MONDRIANULOR :
Exploring the interaction between harmonic division and coloring

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Abstract

We are proposing MOnDrianULOR, a system capable of producing visual forms based on the works of Swiss architect Le Corbusier and Dutch artist Piet Mondrian. The system produces visual forms that employ a rectangular harmonic division of the plane based on Le Corbusier's Modulor principles and a coloring scheme that may use only primary colors so as to produce the strongest visual effect, as Mondrian has suggested, or other, even random, colors. The Mondrianulor framework allows both basic research on color and structures as well as applied research in the context of architectural forms.

1. Introduction

The major concern of the complexity sciences is how simple rules can give rise to complex phenomena and, inversely, how a complex phenomenon may be explained by or "encoded" in a simple rule [10][11]. On the other hand, artists have been traditionally concerned with expressing simple ideas or feelings with complex visual forms and, inversely, with understanding how complex realities can be represented with and express simple, abstract rules [13][14][3]. Thus, both scientists and artists often depart from the position that reality is in essence simple but possesses an infinite potential for expression and representation.

The goal of our research is to bridge the intentions of scientists and artists in understanding complexity by experimenting, rather than by using arbitrary complex models to create interesting, complex or aesthetically pleasing visual forms [1][2]. To this end, we start with "minimal" expression models and we try to explore and classify the range of visual forms that they may give rise to. The term "visual form" is used here in a general everyday sense that captures all features of structure, color, manner or style, etc. Those features or elements should be explicitly defined and represented in a manner with as little arbitrariness and subjectivity as possible.

In earlier work [18][19] we have used the Fibonacci number series as such a "minimal" expression model, because it is simple (the whole series is usually represented with a single simple mathematical expression), inflexible (once started, it cannot be changed), infinite (it never ends), it is often encountered in nature and said to possess aesthetic properties, while being mathematically intriguing as well [7][6], and it has been already extensively used by at least one artist, the Italian Mario Merz [4] ("Fibonacci", 1975, "Fountain", 1978, "Igloo Fibonacci", 1970, "Fibonacci Drawing", 1977).

In [18] we have demonstrated the expressive power of our approach in a constrained 1D and 2D space with additional color control and the introduction of behavioral parameters, while in [19], the same technique has been applied to morphing of polygons using Fibonacci numbers as coordinates of control points. In both configurations, the wealth of resulting visual structures is demonstrated on a set of examples.

In the present work, we are extending the above framework and we step beyond the mere expression of simple rules in aesthetically pleasing or innovative visual forms, which are abstract in essence but demonstrate expressive power and/or potential. We achieve this by combining geometric and color properties of shapes in a more principled manner that, on the one hand, exhibits mathematical and natural relevance while, on the other hand, yielding structures that look like some created by well known artists of the modern era.

More specifically, we are proposing MOnDrianULOR, a system capable of producing visual forms based on the works of Swiss architect Le Corbusier and Dutch artist Piet Mondrian. The system produces visual forms that consist of the following:

- A rectangular harmonic division of the plane based on Le Corbusier's Modulor principles. This uses two related Fibonacci series for the two visual axes (-x and –y) and selects and shuffles randomly chosen consecutive numbers as sizes of the grid's tiles, thus yielding an irregular but harmonic grid that looks natural to the human eye.
- A coloring scheme that may use only primary colors so as to produce the strongest visual effect, as Mondrian has suggested, or other, even random, colors.

This line of research opens up new perspectives that match both abstract art concerns [15] and early computer art themes that were later abandoned [17].

2. Harmonic divisions : Modulor and beyond

Throughout the years, divisions of the plane have fascinated mathematicians and artists alike, because of the wealth of visually surprising combinations that a seemingly simple rule may produce. The most often cited and well used example in the art and science literature is the work of Dutch graphic artist M.C.Escher on RDPs, or regular divisions of the plane [16]. In Escher's view, the plane is divided regularly in squares, rectangles or parallelograms, that may be further deformed using transition rules that preserve regularities, so that the plane may be finally filled with one or more "motifs".

In the present work, we are adopting Le Corbusier's "Modulor" rule to produce divisions of the plane. Unlike Escher's regular division, however, Modulor-derived division is by no means regular, nor deformed regular in Escher's sense. Instead, the Modulor rule produces unequal or irregular divisions where any two tiles almost always differ, but the overall division's aesthetic value stems from an inherent "harmonicity" of the rule, namely the preservation of golden ratio relationships between tile sizes. Le Corbusier devised a configuration where "units" along the x- and y- axes are not unform but are defined by numbers drawn from a Fibonacci series (originally, $f[0] = 1$, $f[1] = 1$, $f[n] = f[n-1] + f[n-2]$). His originality was manifest in imagining different scales for the two axes, i.e. using two different Fibonacci series for the two axes, the so-called red and blue series, respectively. Their relation is connected to the golden number $\varphi = 1.618\ldots$ because the blue series (y-series) uses a root that is the double of that of the red series (x-series), blue[0] = 0.52 meters, red[0] = 0.26 meters, and their absolute values have been chosen by the architect to match real human measures, as explained in his book [12].

