Spirograph Designs for Ambient Display of Tweets

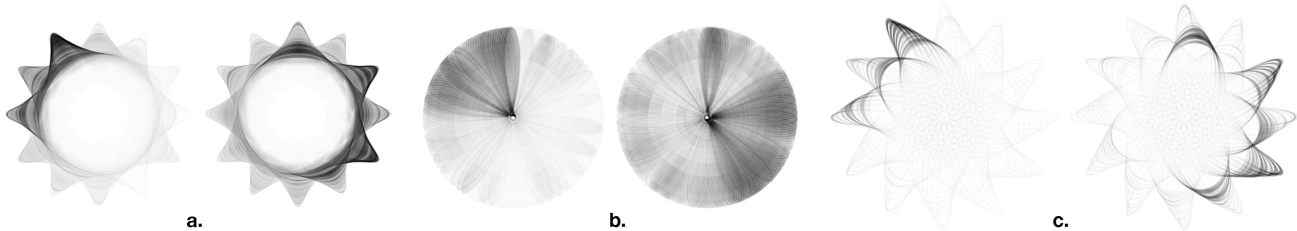Ye Lin, Romain Vuillemot

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a. **b.** **c.**

Fig. 1. Three pairs of Spirographs, each showing morning and afternoon Tweets with hashtag #CHI2013 on April 29th, the first day of the CHI 2013 conference. They illustrate interesting design variations of Spirographs and their use for relatively large time-oriented datasets.

Abstract—This paper explores elegant design variations for Spirographs to display Tweets. Our method consisted in first tweaking Spirographs parameters using a drawing tool we developed specifically. We then identified particularly interesting Spirographs patterns and gave them flower names to better recall and describe them: sunflower, daisy or chrysanthemum, to name a few. We further customized those patterns, and eventually combined them with other Spirographs to construct more complex ones. As those Spirographs patterns were well suited to segment time into hours or minutes with their "petals", we investigated one particular scenario: Tweets visualization collected during CHI 2013, where each Tweet is represented as a particle that decorates the Spirographs. The resulting visualization is appealing and efficiently shows Tweets distribution over time and trends both during short and long time spans. Those early results show that Spirographs can go beyond simple artworks and can effectively bear both attractiveness and structure, which make them perfect candidate for ambient display.

Index Terms—Spirograph, Casual Visualization, Twitter, Ambient Display.

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1 INTRODUCTION

Spirographs are geometric curves repetition forming visually appealing patterns, while conserving a strong geometrical aspect, such as symmetries. Such patterns can either have explicit divisions similar to flowers (Figure 1, middle), either have subtle ellipsoid (Figure 1, left), or the combination of both (Figure 1, right). While those Spirographs are visually very different, they actually result from the very same drawing process, but with different configuration. Spirographs can be manually drawn using two different sized gears (mobile and static), and a pen. Gears provide the mechanisms for guiding the pen, which is controlled by a **mobile gear**, rotating within a **static gear**. The mobile gear has **several holes** on its surface to put a pen in it, each of them generating a different Spirograph. One may also rotate the mobile gear outside of the static gear circumferences to draw different kinds of Spirographs. The trace left by the pen is the actual Spirograph. Those gears can either be implemented as physical toys, such as the one designed by British engineer Denys Fisher in 1965. Or computer-generated using any programming language with a visual output.

Despite their simple creation process, both in the tangible and virtual space, Spirographs have a unique visual signature, which attracts attention. This is probably because people have memories playing and interacting with Spirograph in their childhood. Indeed, they were

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extensively used as educational material to explore complex and beautiful patterns. Computer-generated Spirographs are also numerous and inspirational, as can testify a query on Google Image or by the number of examples and online tools supporting their creation. Additional decoration and composition may be added to Spirographs, but the construction process remains the same, e.g. just changing the pen colour or stroke, as well as drawing over an existing Spirograph. In summary, Spirographs have the following properties:

- Geometric and replicable shapes;
- Progressive construction in a limited space area;
- Visually appealing, trigger curiosity and are associated to memories.

Exploring the potential of Spirographs beyond educational or artworks remains a challenge. From the best of our knowledge, only one prior work has explored Spirographs in the context of information visualization. Lauren Thorson's "First 24 Hours of Spring" [1] uses Spirographs to visualize weather data of the first day of spring. A related work is the Lombardi Spirograph-inspired graph layout [2], which uses curved circles for edges similar as Spirographs. Those two previous works provide us with two application domains to start exploring Spirographs design:

1. Time related data
2. Connectivity among nodes in a network

In this article we focus on the exploration of time related data. As we mentioned earlier, Spirograph are created via holes in rotating circles, and the line drawn by the pen will represent time. The hole's position and circles teeth count compose a set of independent variables -the design space- that are to be explored for drawing Spirographs, and will cause different time representations. As naive Spirographs generation, e.g. with random configurations, may potentially be infinite, one has to go beyond trial and errors for efficiently finding

interesting Spirographs. Because physical Spirographs only implement a series of parameters, and can eventually be combined (swapping different circles size and shapes over the same Spirograph), computer-generated Spirographs have potentially no limit and no cost.

