

Toward Epidemic Computer Art

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Abstract

In this work, we are presenting an experimental system for painting, compositing and color manipulation. This is a semi-automatic generative and interactive environment using a behind the stage agent-based system, i.e. a system that is hidden, but that controls the process and the generation of color on the canvas. The design of the agent-based system is inspired and derived from epidemic modeling and it allows to generate computer images or paintings with a mix of compositing and painting techniques in a multi-layer hierarchy.

Keywords

Digital painting, generative art, epidemics.

1. Introduction

Modern painting since the 1890's has insisted on the independence of color on the canvas outside a direct representational function. Starting from the

impressionists and the cubists, the chromatic content of the canvas is not forced to have a real or obvious correspondence to a physical reality.

Inspired by this concept, we have been experimenting with agent-based systems that work behind the scenes and control the generation and flow of color in the canvas ([1] and others).

In the present work, we turn to compositing alongside simple painting by color depositing. More precisely, we want to compose two or more images that are initially placed one on top of the next in a hierarchy. The idea is that one image can "infect" another in some positions and the infections can spread around these positions and/or blend with the original. Alternatively, an image may be infected by one or more colors at one or more positions and the infections spread in the same way as before.

2. Painting epidemic process

Agent-based and artificial life systems have been employed in digital painting and more generally in art and music [2] [3]. Our agent-based system is hidden from view but controls the colors in the canvas through defining one agent per pixel and per level in the hierarchy of images, for instance in a hierarchy of 3 images there will be 3 agents for each pixel. Each agent is a virtual entity that has a set of infection features corresponding to the biological ones of a

basic SIRS epidemiological model [4]. A SIRS model takes its name from the three possible states that it defines for an agent:

- **Susceptible:** Not infected, but susceptible to being infected when in contact with an infectious agent. In our system, there is contact when two agents lie in adjacent pixels.
- **Infected:** Actually both infected and infectious. In many advanced realistic models an infected agent is not necessarily infectious or not right away after infection.
- **Recovered:** After an infection has completed a cycle of determined length.

In a pure SIR model, a recovered agent is protected for life and cannot become susceptible again, while in a SIRS model a recovered agent will become again susceptible after a certain time has elapsed. Moreover, an agent may “die” by an infection, with the result that the lower level agent at the same position will take control, if there is one. Thus, an agent defines the following epidemiological parameters:

- **state:** One of susceptible, infected, recovered.
- **pl:** Probability of infection at contact with an infected agent
- **Ti:** Duration of infection (which controls the distance of spreading on the canvas)
- **Tr:** Duration of protection after recovery
- **vulnerability:** Probability of death by the infection.

We have also introduced an additional state, quite common in epidemiological modeling:

- **Immune:** An agent immune to an infection. This is equivalent to a recovered for life agent, except that the immunity is not acquired but the agent is born with it.

The basic outcome of infection by an adjacent infected agent is the adoption of a new (infection) color that is blended with the original in this position of the canvas. The blending is such that the original color starts converging toward the new infection color with a “reactivity” or rate parameter, such that ***new_red = old_red + reactivity_red * difference (= new_red - old_red)*** and similarly for the blue and green color components. The actual color with which an agent is presented during infection may be defined in many ways that are described in the following section. One possibility is to use a specific color by agent that may in principle differ from agent to agent or across levels. All these parameters may be controlled via an epidemics editor (see system snapshot 2, editor of epidemics data). Note that the presence of immune agents, that resist to infection and change, gives an impressionistic effect.

3. Software environment

The environment is developed in the Java language and a snapshot is given below (system snapshot 1).

The epidemic process can be started in several ways:

- Infection of an image by an image at the next level of hierarchy (below)
- Infection of an image by a user-defined color
- Infection of an image by a position-specific color, defined by an agent at that position

The infection areas can be input with one of the following methods:

- Triggered with the mouse at specific positions in the canvas
- Automatic (generally with a single infection event 100 random positions on the canvas are infected)
- With a brush-tool that infects all the positions that it is driven through

For example, the sample composed images 1 and 2 use a triggered method, whereas system snapshot 1 (user interface) shows the result of a brush action with lower-level infection of the image (the level below is revealed by the brush). All these parameters may be set via a controls editor (see system snapshot 3, editor of painting controls).

