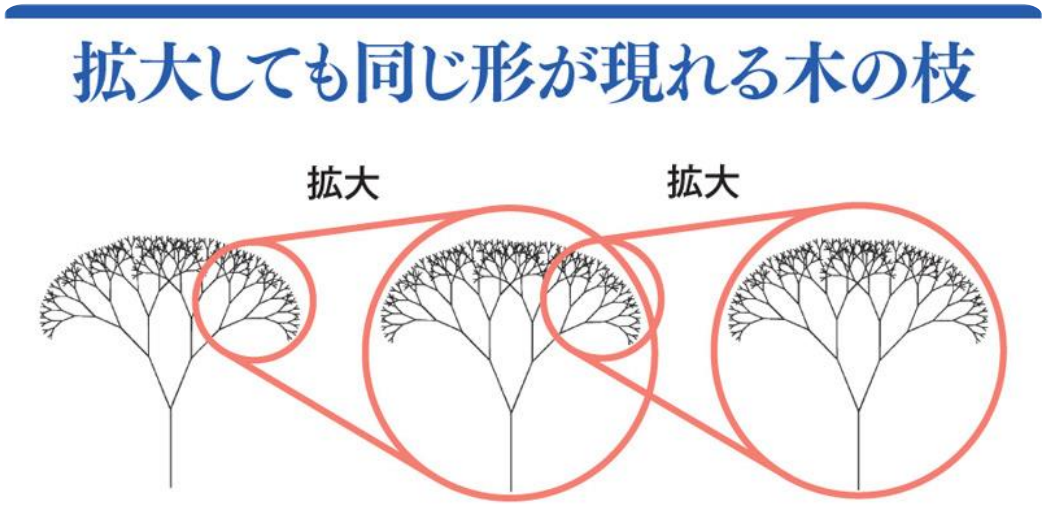
Mathematical patterning
数学的なパターン化

To be a little more specific...

What I'm thinking of using now is "fractal“

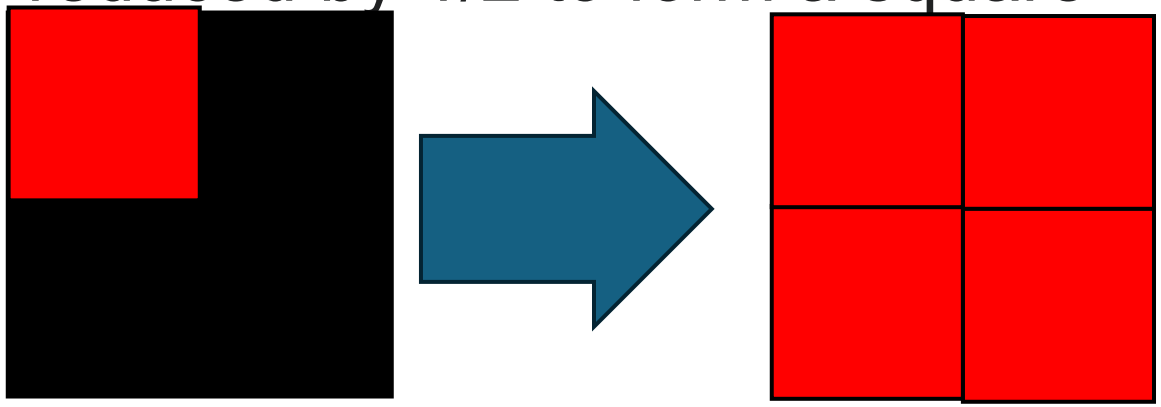
The concept of geometry introduced by the French mathematician Benoît Mandelbrot

A fractal is a geometric structure that has a special property called "self-similarity", for example, "When the whole figure is broken down into several parts, the same shape as the whole is reproduced".



Fractal Dimension

- The three most important theoretical fractal dimensions are the Lenny dimension, the Hausdorff dimension, and the packing dimension.
- (I understood it for the time being) Calculated Wolf Dimension)
- When a d-dimensional figure can be reduced by a factor of 1/k, it is thought that the required number of k**d is
- Example: 4 squares reduced by 1/2 to form a square
- Calculation method
- Using Log



Objectives and Targets

・We will deepen our knowledge of fractal structures and make use of them in future research.