Better supporting and understanding the structure of Spirographs design space, such as the best parameter combinations and anticipate their suitability, is a first step to support further investigation to use Spirographs for accurate data display. In the next section we explore the design space, and in the rest of the article we use Spirographs for a specific application: Tweets visualization in a casual context, as they combine both visual appeal and structure.
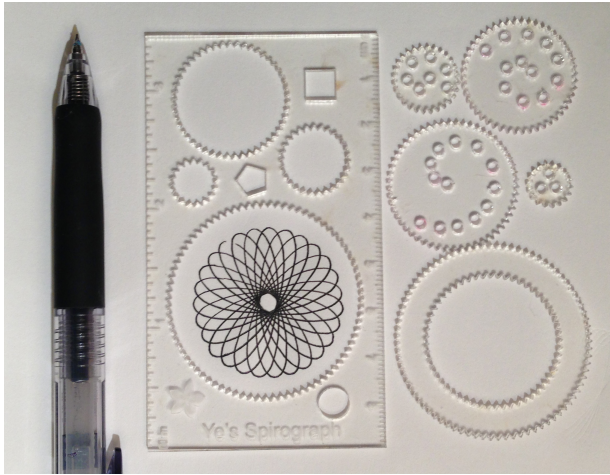

Fig. 2. Physical Spirograph, printed by laser cutter using online blue print http://www.thingiverse.com/thing:641

2 SPIROGRAPHS DESIGN SPACE

Spirographs' design space is parametric in the sense that all Spirograph variations rely upon a set of the independent variables we introduced earlier: static gear teeth, mobile gear teeth and pen point distance on the mobile gear. Our first step was to create a web-based tool (Figure 2) to facilitate Spirographs' creation and composition, which happened to be really helpful to dynamically 'browse parameters interval and explore alternatives from interesting Spirographs: we indeed often generated one single Spirograph as a starting point, and slightly change their parameters for variations. All those figures in this section are generated using this tool. We generated hundreds of Spirographs, and only selected the good candidates based on their originality compared to others and their unique visual appeal.
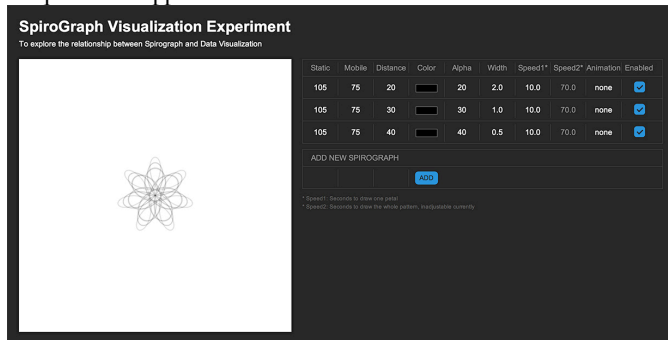

Fig. 3. Spirographs web-based creation tool. Left: preview or result, Right: parameters for one Spirograph (one line) and their composition (by selecting multiple lines).

2.1 Spirograph Parameters

All kinds of Spirographs can be generated based on those three parameters, we call them *outer* parameters:

- Static gear teeth
- Mobile gear teeth
- Pen point distance on the mobile gear

Those parameters are visible on physical Spirograph toys (with gears teeth and holes) and can also be simulated using computer programs, such as our web-based interface. Figure 4 shows five Spirographs using each a unique set of parameters, which is indicated below each.
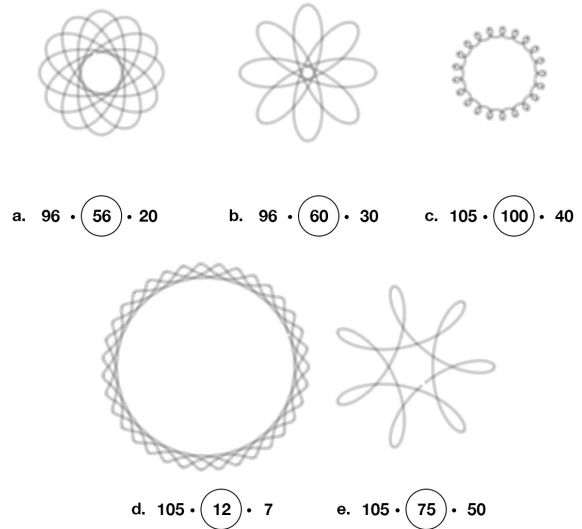

Fig. 4. Examples of variation of the three Spirographs parameters. Below each Spirograph is the set of three parameters: static gear teeth, mobile gear teeth and pen point distance on the mobile gear.

