Expanded Sensing Intelligent Systems Multi-sensory interactive system development

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Abstract

This document contains information about the art installation as a part of my Creative Technology Toolkit project on the topic of Expanded Sensing Intelligent Systems: Multi-sensory interactive system development. Divided into three major parts, this paper consists of a Research Journal, a design proposal and finally a prototype report. The research journal will contain background information on the topics considered, discuss sources of inspiration, and shed light on similar work done by other creative technologists. The design proposal will contain a description of my plan about the installation, including the aim and a methodology. Finally, the prototype report will consist of reflections having done the project on things I could improve or change and thoughts on how this has affected the viewers.

Author Keywords

Generative audio; Openframeworks; Colour tracking; Colour detection; OSC; Digital Audio Workstation;

Figure 1: This image shows a variety of tropical fish species. Tropical fish are known to be more vibrantly coloured than freshwater fish. The group of bright yellow fish on the right side of the image are called Yellow Tangs. They are one of my two selected fish species for the project as they allow for a high contrast which is ideal for this project. Photo CC – By Jean Ferraiuolo on The Richest.

Introduction

Marine life, a wonder that started to form over 2 billion years ago with single-celled prokaryotic organisms [1] has been estimated to have evolved into over 1.4 million species [2]. By definition, a fish is an aquatic craniate that has gills and lacks limbs with digits that belong to the phylum Chordata. The World Register of Marine Species which was launched in 2008 by the Census of Marine Life, it claims that the number of species of Chordata recorded so far is approximately 72,500 [3]. Most of these species have particular living conditions that need to be met to ensure their survival. Due to this phylum's adaptability to different environmental conditions, Chordates have developed very distinct physical features, one of which being bright and vibrant colour for some species. This is a feature that the installation will explore in fish. The vision is to create an audio-visual installation that shows how calm and serene aquatic life can be, exploring the possibility of an aquarium where a viewer could watch and listen to fish create music. The idea revolves around colour tracking a fish to understand it's movements and using that information to trigger sounds in order to create music.

Research Journal

This section of the paper will present some background information on the topics considered, shed light on similar work done by other creative technologists in our university and around the world and discuss inspirations.

Background information

The initial thought when considering a project on the theme of nature was for it to revolve around aquatic animals, due to the fact that in the oceans was where the evolution of life started. The movement of multiple aquatic animals on display at the Bristol aquarium was studied such as the common Chordata fish, multiple specimen of the subphylum Medusozoa jellyfish and Batoidea stingrays. In the study, the focus was on the unusual physical characteristics that would engage the attention of the viewers. It was noted that the jellyfish had a fascinating motion of movement. However, the movements of fish were more uniform and smooth; it was found that the colour of most common species of both jellyfish and stingrays are less intriguing than of tropical fish. Therefore, a decision was made that the tropical fish would be the subject of the installation because of their distinct and vibrant colour and their smooth movement. Consequently two ideas were thought out, the first was to use Google's Deepdream algorithm to make the fish look like leaves [4] as illustrated in Figure 2 and the second was to track the fish using its distinct colour to create music.

Research on considered projects

Through the study of the deep-dream algorithm it was established that Caffe, a deep learning framework and both Python and C++ were needed to execute this fully and upon further research it was realized that it was near impossible to run the deep dream algorithm on a live camera feed as processing each frame of the camera feed to produce the manipulated images takes time, therefore it would result in a great deal of lag and so the experience would not be immersive for the viewer.

Figure 2: This image shows a Deep Dreamed version of Figure 1. Image CC-BY-ND Deepdreamgenerator.com

Through the study of colour tracking came an introduction to OpenCV, an open source computer vision library that contains functions which allow for colour detection and blob tracking through a minimal amount of code [5]. Inspired by work done by a fellow creative technologist Kyle Macdonald who has been an adjunct professor at NYU's ITP, a member of F.A.T lab, community manager for openFrameworks and artist in residence at STUDIO for Creative Inquiry at Carnegie Mellon as well as YCAM in Japan it was discovered that Macdonald's work on an alternative approach to interfacing with OpenCV from openFrameworks was very interesting and useful to this project, he had uploaded examples of simple algorithms that he would use in projects, such as face detection and tracking, edge detection, contour detection and colour tracking [6].

