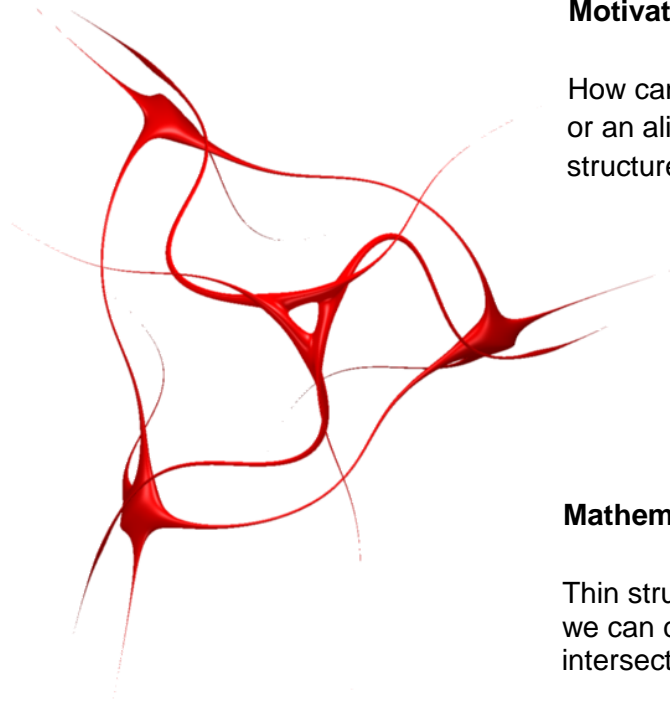


Alien vs. Virus

SURFER Experiment

by Andreas Daniel Matt



Motivation

How can we create an image that looks like a virus or an alien with a small, complex, thin, tree like structure like the example on the left?

Mathematics behind it

Thin structures are generally curves. With SURFER we can create interesting thin structures by intersecting two surfaces.

Let's say we have two different surfaces $f=0$ and $g=0$ (f and g can be any formula you can enter in SURFER). The intersection curve of f and g is given by all points that satisfy both equations (it might be empty).

To show this curve in SURFER we have to use a property of the sum of squares: it is only zero if all squares are zero. This way we can combine the two equations in a way that both of them have to be zero and thus result in the intersection curve:

$$f^2+g^2=0$$

As you see the above equation only holds if $f=0$ AND $g=0$ and thus we obtain all points of the intersection curve.

SURFER cannot visualize isolated points or curves: they have to be made "thicker" by adding a noise parameter a . We obtain:

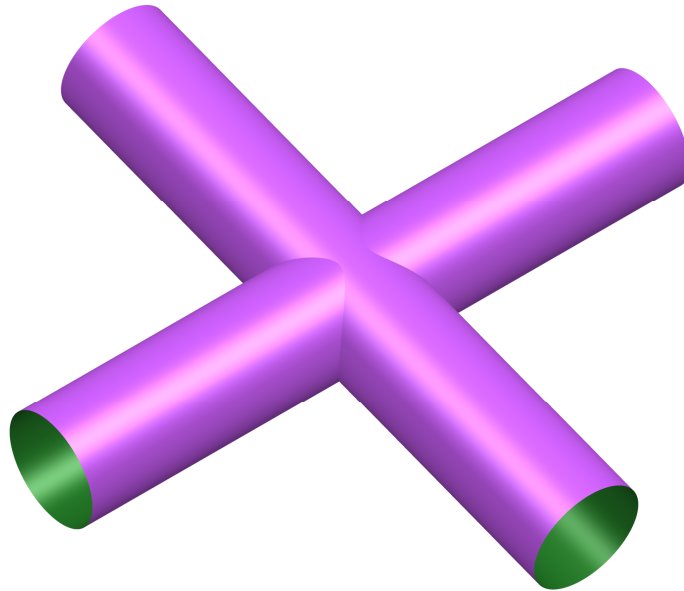
$$f^2+g^2=a$$

For small positive parameters a .

The "noise" parameter a makes the intersection curve thicker, i.e. it becomes tubular (can you see its similarity to the equation of the circle?).

SURFER can be downloaded for free: <http://imaginary.org/program/surfer>

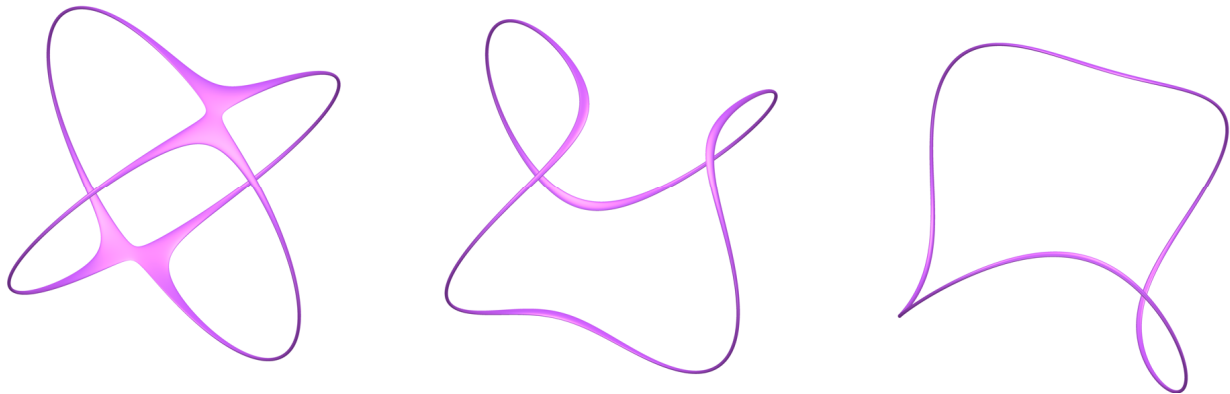
As an example, let's take two cylinders, one horizontal and one vertical and look at their intersection curve. The cylinders are given by:



$$(x^2+y^2-1)*(z^2+(y+3-6*b)^2-1)=0$$

The second one can be moved in y-direction between -3 to +3 units by changing the value of b.

