THE QUAD SERIES:

THE WORLD'S FIRST COMPUTER GENERATED SCULPTURES

by NICHOLAS RAKITA

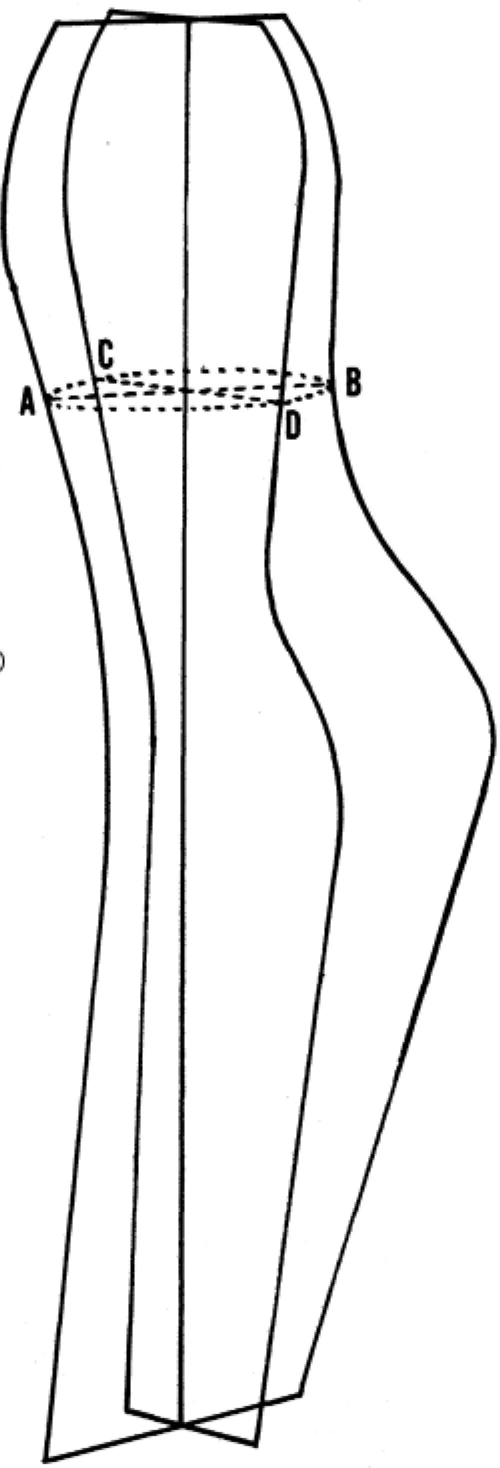


Fig A.

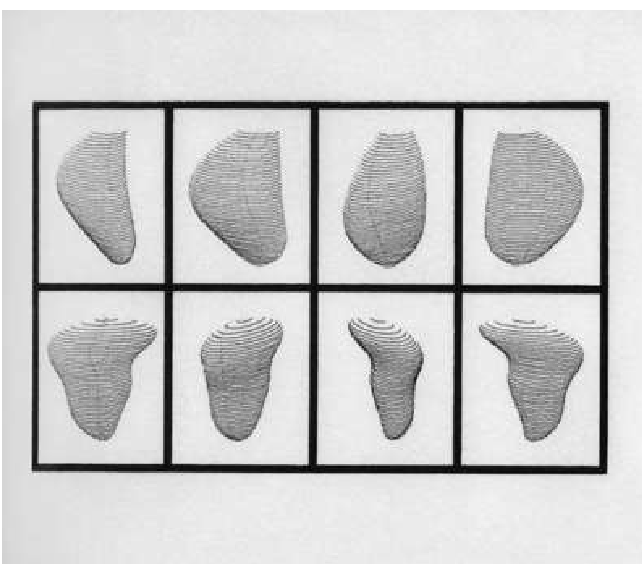
In the late 1960's a new artistic medium began to emerge with properties vastly different from those used before. It was called the computer, and was manipulated with neither brush nor chisel, but instead a keyboard. Using this new medium artist Robert Mallary produced a collection of four pioneering works, the *QUAD* series, widely held to be the first sculptures designed by programmatic means. The *QUAD* series is significant due to the unique process used to create these sculptures, both because it was highly innovative at the time, and because many of the techniques it employed were prophetic of those in common use today.