・Finding fractals in everyday life in Australia

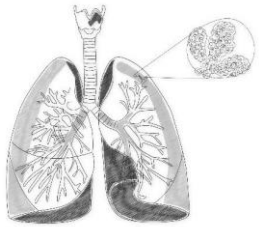
Apart from this...

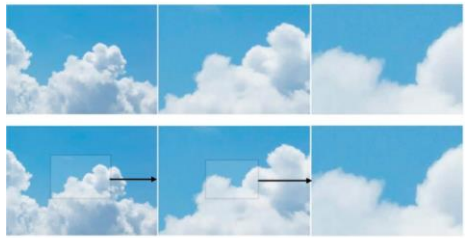
・It would be even better if we could examine plants that are unique to Australia and expand our knowledge of those plants

Fractal structures in everyday life

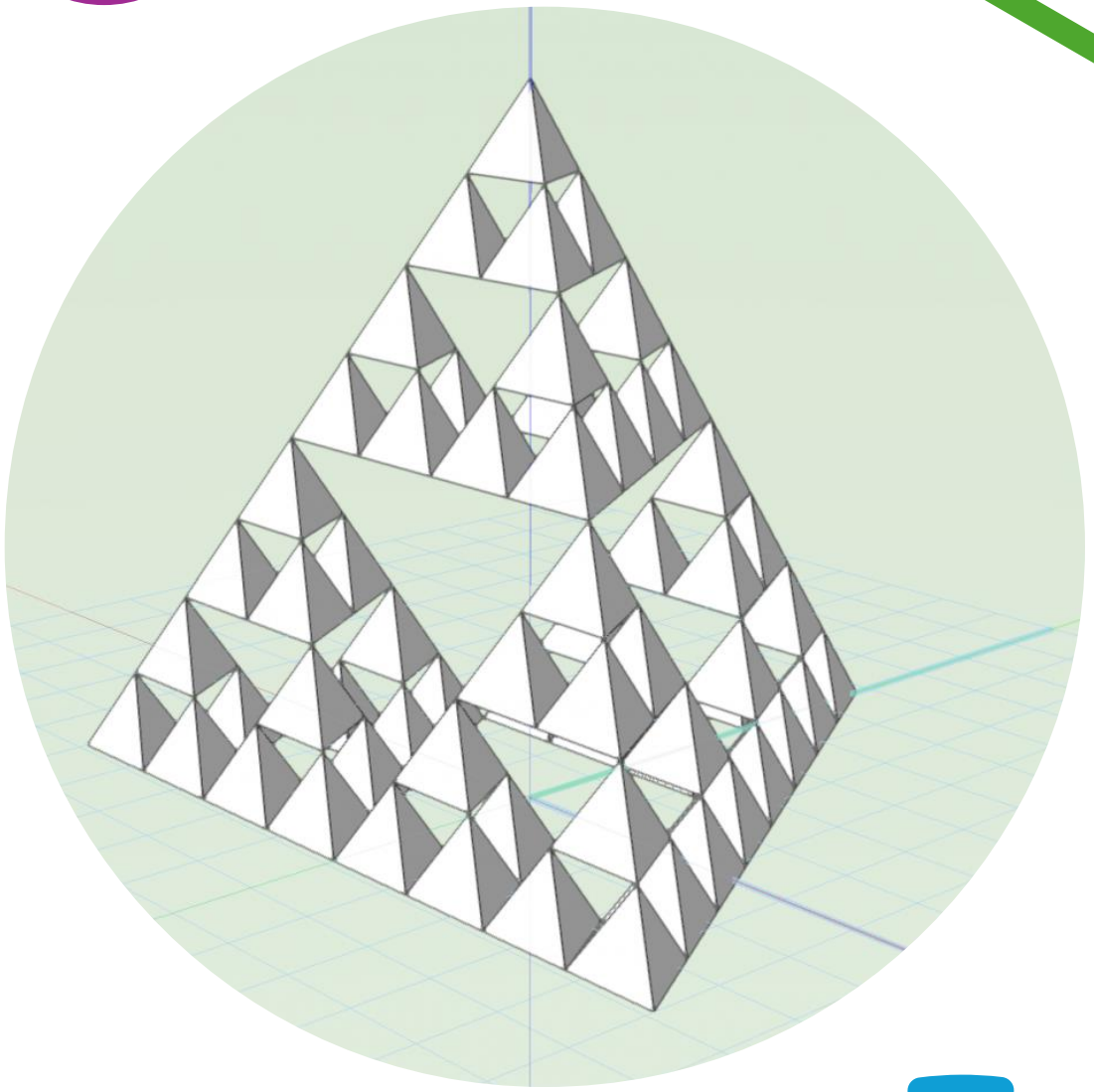
Coastline Human (lungs, blood vessel structures)
Shape of clouds
Fern

