

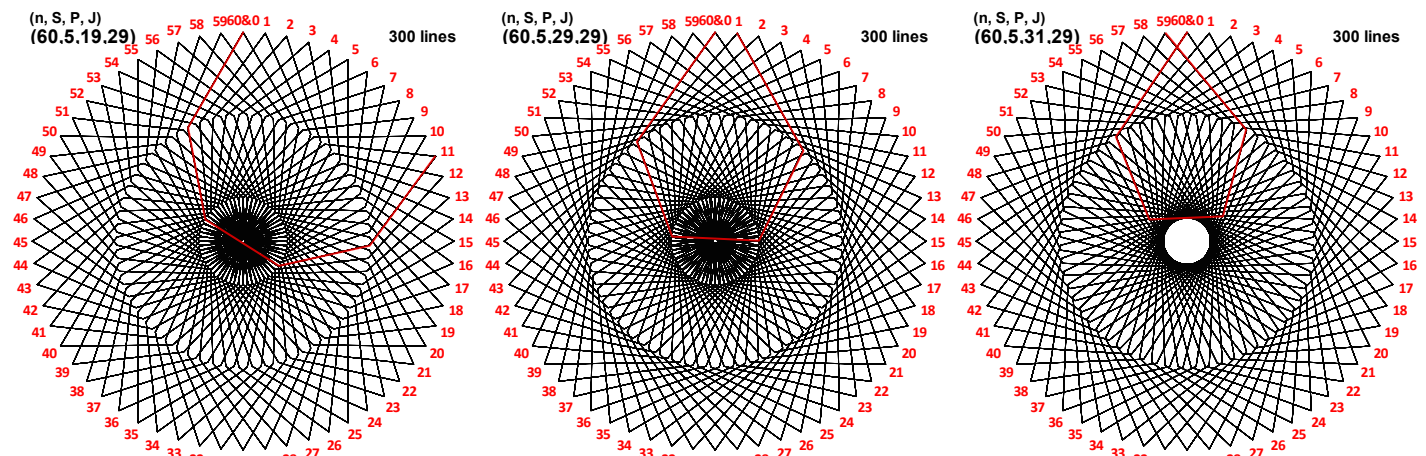
One-Time-Around, Single-Step and Smallest-Step Images

The counting rule **P** provides a structure for where each line is placed in the final image. Despite this regularity, if you watch the image get drawn, it is often the case that the image appears randomly drawn. On the other hand, there are situations where the way that the image gets drawn appears very systematic. There are technical mathematical reasons for why such images occur (having to do with modular multiplicative inverses, [E24.1](#)), but we do not focus on those reasons here. Instead, we examine some of the geometric attributes that produce images that appear systematically drawn. We start with *One-Time-Around* images.

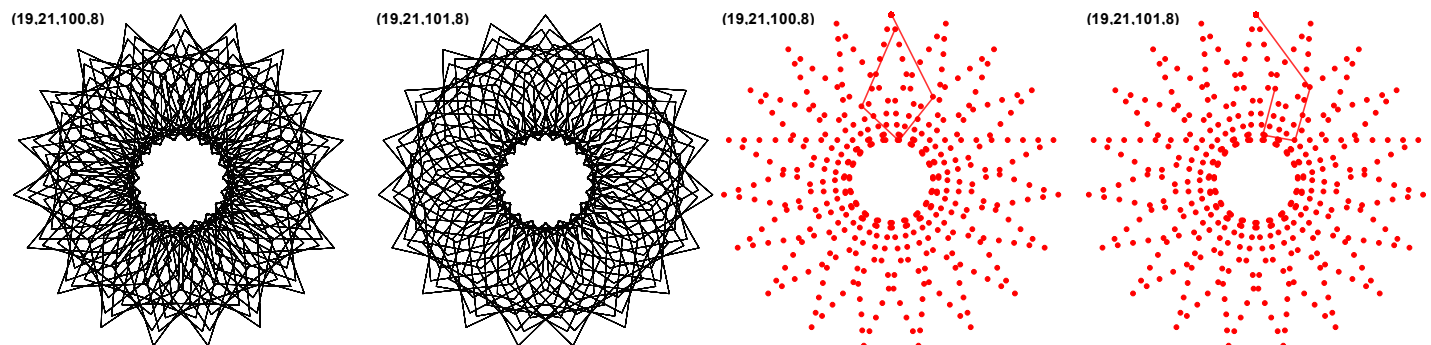
One-Time-Around Images. If the first cycle ends at the first used vertex in either direction from the top, then the image will appear to be created in a single pass around the outer edge. Here, are three 300-line 60-cycle images. If you did not see the **5-line red cycle, noted in red** in the left and middle images, you would probably consider the two images to be very similar. Note that all three only differ in the value of **P** used to create the image.

