Furniture design inspired from fractals.

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Abstract:

Fractals are a new branch of mathematics and art. But what are they really?, How can they affect on Furniture design?, How to benefit from the formation values and properties of fractals in Furniture Design?, these were the research problem .
This research consists of two axis .The first axe describes the most famous fractals were created, studies the Fractals structure, explains the most important fractal properties and their reflections on furniture design. The second axe applying functional and aesthetic values of deferent Fractals formations in furniture design inspired from them to achieve the research objectives.
The research follows the descriptive methodology to describe the fractals kinds and properties, and applied methodology in furniture design inspired from fractals.

Keywords:

Fractals
Mandelbrot Set
Julia Sets
IFS fractals
L-system fractals
Fractal flame
Newton fractals
Furniture Design

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Introduction:

Nature is the artist's inspiring since the beginning of creation. Despite the different artistic trends across different eras- ancient and modern- and the artists perception of reality, but that all of these trends were united in the basic inspiration (the nature).
Mathematicians also had influenced by the nature's properties. They started from the past to study the nature and conclusion the mathematics relationships which explain its properties, and analyses these relationships to get results that benefited the world generally and inspired the artists specially.
The connection between mathematics and art goes back thousands of years. Mathematics has been used in the design of Gothic cathedrals, Rose windows, oriental rugs, mosaics and tiling's. Geometric forms were fundamental to the cubists and many abstract expressionists, and award-winning sculptors have used topology as the basis for their pieces. Dutch artist(M.C. Escher)represented infinity, tessellations, deformations, reflections, Platonic solids, spirals, symmetry, and the hyperbolic plane in his works. http://www.ams.org/mathimagery/
Only in the past century have mathematicians developed an understanding of such common phenomena as snowflakes, clouds, coastlines, lightning bolts, rivers, patterns in vegetation, and the trajectory of molecules in Brownian motion (Dalton Allan- 2010). This branch of mathematics is known as fractal. Fractals force us to alter our view of dimensionality, produce patterns from nearly identical starting positions, and have real world applications in nature and human creations.
Some architectures and interior designers turn to draw inspiration from the decorative formations, geometric and dynamic properties of fractals in their designs which enriched the field of architecture and interior design, and benefited from them by adding functional and aesthetic values to design.
So that the research studies the Fractals structure and their reflections to design furniture inspired from them.

Problem:

1. How can Fractals affect on Furniture design?
2. How to benefit from the formation values and properties of fractals in Furniture Design?

Objectives:

1. Inspiration from the geometric and dynamic properties of fractals in Furniture Design.
2. Appling functional and aesthetic values of deferent Fractals formations in Furniture Design.

Importance:

1. The research describes and analyzes the Fractals types and properties.
2. Explanation the effect of Fractals on furniture design.
3. Mentioning the applications of Fractals in furniture and interior design.

Hypotheses:

Designing contemporary furniture inspired from fractals adds functional and aesthetic values to design.

Methodology:

The research follows the descriptive methodology to describe the fractals kinds and properties and applied methodology in furniture design inspired from fractals.

Definition of Fractal:

"The term was coined by Benoît Mandelbrot* in 1975 and was derived from the Latin *fractus* meaning "broken" or "fractured.

The fractals are a never-ending pattern. They are created by repeating a simple process over and over in an ongoing feedback loop.(Martin Churchill, 2004)

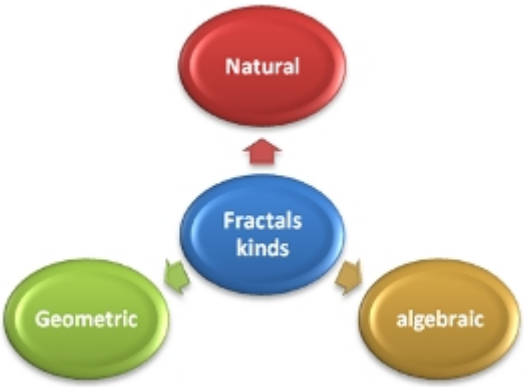
The fractals are a geometrical shape that can be divided into parts, each of which is a smaller duplicate of the whole (Michael Frame - 2016).

The fractal is based upon an equation that undergoes an iteration or recursion – that is, a repetition of itself. The object does not have to exhibit exactly the same structure on all scales, but the same type of structures must be apparent on all scales for the structure to be considered a fractal (ERIN PEARSE, 2005).

Benoit B. Mandelbrot **(**1924 –2010) was a Polish-born, French and American mathematician with broad interests in practical sciences, especially regarding what he labeled as "the art of roughness" of physical phenomena. He referred to himself as a "fractalist"**(** Mandelbrot, Benoit (2012).He is recognized for his contribution to the field of fractal geometry, which included coining the word "fractal"', as well as developing a theory of "roughness and self-similarity" in nature.

Fractals kinds: (www.FractalFoundation.org- 2009)

There are many different kinds of fractal images and can be subdivided into several groups.



In Nature

Fig.(1) Aloe Plant

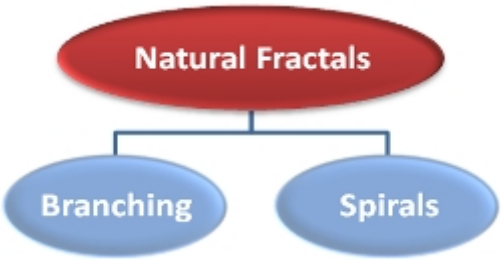
In Geometry

Fig.(2) Sierpinsky triangle

In Algebra

Fig.(3) Mandelbrot set

1. **Natural Fractals: (**Michael Frame- 2016)



1. 1- Branching:

Fractals are found all over nature, spanning a huge range of scales. We find the same patterns again and again, from the tiny branching of our blood vessels and neurons to the branching of trees, lightning bolts, and river networks. Regardless of scale, these patterns are all formed by repeating a simple branching process.

A fractal is a picture that tells the story of the process that created it.

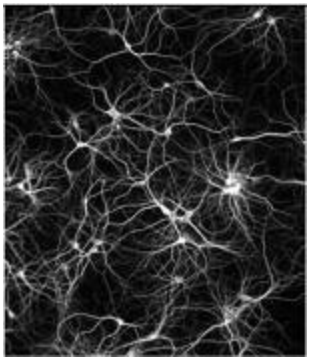


Fig.(4) Neurons from the human cortex. The branching of our brain cells creates the incredibly complex network that is responsible for all we perceive, imagine, remember.

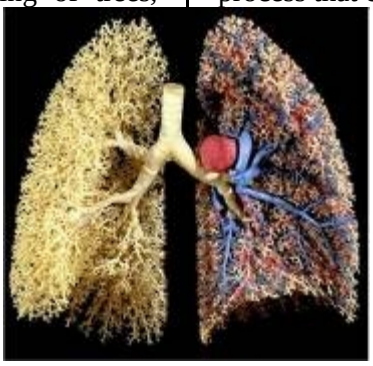


Fig. (5) our lungs are branching fractals with a surface area~ $100m^2$ The similarity to a tree is significant, as lungs and trees both use their large surface areas to exchange oxygen and co_2.

Fig. (6) Lichtenberg " lightning" formed by rapidly discharging electrons in Lucite.

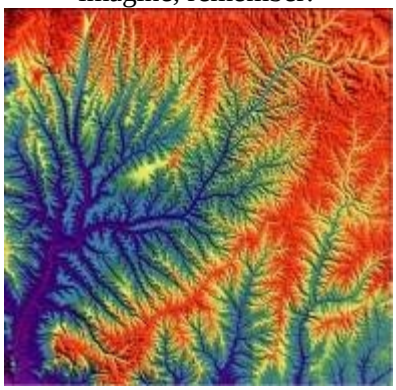


Fig.(7) river network in China, formed by erosion from repeated rainfall flowing dowenhill for millions of years

Fig.(8) Dragon tree, formed by a sprout branching, and then each of the pranches branching again, etc.

