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Analysis of Fibonacci Sequence on Violet Flower's Petals

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Abstract: Fibonacci sequence is commonly found in everyday lives either in nature such as animals and plants or in the infrastructure itself that occurs naturally which somehow, people are not aware of how important nature is and do not recognize the beauty that nature had offered to them. This project focuses on the Fibonacci sequence and the Golden Ratio to analyze the violet flower's petals and create a visual design of the violet flower's petals and delves into the mathematical patterns found in violet flowers. In this project, MATLAB software was used to create a simulation of a violet flower's petals to analyze the flower in three different characteristics, which are the number of the petals, the size of the pistil and the colour of the flower. Therefore, the most realistic visual design of a violet flower would be chosen, and the Fibonacci sequence and Golden Ratio would be analyzed. Therefore, referring to a professional who has more knowledge in MATLAB and adding some leaves are some suggestions that can be recommended for future work in order to achieve a better result.

Keywords: Fibonacci Sequence, Golden Ratio, Velvet Flower's Petals

1. Introduction

Art can be defined as any creative human action or its outcome. Painting and sculpture are two of the most well-known visual arts [1]. Clothing, fabrics for clothing, and upholstery; machine-made carpets and rugs; furniture; ornamental glassware, porcelain, and faience; and metal artefacts, including accessories, are examples of decorative applied art objects that are used to improve everyday living and house interiors. However, the pattern on violet the flower's petals can also be an art that everyone should be aware of because of its natural beauty.

Violets are one of the brightest small flowers in the garden. True violets are not the same as African violets, which are endemic to east Africa. Our native violets are native to the temperate regions of the Northern Hemisphere and, depending on the species, can bloom from spring through summer. The genus Viola has over 400 different species of violet plants. The numerous violet plant kinds ensure that

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there is a sweet little Viola suitable for practically any gardening purpose [2]. However, the emphasis of the study will be on the patterns of violet flower and how they relate to the Fibonacci series, golden mean, and fractal evidence.

The flowers of the vast majority of the species are strongly zygomorphic with bilateral symmetry and solitary, however they do produce cymes on occasion. The blooms have five petals: four are upswept or fan-shaped, with two on each side, and one broad, lobed lower petal pointing downward. This petal is barely differentiated and may be somewhat or much shorter than the others. Many species are distinguished by the form and arrangement of their petals. For example, some species have a "spur" on the end of each petal, but the majority have a spur on the bottom petal [3].

1.1 Fibonacci Sequence

The Fibonacci sequence appears so frequently in the natural world. The spacing of joints in human fingers, the arrangement of seeds in sunflowers and the spiral of a nautilus shell as well as peacock's feather are all examples of its proportions. The number of petals on flowers is another clear example of where the Fibonacci sequence can be found in nature. Most flowers have three petals (like lilies and irises), five (parnassia, rose hips) or eight (cosmea), 13 (some daisies), 21 (chicory), 34, 55 (like lilies and irises), or 89 (asteraceae) petals. Although the spiral has been used in imaginative ways, many of these designs have focused on numbers and rectilinear shapes [4].

1.2 Golden Ratio

The Golden Ratio can help decide where to put our material and helps create a composition that will draw the eyes to the important elements of the photo. The Golden Ratio sometimes called "divine proportion" is best approximated by the Fibonacci numbers. The Golden Ratio is about 1.618, and is represented by the Greek letter phi, Φ. The petal of a violet flower is a great visual image of the Golden Ratio in terms of makeup and appearance. Similarly, the ratio of any two consecutive Fibonacci numbers converges to rough values of 1.618 or 0.618. This diagram illustrates the connection between Fibonacci numbers and the golden ratio. Ancient Egyptians utilised this Golden Ratio in the construction of their enormous pyramids [5].

1.3 Fibonacci Sequence on Velvet Flower's Petals

Fibonacci numbers can be found in the flower realm as well. The central component of the flower, known as the pistil, follows the Fibonacci pattern in the same way that the petals do. In reality, pistils follow the Fibonacci sequence far more closely. The curving pattern they generate using the Fibonacci sequence creates a gorgeous and detailed design that genuinely resembles a work of art. Leaves of flowers, cactus, and other succulents' leaves also follow the Fibonacci sequence and are organised in both left-handed and right-handed spirals. The veins in the leaves also follow Fibonacci and branch out in an outward orientation. Their alignment is also in the shape of two Fibonacci numbers. After a specific spiral turn (1, 2, 3, 4, or 5) there will be a leaf aligned in the direction of the original leaf, and the pattern will continue [6].