After all the parameters are set, the user may run the epidemics process (button "Spread" in system snapshot 1) for a number of steps, usually a few tens of steps.

4. Potential

All the epidemics and user control parameters may be also controlled and set by the user programmatically. Co-infections, re-infections and other intricacies are possible. The methodology allows a vast range of manipulations to be explored and effects to be produced. Most importantly, there are numerous possibilities to be explored as to how two colors blend when they come into contact. Does blending depend on the relation between two colors? Do colors fade during spreading? Do some colors take precedence or show bias? These and other ideas should be the object of experimentation with different types of images, for examples real life photos and photos of paintings. Additionally, we plan

to extend the system to allow the use of advanced brushing tools such as [5][6].

5. References

[1] **E.S.Tzafestas.** Quand la complexité se trouve dans la graphique : Un outil pédagogique pour la vie artificielle, *Actes des Journées de Rochebrune 2000*, Rochebrune, France, January 2000.

[2] **C. Neufeld, B.J. Ross, W. Ralph.** The Evolution of Artistic Filters, in "The Art of Artificial Evolution, A Handbook on Evolutionary Art and Music", pp. 335-356, Springer, 2007.

[3] **G. Greenfield, P. Machado.** Ant- and Ant-Colony-Inspired ALife Visual Art, *Artificial Life* 21: 293–306, 2015.

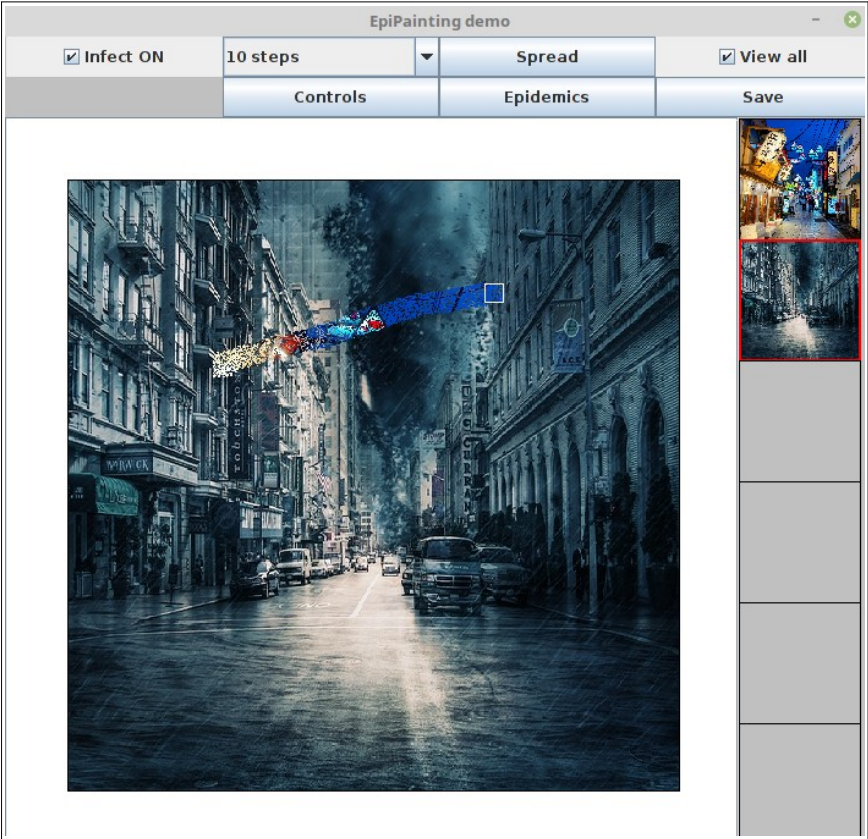
[4] **H.W. Hetchcote.** The Mathematics of Infectious Diseases, *SIAM Review*, 42(4):599-653, 2000.

