Computer based generative art and my series Structure 193, Chrysé tomé, XT3, Te-XT rumor, Te-XT rumor automat and System 25XT3

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Abstract

I have been concerned with computer generative art (CGA) since the late 1970s (a time, incidentally, when any explicit definition or theory of this approach were still absent). My first CGA series was titled *Structure 193.* In it, a constant number (193) of identical elements generated a structure growing from a central point, ultimately yielding a form determined by the random variation of four visually distinct types of connections between the individual elements.

From 2012 I engaged in developing an algorithm which was intended to generate elaborately structured compositions on a square-shaped surface, including circles, lines, oblongs or squares, uniquely in proportions of the golden ratio. In 2015 I proceeded to minimalize this structure, scaling it down to a network made up of three horizontal and three vertical lines observing the golden ratio, with a superposition of squares and circles, in nontransparent white and black (*XT3*). This opened up the possibility of generating an immensely rich repertoire of black-and-white square-shaped symbols, which I subjected to selection and subsequently treated in the same way as letters in a natural language text, i.e., classifying them along the lines of different frequency of the various symbols and rate of probability of their mutual positioning (*Te-XT rumor*).

The following programme (*Te-XT rumor automat*) involved the linking of the individual elements along lines determined by their neighbourhood in both directions (division of square-shaped format). Its follow up (*System 25XT3*) consisted in the random pick of a central element to which the programme added further elements starting from the centre, observing corresponding proportional divisions. The

composition thus grew in a manner determined alternatively by newly specified elements and division axes. The originnal black-and-white palette was transformed to the combinations of white-grey-black, or white and three shades of grey.

An outstanding issue confronting computer generative art is the question of a point at which a programme of this type can be regarded as a manifestation of artificial intelligence. While an expert system which makes decisions in “search space” – i.e., one which picks correct answers – is standardly classified as intelligent, it is also true that in the creative domain intelligence is widely held to start only at the level of seeking out potential new formulations of questions.

1. Structure 193

During my final year of studies at Charles University´s Faculty of Arts, I began to ponder the possibility of exploring the correlation between the variability of form and the rationally, statistically defined rules of its origin. I then found the use of a computer quite natural, surely also due to the fact that my teacher at that time was Zdeněk Sýkora, a pioneer in the field of using computers in art [1]. I was then in the process of writing, under his tutorial guidance, my master´s thesis, *Real Motion as a Medium of Art*. Its subject reflected my interest in kinetic art and the actual dynamics present in visual aratwork.

Between 1979 and 1985 I made a computer generative series (at a time when this approach was still waiting for a precise definition and theoretical framework) [2], [3]. The series is named *Structure 193*, with an explanatory subtitle, *Study of a Finite Plane Structure.* In it, a constant number (193) of identical elements generated a structure growing from a central point, ultimately yielding a form determined by the random variation of four visually distinct types of connections between the individual elements. The process of connecting was statistically determined. One of its outputs was a set of 30 silkscreen prints, four paper reliefs, and one three-dimensional object (see Fig. 1). After its completion, I published information about this series in 1988, in the journal *Constructivist forum* [4].

Fig. 1: Two silkscreen prints *from series Structure 193, 1985 (A-CON-5 a NUCL-A-0) and a paper space relief (NEGCND-1).*

2. Series Golden ratio and Chrysé tomé

From 2012 I engaged in developing an algorithm which was intended to generate elaborately structured compositions on a square-shaped surface, including circles, lines, oblongs or squares, uniquely in proportions of the golden ratio [5], [6].

2.1 Composition of Random Circles with Radiuses in a Golden Ratio Arrangement

In its initial stages, the programme´s scope was limited to randomly filling the pictorial surface with circles whose radiuses were derived from the format of the whole composition, and which were in mutual correspondence with the golden ratio (see Fig. 2).

