On Generating Dot Paintings in the Style of Howard Arkley

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Abstract

We investigate algorithms for reverse engineering certain dot paintings by Australian born artist Howard Arkley (1951-99). Arkley's biographer John Gregory discusses his dot paintings under the category "pattern and repetition." They display a curious mix of algorithmic and random elements. We develop rules for reverse engineering some of these paintings in order to try and generate additional examples that replicate Arkley's dot painting style. Our goal is to try and better understand what compositional elements make Arkley's dot paintings so visually compelling.

1 Introduction

In December, 2008, while combing the depths of Art Gallery of Western Australia in Perth, Australia we encountered two side by side breathtaking paintings titled *Metallic* and *Ornamentic* by Howard Arkley, a painter whose name we did not immediately recognize. As it turns out, Howard Arkley (1951-99) was a well known Melbourne, Australia artist who was most famous for his vividly colored, spray painted (i.e., air brushed) exterior and interior paintings of suburbia, and for his many vividly colored wallpaper patterned paintings and modern furniture designs. The two paintings we saw in the Perth Museum are reproduced on pages 66–67 of John Gregory's biography of Arkley titled *Carnival in Suburbia: The Art of Howard Arkley* [5]. Although our original impetus for tracking down this source was to investigate the feasibility of extracting rules for algorithmically generating works similar to those we had seen, after reading the following daunting description by Gregory of *Metallic* [5, pp. 66–67] we chose to focus, instead, on some of the examples of Arkley's more accessible iconic works done in a style we call "dot painting."

> The complicated optical and geometric effects here — difficult to register adequately in reproduction — deserve detailed consideration. Hard-edged (not sprayed) black dots and fine black lines, in a discernibly regular but also rather fugitive pattern, seem to project forward from the surface of the canvas. Somewhat 'behind' them, sprayed in fuzzy black paint, float star and parallelogram or lozenge forms, derived from one of the Islamic patterns in Arkley's library.
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> In turn, several series of related lozenge and arrow forms, in sprayed paint of various hues, appear to be located a little bit deeper in space, at differing intervals depending upon their colour. These components, in red, brown, and recessive blue, seem to float against the dull glow of the scumbled coppery background, which unifies the diverse metallic tones of the decorative elements. The overall impression is of a spectacularly enhanced microscopic view into an intricate crystalline structure or organism, its components at various stages of growth or decay. Nevertheless, for all its strong illusion of three-dimensionality, the painting is also knit together on the surface by the vigorous, repetitive patterning; that is, the grid remains a dominant factor.

While many of Arkley's dot paintings are simply repeating wallpaper designs (see, for example, the painting in the installation *Homezone* [5, pp. 82–83]), or contain many regular elements (see, for example, the installation *Muzak Mural* [5, p. 64] or *Tram no. 384* [5, pp. 60–61]), the ones that we found most interesting seemed at first glance to be somewhat more random in their composition. The background paintings in the installation shown in Figure 1, Arkley's 1980 *Muzak Mural Chair Tableau* (also reproduced in [5, pp. 62-63], is the dot paining whose style we chose to reverse engineer first. Later, we also considered the Arkley dot painting *Disco* shown in Figure 2. It does not appear in [5].

Figure 1: *Muzak Mural Chair Tableau*, 1980-81, Howard Arkley, National Gallery of Victoria, Melbourne.

This paper is organized as follows. In Section 2 we survey some of the literature on replicating artist's styles. In Section 3 we begin analyze Arkley's dot paintings. In Section 4 we present further analysis and our computer generated examples. In Section 5 we give our conclusions.

2 On replicating an artist's style

As early as 1965, Noll [10] conducted a psychology experiment to see if viewers could differentiate a computer generated Mondrian from a real Mondrian. The goal of automatically generating imagery in the style of Mondrian continues to this day as is evidenced by the 2004 effort of de Silva Garza and Lores [3]. Similarly, the goal of mimicking Escher can be traced back as least as far as efforts by Kolomyjec in the early seventies [8]. "Escherization" was more broadly popularized by Kaplan and Salesin in 2000 [6]. Since then, the area of computer generated images in the style of Escher has continued to expand, with certain well-known images receiving particular attention: Kaplan [7] considers Escher's *Metamorphosis*; a series of papers by Dunham (see [4] for the most recent) focuses on Escher's *Circle Limit* hyperbolic patterns; and Sugihara [11] concentrates on Escher's *Sky and Water*. The most complete account of computer generated imagery in the style of Jackson Pollock that we are aware of is by by Lee et al. [9]. Recently, Aboufadel et al. [1] have considered the problem of generating portraits in the style of Chuck Close.

