

# Chaos, Noise, Randomness and Coincidence as Constitutional for Generative Art

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## Abstract

In this paper we discuss the aspect of randomness in the arts and its mathematical principles. By means of two concrete examples, we are especially interested in the evolutionary process of random paintings and dynamic algorithms, related to works in computer animated generative art. Our aim is to demonstrate ways of using randomness under mathematical conditions as they are constitutional aspects for the production of contemporary art.

## 1 A Historical Overview of Randomness in the Visual Arts

The use of random, i.e., not intended structures, in the visual arts lasts probably much longer than the Italian Renaissance when Leonardo da Vinci gave the advice to use the random structures one can see on corroded, humid walls as inspirations for painting landscapes with mountains, rivers, rocks, trees etc.<sup>1</sup>. This (not expressive but constructive) attitude in getting inspiration from random structures has its today equivalent in using random noise generators to create 2d and 3d procedural texture maps with painting- and 3d animation-software algorithms [12, pp. 278–280]. The tradition of using random elements in the arts ranges from compositions of landscape and clouds with “blotting” (Alexander Cozens, Claude Lorraine, 18th century) [10, pp. 154–169] to the creation of automatic paintings and structures by surrealist techniques of the Frottage (Brass Rubbing), the Décalcomanie by Max Ernst [11, pp. 75–83] and the “Objets Trouvés” and ready mates introduced by the Dadaist and Surrealist Movement (Duchamp) [14, pp. 205–206] in the beginning of the 20th century.

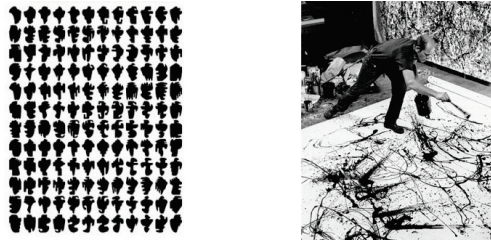
Introducing randomness and uncertainty in artworks shows two new aspects of art production. At first the origin of art is shifted from being a result of a totally planned concept to a more accidental and even easier accessible result within the production process. On the other hand this kind of randomness challenges the viewer in accepting the change of focus from technical mastery to more intellectual levels of reception. The viewer has to deal with ambiguous and inconsistent situations. This is one of the key features of modern art.

Randomness is on the same level of importance as two other significant aspects of modern art: seriality and repetition. A contemporary example of an artwork which subsumes all three categories is a piece by the artist Allan McCullum (known since the 1980s for his installations with series of identical or slightly varying objects). Over the past several years (until spring 2010) he has developed the “*Shapes Project, a system that can produce 31,000,000,000 unique two-dimensional shapes, more than enough to create an individual shape for every person on the planet.*” [19], cf. Figure 1. One of the most well known modern paintings being created without total control of the artist himself, are the so called Drip Paintings of Jackson Pollock (“Jack the Dripper”) [5, p. 47]. These could be seen as the prototypes of artworks where randomness is the constitutional factor of production, cf. [18, p. 422].

These developments (in all periods of art history also seen as accidental mistakes and artistic failure) constitute the most cliché attribute of avantgarde painting [6, pp. 168 - 171] in the 50s of the 20th century and are later transferred to ornaments in ironic appropriations by pop artists like Andy Warhol and Roy Lichtenstein. Now they are back like zombies in heavy metal logos and as an ornamental and stylistic feature in graffiti and street art tags.

Peter Bürger draws a distinction between direct (*unmittelbarer Zufall*) and indirect randomness (*mittelbarer Zufall*) [4, p. 91]. As examples for direct randomness he refers to spontaneous forms of creation in fine arts like Action Painting and Tachism, where the artist is concentrated on the process of production suspending rules of compositing

<sup>1</sup>Leonardo da Vinci, *Sämtliche Schrifte zur Malerei*, München 1990, in [11, pp. 63–65].