Applying our intersection expression, we obtain:



$$(x^2+y^2-1)^2+(z^2+(y+3-6*b)^2-1)^2-0.01*a=0$$

where $a=0.05$ and $b=0.5, b=0.48, b=0.55$ (from left to right)

Advanced Examples

1. Pink Circular Virus



$$\begin{aligned} &((b*x^2+(y-0.3)^2+z^2-0.5)*(c*x^2+y^2+z^2-0.5)*(d*x^2+(y-0.5)^2+z^2-0.1)-a)^2 \\ &+(x*y*z)^2-0.000001=0 \\ &\text{with } a=0.01, b=0.33, c=0.12, d=0.23 \end{aligned}$$

The pink circular virus is just the intersection of the melted snowman from our first experiment and the surface of three planes ($x*y*z$).

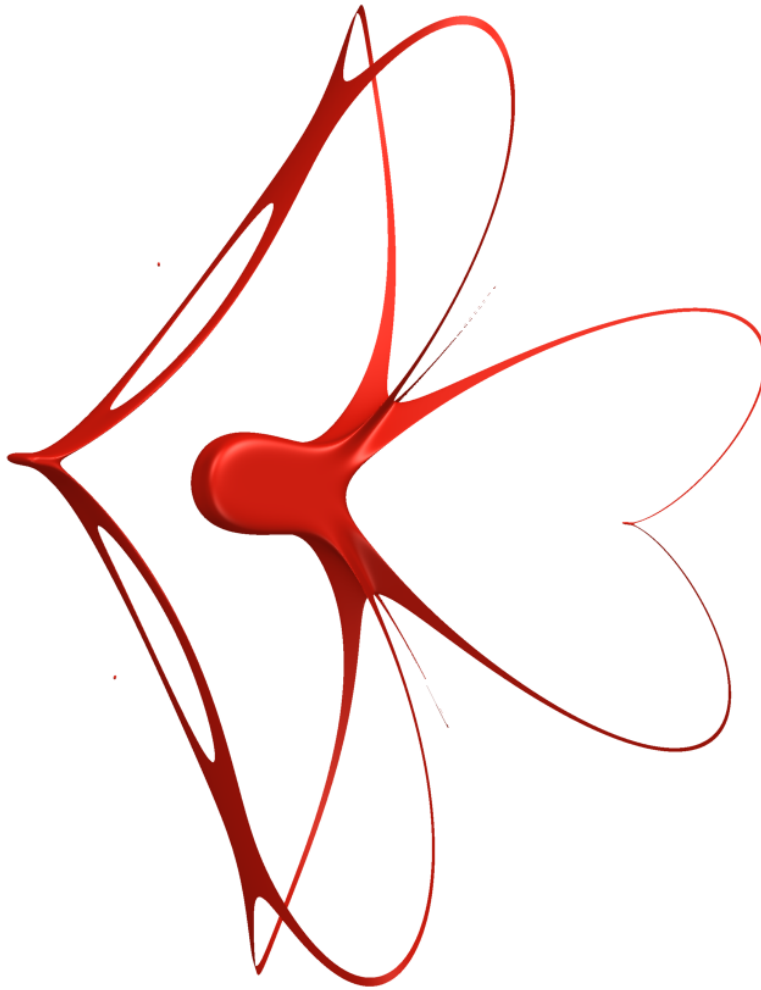
You can see, that there is actually a shape hidden inside the melted snowman.

It is easier to spot if you intersect the snowman with one plane at a time:



Intersection of the melted snowman with the planes $x=0$, $y=0$ and $z=0$ (left to right)

2. Octopus Alien



$$(6*x^2-2*x^4-y^2*z^2)^2+(8*z^9-24*x^2*z^6-24*y^2*z^6+36*z^8+24*x^4*z^3-168*x^2*y^2*z^3+24*y^4*z^3-72*x^2*z^5-72*y^2*z^5+54*z^7-8*x^6-24*x^4*y^2-24*x^2*y^4-8*y^6+36*x^4*z^2-252*x^2*y^2*z^2+36*y^4*z^2-54*x^2*z^4-108*y^2*z^4+27*z^6-108*x^2*y^2*z+54*y^4*z-54*y^2*z^3+27*y^4)^2-0.01=0$$

The octopus alien is simply created by intersecting the two surfaces “Helix” and “Quaste” from the SURFER gallery of fantasy surfaces. Can you spot the two equations?

Further Questions (without solutions)

To simulate the evolution of an alien virus, you can move one of the two surfaces by translating it or even rotating it and observe the resulting intersection curve. Make sure that it does not spread!