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The Choreography of the Creative process: Drawing in Time and Space

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ABSTRACT

This paper provokes a new perspective on the contribution of computers to visual art, questioning how both the aesthetic qualities of the visual product and the making process itself can render a hybrid artistic outcome. We advocate for a medium that *unifies* the physical product with the spirit of the making process, as a territory with extensive innovative potential for computational artistic practice. The paper demonstrates various techniques to visualize the motor performance of artists in activities such as drawing and carving. We rely on digital tracking of the artists' movements and computer graphic tools to expose the expressive performance of artists, highlight their working style, and bring the hidden paths of their strokes to the front of the artwork. Furthermore, we discuss the contextual implication of this form of visualization to new domains of visual art.

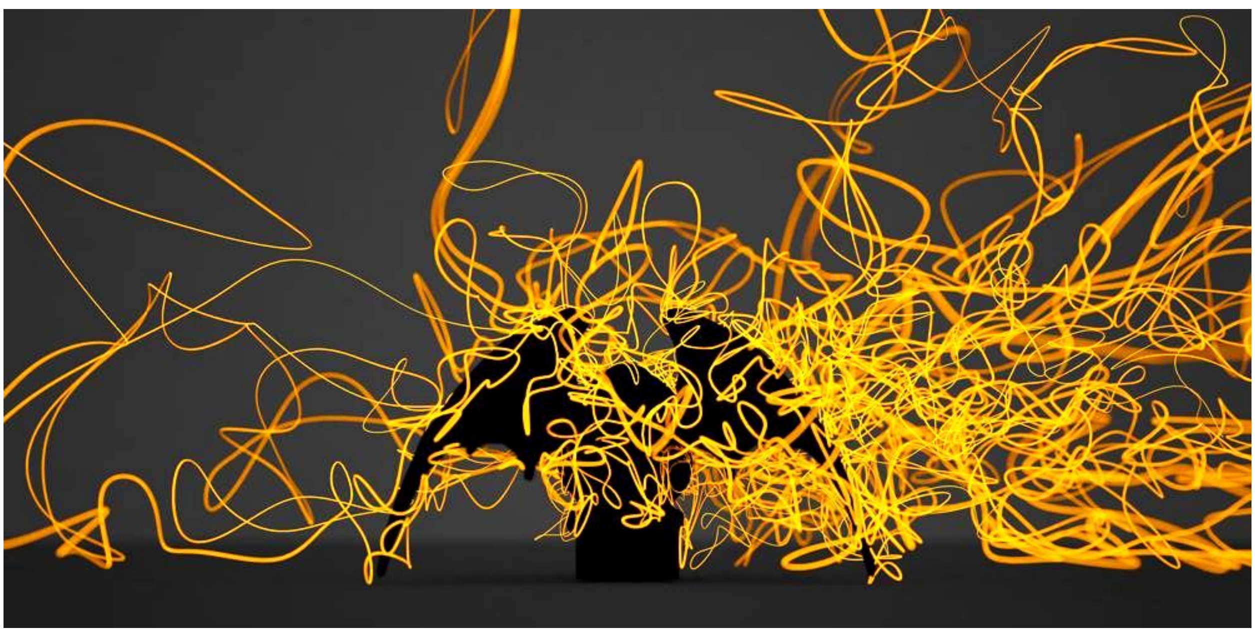

Figure 1: *Gargoyle, reborn*---smoothed tool-path visualization of the first author working on a gargoyle project using the FreeD tool, embedded around a CAD model of the gargoyle. Rendering by Rhino and VRay. (© Amit Raphael Zoran)

Introduction

Visual art products resonate values through a variety of means and channels. Traditionally, in the history of visual art, we have praised the uniqueness, material qualities, and *aura* of physical artworks. Because computational mediums, by definition, cannot generate the same unique physical qualities, they are subject to some conservative criticism [1].

Yet the creative rule of technology is a dynamic agent: as McLuhan noted in *Understanding Media: The Extensions of Man*, the *medium* of interaction can be even more important than the content itself [2]; Dourish later advocated for a holistic perspective on human-computer interaction (HCI), highlighting engagement, skill, and practice in embodied interaction [3]. Digital mediums span new possibilities for artistic engagement, and changing the rule of manual skills in visual art.