**Figure 1** : (l) McCollum's, *Shapes for Hamilton* [19], (r) Jackson Pollock at work (drip painting)

and form. Moreover, there is an indirect usage of randomness with exact calculated ways of composition and construction. Paraphrasing Adorno in his *Aesthetic Theory*: the subject is in total consciousness of its disempowerment through technology and puts this insight on top of its agenda [1, p. 43].

As Hans Ulrich Reck suggests: there is no randomness (Zufall) in the visual art, though many things look like accidental. What we call randomness is a peripheric factor in an extreme complex process. The viewer as well as the artist himself recognizes its impenetrability as a characteristic structure and calls its sub-structures arbitrary or random describing the modifications, changes, alterations as vaguely ephemeral<sup>2</sup>.

Using randomness in art, i.e., creating art not fully determined by the subject, is one of the strategies to undermine the heroic aspects of being an artist. According to this theory randomness is only one variable among others in a series of decisions, but always acting as a catalyst in the arts.

We will only focus our text on the use of randomness generated by algorithms used in computer software. *To create random numbers, programmers have designed a special type of algorithm called "random generator". Random generators can produce random numbers only when fed with a "seed". A seed is a number taken from somewhere outside of the algorithm (usually the time, the temperature of the processor, or other sources accessible to the algorithm).*<sup>3</sup>

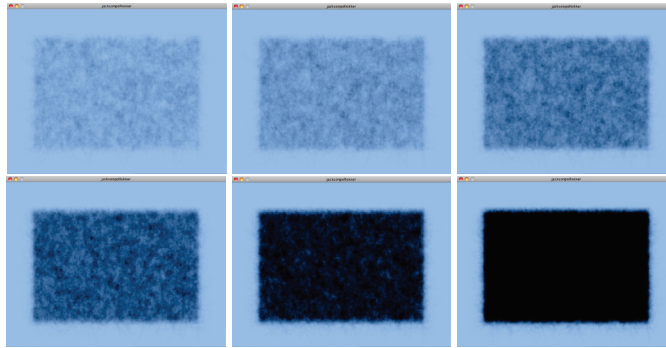
## 2 Computer Generated Randomness and Its Mathematical Description

In the following we discuss two examples for computer generated randomness and their mathematical description. Unlike the historic examples of expressionistic art we are now interested in the dynamics of animated structures. On the one hand, in Figure 2 we shall see a randomly evolving process based on uniformly distributed random numbers. Here, randomness is the seed of every single output produced by the process. On the other hand, we present the deterministic process of a higher-order nonlinear diffusion process, whose evolution is dependent on an initial "random" state, cf. Figure 3. In this case randomness only serves as an initial seed whereas the process itself is deterministic.

**Random strokes** In Figure 2 a sequences of images is shown, generated by random strokes distributed within a predefined rectangle. More precisely, the rectangle is iteratively filled with black lines with uniformly distributed random lengths, random widths, random positions and random angles. The black lines are plotted with a one percent transparency, i.e., with an rgba value of (0,0,0,0.01)[17]. The painting process consists of two nested iterations. The outer iteration is initialised with a random position within the rectangle. Then, from this position, an inner iteration draws a vertical line of random width and of random length between 0 and 10 pixels. Next the position is shifted by 8 pixels to the right, the slope of the line is altered by a random value and its width is decreased by one. This inner iteration stops when the width equals zero. Then the outer iteration starts again with a new random position and a vertical line as before. In this way, the centered rectangle is iteratively more and more filled with black and slightly

<sup>2</sup>Hans Ulrich Reck: *Aleatorik in der Bildenden Kunst*. In [9, p. 160]

<sup>3</sup>Michael Schwab, *Early Computer Art and the Meaning of Information*. April 2004 p.29. available from: [http://www.seriate.net/Early\\_Computer\\_Art.pdf](http://www.seriate.net/Early_Computer_Art.pdf)



**Figure 2 :** *Generative art à la Jackson Pollock: strokes with random colour and random position within a rectangle.*

transparent uniformly distributed random strokes. The algorithm has been written in the *Processing* software [15, 16].

