S.A.R.A.: synesthetic augmented reality application

Introduction

S.A.R.A. (synesthetic augmented reality application) is an App exploring the potential of visual music via a mobile device acting as a unique and wearable musical interface. S.A.R.A. was originally developed as a standalone App to translate the surrounding environment into sounds on mobile devices (iPhone/iPod and Android). The imagery captured via the mobile device's onboard camera is translated into real-time generated synesthetic-inspired sounds, resulting in the extension of our senses thru the use of technology. In effect, the App augments the senses by creating a digitally augmented synesthetic experience for the user based on a tradition of visual music. Visual music, a term coined by painter and art critic Roger Fry in 1912, are systems which convert music or sound directly into visual forms such as film or computer graphics, by means of a mechanical instrument, an artist's inspiration or a computer.[1]

Our interests in developing this project stemmed from the desire to explore these research questions: Can technology be used to create a synesthetic augmented reality? What sonochromatic sound mapping should be used? Do we allow for a variety of mapping choices? Should a visual element be used as well? How do we deal with sound?

This paper presents the conceptual groundwork manifested in our concept for S.A.R.A., how the App progressed into a wearable performance instrument and as to why we have chosen to release the App via an open source license.

Synasthesia and Visual Music

> *"One hears a sound but recollects a hue, invisible the hands that touch your heartstrings. / Not music the reverberations within; they are of light. / Sounds that are colored, and enigmatic sonnet addressed to you."*

- Vladimir Nabokov – excerpt from a poem written in 1918.[2]

Nabokov in a very poetic way describes the multimodal experience that is synesthesia. The term synesthesia refers to one sense stimulating another, causing involuntary experiences in a second sense and stems from the greek syn = together and aesthesia = sensation.[3]

Synesthesia can occur between any 2 senses (and sometimes more) and there are several know forms of synesthesia. Grapheme-color synesthesia refers to colored letters, spatial sequence synesthesia to see numerical sequences as points in space, or auditory tactile synesthesia where sounds can cause sensations on the body.[4]

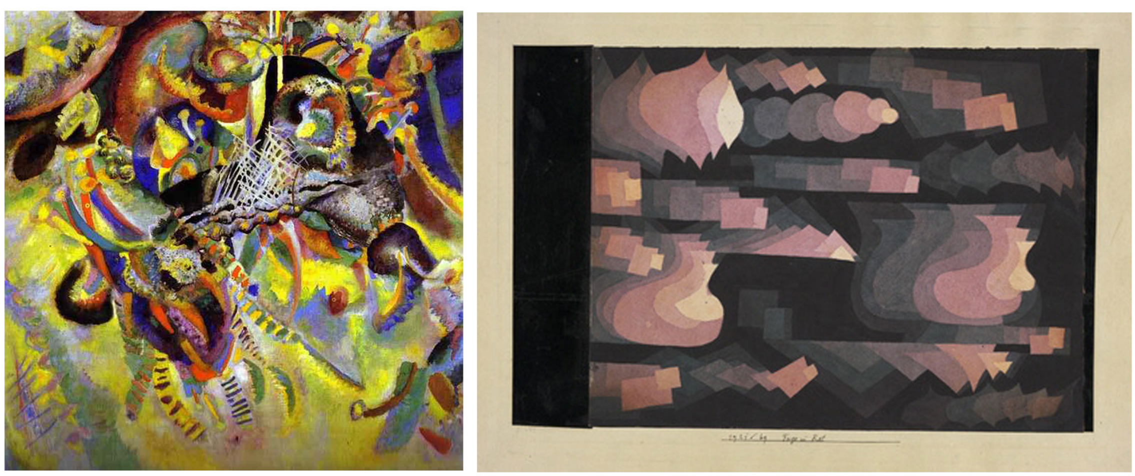
Chromesthesia - visual color synesthesia is one of the most common types of perceptual synesthesia.[5] A person experiencing this type of synesthesia would associate everyday sounds with colors. Accentuated sounds, like people engaged in conversations, a barking of a dog, cars honking are associated with different colors. Although synesthetic individuals will generally disagree on the same color for a given sound as their synesthetic sensation is individually different.

For the purposes of our App we chose to work with chromesthesia as the main inspirational source and therefore investigated color synesthesia in art. There is a well-established history of works by visual artists that explored this audio-visual connection (even if the artists themselves have synesthesia or not).