There are several examples of Fibonacci sequence in the food we eat, such as pineapples, artichokes pinecones, apples, bananas, lettuce, cauliflower, and broccoli. Famous examples include the lily, which has three petals, buttercups, which have five, the chicory's 21, and the daisy's 34. Observing the geometry of plants, flowers, or fruit reveals the presence of recurring structures and forms. The Fibonacci sequence, for example, is important in phyllotaxis, which is the study of the arrangement of leaves, branches, flowers, or seeds in plants with the goal of showing the occurrence of regular patterns. Surprising mathematical regularities govern the different combinations of natural elements: D'arcy Thompson discovered that the plant kingdom has an odd affinity for specific numbers and spiral geometries, and that these numbers and geometries are tightly related [4].

Throughout this study, there are some contributions that could be achieved by conducting this research. Firstly, the art industry can use the violet flower to design anything such as outfits, carpets, ceramics, paintings, etc. From this, people will start to see the true beauty of the violet flower that is being ignored throughout time. Thus, this study will discuss the mathematical pattern in violet flower's petals by using MATLAB software. Besides, people can learn about the Fibonacci sequence and the golden ratio found on the violet flower's petals. Therefore, people and the art industry itself will gain benefit from the research.

2. Methodology

2.1 Fibonacci Sequence

A closer look at the numbers that make up the Fibonacci sequence reveals a plethora of intriguing patterns and mathematical features. Although Fibonacci does not specify these patterns in his book, the following are a few that have been discovered after years of studying the numbers in the sequence. Because they share no factors, any two consecutive Fibonacci numbers are compared prime. For instance:

$$5, 8, 13, 21, 34$$

$$1 \cdot 5 = 5$$

$$2 \cdot 2 \cdot 2 = 8$$

$$1 \cdot 13 = 13$$

$$7 \cdot 3 = 21$$

$$2 \cdot 17 = 34$$

When we add ten Fibonacci numbers together, we will always obtain a number divisible by eleven. For instance:

$$1 + 1 + 2 + 3 + 5 + 8 + 13 + 21 + 34 + 55 = 143$$

$$\frac{143}{11} = 13$$

$$89 + 144 + 233 + 377 + 610 + 987 + 1597 + 2584 + 4181 + 6675 = 17567$$

$$\frac{17567}{11} = 1597$$

Every third Fibonacci number is divisible by two, or F_3. Every fourth Fibonacci number is divisible by three, or F_4. Every fifth Fibonacci number is divisible by five, or F_5. Every sixth Fibonacci number is divisible by eight, or F_6, and the pattern continues. With the exception of the fourth Fibonacci number, Fibonacci numbers in composite-number locations are always composite numbers. In other words, if *n* is not a prime, neither will the *n*-th Fibonacci number [7].

$$F_6 = 8$$

$$F_9 = 34$$

$$F_{16} = 987$$

Finding the value of a Fibonacci number based on its location in the sequence can be time-consuming and difficult, especially if the number is further down the sequence. The fifth Fibonacci number is not difficult to find. Locating the fifty-first phrase is significantly more difficult because it necessitates finding and adding the previous forty-nine terms. Jacques-Philippe-Marie Binet, a French mathematician, discovered a formula in 1843 that could calculate any Fibonacci number without having to find any of the previous numbers in the sequence. The golden ratio, $\frac{1+\sqrt{5}}{2}$ and its inverse are used in this formula to calculate the *n*-th Fibonacci number [7].

$$F_n = \frac{1}{\sqrt{5}}\left[\emptyset^n - \left(-\frac{1}{\emptyset}\right)^n\right] = \frac{1}{\sqrt{5}}\left[\left(\frac{1+\sqrt{5}}{2}\right)^n - \left(\frac{1-\sqrt{5}}{2}\right)^n\right] \qquad \text{Eq. 1}$$

Because the Fibonacci sequence is a second-degree linear, homogeneous recurrence relation, the following formula can be derived:

