Animated Patterns: Applying Dynamic Patterns to Vector Illustrations

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Figure 1: Example illustration featuring animated patterns in a variety of visual elements

ABSTRACT

Vector illustrations are object-based, comprised of strokes and shapes typically filled with flat and gradient colors. For the artist, this lends a lack of control over pixel-scale details, like shading and texture. These shortcomings have contributed to the rise of flat, geometric art styles which have become synonymous with vector graphics. We propose the use of animated patterns to give artists greater expression and streamline the creation of new visual results in vector illustration. By examining the interactions that occur when artists draw and customize these dynamic patterns, we discover design considerations for future vector illustration systems that may facilitate the creative authoring of such visuals.

CCS CONCEPTS

• **Human-centered computing → Web-based interaction**; **Graphical user interfaces**.

*The research in this paper was completed at Brown University.

CHI EA '23, April 23–28, 2023, Hamburg, Germany

ACM ISBN 978-1-4503-9422-2/23/04.
https://doi.org/10.1145/3544549.3583941

KEYWORDS

vector illustration, patterns, animation, kinetic textures, SVG

ACM Reference Format:
Joshua Kong Yang. 2023. Animated Patterns: Applying Dynamic Patterns to Vector Illustrations. In *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems (CHI EA '23), April 23–28, 2023, Hamburg, Germany.* ACM, New York, NY, USA, 7 pages. https://doi.org/10.1145/3544549.3583941

1 INTRODUCTION

Patterns are everywhere. Stripes. Polka dots. Chevrons. These simple configurations of repeating geometric shapes make their presence in our everyday lives. Patterns create visual excitement, convey symbolic meaning, and are a timeless staple of graphic designers and illustrators. As author Jude Stewart writes in *Patternalia*, "On a gut level, we imbue patterns with personality"[17]. Red-and-white checkerboard conjures images of picnic baskets and fast food liners. The gilded, sleek patterns of the Art Deco movement make the time period of the 1920s and 1930s instantly recognizable. Screentones and crosshatching have been employed by American and Japanese comics for decades.

With the advent of digital mediums, artists gained a new tool in their creative arsenal: animation. Movement in artwork captures attention and augments the visual information conveyed. Moreover, the omnipresence of screens in our modern lives allows animation to displayed almost anywhere. We focus on a subset of animation called looping animations. They are an accessible way for individuals seeking to add dynamic elements to their artwork. Looping animations affix repeating motions to select details, like shimmering leaves or rippling water, to capture the *impression* of a moment in time. In illustration, these elements are known as kinetic textures which bring static artworks to life [11].

Here we propose animated patterns: a system that animates patterns intrinsically–where the repeated details inside a pattern can transform. We believe this combination lends new visual styles for artists to employ in the realm of vector graphics. The vector graphics format features infinite resolution, and its prevalence is on the rise with the ever-increasing pixel density of modern displays. However, it follows an object-based paradigm with discrete strokes and shapes that lacks control over shading and detailing traditionally done at the pixel level. Shapes are almost always filled with flat or gradient color. This results in a minimal, geometric art style that has become synonymous with vector graphics, colloquially dubbed the "corporate art style" or "flat art"[6, 8]. Animated patterns offer a striking contrast against such "flat art," and we recruit hobbyist and illustration students to create new visual styles with these patterns. Vector graphics are standardized by the World Wide Web Consortium (W3C) in the Scalable Vector Graphics (SVG) format [3], and we implement animated patterns within the bounds of this specification. By observing key behaviors and preferences shared amongst artists using this system, we investigate how individuals think, use, and apply this new digital medium.

The contributions of this extended abstract include 1) a system for animated pattern authoring and display which can be integrated into any vector illustration software that supports the W3C specification and 2) a pilot study revealing design considerations for future pattern tooling in vector graphics.

2 RELATED WORK

Vector Texture Synthesis: Textures in vector graphics have been a topic of long interest. New proposed structures such as Diffusion Curves [15] and L. Wang et al's solid texture representation [20] have achieved impressive visuals, synthesizing regions containing complex folds of colors and natural solid textures respectively. However, these techniques are often inaccessible due to lack of support from common vector renderers. On the other hand, automatic procedural methods like Clustered Vector Textures [19] and Vignette [12] take a different route, using pattern extraction on user-inputted examples. These methods are successful with replicating specific visual styles such as pen-and-ink illustration with Vignette. Another technique, Data Dependent Triangulation [1], recreates similar pixel-based image input in the vector format. These techniques output standard vector files that display well in the browser.