Fig.(9) fern leaves, formed by branching, and then each of the pranches branching again, etc.

Fig.(4:9)Natural branching Fractals **(**www.FractalFoundation.org-2009) (Karl Richard- 2011)

1-2-Spirals:

Fig.(10) A fossilized ammonite from 300 million years ago. A simple, primitive organism, it built its spiral shell by adding pieces that grow and twist at a constant rate.

Fig.(11) A hurricane is a self-organizing spiral in the atmosphere, driven by the evaporation and condensation of sea water.

Fig.(12) A spiral galaxy is the largest natural spiral comprising hundreds of billions of stars

Fig.(13) The plant kingdom is full of spirals. An agave cactus forms its spiral by growing new pieces rotated by a fixed angle. Many other plants form spirals in this way, including sunflowers, pinecones, etc.

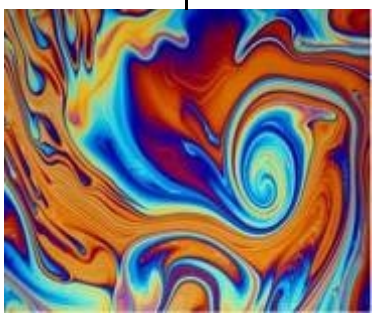
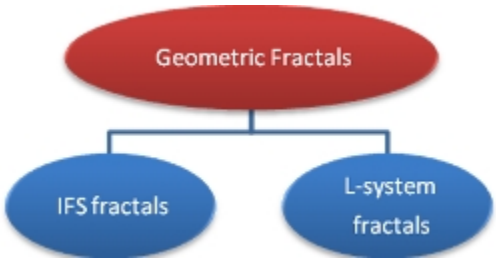


Fig.(14) The turbulent motion of fluids creates spirals in systems ranging from a soap film to the oceans, atmosphere and the surface of jupiter

Fig.(15) Snail shell is a self-similar that forms as a spiral of spirals of spirals.

Fig.(10: 15)Natural spirals Fractals (www.FractalFoundation.org-2009) (Karl Richard- 2011)

2. Geometric Fractals:



2-1-IFS (iterated function systems):

Fractals geometry, branch of mathematics concerned with irregular patterns made of parts that are in some way similar to the whole, a property called self-similarity or self-symmetry. Purely geometric fractals can be made by repeating a simple process. (www.FractalFoundation.org-2009)

Fractals derived from standard geometry by using iterative transformations on an initial common figure like a straight line (the Cantor dust or the von Koch curve), a triangle (the Sierpinski triangle), or a cube (the Menger sponge).(Erin Pearse-2005)

IFS fractals, as they are normally called, can be of any number of dimensions, but are commonly computed and drawn in 2D. The fractal is made up of the union of several copies of itself, each copy being transformed by a function (hence "functions system"). (Draves, Scott- 2007).

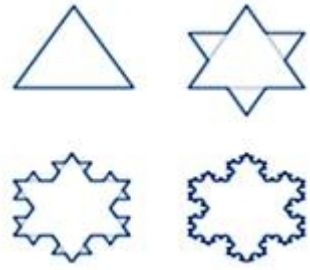


Fig. (16) von Koch curve

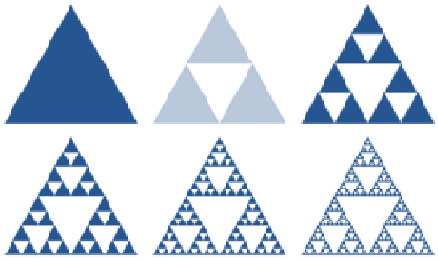


Fig. (17) Sierpinski triangle

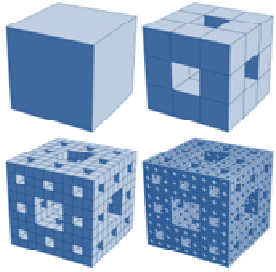


Fig. (18) Menger sponge

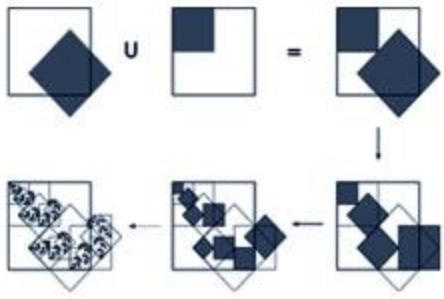


Fig. (19) IFS being made with two unctions.

2-2-L-system fractals: (Stefan Kottwitz-2011)

An L-system or Lindenmayer system is consists of an alphabet of symbols that can be used to make strings, a collection of production rules that expand each symbol into some larger string of symbols, an initial "axiom" string from which to begin construction, and a mechanism for translating the generated strings into geometric structures. L-systems were introduced and developed in 1968 by Aristid Lindenmayer, a Hungarian theoretical biologist and botanist at the University of Utrecht. Lindenmayer used L-systems to describe the behavior of plant cells and to model the growth processes of plant development. L-systems have also been used to model the morphology of a variety of organisms and can be used to generate self-similar fractals such as iterated function

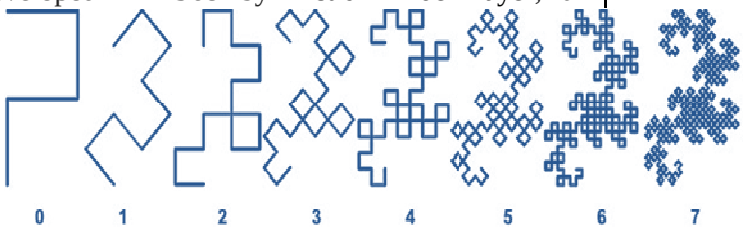


Fig. (20) The dragon curve drawn using an L-system.

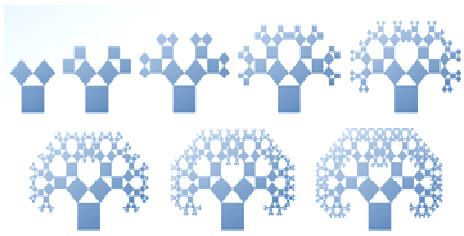
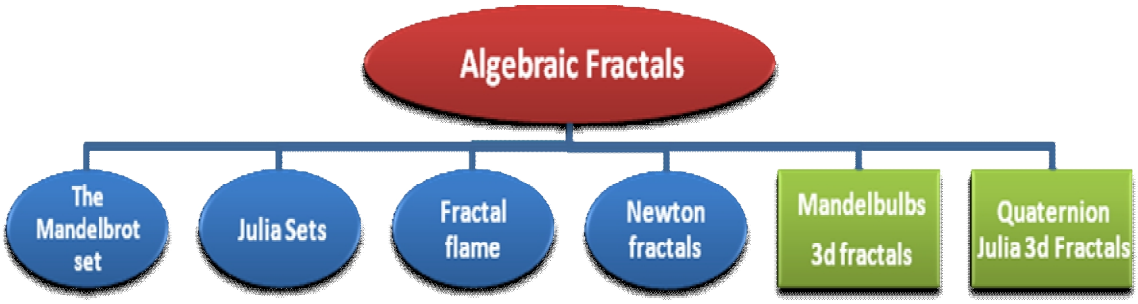


Fig. (21) Pythagoras tree by L-system.