[5] **E.S.Tzafestas.** Integrating Drawing Tools with Behavioral Modeling in Digital Painting, *Proceedings of the First International Workshop "Bridging the Gap: Bringing Together New Media Artists and Multimedia Technologists"*, Los Angeles, CA, November 2000, ACM Press.

[6] **K.Ryokai, S.Marti, H.Ishii.** I/O Brush: Drawing with Everyday Objects as Ink, *Proceedings of CHI 2004*, April 24-29, 2004, ACM Press.

System snapshots

1. Main user interface



2. Editor of epidemics data

Epidemic parameters			
Infection	0		Set
Ti (<=30)	10	Tr (<=1000)	10
Pi (<=1)	1.0	Immunity	0.3
Vuln min (<=0.5)	0.0	Vuln max (<=0.5)	0.1
d(R) min (<=0.8)	0.03	d(R) max (<=0.8)	0.2
d(G) min (<=0.8)	0.03	d(G) max (<=0.8)	0.2
d(B) min (<=0.8)	0.03	d(B) max (<=0.8)	0.3
Agent(R) min (<=255)	0	Agent(R) max (<=255)	255
Agent(G) min (<=255)	0	Agent(G) max (<=255)	255
Agent(B) min (<=255)	0	Agent(B) max (<=255)	255
Reset			

3. Editor of painting controls

Painting controls				
Type	BRUSH	Source	LOWER LAYER	☒ Self color
Brush shape	SQUARE	Brush size	15	☒ Irregular
User color	255	255	0	Set

Sample images

1. Original image 1



2. Original image 2



3. Original image 3



4. Original image 4

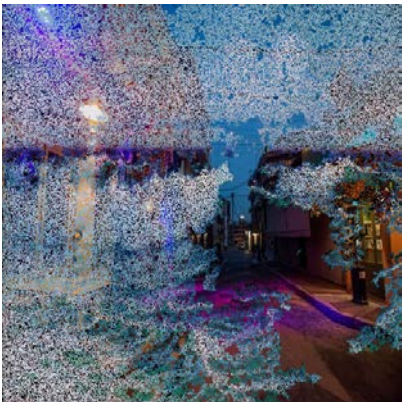


5. Composed images 1

Original image 2 on top of original image 1 and infected by it.

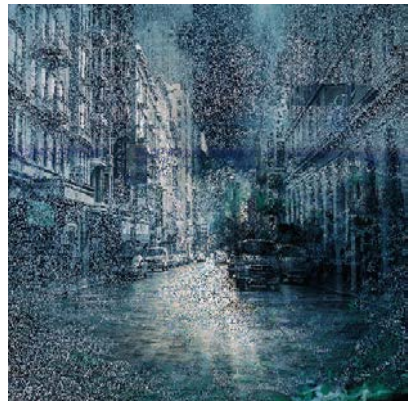
In this and the following composed image, the epidemic pl of agents is not fixed but dependent on the colors that come into contact through the agents.

Infection is point-wise, as shown in the first image below (“patches” emerge after 20 steps). The structure of the original image 1 of the lower layer starts to be visible in the second image below after 150 iterations (spreading steps), for example the long band of dark sea in the horizon. Note that a large dark area in the middle-right resists to infection and hinders spreading because the colors of the two images at this region are too close.



6. Composed images 2

In case of images of similar coloring spaces, the infections spread faster and better. Original image 1 on top of original image 3 and infected by it. Infection is brush-driven, as shown in the first image below, where the “painted” areas are visible. The original image 3 of the lower layer is largely retrievable as shown in the second image below after 150 iterations. Note also, that it is almost fully retrievable after just 30 steps, if random reinfections are allowed at every step.



7. Composed images 3

Original image 3 on top of original image 4 and infected by it. Here pl is 1 for all agents, so the infection is controlled by medium reactivities (from 0.1 to 0.4) and high vulnerabilities (from 0.4 to 0.5). The snapshots are taken at start (with a brush infection) and at $t=60$. In this case, at $t=60$ the two images blend seamlessly. But if the color palettes of two images were not close enough, the resulting images might have been surprising.