The difference is that the left is an *11-times* around image. It is named as such since the vertices from 1 to 10 are filled in during later passes around the outer edge of vertices. Because the first cycle ends at vertex **11**, the second cycle ends at **22**, the 6th cycle ends at vertex **6**, and the 11th ending at vertex **1** ($6 \cdot 11 = 6 \bmod 60$ and $11 \cdot 11 = 1 \bmod 60$). The middle is a *one-time* around image because the first cycle ends at vertex **1**. If you watch the image get drawn five lines at a time using *Drawing Mode, Fixed Count Line Drawing, FCLD*, with *Drawn Lines* = DL = 5, [the left](#) appears to be a swirling 5 petal flower. [The middle](#) looks like a rotating pentagon that clicks off vertices clockwise (↻) one vertex at a time, just like the second hand on a clock. This is an example of a 60-second image as discussed in [E13.1](#) and [Bridges, 2023](#).

The right image admittedly does not look that similar to the other two because it has a larger hole in the middle. Nonetheless, it is a one-time around image because the first 5-line cycle ends at vertex **59**, one vertex from the top of the image. If you watch [the right](#) image get drawn with DL = 5, it looks like a rotating pentagon that clicks off vertices counterclockwise (↺) one vertex at a time, *just like the second hand on a clock if time moved backwards!*



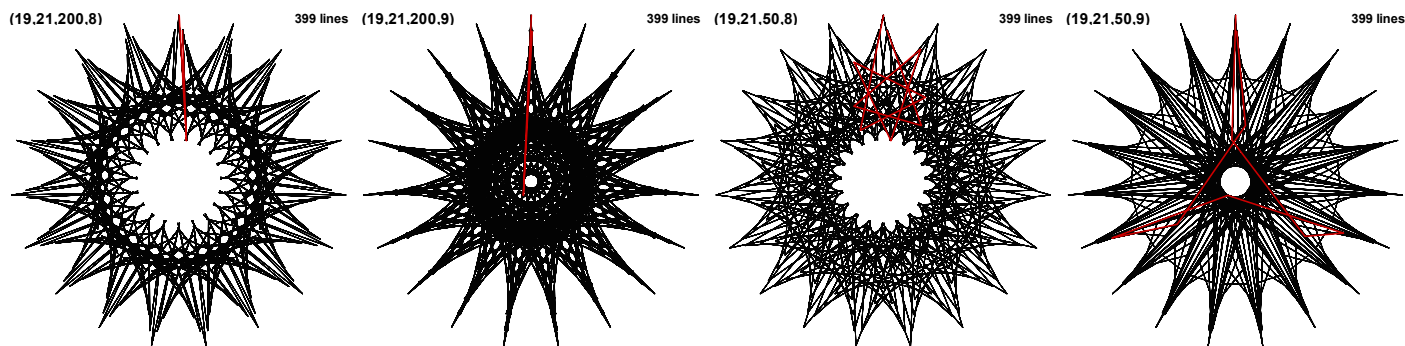
Single-Step Images. The second pair of images differ from one another by **P** = 1. Both are 19·21 = 399-line images which look like spiky donuts. The second set of images are the subdivision **dots** with the **first four lines shown in red** ending at subdivision point 1 for the [left image](#) ($4 \cdot 100 = 399 + 1$), but at subdivision point 5 for the right image ($4 \cdot 101 = 399 + 5$). The left is *single-step of length 4*. Set DL = 4 in FCLD, and watch the image get drawn as a shape-shifting quadrangle that is ↻ 2-times around (since even vertices are used first and odd vertices are used afterwards: 2,4,...,18,1,3,...,17,19=0).