In our artificial design, we define red[0] = 6, red[1] = 9, blue[0] = 12, blue[1] = 18, but other combinations are possible. By controlling the system's parameters we can obtain various types of planar harmonic divisions :

- "Ordered" divisions along both axes, much in the classic Modulor line of thought (Figure 1).
- "Shuffled" divisions, where the "units" used in the two axes are non-consecutive red or blue series numbers and are furthermore shuffled to produce more visual complexity (Figure2).
- "Recursive" divisions again in the original Modulor spirit, where tiles may be further recursively subdivided into harmonic tilings at an arbitrary depth (Figure3).
- Divisions using distant Fibonacci numbers, that yield longitudinal tiles (Figure 4).

3. Colorings : Mondrian and beyond

Another important research theme in art and design studies is the coloring scheme, i.e. the color combinations that produce various visual effects and how to design such combinations. The Dutch pre-war artist Piet Mondrian has used extensively primary color combinations in grid-like drawings (some of them using golden rectangles, for example “Composition in Red, Yellow and Blue”, 1926) to claim purity of visual and emotional effect and consecutively philosophical relevance with the man-nature duality issue [14]. Inspired by this work, we endow each of our Modulor tiles with a color, initially primary, in an attempt to further complexify the resulting harmonic tilings. By controlling the system’s parameters we can obtain various types of colored tilings :

- Minimal divisions with bright colors, that look like flags (Figure 5) or classic Mondrian paintings (Figures 6 and 7).
- Single color divisions, which are pure Modulor combinations (Figure 8).
- Detailed multi-color recursive divisions, which look like patchworks (Figure 9).
- Divisions using random colors, which appear “fluid” or like “dirty patchworks” and have an attenuated effect, unlike pure Mondrian forms (Figure 10).

A mathematical investigation of color combinations does not exist, but this is a rather a subject of pure art research, starting from the pioneering works of Johannes Itten [8] and Wassily Kandinsky [9]. As this stage, we embrace Mondrian’s empirically sustained view of primary colorings as the fundamental harmonic colorings that induce maximal emotional effects : for example, minimal coloring may be regarded as a means to “reveal” the underlying tiling or grid structure (Figure 11). However, the wealth of colorings remains an open issue and the notion of harmony in colors from a mathematical point of view is yet to study.

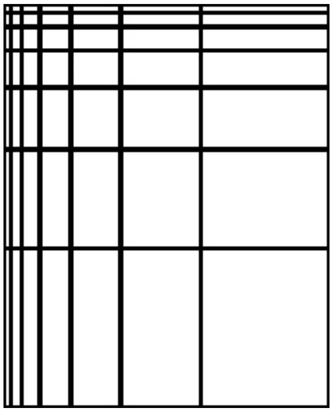
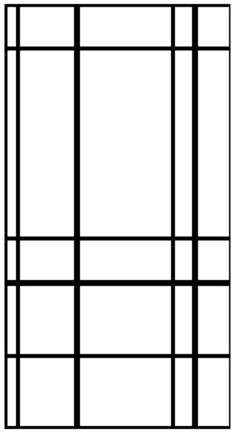
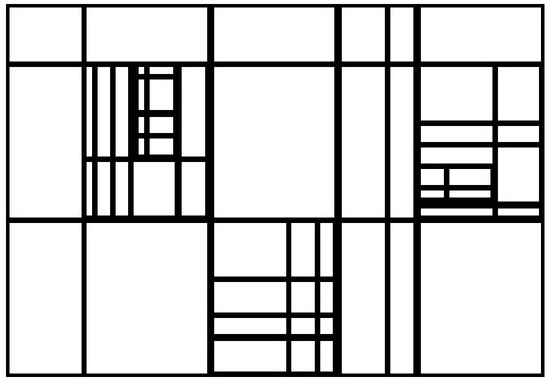
We should stress that both harmonic division and coloring produce complex structures but not necessarily interesting ones. This means that Mondrianulor cannot be used as an automatic form generator, but as a form generator controlled by a designer. Furthermore, in the case of the harmonic division, we suspect that in some cases this may be done systematically by introducing “visual corrections” to otherwise exact “harmonic designs”, in the spirit of ancient Greek architecture. Interactions with the coloring scheme are expected to uncover additional interesting structural properties.