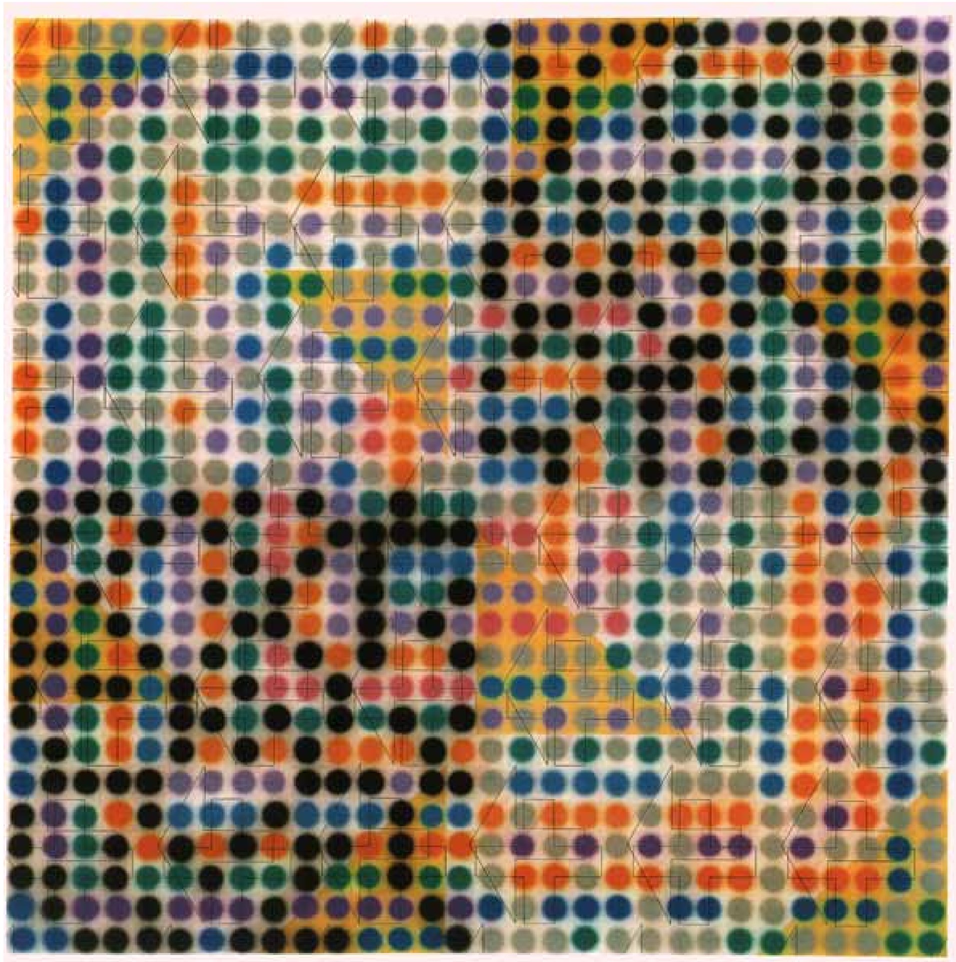

Figure 2: *Disco*, 1981, Howard Arkley.