Commercial Vector Software: Drawing applications such as Adobe Illustrator [9], Inkscape [16], CorelDRAW [5], and SVGator [18] are common tools artists use to create and work with vector graphics. These graphic editors implement the W3C vector specification to varying degrees. Illustrator and Inkscape both offer pattern creation, but the results retain the flat look of mainstream vector graphics. Solutions like SVGator offer animation capabilities, but animation is applied to overall shapes and not the geometric forms that constitute a pattern. These tools do not offer the freedom to cohesively combine vector patterns with vector animation.

Animated Textures: A well-known application of animation in digital illustration is applying movement and transformations to individual shapes as seen in SVGator [18]. Recent work has further focused on animating the textures *within* each shape. Draco introduces the idea of *kinetic*, or animated, textures where users attach looping motions to clustered, repetitive elements of an illustration [11]. Filtered.ink explores animating textures even further with SVG filters, procedurally generating vector textures via parameters that can be animated [22]. Our animated patterns build off filtered.ink with the addition of discrete patterns into the dynamic SVG filter workflow it presents.

3 IMPLEMENTATION

Our animated patterns are graciously housed and implemented in the filtered.ink web-based vector graphics editor for its GUI, which abstracts away the XML code behind vector graphics into a node-based interface. Our design choices are grounded in strategies found in current illustration software and we seek to extend them for use with animated patterns.

3.1 Implementing Patterns and Animation in SVG

The W3C vector specification describes a `<pattern>` element that is the backbone of displaying patterns in vector graphics. It tiles a child graphical element–the base *unit* of a pattern–along a rectangular grid according to a set of attributes: tile width, tile height, tile x-axis offset, and tile y-axis offset (see Figure 2). For more visual intricacy and detail, multiple pattern elements can be layered on top of each other by linking each `<pattern>` element with an `<feImage>` element. Notably, there exists an `<feComposite>` element which performs the desired layering behavior with multiple input `<feImage>` elements. Transformations like translation, scaling, and rotation can then be applied to both the individual unit and overall pattern. Careful combinations of layering and transformations affords patterns to break from the baseline rectangular grid if desired (see Figure 3). Finally, the resulting pattern element are applied to the various shapes defined in the vector format that users draw (`<polyline>`, `<path>`, `<circle>`, etc).

We next rely on W3C-specified SMIL animations to animate the transformations applied to the unit and pattern elements. SMIL allows sets of transformation parameters to be described as keyframes and interpolates between them, thereby creating motion as the "dynamic" transformations morph the respective element over time. The cycle of keyframes repeat so this work falls under the subset of looping animations. Note the transformations applied to the individual unit must be scaled proportionally to the `viewBox="0 0 x y"` attribute associated with each `<pattern>` element, namely the ratio between the viewBox `x` and unit width.

Within the filtered.ink editor, these parameters are represented as a series of interactive sliders and selectors (see Figure 4) for each animated pattern. Users can create patterns from scratch or adjust the parameters of preset patterns.

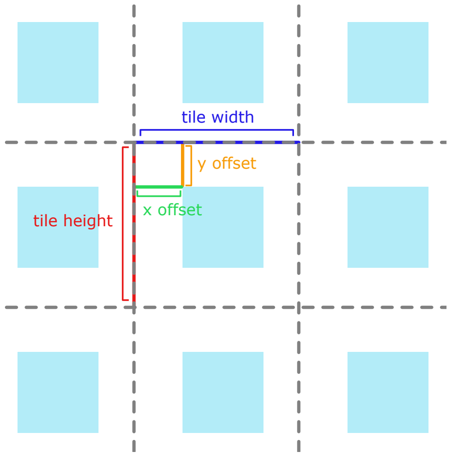

Figure 2: The teal square represents the bounding box of any child element being tiled. The grey dotted lines delineate the rectangular grid `<pattern>` tiles over. Tile height, tile width, x-axis offset, and y-axis offset are highlighted in red, blue, green, and orange respectively.