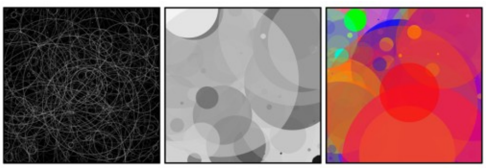

Fig. 2: Three output variants of the initial programme: ZR-022b-0348, 2012; ZR-05-1193, 2012; ZR-066-1783, 2012.

The multiplying complexity of overlapping circles brings to the fore the rudiments of a uniform structural order, induced by the radiuses´ correlated gradual incrementation. The seminal lapidary set of merely either positive or negative circles on black or white background was subsequently enhanced by transparent values of grey surfaces, or by surfaces made up of randomly picked, again transparently overlapping colour hues.

2.2 Composition of Random Circles Located within Golden Ratio Intervals

My next aim was to organize the continuously generated circles, or more specifically, their centres, on the pictorial surface, also in mutual correspondence with the golden ratio intervals. These compositional alternatives were tested out in black-and-white line drawings as well as in corresponding surface variants using various degrees of grey as well as in different colour hues which were manifest both in the colour of a circle´s surface, and in the colour of its contour line (see Fig. 3).

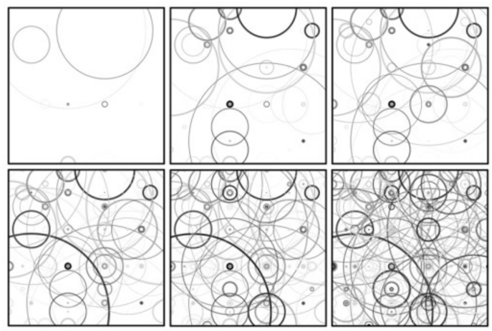

Fig. 3: Record of the development of one variant of a programme which was already set on mapping the placement of circle centres in mutual correspondence with the golden ratio. The last stage corresponds to the print GR/wb/lin_1209, 2012.

While this exclusive focus on the geometrical shape of the circle inevitably led to an optical condensation of the pictorial surface, the method of progressive overlapping of various colours and different degrees of transparency resulted in a continual transformation which in its turn made possible the regulation of the number of circles added at each individual step, and thereby also increase in the rate of change of the density of elements across the composition as a whole (see Fig. 4).

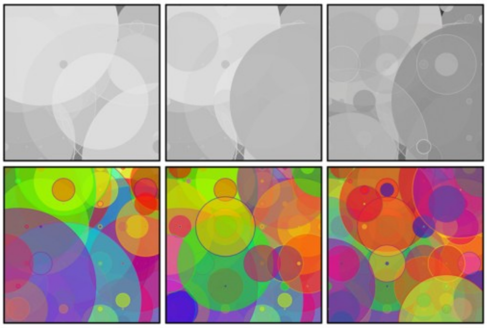

Fig. 4: Record of the development of two variants of a programme mapping the placement of circle centres in mutual correspondence with the golden ratio. The first variant features a black-and-white scale (top series, the last stage corresponds to the print GR/wb/pl_1209, 2012), the second variant is multicoloured (bottom series, the last stage corresponds to the print GR/coVpl_1209, 2012).

2.3 Compositional Grid Generated along the Lines of the Golden Ratio

The further development of these programmes took as the starting point a rectangular grid, once again derived by division of the format according to the golden ratio. The division itself may be initiated at each step by either a "small" or a "large" section, which is left up to random choice, in a process consisting alternatively of either seven steps (see Fig. 5), or 15 steps. Such division of pictorial format by its progressive golden-ratio division yields different variants of an ideal grid which may then be employed as the seminal structure for the further placement of visually active elements.

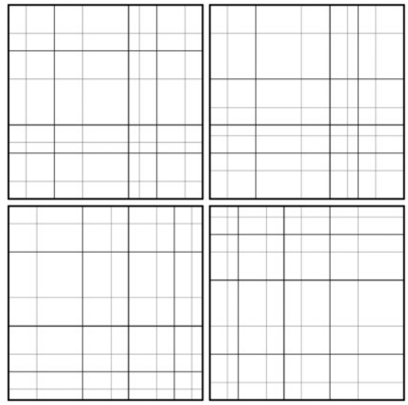

Fig. 5: Four random results of the division of a square into eight sections, horizontally and vertically, according to the golden section.