20th century artists have already challenged the traditional emphasis on the product, by physically manipulating the techniques used in the making process (see Yves Klein's anthropometry, where he used the body of a human model as a brush [4], or Henri Michaux painting under psychedelic influence [5]). In this spirit, computers may contribute alternative merits to making practices and their artistic results. For example, they can expose elements that traditional art products neglect, such as the aesthetic qualities of the making process itself.

In our work, we present a portfolio of visual examples that reveal hidden qualities of the making process. Focusing on motor performance in drawing and carving, we demonstrate approaches and techniques that help us visualize strokes, movements, and artists' creative activities. These visualizations manifest a perspective shift, referring to the physical art product as a *trigger* for the performative creative process, where the artist imprints her working style in the time and space of the process.

We combine methods of digitally tracking art tools with computer graphic technologies to visualize the creative gestures artists perform while working. Using a custom-made carving tool (FreeD), a clay-relief knife, or a Wacom monitor, we recorded tool-paths and painting strokes (where we, the authors, are the artists), then used a range of techniques to visualize the information we captured. The outcomes expose the expressive performance of the artists, bringing the process to the fore by marking the hidden tool paths of strokes and hand movements.

We now move on to related work and the technical background for our research, prior to presenting projects arising from our experiments and explorations. We then discuss the potential impact of our work.

Related Work: Capturing the Creative Path

The idea of exposing traces in the creative space is not new. As photographic technologies evolved, some artists explored the creative potential in capturing motoric performance to produce new forms of art. Pablo Picasso's light drawings from 1949, created with photographer Gjon Mili for *LIFE* magazine [6], used slow-exposure photography and a light to capture hand traces in open 3D space. In the mid-20th century, Harold "Doc" Edgerton used stroboscope photography to capture the movements of a tennis player, a gymnast, and a golfer [7].

While the works by Picasso et al. and Edgerton were produced in analog mediums, digital monitoring technologies and computer graphic visualization tools introduce new capabilities. For example, Tobias Gremmler is a visual artist whose experiments [8] include tracing the movements of conductor Sir Simon Rattle and developing animated art based on them [9]. Geoffrey Mann visualizes birds' flights and dogs' fights using long exposure photography [10], embedding complex movement into still visualizations.

Similarly, researchers have been studying how to harness such tracking and monitoring technologies to allow a direct-manipulation 3D drawing practice in virtual and hybrid environments [11,12]. A recent publication in *Journal of Archeological Science* explores a new approach to visualizing the changes in a potter's style, by generating virtual loft objects that represent the time-dependent evolution of the cross-section of the necks of pots, suggesting that an individual's style can be represented over time as a unified 3D object, where two dimensions represent the neck's cross-section and a third dimension represents time (see [13]). Recent research on the dynamics of artistic style takes a similar approach to studying individual creative signatures, as discussed below.

Technical Background: In Search of the Dynamic Qualities of Style

The "signature" of the artist's style and its dynamic characteristics marks the texture and details of an artistic object. Knife, hammer, chisel, and sanding tools all display diverse working techniques and render unique textures on the surface of carved artifacts, resembling the traces of brush strokes on canvas, pencil marks on paper, or the flowing patterns of watercolors. In a sense, these textures represent the complex human activities of an artist working in a physical medium.

The work we present here relies on the research on motoric style in creative tasks that we began several years ago, across a range of experiments and art forms[1]. In this ongoing and long-term research, we hypothesize that there is a time-variant dependency between personal style and

[1] The technical discussion and contribution of our research on dynamic style will be presented elsewhere. In this paper we emphasize the *visual qualities* of the data, rather than the analytical discourse regarding personal style.

motoric skills in visual art and craft tasks. To validate this assumption, we study the development of users' personal styles over time, learning which qualities tend to change and which reflect a lasting signature.

While this time-varying information depends on the artistic task itself, it also reveals identifying characteristics of the observed subject. Hence, in our on-going research we investigate which characteristics of creative style depend on elements of the creative performance---such as the morphology of the task, its social context, the mental model, and the user's experience---and which are unique to the user and appear in all of her or his work.