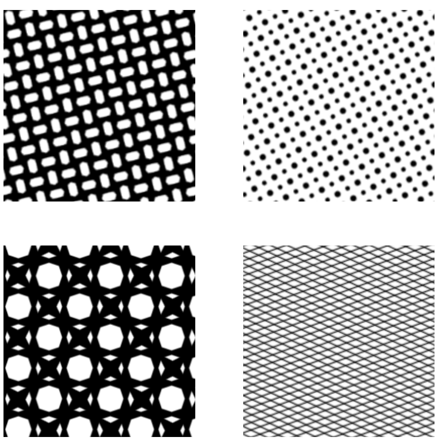

Figure 3: Example patterns achieved through layering multiple `<pattern>` elements. Note the use of scaling in the screentone texture and rotation in the pills texture to create variance in the pattern.

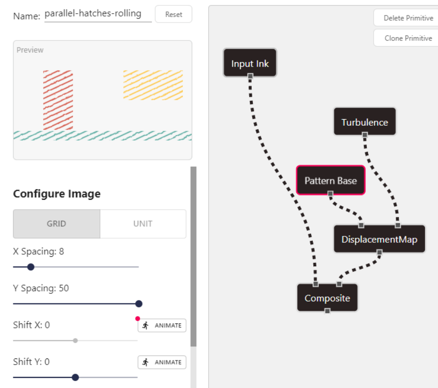

Figure 4: The animated pattern authoring interface in filtered.ink. Sliders control pattern parameters, and compositing is done via filtered.ink's node editor.

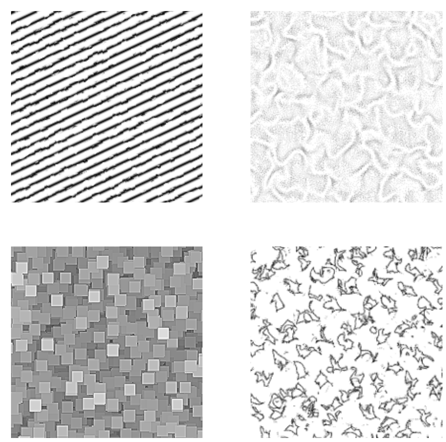

Figure 5: Example vector textures created by using SVG filters on top of the base animated patterns.

3.2 Augmenting animated patterns with SVG filters

SVG filters are a graphical transformation akin to shaders in computer graphics [22]. However, filters in vector graphics dynamically recompute at any given display resolution. These filters are used in a `<filter>` element, and child elements define the SVG filter behavior. Notable child types include `<feTurbulence>` which describes a continuous noise function, `<feDisplacement>` which describes a pixel warping function, `<feConvolution>` which describes a image convolution function, and `<feMorphology>` which describes a erosion and dialation function. Filtered.ink presents the use of these filters to achieve a variety of vector textures. We similarly augment animated patterns with these SVG filters, unlocking further visual possibilities like pen-and-ink and grainy effects in vector graphics (see Figure 5).

3.3 The brush and lasso tool

We offer two methods for the user to draw shapes. The first method is a pressure-sensitive brush that dynamically generates a shape based on user input. The width of the stroke is adjustable. The second method is a selection "lasso" tool where users directly draw the shape perimeter. The animated patterns are applied while the shape is being drawn, such that the user immediately sees the selected pattern appear on their incomplete shape. This takes the guesswork out from applying a pattern post-stroke, and artists can react