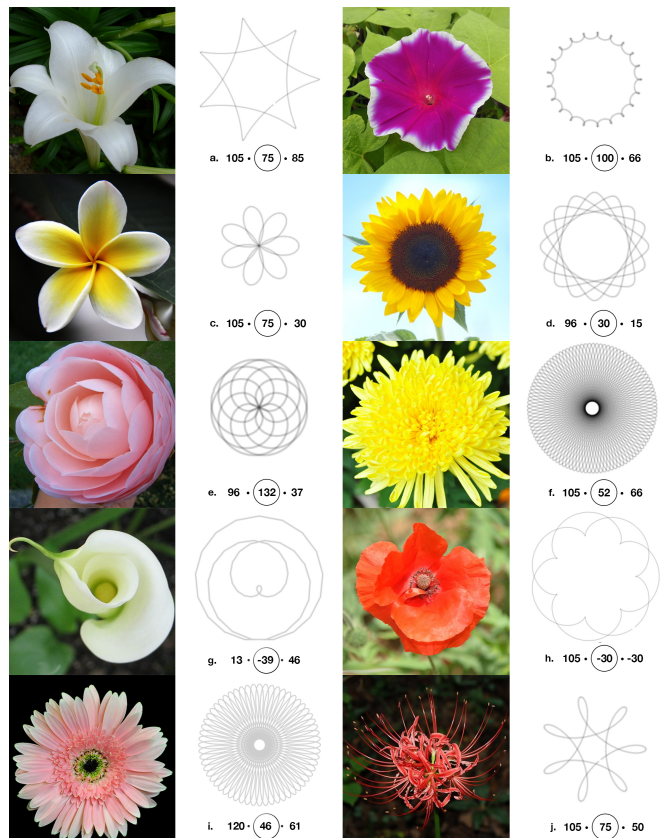## 2.2 Spirograph Patterns

Fig. 5. Examples for Spirographs patterns: (a) Lily, (b) Morning Glory, (c) Plumeria, (d) Sunflower, (e) Camellia, (f) Chrysanthemum, (g) Calla, (h) Poppy, (i) Daisy, (j) Lycoris Radiate

We identified Spirograph families with unique visual patterns and we gave them flower-related names (Figure 5). Those families are not exhaustive, but already show the variety of patterns.

Some patterns are actually transformation from other patterns: Plumeria (c) and Chrysanthemum (f) are indeed quite similar. Chrysanthemum usually has more petals and petals are not distinguishable. Plumeria have less and distinguishable petals, which can be counted. Morning Glory (b) and Lycoris Radiate (j) are similar. Morning Glory usually draws consecutive petals on a Gear and addresses on the outer shape of the flower. On a Lycoris Radiate, there are N petals in between two consecutive petals, which are thinner and longer. Sunflower (d) and Daisy (i) are similar. Sunflower has bigger centre holes. Daisy has two layers of petals. Lily (a) and Sunflower (d) are quite similar too. The inner pattern of Sunflower forms a circle. For Lily, the outer tip is more obvious.

2.3   Spirographs Patterns Parameters

By adjusting Spirographs outer parameters, we observed that Spirographs preserve its own pattern parameters, which are the variation of patterns. We call them *inner* parameters:

- Petal numbers on the pattern
- Radius of the pattern
- Drawing range (the distance between the innermost point and outermost point of a petal)
- Petal radian
- Angle between two consecutive petals when drawing
- Drawing percentage (complete/incomplete)
- Shift tooth parameters

Inner parameters are mostly relying on outer parameters. It's hard to use one numerical parameter to control each attribute.
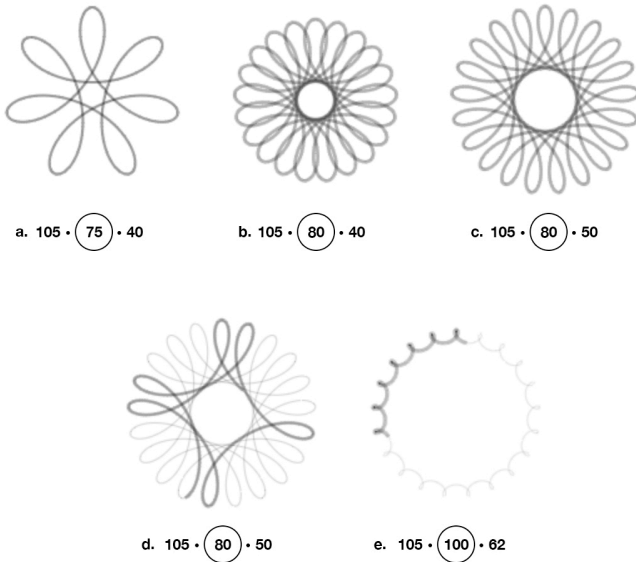

Fig. 6. Examples for Spirographs patterns parameters. a, b, c are complete Spirographs, d, e are incomplete Spirographs while continuous drawing.

In Figure 6, for instance, flowers may have different numbers of petals (a, b), different radius (a, b, c). The drawing range (the distance between the innermost point and outermost point of a petal) could be different (b, c). We may also adjust the drawing percentage (d, e). Pre-draw the whole pattern to show the potential Spirograph and then redraw the whole pattern to emphasize the current point and drawing process. The angle between two consecutive petals in the drawing process could be different, for (d) has five petals and (e) has zero petals in between two consecutive petals.

See Appendix 1 for more details on the patterns visual exploration examples.