In our work, we used several craft mediums, tools, and techniques, as described in three later subsections. The work presented in *Strokes in time and space* (see Fig. 2) was captured in a *2D style drawing study using a Wacom Cintiq 24HDT device*[2], with a touchscreen and a digital pen. We rely on real-time custom software to extract and record the digital signal of a sketcher as a series of samples, with each sample containing different features: 2D position, pressure, azimuth, and 2D tilt. We supplied participants with references for the sketching in a gray-scaled image, to learn how their styles would evolve over a relatively long period, and what characteristic features identify their styles. We will discuss the analysis of this study elsewhere; here we share the visual outcomes of this investigation.

Compositions of presence and absence focuses on the *FreeD*, a freehand, digitally controlled milling device monitored by a computer using a magnetic motion tracking system (MMTS)[3]. It is tracked and controlled with reference to a virtual 3D model, and allows unskilled makers to succeed in complex carving tasks [14-16]. The FreeD is part of a growing body of research on "smart" manual tools (see [18-20]) that preserve the maker's freedom to manipulate the work, allowing manual and computational design modification during fabrication while rendering a unique 3D model directly in a physical material. Relying on a pre-designed 3D model, the computer affects the user's action only when the milling bit risks the object's integrity, by slowing down the spindle's speed or drawing back the shaft; otherwise, it allows complete gestural freedom.

In prior work, Zoran et al. extracted identifying features from tool-path data in carving tasks using the FreeD (such as 6-DoF tool path and orientation), assuming these features would sufficiently represent the working style of different users as they operated the device over time [17]. The works presented in Fig. 1, 3, 5, and 6 rely on the data captured by the FreeD.

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[2] Model DTH-2400, with samples collected at an averaged frequency of 60Hz.
[3] For the MMTS, the FreeD uses the Polhemus FASTRAK system, an AC 6D system that has low latency (4ms), high static accuracy (position 0.76mm/orientation 0.15 RMS), and a high refresh rate (120Hz).

Finally, *Points of voids* presents data captured in additional research projects, where we use a *semi-standard carving knife for clay-relief techniques*. Augmenting the knife with MMTS (the same system discussed above), we tracked and extracted carving features[4] to study the working styles of master artists as well as novices. We then processed and analyzed this information to study how the (controlled) topic of the artwork impacts the motoric style, and whether an artist's style is consistent even for novice users. Fig. 7 shows work captured in that process.

Such means of visualization introduce new perspectives for analyzing motor performance and personal style, and contribute new scientific methods to unlock the mechanisms behind creative practice [13]. Nevertheless, here we take a non-utilitarian approach and harness these visualization techniques to generate visual products that stand on their own, where the creative medium itself is the main message of the art practice. As digital mediums bring transformative qualities to manual creative processes, we highlight several aesthetic examples that suggest a perspective shift regarding the agency and value of art processes and products.

Visualization of the Performative Qualities of Making

A physical artwork encapsulates both the physical space it holds and the projections of gestures and strokes that the artist performed while working. Hence, a work of art is more than its physical incarnation: it is a manifest for the time, skill, and efforts invested in the process.

In his pivotal work, Walter Benjamin states that the *aura* of an artwork, representing the physical uniqueness and material qualities of an art piece, is an exclusive quality that cannot be captured or copied via mechanical reproduction [21]. While Benjamin focuses his dissertation on photography, one can apply similar analysis to computer graphics.

While digital mediums neglect physical qualities due to their virtual nature, the same *virtual* qualities can memorialize the creative events that have faded, yet left behind signs, marks, and textures. In a sense, one can bring some of these lost creative spirits back to life: the gestures, the strokes, the performance, the artists' movements. Using tracking and recording technologies, and computational simulation and rendering, we can reconstruct the artists' process, and generate additional visual qualities hidden in the original artwork.

The following works visualize either the artist's movements or a hybrid of the visualizations of such movements and a representation of the subject of the making process. All of the projects below were created by the authors using the technical settings and considerations described in the previous section, parallel to our research in motoric style.

Strokes in time and space

[4] With a sampling rate of 50Hz.

Traces of motor activities can either be subtractive or additive. Some visual art and craft techniques are based on the removal of material to achieve the desired form, while many 2D visual arts, such as drawing, are additive. Although a drawing or painting is made up of all the strokes ever applied to the flat medium, information about temporal aspects of the drawing process itself is missing from the final product.

