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Digital Circlism: Algorithm for Generation of Artistic Images by Human Computer Interface

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Abstract. Algorithmic programming is being used recently to generate visual effects templates in place of existing platforms like ADOBE or COREL Painter used to simulate textures and visual transformation on two-higher preference for digital circlism in at least 3 categories while one category namely, dimensional input images. Recently the Coin Denominational algorithm for Packing Circles have been used to generate circle textures over input imagery. Some amount of human intelligence, heuristics and algorithmic packing may transform imagery to create the kind of art that has been counted among the prized collections of our heritage. Starting from the filled in segments of primitive petroglyphs, Roman mosaics, to the pointillism of Seurat and the cubists, texture has been central to the artistic discourse. More importantly, this project takes its departure from digital circlism to analyze and assess why it creates aesthetic effects.

Keywords: Digital circlism, algorithmic art, pointillism, texture, machine art.

1 Introduction

Digital circlism has emerged in recent years for enhancing basic input images. Such enhancements generate novel and exotic artistic effects for viewers (Demaine 2010; Bhowmik and De 2013). Packing produces better articulation and consequently complex artistic experiences for the viewer. In principle, it secures effects similar to those evoked by nineteenth century impressionists who used brushstrokes to articulate objects and perspectives. Similarly, we know that 'pointillism' evolved as a technique in which points or dots of paint filled up surface areas for denotation of features and colors on landscapes. We may say for example, that effects produced by circlism resemble the pointillistic color distribution of Georges Seurat's neo-impressionist classic *La Gran Jatteue* (1884), which essentially consists of dots with points of color to fill planar segments.

But given the smooth effects of organization brought around by Seurat's points of color (which have a distribution pattern similar to circle-filling in digital circlistic technique), what – we may ask – are the common cognitively incumbent factors for this often artistically satisfactory perception?

If circles, like points are being packed to create a visual surface: what are the reasons behind their perceptual success? Could we possibly suggest a computational model for better articulation of segments within a scheme?

There is no doubt that packing circles into segments creates texture and consequently increases the psychological (perceptual) effects of the image (Meihoefer 1973; Levi and Klein 2000). This visual process has been already exploited by professional artists who have mostly used software like Photoshop CS4, *Studio Artist* or *Corel Painter* to simulate textures having exotic and visually complex surface-features and effects. Experts on Photoshop *Filter Forge* have used exclusive filters for packing geometrical units and composites over image segments. Now NP-hard *Euclidean Distance Transform* algorithms helps in programming similar visual effects with great reduction in time and effort.

Whereas previously an immense amount of time was needed to fill up segment-planes in a manual manner now a predictive algorithm-based program (coupled with some human intelligence) can render the same effects very quickly. The artist does not need the time to fill up the space since the algorithm itself covers designated contour bound areas. That this represents a further step in the direction of *Machine Generated Visual Art* (henceforth MGVA) there is no doubt. We shall try to underscore how MGVA may be used to achieve better results on a scale of perceptual preference for *novelty* in visual images. Depending on the success of MGVA programs we should be able to suggest whether or not machines could be capable of feeding the hunger of innovations in visual art, a tendency which has also marked conventional practices art history.

Instances of 'circlist' or more precisely packing techniques are found way back in time in Roman mosaics - although they use mostly the square shaped tesserae, sometimes with curved edges to create constitutive color blocks. Circular tesserae appears in Aztec turquoise mosaics representing circular eyes or ornaments on animal and supernatural divinities in the Great Temple of Tenochtitlan (McEwan 2006).

Experience show that in most cases involving circlism both in portraits and landscapes digital circlism produces considerable cognitive harmony. Our objective here is to demonstrate that packing based improvisations could be quickly and effectively exploited for aesthetic consumptions. A set of conventional images from cross-cultural and (pre-)historical art specimens was used as sample for examining perceptual satisfaction following Cupchik (2009) and Bullot's research on aesthetic satisfaction (Bullot 2013). A whole range of images, which create effects similar to packing - from aboriginal 'dot art' to nineteenth century post-impressionist 'pointillism' are chosen for response elicitation.