Code development

Considering the newly discovered code, it was only wise to base the program around Kyle Macdonald's contour detection through colour example called contour-color [7]. Using the contourFinder() function that Kyle had developed the program was able to track the contour of a piece of cardboard that had been coloured through the webcam on my laptop using the ofVideoGrabber. Later the code was edited in order to allow the use of a video of an aquarium using the ofVideoPlayer to depict the environment of that actual project better, also adding in features that allowed multiple colours to be tracked. The program was finally able to track two distinct colours of fish in a video.

Consequently the focus shifted towards the sonic aspect of the installation. It was exciting to be able to use the ofxOSC addon of openFrameworks to produce midi signals from the tracked fish and play the sounds on a Digital Audio Workstation running on a laptop in order to create an immersive and ever-changing sound. Although, before the trial it was established that the laptop (MacBook Air 2012 model) is not able to run FL Studio which is the chosen DAW. Therefore it was decided to use pre-recorded samples instead of midi signals. Using the ofSoundPlayer the program was able to playback samples at different volumes and speeds, even being able to trigger the samples more than once during the playback using the MultiPlay feature.

As far as sound selection goes, it was decided to use string instruments because I believe that instruments such as violins and cellos best represent the movement of fish in the ocean. Therefore two samples were chosen, the first was to be a more omnipresent sound which felt like a backing track achieved by the cello playing long single notes and the second was a violin lead playing higher pitched staccato notes. When played together it produced a mellow orchestral sound which matched the look and feel of the fish and their movements.

Similar projects

Dr. Chris Nash of University of the West of England, Bristol, a senior lecturer and experimental music technologist and researcher had a live generative music installation at the Bristol Temple Meads train station which used computer vision algorithms to detect the movement of passengers across the platform and used the data to input into a generative music system which Chris had made called the Manhattan Project. The resulting musical piece alters and responds to the changing rhythms of the life of the station.

Dr. Nash's installation was a source of inspiration for the project as my program too would use computer vision algorithms to create a generative music piece. The only difference being the subject of my installation would be tropical fish, and it would be using a commercially available DAW to produce sounds.

Ideal project environment

There are a few parameters that need to be controlled in order for the program to deliver the best possible experience. Firstly, there needs to be distinctly coloured fish, where each fish is of a different colour or it may result in unpredictable tracking, secondly, the background of the aquarium needs to be of a different colour to all of the fish so as to not track the background, thirdly, the aquarium must be well lit from multiple angles so as to not create shadows on the bodies of the fish which might affect the colour of the fish and finally, there must be a 5:1 ratio of each coloured fish, for example if there is one yellow fish, there must be at least five red fish.

Downsizing for the demonstration
The project has been downsized for the demo and therefore many of the features proposed for the final project have not been implemented and some have reduced capabilities.

Firstly, the installation was initially designed to be performed live using a camera to capture the fish and their movements. For the purposes of the demo the live camera feature was replaced with a video that was created using png images of the desired fish (Yellow Tang and the Red Blood Parrot) using OpenShot Video Editor, a free video editing software with advanced features.

Secondly, the detection and tracking algorithm has been scaled down. Initially, the program would first be using a blob tracking algorithm which would detect any moving object in the video feed and then a colour detection algorithm to detect the colour of the blob. This would result in a highly sensitive object tracker which would be able to differentiate between object and background even if both had similar colours, and also if the object itself had multiple colours. The scaled down algorithm only uses a colour detection algorithm, therefore the tracking is not as accurate. Some problems may arise when using this scaled down algorithm such as an object which has multiple colours are considered multiple objects. Therefore a fish with two stripes orange and white respectively would be detected as two objects.

Thirdly, the number of colours of fish has been reduced. The initial plan was to use three to five distinctly coloured fish in order to create a five-piece string orchestra, however the number of colours of fish has been reduced to two so as to reduce complexity for the demo. Although, it is simple to add new colours and instruments as one could add contourFinder objects using the RGB colour codes and add sound samples corresponding to each colour.

Finally, the external screen where viewers would have been able to select and isolate the sound of each fish has been removed for the purposes of the demonstration. This was done because adding this physical feature would add more complexity to this demonstration, as this ability to isolate the sound of a fish at its core is already implemented in code. It would also have been more effective to have this feature if there were multiple colours of fish creating an orchestra, instead of just two.