The work presented in Fig. 2 visually exposes the time scale in drawing, by embedding the strokes of the artists in 3D space using time indexes, and assigning time to the Z axes, while the XY axes are the 2D drawing medium. Using Wacom devices and data post-processing, we record the strokes of the artists (the first and third authors) and visualize them, creating virtual 3D objects representing how the artifacts evolve in time and space during the work. The time axes become as meaningful as the other 2D drawing space, constructing a 3D object (Fig. 2C, 2D, 2G and 2H). Only a top projection will reveal the figurative qualities of the original drawing (Fig. 2B and 2F), while alternative views can inform us about the making process and variability between artists (Fig. 2D and 2H).

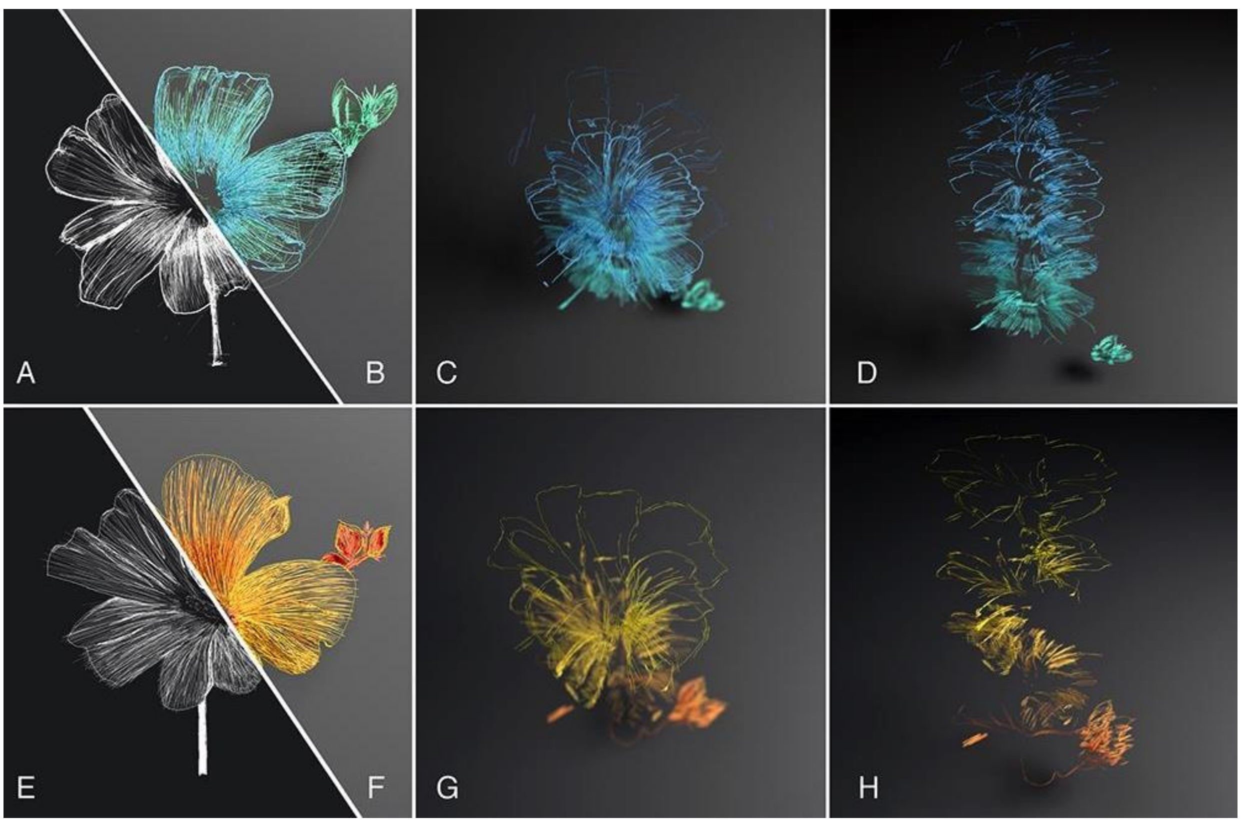

Figure 2: ***Flowers, unraveled*****---visualization of strokes in Wacom, embedding different time periods as different rendering heights: (A,E) part of the original drawings; (B,F) top view; (C,G) side view; and (D,H) an additional side-view rendering of the strokes. We used two different color codes for the strokes to represent drawing time. The work in the top line (A, B, C and D) is by the first author, while the work in the bottom line (E, F, G and H) is by the third author. Rendering by Rhino and VRay. (© Amit Raphael Zoran)**