3. Algebraic Fractals:

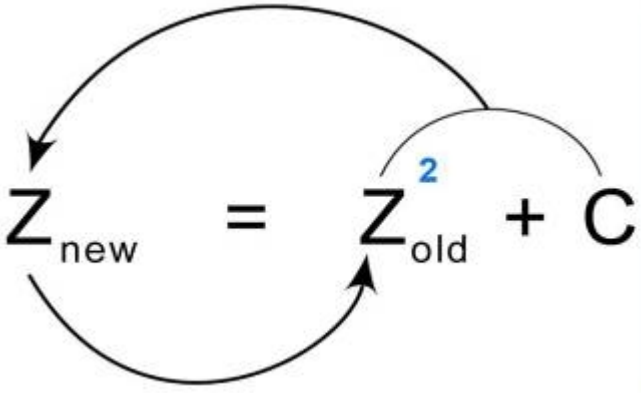


"We can also create fractals by repeatedly calculating a simple equation over and over. Because the equations must be calculated thousands or millions of times, we need computers to explore them. Algebraic fractals are rarely drawn or painted by hand. It is usually created indirectly with the assistance of fractals-generating software, iterating through three phases: setting parameters of appropriate fractals software; executing the possibly lengthy calculation; and evaluating the product." (www.FractalFoundation.org-2009)

3-1-The Mandelbrot set:

We start by plugging a value for the variable 'C' into the simple equation below. Each complex number is actually a point in a 2-dimensional plane. The equation gives an answer, 'Znew' . We plug this back into the equation, as 'Zold' and calculate it again. We are interested in what happens for different starting values of 'C'. (www.FractalFoundation.org-2009)

Generally, when you square a number, it gets bigger, and then if you square the answer, it gets bigger still. Eventually, it goes to infinity. This is the fate of most starting values of 'C'. However, some values of 'C' do not get bigger, but instead get smaller, or alternate between a set of fixed values. These are the points inside the Mandelbrot Set, which we color black. Outside the Set, all the values of 'C' cause the equation to go to infinity, and the colors are proportional to the speed at which they expand. (Karl Richard- 2011)



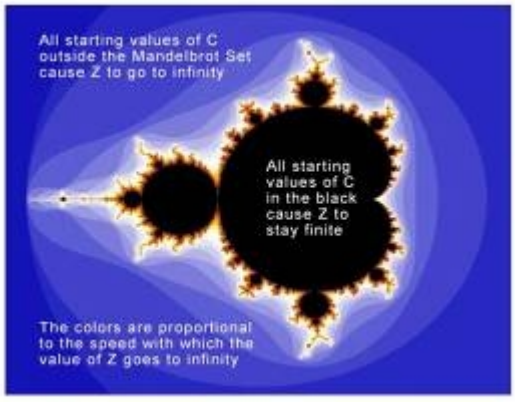
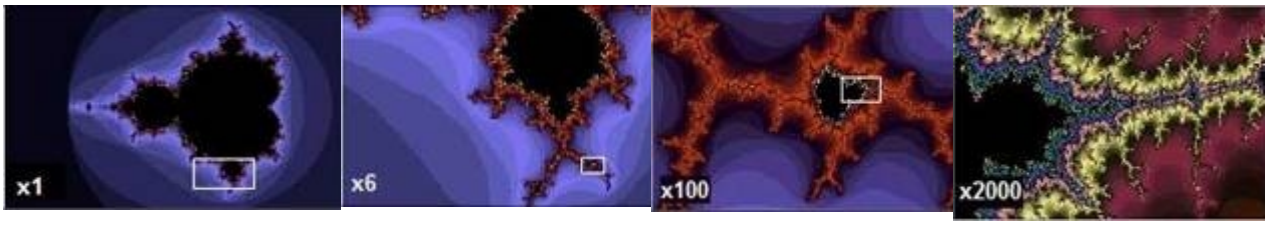


Fig. (22)Equations of Algebraic fractals Mandelbrot Set



Mandelbrot set: Self-similarityillustrated by image enlargements. This panel, no magnification.

The same fractal as above, magnified 6-fold. Same patterns reappear, making the exact scale being examined difficult to determine.

The same fractal as above, magnified 100-fold.

The same fractal as above, magnified 2000-fold, where the Mandelbrot set fine detail resembles the detail at low magnification.

Fig.(23) zooming in Mandelbrot Set

As mathematical equations, fractals are usually nowhere differentiable.(Edyta Patrzalek -2002), An infinite fractal curve can be conceived of as winding through space differently from an ordinary line, still being a 1-dimensional line yet having a fractal dimension indicating it also resembles a surface. (Mandelbrot, Benoît B. - 2004).

3-2- Julia Sets(Karl Richard- 2011)

When people see the intricate and beautiful patterns produced by equations, they lose their fear and instead become curious.

Exploring fractals is fun, and we can play with the equations to see what happens. The 4 images bellow are algebraic fractals known as Julia Sets. The first image in the upper left comes from the same equation as the Mandelbrot Set, $Z = Z^2 + C$. When we raise the exponent to Z^3 (i.e. Z*Z*Z), the Julia Set takes on a 3-fold symmetry, and so on. *The degree of symmetry always corresponds to the degree of the exponent.*

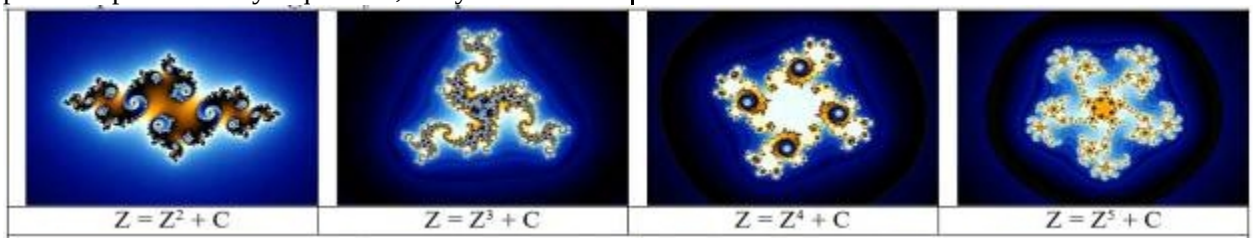


Fig. (24) Equations of Algebraic fractals (Julia Sets)

3-3-Fractal flame:

Fractal flames are a member of the iterated function system class of fractals (Mitchell Whitelaw -2004).created by Scott Draves in 1992. Draves' open-source code was later ported into Adobe After Effects graphics software and translated into the Apophysis fractal flame editor.

"Fractal flames differ from ordinary iterated function systems in three ways:

1. Nonlinear functions are iterated in addition to affine transforms.
2. Log-density display instead of linear or binary (a form of tone mapping)
3. Color by structure (i.e. by the recursive path taken) instead of monochrome or by density.

The tone mapping and coloring are designed to display as much of the detail of the fractal as possible, which generally results in a more aesthetically pleasing image." (Draves, Scott- 2007)

Fig.(25) A fractal flame created by the Electric Sheep*.
*Electric Sheep: a distributed computing project for generating, downloading, and playing fractal movies while the screen saver is running

Fig.(26) Fractal flame created in Apophysis * (software).

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3-4- Newton fractals, including Nova fractals:

Newton's fractal is a special case of a Julia set. It is a type of fractal derived from the Newton-Raphson method, which is more normally used as an approximate method of solving equations.(Aaron Burton-2009)

Newton fractal for three degree-3 roots ($p(z) = z^3 - 1$), coloured by root reached

Newton fractal for $p(z) = z^3 - 2z + 2$. Points in the red basins do not reach a root.

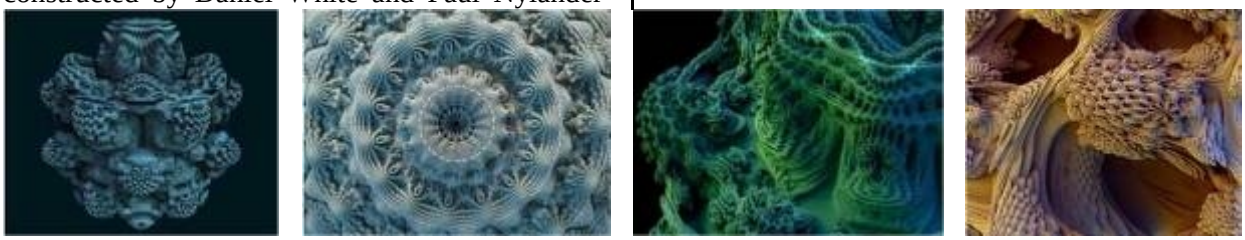
Newton fractal for $x^8 + 15x^4 - 16$

Newton fractal for $p(z) = \sin(z)$, coloured by root reached, shaded by number of iterations required

Fig.(27) shapes of Newton fractal.(Aaron Burton-2009)

3-5-Mandelbulbs fractals.

