
California Drought Impact v2: Data Visualization and Sonification using Advanced Multimodal Interaction

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Abstract

California Drought Impact v2 is an interactive data visualization and sonification that depict the causes and impact of the drought and promote awareness of water consumption. It uses multivariate data of the California drought to create wooden data sculptures and projection-mapping images. This newer version improved the previous version by enhancing accuracy of sensing system, incorporating tactile input system and water sound. This work expands the possibility of creating diverse audiovisual results based on user interaction, and depicts the past, present, and future of the drought, which is a major concern on our environment and society. This multimodal data representation not only provides an aesthetically meaningful visualization but also explores how to coexist between art and our environment using the hybrid practices of art and design.

Author Keywords

Interactive Art; Data Visualization; Data Sonification; Multimodal interaction; Sensing Interface; California Drought; Drought Impact;



Figure 1: Previous version of California Drought Impact exhibited at the IEEE VIS 2016 Arts Exhibition, Baltimore, USA

ACM Classification Keywords

J.5 Computer Applications: ARTS AND HUMANITIES;

Introduction

Drought in California has been a major environmental issue during the past six years [1]. As an artist living in California, both the causes and impacts of drought have been my questions, artistic inspirations and materials as it has brought significant impact on the environment. I believe meaningful narratives, which are often hidden in big data offered by the United States Geological Survey (USGS), can be discovered through artistic exploration. The hidden results can be the keys factors in resolving the significant impact of the drought and/or can encourage the public's awareness of the drought in an artistic realm.

Based on these inspirations and issues, a previous version of *California Drought Impact (v1)* - an interactive multimodal data representation - was developed in 2016 [3] using Kinect and Leap Motion cameras to manipulate both past and present data to predict the future of droughts in the region. This project allowed the audiences to not only observe past and present water data (reservoirs and snowpack data) but to manipulate the present data by moving their hands toward a projection screen. Although users were active and satisfied with experiencing the artwork, informal user studies revealed complaints of inaccuracy of hand positions and oversensitivity of the camera to hand motions, which made it difficult for the audience to control visualization on a small screen. For example, if a user wanted to point out a reservoir in Los Angeles, they needed to move their hand extremely slowly to point out the exact location. Two possible solutions included increasing the screen size and using more

accurate sensing technology. California Drought Impact v1 used a 5 ft. W x 3 ft. H projection on top of a wooden sculpture; however, it was determined that, if the screen size was increased, users would be able to move their hands more freely in a larger range and increase the accuracy of synchronized pointing locations. Another issue from v1 was the separation between the wooden sculptures and the interactive installation. In v1, there were two main components: 1) wooden sculptures to represent the past data and 2) interactive visualization with sonification to show both present and future data. Many participants noted that the wooden components were only emphasized in the past data. Therefore, incorporating wooden parts on the interactive installation would make the artwork more cohesive.

By resolving these issues, this project aims to create interactive artwork that explores the predictive analysis of the California drought data by transforming multimodality into physical sculptures and digital projections. To do so, both the artistic experience and engagement with the audience are critical because the audience becomes part of the artwork, and the artwork evolves based on their input and interaction. It is anticipated that California Drought Impact version 2 (v2) could be exhibited at various locations (e.g., art galleries, public spaces, or outdoor environments in nature or urban areas) due to its flexible dimensions and more enhanced hand motions. I believe that this interactive data visualization will further explore ways for art and our environment to coexist via more accurate sensing technology, intuitive water sounds, and new wooden interfaces.

Related Works

Many previous data visualizations using the California drought have been sorely focusing on showing scientific data and delivering key information that limited in the previous five years' data. New York Times [4] and USGS [2] designed simple map-based visualizations and charts to show causes and conditions of drought. Predictive analysis has been used for several researches, however any aesthetically meaningful visualization/sonification have not been investigated yet. Artistic investigations on creative data representation can reflect our environment more intuitively and relationships between human and environment, human and data, and human and interface. Digital fabrications and sculptures have brought tactile representation of data and their 3D physicality and haptic experience allow users to understand multivariate data in 3D space. Water works [5], California water [6] and The Snow Water Equivalent Cabinet [7] are the good examples of the data sculptures. Even though the California Drought is caused by mostly environmental factor, the water usage by the human can resolve the issue gradually. Water changes and the ecosystem in the California are the key causes of the drought. When the water data can be tweaked and updated by body interaction in artworks, we may be able to realize how much the current situation is severe directly. The previous version of California Drought Impact [3] explored how to control the past, present and future of the water data using the human interaction.

Design of California Drought Impact v2

The concept behind *California Drought Impact v2* is to allow users to explore the past, present, and future of drought data via user interactions, visualization, and

sonification. In this second version, more accurate hand motions with tactile interaction, new sculptural aspects, and advanced sonification enhance the multimodal user experience in various ways. The audience can also check their recorded and manipulated data results after finishing their experience because all the data processed will be not only recorded but archived. Thus, the future of drought will be different and stored as a multi-sensory experience and newly created data by each audience member.

