound in a process called sonification. The sound can be output to headphones or to a speaker during an event to make the entire event more accessible while capturing the dimming of the Sun in the form of sound. All documentation and software needed to build and use the LightSound are open source and free for download and modification. As the 2023 and 2024 North American solar eclipses approach, we aim to increase the number of LightSounds across the paths of totality so that the experiences can be more inclusive and accessible. In the astronomy community, we are holding a series of workshops through the American Astronomical Society to train new users to build and use the devices, but we hope to expand to a more general audience by connecting with organizations such as libraries, museums, national parks, girl/boy scouts, and others groups who we can help to build the necessary devices for communities and events in need. In addition to eclipses, the LightSound has exciting potential for use as a teaching tool at both K-12 levels and undergraduate levels and for raising awareness about sonification as a powerful and important analysis method in science.

RESUMEN

Personas de todo Estados Unidos (y del extranjero) acudieron en masa al camino de la totalidad para presenciar el Gran Eclipse Solar Americano en 2017. El sentimiento fue el mismo para los eclipses sudamericanos de 2019 y 2020 que pasaron por Chile y Argentina. Si bien un eclipse solar total generalmente se considera un fenómeno visual sorprendente, no es la única forma de observarlo, y para las personas ciegas o con problemas de visión, tener un medio alternativo para observar un eclipse es una necesidad. LightSound es un dispositivo portátil de bajo costo que se desarrolló originalmente para el eclipse norteamericano de 2017. Tiene un sensor de muy alto rango dinámico que convierte la luz en sonido en un proceso llamado sonificación. El sonido se puede enviar a auriculares o a un altavoz durante un evento para que todo el evento sea más accesible mientras se captura el oscurecimiento del Sol en forma de sonido. Toda la documentación y el software necesarios para construir y usar LightSound son de código abierto y gratuitos para descargar y modificar. A medida que se acercan los eclipses solares norteamericanos de 2023 y 2024, nuestro objetivo es aumentar la cantidad de LightSounds en los caminos de la totalidad para que las experiencias puedan ser más inclusivas y accesibles. En la comunidad de astronomía, estamos realizando una serie de talleres a través de la Sociedad Astronómica Estadounidense para capacitar a nuevos usuarios en la construcción y el uso de los dispositivos, pero esperamos expandirnos a una audiencia más general al conectarnos con organizaciones como bibliotecas, museos, parques nacionales, girl/boy scouts y otros grupos a los que podemos ayudar a construir los dispositivos necesarios para las comunidades y eventos que lo necesiten. Además de los eclipses, LightSound tiene un potencial emocionante para su uso como herramienta de enseñanza tanto en los niveles K-12 como en los niveles universitarios y para crear conciencia sobre la sonificación como un método de análisis poderoso e importante en la ciencia.

Key Words: sonification

1. INTRODUCTION

A solar eclipse is a visually stunning sight and it can be a personal, and even emotional, experience for an individual. Accessibility should be at the

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forefront of event organizers' minds and not an afterthought. The LightSound device is a tool that allows a blind or low vision individual a way to observe a solar eclipse with sound. Having a LightSound device at an eclipse event allows people to interpret the eclipse through their own observations with sound. These devices have been used during the 2017 North American eclipse and during the 2019 and 2020 South American eclipses. We are now trying to connect with communities and event organizers that are preparing for the 2023 and 2024 eclipses that will have in North American, Mexico, and parts of South America. We anticipate that the the 2023 and 2024 events will be even bigger than the 2017 events given the publicity and success of the 2017 eclipse.

2. LIGHTSOUND DEVICE AND RESOURCES

LightSound (Bieryla et al. 2020) was designed to be a low-cost, open source device that exists as a tool for a blind or low vision individual to experience a solar eclipse or other light phenomena. The device uses a high dynamic range light sensor to collect light which is then converted into sound based on the intensity of the light. Different instruments are mapped to the light to give a full dynamic range of sounds. The sound can be output via an audio jack to a speaker or headphones. A micro-USB port allows the user to save the data to their computer while also powering the device. The LightSound can also run off of a 9-volt battery.

The code is available via GitHub[3] and users can modify the instruments used or any other aspect of the code to customize the device to their needs. LightSound uses Arduino technology [4] to convert light into sound in a process called sonification. The device components are produced by Adafruit Industries [5]. A detailed manual[6] has been written, in English and Spanish, to describe the device assembly.

2.1. *Past Eclipses*

2.1.1. *2017 North American Eclipse*

LightSound was originally designed for the 2017 North American solar eclipse. There were two devices in Kentucky and one device in Wyoming. The devices were more or less in prototype mode and were deployed as a proof of concept. The devices in Kentucky were used to collect data to plot and sonify at a later time while the device in Wyoming was used to stream the sound live via the internet to people around the globe. The LightSound performed as expected but the eclipse gave us ideas to improve upon the prototypes.

Fig. 1. LightSound device with headphones attached on a bendable tripod.

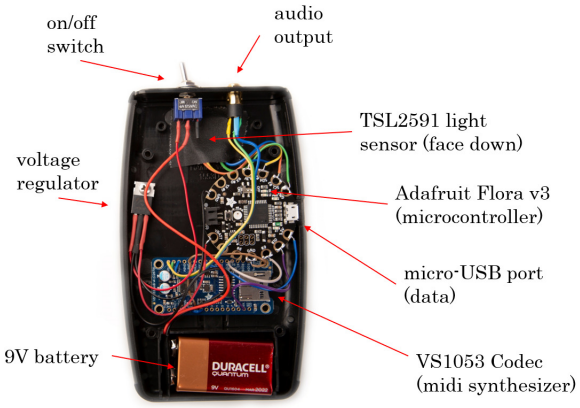

Fig. 2. Diagram of LightSound showing Adafruit Flora and MIDI boards, power switch, voltage regulator, and 9-volt battery.