The Mandelbulb is a three-dimensional fractal, constructed by Daniel White and Paul Nylander using spherical coordinates in 2009.(Daniel White-2009)



A ray-traced image of the 3D Mandelbulb for the iteration $v \mapsto v^8 + c$.

The top of 3D Mandelbulb

Zoom in 3D Mandelbulb

More Zoom in 3D Mandelbulb

Fig.(28) zooming in 3D Mandelbulb

3-6-Quaternion **Julia Fractals** :(Paul Bourke - 2009)

Quaternion Julia fractals are created by the same principle as the more traditional Julia set except that it uses 4 dimensional complex numbers instead of 2 dimensional complex numbers.

Fig.(29)forms of 4d. Quaternion Julia Sets fractals

4-Properties of fractals

4-1-Self-Similarity:

In geometry though, similar means something very specific. Geometric figures are ***similar*** if they have the same shape. In order for one figure to be similar to another, you must be able to magnify the length of the small figure by the scale factor, and it will become exactly the same size as the larger figure.(Cynthia Lanius -2007)

In architecture, interior design and furniture the concept of self-similarity has very often been used in the case of the 'golden section'. Showing this self-similarity first a rectangle is drawn with the larger side length being 'a' and the other 'b', with the 'golden section' being defined as the relation a/b=b/(a-b). In the second step a square of the shorter length 'b' is put into the rectangle. Next again a square is drawn, this time in the remaining part of the 'a-b'-side length and so on. The resulting image is a self-similar spiral of rectangles, produced by a cascade of self-similar proportions.

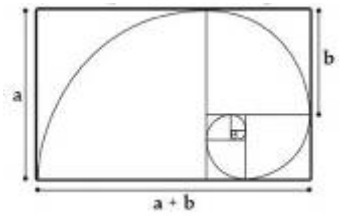


fig.(30) the 'golden section'. Showing the self-similarity

4-2-Iterative Formation:

Below is a picture of a similar iterative operation that *is* fractal. Take a line segment (see below) and remove the middle third. What is the resulting figure? That's a more complicated figure. It's a line segment with a hole in it.

Repeat the process on that figure. In other words, remove the middle third of both of those sections. This produces an even more complicated figure. Now think of doing this infinitely many times. In fact, this is a famous fractal called **Cantor Dust.(** Cynthia Lanius -2007)

4-3-Ability of branching:

(www.FractalFoundation.org-2009)

Just as we find branching fractals in nature, we also find branching within mathematic fractals like the Mandelbrot Set. Known as "Bifurcation", branching in these fractals is a never-ending process. The four images below are successive zooms into a detail of the $Z = Z^2 + C$ Mandelbrot Set. Two-fold symmetry branches and becomes 4-fold, which doubles into 8-fold, and then 16-fold. The branching process continues forever, and the number of arms at any level is always a power of 2.

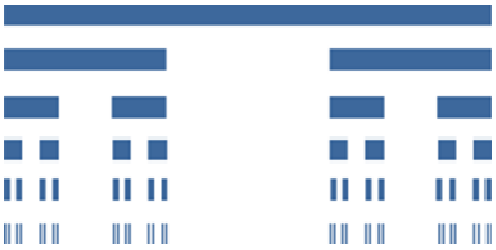


Fig.(31) Cantor Dust fractal

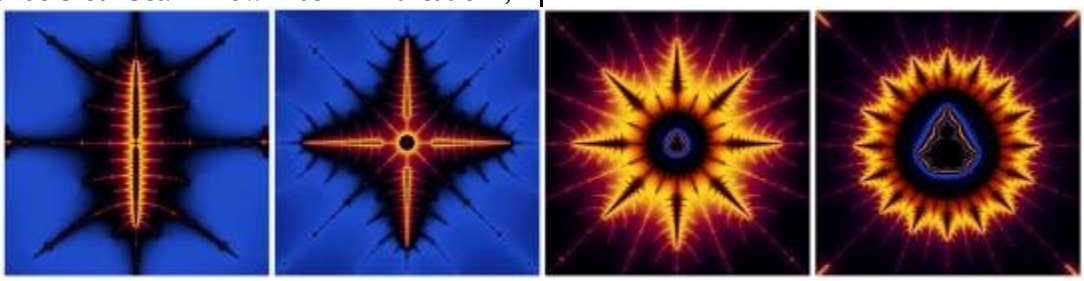


Fig. (31) branching within algebraic fractals ($Z = Z^2 + C$ Mandelbrot Set). Known as "Bifurcation"

If we explore other algebraic fractals, we find similar patterns and progressions. The two images below are details from the $Z = Z^3 + C$ Mandelbrot Set. Since the equation involves Z *cubed*, the arms now branch in 3-fold symmetry. Each of the 3 arms branches into 3 more arms, becoming 9-fold symmetry.This then trifurcates into 27 arms, 81, 243, etc. where the number of arms is always a power of 3. (www.FractalFoundation.org-2009)

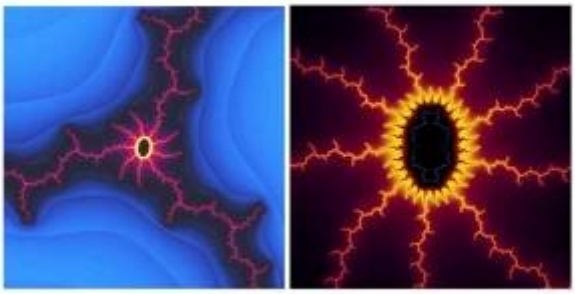


Fig. (32) branching within algebraic fractals ($Z = Z^3 + C$ Mandelbrot Set). Known as "Bifurcation"

4-4- Growing scale:

(www.FractalFoundation.org-2009)

Mathematical fractals are infinitely complex. This means we can zoom into them forever, and more detail keeps emerging. Or, to look at it another way, as we zoom into the fractals, the original object keeps growing.

All of these zooms are just scratching the surface of the infinitely complex. Some fractals, like the Mandelbrot Set, become even more intricate and beautiful the deeper we explore. The image above exists at a depth of 10^{176} magnifications!

Fig. (33) the Mandelbrot Set at a depth of 10^{176} magnification

4-5- Dynamical Systems: .(Tsuneyoshi Nakayama-2009)

A dynamical system of fractals is the mathematical formalism/rule which describes the deterministic evolution of a point in phase space.

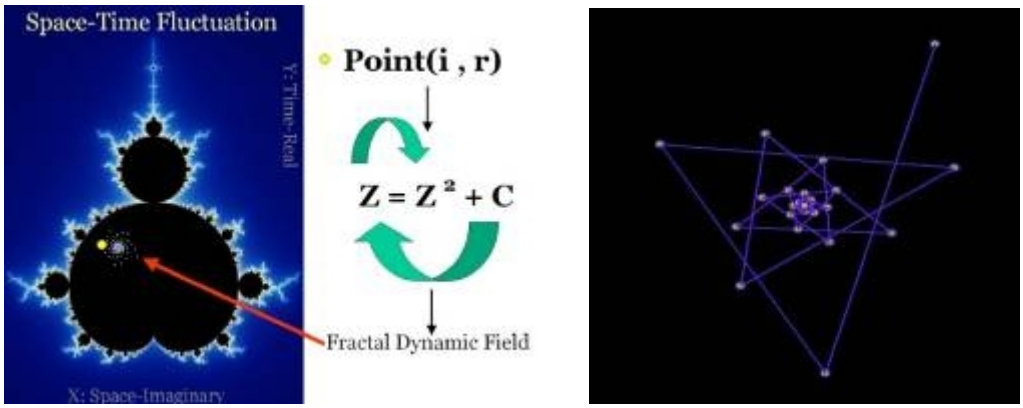


Fig.(34) Fractal Dynamic Field

1. **Fractal Dynamic Fields:** .(Lori Gardi-2009)

Here is a close up of a Fractal Dynamic Field starting with a point from the INSIDE of the Mandelbrot Set. Each point represents one iteration or one time through the feedback loop. If connected consecutive points with lines so we can better understand how this dynamic is being formed.It will noticed that the points from this dynamic appear to be orbiting around and spiraling into a single point or singularity, within the space-time continuum. Also, notice how the "lines" connecting the points are getting shorter or becoming more compressed as they get closer to the singularity at the center of this vortex. So, space and time are both contracting toward singularity.