Design proposal

Project considerations
When beginning this project, a variety of focus points were considered such as:

• Visual – Using the Deep Dream Machine Learning algorithm to generate live optical illusions of fish.

• Aural – Using colour and motion tracking on fish to generate audio.

After careful evaluation and research, the aural route was found to be more feasible, as implementing the Deep Dream optical illusion would create a lag issue when used on live video.

Figure 3: This image shows the Yellow Tang, a tropical fish species. This fish was selected for my project because of its distinct and vibrant colour which makes it easily trackable using computer vision. Photo CC – By Katie McConnachie on Katiesfineart.com.

Figure 4: This image shows the Red Blood Parrot, a tropical fish species. This fish was selected for my project because of its distinct and vibrant colour which makes it easily trackable using computer vision. Photo CC – By Larissa Sawyer on pngtree.com.

Project description

This interactive installation will observe fish in the Bristol aquarium and generate sounds according to their colour and movements.

RELEVANCE

For my project I have taken inspiration from fish, as marine animals were one of the first prominent life forms to evolve and currently occupy the most significant area on Earth. The Bristol Aquarium was chosen as the location for the installation as it hosts the most extensive collection of aquatic life in the city. I have chosen to use two features of a fish as input- the colour and the movement speed. The colour is a distinct characteristic of a fish which is why it will be used to trigger sounds, the speed on the other hand is a common property for all fish which is why it will control the volume of the sounds triggered by the fish. I agree with Roul [8] when he states that the target audience for this installation are children aged three to six as this is when audio-visual intervention improves cognitive development.

Aims

The objective of this installation is to explore the notion of aquatic animals producing music, using a camera to observe and track their movements and body colour. There will also be an interactable device present (tablet or a laptop) displaying the area in the field of view of the camera, where the members of the audience will be able to interact with the installation by selecting a fish to isolate its sound. The installation is specifically designed to be located in the Bristol Aquarium.

Methodology

The plan of action is relatively straight-forward, the significant pieces of equipment required are a camera and a laptop. The plan is to use the camera to live capture only a part of an aquarium tank containing distinctly coloured fish. This feed will then be used to colour and motion track each fish using the openFrameworks Computer Vision library. The colour information in RGB will correspond to a sound or sample preloaded in a Digital Audio Workstation (DAW), and the motion information will be used to manipulate the volume or amplitude of the sound in dB. The speed of the motion tracked fish will determine how loud the sound or sample is when played back. The openFrameworks OSC library will be used to communicate between the tracking program and the DAW.

Audience engagement is of a high priority, therefore interaction with the system will be implemented by using a display where the audience members will be able to select a fish which will in turn isolate the sound that corresponds to the fish.

Prototype Report

This is the final section of the document and it will reflect on the decisions made before and during this project.

Complications

The original idea of using Google's Deepdream algorithm to morph fish into leaves and other objects was met with a few issues that would not allow implementation of the project in a live setting. Some of those issues include the use of multiple programming languages, the use of interprocess communication and the speed of processing the data. The major obstacle for this idea was the laptop being used, a MacBook Air 2012 model. Firstly, in order to finish implementing this idea, there was a need to use both openFrameworks for C++, and Python. Python is essential for the use of the popular deep learning library Caffe, which contains functions that allow the Deepdream algorithm. Obstacles arose when installing and using Python on the laptop which could not be corrected, therefore using the desktop computers on the university campus was the only option. This was the first obstacle in the path to executing this project idea. Secondly, after extensive research a suitable algorithm for interprocess communication was left to be found. The first instinct was to use a text file as a buffer, which both the openFramework and the Python programs could access and write to, however it was not appropriate for this project. Finally, it was established that the complete processing time for executing the whole program is not suitable for implementation in a live setting.

Problems arose when trying to achieve the velocity tracking feature of the fish in my final generative audio project idea, for the purpose of controlling the volume of the sample being played back. The function contourFinder.getVelocity() created by Kyle Macdonald returned unreliable values when tracking the fish therefore the use of the getVelocity() function was discontinued. Instead, the velocity tracking feature was replaced with position tracking as far as volume control. The Yellow Tang was position tracked and it's x and y coordinates were mapped to the panning and the volume respectively.