By contrast, $P = 101$ appears haphazardly drawn (use the link for the left image and simply increase P by 1 while in FCLD). This mode continues drawing as changes are made, so let the drawing finish before seeing a clean new image.

This is an example of a single-step image that has multiple options because 19 and 21 are difference between squares numbers, [E8.5.2](#). Here are examples given $n = 19$ and $S = 21$. the length of the single-step is $400/P$, and the **first single-step is shown in red** in each image. To move between the [left two](#) and between the [right two](#) simply adjust J (and, to see more single-step of length 2 for left and of length 8 for right, continue adjusting J). And, to obtain additional single-step images, switch n and S but note that in this instance, $J = 9, 7, 6$, and 3 will not have 21 vertices since $VCF > 1$.

From left to right these four images are $\odot$ 4-times around, $\odot$ 5-times around, $\odot$ one-time around, $\odot$ 7-times around (because the 21st line ends at vertex 13 and $7 = 19 - 13$) but it APPEARS that it is $\odot$ one-time around because vertices 1-6 are filled in in succession (vertex 1 is the end of the 63rd line at the end of the 3rd cycle, $1 = 13 \cdot 3 \bmod 19$). The first two are examples of *porcupine stars*, [E11.3](#), the third is a spinning 8,3-star, [E10.5](#), and the last is an 8-line analogue to *three-shape-shifting triangles*, 3SST, [E8.4](#) and examined in detail in [Chapter 13](#).



Smallest-Step Images. Unlike single-step images, smallest-step images are based on $SCF > 1$, [E9.4](#). In this setting, only $1/SCF$ of the possible subdivision endpoints are used in the final image. Here, we are looking at a notion of “nearby” that is different from simply being the next subdivision on the vertex frame. After all, the first subdivision used in this setting will be numbered SCF, and that may not be near the top of the image. Here are three examples, each shown with subdivision **dots** and the **first smallest-step lines in red**.

Left. [\(28,21,136,13\)](#), is a 147-line spinning needle star, [E11.8.1](#), used on the [front page of PwP](#). It is smallest-step of length 2 and $SCF = 4$ with 7 cycles. It is also a $\odot$ one-time around image. The second endpoint is subdivision 272 = $2 \cdot 136$, and the numerically smallest subdivision used, $4 = SCF$, is the 13th endpoint used because $13 \cdot 136 = 1768 = 3 \cdot 588 + 4$. This image is examined further in [Section 14.14](#).

Middle. [\(20,19,30,9\)](#), is a 38-line 3SST image discussed in [E9.5](#). It is smallest-step of length 7 and $SCF = 10$ with 2 cycles. The 7th endpoint used is $210 = 7 \cdot 30$. But the numerically smallest numerical subdivision used is $SCF = 10$, the 13th endpoint used because $13 \cdot 30 = 390 = 380 + 10$. Note that subdivision 10 is near the center of the image, given $S = 19$.

Right. [\(19,8,19,8\)](#), is an 8-line 8,3-star that is an example of a small image, [E12.4](#). It is smallest-step of length 3 and $SCF = 19$ with 1 cycle. The 3rd endpoint used $57 = 3 \cdot 19$, and the numerically smallest numerical subdivision used is $SCF = 19$, the first endpoint used.