2.4   Spirographs Visual Composition

Multiple Spirographs can be combined into a more complex one, by means of spatial composition:

- **Juxtaposition:** Spirographs share the same space, such as side by side or as small multiples, if many (Figures 1);
- **Superimposition:** Spirographs are put on top of each other, often sharing the same centre but with different teeth (Figure 7, a, b, d) or by shift N teeth right/left (Figure 7, b);
- **Nesting:** One Spirograph is inside another, but not aligned with their centre (Figure 7, c).
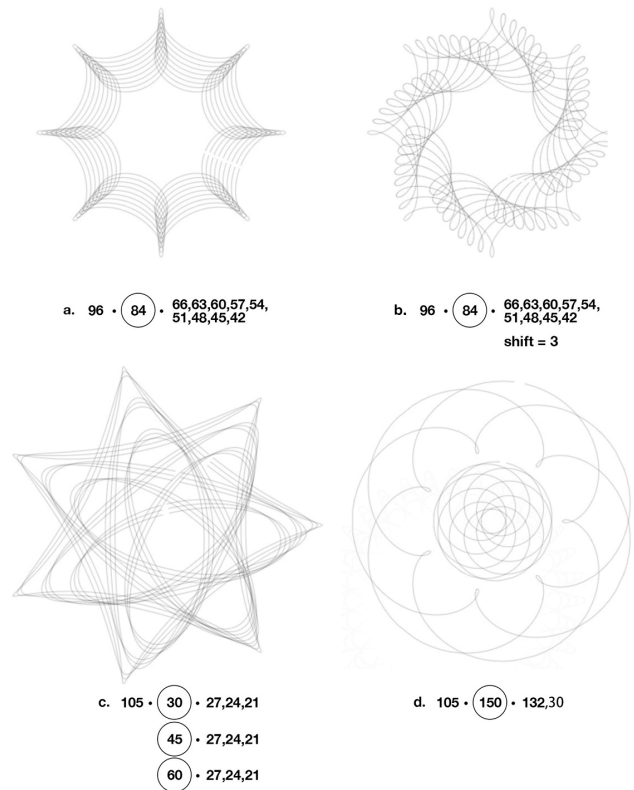

Fig. 7. Examples for typical Spirographs composition by superimposition.
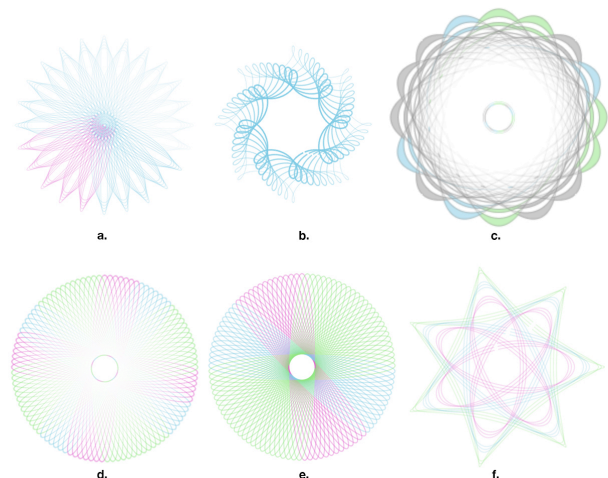
2.5   Spirographs Decoration

Fig. 8. Examples of using visual variables for Spirographs decoration.

So far, Spirographs only consisted in plain line drawing with only some variations in stroke opacity. We now explore further use of such visual variables, and their attribute. This part of the design space is we referred to as "decoration".

We created a few Spirographs in Figure 8 using new visual variables: **line stroke** and **petal filling**. Regarding, their attributes, we explored the following as defined in Table 1.

Table 1. Spirographs Visual Attributes

Attr.	Type	Detail	Reference
	Single Colour Stroke	Colour the same colour to draw one single Spirograph	(b), (f)
	Dynamic Colour Stroke	Change colour, while continue drawing one single Spirograph	(d), (e)
Colour	Special Colour Stroke	Assign special colour to some petals	(a), (e)
	Solid Filling	Fill in solid colour to petals	Figure 1, middle
	No Filling	No Filling on petals	(a), (b), (d), (e) & (f)
	Inner Change	Change alpha value within one Spirograph petals to emphasize the current point	(a)
Alpha	Outer Change	Change alpha value between adjacent Spirographs	(b)
	No Change	No Change	(c), (e)
	Sketch Rendered	Use sketch rendered stroke	(e), (d)
Stroke	Normal	Use normal stroke	(a), (b), (e) & (f)
	Pre-draw	Pre-draw the whole Spirographs use a lighter alpha stroke	(c)
Line Width	Change	Change line width between adjacent Spirographs	(b)
	No Change	No Change	(a), (c), (d), (e) & (f)