Recurrence relation: $f_n = f_{n-1} + f_{n-2}$

Initial conditions: $f_0 = 0, f_1 = 1$

Assume that $f_n = r^n$ is a solution,

Then $r^n = r^{n-1} + r^{n-2} \quad \rightarrow \quad r^2 = r + 1 \quad \rightarrow \quad r^2 - r - 1 = 0$

Using the quadratic formula to solve this equation results in $r_1 = \frac{1+\sqrt{5}}{2}, r_2 = \frac{1-\sqrt{5}}{2}$

$$f_n = \alpha_1 r_1^n + \alpha_2 r_2^n \quad \rightarrow \quad f_n = \alpha_1\left(\frac{1+\sqrt{5}}{2}\right)^n + \alpha_2\left(\frac{1-\sqrt{5}}{2}\right)^n \qquad \text{Eq. 2}$$

$$f_0 = \alpha_1 + \alpha_2 = 0$$

$$f_1 = \alpha_1\left(\frac{1+\sqrt{5}}{2}\right) + \alpha_2\left(\frac{1-\sqrt{5}}{2}\right) = 1$$

$$\alpha_1 = -\alpha_2 \qquad \text{and} \qquad \alpha_2 = -\frac{1}{\sqrt{5}}$$

$$f_n = \frac{1}{\sqrt{5}}\left(\frac{1+\sqrt{5}}{2}\right)^n - \frac{1}{\sqrt{5}}\left(\frac{1-\sqrt{5}}{2}\right)^n$$

$$\frac{1-\sqrt{5}}{2} \cdot \frac{1+\sqrt{5}}{1+\sqrt{5}} = \frac{1-5}{2+2\sqrt{5}} = -\frac{2}{1+\sqrt{5}} = -\frac{1}{\emptyset}$$

$$\therefore f_n = \frac{1}{\sqrt{5}}\left[\emptyset^n - \left(-\frac{1}{\emptyset}\right)^n\right]$$

2.2 Golden Ratio

We divide the image into three unequal pieces using the Golden Ratio, then use the lines and intersections to create the image. The golden ratio is computed by splitting a line segment so that the longer portion (L) is proportionate to the shorter section (S), and the longer portion is proportional to the entire line segment. The formula $L + S = \frac{L+S}{L}$ can be used to express this relationship in general. Then, $x = 1 + \frac{1}{x}$. Finally, using the quadratic equation to solve for 8 yields the numerical value for the golden ratio, which is commonly represented by the Greek letter phi.

$$\emptyset = \frac{L}{S} = x = \frac{1+\sqrt{5}}{2} = 1.6180339887 \ldots \qquad \text{Eq. 3}$$

Because the ratio is 1: 0.618: 1 therefore the width of the first and third vertical columns will be 1 while the width of the center vertical column will be 0.618. Likewise, with the horizontal rows: the height of the first and third horizontal rows will be 1, and the width of the center row will be 0.618.

When powers of phi are examined, Fibonacci numbers become even more intimately tied to the golden ratio. First, $\emptyset^2$ is written in terms of $\emptyset$, which after simplification yields $\emptyset^2 = \emptyset + 1$. Each successive power of phi can then be written in terms of factors of previous powers of phi. The result of each power is a multiple of $\emptyset$ plus a constant. It turns out that the phi coefficient and the constant are both Fibonacci numbers in the same order [7].

$$\emptyset^3 = \emptyset \cdot \emptyset^2 = \emptyset(\emptyset + 1) = \emptyset^2 + \emptyset = (\emptyset + 1) + \emptyset = 2\emptyset + 1$$

$$\emptyset^4 = \emptyset^2 \cdot \emptyset^2 = 3\emptyset + 2$$

$$\emptyset^5 = \emptyset^3 \cdot \emptyset^2 = 5\emptyset + 3$$

$$\emptyset^6 = \emptyset^3 \cdot \emptyset^3 = 8\emptyset + 5$$

2.3 Developing a design using MATLAB

MATLAB is a computer language that engineers and scientists use to study and build systems and products that change the world. The MATLAB language, a matrix-based language that allows the most natural expression of computational mathematics, is at the heart of MATLAB. It combines computing, visualization, and a programming environment into one package. MATLAB is also a modern programming language environment, with advanced data structures, built-in editing and debugging tools, and object-oriented programming capabilities. Because of these features, MATLAB is an outstanding teaching and research tool [8]. In this research, the design for the Fibonacci sequence and the Golden Ratio was developed by using MATLAB software. Then, we analyze the comparison within three characteristics which are the number of the petals, the size of the pistil and the color of the flower to find the suitable visual design of a violet's flower petals.