For example Wassily Kandinsky (a synesthete) is a good example of such an artist. Kandinsky, a painter, was also a cellist and he pursued to “evoke sound through sight.”[6] His favorite way of expressing synesthesia was to ascribe music timbre to color tones.

Paul Klee, another visual artist, was also a trained musician who tried to capture chromatic tonalities and temporal movement in his Polyphonic paintings. He attempts to capture the time element – spatially in his compositions. The work has multiple layers of objects in different shades that evoke movement. He approaches synesthesia from a emotional standpoint interpreting “personally felt impulses.”

Figure 1 shows a reproduction of Wassily Kandisky’s painting Fugue from 1913 next to a reproduction of Paul Klee’s painting Fugue in Red from the years 1921-1922.[7a-b] Even though both artists work with sound-to-hue sonochromatic mappings in their artwork each work is individually driven by the artist’s interpretation and vision of what visual music is.



Kandinsky Klee

Figure 1: A reproduction of Wassily Kandisky’s painting Fugue from 1913 (left) and a reproduction of Paul Klee’s painting Fugue in Red from the years 1921-1922.

Arguably, the grandfather of visual music is Oskar Fischinger. He was a German-American painter, filmmaker and abstract animator in the early 20th century. His animations “Kreise” (1933) and “Composition in Blue” (1935) were tightly scripted to the music, introducing the tendency to associate low-pitches with dark colors and high-pitches with light colors.[8a-b] This association is a common one and often takes place in synesthetes or non-synesthetes. His work laid the groundwork and influenced many artists in several different mediums. It was clear from researching the various synesthetic natured artworks that one of the most important aspects to the project would be the sonochromatic mapping of the sound to color.

Sonochromatic Scales

There are several variations of sonochromatic sound mappings, yet pitch-to-hue seems to be one of the most common sonochromatic mappings. Figure 2 by Fred Collopy titled *Three Centuries of Color Scales* is a infographic in a matrix format showcasing a variety of different pitch-to-hue mappings throughout the ages starting with Isaac Newton.[9] It shows 12 hues (stemming from the primary color wheel red, yellow and blue) each mapped to a semitone of an octave.

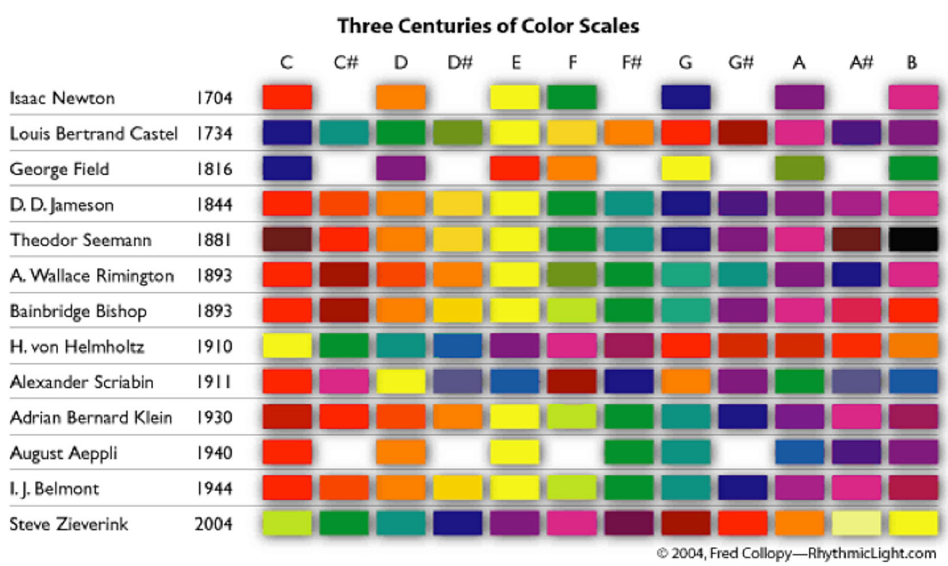
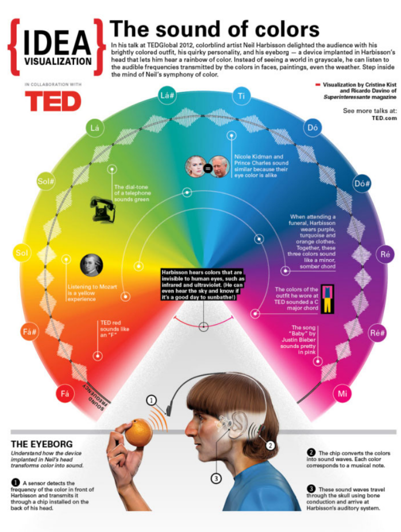


Figure 2: Fred Collopy's Three Centuries of Color Scales, a sonochromatic scale matrix.