3 An analysis of Arkley's dot paintings

There are four panels in the background of Arkley's *Muzak Mural Chair Tableau* installation (see Figure 1). If we adopt the convention that "missing dots" in those panels are not really missing, they are just invisible because they were painted using the background color, then each panel is 15 dots wide by 40 dots high. Each panel has a background color (light gray, medium gray, or yellow). Scanning left to right the background color assignments are: light gray, medium gray, yellow, light gray. Each panel also has a preponderance of (visible) dots that are grayscale — either dark gray or black. Scanning left to right the grayscale dot alignments for the panels are: dark gray, black, dark gray, black. In fact, every row of each panel has some dots that are painted in the grayscale color. A few rows of each panel consist wholly of dots that are either (invisible) or grayscale, but most rows have dots that are either grayscale or one additional color. There are four additional colors to chose from. Here we denote these four "off" colors as pink, turquoise, purple, and orange. Thus the problem of constructing, or reverse engineering, a single panel is reduced to making forty consecutive choices of off dot colors (i.e. pink, turquoise, purple, orange, or background) for rows and as these choices are made filling rows consecutively with fifteen dots in such a way that every dot in the row is either in the grayscale color or the chosen off color.

Can it really be that simple? No. Closer inspection reveals there are other considerations. Because the number of grayscale dots determines the number of off color dots in any row, the first question to address is: Can the number of grayscale dots used in a given row be chosen at random? Examining the rows that are visible in the left most panel of Figure 1 reveals that the number of grayscale dots per row is restricted to lie between 4 and 9 inclusive. Moreover, the resulting row by row distribution is not uniform. Based on the data obtained from this panel, we decided to use as the distribution for grayscale dots in a row 2:4:8:7:5:5 meaning 2/31 of the time a row should contain 4 grayscale dots, 4/31 of the time it should contain 5 grayscale dots, ..., 5/31 of the time the row should contain 9 grayscale dots.

Once the number of grayscale dots d for a row has been determined, the second question to ask is: Can the positions for where to place the d grayscale dots be chosen at random? Once again, the answer is decidedly no. In the panels in Figure 1 no row has more then five consecutive grayscale dots or five consecutive off color dots. When we tried randomly placing the d dots in rows either by using the method of choosing positions at random until d dots were placed, or by using the method of placing d grayscale dots followed by $15-d$ off color dots in the row and then applying 10,000 pseudorandomly generated transpositions to the row, we always obtained at least one row with six or more consecutive dots of the same color. Because it was easier to pseudorandomly place the grayscale dots in unoccupied positions as opposed to applying permutations, we chose to use this method and then to try "repair" rows that did not satisfy the maximum five consecutive dot constraint. For us, a repair operation consisted of first searching for a subsequence of length six or more dots having the dot color of interest. If one was found then we located the longest subsequence of the other dot color. Finally, we exchanged interior dots from each of these two subsequences. Note that some care must be exercised when the other sequence is short and it is adjacent to the long sequence. For safety, we ran the repair operation four times, twice with the grayscale color as the target color of interest, and twice with the off color as the target color of interest. Further, the repair operation was implemented in such a way that even if the longest subsequence found for the target of interest was of length five, with probability one-half, a row repair was still performed. This helped further reduce the number of occurrences of contiguous subsequences of length five.

At this stage, one could argue that further constraints regarding the distribution and placement of the grayscale dots should be added. It is hard problem to theoretically predict what the distribution of contiguous (grayscale) dot subsequence lengths will actually be according to the constraints we have imposed so far. In the far left panel of Figure 1, almost 65% of the contiguous subsequences of grayscale dots have length one. These are "isolated" grayscale dots. It also appears to us that in rows where d is small the grayscale dots are rarely contiguous, and that there is a preference to have a gayscale dot start a row. Because the data is limited and sketchy, rather than add more rules about grayscale dots, we chose instead at this point to generate lots of examples and then select those images that had the fewest anomalies.

Based on Figure 1, additional rules that are needed to cover the off color dots include: (1) For each panel, the background color cannot be used as the off color in the top or bottom row; (2) For each panel, the same off color cannot be used in successive rows; (3) For two side by side panels, the off color cannot be used in the same row unless it is the background color. Although once again one might consider formulating additional rules governing off color dots, we chose to leave well enough alone and relied on our ability to generate multiple examples to help obtain images in the desired style. We note, however, that a rule that is very tempting to add (but is perhaps somewhat difficult to implement) is: When the grayscale dot color is dark gray, those rows where the off color is the background color should be approximately evenly spaced apart. We defer our analysis of the dot painting *Disco* until we have presented some examples of our results.