3. Results and Discussion

In this research, the objectives are to analyze the Fibonacci sequence and the Golden Ratio on violet flower's petals and to create a visual design of the violet flower. The method was conducted using MATLAB software to create the design with different colours, number of petals and size of the pistil for the violet flower. Figure 1 shows the coding of violet the flower:

```
Command Window

>> clear all
>> n=1000;
r=linspace(0,1,n);
theta=linspace(0,2*pi,n);
[R,THETA]=ndgrid(r,theta);
petalNum=_;
x = 1 - (1/2)*((5/4)*(1 - mod(petalNum*THETA, 2*pi)/pi).^2 - 1/4).^2;
phi = (sqrt(5)-1)/2;
y = 1.95653*(R.^2).*(1.27689*R - 1).^2.*sin(phi);
R2 = x.*(R.*sin(phi) + y.*cos(phi));
X=R2.*sin(THETA);
Y=R2.*cos(THETA);
Z=x.*(R.*cos(phi)-y.*sin(phi));
mapSize=__;
blue_map=linspace(___,___,mapSize)';
blue_map(:,2)=linspace(___,___,mapSize)';
blue_map(:,3)=linspace(___,___,mapSize)';
gold_map=[255 215 0; 250 210 0];
violet_map=[gold_map; blue_map];
surf(X,Y,Z,'LineStyle','none')
colormap(violet_map/255)
view([-12.700 81.200])
```

Figure 1: Coding of a Violet Flower

The number of *n* is set to 1000 because it returns the product of all positive integers less than or equal to n, where n is a nonnegative integer value. The value must be in a positive integer in order to create a non-inverted image. The size of the pistil, the number of petals and the color of the violet flower are selected to analyze to create a realistic image of violet flower's petals. Based on Figure 2, 3 and 4, the results for each characteristic are recorded as an image has shown.

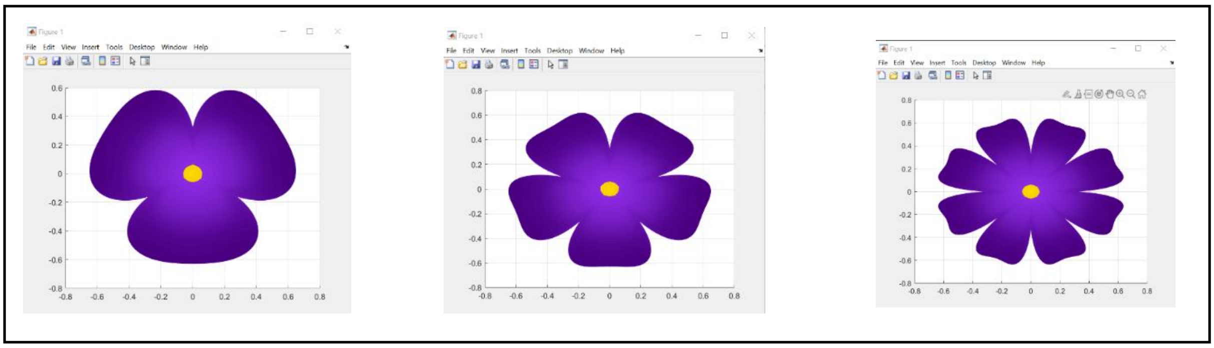

Figure 2: The Image of Violet Flower with Different Number of Petal

Based on the Figure 2, as the variable of the number of petals in the coding increase, the number of the petals in the visual image also increases. The number of petals changes in the coding according to the number in the Fibonacci sequence which are 3, 5 and 8. Since the actual number of petals in violet flower is 5, therefore the image shown with number of petals 3 and 8 is unrealistic and did not illustrate the real violet flower in real life. The number of petals of a flower follows the Fibonacci sequence consistently. Phi emerges in petals as a result of Darwinian processes selecting the optimal packing arrangement; each petal is placed at 0.618034 per turn (out of a 360° circle), providing for the best potential exposure to sunlight and other elements. From the image shown in this figure, it shows that the image of violet flower with the petal number of 5 is the best suit to create a realistic visual image of violet flower.