4-6-Fractals Energy: (Djendji Samardzija-2011)

Fractals are artistically shaped energy – vibration-imprinted on matter. They are unique artistic paintings that will bring into your space the energy spectrum of the universal field with the same vibration as its own, that is, with which it resonates in harmony. This harmony and resonance are passed on to the surrounding space and bio-system.

Creation of fractal energy is a process of weaving threads between energy and matter. The purpose of creating energy fractals is to materialize the energies of our aspirations, wants and needs of the physical, emotional and spiritual levels – energies which make up our Essential Being.

It can become a material basis for the structure of our desires, needs as well as for the growth and development of our inner being. Fractal energy penetrates much deeper into the being than we could possibly imagine.

5- Functional and aesthetic values of Fractals:

During (Prucia Buscell) study of Jackson Pollock's paintings, physicist Richard Taylor began to wonder whether the fractal patterns he discovered on the paint splattered canvases were the source of Pollock's timeless appeal.

"Taylor and perceptual psychologists in Australia and England gathered fractal patterns that were natural, computer generated and manmade and asked 50 subjects their preferences. The found that 80 percent of the time, regardless of how the fractals were generated, the subjects liked patterns that had subtle variations on a recurring theme rather than patterns that were monotonously regular or incomprehensibly random. That work is described in Jennifer Ouellette's 2001 story on Pollock's Fractals in Discover Magazine. The story quotes an environmental scientist as saying that our ancestors on the African Savanna may have become attuned to fractal pattern recognition through their need to know whether the grass was ruffled by the wind or a stalking lion. This kind of heritage, some scholars speculate, might help explain why artists, architects, writers and musicians instinctively mimic the fractal patterns found in nature.**" (Prucia Buscell- 2013)**

Taylor, whose scholarship includes the visual science of fractals, writes in a Physics World article "Vision of Beauty" that research with hundreds of participants over the last decade-his and that of others-confirms that people find those mid-range fractals most aesthetically appealing. Further, he writes, exposure to these pleasing fractals, the kinds found in clouds, trees, galaxies, lungs and neurons, can reduce our physiological responses to stress and activate brain areas associated with happiness. Aesthetics and function are intricately linked. Taylor, now director of the University of Oregon Materials Science Institute, describes research in the article on how nano scale fractal eye implants that mimic and communicate with neurons might restore the vision of people who have lost their sight to macular degeneration. A university news story reports the implants would be nano flowers seeded by nano particles of metal that self-assemble in a natural process. **(Prucia Buscell- 2013)**

Artists have always used geometry in the one or other way for their works, although they may not have been conscious of that. First the decision has

to be made if something should be formed in three or two dimensions. Second there are many rules for composition and proportion found in design and art that are based on dimensions. Thinking of one of the most important proportion-rules, namely the 'golden section', this turns out to be, as mentioned before, a fractal sequence. Beside that art can be interpreted as a way for finding the basics of beauty and harmony that are found in the laws of nature. In this way fractal geometry may help to explain and prove the 'rules' of beauty. "(Wolfgang E. Lorenz – 2003).

"The fractal new geometric art shows surprising kinship to Grand Master paintings or Beaux Arts architecture. An obvious reason is that classical visual arts, like fractals, involve very many scales of length and favor self-similarity"(Wolfgang E. Lorenz – 2003).

6- The effect of fractals on furniture design:

1. Fractals have aesthetic formation (Branka Spehar-2003) (Wolfgang E. Lorenz – 2003)which add aesthetic values to the design.
2. Fractals have dynamic properties such as vibrational excitations, transport, and spin waves in fractals structures.(Tsuneyoshi Nakayama-2009) They indicate the movement and energy to the design.
3. "Every fractal in itself has some energy effect just like any color or a picture on the wall has. However, fractals energy is conceived in such a way as to increase and enhance specific and given frequencies, depending on the intention and purpose of the energetic fractal image. They are programmed to emit specific vibrations – those which you wish to have in your office, meeting room or bedroom... to be your personal energetic basis and support whether you desire to achieve a physical, emotional or spiritual goal." **(**Djendji Samardzija-2011)
4. The functioning of energy fractals is based on principles of vibrational healing, i.e. of frequency, while its effect is based on resonance. The source of frequency is the color, light, shape, number, structure, and fractal recurrence, which form the thing that we attune ourselves to and harmonize our vibrations with, based on a principle of harmonic resonance. Human being easily attunes to and harmonizes with that vibration and comes into resonance with the more powerful or constantly present fields. When those fields have a beneficial effect, they are health and life supporting. If, however, their effect is of a negative nature, they deplete the life force and very soon lead to deterioration of health and vitality. (Umberto Mosco-2009)
5. Exposure to pleasing fractals in design can reduce our physiological responses to stress and activate brain areas associated with happiness (functional values) **(Prucia Buscell-2013)**.

7- Fractals Applications:

The designers had begun copying natural fractals for inspiration to build successful devices. Below there are just a few examples of fractals being used in architecture, interior design and furniture.

7-1-Fractals Applications in Architecture:

Fractal geometry may help us to understand and analyze complexity that can be found in towns of the Middle Ages but also in cathedrals and other man-made objects up to these days. It may also help us to transfer this complexity, which also arises from the development over time, to newly planned cities and buildings – cities and buildings may then also be reduced to simpler algorithms (Wolfgang E. Lorenz – 2003)

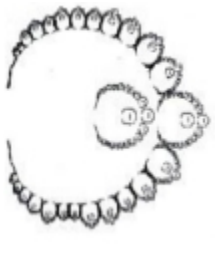


Fig.(35) An ancient African settlement (Ba –lla) of southern Zambia,

Fig (36),North Indian temple,

Fig (37), Anthony Batchelor , South Indian Temple.

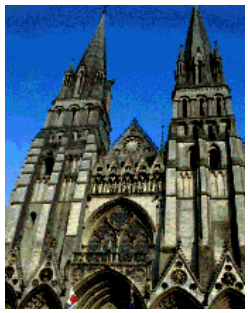


Fig.(38), Cathedrals in Europe

7-2-Fractals Applications in interior design

Interior designers used fractals shapes to decorate and design interior spaces to benefit from their formation values and properties of fractals in design and add functional and aesthetic values to design.

Fig.(39) cool wall in a sneakers store: Dear Design, Munich Fractals, Spain

Fig.(40) Gramercy Park Townhouse Design by Fractal Construction,

Fig.(41)Wall paper – Fractal // Yellow by Johanna Ek

Fig.(42) Pythagoras Tree fractals Mirrors at wall

7-3-Fractals Applications in furniture:

Furniture designers design their products using fractals shapes to benefit from their formation values and properties of fractals in design and to add functional and aesthetic values to design.