[3]https://github.com/soleyhyman/LightSound2.0
[4]https://www.arduino.cc
[5]https://www.adafruit.com
[6]http://astrolab.fas.harvard.edu/lightsound_instructions_v_2_1.pdf

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2.1.2. *2019 and 2020 South American Eclipses*

For the 2019 and 2020 South American Eclipses, we updated the LightSound design to use a sensor with a higher dynamic range, which enables sensor readings all the way from full nighttime to direct sunlight. Early testing of the sensor during the January 2019 found that it was sensitive enough to detect light changes as totality ended.

With the addition of musical instrument digital interface (MIDI) board, we also mapped various brightness ranges to different instruments to serve as a guide for the listener. Full darkness to indoor lighting is represented by a series of clicks that speed up as the light intensity increases, a clarinet sound indicates indoor lighting to daylight, and a flute sound indicates daylight to direct sunlight. In the case of extremely bright, direct sunlight, the sensor can occasionally saturate, and a plucked string sound plays to represent that.

With the support of an IAU100 Special Projects grant and our colleagues in Argentina (Beatriz Garcia) and Chile (Paulina Troncoso Iribarren and Erika Labbe), we built and distributed 20 LightSound devices to communities and organizations in Chile and Argentina for the July 2019 total solar eclipse as part of the effort to make the events more accessible to blind and low-vision individuals. For the total eclipse that followed in December 2020, our South American colleagues redistributed the 20 devices to communities and organizations that would be holding events. In Chile, with a grant from the European Southern Observatory (ESO), approximately another hundred devices were built and distributed across the country.

2.2. *Preparing for 2023 and 2024 N. American Eclipses*

2.2.1. *2023 Annular Eclipse*

The Americas continue to be a hotspot for eclipses. On 2023 October 14, an annular eclipse will pass through the United States (most notably Oregon, Utah, Colorado, Arizona, New Mexico, and Texas), many Central American countries (i.e., Mexico, Belize, Honduras, Guatemala, Nicaragua, and Panama), Colombia, and northern Brazil. In the United States, this path includes many national parks, monuments, and recreations areas, as well as several major cities, providing excellent opportunities for outreach.

2.2.2. *2024 Total Eclipse*

Much like the total solar eclipse of August 2017, the April 2024 total solar eclipse impacts many large populations areas throughout the United States,

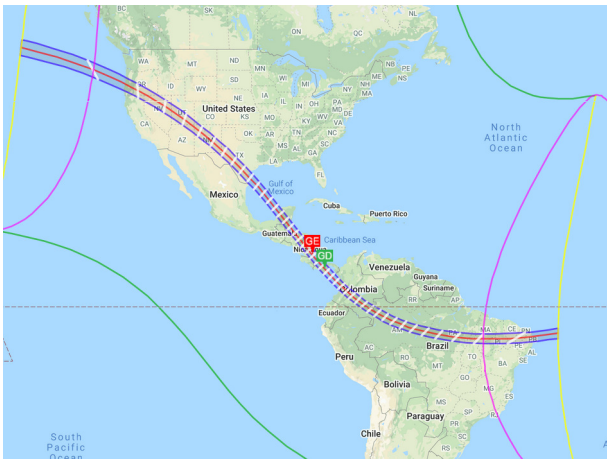

Fig. 3. Map of the path of the annular solar eclipse on 2023 October 14 across the United States, Central America, Colombia, and Brazil.

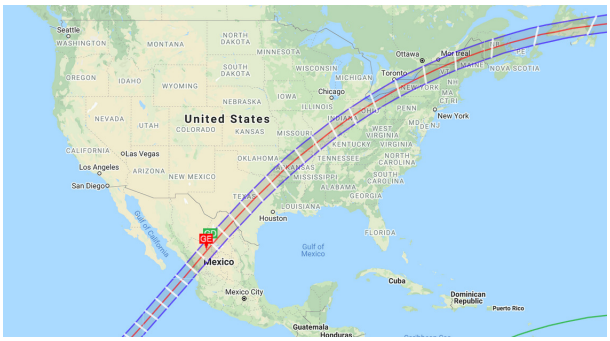

Fig. 4. Map of the path of the total solar eclipse on 2024 April 8 through Mexico, the United States, and southeastern Canada.

Mexico, and Canada. In the United States, the path of totality includes the states of Texas, Arkansas, Missouri, Illinois, Indiana, Kentucky, Ohio, Pennsylvania, New York, Vermont, and Maine. Many of the countries largest cities will be either in the path of totality or very close to it. The entirety of Mexico will experience at least a partial eclipse, with totality passing through the states of Siniloa, Durango, and Coahuila. Similarly, Canada will have totality in five provinces, namely Ontario, Qubec, New Brunswick, Prince Edward Island, and Labrador, with several major cities also falling in the path.

2.2.3. *Workshops*

We developed a full day workshop to teach participants how to build and use the LightSound device. The workshop does not require participants to have any prior soldering or software skills. We held a workshop at the American Astronomical Society

(AAS) winter meeting in Hawaii in 2020 and have another workshop planned at the 2022 summer AAS meeting in Pasadena, CA. Our intention is to hold a few workshops each year in preparation for the 2023 and 2024 eclipses. Our focus is to engage participants from universities, museums, community organizations, etc., to participate in a workshop so that they can then lead workshops in their own communities and organizations. It is through the training of workshop leaders than we can spread the knowledge and skill set of building and using these devices for eclipse events.

We hope to partner with organizations and institutions along the eclipse path to distribute as many LightSounds as possible to ensure that events are accessible for the blind and low vision community.

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