3 APPLICATION TO CONFERENCE TWEETS

We now present an application of the Spirographs design space to visualize Tweets collected during the CHI 2013 conference using #CHI2013 to retrieve them. We first depict the visualizations themselves and their position in the design space, which enabled us to later easily create two design variations. Then we describe the result displayed as one-day view in Figure 1, and ten days view in Figure 9, Figure 10, and Figure 11. The web page for this application and a high-resolution video can be found here:
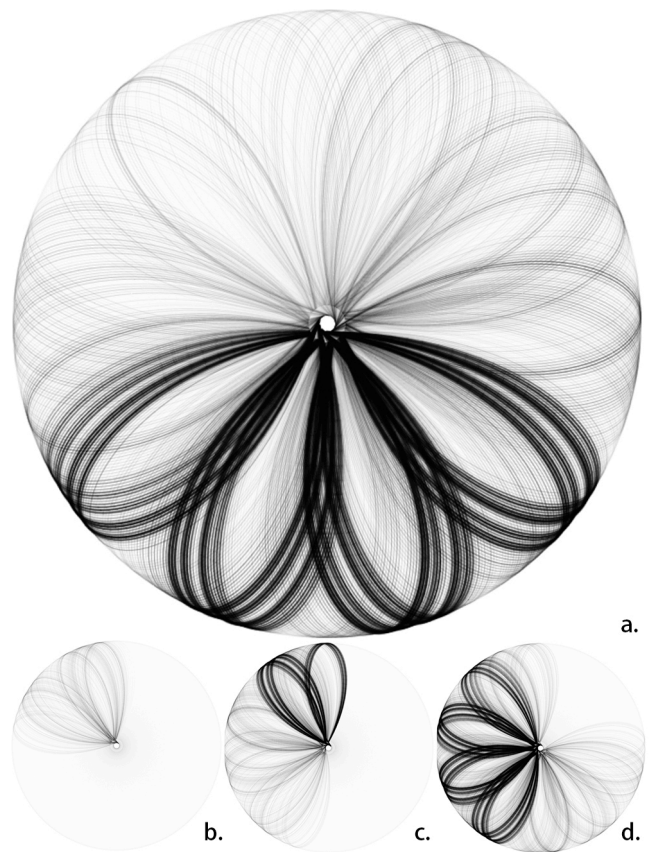http://www.aviz.fr/Research/SpiroViz

Fig. 9. Variation using Chrysanthemum pattern for ten days' tweets visualization. (a) is the final state of Spirograph, (b), (c), (d) are the drawing process.
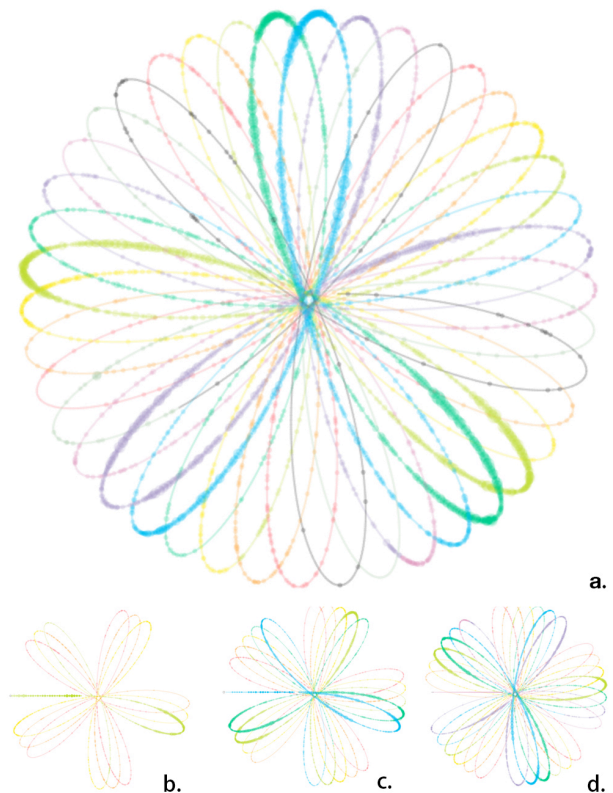

Fig. 10. Variation using Plumeria pattern for ten days' tweets visualization. (a) is the final state of Spirograph, (b), (c), (d) are the drawing process.