Each of the sculptures resemble asymmetric blobs, and range in height from the tall *QUAD* II, measuring 84cm, to the squat *QUAD* IV, at only 28cm. The pieces consist of rounded horizontal slices which are stacked together, and ground to a smooth contour. The material used for these cross-sections in the first three is laminated plywood, giving them a striped texture not unlike sandstone, and the outlier *QUAD* IV is instead made of marble. To produce these slices Mallary used a program of his own design, called TRAN2, which enabled him to manipulate and prototype the sculptures digitally before their physical construction.

Fig B. *QUAD III*

Mallary is better know in the art-world for his Neo-Dada junk-art sculptures, produced from an array of found materials which were fixed into bizarre forms using polyester resins. The *QUAD* series may at first glance appear unrelated to his early sculptures, however common to them both is an intentional subversion of traditional aesthetic properties of sculptural form in favor of grotesque and somewhat disturbing appearances, and a conceptual emphasis on process. Eventually in 1964 he abandoned this technique when it was discovered that the resins possessed toxic qualities, and was one of the first artists to openly discourage their further use (Database of Digital Art: Robert Mallary). Mallary then turned his attention to the burgeoning field of computer art, where he produces several series of drawings utilizing computer controlled plotters. These drawings share many motifs with the *QUAD* series such as iterative transformations on a shape as in the *INCREMENTAL* series, or progressive interpolation between forms as in the *TRPL* series. When asked if his computer works related to non-computer art, Mallary answered: "Definitely yes, particularly to the geometry and formalism of Constructivism and Neo-Plasticism. In fact, the more geometric and mathematically-based kinds of computer art (like spiralgraphics) might even qualify as a subset and offshoot of Constructivism, which in turn is likely to be both revitalized and broadened by this new development in art-and-technology. And the same holds for Op Art, in which are buried a number of still unexplored potentials that only a computer can uncover" (Ruth Leavitt, 1976).

TRAN2, the program Mallary developed to produce the *QUAD* series, represented the volumetric form of the sculpture using a set of profile curves which defined the vertical contours of the shape (as depicted in Fig A. on the cover page). The program offered two differing methods of inputting these profiles. The first involved a specially designed contour grapher which used a swinging probe to scan the curvature of a styrofoam prototype, and the second simply used an array of coded numerical values derived from flat drawings of the curve (Mallary, 1970). Each provided profile could be used to define the contour of an axis of the final sculpture, where the number of profiles determined the symmetry of the final output. When only one profile was inputted the sculpture used this curve along all four axes, resulting in a radially symmetric sculpture, inputting two curves resulted in a sculpture having two planes of symmetry, three resulted in a bilateral sculpture, and four produced a fully asymmetric form (Mallary, 1970). Once these profiles were inputted into the program, various transformations could be applied to them in order to change the shape of the sculpture. These operations could be used to scale the profile curves or introduce rotation of the slices along the vertical axis, and because they could be composed the number of potential forms the program could produce was quite numerous. The system also included a subroutine capable of plotting views from several angles of the virtual form, allowing the user to preview the sculpture before attempting its construction (Fig C). When the user was finally satisfied with the shape, another subroutine would plot each horizontal slice of the form onto the material (Fig D). These slices could then be cut out, adhered together, and polished to produce the finished sculpture.