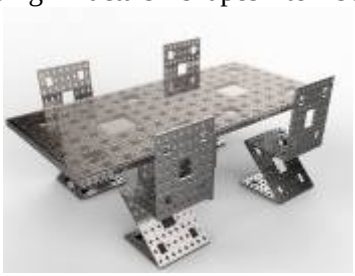


Fig.(43) Menger dining table ,Chair by John Brevard

Fig.(44) Homune Table by Michael Young

Fig.(45) Fractals Rotating squares table by Tom Cecil

Fig(46) The 23 drawers clothing storage by Takeshi Miyakawa

Fig.(47) Mandelbulb 3D Export fractals table by Nic

Fig,(48) the Fractal Table is a table developed by Platform Wertel Oberfell and Matthias Bär

7-4-Fractals Applications in accessories:

Fig.(49)fractals accessories , Mandelbulb 3d model Source: http://nic022.deviantart.com/art/Mandelbulb-3D

7-5-Fractals Applications in cinema decoration and graphic design

After Loren Carpenter, co-founder of Pixar Animation Studios, read Benoit Mandelbrot's *Fractals: Form, Chance, and Dimension*, he began experimenting with fractals to make his computer graphics look more realistic. This technique gave rise to software programs now widely used across the computer graphics industry to create special effects, including fictitious landscapes and imaginary worlds—such as the Genesis planet sequence in *Star Trek II: The Wrath of Khan*and the damaged Death Star in *Return of the Jedi*.

http://www-03.ibm.com/ibm/history/ibm100/us/en/icons/fractal/transform/

Fig.(50) Checker Stir by Aurelius Cat , Mark Brady/United States

Fig. (51) Ancient labyrinth by Theli at/Swiden

Fig.(52) Tipping point by Hal Tenny /United States

Fig.(53) At the edge of desert gulch by Dainbramage , Brent/ United States

Fig.(54) Mandelbulb Sphere by fraxialmadness, Jaen/ Francs

Fig.(55) Asteroidean mechinoderm by Graham sym, Graham Symmons /United Kingdom

Suggested projects :

Project 1:Furniture inspired from natural branching fractals:

1. Model 1:

The chair has a branching fractals unit in the back inspired from branching fractals tree, with self symmetry and growing scale outside.

This unit provides us with growing positive energy through branches growing.

The chair made of wood with a hole in back, the fractal unit made of then metal plate cutting by laser and fixed with the chair back from front and back .

Fig,(56) the branching fractal chair –designed by the researcher

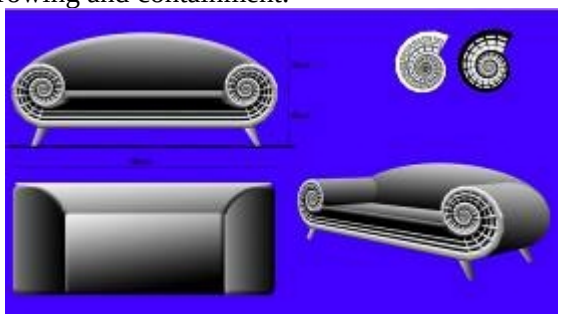
Project 2: Furniture inspired from natural spiral fractals:

2. Model 2:

Spiral arm sofa inspired from natural snail shell.

the fractal unit used in design has Self-Similarity, similar iterative operation , growing scale and dynamic properties such as vibrational excitations and spin waves in fractals structures.

the design has dynamic energy inspire with growing and containment.



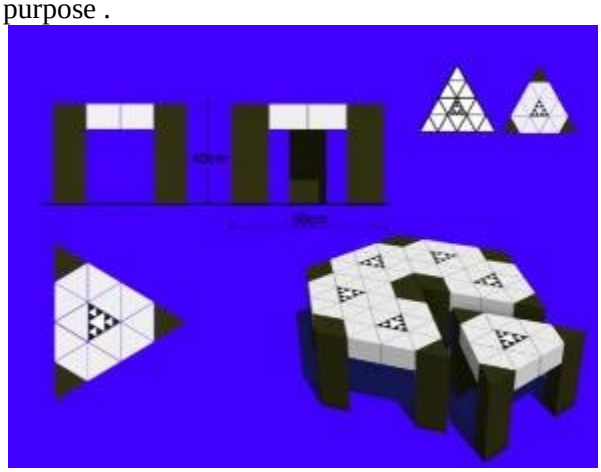
Fig,(57) Spiral arm sofa inspired from natural snail shell - designed by the researcher

Project 3: Furniture inspired from geometric fractals:

1. Model 3:

fractal triangle tables inspired from Sierpinski triangle . Every triangle table top has devided into small triangles with Self-Similarity ; the group triangle tables form a hexagonal table with similar iterative operation.

The design is functional for deferent spaces and purpose .

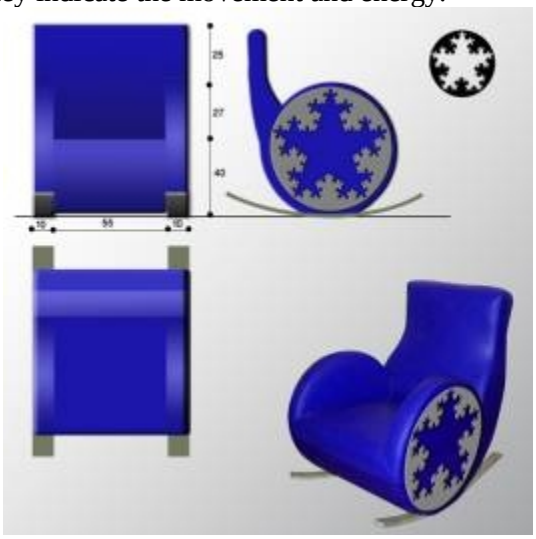


Fig,(58) fractal triangle tables inspired from Sierpinski triangle .

1. Model 4:

Arm chair inspired from (von Koch curve) .

The design has self-similarity, similar iterative operation, Ability of branching, Growing scale, Dynamical Systems. Fractals have dynamic properties such as vibrational excitations, transport, and spin waves in fractals structures. They indicate the movement and energy.



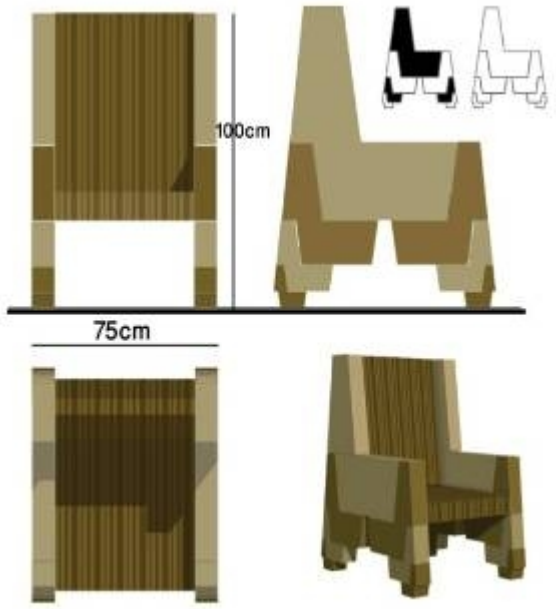
Fig,(59) Arm chair inspired from (von Koch curve) .

2. Model 5:

Arm chair inspired from fractal geometric shape .

The design has self-similarity, similar iterative operation, Growing scale and dynamic energy to up.

Upholstery Fabric designed from fractals lines with similar iterative which provide dynamic vibrations.



Fig,(60) Arm chair inspired from fractal geometric shape

1. Model 6:

Panel inspired from fractal geometric shape of squares and circles . it can be used as a sliding door in a bookcase ,or apanel on a wall .

The design has Self-Similarity, similar iterative operation, Ability of branching , Growing scale and dynamical systems. Fractals have dynamic properties such as vibrational excitations, transport, and spin waves in fractals structures. They indicate the movement and energy.

fig. (61)Panel inspired from fractal geometric shape of squares and circles.

Model 7:

the chair has a geometric fractals unit in the back inspired from snowflake fractals, with self symmetry and growing scale inside.

This unit has centering positive energy and attractive dynamic moving through unit growing inside.

The chair made of wood, the fractal unit made of textile Upholstery Fabric to be comfortable and functional use.