By visually active elements are understood here colour surfaces which either fill in the individual rectangles (see Fig. 6), or, in a later variant, proceed to locate within the grid´s newly generated squares circles that subsequently alternate, randomly once again, with square-shaped surfaces.

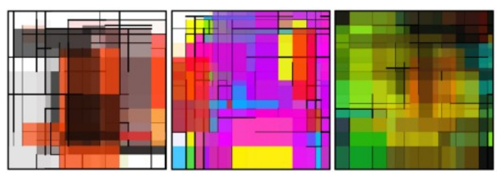

Fig. 6: Three colour compositions in a grid divided in 15 steps. XT_Ch15_L&R-CC-C0046, 2014; XT_Ch15_line_rect_CC05-00176, and Ch15_L&R-CC-E8067, 2014.

In naming this series I chose to use the Greek letters *chi* (X) and *tau* (*T*).

Materialized variants of these concepts included, apart from digital prints on paper or canvas, also reliefs in wood, glass or plastic (see Fig. 7).

Fig. 7: Four space compositions from series XT_Ch7: XT_Ch7_LCR-04, 2015; XT_Ch7_CPR-C001, 2015; XT_Ch7_CPR-A0005, 2015 a XT_Ch7_AGR-A0001, 2015, each 50 × 50 cm.

2.4 Golden Ratio Composition of Circles and Squares

The last programme is designed to detect, in a grid defined by golden ratios, squares within which it randomly inscribes circles or fills them with colour. The resulting colour choice is stratified at infinitely variable values (for examples, see Fig. 8).

3. Colour Space as a Source of Colour Relationships

More than a few of my compositions employ colour to achieve various types of emotional effect. A major modern-age tradition of scholarly reflection on colour was initiated by Johann Wolfgang von Goethe. His work, *Zur Farbenlehre (Entwurt einer Farbenlehre)*, of 1810, sparked off the systematic study of human experience with the psychological effect of colours. However undeniable it may be, this effect for many reasons defies a truly objective description. This is due not only to the subjective nature of individual experience, but above all to the fact that what we deal with here is an area of considerable structural complexity. In the traditional analytical approach, the whole of a living system is dissected into partial elements which may be easier to describe and control, though only at the price of loss of their actual functionality. While Goethe´s study did point at the relevance of individual colours in terms of emotional impact, its ultimate oversimplification inevitably leads to either downright false or at least inconclusive, scarcely verifiable findings. During the 19th and 20th centuries, the study of both physical and physiological properties produced a plethora of new discoveries which accelerated experimentation in art, and eventually also became instrumental in broadening the horizon of the art-loving public. A most sophisticated contribution was rendered to this process by the avant-garde Bauhaus art school. There in particular, two key figures, Johannes Itten [7] and Josef Albers [8], made crucial inroads into the study of empirical properties of colour as a complex phenomenon which made it mandatory to regard colour as a contextually bound quality contingent on hue, lightness, saturation, and transparency.

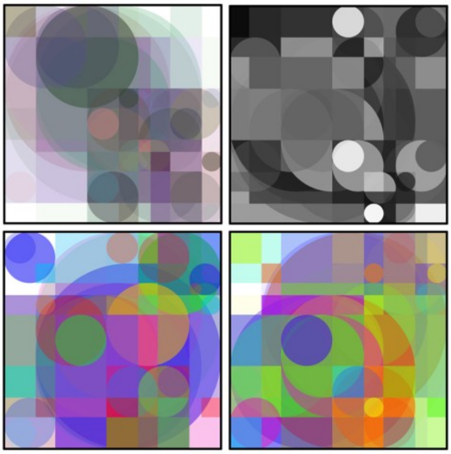

Fig. 8: Four compositions in a grid divided by seven ratios, filled in with circles and squares. Top row: XT_Ch7_C&C-G0262, 2014. XT_Ch7_C&C-H0157, 2014; Bottom row: XT_Ch7_C&C-H0036, 2014; XT_ Ch7_C&C-H0038, 2014.