Responses were collected from subjects who are mostly experts or well initiated in the discourse of arts. In the next step of our investigations, examples of circlist art generated with coin denominational circle packing techniques were used to test perceptual success achieved with human-computer MGVA. For this purpose, we developed a set of inclusive and representative visual effects with circle packing algorithm on coin denominated EDT programming developed at our laboratories. ANOVA findings were based on (a) experts opinion on effects of aesthetic value and satisfaction first for conventional art-historical images and then for (b) images simulated at the IIT labs.

A comparision of results indicates possibilities and future directions future directions of machine art (Sephar 1988 Güçlütürk 2016). The problem of effects achieved with digital circlism need not be addressed at the fundamental level of aesthetic 'emotions' elicited as Cupchik (2009) or Zeki suggests (Cupchik et al. 2009; Lengen 2015).

Questions of ‘perceptual organization’ are more immediately relevant to this process. Visual effects of creative surprise and attention elicited by such imagery may be measured within shorter temporal limits (Tschacher et al. 2012; Ostrovsky and Shobe 2015; Marin 2016).

A brief history of the literature on psychological models of aesthetic perception would show that we need to develop a new satisfaction scale (Appendix A and B). So far research on aesthetic effects concentrates on aesthetic preference (Ramachandran and Hirstein 1999), color (Zeki 1980) symmetry and also, what is more relevant for us, gestalt (Arnheim 1954;;Locher 2003). In this case, we are perhaps looking at a questionnaire incorporating Need for Cognitive Closure (NFC) patterns in digital circlist imagery (Wiersema 2012). We thus developed a new aesthetics questionnaire on a proto-Likert scale, as well as ANOVA for closure with circle geometry (Kovacs and Julesz 1993; Levi and Klein 2000).

2 Suggested Possibilities of Cognitive Success With Circle Packing

Designing output images by denominational incongruent circles is an NP hard problem that has already been dealt with in non-aesthetic packing problems (Fejes Toth 1967; Dickinson 2011; Melissen 1995). If we were to posit the question of how is it that circle packing could achieve a psychologically optimal viewing experience for images we would have to take more than one factors of perception into account. There is evidence in the literature of multiple levels of integration at work for any process of perceptual organization (Hochberg and McAlister 1953; Hochberg 1999). These are also precisely the factors we had to keep in mind in deciding to build a set of circle packing effects for a set of images forwarded for a relevant satisfaction test questionnaire.

A. Circles May Be Cognitive Primitives

One answer to this problem is perhaps implicit in the fact that circles offer better visual organization than any other geometrical or polygonal form (Chow et al 2002; Kovacs and Julesz 1993; Levi and Klein 2000). In any set of images that are therefore depicted with circlistic fillings what therefore are the mental structures that are identifiable.

1. The circlism algorithm is specially suited to address an intrinsic - and perhaps the most crucially intrinsic property of vision, namely the fact that circles (or near-circular shapes) are more abundant in natural settings, along with straight or curvilinear formations (Sigman et al 2001; Chow eta al, Drezhe and Chevez 2002).

2. However, mostly if circles are indeed more abundant in nature circular contours may be more easily available than any other Euclidean shape - and this might as well be a component of organization based on experience (Field et al 1992; Chow et al 2002; Hochberg 2007; Pinna 2011).

3. The fact that curvilinear boundaries of circle arcs bind in more readily with curvilinear borders and have an overlapping effect on perception. The problem was discussed already in statistical variance analysis of gabor patches by Marr

and Hildreth (1992) and Field (1992). Therefore, it is evident that circlism will generate better results of perceptual organization – rather than other polygons, but evidence from tesserae of mosaics in the Roman and Middle Eastern architectural samples leaves the question open for other Euclidean shapes. Experiments with polygons tend generally to show that polygon edge detection samples better congruence in perceptual organization for architectural objects and edifices (Crow 1977; Mumford et al. 1987).

