Fractals: How nature just keeps on giving

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This week's guest blogger is Jovan Nedic, a PhD student in the Department of Aeronautics at Imperial College, London. His work looks at understanding how fractal geometries can be used to interact with fluids and how they can be implemented in engineering applications.

It is difficult in this day and age of scientific enlightenment to even think there is something in nature that can allow us to understand, and more importantly, exploit the world we have created for ourselves, but fractals are certainly one of those things.

I always love explaining what fractals are to others, mainly because I get to see the expression on their face change from a blank, vacant, almost bored expression, to a sudden realisation that fractals really are everywhere you look and that conceptually at least, they are relatively simple to understand. The tree is my favorite example, because it's the easiest. Have a look at Figure 1 and you will see what looks like the various stages of a tree's growth, or is it? Well it is, except in this example all you are really looking at is the different components of the final tree on the right which I arranged in a fractal manner.

Figure 1

Now look at the Figure 2 below, courtesy of Per Ivar Somby. Can you spot the similarities? Put simply, a fractal is a self repeating pattern where if you kept zooming in, you would always see the same pattern. Mathematically, this means that you can go on for infinity, but practically there are obvious limitations.

Figure 2

The mathematics of self-similar shapes has existed for centuries, but what was rather surprising was realising that this is a natural phenomena, and trees are not the only example. River networks, clouds, coral reefs, leaves, lightning bolts, birds wings, broccoli, and the cardiovascular system are just a few examples that illustrate the abundance of this fractal pattern in nature. So there must be a reason as to why this is a naturally occurring phenomena and more importantly, could we exploit this in some way?

This is what myself and the rest of the researchers in the Turbulence, Mixing and Flow Control Group in the Department of Aeronautics at Imperial College London, under the supervision of Professor Vassilicos, are doing. Our aim is to not only understand how they might affect fluids, but to also apply this knowledge to real life applications.

One of the first things, and probably the most fundamental aspects of fractals to understand, is that fractals allow you to maximize the volume or space you are given. For plants this is vital because they want to capture as much sunlight as possible so they can grow. For our lungs it allows us to take in as much oxygen as possible and distribute it to the rest of the body as quickly as possible. Where does this come in handy for engineering applications? In-line mixers are one example that has been looked at; finding the most efficient way of mixing two fluids is vital for chemical combustion.

None of this happened by chance, and for the last ten years or so, there has been a lot of work on understanding how fractal geometries might be used to control turbulence and flow in general. Some of the results coming from these studies, as well as ones that are currently being carried out, show that certain turbulent parameters are not as universal as people once thought. This is not to say that scientists have been wrong in the past; scientific conclusions are based on the data that is in front of them, and as these change, so do the conclusions. This is how science evolves.

As our understanding of this new type of flow grows through experimental and numerical work, we can begin to use it to our benefit. One of the recent studies carried out in our group, and one that I have been working on, is for acoustic manipulation, specifically onaircraft wing spoilers. The noise generated by the spoilers comes from the unsteady flow created by it, which give off a very low frequency booming noise that can travel for miles on end; as you can imagine, this is a problem for the aviation industry! There were some signs that by simply adding holes to these plates, you would shift the noise to higher frequencies, frequencies we can't hear. Dogs might, but they won't be on the plane so that's not too much of a problem. What we noticed however, is that if you used a fractal pattern to created the holes, you would get better results and furthermore, you could control the noise level.

Currently my work has started to look at using fractal generated geometries on wings, again following in the footsteps of nature as birds' wings have a fractal element to them. This is still a work in progress but initial signs look promising. These are just a few examples, but interest in this field is growing every year and is not just confined to the UK, so expect to see many more examples of how fractal geometries are being used to help the world around us.

Note of Jules Ruis:

For more information about fractals: www.fractal.org

And fractal trees: www.fractal.org/Julius-newtree-set.pdf