4. Perspectives

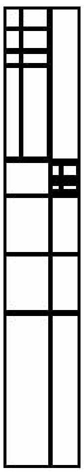
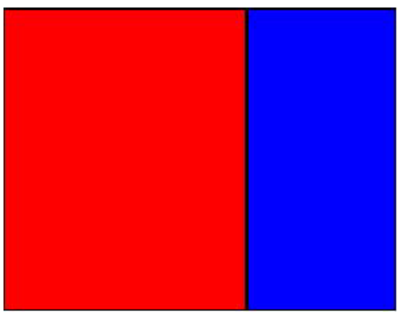
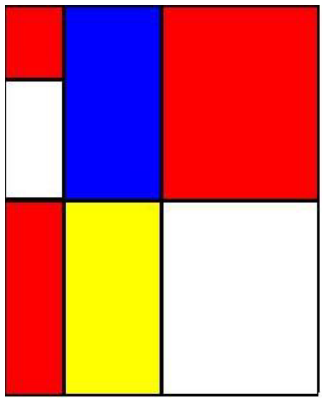
The former possibilities allow us to:

- Produce complex, but harmonic, tilings, using various coloring schemes, as standalone artworks or in order to better study their mathematical properties.
- Create complex geometric animations by defining and manipulating transitions between different divisions, again as standalone artworks or in order to study the effect of transitions of forms on perception.
- Perform experiments to understand human visual perception.
- Train users on color and integer series properties.
- Design experiments to identify the range of system parameters that define “gray regions”, i.e. regions lying midway between extreme effects, for example: (i) what combination of tile length, grid dimension and recursion depth may define forms perceivable as both almost pure Mondrian-esque and almost pure Modulor-derived figures, (ii) how many colors and in which relation to each other do we need to produce the minimal fluid effect described above.

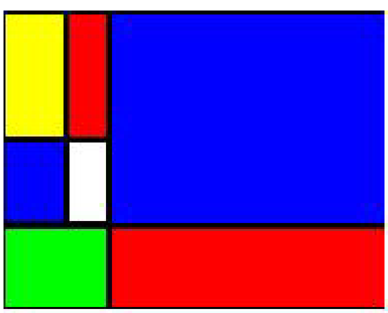
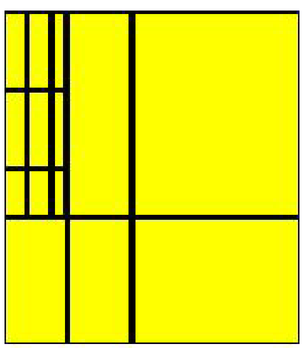
Beside visual experiments with structures and colors in an abstract way, as described above, the Mondrianulor framework presents the potential for applied research on architectural forms, like other approaches drawn from the complex adaptive systems domain [5].

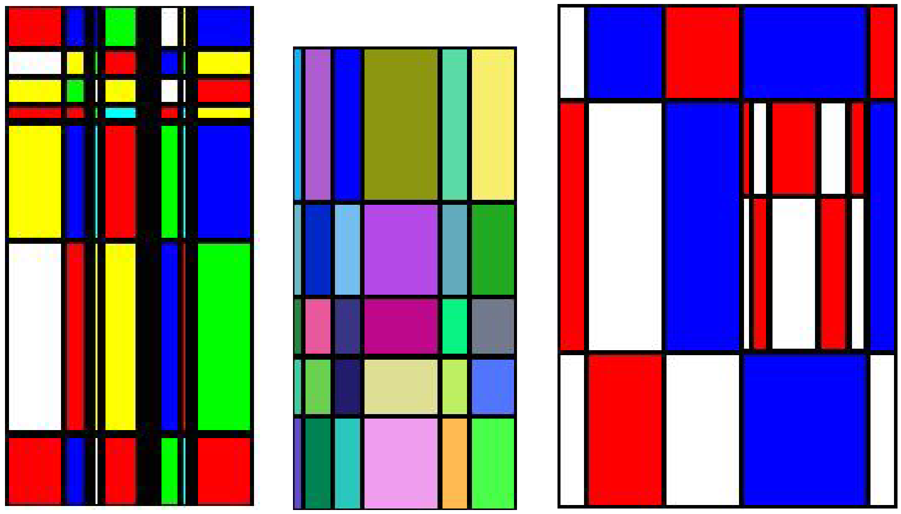
Figures 1, 2, 3

Figures 4, 5, 6

Figures 7, 8



Figures 9, 10, 11

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