B. Contour Appreciation

But beyond this edge detection problem the more immediate example to consider here is that of circle packing, and the organizing principle of packing for the formation of more defined shapes in the 'figure'/ 'ground' dualism, as much as contour detection and perceptual binding between arcs. We could therefore say that contour detection and perceptual continuity - what classical Gestalt philosophers called the law of "good continuation" (Hochberg and MacAlister 1973) in matters of circles filling near-circles and ovoids is an important strategy that explains the success of perceptual organization.

That digital circlism may be a product of syncretic contour detection in which perception of both a perimetric enclosing area may be coterminous with contour binding or edge-detection. Is co-circularity a viable theme here? (Edge detection may be simultaneous with enclosure perception [Koffka 1935]). The hypothesis of good continuation has been defended with the help of quantifying measures. Perhaps digital circlism also begs a quantifying invariance analysis on responses to edge detection and congruence distance between arcs in circlism.

2.1 Contour Appreciation Ratio for Curvilinear Outline of Segments

Reasonably we could still identify contour matching as an integral feature in the hierarchical mechanism of perceptual goodness for shape detection, and of course which is not as such exclusive.

It seems that the success achieved with an EDT circlism program arises out of contour binding (Kapadia, Ito, Gilbert & Westheimer, 1995, Gilbert, Das, Ito, Kapadia & Westheimer, 1996, Lamme & Spekreijse, 1998 and Polat, Mizobe, Pettet, Kasamatsu & Norcia, 1998). Circle arcs, when packed in increasing numbers, is also proportionally increasing the metrics of binding: perhaps there is a directly proportional differential reduction in cognitive stress factors or conversely - and more plausibly for the increase in spatial coherence achieved because of contour binding.

Binding is logically better achieved with a defined outline. How is the binding factor to be calculated at all? Weber's fraction may be used to calculate an ideal arc or radian distance of the curve. The threshold has to be maintained for any successful binding act - we need to consult the literature to see if any average circle to outline can be deployed. Once an average is determined we could calculate the differential rise in binding length depending on the increase in the number of circles that are getting packed.

The question is if in this manner the comparison of contour binding to the increased contour binding achieved with successive iterations of packing may help in determining if there is an optimal level being achieved.

From common sense perspective a positively increasing contour binding length (value) will generate smooth perception. This smoothness effect might have been intuitively grasped by Seurat in his pointillistic techniques.

In this context it is necessary to point out if a sensitivity index is at work, as the “summation: area increases (Redmond et al).

C. Articulation

Not only this, a second point in this perceptual organization is that algorithms using circles as fillers may produce significant harmony by *maximizing* the number of circles for objects in the foreground, and inversely produce harmony of vision by *minimizing* the number of circles for the backdrop. This principle of foregrounding with the help of increasing density in packing parallels what Gestalt psychologists called the ‘ground’ (Koffka 1935; Wertheimer 1938).

They also refereed to this fact of perceptual organization of components on two dimensional images as the figure-ground dynamics in the Gestalt school - one in which figures (in the foreground) against an usually distant backdrop (background). Once the foreground is defined by a selective maximization of packing density for individual segments foregrounding would subsequently anticipate an artistic *articulation* involving packing to the extent of defining an object or aspect of the image. Packing density may in principle be followed in digital circlism to create impressions of relative depths in the features of objects depicted (Bhowmick and De). In individual instances of algorithmic packing the artist would have to intelligently predict or ‘check’ a range of circle or dot sizes in any task.

Articulation of ‘figure’ is achieved by means of density of circles packed into enclosed shape. There may a predictive hunger for contour binding as circles keep filling inside of a given space. Testing algorithmic circlism for a given set of digitally augmentable images demonstrates that circles act as efficacious cognitive primitives as much as for appreciation of contour and of articulation. Articulation/density is one among other factors which helps in recognition of depth of features (along with luminance, color etc. [Buhmann et al.]).

More notably one way in which depth sense is achieved is by defining a visual of an object in the foreground - already shown by Gestalt school philosophers like Wertheimer (1938) and Koffka (1935) as constituting a ‘figure’, as against the backdrop or ‘ground’.