Fib C. *Plotter Preview*

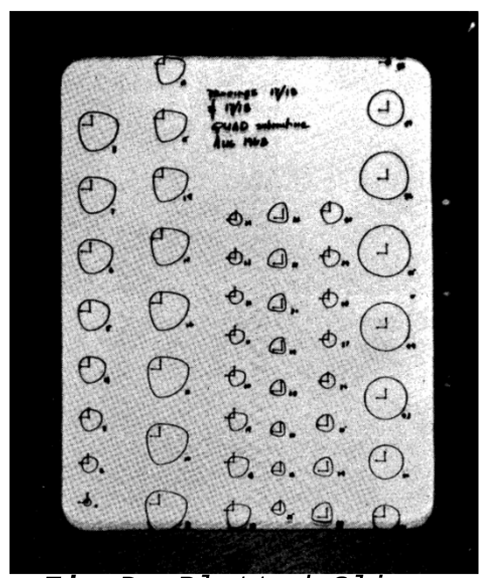


Fig D. *Plotted Slices*

To understand the importance of the *QUAD* Series as a pioneering work once must first understand the context from which it comes. Today use of computers in the arts is widespread, but in the 1960's their application to artistic practice was only just starting to be explored. This was due not only to lack of public awareness of computers, but also because of the many technical hurdles an artist would have to surpass in order to use them. One can gain a considerable respect for Mallary's work upon understanding the difficulties it entailed.

Relative to today, the ubiquity of computer systems in the 1960's was extremely limited. Computers mainly existed in academic settings, and because of this artists would have to collaborate with universities to gain access to them. In fact, the earliest computer art exhibitions, occurring almost simultaneously in 1965, presented works not from artists, but rather scientists: Bela Julesz and A. Michael Noll at the Howard Wise Gallery, New York; and Georg Nees and Frieder Nake at Galerie Niedlich, Stuttgart, Germany (Dietrich, 1986). In 1967 Mallary began working as a professor at the University of Massachusetts, Amherst, and because of this he was able to use the institution's IBM 1130 machine.

Not only did the rarity of computer systems make their use difficult, but also the embryonic state of computational hardware. The computer on which Mallary worked possessed processing capabilities several orders of magnitude less powerful than even today's smartphones. The implication of this being that any software written for these primitive machines had to be skillfully optimized in order to fit within the computer's limited memory and terminate in a reasonable amount of time. Because of this many early computer artists interested in designing complex systems like TRAN2 engaged the help of programming experts. Despite having taught himself programming, Mallary admitted: "When confronted with a really formidable programming task, I like to work with an expert. In this case my contribution is to specify the over-all character and purpose of the program, insist on some user-oriented features, and help in defining and naming the variables and parameters that are needed." (Ruth Leavitt, 1976).

Designing these programs was also a difficult exercise due to the fact that they essentially had to be written from scratch. In the 1960's the fragmented landscape of computer hardware meant that very few programs were portable between different systems. This factor, along with the novelty of computer art in general meant that code libraries for graphical operations were virtually non-existent. What's more, the few early graphics languages that were available to Mallary such as Ken Knowlton's EXPLOR and BEFLIX libraries would have been completely inapplicable to the *QUAD* series, as they only provided subroutines suitable for producing two dimensional computer art. Mallary lamented this, saying "I have yet to come across any canned program or so-called graphics language that can do any of the things I am likely to ask of a computer" (Ruth Leavitt, 1976).

