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Creating Generative Art through Processing using Heart Rate Sensing

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Abstract: ***Art is a beautiful form of expression and should not be hurdled by impairments of any form. Impairments such as partial forms of paralysis and various conditions that cause loss of muscle movement are obstacles faced while trying to make various artforms. Keeping the interests of the patient into consideration, and trying to provide a means of entertainment by helping the patient feel productive, an attempt is being made to achieve the same. The idea is to integrate and enhance the concept of generative art by implementing it using a heart rate sensor, which allows people to create different artworks by using their heart rate as a parameter that will affect the artwork being generated. Through the help of various software pertaining to generative art an extensive inclusion of code, the output obtained from heart rate monitor helps obtain randomized, yet unique, artforms.***

Keywords: generative art, heart rate sensing, emotion detection, processing, beats per minute (bpm), RGB (red, green, blue)

I. INTRODUCTION

Generative art is a form of art production where artworks are produced by following a set of rules, a computer program or by making use of an autonomous system. Through code various parameters of the art form created can be controlled and manipulated. The more complex the code and the specifications to the parameters, the more interesting, and even at times unpredictable the artworks formed.

The systems controlling the generation of artworks are called autonomous systems. These systems can be controlled by the use of code and this is what makes generation of artworks virtually possible. The artwork formed by the autonomous systems are system dependent rather than user dependent, although the user can have their say by making relevant manipulations or by developing the system and specifying its parameters in accordance to the required results.

Types of generative art are:

- Music
- Live coding
- Visual art
- Architecture
- Software art (Fig.1, Fig.2) etc.

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Fig.1 VVRRR, Manolo Gamboa Naon

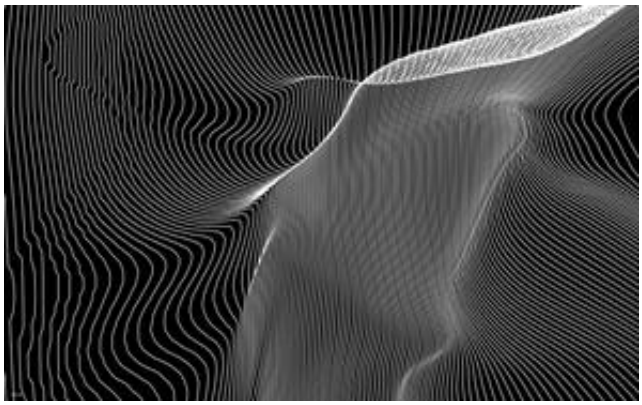

Fig.2 Floating lines in deep space

Various paralytic deceases should not be an obstacle to the generation of art. Keeping the interests of the patient in mind, we are trying to achieve the possibility for people suffering with paralytic deceases to generate artworks which then could be used commercially. This not only helps elicit the patients' exulting feelings but also gives them a sense of purpose in society.

II. LITERATURE SURVEY

Here, Philip Galanter [1] offers a definition of generative art. Not just application but in theory, the expansive nature and possible outcomes of it are also explored, thus making our understanding of the subject better. This is achieved by disintegration of the question and trying to answer it separately, that being, "what is art" and "what is generative". Order and disorder of information in systems, algorithmic complexities and the relation between generative art systems and complexity theory are explored, and the concept is looked at from various perspectives of different approaches to achieve the same.

A most interesting of theories is produced that suggests that generative art is not just art generated though computers but it also could be in the form of hand-made art.

Selcuk ARTUT [2] explores the aesthetic constituents and procedural methodologies shared amongst futurism art and computational generative art. Conceptualization of procedural repetition and recursion and the dynamism of abstraction in artworks is discussed. Implementations of Futurism art by various artists is discussed. Works of artists like Yves Klein, Giacomo Balla, Casey Reas and Joshua Davis are talked about, pointing out the various ways in which they have used procedural repetitions and recursion to create different abstract forms of computer based generative art. The idea that Futurism art and computer based generative art are very similar in their endeavor of creation of art is emphasized with an acknowledgement of their inevitable dissimilarities.

Christopher Fry [3] considers the characteristics of Generative Artworks that may shape their reception, as well as both the artist's and audience's understanding of the experience they offer. He suggests that the relationship between an artists and their work plays an important role in the reception of the art, similar to audience's relationship with the art dictated by their perceivance and interpretation of the work. Christopher points out that the complexity of the system is not a necessity in generation of complex and virtuous artworks. The opacity of code, at some level considered necessary, results in various interpretations and misinterpretations of the artwork. Ultimately, the difference in perspective, understanding and circumstances results in a catalogue of receptions of various generative artworks making the it lively and enchanting.