Fig. (62) geometric fractals dinning chair

2. Model 8 :

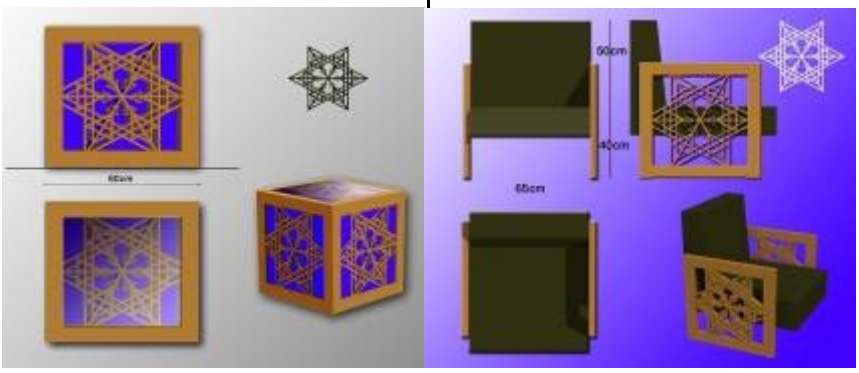


Fig. (63-64)Geometric fractals triangles applying in lighting table and arm chair.

Fig. (65)Geometric fractals triangles applying in a bookcase.

4. Model 10:

Simple coffee table has a Geometric fractals shape made of decorative wood veneer on top .

The fractals design has centering positive energy and attractive dynamic moving through unit growing inside.

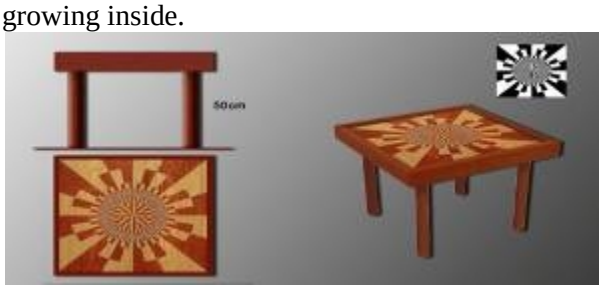


Fig. (66) Fractals Simple coffee table has a Geometric fractals.

Fractals squares coffee table top .

The fractals unit consists of group of squares divided by axis into small symmetric triangles, with deferent hatching inside to provide variety in design.

The design has Self-Similarity, similar iterative and growing scale.

The table has a glass panel on the top to be functional in use.

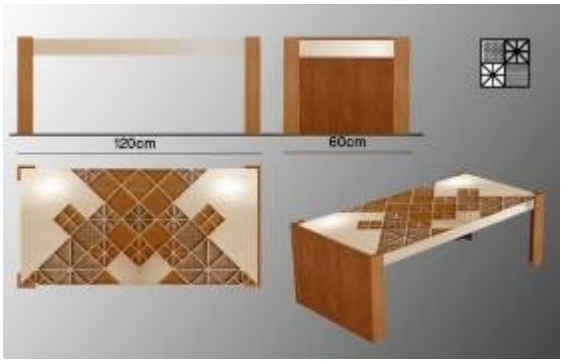


Fig. () Fractals squares coffee table top .

3. Model 9:

Geometric fractals triangles applying in lighting table, arm chair and a bookcase.

The design has central attractive, self-similarity, similar iterative and growing scale.

Fractals have dynamic properties such as vibrational excitations and transport in fractals structures. They indicate the movement and energy.

Model 11:

3d.printing geometric fractals chair made of metal construction and a fractal unit in back and base made of 3d printing polyamide material.

The fractal base unit consists of triangle divided into small triangles as shown in fig.() , and had repeated to consists a hexagonal shape .

The fractals design has Self-Similarity, similar iterative operation, dynamic properties such as vibrational excitations and transport. They indicate the movement and energy.

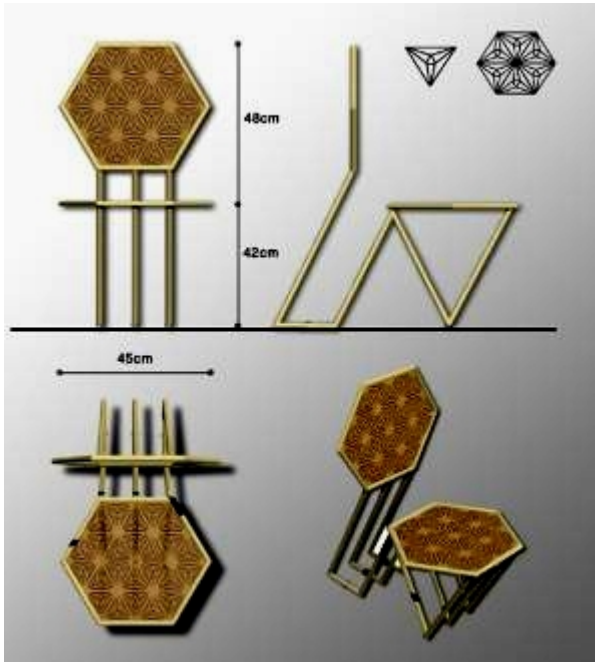


Fig. (67)3d.printing geometric fractals chair.

Project 4: Furniture inspired from 3D fractals:

5. Model 12:

3d fractals coffee table made of group of cuboids with Self-Similarity, similar iterative operation, Growing scale, Dynamical Systems, They indicate vibration and growing energy.

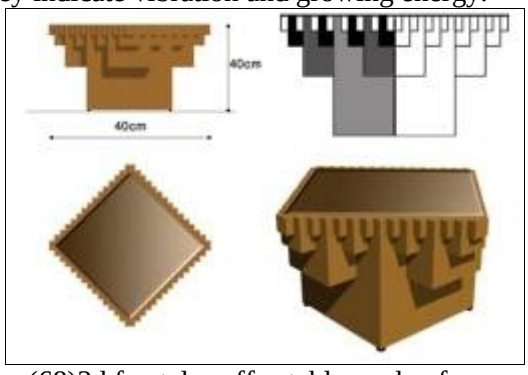


Fig. (68)3d fractals coffee table made of group of cuboids

6. Model 13:

3d fractals coffee table inspired from 3d mandelbulb,

The design made of metal and glass top. It consists of a rectangle which iterated by 120° round and then branching into symmetric iteration

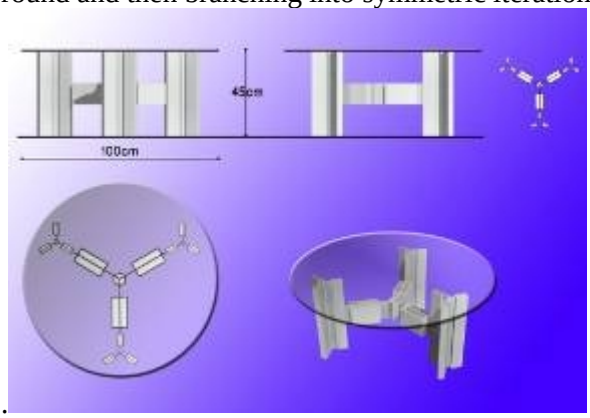


Fig. (69)3d fractals coffee table inspired from 3d mandelbulb

7. Model 14:

3d fractals table inspired from geometric squares.

The design has central attractive, self-similarity, similar iterative and growing scale.

Fractals have dynamic properties such as vibrational excitations and transport in fractals structures. They indicate the movement and energy.

The design made of 3d printing wood or metal material with a glass top.