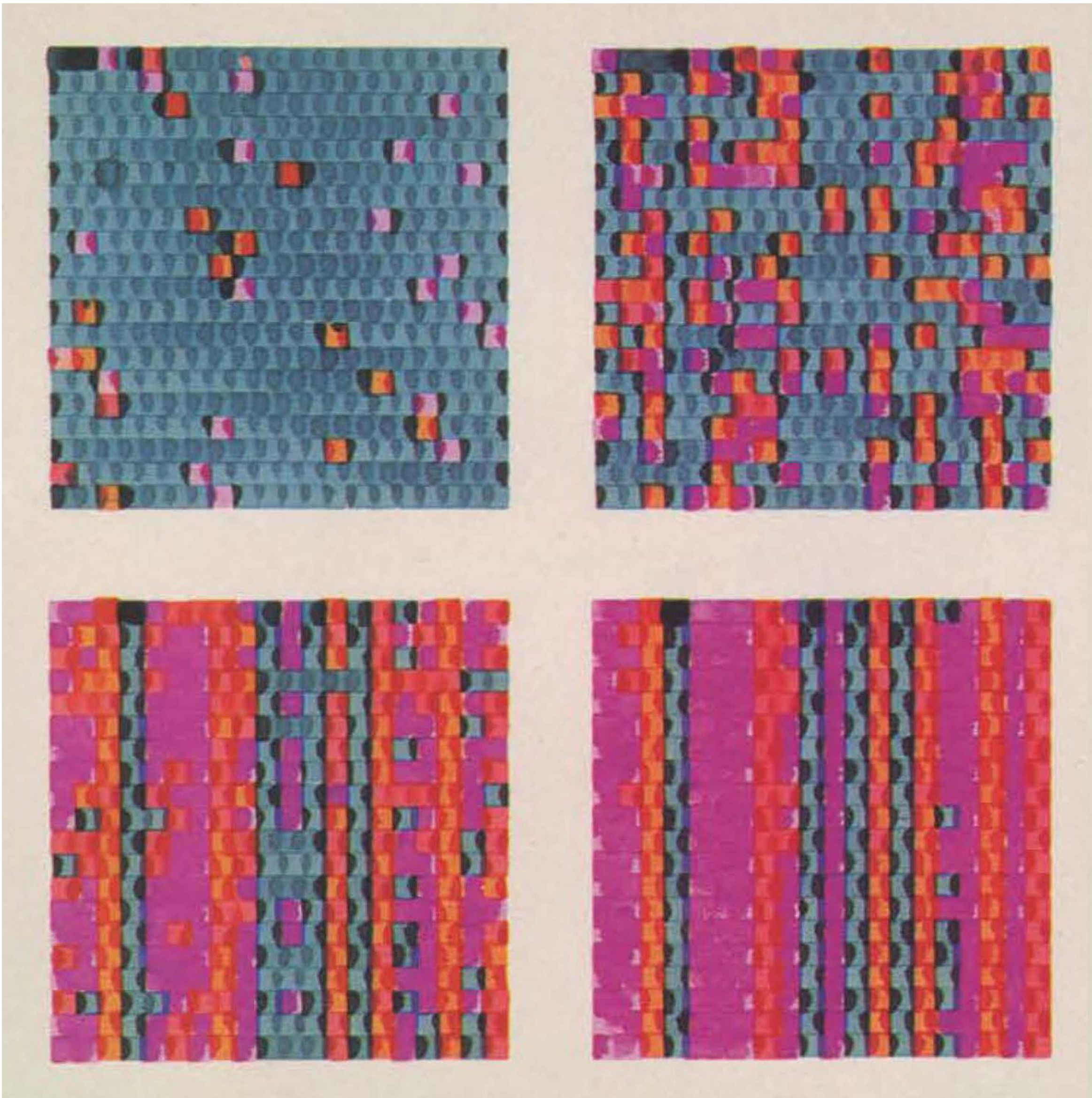


Fig E. *Frieder Nake: Matrizenmultiplikation Series 40*

The *QUAD* series is unique among early computer art simply by virtue of being a sculptural work rather than a pictorial one. Most other computer art from this era was displayed either as plotter drawn images or directly on early vector monitors. Despite this essential difference though, the *QUAD* series does indeed feature many of the same motifs found in other early computer art. One such example is its usage of structural repetition in the form of the slices from which the sculpture is constructed. Early computer artists utilized the capability of computers to rapidly manipulate arrays of similar forms, resulting in pieces that emphasise repetition or iterative progression. A good example of this theme can be found in Frieder Nake’s *Matrizenmultiplikation* series (Fig E), wherein large matrices of numeric values were repeatedly multiplied by themselves and then mapped to chromatic values. The product of this process are grids of colorful squares which despite deriving their arrangement by a highly ordered process, appear to be composed at random. TRAN2’s ability to produce sculptures of varying degrees of symmetry was also prototypical of early computer art. Programmatically generated images could easily be constructed in symmetric ways, and because of that this many varieties were explored in early computer art including: translational symmetry (as in Vera Molnar’s, *1% Unordnung, Fig F*), reflectional symmetry (as in Ruth Leavitt’s, *Prismatic Variation V, Fig F*), and rotational symmetry (as in Manuel Barbadillo’s, *Composición Modular, Fig F*). As a final point of similarity, the *QUAD* series like many other early computer art pieces can be understood as a visual expression of mathematical processes. Frank Dietrich summarized the use of mathematical objects in early computer art, writing: “Artist/scientists would display modular relationships or particular properties such as primeness or various stages of a matrix multiplication approaching its limiting boundaries. The use of mathematics does not necessarily imply a highly geometrical result. Some scientists tried to model irregular patterns. Knowlton, for example, simulated crystal growth, and Manfred R. Schroeder visualized equations describing noise in phone lines” (Dietrich, 1986). The use of interpolation between profile curves to generate spatial structures in the *QUAD* series can be seen as yet another instance of this motif.