Romanesco





（出典）pixta より



Examples of the use of fractal structures

(1) Sunshade Although it has many gaps on the outside, it is low-cost and highly efficient. Example: Sierpinski tetrahedron

(2) Music It is used as one of the mathematical models in the composition method that uses computers and leaves it to contingency.

(3) Financial modeling: Stocks, etc., are randomly modeled on the premise of the party.

(4) Look at the Fibonacci sequence, the formula of the golden ratio, etc., self-similarity is seen.

(5) Medical field: Early detection of cancer and other diseases can be achieved by fractal analysis.

Questions

What are the advantages of this fractal structure?

Research Project

Regarding fractal structure, since this is a training trip to Australia, analysis of fractal structure in plants in relation to Australia

Advantages of fractal structure and comparison with plants without fractal structure

Method (1)

Examine previous research.

In thinking about plants, we consider the advantages from a graphical point of view, such as by actually generalizing them.

From previous research

- Examples of the usefulness of fractal structures
- Super water repellency due to fractal structure
- The hemispherical structure with a diameter of about 50 μm, which is relatively large, can be regarded as a primary structure, and the scaly crystals on the surface can be regarded as a secondary structure. In this way, the surface area multiplier factor (L/l) D-2, which affects the wetability of the uneven surface, is considered to be larger than that of a purely concave-convex structure, and a super-water-repellent surface surface is realized. (Journal of the Japan Oil Chemists Society Vol.46,No.6)