Other potential sonochromatic mappings could include elements of color (hue, saturation, value) and sound (pitch, amplitude, tone color) for example pitch could be mapped to lightness, timbre to chroma and tempo to shape. For example the faster the music, the sharper and more angular the visuals would be, whereas slower music would result in rounder and larger shapes.

Roy de Maistre, an Australian artist, went a step further in developing his own color-music mapping: he added the UV spectrum to the sonic scale. In his scale G falls off into the Ultra Violet spectrum (outside of what our eyes can see).[10] While we did not implement this into the S.A.R.A., his idea to expand sonochromatic mappings into spectrums that are not visible to the naked eye, such as UV (or IR), is something that could potentially be done with current camera technology.

Moving this idea even further is artist Neil Harbisson. Harbisson was born with achromatopsia, a condition that allows him to only see in gray values.[11] In collaboration with Adam Montandan they developed a technology called the eyeborg to translate colors to sound (see Figure 3).[12a-b] Neil is the first person to have an antenna osseointegrated into his skull and is officially the first cyborg recognized by the UK when he was permitted to take his official passport photo with the eyeborg device.[13]



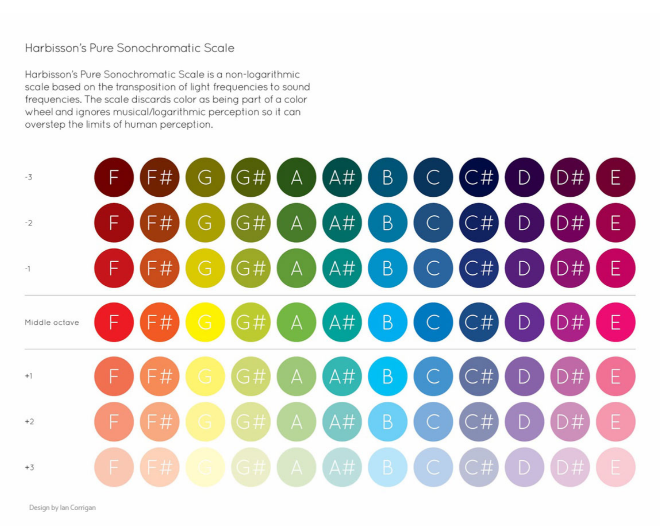


Figure 3: Neil Harbisson's Eyeborg Device and Pure Sonochromatic Scale.

His pure sonochromatic scale is able to push the sonochromatic scale past the limits of human perception due to the use of his eyeborg technology. In effect, he discards the color wheel and if he uses a camera that can see these spectrums, he can sense and listen to ultraviolet as well as infrared spectrum light. He is essentially using technology to augment his senses and thereby extending his eye's spectrum to light waves that the human eye cannot see.

S.A.R.A. and its concepts

Given this particular framework for synesthetic approaches, it was important to establish a conceptual framework of our own. Essentially we wanted to use color synesthesia as the conceptual background for our App. Our goal was to create a reverse color synesthetic interpreter that picks the colors up via the camera and then converted them to sound. This automatically limited us to the color range of the device's onboard camera that is limited to the visible spectrum as these cameras contain filters for the infrared spectrum. Furthermore, we needed to develop a simple color mapping system.

Early on we established that we did not want to use canned sounds or sound bytes but rather work with a data driven generative sound creation method. Additionally, we wanted to ensure that we also had access to more sensors besides having access to the camera and decided to go with a standard mobile platform like the iPhone and Android devices. They were both easily/readily available, portable and this availability and affordability would extend the audience that could interact with the App. In our programming process we determined that the easiest way to map sounds would be to assign the average of R (red) G (green) and B (blue) values coming in from the camera to three variables and let these drive the audio synthesis. We assigned variables to the pitch, roll and way of the mobile device to enhance the audio synthesis. In order to achieve all this we decided to code the S.A.R.A. app with the help of openframeworks and Xcode.[14a-b] We use Xcode and openframeworks to get to the camera input data and display, additionally to filter the live video streams as well as the get the onboard sensor data. Xcode is Apple's coding environment for objective C. OF is an open source C++ coding toolkit. We chose this combination because it has an open source component in openframeworks and will provide both code bases for Xcode and openframeworks.