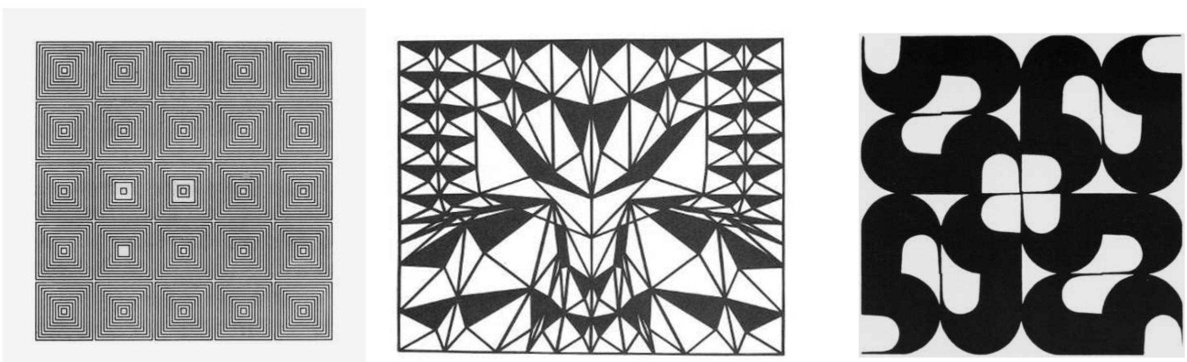


***Fig F**. (Left to Right)   1% Unordnung, Prismatic Variation V, Composición Modular*

Leaving the past and moving on instead to the present, many of the techniques used in the *QUAD* series can be seen as prophetic towards contemporary methods of using computers in sculpting. Perhaps the most important of these found in Mallary’s process is the virtual art object, wherein an art piece is described or induced by a digital form. This method is a central component of all computer art, and was readily applied by many of Mallary’s peers, however his implementation is notable for being the first to describe a volumetric piece. Also important were his methods for transduction between virtual and physical forms. The TRAN2 system was capable of scanning real-world prototypes into virtual representations, and inversely produce physical instances of the virtual sculptures. Today these techniques have direct analogues in the form of 3D-Scanning and 3D-Printing.

The virtual art object is a key component to both the *QUAD* series and to computer art in general. Representing art pieces as digital data has many interesting implications to the process of an artist who utilizes this methodology. Because the virtual art object can be manipulated by a computer program tedious aspects of its production can be automated. For example, TRAN2 enabled a user to rescale an entire axis of the sculpture with a few keystrokes. This automation allows the artist to spend more of their time on the creative aspects of their process and leave the heavy lifting to a computer. By freeing the artist from tiring and repetitive work, automation results in the feasibility of vastly more ambitious projects in regards to scale, complexity, or precision. Another important tool unlocked by digital representation is the ability to save many copies of the work, meaning all changes can be rolled back if they are found to be unsatisfactory. This allows the artist to experiment freely without worrying about making irreversible changes to the work. Further, a digital art object can easily be displayed on a graphic peripheral such as a monitor or computer plotter, meaning the artist can experiment interactively with the work. All of these features enable a computer equipped artist to rapidly prototype works at a pace much faster than traditional methods would allow. Mallary said in reference to the synergetic usage of computers by artists, that they represented: "a tool for enhancing the on-the-spot creative power and productivity of the artist by accelerating and telescoping the creative process and by making available to its user a multitude of design options that otherwise might not occur to him" (Dietrich, 1986).