#CHI2013

April 26, am

April 26, pm

April 27, am

April 27, pm

April 28, am

April 28, pm

April 29, am

April 29, am

April 30, am

April 30, pm

May 1, am

May 1, pm

May 2, am

May 2, pm
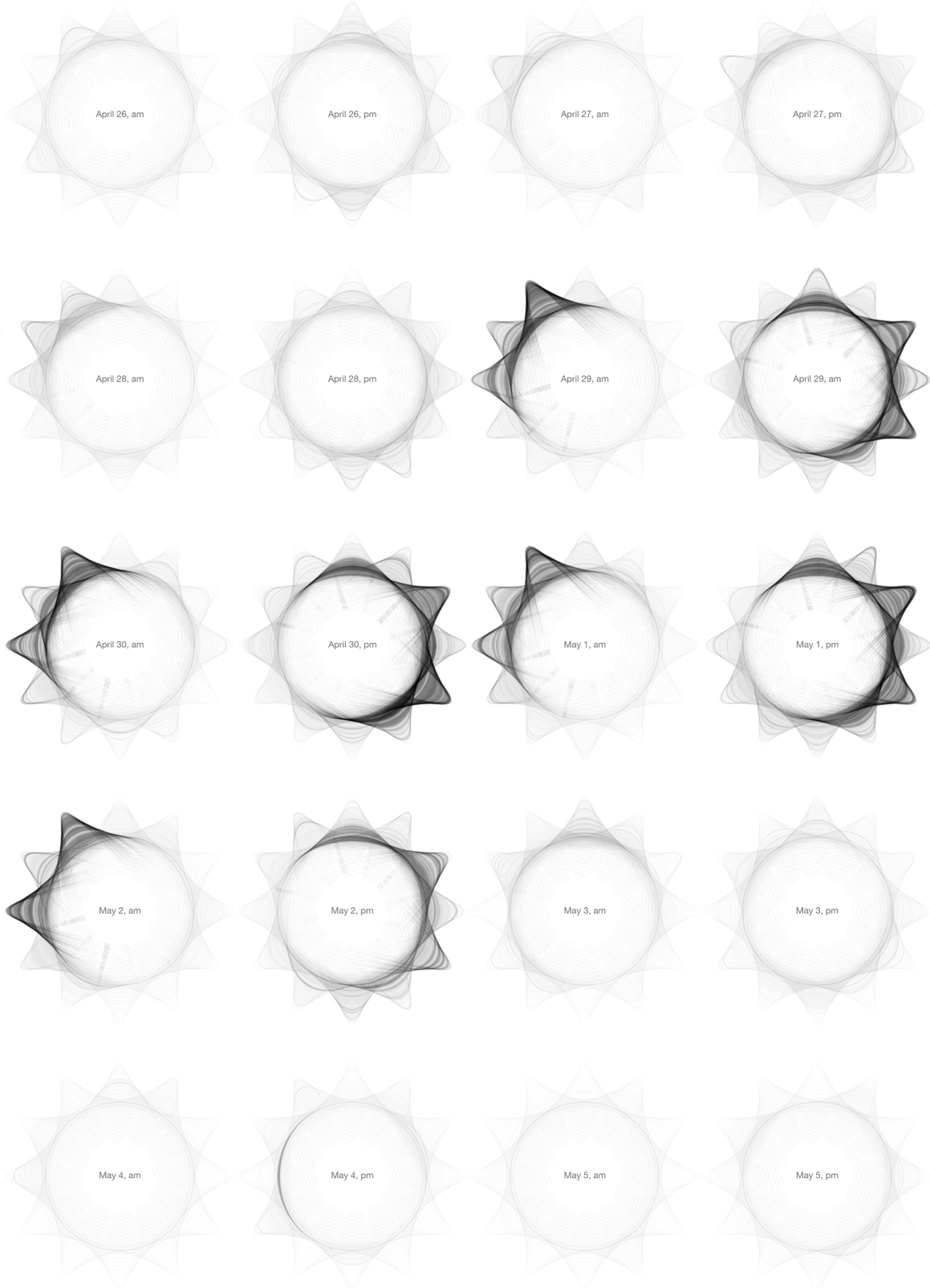
May 3, am

May 3, pm

May 4, am

May 4, pm

May 5, am

May 5, pm

Fig. 11. Variation using Sunflower pattern for ten days' tweets visualization.

Table 2. Spirographs Basic Parameters

Fig. Num	Data Source	Mobile Gear Teeth	Static Gear Teeth	Pen Point Distance	Pattern
Fig.1 (a)		96	40	[-3,30]	Sunflower
Fig.1 (b)	One day's Tweets with hashtag #CHI2013 on April 29th	199	118	85	Chrysanthemum
Fig.1 (c)		120	70	[20,55]	Plumeria
Fig.11		96	40	[-3,30]	Sunflower
Fig.9	Ten days' Tweets with hashtag #CHI2013 from April 26th to May 5th	499	338	170	Chrysanthemum
Fig.10		210	85	130	Plumeria

Table 3. Spirographs Design Space Mapping

Fig. Num	Visual Composition	Petal Num	Mapping			
			Spirograph	Tweet	Hour/Day	Minute*
Fig.1 (a)	Juxtaposition	12	1/2 day	One stroke	One petal	Minute Axis
Fig.1 (b)	Juxtaposition	199	1/2 day	One stroke	30 degrees each	Hour Hand Mapping
Fig.1 (c)	Juxtaposition	12	1/2 day	One stroke	One petal	Minute Axis
Fig.11	Juxtaposition Super-imposition	12	10 days	One stroke	One petal	Minute Axis
Fig.9	None	499	10 days	One stroke	36 degrees each	Hour Hand Mapping
Fig.10	None	42	10 days	One bubble	One colour	Timeline Mapping

* **Minute Axis** - Adding a minute axis from the innermost petal to the outermost petal. Visualizing minute info on this axis.
Hour Hand Mapping – Hour and Minute data are mapped with a 12 hour-clock's hour hand's position.
Timeline Mapping – Time sequential data are mapped on a straight timeline. Rotating this straight timeline in shape of Spirographs.

Table 4. Spirographs Decoration Parameters

Fig. Num	Colour	Alpha	Stroke	Line Width
Fig.1 (a)	Single Colour Stroke Gradient Filling	Inner Change (Tweets quantity)	Sketch Rendered	Change (Tweets quantity)
Fig.1 (b)	Single Colour Stroke Gradient Filling	No Change	Normal	No Change
Fig.1 (c)	Single Colour Stroke No Filling	No Change	Sketch Rendered	Change (Tweets quantity)
Fig.11	Single Colour Stroke Gradient Filling	Inner Change (Tweets quantity)	Sketch Rendered	Change (Tweets quantity)
Fig.9	Single Colour Stroke No Filling	Inner Change (Tweets quantity)	Normal	Change (Tweets quantity)
Fig.10	Dynamic Colour Stroke No Filling	No Change	Normal	No Change