For the sound synthesis component of the App we are using the LIBPD library created by Peter Kirn.[15] It is based off of the open source sound synthesis software, pure data. It allows us to generate sound on the fly from the input variables of the device. After installing, you can point and move your smartphone camera at your surrounding environment and listen to the colors that the camera averages and your movement produces. In addition, you can choose different image filters and built-in sound generating patches in the interface. Furthermore, via the connectivity of iTunes users can load their own sound patches as long as it adheres to the App's naming convention. This is an important part of our conceptual development, as there are several levels of interaction between the users and the S.A.R.A. App. Firstly, you can simply use it to interact with and enjoy the sounds of your surroundings and interactions. Secondly, you can load your own pure data (generative audio) patches into the App and use the S.A.R.A. App to drive it with your own composition. Lastly, as we are releasing the entire app open source you can rebuild and customize S.A.R.A. to suit your needs or adapt it to your liking.

S.A.R.A. is not only an interface and an interactive software application for consumption, play, discovery and joy but is a jump off point for a larger discussion on transformational strategies in regards to both S.A.R.A. as a (potentially) wearable musical/performance interface but additionally in the open source distribution of S.A.R.A. as a tool.

S.A.R.A. as a Performance Tool and Wearable Tech

Once we started to work on the application it led us to the realization that the S.A.R.A. App and interface would be best explored in a performance setting. Dance is in a way similar to synesthesia; it is another example of "cross-sensory mapping in which body rhythms effortlessly correspond to sound rhythms both kinetically and visually."[16] In dance, sound, sight and movement are all explored in a choreographed manner.

We became truly interested in adapting the system to provide a wearable hardware unit running the App with which dancers could use to produce the sonic elements via dance improvisation. Through our home institutions we were able to collaborate with a local dance troupe that agreed to utilize S.A.R.A. as part of their repertoire. This added certain questions in the usability of the App: Do we allow for a variety of mapping choices, and a variety of sound patches? Should a visual be used as well? The performance setting brought up even additional questions: How wearable can these devices be made in their current configuration? What is the best placement on the body for these devices that does not impede movement but allowing for maximum control of the App? What does it mean when one performer wears a device like this? Multiple performers? Does wearing this device change the role or mechanism of the performer? Does the lighting need to be differently thought out for the stage and performers? Should additional light be placed on the dancers if they can't be lit in traditional methods? Can other dance troupes benefit from the technology?

As a result the performance version of the S.A.R.A. App consists of the mobile device and is complemented by a pico laser projector (device at the top of Figure 4). Both are then securely mounted in a sleeve worn by each of the dancers. The sleeve is made of Neoprene, a pliable and stretch fabric that not only protects the hardware but also let's the dancers move unimpeded.

Figure 4: A pico projector, an iPod Touch and neoprene sleeve turn S.A.R.A. into a wearable dance device.

By the act of wearing this sleeve, S.A.R.A. becomes an extension of the dancer's arm and allows for natural movement to occur. The role of the performer is then augmented as they are now gatekeepers of what sounds are made as well as what images are projected. They are in control of deciding what live imagery and angles look most appealing to rebroadcast to the audience. Performers can choose to project images on themselves, their co-performers or onto the architectural structures of the venue. This format allows for a completely new interaction with wearable technology - augmenting and mediating their performance via several technological input and output mechanisms while still maintaining choreography as well as allowing for subjective choices during the performance. There is no 3D gesture mapping control. Rather than pre-scripted gestural tracking, the App allows the dancer the freedom to explore the sounds and to improvise movement and add a embodied visual spatial element to the synthesized sounds. The wearable device becomes an extension of the body almost immediately when worn.

Although within a set choreography, the performers role changes as their body's interactions directly produces sounds. The sound generated by each dancer is then transmitted wirelessly to its respective channel on the soundboard. This is done in order for the dancers to not be obstructed by any cables.

The human computer interaction between the dancers and the technology as extension of their bodies creates an altered/mediated/mitigated performance environment that is always unique to the specific performance venue.

The initial performances were in alternate spaces – at festivals and intimate art events – places where the rectangle spatial element of the stage was blurred and the performers had freedom to explore and improvise. By utilizing projectors mounted on the dancers, the screen space is transformed into something new. The emitted light explores the physical space and is no longer constrained it to a simple rectangular shape of a stage.