Beyond these mere technical advantages, a number of interesting philosophical properties also arise from the use of virtual art objects. In the platonic view of art all physical aesthetic creations were considered inferior to the abstract Ideals they imitated. Today however, art represented as data can be seen as a concrete implementation of these Ideal forms; being perfect in a way physical art could never attain. While it is true that Plato disliked art in general, he likely would have approved of the phantasmal digital sculptures produced by TRAN2. What’s more, the existence of these abstract representations of a work enable the work to be copied and reproduced trivially. This can be utilized to distribute the piece across the internet, thus greatly reducing the effort needed to publish a work for public viewing. In doing so the authority traditionally wielded by the art-world’s bureaucratic institutions is weakened and the individual artist is empowered to express themselves regardless of how their work might be received by these institutions. The virtual art object obsoletes the notion of an ‘original’ copy of the work. When all copies are perfect reproductions down to the last bit, how can any one be said to be the original? This aspect of virtual art can be considered the final evolution of a concept explored in Walter Benjamin’s essay “*The Work of Art in the Age of Mechanical Reproduction*”. As Benjamin states, “The technique of reproduction detaches the reproduced object from the domain of tradition. By making many reproductions it substitutes a plurality of copies for a unique existence. And in permitting the reproduction to meet the beholder or listener in his own particular situation, it reactivates the object reproduced. These two processes lead to a tremendous shattering of tradition which is the obverse of the contemporary crisis and renewal of mankind.” (Benjamin, 1935). The virtual art object can be seen as the ultimate tool for transposing the production and consumption of art from a cultural phenomena limited to the elite into one which any individual possessing a computer can participate in.

TRAN2 was also highly influential for its introduction of a primitive kind of 3D-Scanning. Today 3D-Scanning technology is widely utilized within the context of fine art, and enables many new aesthetic possibilities. For example, sculptor Barry X Ball produced his *Masterpieces* series using 3D-Scans of sculptures by the Italian Rococo artist Corradini. Ball used these digital scans to produce mirrored copies of the original sculptures using a variety of non-traditional materials. Ball calls these copies "more perfect" than the already "perfect" originals, as the copies have been fixed in areas where the original sculptures were damaged or simply left unfinished. It is obvious to see how in this case 3D-Scanning enables appropriation and recontextualization of sculptural works in a way which was previously limited only to two dimensional art. Another artist utilizing 3D-Scanning is Clement Valla. For his 2014 piece "*Wrapped terracotta neck-amphora (storage jar)*" (Fig G) he produced a 3D-Scan of a 7th century Greek amphora including detailed information about the surface texture. This texture information was then digitally mapped onto a flat plane and printed onto a piece of linen which was draped over a styrofoam reproduction of the amphora. The result is a visual approximation of the original vase with artifacts produced by the folds of the linen. This piece demonstrates that 3D-Scanning can be used not only to create identical replicas, but also new interpretations of a existing object. Beyond the new aesthetic processes enabled by 3D-Scanning it also has practical implications to the world of fine art. The Versus Art company uses 3D-Scanning to produce topological scans of famous paintings. This process allows them to preserve important textural data from these paintings that would be lost with traditional methods of digitally reproduction. Further using 3D-Printing the company is able to produce near exact physical replicas of the paintings, meaning that visually accurate copies can be displayed in museums across the world, or even in the homes of dedicated art enthusiasts.