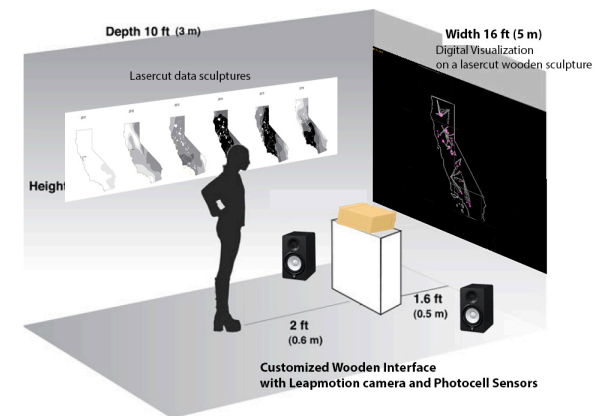


Figure 2: Floor Plan of California Drought Impact v2.

California Drought Impact v2 has been proposed for the CHI 2017 Art Exhibition, as depicted in Figure 2. Although similar to v1, it requires a bigger space and a wider wall to project higher resolution visuals of approximately 16 ft. W x 10 ft. H. The wooden sculpture is 10 ft. W x 10 ft. H. Therefore, a wall large enough to allow for these dimensions is required. In addition, there must be adequate distance between the projection wall and the wooden interface. The wooden



Figure 3: A Prototype of California Drought Impact v2 with a digital projection image on a wooden sculpture and new wooden interface with photocell sensors.

interface should be on a pedestal for independent control because the audience controls all data on the sensing interface. As a part of the artwork, laser cut wooden sculptures (past drought data) will be mounted or placed on a table or a wall. Thus, the different aspects of the artwork range from static sculptures and a non-interactive audiovisual component to an interactive installation to create cohesiveness.

Components

The previous version of *California Drought Impact* consists of three categories:

- Past (2011-2016): Wooden Sculptures
- Present (real-time analysis): Non-interactive visualization and sonification
- Future (predictive analysis): Interactive visualization and sonification

The newer version includes a number of additional features as a part of interaction and interface design. These features are controlled by hand motions, which are mostly dependent on the position, the moving direction and the number of users' fingers toward the Leap motion camera and photocell sensor. Detailed components and interactions are as follows:

- Past: six wooden sculptures (same with the previous version) with non-interaction
- Present: Up-to-dated water and weather data is visualized and sonified with non-interaction
- Future: Users control a wooden interface that has hidden photo sensors and leap motion camera to tweak the present data. The results have changed visuals and sound.

A wooden interface includes:

- Leap motion camera: It changes and controls clouds and precipitations. When hands move around specific locations, the nearby area will have either more or less precipitations or control intensity of water flow.
- Photo cell sensors with Arduino: It allows accurate positioning on all significant reservoirs and rivers, thus users can control and manipulate the capacity of the reservoirs more specifically.
- Wooden exterior box: It has the same design of California map outline on a lasercut wooden sculpture.

Two additional features are a bigger screen and enhanced water sound:

- Digital Projection mapping on a bigger screen and a wooden sculpture give depth and richer dimension.
- Enhanced water sound: instead of using electronic noise and sound used in the previous version, water audio files have been recorded in various locations in California, and manipulated to be used for the installation. Thus, it gives more impact and direct relationship between the visualization and sound. The intensity of water sound is mapped to the capacity of each reservoirs/rivers.

In this project, d3.js [8] was used for the visualization and MaxMSP [9] was used for sonification. A list of hardware includes an Arduino board, photo cell sensors, a Leap Motion Camera and a computer.



Figure 4: Exhibition views of California Drought Impact

Multimodal Sensory Experience

This artwork engages senses – visual, auditory, touch, and motion in embodied interaction. Using multi-sensory experience, this work aims to create a new approach for representing significant societal information using more engaged interaction. Many different materials in nature, especially water transformation, have evolved the California drought. This visualization and sonification represent a variety of transformation of water from the evaporated air, water flow, snow and snow evaporations. The loop of the water morphology is the key aspect of the California drought data, which was mainly focused on this work using multimodal data representation. Thus, this artwork will not only represent the information about the drought, but also encourage more active participation and increased public awareness about possible solutions and next steps to resolve the natural disaster.

This artwork includes both physical data representation and digital audiovisual components, which can tie between nature and artificial element that represents our interaction and input to the nature. This interactive art installation, therefore, may enhance the user's connection to the information and increase the actions needed to reduce or resolve it.

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Conclusions

California Drought Impact v2 offers an opportunity to experience an advanced multimodal interaction using a metamorphosis of water and its impact on the drought. As the previous version did, this newer version continues to depict the past, present, and future of the drought by altering water system in the California. Thus, this multimodal data representation not only provides an aesthetically meaningful visualization and

sonification, but also encourages more awareness and active participation on our environment and nature by using the hybrid practices of art and design. This data representation has used novel methods for artistic manipulation of environmental data with audiovisual components controlled by user interaction. This is especially true for water and climate data regarding the use of hand motions, which has not been attempted previously in the fields of interactive design and art. Therefore, this artwork has the potential to become a leading approach for creating novel data art while also providing an interesting multimodal interaction experience for the audience.

Improvements in v2 from v1 include the following: more accurate interactive use of both the camera sensing technique and analog photocell sensors, an increased physical and sculptural aspect on the digital projection to create more depth, newly added weather data, and richer water sounds that directly apply to the theme of this artwork. These changes create opportunities for the development of infinite scenarios regarding the future of drought. Each time the program is used, both the visuals and sound are not the same, making it impossible to return to a previous result. Similar to nature, every moment provides new growth, metamorphosis, and rebirth, as is seen in the water cycle daily. Although this artwork mimics nature in that sense, it simultaneously empowers the audience to change nature by increasing their awareness of the aftereffects of their input and providing potential scenarios for the transformation of how we consider water usage and nature.

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