The virtual curves illustrating the strokes deconstruct the final piece over its time axes, expose their visual complexity on a 3D space, and reveal patterns of motor movements that represent the behavioral features of the artist. These performative qualities emerge from the artist working in a 2D medium that neglects temporal information; our visualization, however, transforms the way the working style of the artist reveals itself to the viewer, and suggests that the work is a record of the dynamics that originate in the process and its product. Here, the *process* stands for its own physical manifestation, generated by the creative forces that arise from the tension between the intentions of the artist and the results of the drawing.

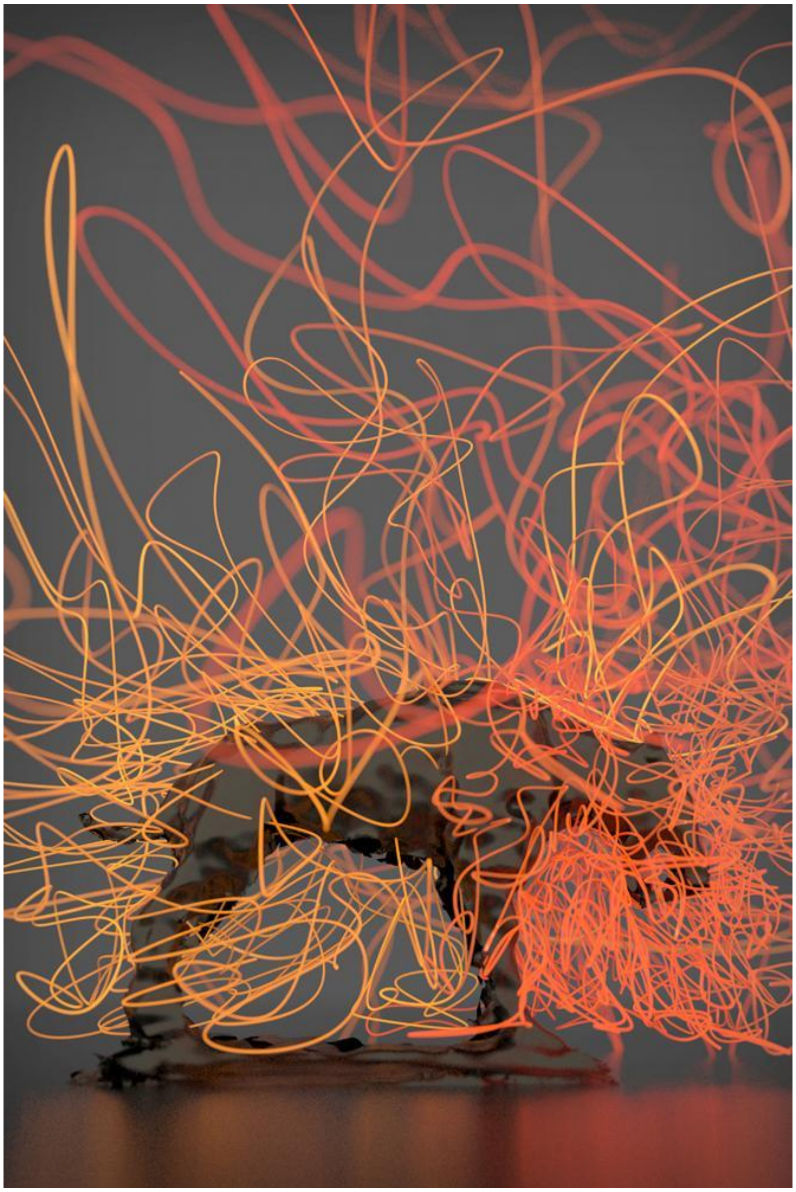

Figure 3: *Tiger, reborn*---smoothed tool-path visualization of the first author working on a saber-tooth tiger project using the FreeD tool, embedded around a CAD model of the animal. Rendering by Rhino and VRay. (© Amit Raphael Zoran)