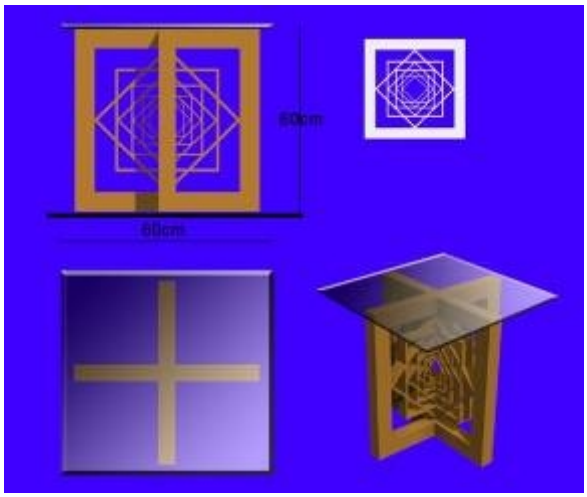


Fig. (70) 3d fractals table inspired from geometric square

Results :

1. Fractals are infinitely complex patterns that are self-similar across different scales. They are created by repeating a simple process over and over in an ongoing feedback loop.
2. Fractal patterns are extremely familiar, since nature is full of fractals. For instance: trees, rivers, coastlines, mountains, clouds, seashells, hurricanes, spiral galaxies to the structure of human lungs, etc.
3. Fractals can also created by repeatedly calculating a simple equation over and over thousands or millions of times by using

computers to explore them.

4. Algebraic Fractals are rarely drawn or painted by hand. It is usually created indirectly with the assistance of fractals-generating software, iterating through three phases: setting parameters of appropriate fractals software; executing the possibly lengthy calculation; and evaluating the product.
5. From the famous properties of fractals: Self-Similarity, similar iterative operation, Ability of branching, growing scale, Dynamical Systems.
6. Fractals have aesthetic formations which add aesthetic values to furniture design.
7. Fractals design is one such dynamic process. It is a generative device which opens up new design possibilities. In this context, fractals serve as an effective and useful generative design. That adds functional and aesthetic values to furniture design, and indicate movement and energy.
8. Benefits accrue when typology as a design method incorporates dynamic process that gives rise to infinitely variable generative suggestions.
9. Fractals are artistically vibration energy that will bring into our space the energy spectrum of the universal field with the same vibration as its own, which it resonates in harmony. This harmony and resonance are passed on to the surrounding space and bio-system. When those fields have a beneficial effect, they are health and life supporting. If, however, their effect is of a negative nature, they deplete the life force and very soon lead to deterioration of health and vitality.
10. The purpose of creating fractals energy is to materialize the energies of our aspirations, wants and needs of the physical, emotional and spiritual levels – energies which make up our Essential Being.
11. Exposure to pleasing fractals in design can reduce our physiological responses to stress and activate brain areas associated with happiness.

CONCLUSION

From the results the research had reached to solve the problem: had defined the concept of fractals, described their kinds and properties. The research had explained the effect of Fractals on furniture design, mentioned the applications of Fractals in architecture, interior design and furniture. So the results had achieved the research importance.

From the suggested projects, the research had reached the possibility of multiple sources of inspiration from fractals and their properties in furniture design. (Natural, geometric and algebraic elements), and applying functional and aesthetic values of deferent Fractals formations in Furniture Design. So the research had achieved the objectives.And verified the research hypotheses that designing contemporary furniture inspired from fractals adds functional and aesthetic values to design.

Recommendations

1. Inspiration from the geometric and dynamic properties of fractals in architecture, interior design and Furniture Design.
2. Furniture Designers should benefit from fractals aesthetics to add formation values to characterize contemporary furniture.
3. Appling functional and aesthetic values of deferent Fractals formations in Furniture and interior Design.

References:

1. Aaron Burton-2009 :"Newton's method and fractals" , https://www.whitman.edu/Documents/Academics/Mathematics/burton.pdf)
2. Branka Spehar & others -2003:" Universal aesthetic of fractals", Computers & Graphics 27 (2003) 813–820, http://www2.psy.unsw.edu.au/Users/BNewell/SCNT2003.pdf
3. Cynthia Lanius -2007 ." Fractals", http://math.rice.edu/~lanius/fractals/iter.html
4. Dalton Allan and Brian Dalke -2010," Fractals", College of Science, Engineering & Technology , Fractals - Saginaw Valley State University , https://www.svsu.edu/media/writingcenter/Allan-Dalke.pdf
5. Daniel White-2009:" The Unraveling of the real 3D Mandelbulb", http://www.skytopia.com/project/fractal/mandelbulb.html
6. (Djendji Samardzija-2011:"the Art of fractals energy", http://www.fraktalneenergije.com/en/energy.html)
7. Draves, Scott; Erik Reckase (July 2007). "The Fractal Flame Algorithm" (pdf). Retrieved 2008-07-17.
8. Edyta Patrzalek -2002 :" Fractals: Useful Beauty (General Introduction to Fractal Geometry)", Stan Ackermans Institute, IPO, Centre for User-System Interaction, Eindhoven University of Technology, http://www.fractal.org/Bewustzijns-Besturings-Model/Fractals-Useful-Beauty.htm

9. ERIN PEARSE, 2005 :" AN INTRODUCTION TO DIMENSION THEORY AND FRACTAL GEOMETRY: FRACTAL DIMENSIONS AND MEASURES" , http://www.math.cornell.edu/~erin/docs/dimension.pdf
10. Gabriele A. Losa and others-2016: " From Fractal Geometry to Fractal Analysis", Applied Mathematics, 2016, 7, 346-354 ,Published Online March 2016 in SciRes. http://www.scirp.org/journal/am
11. Karl Richard- 2011 :" The Universe 'May' Have A Fractal Structure!" , https://polynomial.me.uk/tag/fractals/
12. Lori Gardi -2009 :" Event Horizons, black holes and the Mandelbrot set – close to the edge ", http://www.butterflyeffect.ca/Close/Pages/FractalDynamicFields.html
13. Mandelbrot, Benoît B. -2004:" *Fractals and Chaos". Berlin: Springer. p. 38.*
14. Mandelbrot, Benoit (2012). *The Fractalist: Memoir of a Scientific Maverick*, Pantheon Books. ISBN 978-0-307-38991-6
15. Martin Churchill, 2004: "Introduction to Fractal Geometry", http://mdc.nfshost.com/fractals.pdf
16. Michael Frame and others- 2016 :" Fractal Geometry-fractals, Graphics, &Mathematics Education) , Yale University, http://users.math.yale.edu/public_html/People/frame/Fractals/
17. Mitchell Whitelaw (2004). Metacreation: Art and Artificial Life. MIT Press. pp 155.
18. Wolfgang E. Lorenz – 2003:" Fractals and Fractal Architecture" , Diplom-Ingenieur, Advisor: O.Univ.Prof. DI Dr.techn. Georg FRANCK-OBERASPACH (PDF Download Available).: https://www.researchgate.net/publication/273457875_Fractals_and_Fractal_Architecture [accessed May 20, 2016].
19. Paul Bourke -2009:" 4D Quaternion Julia Set Ray Tracer", http://2008.sub.blue/blog/2009/9/20/quaternion_julia.html
20. Prucia Buscell- 2013: http://www.plexusinstitute.org/blogpost/656763/160028/Fractals-Function-and-Beauty
21. Stefan Kottwitz-2011:" Example: Lindenmayer systems", http://www.texample.net/tikz/examples/lindenmayer-systems/
22. Tsuneyoshi Nakayama-2009:" Fractal Structures in Condensed Matter Physics", Toyota Physical and Chemical Research Institute, Nagakute, Japan. http://subutu-ap.eng.hokudai.ac.jp/nakayama/pdf/Encyclopedia_of_Complexity_and_Systems_Science_Springer-Verlag(2009).pdf
23. Umberto Mosco-2009 :" The Relationship Between Fractal Geometry and Energy" ,https://www.wpi.edu/academics/math/fractal-geometry.html)
26. http://www.ams.org/mathimagery/
27. http://nic022.deviantart.com/art/Mandelbulb-3D
28. http://www-03.ibm.com/ibm/history/ibm100/us/en/icons/fractal/transform/
29. www.FractalFoundation.org-2009 "Fractal Pack 1 Educators' Guide".