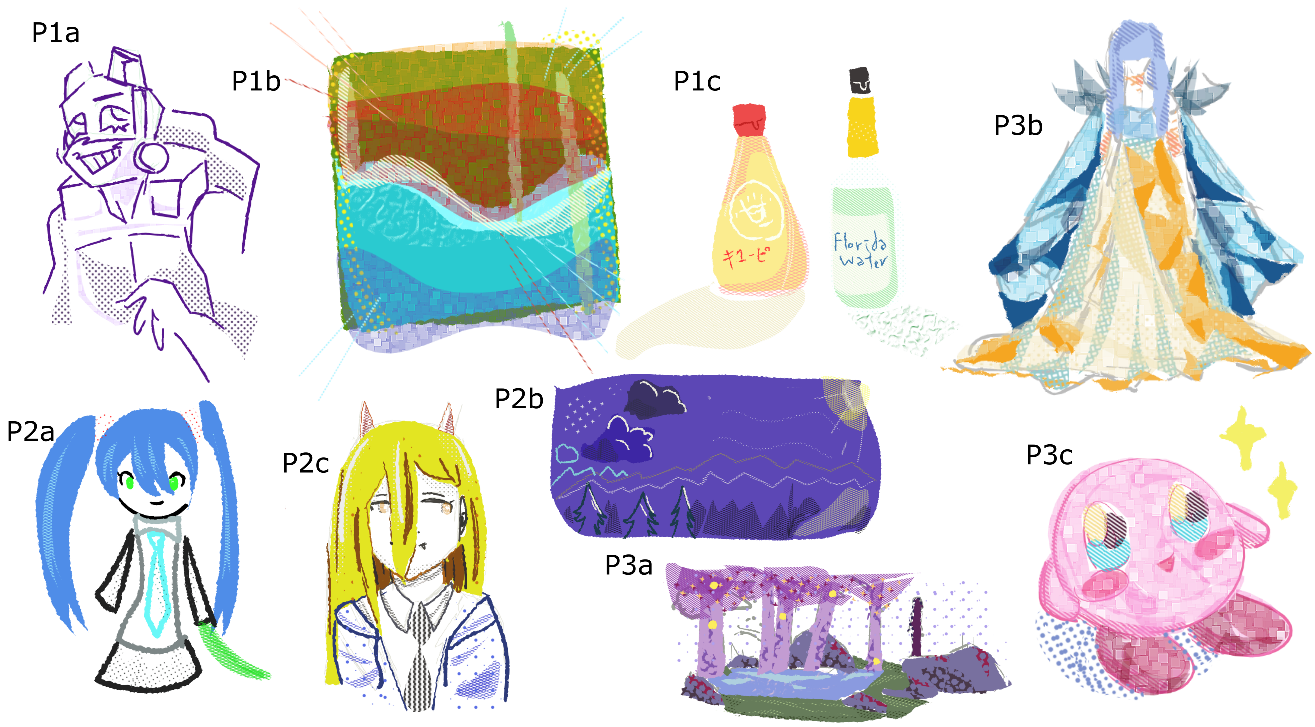

Figure 6: The illustrations participants completed in the study are displayed above. Some illustrations employed animated filters to add variety to shading (i.e. the torso and arms in P1a and clothing folds in P2c) while others used them as general textures (i.e. the sections of skyline in P1b and the character body in P3c).

and make adjustments on the fly. Both tools are common drawing tools found in standard illustration software like Photoshop and Illustrator.

To achieve smooth lines, we apply a spring-based stabilization algorithm with Hooke's law, $F = -k\Delta x$, to denoise user input, a list of screen coordinates. This model is constructed by a simulating forces from a spring between the mouse cursor and the tool tip, such that the mouse cursor "drags" the tool tip around. Δx represents the distance between the cursor and tool tip along each axis. The simulated spring should be overdamped to avoid unwanted oscillations in the output.

4 PILOT USER STUDY

We conduct a pilot user study to investigate how artists interact and use animated patterns. These patterns are only possible with computer technology, and we seek to discover where these patterns may exist in the space of vector graphics for illustrators. Three participants (P1-P3, 2 female, 1 male) aged 17 to 20 years old took part in our pilot study. P1 and P3 are students studying illustration, and P2 is an art hobbyist. All participants had three or more years of digital art experience and were recruited from the researchers' artistic network. Participants were scheduled into individual 90 minute blocks and were compensated for their time.

4.1 Study Protocol

Introduction (10-15 minutes): Participants first filled a questionnaire with generic demographic information and their illustration experience level. After the questionnaire, participants were introduced to the filtered.ink editor and animated pattern features integrated into the editor. The facilitator encouraged participants to try sketching and familiarizing themselves with the system. Participants were then prompted to imagine two subjects–one character and one scene–to illustrate in the next phase of the study.

Drawing (50-60 minutes): The facilitator requested participants to draw the subjects they imagined. Participants were asked to incorporate animated patterns into their illustrations, spending 20 to 30 minutes on each subject. The facilitator regularly encouraged participants to narrate their artistic choices aloud. Participants had the opportunity to use preset animated patterns and to customize their own. Participants were also invited to draw a third illustration with any leftover time they had.

Interview (15-20 minutes): Participants filled out a questionnaire rating the animated patterns based on the creativity support index questions [2]. We then conducted a semi-structured interview to understand participants' thought processes while using the system and their opinions on where animated patterns could be used.