Vlatko Ceric [4] explores the various ways algorithms, math and the parameters involved dictate the art that is generated. The inclusive and collaborative nature of mathematics and art is explored and the extensive use of this concept by artists during the Renaissance is looked at. Computer programs and algorithms have resulted in producing rational and aesthetic visual arts. The norm that computer generated art is not a direct result of what the artist is trying to produce or that the artist is in no way directly affecting the generated artwork is kept aside and instead the idea that the created algorithm and it's mathematical parameters are a direct implication and means through which the artist is producing the desired artwork, is looked at.

Bandana Mallick [5] et al, getting live readings of heart rate of a person and displays it, thus monitoring the heart rate of a person. By keeping track of the heart rate of a person their data can be stored and used for later studies. This is achieved by the use of a finger-tip sensor which uses an infra-red LED to sense the heart beats and transfer the signal to a computer device through an Arduino UNO. With the help of code pertaining to the Arduino device, the data is then transferred to processing software. The processing software in turn, with the help of some code in the processing environment, displays the heart rate of the person. Untimely deaths due to cardiovascular deceases can thus be prevented, by sending alert SMS to mobile devices. The recorded heart rate values are not accurate due to noise. Further enhancements can be made by using high quality sensors. In this paper Valderas MT [6] et al, recognized human emotions by analyzing their heart rate variability (HRV) and analyze various spectral bands to obtain respiratory frequencies. By analyzing the HRV, corresponding temporal and frequency indices are studied to categorize three different emotions i.e, fear, joy, relaxed. Significant differences in the values of the indices, such as heart rate mean (HRM), the standard deviation of consecutive normal beats (SDNN), the standard deviation of successive differences between adjacent normal beats (SDSD), the root mean square of successive differences between adjacent normal beats (RMSSD), and the proportion of beats that differ more than 50 ms (pNN50) were obtained corresponding to the emotions thus making it a viable option to successfully recognize emotions through heart rate sensing. A database of electrocardiogram (ECG), respiration, blood pressure (BP), skin temperature (ST) and galvanic skin response (GSR) for twenty five subjects was recorded during induced emotion experiments at University of Zaragoza. Cases where the RF was found lower than 0.20 Hz, the bandwidth of the HF band decreased dramatically, thus frequencies below 0.20 Hz were not considered. Inclusion of other HRV indices such as nonlinear could improve the accuracy of classification of emotions.

Nanang Husin [7] et al, have used heart rate as a means of biometric to differentiate people. The analysis is done by using an Arduino to detect and compare the heart rate patterns of different people. Samples were taken in the form of heart rate from at least five people. Samples were taken at a duration of one hour from each person. The results obtained, form concurrent evidence that heart pulse pattern varies in different people. Thus, this method can be used in further enhancements in identification of people. Improvements in sensor quality and algorithm can be made to improve the accuracy of the heart rate patterns obtained.

Alex Lobos [8] elaborates on the idea of human and computer collaboration for generative art creation and its impact on product designing. Methodologies discussed in product design are Voronoi patterns, Procedural networks and generative structures that, with the use of Autodesk software, like AutoCAD and Maya show the implementation of generative art on product designing. By increased use of automated designing methods we can find a right balance of functionality and aesthetics to improve product designing. More methodologies and concepts are to be explored to improve product designing.

A. Echeverría Rey [9] et al, generate paintings through emotion detection. They detect emotions through facial feature extraction by taking snaps of facial expressions of a person and with the help of haar cascades in OpenCV library use the extracted results in the generation of colored points that form a cloud like painting. Shigenobu Kobayashi's color image scale has been used to determine the color of the points. Six basic emotions are detected i.e, anger, surprise, fear, happiness, disgust and sadness. Future work may include the detection of micro-expressions with the inclusion of an active appearance model or an active shape model to improve facial feature detection.

Agnieszka Mars [10] et al, create dynamic graphics, inspired from dreams. With the help of applications like 3dsMax, it is possible to create animations that depict one's dreams. Various components and parameters are selected on the basis of Gestalt's psychology, pertaining to a person's dreams, thus creating dream-inspired images.

The images in between the rest are software generated, resulting in a dream-inspired animation sequence. This helps in dream interpretation and introspection. The use of less complex shapes and colors is made. Changes in this respect may lead into improved and more accurate results.