An empirical description of colour can be achieved by various approaches, each of which invariably aims at bracketing its respective chromatic scale within a standard system. The essential prerequisite is always the choice of criteria. The development of the definition of colour in computer-generated imagery in particular has entailed a fairly exact classification involving various models of colour systems which have been mostly centered around three characteristics, and are consequently qualifiable as colour space models. Subjective perception of colour assigns to an observed colour quality the proper colour value (hue) which corresponds to the overall dominant wavelength, apart from which it determines, with respect to the chromatic situation at large and the relation to the light level of the environment, its saturation (where a decrease in saturation translates into an increasingly refracted colour effect), and its lightness which signals a reduction of distinct wavelength definition to a dark, monochrome state. This particular colour model is designated HSB, an acronym made up of the initial letters of the English expressions for the above-listed criteria: namely, Hue, Saturation, Brightness. The corresponding colour space thus offers a pattern involving a relatively unlimited palette which is readily controllable by three scales.

In programming specific compositions, I took the HSB model as my point of departure. Nonetheless, in each individual case, while sticking to the principle of randomness in choosing a newly included colour, the actual choice was subjected to a similarly random process imposing on it certain subsequent limitations. These limitations, enforced at markedly longer intervals, concerned the occurrence of a colour in certain sections of the HSB colour space. For illustration, one can envision an interposed threedimensional object which would once again be describable in terms of the magnitude of the scale pertinent to HSB parameters. In other words, for a definite amount of time during the choosing stage, the complete HSB colour space was limited to a single section which reduced the attainability of colours in accord with its own hue, lightness or saturation. Subsequently then, the choice was limited to colours of similar hues but variable lightness, or else ones of similar lightness and variable hues, and so on. A possible sequence of colour choices is indicated in the sequence of colours by lines, in Fig. 9.

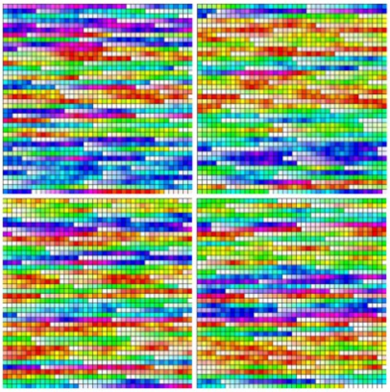

Fig. 9: Four different colour sequences of 1,600 successive randomly chosen hues in an arrangement respecting variable sections of partial limitations.

4. XT3 and the project Te-XT rumor

In 2015 I began to apply a simple rule for the generation of new compositional elements which would be subsequently further interconnectable. Their primary compositional network was obtained by a reduction to three horizontal and three vertical lines according to the golden ratio principle. The network is subsequently filled in, through a process of random superposition, by appropriate squares and circles in nontransparent white and black colours (hence the title *XT3*). This can eventually produce a comparatively very extensive repertoire of black-and-white square-shaped symbols (see Fig. 10).

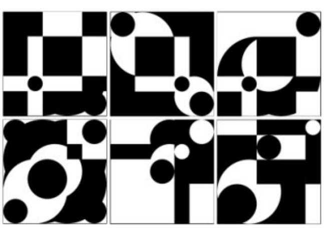

Fig. 10: Six elements of XT3 series, 2015.

During the initial stage of the project *Te-XT RUMOR*, I picked 324 elements out of a much larger set of basic symbols. I presented this selection in the form of a digital print on paper entitled *Signum generator 324* (see Fig. 12).

Fig. 11: Signum generator 324, 2015, 75 × 74 cm, digital print on paper, passe-partout, glass.