4 Examples

Our software implementation for reverse engineering the dot paintings shown in Figure 1 always yields two side by side 15×40 panels. Figure 3 shows an example of two side by side panels before and after our program adds the digital "blur" that we implemented to more closely approximate the spray-painted characteristics of the dots. Figure 4 shows a complete reverse engineered Figure 1 background. It uses two of our blurred side by side panel compositions with the proper background color choices and the proper grayscale dot color choices.

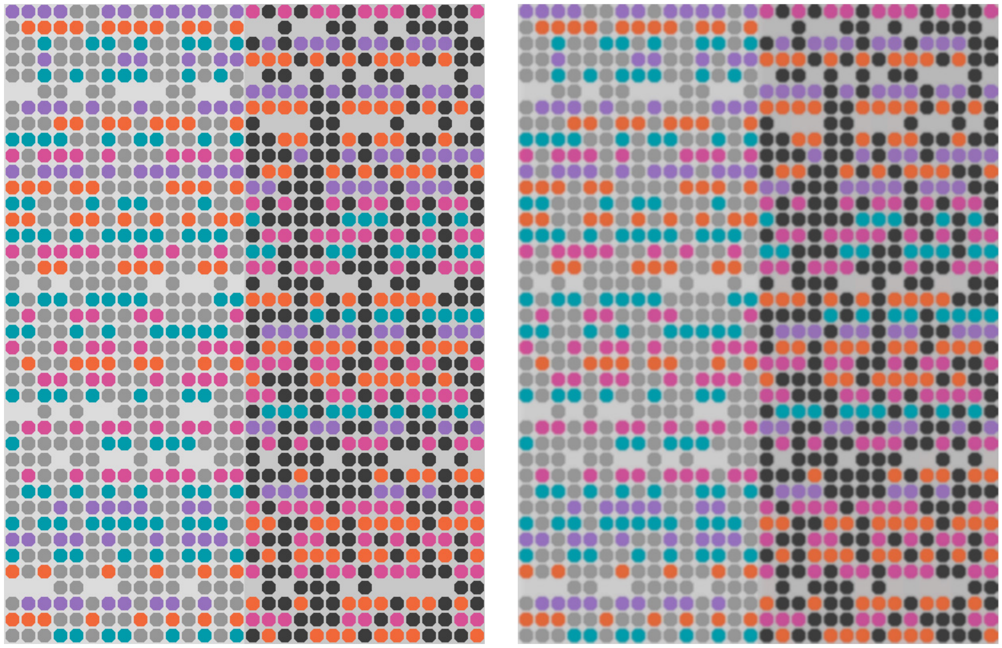

Figure 3: Side by side reverse engineered Arkley dot painting panels shown with, and without, our digital blur added to simulate the spray painted effect.

Attempting to obtain further reverse engineered examples by trying to replicate the 30×30 dot painting style of Arkley's *Disco* shown in Figure 2 was more challenging. This painting is organized into four quadrants. There is only one background color, but there are eight light orange background triangles. The grayscale dot assignments are made such that the first and third quadrants use black and the second and fourth quadrants use medium gray. There are no invisible dots here, but there are now five off colors. After grayscale dot assignments have been made for each row, instead of an off color being chosen for a row of a panel, here an off color must be chosen for a concentric square of the overall composition that has been intersected with a quadrant! Additional "rules" are explained below.

For our attempt to reverse engineer *Disco*, besides changing the panel dimensions so that we considered four 15×15 panels, we altered the number of grayscale dots per row distribution routines in our software slightly so that they yielded not 4 to 9, but 5 to 10, dots per row in the ratios 8:12:2:7:1:1 respectively, but we did not modify the row repair code. Turning next to the five off colors (pink, orange, purple, green, blue), we observed that pink only appears near the center of the composition and, as before, off-colors do not match at quadrant boundaries. That is, within a row (respectively column), it appears two row (respectively column) off-color dots that are adjacent should have different off-colors if they lie in different quadrants. Further, it appears that if two horizontally adjacent or vertically adjacent off color dots lie in different concentric squares yet lie within the same quadrant then they should have different colors. Well, once again, not quite. It is an interesting question as to whether or not in *Disco* the instance of the off color green being used for two adjacent concentric squares in the upper left quadrant or the instance of dots from four concentric squares in quadrant one "spilling over" into quadrant four (i.e. the four dots that are at the far right of the top row of the lower right quadrant that are colored blue, green, orange, and black respectively), are intentional exceptions or accidental exceptions to these two rules. Be that as it may, we enforced these two rules.