A. Inference

A clear understanding of the definition and field of generative art is obtained. Creating artworks through code is a dynamic and extensive process producing aesthetic results. Various methodologies and algorithms can be used to create generative art. Difference in interpretation of generative art from the perspective of artists and audience results in different receptions of the work. Various methodologies such as heart rate sensing, skin conductance, facial feature detection can be used for emotion detection. Heart rate can be used to differentiate people as heart rate pulse patterns are different in different individuals. With the help of heart rate sensors and Arduino toolkit it is possible to detect heart rate. With the help of a biometric signal, such as facial features, from an individual, it is possible to generate artworks. Generative art is having a major impact in the line of product designing and is proving to be a great benefit for most artists in this line of work.

III. METHODOLOGY

The idea is to find a way for people suffering from paralytic deceases to create artwork. Further commercialization of the artwork may invoke a sense of productivity and contributiveness to the society. The fact that such people are constricted with lack of limb movements poses an obstacle in their attempts to create artworks. With the help of computer software such as processing and the incorporation of heart rate sensing to it, this is made possible.

Heart rate is a biometric signal that serves as a means for making the generated artwork unique to the person whose signal it is. A person's heart rate is detected with the help of a heart rate sensor which is connected to an Arduino UNO. The Arduino then converts the analog signal to digital signal and is then fed to the code. The recorded readings are then converted to beats per minute (bpm). This value is then fed to the code in Processing software. The code uses the bpm value as a parameter to help affect the generation of artworks.

The bpm value is used to detect the emotions of the person. This detection process is based on the data and findings of Valderas MT [6] et al, in their paper "Human Emotion Recognition Using Heart Rate Variability Analysis with Spectral Bands Based on Respiration". Knowing the emotion of the person, by following the concepts of color psychology and shape psychology the artworks can accordingly be generated.

There are three emotions that are being detected on the basis of the person's bpm value, i.e, Relaxed/Calm, Joy/Amusement, Fear/Anger. The generated art's colors and shapes are in correspondence to the detected emotion based on the principles of color psychology and shape psychology.

A. Algorithm

//Arduino software

Step 1: Heart rate value is read

Step 2: BPM is calculated by calculating average time between last 10 readings and dividing 60000 with it

Step 3: Send the BPM value to Processing using Serial.println(heart_rate)

//Processing software

Step 4: f = processing serial input

Step 5: if (f < 70) draw circles at random positions with RGB values (0, 128, 128), (0, 255, 255) and (0,255,127)

Step 6: if (f > 80) draw ellipses of random dimensions at random positions with RGB values (220, 20, 60), (255, 0, 0) and (240, 128, 128)

Step 7: if (70 < f < 80) draw triangles at random positions with RGB values (255, 165, 0), (255, 255, 0) and (255, 140, 0)

B. Equation

The equation is used to calculate the bpm value of a person, given that the heart rate readings are recorded. It is necessary to know the value, so that it can be used as a parameter to dictate the generation of the artwork. BPM is calculated by calculating average time between last 10 readings and dividing 60000 (as one minute has 60000 milliseconds in it) with it. This then gives us the bpm value.

$$BPM = 60000/RunningTotal \quad (1)$$

BPM is the beats per minute. RunningTotal is the average of the sum of time intervals of the last 10 readings. The bpm is calculated by dividing 60000 (as one minute has 60000 milliseconds in it) with RunningTotal.

IV. RESULTS AND DISCUSSIONS

By using the calculated bpm value and following the principals of color psychology and shape psychology artworks are generated. Zan Armstrong [11] in her article "The Shapes of Emotions" has talked about how each emotion has its own shape, color and animation. The shapes that are talked about are represented in the form of graphs and are given certain colors in accordance with the emotion they represent. On the website Colour Affects [12], the various properties of color from a psychological aspect is talked about. In accordance with the referred studies, the artworks produced have their respective shapes and colors. Given the case the bpm is less than 70, the detected emotion is that of calmness. The art generated contains soothing colors such as blue, teal and light green and shapes with curves and stability such as a circle as shown in Fig.3. If the bpm value is between 70 and 80, the detected emotion is that of joy. The art as shown in Fig.4, shows colors like orange, yellow and salmon, and the shapes are curved yet unstable i.e, ellipses with random dimensions. And finally, if the bpm value is greater than 80, the detected emotion is that of fear or anger. The art generated as shown in Fig.5, generates colors like red, crimson and light coral, and the shape produced depicts edginess like that of a triangle.