Out of the complete set of elements two smaller subsets were then extracted, each consisting of 13 elements. The criteria for their selection included a degree of morphological similarity, visual compactness, and potential to command interest. Further on, these selections were used in producing structures of 11 × 11 elements, governed by the organizing principle of the probability of the occurrence of specific elements, in a process some-what reminiscent of the probability patterns observed in the arrangement of letters in natural languages (hence the title, *Te-XT rumor*). The ratios of occurrence of the various symbols were once again set in consonance with the golden ratio, so the resulting digital prints on canvas, *Te-XT rumor R1* (2015), and *Te-XT* *rumor B4* (2015) actually demonstrated at all levels subordination to this rule. The set B was subsequently also used in generating along the same lines a larger format (120 × 120 cm), albeit made up of a reduced number of 5 × 5 elements: *Te-XT rumor B GR* (see Fig. 12).

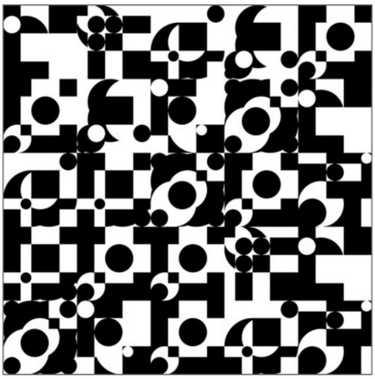

Fig. 12: Te-XT-rumor-B-GR, 2015, 120 × 120 cm, digital print, canvas.

The series was accompanied by this artist statement:

“The primary repertoire of symbols is comprised of forms created on a square background divided in accord with the golden ratio invariably into 16 fields made up of black and white squares and circles. Of the generated 324 symbols which manifest a mutual “genetic” correspondence, share a common constructive order, and at the same time are mutually distinct, two sets of 13 symbols each were selected. Priority was given to symbols which are characterized by a fairly transparent and distinctive structure (see *Signum generator 324*).

Each set of 13 symbols, which are close in nature to ´letters´, may serve for the structuring of a message whose syntactic rules contain the definition of the frequency of individual symbols, approximating the values of their co-occurrence, again in compliance with the golden ratio. The purpose of the resulting message is thus to supply information about the potential beauty of the complexity and symmetry of the structure (*Te-XT*) itself”.

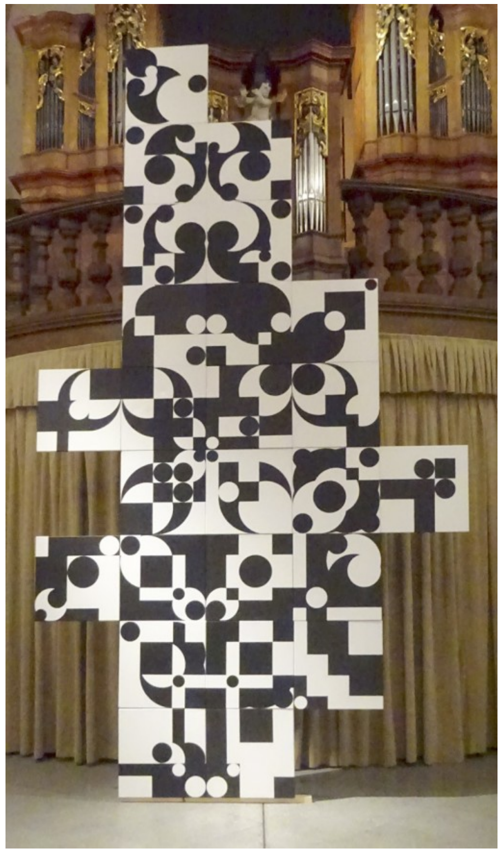

Fig. 13. TeXT rumor variable, 2015, 25 pieces, acrylic, canvas, 55 × 55 cm, number of elements and assembled whole variable; assembled whole 500 × 280 cm.

The last part of the series consists of 25 black-and-white paintings in acrylic on canvas (55 x 55 cm), which may figure as parts of variable arrangements in which they are freely linked with one another (see Fig. 13).

5. The series Te-XT rumor automat and System 25XT3

The following programme (*Te-XT rumor automat*) involved the linking of the individual elements along lines determined by their neighbourhood in both directions (division of square-shaped format – see Fig. 14).