3.1 One Day's View of Tweets Visualization

In Figure 1, we consider each circle as a 12 hour-clock. So we have two clocks side by side for each day, by **juxtaposition**. We also tried a 24 hour-clock at first (Figure 12). But people are more used to 12-hour clocks than 24-hour ones. We now detail each of the Spirographs' design choices in Table 2, Table 3 and Table 4 upper part.
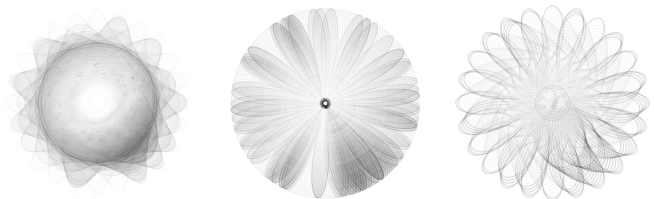

Fig. 12. 24 hour-clock trials

From those visualizations in Figure 1, we may perform, interesting observations. For example, there are fewer tweets from 0 to 9 o'clock, because people are sleeping during that time. The conference starts at 9 o'clock, so after 9 o'clock people start attending sessions and update something new on their Twitter. For each day, the conference has four sessions, which could be matched with the visualization, that there are four time slots with darker colour and more strokes. People eat at 13 o'clock and there is a tea break around 15 o'clock, where there are fewer tweets posted.

3.2 Ten Day's View of Tweets Visualization

We also created some Spirographs for visualizing 10 days tweet data, as in Figure 9, Figure 10 and Figure 11. The generation process is best visible animated, and is provided in the video attached to this article. The drawing point (i.e. the position of the pen) in those examples is always fixed at the centre top, which gives the user a fixed point to look at for data updates. We now detail each of the

Spirographs' design choices in Table 2, Table 3 and Table 4 bottom part.

In Figure 10, it's a variation using flower pattern and decoration. We used **Plumeria** pattern with bubbles (i.e. each Tweet is represented as a small circle which **decorates** the Spirograph), which is inspired by Visual Sedimentation [5]. We have ten days data, and we used decoration mapping of changing colour, while continuing to draw one single Spirograph at a time. We keep the incoming point fixed on the screen and rotate the previous drawn Spirograph according to the tangent line of the incoming point. In the middle, there is one incoming line showing the density of incoming data. The incoming line is like a continuous updated timeline, with tweets generated on it. Each bubble represents one tweet. Bubble size and alpha would vary according to tweets quantity. Bubbles keep moving towards the Spirograph. The Spirograph rolls up all the data while preserving the same data colour and data density. Although this one is harder to read, we think this one is more interesting from an artistic point of view. By controlling Spirograph parameters; each day would draw five petals. The colour sequence on neighbouring petals is always day-by-day (e.g. red, orange, yellow... red, orange, yellow), which allows people to compare data between neighbouring petals.

4 RELATED WORK

Previous works already investigated the use of art related visualization for ambient display. Some of them are *pragmatic* infovis. For example, Skog's ambient display [3] uses a Mondrian-like graphic to visualize bus schedules. While visualization is hard to read for beginner, it is actually easy for experts or regular users to decode information. Some of them are *not* pragmatic infovis, but focus on influencing and attracting the viewer. For example, "Last Clock" [4] traces what has been happening in front of a camera by compressing captured images in shape of a clock. It updates every seconds.

Tweets visualizations have also been very fruitful recently. [6] encodes Tweets as particles on a map to indicate their provenance. More generally, the challenge behind Tweet visualization is to show sequential information that updates frequently, while preserving context and past information [7]. However Tweets streams are not known in advance, therefore the visualization needs to scale to large amount of data in short amount of times [5].

5 CONCLUSION AND PERSPECTIVES

We presented a first investigation of Spirographs design space, and its application to Tweets collected during #CHI2013. We first designed tools to facilitate Spirograph creation, which enabled us to find interesting visually look Spirographs. We identified patterns and parameters to customize them. We applied them to Tweet visualization. We consider the following as future work:

- Application to other time-related data: weather and bus schedule. In the case of weather, it is even possible to show weather forecast, by drawing Spirograph ahead of their current time. Uncertainty can even be communicated using sketchy lines. In the case of buses, we want to support decision-making such as deciding the proper time to catch the bus.
- Application to other data types, such as graph layouts to display communication among nodes in a graph: Email communications, collaboration in teams, etc.
- Application to Ambient / Public Display Visualization. Using Spirographs for visualization would result in a more artistic view of data and hard to decode visualizations which provides access control to the visualization.
- Automatically generate instruction for 1) physical construction (such as printing) and 2) physical drawing of Spirographs based on our tool Spirograph generation.