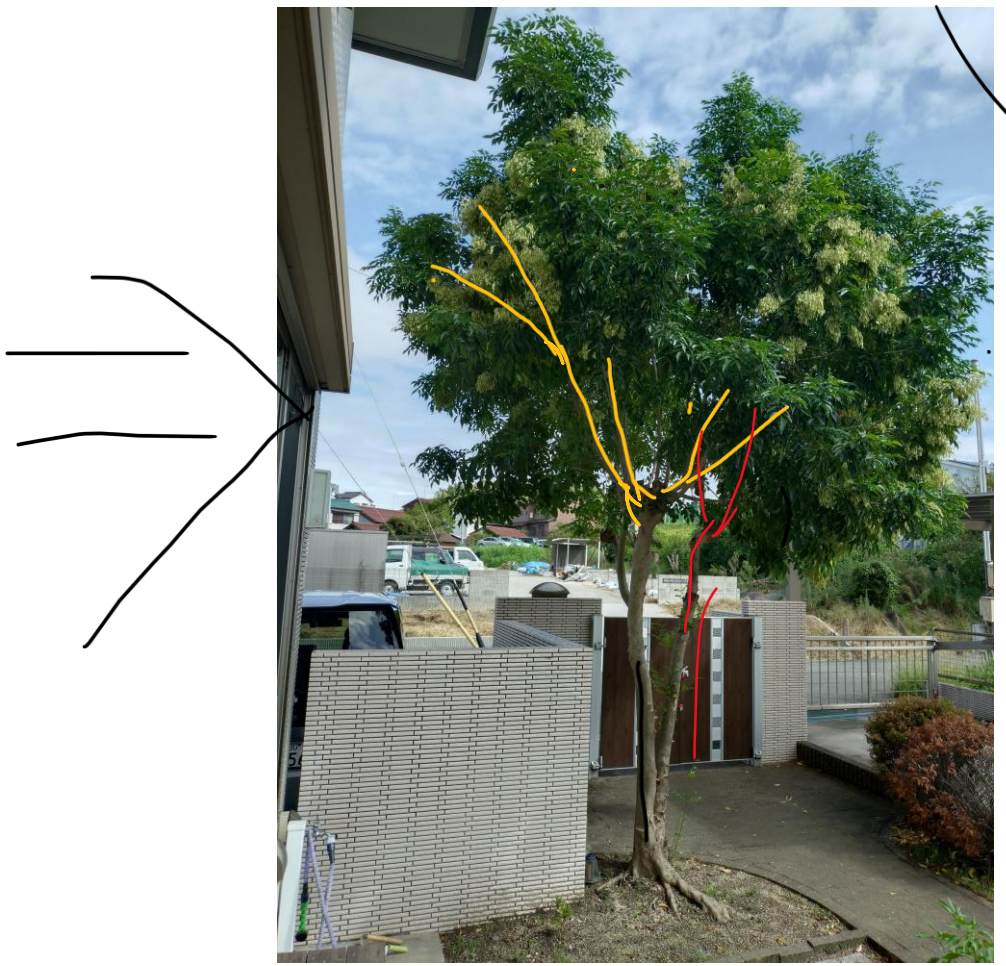
Practice

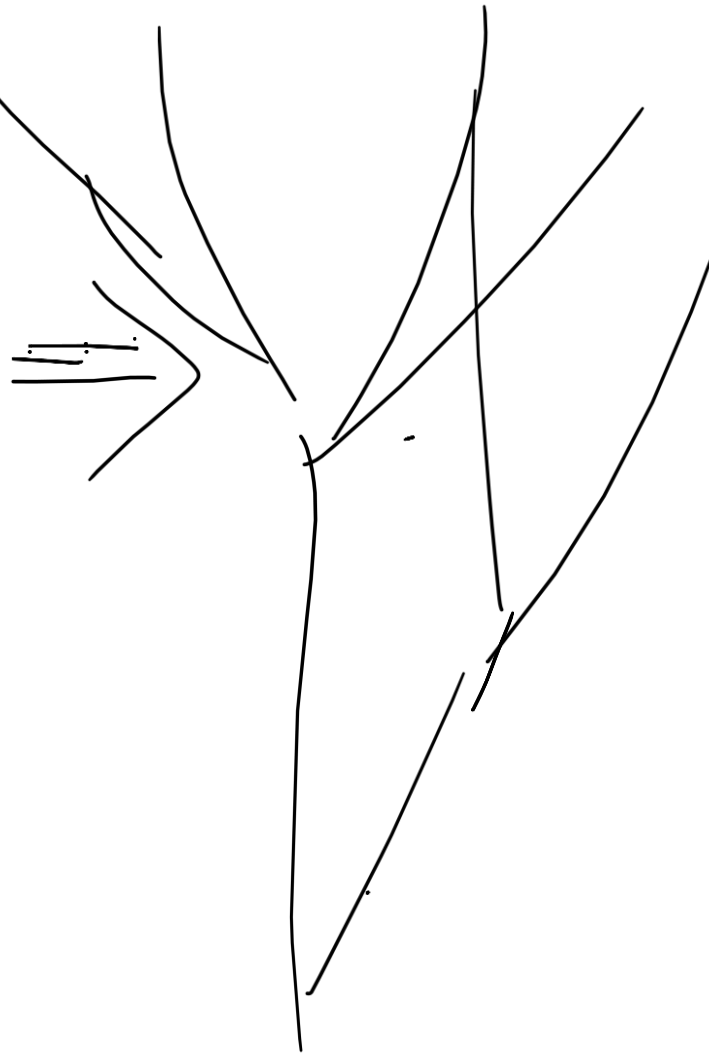
- This time, we will make a pattern... The outline of the branches of the tree
- This is because the tree is thick, so it has many thin branches, and it is difficult to distinguish a part of this branch from the enlarged whole, and it is said that it has a similar shape and a fractal structure.

Method (2)

- About Patterning
- Basically, take a photo of the subject
- Make generalizations in practice
- The basics are done by hand