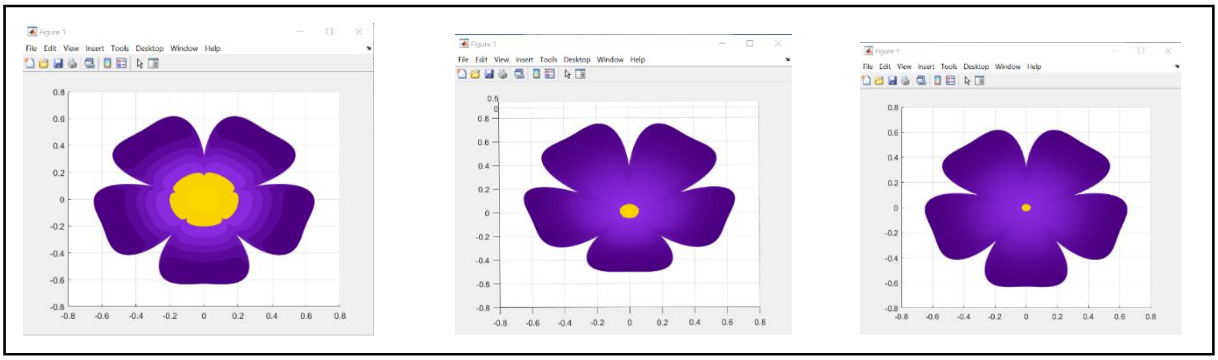

Figure 3: The Image of Violet Flower with Different Size of Pistils

Based on the Figure 3, as the variable of the size of pistil in the coding increase, size of the pistil of the flower in the visual image also increases. The central component of the flower, known as the pistil, follows the Fibonacci pattern in the same way that the petals do. The size of pistil used in this coding are 5, 20 and 40. The variable used in the first image shows that the size of pistil is too big while the third image shows that the size of the pistil is too small. Therefore, the second image shows the most realistic image to represent the actual image of violet flower in real life. In reality, pistils follow the Fibonacci sequence far more closely. The curving pattern they generate using the Fibonacci sequence creates a gorgeous and detailed design that genuinely resembles a work of art. From the image shown in this figure, it shows that the image of violet flower with the size of pistil 20 is the best suit to create a realistic visual image of violet flower.

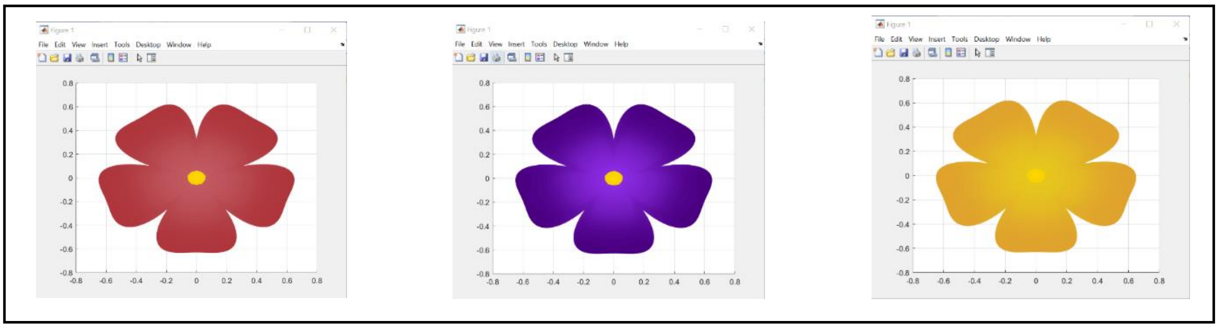

Figure 4: The Image of Violet Flower with Different Colour Code

Based on the Figure 4, as the colour code variable in the coding change, the colour of the violet flower in the visual image also changes. The colour code used for violet flower are [138, 43, 226] and [75, 0, 130] and the colour code used for red flower are [193, 90, 99] and [175, 54, 60] while the colour code used for yellow flower are [231, 199, 31] and [224, 163, 46]. Since the actual violet flower's colour is violet, therefore the red and yellow colour of violet flowers are unrealistic to be compared with real life violet flower. From the image shown among these three figures, it shows that the image of violet flower with the violet colour code is the best suit to create a realistic visual image of violet flower.