Compliance with the guidelines

This project is compliant with all the instructions stated in the project brief. The theme revolves around nature, as the main subject of the installation is fish. The intended location for this installation is the Bristol aquarium where this setup would presumably suit any of the tropical fish tanks, because the program would be able to detect most fish when using the combined blob tracking and colour detection algorithms. Regarding the number of inputs and outputs of the program, it has two inputs fish colour and position of the fish, and one primary output- music. The input variable fish position is further subdivided into two, the x coordinate which sets the panning of the sample and the y coordinate which manages the volume of the sample. There is a secondary minor visual output present in the fact that the video feed when seen on the laptop screen has each detected fish outlined which allows for feedback by the system.

Reflection on the development process

From previous experience breaking the whole program down into two parts the visual and the sonic was critical as it improved efficiency drastically. A basic form of agile software development was used where the project was broken down into small tasks; test-driven development was also used in order to fail early and be aware of weaknesses in coding knowledge instead of failing at a more critical stage. Using Test-driven development meant that any code which had been written would work without a doubt in any situation because of the consideration most use cases.

The openFrameworks tutorials by Dr. Daniel Buzzo at the University of the West of England have been immensely helpful, because of the lack of prior C++

knowledge. His tutorials were very detailed and covered all the topics needed for the purposes of completing this project such as GUI, computer vision and sound. The sound playback feature is based on sample code written by Daniel for the Creative Technology Toolkit tutorial sessions.

Editing skills were required for the creation of the demonstration video. This section of the project was especially challenging as I had no prior experience with video editing. Aquiring video editing software was arduous as most of the programs available on the market are expensive, and most of the free software do not have features advanced enough to create a convincing video.

Potential improvements or changes
This project could be improved in multiple ways, one could increase the number of distinctly coloured fish in the aquarium in order to create a sixteen-piece orchestra, or even create a 4 player rock band with each fish triggering an integral instrument such as guitar, drums, bass guitar and keys.

It would also be very interesting if the Deep-dream algorithm was implemented alongside this project at a lower scale. It would provide a much needed visual aspect to this sonic installation. The x-coordinate of each fish could correspond to the number of iterations run of the neural net which would result in different levels of manipulation in the images and the y-coordinate could correspond to the neural network layers used to process the image. This would result in an immersive and ever-changing visual response, which would match the sonic aspect well.

The samples chosen for the demonstration could be improved in quality. Currently, the samples are wav files with a low bit rate of 192 kbps, therefore a sample with a bit rate of 320 kbps would sound better. Stacking multiple samples together may also produce an improved experience. The backing sample which is played on a violin would sound better if it had a fade out effect to match the fade in effect.

The sample playback itself could be modified so that as a fish leaves the detection region, the sound amplitude is slowly reduced to 0 dB instead of it stopping abruptly. This would make the experience more seamless and immersive for the viewer.

The demonstration video could have been made better, as using still png images to represent fish does not look realistic. Animating the fish with physical movements such as their fins and tails would make the video look more lifelike. Adding foliage to the background of the video would have also improved the believeability.

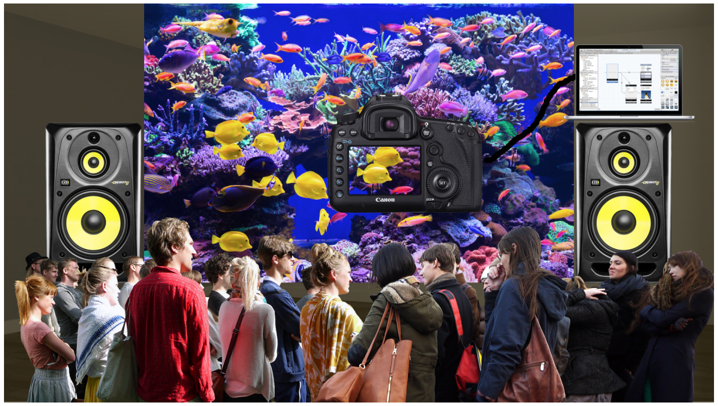

Figure 5. This is a visual representation of how this project would look in a real setting at the Bristol Aquarium. Photo: By Semon Ganguly

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