Figure 4: ***A chimera*** **---embedding and rendering of two gargoyle CAD models: (1) the original gargoyle reference in partially transparent grey (purchased from the TurboSquid CAD website); (2) a 3D scanned model of the gargoyle made by the first author using the FreeD tool in white. The mottled surface of the gargoyle reflects the imprecise nature of the manual fabrication and working textures. Rendering by Rhino and VRay. (© Amit Raphael Zoran)**

Compositions of presence and absence

While in drawing each new stroke adds to the visual outcome, in carving each hand gesture and knife or chisel stroke *removes* materials, forming the “negative space” of the work. Stroke by stroke, the raw material slowly converges into its final form, but *only the last* layer of strokes will be represented in the texture of the final artifact. Unlike drawing, a carved artifact does not radiate information about the full complexity of the making process, as the process merges into the negative space of the final artifact.

As we did by using time as the third axis to embed the process of drawing into the 3D space, we now present a method of visualizing 3D carving projects enabled by the FreeD device. In Fig. 1 and 3 we present a ray-traced rendering that visualizes the artist’s performance as embedded in the negative space of CAD models. In the center of these works, we position a dark version of the model that was made using the FreeD, while the morphology of the objects is highlighted by the shiny strokes of the artistic performance, (virtually) challenging the traditional relationship between physical carving and its negative space. Fig. 5 demonstrates a 2D projection of carving strokes using Processing. In addition to this fully virtual 3D visualization of the subjects of the carving process, we present two projects (Fig. 4 and 6) that position a representation of the physical carving subject in the same frame with the visualization of the making process. Both works hybridize the process with its outcomes, and generate a new medium of visual work.

Within these works we visualize the strokes, gestures, and movements applied by the tool and captured using our MMTS in the space surrounding the final artifact (i.e., the negative space of the work). The visualization represents the activity of the artist, the performance, and the carving process. This information, which is traditionally missing from carved artifacts, both records the artistic process in 4D (space and time) and shapes the boundaries of the object. Our visualizations are compositions of presence and absence, positioning and contrasting the static (and physical) outcome with a dynamic process that originated it; and highlighting the boundaries of the carved object by the material that was left, and the material that was removed.