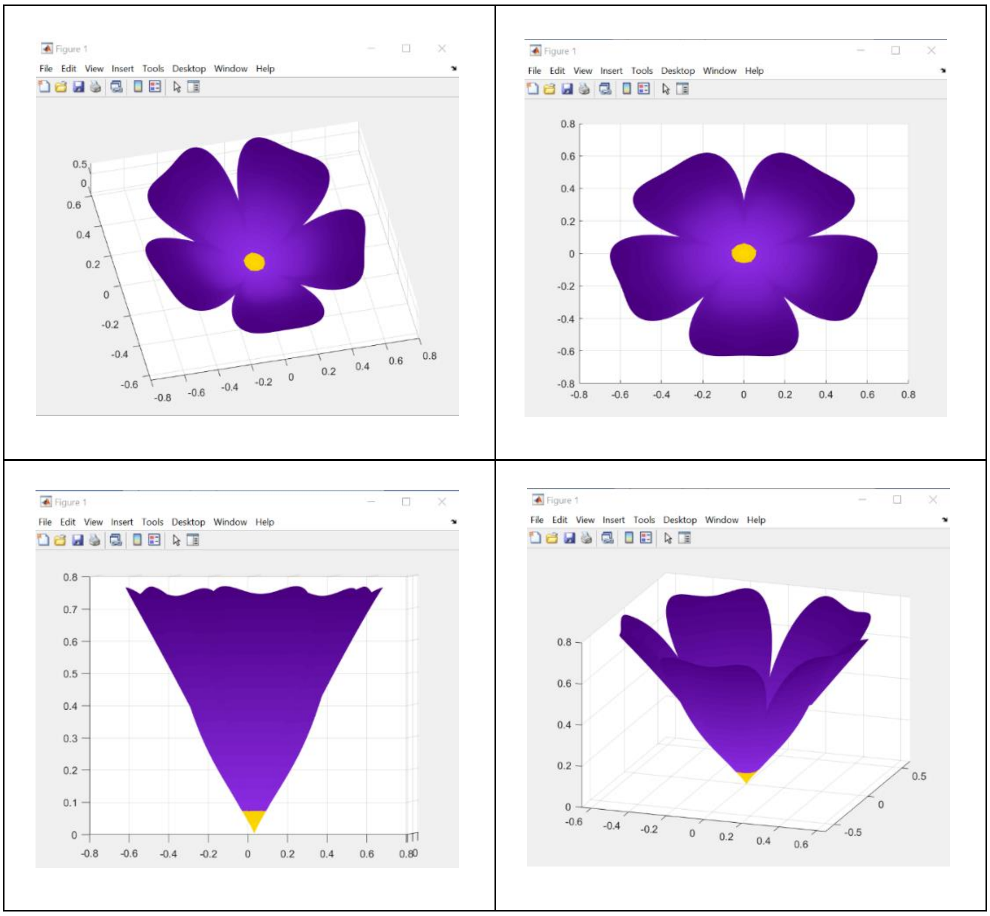

Figure 4.11 Visual Image of Violet Flower in Different Angle

Based on the results in above figures, there are three analysis that have been discussed which are the number of petals, the size of the pistil and the colour of the violet flower petals. From the result, we can see that the Fibonacci sequence and the Golden Ratio has applied in order to get the result. The formula of phi which is $\emptyset=(1+\sqrt{5})/2=1.6180339887$ has been used to calculate the Golden Ratio of the flower. As for the final result, the number of petals which is 5, the size of the pistil which is 20 and the violet colour code have been chosen as the final result of the analysis since it has the most realistic visual image to represent an actual violet flower.

4. Conclusion

This research project studies the Fibonacci sequence ad the Golden Ratio. As in this project, we analysed the petals using MATLAB software to produce graphical results. To obtain the visual design, a Fibonacci sequence and Golden Ratio has applied in the coding. With this coding, we can help the art industry to create a violet flower's petals for people to see how beautiful the nature is. Thus, we created the analysis by some characteristics which are the number of petals, the size of the pistil and the colour of the flower to choose the perfect design of a violet flower's petals.

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