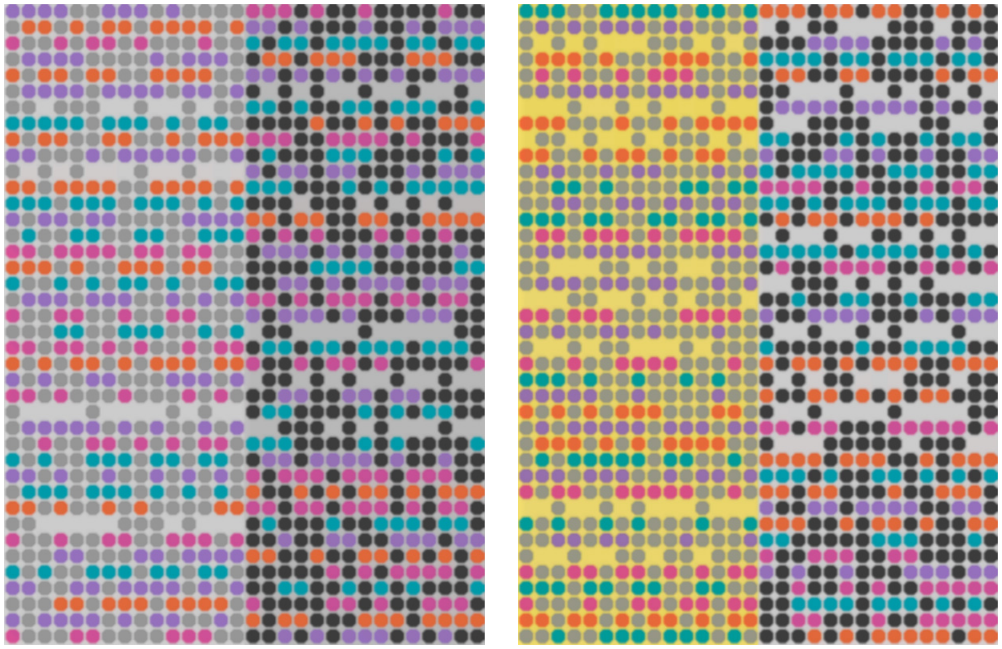

Figure 4: An example of our mural background dot paintings in the style of Arkley (compare with Figure 1).

It is also not clear how often the four off colors in the quadrants determined by a fixed concentric square should be distinct, thus we did not make a rule covering this situation. Nor did we try to control the distribution of off-colors with respect to the number of times they appeared in concentric squares within the quadrants. Perhaps, more importantly, we did not try to insert the hard edged underlying grid that is sometimes visible and sometimes partly obscured in *Disco* into our algorithmic composition. Besides the anti-aliasing problem one would encounter when trying to implement this effect digitally at the level of pixels, a comment in [5] suggests that Arkley copied patterns from Islamic art books found in his library when employing this effect, and if this is indeed the case, the overpainting in *Disco* makes it difficult to infer what the underlying pattern really might have been.

Out effort to replicate *Disco* is shown in Figure 5. A key problem with trying to digitally replicate *Disco* is its physicality. By this we mean the resulting imperfections such as the dot colors not being uniform and the registration not being perfect. Even the dot blur is not very uniform. Some dots "pop" more than others and some exhibit more color bleeding than others. The problem of dirtying-up crisp, clean computer graphics images for computer animation or computer games (and now for computer generated art?) in order to add more realism and physicality is a notoriously difficult one.

5 Conclusions

In commenting on Arkley's development as an artist, with respect to Arkley's compositions that Gregory classified as pattern and repetition, Gregory makes note of "Arkley's rapidly developing technical skill and visual intelligence" [5, p. 67]. By closely analyzing dot paintings examples such as the ones we have considered here for possible rules and algorithms, we hope we have established additional insight into Arkley's mastery in this domain. Our insight is that Arkley's "visual intelligence" was not the result of relying only on random effects. We are almost certain that Arkley did not formulate explicit rules. We hope we have shed some light on some of the possible underlying principles that make Arkley's dot paintings so compelling.