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6 APPENDIX 1: RELATIONSHIP BETWEEN PARAMETERS AND PATTERNS
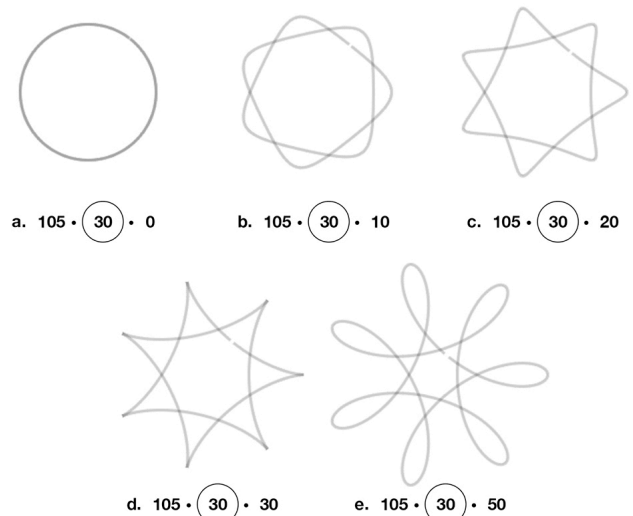

Fig. 13. Examples for Spirograph parameters, by changing pen point distance on the mobile gear
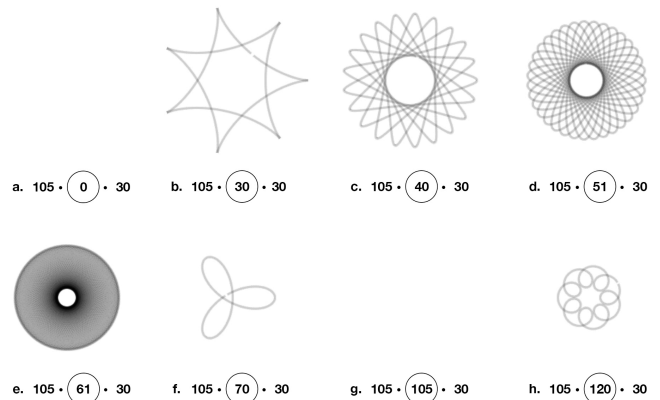

Fig. 14. Examples for Spirograph parameters, by changing mobile gear teeth

a. 75 · (30) · 20   b. 85 · (30) · 20   c. 105 · (30) · 20

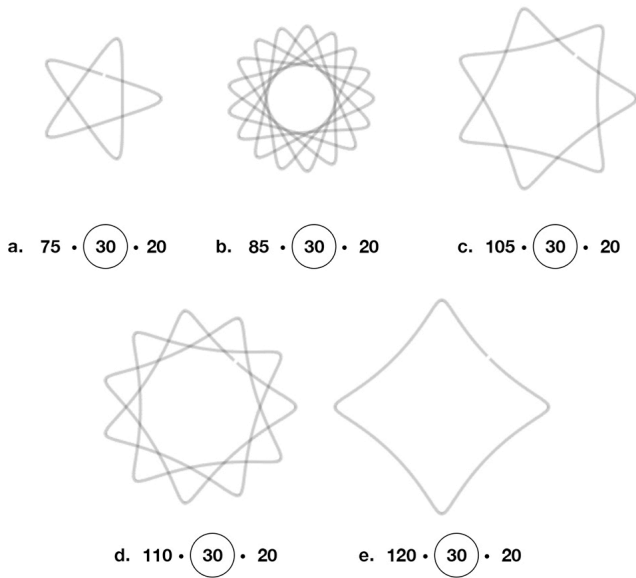d. 110 · (30) · 20   e. 120 · (30) · 20

Fig. 15. Examples for Spirograph parameters, by changing static gear teeth

The pen point distance on the mobile gear would influence on the whole pattern of Spirograph (Figure 13), the radius of the pattern, the drawing range (the distance between the innermost point and outermost point), petal radian, etc... But it has no effect on petals number. Except for the extreme value zero, which the pattern would be a circle.

The mobile gear teeth and the static gear teeth would both influence the petal number (Figure 14, Figure 15). Petals number can be defined as static gear teeth / gcd (static gear teeth, mobile gear teeth), which is depend on the greatest common divisor between static gear teeth and mobile gear teeth. The mobile gear teeth cannot be 0 or as the same as static gear teeth (Figure 14, a, g). The mobile gear teeth can be bigger than the static gear teeth (Figure 14, h).

The petal radians are all the same in Figure 15, which are controlled by the same mobile gear teeth and pen point distance on the mobile gear.

Negative Parameters

a. 105 · (30) · 20   b. 105 · (30) · -20   c. 105 · (-30) · 20   d. -105 · (30) · 20
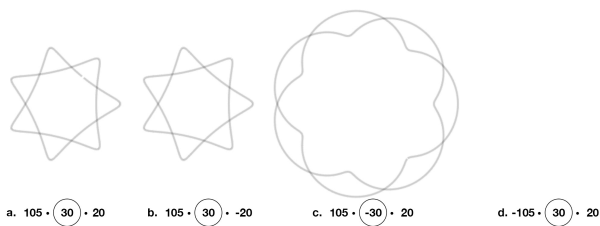
Fig. 16. Examples for Spirograph parameters, by assigning negative values

Then we explored the negative value effect on Spirograph. The results are shown in Figure 16.

The pattern would remain the same if we set a negative value on pen point distance on the mobile gear (Figure 16, a, b). The pattern would be quite different if we set a negative value on the mobile gear teeth (Figure 16, a, c). We get nothing if we set a negative value on the static gear teeth (Figure 16, a, d).