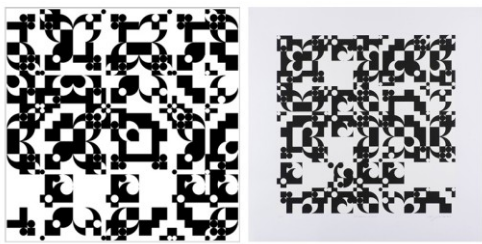

Fig. 14: TeXT rumor automat 16-10-6, 2016, 120 × 120 cm, digital print, canvas; TeXT automat 7 16-12-12, 2016, silkscreen, paper, 700 × 700 mm

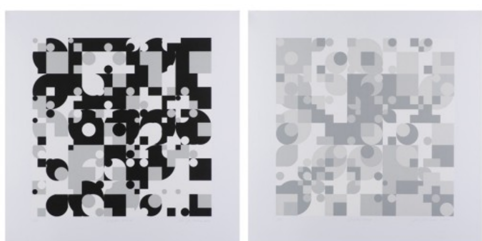

Fig. 15. System 25XT3 17-03-18, 2017, silkscreen, paper, 700 × 700 mm; System 25XT3 17-04-27, 2017, silkscreen, paper, 700 × 700 mm

Its follow up (*System 25XT3*) consisted in the random pick of a central element to which the programme added further elements starting from the centre, observing corresponding proportional divisions. The composition thus grew in a manner determined alternatively by newly specified elements and division axes. The original black-and-white palette was transformed to the combinations of white-grey-black, or white and three shades of grey see Fig. 15).

6. System 25XTS – variable magnetic collages

As I intended to retain in the artefact´s final version the possibility of transformation, another variant of the process came to include a composition made up of separate elements planted on a magnetic support (see Fig. 16).

Fig. 16: Variable magnetic collages: System 25XT3 BW 17-07-10, 2017 a System 25XT3 COL 17-07-20, 2017, variable collage, digital print, paper, magnetic elements, 70 × 70 cm;

7. System 25XT3 based on genetic algorithm

The alignment of a random choice of colours distributed among 25 component parts of System 25XT3 in pursuit of preferred colour combinations of the various colour neighbourhoods is the task to be dealt with by the genetic algorithm.

The generated extensive basic population of structures with 25 random elements is evaluated by a fitness function which is calculated for each structure by adding up the values assigned to the individual elements classified according to colour relations within them and the correlation between their bases. The positive number 1 is assigned to the superimposition of smaller squares or circles above larger ones in those cases where the colours are mutually adjacent or complementary within the colour wheel. Similar evaluation mode applies to colour neighbourhoods between the elements´ bases.

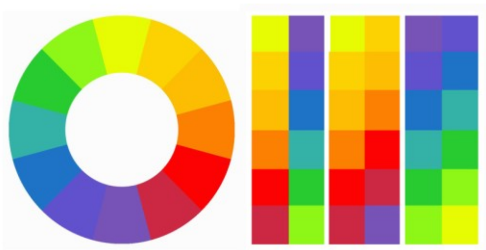

Fig. 17. Colour wheel used by GA and three paired columns of preferred colour combinations

Random combinations of more favourably evaluated parts of structures are instrumental in the production of new structures in ensuing generations. Repeated fitness function evaluation enhances the visual impact of compositions in subsequent generations.

An outstanding issue confronting computer generative art is the question of a point at which a programme of this type can be regarded as a manifestation of artificial intelligence. While an expert system which makes decisions in "search space" – i.e., one which picks correct answers – is standardly classified as intelligent, it is also true that in the creative domain intelligence is widely held to start only at the level of seeking out potential new formulations of questions.

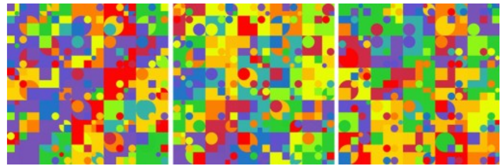

Fig. 18: Results of new generations.

8. References

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