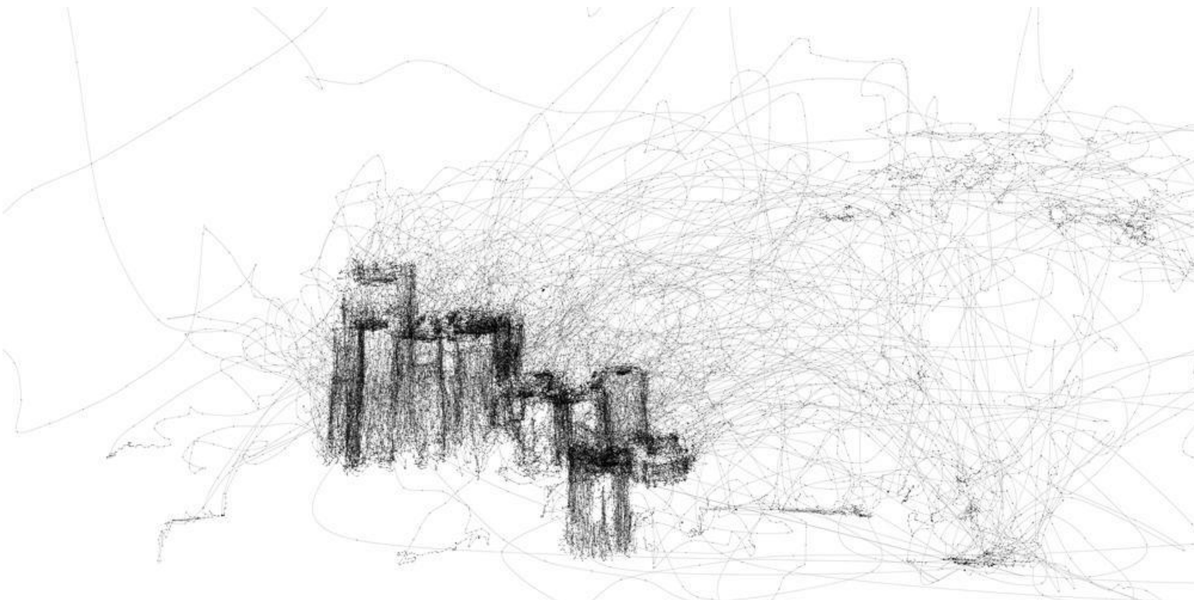

Figure 5: *Drawing in time and space*---tool-path visualization of the first author working on a castle project using the FreeD tool, projected onto a 2D plane. The small points represent sampling of tool location using the MMTS, while the lines were constructed using interpolation. Visualization was done using Processing. (© Amit Raphael Zoran)

Points of voids

In the previous sections, we discussed methods of highlighting and visualizing the making process. However, the original digital records do not accurately capture either strokes or any other artistic gestures: the computer holds only sampled data, represented in series of recorded locations of the working tool as captured by our tracking technologies. In this section, we continue the prior discussion but turn to a more raw visualization of the recorded data: the discrete, original 3D points of locations captured in 60Hz.

Fig. 7 presents documentation of a clay relief work that was made over seven weeks (one day a week, about half an hour a day). Unlike the work done using the FreeD, here we connected our MMTS to a traditional carving knife, monitoring and recording the position of the tip of the knife in the 3D space at a time resolution of 60 times per second. This work unfolds the dots recorded in the process, from the first week to the last, perpetuating the negative space of the work---the space where the sculptor's actions moved the carving knife. While the prior works emphasized tool paths and strokes, here the representation is discrete elements in space.

This documentation enables us, using a computer simulation, to document and illustrate the creative process itself; when the recorded data is presented together, a new type of object appears, holding full agency over the negative space as created by the artist, while the digitally generated form casts the morphology of the physical artifact.

Figure 6: *Unification in differences*---a castle model fabricated using the FreeD, and the tool path of the device used by the author in making this castle. Rendering by Rhino and VRay, and Photoshop editing. (© Amit Raphael Zoran)

Summary and Conclusions

By presenting techniques for visualizing motor performance in activities such as drawing and carving, we highlight hidden qualities of visual art. Working techniques and the dynamic qualities of artistic style (as embedded in artists' motoric performance) become the focus of our visual explorations. Moreover, some of the work presented here (such as Fig. 1, 3, 6, and 7) provokes an additional perspective on the negative space of the work, as we embed the tool-path visualization there to render a visual outcome that is a hybrid between the artifact and the making process. We consider various dimensions of aesthetic documentation, such as the creative performance and its progress in time, sections of motoric efforts vs. idle actions, and the visual characteristics of an artist's dynamic style.

Figure 7: ***Points of voids*---visualization of sampling points of clay-relief carving knife, based on work by the second author. The color code represents varying time periods of the work. Rendering using Rhino and Octane Render. (© Amit Raphael Zoran)**

Within this work, we assert that the traditional measures of valuing artistic processes are subject to transformation by computers. While the physical form and unique characteristics of traditional art works cannot be fully represented in *virtual* mediums, the latter can record the space and time involved in the making process, potentially altering the motivation of physical making. While a few historical art movements (such as *abstract expressionism* [22]) emphasized strokes and gestures, they still constrained the artist's movements within traditional 2D or 3D mediums.

Visualizing the digital records of the process, however, brings to the fore qualities that cannot otherwise be fully presented in a physical artform, allowing for post-processing of the creative medium. Hence, we hope our work will encourage artists to experiment, manipulate, and explore such hybrid mediums in developing a new expressive artistic domain.

While questioning how the differences between the aesthetic qualities of the visual product and the making process itself can render a unified product, we maintain that computers will highlight and expose otherwise intangible elements of the creative practice. To take full advantage of this hybrid medium, artists must develop new skills, always considering the aesthetic effects of recording every gesture---both on the physical work, and on the captured data. Here, ones motoric style is viewed through its performative qualities: choreography of the creative process with its own aesthetic qualities. Thus, the making process can incarnate a new type of object, holding both the physical artifact and the creative process within itself, suggesting a hybrid creative medium that brings together contemporary digital technologies and the tradition of visual artwork.

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