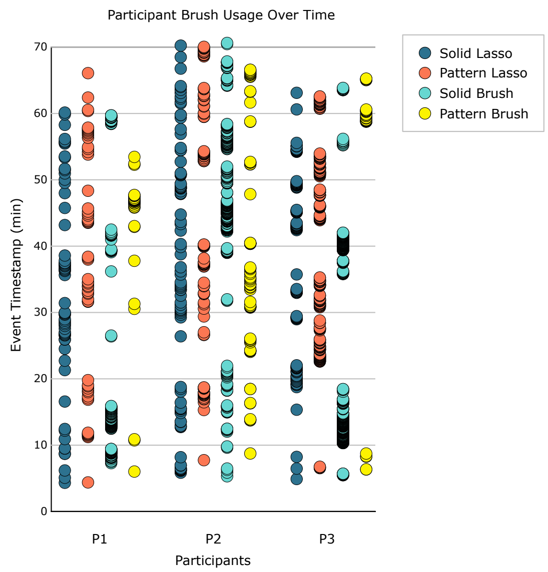

Figure 7: A plot that displays each event when participants drew shapes and the tool type used over time. All four combinations were regularly used, though the pattern brush was used the least.

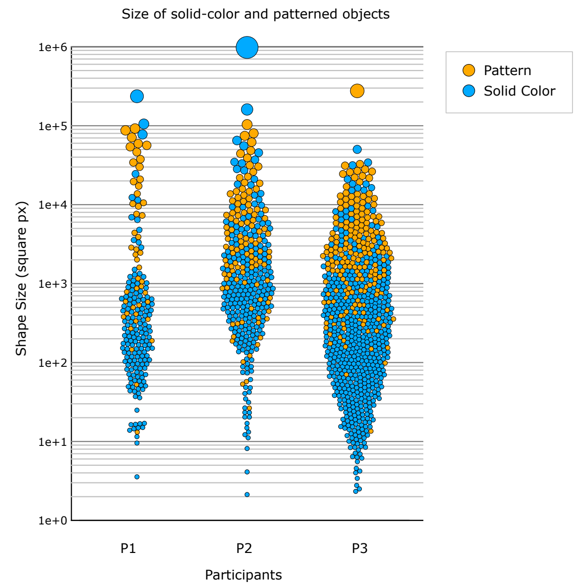

Figure 8: A plot that displays each event when participants drew shapes and the respective shape type, sorted by surface area. Solid-color was used more with small shapes while patterns were used more with large shapes.

5 RESULTS AND DISCUSSION

5.1 Tool Choice with Animated Patterns

We log the user's shape-drawing interactions with both animated patterns and solid colors in Figure 6. Each point represents an individual stroke or shape drawn by the participant in the drawing phase of the study. In this plot, "Brush" and "Lasso" refer to the tool used in each interaction; "Solid" and "Pattern" refer to whether solid color or animated patterns were used respectively. During the study, we observed the solid brush combination was predominantly used for linework and outlines. The other three combinations were employed across a variety of visual elements. Participants intermittently swapped between combinations as they worked, drawing an average of 13 shapes before every swap, suggesting the combinations had different uses in the various steps of the illustration process.

We also calculate the size (surface area) of every shape the participants drew in their illustration and track whether solid color or animated patterns were used. We plot this distribution in Figure 7, where each point again represents an individual shape participants drew. The majority of shapes erred on the smaller size with few large shapes–note size is plotted on a logarithmic scale. Here we discover a correlation between shape size and use of animated patterns: animated patterns tended to be used with larger shapes while solid colors tended to be used with smaller shapes. With the largest shapes, however, both solid color and animated patterns were used as background elements.

Overall, participants reported they enjoyed the animated aspect of the patterns. We observe animated patterns were used to quickly fill–typically large–spaces that would otherwise be flat color or empty, adding exciting variation to their artwork. While drawing, participants liked applying a layer of solid color with the solid lasso before employing the pattern lasso on top, using these two tools the most. P3 said they could layer patterns on top of each other to build up depth. P2 meanwhile noted that the animated patterns were more effective with the lasso tool because they could predict the moving boundary of the pattern better, and 70.5% of patterned shapes among all participants were drawn with the lasso tool. Parallels were drawn to the traditional screentone application process, where shape boundaries are cut from a pattern sheet and transferred to the canvas [13]. On the other hand, participants preferred to complete small details with the brush tool, citing intuitive control similar to real-life pens. Most participants chose to complete detailing with the solid brush in particular, and P1 mentioned that brushed animated patterns "had shifting see-through" sections which made them difficult to see at small scales. This is consistent with our findings in Figure 7, where the majority of small shapes were drawn with solid color. In general, the dynamic movement of animated patterns introduces new capabilities as well as challenges for the artist. Artists also leaned on prior knowledge with other art mediums to guide themselves in our system.