Fig G. *Wrapped terracotta neck-amphora*

3D-Printing is another technique which the *QUAD* series pioneered. In fact, the method employed by Mallary in which the volumetric object is sliced into horizontal segments is remarkably similar to the way modern 3D-Printing machines function. Just as 3D-Scanning enables many new techniques in the sculpting process, 3D-Printing can be used to produce works which would be otherwise impossible. Dario Santacroce's *SPHERICAL CREATIONS* sculpture series (Fig H) is a good example of a project only feasible because of 3D-Printing. In it, he explores the many three dimensional shapes created by the intersection of three spheres placed at the vertices of an equilateral triangle. In order to physically sculpt these forms a precision would be required that is impossible to achieve with traditional sculpting tools, thus

Santacroce uses a 3D-Printer to render his pristine geometric forms in sandstone. The *Digital Grotesque* project represents another instance of 3D-Printing being used to produce new kinds of sculptural objects. Architects Michael Hansmeyer and Benjamin Dillenburger using a program of their own design to produce models of large symmetric grottos whose fractal-like form was defined completely algorithmically. The shape of these grottos is so complex that to sculpt them by hand would be completely infeasible, however using 3D-Printing the structures were able to be produced in the span of a month. This project highlights the potential usage of 3D-Printing to manufacture structures of incredible intricacy. As a final example, the work of Jonathan Keep is notable for utilizing 3D-Printing to tranduct between different sensory fields. In his *SOUND SURFACE* series he produced several 3D-Printed vases using waveform data from different pieces of music. The collection is particularly interesting as it demonstrates the potential to produce sculptures forms derived from other kinds of art, in this case music.