We would posit that numerically increase in articulation or density produces or anticipates figure recognition and depth (Koffka 1935). Depth is therefore another feature of the success achieved with digital circlism that we would have to factor in for the cognitive mechanisms for circlistic enhancement of images.

Here we explore the correlation between digital circlism and success in perceptual organization for artistic effects.

Closed loops formed by enclosing *figural* areas within portraits and a directly proportional amount of contour binding offers closure, - especially seen in the kind of model generated by the EDT algorithm that enables packing of a larger number of incongruent circles for articulation of shape and contrast to figures in the foreground.

Related to the same process is the binary tendency of reducing the number of circles for better articulation of background region in a given image. Is there an inversely proportional relationship to packing parameters for the figural and background components of an image. This may be attributed again to the contour appreciation feature achieved with congruent arcs (Fields et al. 2004), as is also the case with articulated contour binding processes.

3 Multiple Depth/Articulation and Contour Appreciation are Both at Work

Some general observations to detailed finding lead us to consider the problem of how Digital packing algorithms functions in order to create satisfactory perception. Perceptual satisfaction to say the least does not depend on mere association, as empiricists observe but in terms of relational ratios between visual domains. The classic formulation of the problem is in Wertheimer and Koffka, in the dynamic interrelations between enclosures within a two-dimensional visual plane. The problem was already set by Wertheimer, Kopfermann and Koffka in the early decades of the last century by the title of the figure ground problem. Computer vision algorithm has to negotiate the figure-ground problem on the basis of vision on a two-dimensional plane.

First, there is more reason to side with Hochberg's claim and later supported by other quantitative research on the problem of perceptual goodness (Hochberg and McAlister 1953; Hochberg 2007). Recommendation for a multi-level perceptual structure may be said to have a more plausible contribution to the perception of perceptual wholeness - and this may include experiential parameters as already underlined by Johansson, Hochberg and others. In case of circlism the same contention holds to a large degree, since under all nontrivial consideration of aspects demonstrate the importance.

4 Experiments

4.1 Objectives of the Experiments

But why does algorithmic digital circlism create artistic effects? Could we possibly trace how or why algorithmic circlism generates effects typical of good aesthetic perception. How could such strong effects be generated? Perhaps the effects could be secured with human intelligence (heuristic) contributing to effective choice in increasing density for packing circles. There is a human element involved in what is an NP hard problem. But this heuristic anticipation could generate figural goodness by predicting circles on the basis of the figure ground problem in gestalt theory. Given our psychological enquiry into aesthetic textures we could possibly identify some of the sources of numerically denominated optimal circle packing algorithms for a successful generation of painting effects.

In this paper therefore we shall investigate an algorithm of packing incongruent circles for surface segments of images. The target of such algorithm is to *optimize* the number of circles within defined contours for achieving satisfactory visual experience for both specific enclosures and for total effects - perhaps in keeping with a statistical record of perceptions for a proto-Likert Primary Factor satisfaction scale (Michailidou et al. 2008; Godey 2009; Jin 2015).

The best model for assessment of the suggested good continuation method of perceptual organization should be to measure the variances of satisfaction generated in terms of circles. Good continuation theory presupposes an increase in density. Circlism achieved with the Bhowmick algorithm for example demonstrates on a layman's observable level that increasing the number of circles in the definitive inner or geometrically smaller areas is creating better perceptual continuity.

A second parallel feature of perceptual organization is reflected in the manner in which contiguous and geometrically larger areas achieve perceptual organization with minimal overlap.

5 Method

5.1 Procedure

The basic experiment consists therefore of ascertaining the degree of *perceptual satisfaction* achieved with interactive human-computer execution on task, in this case already defined as circlist filling of segments by EDT. EDT gives a measure for introducing circles with projected radii - which again creates a feedback for the designer participant. A selection of four categorical image enhancement input correlates were fed with EDT algorithm, the quadruple being selected on the art historical practices of (a) tessaraed mosaic (b) prehistoric filled-in image prototypes - as in Australian dot painting (e) pointillism (d) popular celebrity circlism on PhotoShop and Corel generated celebrity portraits. A reasonably narrow range of conventionally enhanced input prototypes were chosen to facilitate contextual recognition for algorithm based digital circlist imagery generated specifically for the experimental verification of aesthetic value and satisfaction.