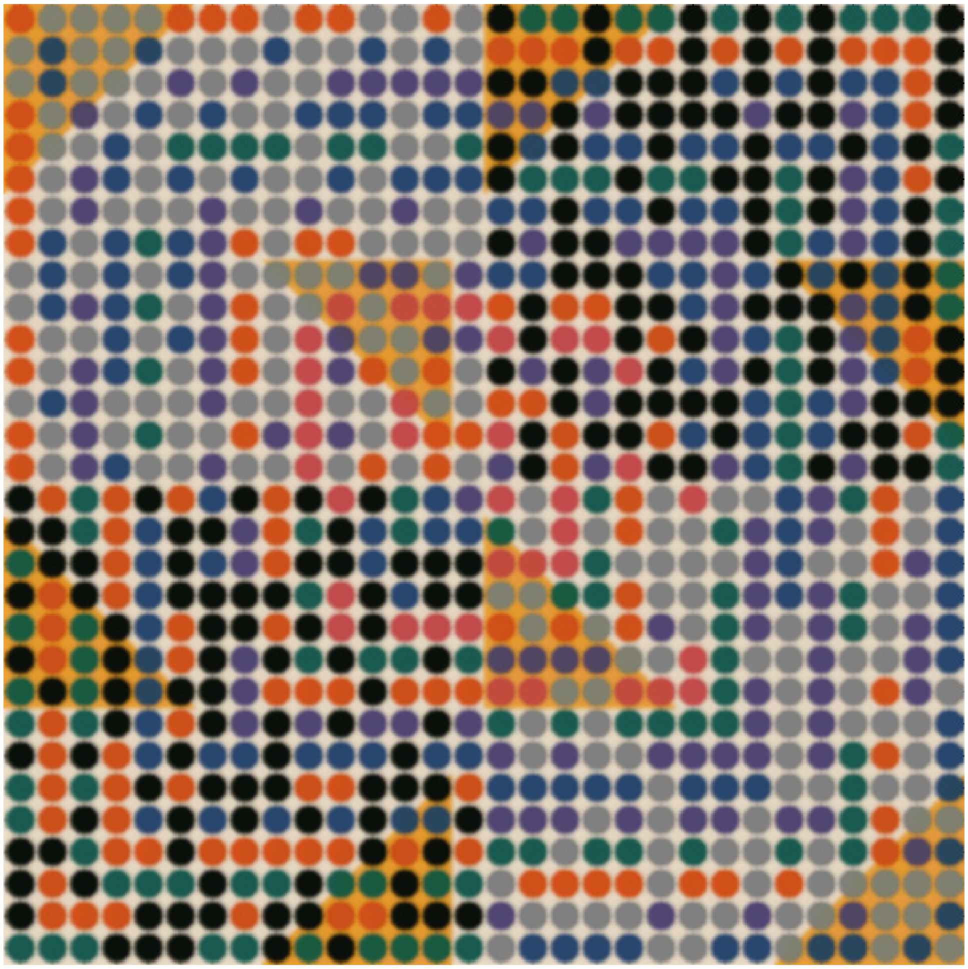

Figure 5: An example of a dot painting in the style of Arkley's *Disco* (compare with Figure 2). Replicating this painting offers more of a challenge.

Of what use are the replicated images we have digitally created? Our purpose is not too flood the market with "fake" Arkley's, or to devalue his work. Ethical questions surrounding the endeavor of programming autonomous digital artists, ethical issues in research on computational creativity, and the uses of works of art "in the style of" are contentious topics, perhaps even more so in the discipline of music than in the visual arts. For example, in order not to devalue the work, as cited in Boden [2, p. 33], David Cope destroyed his *music* stylization program *Emmy* which composed musical pieces modeled after Bach, Beethoven and Chopin so that *Emmy* would have a finite oeuvre! Thus we feel it is important to repeat one last time that our objective is not to mimic or devalue Arkley but simply to try and discern whether the compositional elements that make his work so creative can be extracted and codified.

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