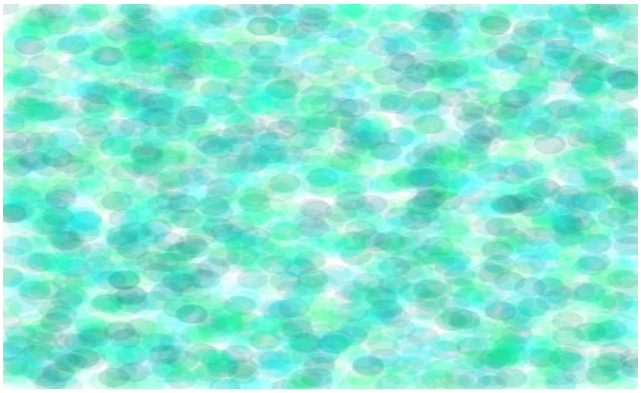

Fig.3 Calm

Fig.4 Joy

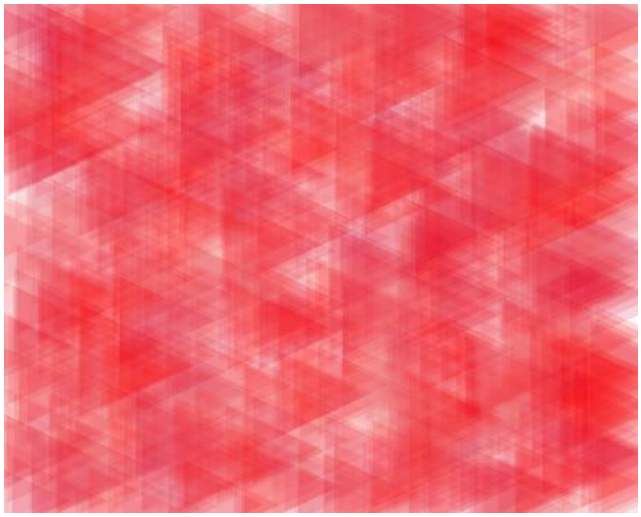

Fig.5 Anger

Table.1 BPM readings and corresponding results

Sr. No	BPM	Emotion	Color	Shape
1.	68	Calm	Blue/Teal/Light green	Circle
2.	71	Joy	Orange/Yellow/Salmon	Ellipse of random dimensions
3.	66	Calm	Blue/Teal/Light green	Circle
4.	83	Fear	Red/Crimson/Light coral	Triangle
5.	77	Joy	Orange/Yellow/Salmon	Ellipse of random dimensions

As shown in Table.1, heart rate readings from different people are taken and their corresponding emotions are obtained. Through the processing software art is generated containing shapes and colors in accordance to color psychology and shape psychology. As bpm value varies constantly, the art is generated accordingly, superimposed the previously generated art as shown in Fig.6.

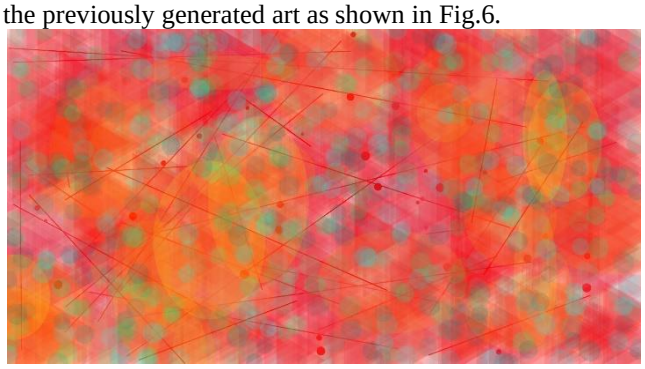

Fig.6 Result when constant change in bpm is observed

Line segments and dots of random dimensions and positioning are generated in case of bpm going above 90, for aesthetic appeal.

V. CONCLUSION

Generative art is the generation of various artforms by following a set of rules in a procedural format. There are various approaches and methodologies to achieve aesthetic and abstract forms of generative art. These concepts can make the use of bio signal parameters like facial feature detection, heart rate sensing, skin conductance etc., to achieve the same. Detection of heart rate through heart rate sensing is possible, and further inclusion of it as a parameter in the generation of art can act as a means for paralysis patients to be able to generate artwork. The calculated value is used to detect the emotions of the person and thus generate artworks containing shapes and colors that are in accordance with the principles of color psychology and shape psychology. Future improvements may include, detection of more emotions, thus resulting in a more complex and aesthetically appealing art. Better quality of sensor can help obtain more accurate readings. Inclusion of more biometric signals such as, facial feature detection, skin conductance, temperature sensing etc. can help in getting more parameters to dictate the art being generated. Optimization of code and inclusion of mathematical functions pertaining to emotions, color psychology and shape psychology may help improve results. Apart from eliciting a patient's exulting feelings, further commercialization of the artworks could help give patients a sense of productivity and contributiveness in society.

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