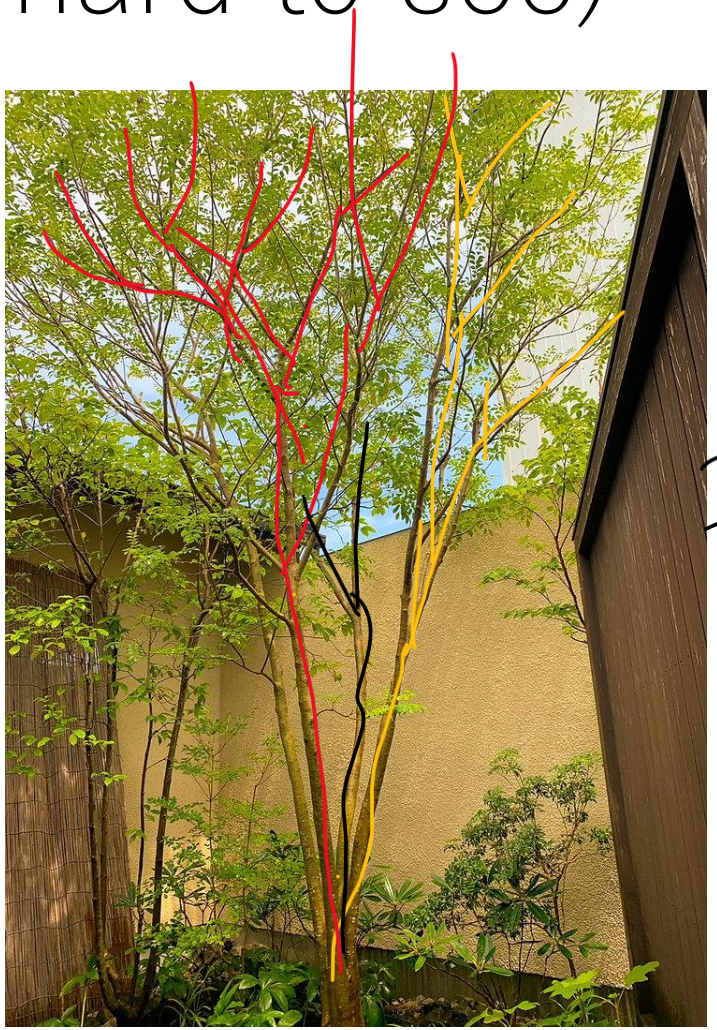
Actual image Example 1 house (striped ash tree)



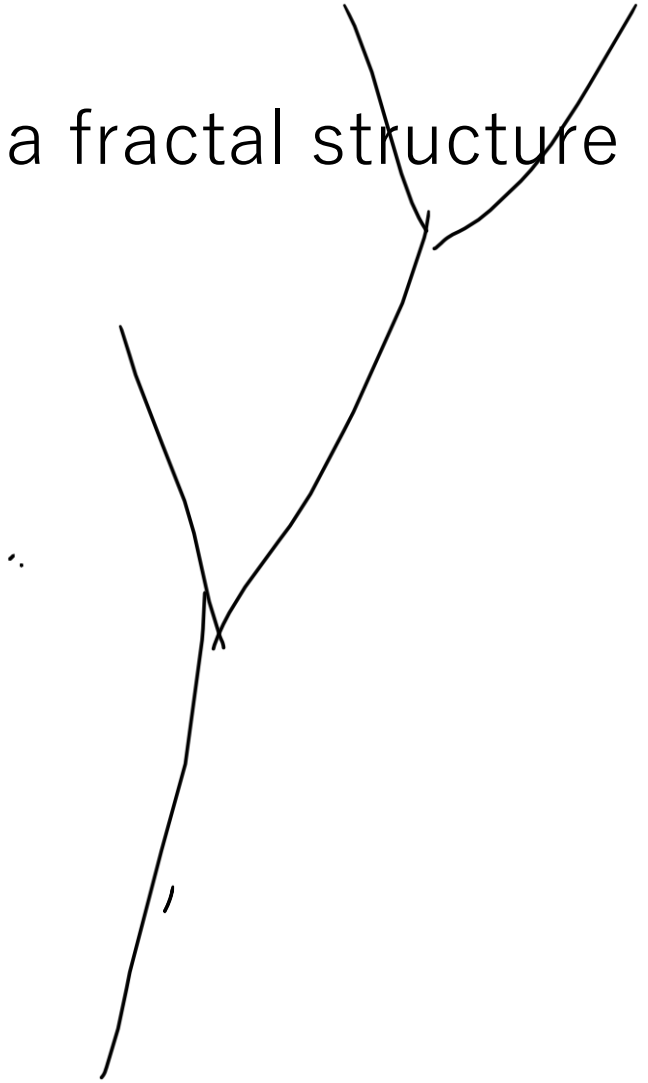


Example 3: Nearby Mountains

Example 2: Striped ash (the house was hard to see)



Each tree has a fractal structure



Thoughts and Impressions

Since it was natural and handwritten, the outline of the tree branches, although not perfectly, was still fractal-structured.