**Pseudo random numbers, white noise and diffusion** The random numbers used to create our example in Figure 2 are computer generated random numbers. Namely, they are generated on the computer by special methods which are called random number generators (RNG). Most programming languages and software packages use a deterministic RNG [13]. The so generated numbers are called **pseudo random numbers**. Here, “pseudo” stands for the fact that these numbers, although they look random enough for the observer, strictly speaking they are not since they result from a deterministic process. However, for our needs of “visual” randomness the quality of this pseudo RNG is enough.

Moreover, our random numbers are **uniformly distributed** within a predefined range of values. This means that every number within this range appears with the same probability  $1/\text{range}$  [8]. In our example the position, width, length and angle of the strokes in Figure 2 are uniformly distributed random numbers.

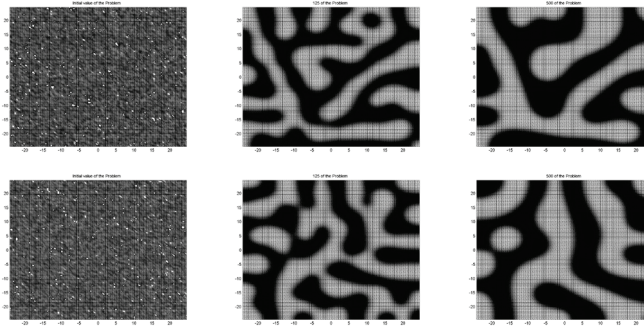
Further, the grayvalue of every random stroke in Figure 2 has an rgba value of black with a one percent transparency. This means that the grayvalue at a position  $(x, y)$  is approximately given by  $g(x, y) = \sum_i g_{(1-\alpha)} \cdot p(x, y)$ , where  $\sum$  sums over all iterations  $i$ ,  $g_{(1-\alpha)}$  denotes the grayvalue black with  $\alpha$  percent transparency, and  $p(x, y)$  is the probability that a stroke colours the pixel  $(x, y)$ . As just explained the probability  $p$  is uniformly distributed. From the central limit theorem [8] we deduce that the grayvalues  $g$  are **normally distributed**. More precisely: The central limit theorem tells us that the average of elements of a sample tends to a normal distribution as the sample size increases, regardless of the distribution of the sample except when the moments of the parent distribution do not exist. Hence, the average value of  $N$  uniformly distributed numbers is approximately normally distributed and in the limit  $N \rightarrow \infty$  exactly normally distributed. As a consequence, the averages of random colours of the strokes created in Figure 2 are normally distributed. This leads us to another interpretation of our generative process as a generator of “**white**” **noise**: statistical noise which is normally distributed.

Another consequence of the central limit theorem is the close connection of the normal distribution with a **random walk** and in the continuum limit with solutions to the diffusion equation. Roughly speaking the end points of a random walk in the plane are normally distributed and further their probability density in the continuum limit (i.e., letting the step size of the motion tend to zero) is a solution of the **diffusion equation** in the plane, i.e.,

$$\frac{\partial p(x, t)}{\partial t} = \frac{\partial^2 p(x, t)}{\partial x^2},$$

where here the time-variable takes over the role of the spatial steps for the evolution process of the random walk.

**Pattern formations** Eventually, we consider more sophisticated forms of evolutionary diffusion, i.e., highly-nonlinear and higher-order diffusions, which promise to produce visually interesting patterns. Here the “randomness” is deterministic and uniquely defined by the initial state of the evolution process, i.e., the initialisation of the process



**Figure 3:** Evolution of the Cahn-Hilliard equation for two randomly (“white noise”) chosen initial states.

by the artist. One example for two different initial states and the corresponding algorithmic dynamics are given in Figure 3 for the so-called Cahn-Hilliard equation [3].

### 3 Conclusion

We outlined the importance of randomness in generative art and its expression in computer supported, algorithm based, arts production. By means of two examples in Figure 2 and 3, we sketched the possibilities of such an algorithmic approach, also using sophisticated mathematical tools, like higher-order diffusions. In both examples the remarkable aspect of randomness lies in the dynamic evolutionary process rather than the final result only.<sup>4</sup>

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