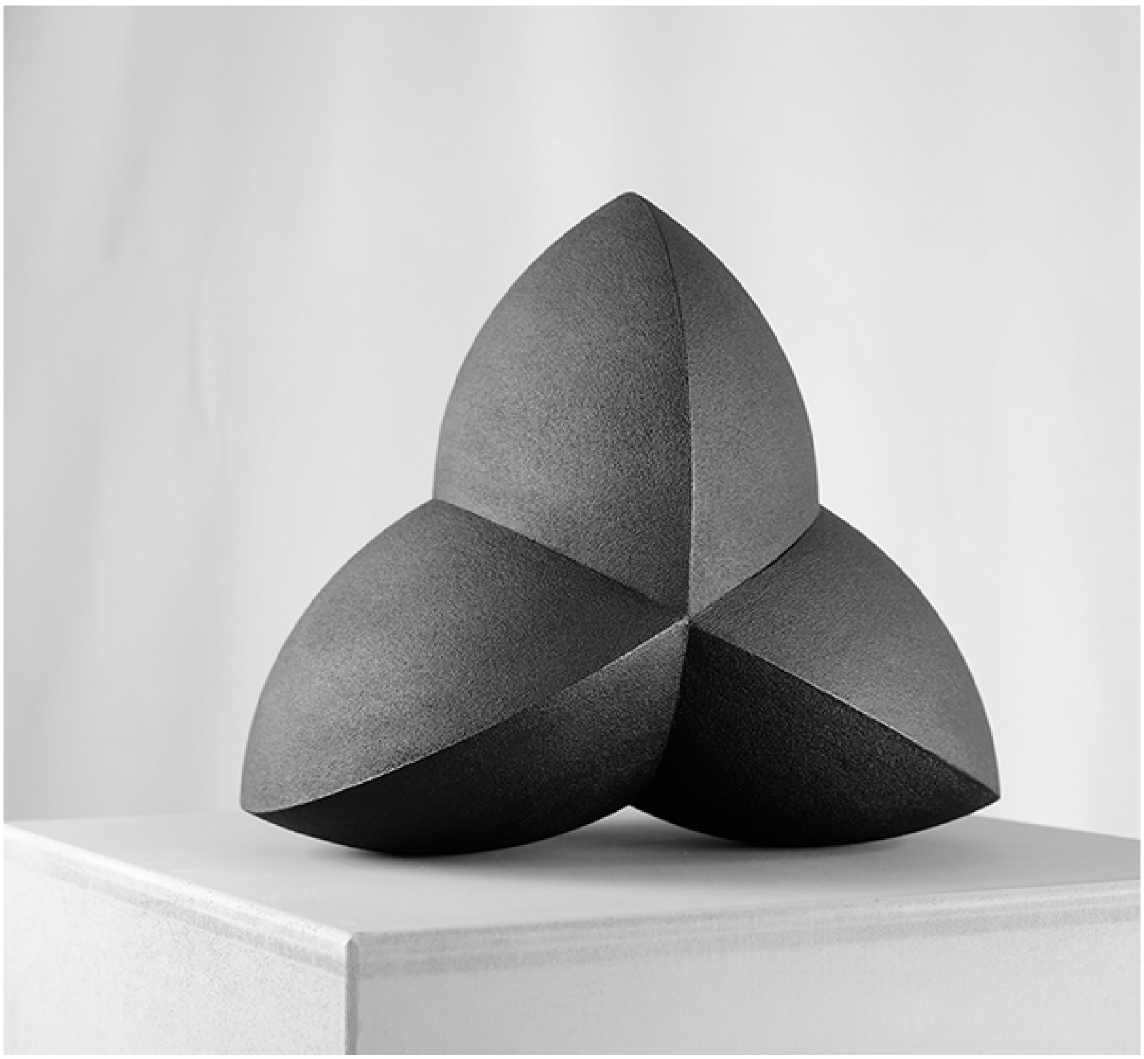


Fig H. *Spherical Creation II*

Mallary’s work on the *QUAD* series remains an important collection today. From a historical perspective it can be appreciated both as a prototypical example of early computer art and as an innovative piece which pushed forward the use of computers in sculpting. Considering the contemporary implications of the project, we can also find value in the fact that Mallary’s process was the first to utilize many techniques widely applied in sculpting today. Mallary saw the computer not just as a tool to facilitate the sculpting process, but as a creative partner that would fundamentally change the way artists worked. In his 1969 article “Computer Sculpture: Six Levels of Cybernetics” he anticipated a hierarchy of capabilities through which computers in the fine arts would progress. These “Six Levels of Cybernetics” can be summarized as follows:

1. Automation of tedious tasks as specified completely by the artist. Such tasks would still be able to be performed by humans, albeit with great effort.
2. Automation of tasks not capable of being performed by humans, either due to the intensity of their scale or the precision required to fulfill them.
3. This stage is marked by the addition of some autonomy to the program, such that within a system strictly defined by the artist the program may execute operations based on conditions of the current state of the art piece. At this stage the artist still maintains his position in the driver’s seat of the creative process, only using the program to explore permutations on the work according to a logic of his specification.
4. Stage four is defined by the program’s ability to make discriminatory decisions and operations on the piece not anticipated by its creator. This stage represents the first in which the creative aspects of the process rest completely with the machine. Decisions made by the program are still ultimately executed in accordance with heuristic evaluation of the work by models defined by the artist, thus the aesthetic principles of the program are still equivalent to those of its master.
5. At stage five, the program achieves a creative capacity equal to or surpassing that of its creator. It produces art completely autonomously, acting towards aesthetic ends not specified by its programmer. Any input from the artist only serves to hinder the output of the machine, and thus the human artist becomes obsolete.
6. Stage six differs from the previous stages because the human is unable to even disable the artistic mechanism. Here the program achieves complete autonomy, being able to ensure its own existence and the ability to proceed with any desires it may have beyond even the intentions of its creator.

TRAN2 represents a program of the first stage, being merely a sophisticated tool for reducing the tedious aspects of sculpture production. However, in the 50 years between the publishing of Mallary’s article and this paper many important advancements along the stages have been achieved. Many of the sculptures mentioned above such as the *Digital Grotesque* project or the work of Clement Valla can be understood as examples of the second stage being reached. Likewise, much of today’s generative art easily sits upon the third or fourth stage, in that computer programs are now capable of making highly advanced executive decisions towards nearly all aesthetic aspects of a work. In recent months the world's first portrait produced entirely by an Artificial Intelligence program was sold for an astounding sum, bringing the world’s eyes to the status of cutting edge computer art and indicating that arrival at the 5th stage is just around the corner. If Mallary’s predictions are to be believed, then the unstoppable force of technological progress will bring not only new possibilities to the artist, but also his own obsoletion.

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Fig H. Available at: https://www.dariosantacroce.com/spherical-creations/

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