In the case of wood, it was almost symmetrical and had a shape that opened outward

I tried to make it generalized, so it took shape, but I felt that there were still many areas for improvement

Questions from the discussion

- In this quest, we will consider the advantages of fractal structures
- What are the advantages of the outline of the branches of the tree this time?

Hypothesis

(1) The structure was designed to open outward→ but the area from the top expands→ the more leaves absorb sunlight (light) more easily.

(2) It had a structure that spreads symmetrically to some extent + the structure of the tree that spreads in the same way → is more stable

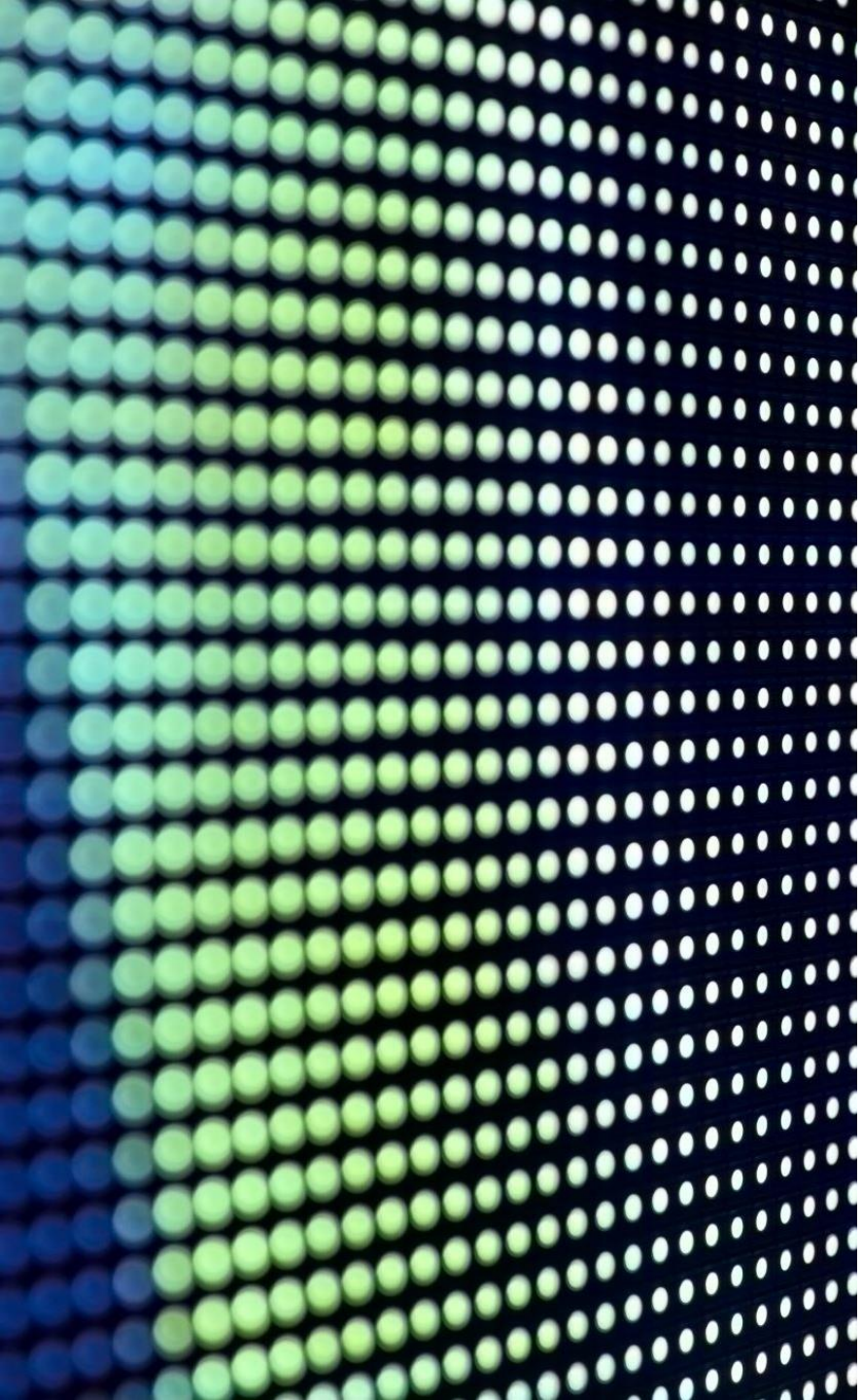
Verification (1)