5.2 Animated Patterns on Aesthetic Expression

The illustrations participants completed can be seen in Figure 8. In the final interview phase of the study, participants were asked to rate their experience using animated patterns according to several metrics from the creativity support index which evaluates the effectiveness of creative tooling [2]. On a scale from one to five, participants rated their ability to express their vision a 4.7 on average. P1 stated animated patterns allowed them to create vector graphic visuals that would be nigh-impossible in Adobe Illustrator. P2 cited the animated pattern's ability to achieve greater visual variance and motion in vector art. Participants also rated their engagement and effort/reward trade-off while using the animated patterns an average 4.7. P1 believed animated patterns would make illustrating for "web design so easy," and P2 noted that animated patterns make looping animations in illustration "super accessible" as keyframe looping animation requires redrawing variations of the illustration "at least three times". Ease of use lets users focus on creating their artwork instead of manipulating tools.

All three participants also noted the ability of animated patterns to draw attention to details. P2 used animated patterns to contrast still and moving objects: "some objects are expected to move like clouds, while others are static [like mountains]" (Figure 8 P2a). P3 liked the atmosphere animated patterns adds to textures, particularly in clothing, and nodded to a dynamic shimmer they thought would highlight a metallic tulle fabric (Figure 8 P3a). Both P1 and P3 said animated patterns were a fantastic tool to accentuate sparkling speculars and moving shadows. We recognize the dynamic nature of animated patterns can add nuance and character to particular elements of an illustration. Furthermore, most of the completed drawings exhibited styles different from the flat, geometric style typically associated with vector graphics; the use of animated patterns breaks up the flatness of solid color.

5.3 Use-Cases for Animated Patterns

Participants were also asked to imagine future avenues for animated patterns. P1 related them to their training in graphic design, "They're great for fun backgrounds [to capture] attention." Similarly, P2 envisioned the use of animated patterns in product design: "[They make] a product more friendly, not being static." The patterns create engaging stimuli suitable for any scenario that wants a visual pop or an audience's attention. Other ideas included digital scrapbooking, e-diaries and journals, and productivity tools. For illustration, participants noted the contributions of simplifying looping animation creation as more digital artists shift to video formats in the age of social media and short-form video.

6 CONCLUSION

In all, animated patterns are a new tool in the artist's tool belt. Our exploration presents the subtle directions animated patterns take with different drawing tools, informing the development of future vector illustration systems. This investigation into disrupting the prevalent "look" in vector graphics also offers insight for future illustration software designers to facilitate the creation of new visual styles. We hope our exploration informs further development and adoption of animated patterns in the vector format.

7 LIMITATIONS AND FUTURE WORK

We only recruited three participants for our study, and future studies with more participants covering a broader range of experiences–including those with professional experience and those with no experience at all–can better inform us on how artists employ dynamic patterns. Furthermore, participants only drew for 50 to 60 minutes total, and additional sessions of observing artists adapting and working with animated patterns could help reveal further design considerations may be valuable for future vector graphics software.

Unfortunately, only some vector renderers fully support the W3C SVG specification for vector graphics. Our implementation of animated patterns uses local `href` linking that is only supported by Chromium browsers. Until more SVG rendering engines support the complete W3C specifications, animated patterns will not properly display in Firefox, mobile browsers, or software like Adobe Illustrator. This study also primarily focused on the usage and behaviors around the usage of animated patterns. We did not cover the animated pattern *authoring* experience beyond simple twiddling with sliders. The process is rather involved and future work could investigate simplifying the authoring experience for laypersons without sacrificing expression.

ACKNOWLEDGMENTS

To Tongyu Zhou and Professor Jeff Huang for their enlightening mentorship and this research opportunity. To the Brown HCI Group for their support and use of the filtered.ink editor.

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Received 19 January 2023