Four similar categories of input images were chosen for Digital Circlist application b the EDT Coin denomination algorithmic program - and the rsultant imagery was again subjected to a sensitivity and perceptual satisfaction scale. Any measures of such activities may also be scrutinized with the help of brainwave entrainment for uch experiences and a certain exact curve of interests generated.

The differences in the responses to these two separate categories were take into account to measure the deviation in perceptual preference for two kinds of targets.

Our solution Compute Euclidean distance transform (EDT) Use EDT to pack denomination circles in different segments. DP technique of solving the coin denomination problem.f Recompute the EDT of a segment after packing a circle and then greedily check feasibility of placing the next circle.

5.2 Participants

The maximum number of participants were selected from an arts backdrop with a considerable expertise in matters of execution as well as perception (xx being expert designers, academic evaluators, xx were students from final year of graduation in an arts and technology curriculum as well as a high). The standard deviation for age, gender, expertise counted in terms of number of years of exposure to visual art prototypes generated for the experiment.

Equipment description, program etc. Elaborated in terms of bhowmick and de 201. Random space filling: Attempts to solve the problem by iterative filling. Problems

Table 1. Average of responses to images of paintings and digital circlism by participants in perception test (n = 103).

	Clarity		Color		Organization		Preference	
	Paintings	Digital	Painting	Digital	Painting	Digital	Painting	Digital
Age > 21	1.2114	1.3286	1.1829	1.5143	1.2457	1.4657	1.1114	1.3857
Age ≤ 21	1.6361	1.8814	1.6631	1.9677	1.7358	1.9407	1.5957	1.9299
Digital Artists	1.5125	1.6281	1.5193	1.7483	1.5624	1.7075	1.3946	1.6485
Art Lovers	1.6008	1.7143	1.6321	1.8552	1.7299	1.8278	1.5519	1.7691
Computer Users	1.5616	1.7217	1.5813	1.7660	1.6010	1.7709	1.4360	1.7143

Table 2. P value tests for preferences to questions of clarity, color, organization and genera preference for individual images.

P- Value for individual image pairs										
	1	2	3	4	5	6	7	Ho= Ha	Painting · Dig. Circlism	Dig. Circlism · Painting
Clarity	0.0809	0.0438	1.98E -11	0.1746	0.0404 51474	0.0006 47458	0.7445 97617	3	3	1
Color	0.0002	0.0923	5.50E -08	0.5171	0.0002 60736	0.0031 56185	0.1470 26698	3	3	1
Organization	0.0014	0.1442 04535	8.43E -10	0.0677	0.0060 86769	0.0052 67851	0.7824 26134	3	3	1
Preference	0.0003	0.6519 46506	2.32E -09	0.5549	0.0021 67947	0.0163 33574	0.3194 14029	3	3	1

Table 3. Art Lovers prefer more DC than conventional painting.

	To	Prom	P-V	Ar Lo>Ar Di
Digital Artists	63	1.683106576	0.02067807	True
Conventional Artists	73	1.791585127		

Increasing inefficiency as more and more circles are packed. Situation worsens in case of region with an arbitrary shape—a usual outcome of natural object segmentation.

6 Results

Two sets of statistical measures were obtained. In keeping with Sephar's more general claim in relation to sensitivity experiments for design with increasing complexity.

7 Conclusion

An understanding of cognitive preferences explains why packing of circles or polygonals based on segment recognition decisions will not alienate artists, but greatly reduce time and optimize the visual experience of finished products. Participants were asked to respond to a images of painting and digital circlism. Scores for at least four aspects clarity, color, organization and general visual preference were collected. Wilcox Rank sum test indicates that conventional artists have higher preference for digitl circlism.

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