- (1)
- The photo on the right is a general shot of the tree of the first house taken from above
- Even parts that would go inside, such as the red circle, can be observed from above

Verification (2)

- As a method, consider it based on the balance of gravity

image



practice

Since it is difficult to obtain an index for hypothesis (1) and it is difficult to verify, we will focus on the verification of hypothesis (2)

The procedure for hypothesis (2) is performed by the following procedure

(1) Data collection

(2) Calculations using data

(3) Discussion based on the results

Data

Since it is not possible to determine the mass of the tree, a part of the tree is cut down and estimated from the mass to verify it

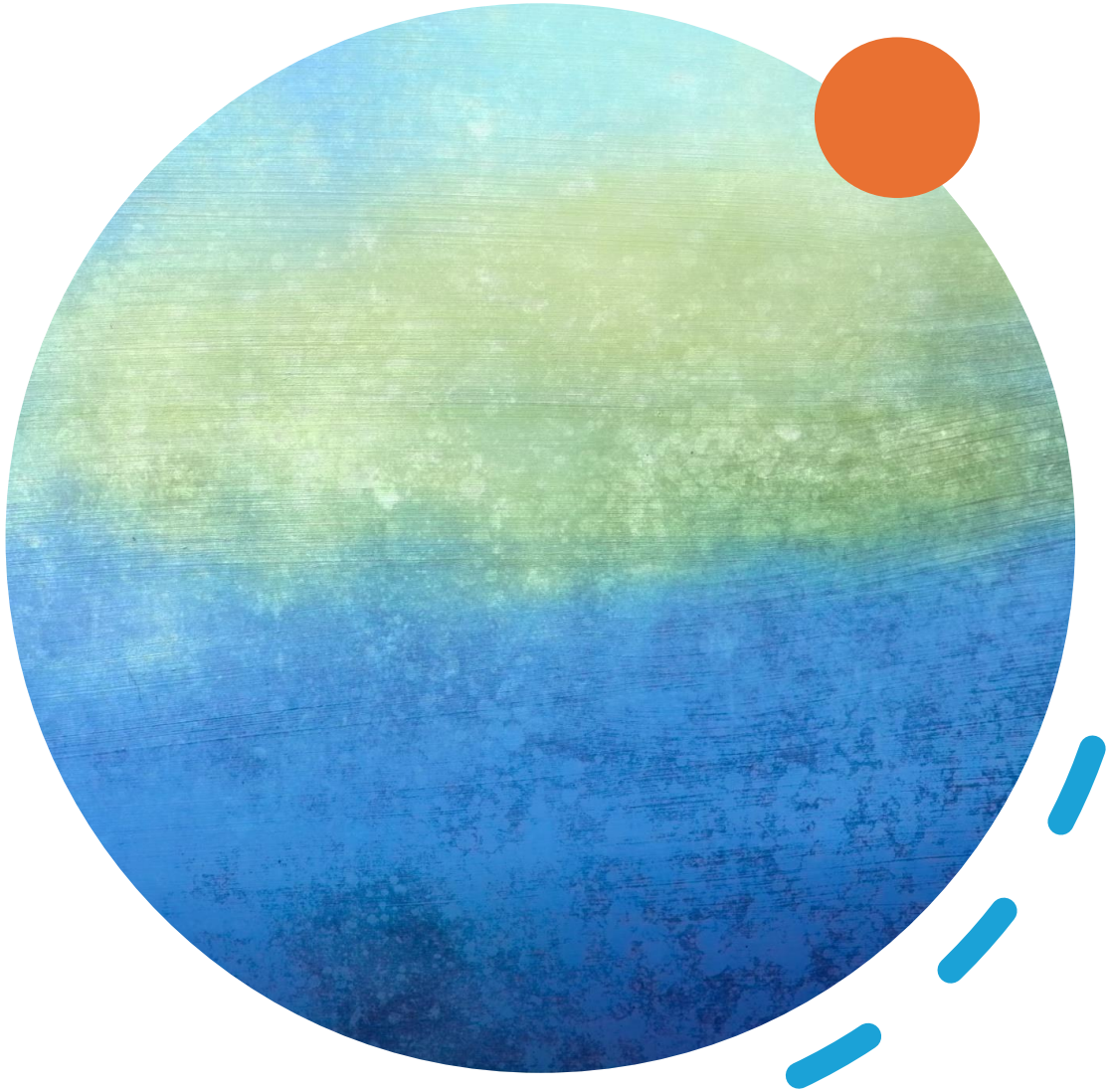
There is little difference in the length of the branches in terms of self-similarity