During various beta performances it became obvious that the lighting source needed to be on the performers body rather than from an external source. In response we decided to create a custom LED setup to provide a light source for the camera to pick up imagery more effectively. We integrated the LEDs into a neck cowl and designed the rest of the costume in white to provide a clean and reflective surface to project on. The App was also extended to allow it to transmit the visuals to a full-scale projector to provide additional light for the dancers and staging area.

Figure 5: Still image of a S.A.R.A. performance.

We were fortunate to receive funding from the National Endowment for the Arts New Media Artworks Grant as well as from both of our respective universities, Kent State University and the University of Akron and lastly from a local organization – Ingenuity Cleveland. The university funds were collaborative grants, which were geared to having students experience interdisciplinary projects. This year we have been working on a structured improvised performance with 5 dance students and were able to work with 2 students and an alumnus to design and construct the costumes and cowls. We created light up cowls containing 6 RGB LEDs that are programmable and the rest of the costume is designed in white to easily provide a surface to project on. The cowl is built so we could easily swap between two different Arduino based microcontrollers: a tiny-lily and a Wi-Fi enabled tinyduino. The tinyduino is an Arduino clone with a very small form factor. We currently use the tinylily controller that sends a pre-programmed animation to the cowl. If we switch the microcontroller to the Wi-Fi tinyduino we can control the collar program remotely and in real-time via a website or mobile phone. The cowls add a variable light source that the dancers can use with the camera. The LED’s in the cowl animate color change and the dancers can use the color to as an extra element of their improvisation. The costumes are custom fitted unitards and are made with nylon lycra. The dancers wear tunics over their form fitting body suits. The tunics are mix of mesh and organza to allow for movement and the projection to light through and allows for the visualization of a layered digital skin. The dancers can easily move in the costumes and are enjoying the extra surface to project on.

Figure 6: Dancer Caroline Dunn demonstrating the S.A.R.A. unit.

S.A.R.A. is not only a wearable interface and an interactive software application for consumption, play, and discovery but really hopefully acts as a jump off point for a larger discussion on transformational strategies, open source ideology, wearable dance technology and potential collaborations.

Open Source & Open Design

Open source is a licensing term used for software that anyone can use, modify or hack and is usually available for free.[17] Any user can custom craft and extend the S.A.R.A. software. We will provide the software under a creative commons license: Attribution, Non-commercial.[18] The technology info sheet will also be available and it is potentially possible to custom craft new versions for every performance or for other dance troupes to adapt the technology with their artistic vision. Creating the App for an existing platform device such as an iPod touch and utilizing a relatively inexpensive laser pico projector (<$500) S.A.R.A. can be added relatively simply and cheaply as a versatile tool to their technology performance toolkit. Therefore the artwork we created provides a new tool set for other artists. Open source allows for stronger community participation, infusing a level of creative energy that can be integrated into the extension of the project. Open sourcing the App should create a community of invested users that contribute to the artistic dialogue.

Conclusion

In conclusion S.A.R.A. has advanced from a simple idea of creating a synesthetically inspired App for a mobile device to a full-scale tool for artists utilizing dance and media in their work. Furthermore it will allow for customization via the use of open source software and by releasing the entire software open source. The hardware tech sheet and the sleeve pattern will also be available for review.

The choreography with the S.A.R.A. App at its center-piece has been performed over 18 times in different venues, attracting in combination over 1000 spectators. Beginning in Fall 2011, after the receipt of the National Endowment for the Arts grant, the App and the performance have seen several iterations culminating in it’s final official release at s-a-r-a.com, the iTunes store and Google play this Fall 2014 at ingenuityfest in Cleveland, OH.

It is our sincerest hope that the artwork we created provides a new tool set for other artists, designers makers and scientists alike. It is our belief that the democratic access to the idea and the execution will cast a greater circle of interest for the work. We are relinquishing control over the project by sharing the original idea, in the hopes that fruitful collaborations, with S.A.R.A. as the centerpiece can develop over time. It is our opinion that open source allows for stronger community participation, infusing a level of creative energy that can be integrated into the extension of the project, in turn creating a community of invested users that contribute to the artistic dialogue. Given the community full access to our research findings and conceptual process shall reinvigorate the discussion about synesthesia, wearable dance interfaces, open source and media performance at large.

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