Thick branch: Diameter 3,47 cm, Radius 1.74, Circumference: 10.9, Length: 179,1 cm (cylinder) + 93,75 cm (cone), Mass: Branch: 2,3 kg (5,8 kg with leaves)

Thin branch diameter 2,70 cm, radius 1.35 circumference 8.48 length 178 cm (cylinder) + 62,5 cm (conical) mass branch 1,1 kg (2,7 kg with leaves)

Branches more than these two: leaf mass is about 2:3

Think in the foreground of the tree in the photo



Calculation

- Think about the balance
- Left circumference 7,1 cm Radius 1.14 cm 1 10,9 cm Radius 1.74 cm 1 piece 20,1 cm Radius 3.20 cm 1 piece
- Right circumference 8,48 cm Radius 1.35 cm 1 14,2 Radius 2.3 cm 16,9 cm Radius 2.69 cm 1

〈Formula〉 From mass ratio = volume ratio左 $(1.14)^3$:x=$(1.74)^3$:2.3 If you think about it in the same way,

From left: 0.65 (1.62), 2.3 (5.75), 14.3 (35.5), total 17.25 (42.87)

Right$(1.35)^3$:X=$(1.74)^3$:2.3 If you think about it in the same way,

From left to right: 1.1 (2.7), 5.31 (13.28), 8.50 (21.25), total 14.75 (37.23)

Thoughts and Impressions

- There was a difference in the thickness of each of the thick branches, which are the main mass, but there was not much difference in the position and number of branches growing
- Also, from the viewpoint of the mass of balance, there was a slight difference between the left and right, but it was not so large, and some balance was seen
- In this calculation, the approximation is conspicuous, so it is conceivable that the value will actually be slightly off (the limit point of the study)
- It was difficult to go into detail about Verification 1, but the light was able to reach the leaves in the back from the photo above
- As a verification, it seems that the fractal structure is one of the supporting factors in terms of the stability of the tree

オーストラリア研修について

①講義

変化率（微分）についての講義を受けた

最初の導入は「歩行」で誤差についてから始まった

秒間について縮めれば誤差は小さくなる

これを用いて人工衛星の軌道を考えた（フラクタル）

X軸とY軸それぞれで重力加速度を考えていたのが驚きだった

秒間（Δt）が1に近いほどほど軌道が正確に描かれ大きくなればなるほど楕円状になっていった

X軸Z軸でも同じように行った

自分が今回着目したものとは別の分野でフラクタルを用いた研究になっておりすごく参考になった

②質問

フラクタル次元について質問した

図を用いてわかりやすく説明してくださった

線を用いた例やシェルピンスキー四面体を用いて説明しており

線ではないが点ではないといったようなものを表すのがフラクタル次元であるらしい

いまいちつかめていなっ方がなんとなく概要を理解することができた

③MARYMEDEの先生

海外のサイトを教えていただいた

そこでは日常のフラクタルについて書かれており、ロマネスコのような自分で調べたものや、パイナップル、松ぼっくりなどこれもそうなんだと思うようなものもたくさんありとても刺激になった

bibliography

- フラクタルの概念は社会でどのように利用されているのか－フラクタルの応用例－　|ニッセイ基礎研究所 (nli-research.co.jp)
- フラクタルは自然界でも多く観測されるって知っていますか－植物や各種の地形にも多くみられる－　|ニッセイ基礎研究所 (nli-research.co.jp)
- フラクタルってなに？～その特徴と歴史その①～｜数学・統計教室の和から株式会社 (wakara.co.jp)
- 第24回「シェルピンスキーのギャスケット」 – Vectorworks Design Blog (aanda.co.jp)