Computing Analogue Interactive Installations

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Abstract. This paper documents the development and application of a set of computational tools and fabrication methods to support and facilitate the design, simulation and realization of 3D Moiré Animation installations. Setting-out from the technique of traditional 2D Moiré Animations, the authors developed tools to examine a novel approach which combines the depth of field and motion of the spectator to achieve large-scale, analogue animations in three dimensions. Furthermore, the authors suggest that large scale outcomes can enhance the way people interact with outdoor spaces. For that hypothesis the particular paper illustrates the application of the tools for the realization of two large-scale interactive analogue motion graphic installations; a memorial and a temporary centrepiece for a dance festival in Cyprus. The tools operate as a free plugin for Grasshopper 3D and can be downloaded.

Keywords: 3D Moiré Animation · 2D Moiré Animation · Computational Design · Digital Fabrication · Interactive Installations

1 Introduction

This study presents current developments and outcomes of ongoing research, aiming towards supporting the design, simulation and realization of 2D and 3D Moiré Interactive Installations. A set of computational tools developed within the context of the research, and the application of digital fabrication techniques aims at automating the design and production of physical large scale analogue animation apparatuses created by the interaction of two superimposed layers. While for 2d Moiré Animations one needs to create a "grating" (a transparent screen with plain, evenly spaced strips or slits) and a "composite" image formed by parts of the frames in the animation, this technique is based on creating the circumstances to mask all but one frames of the animation at a time, using the grating layer. This successive registration of frames generates an "apparent motion" effect, an illusory phenomenon of movement that occurs when "two or more adjacent stimuli are briefly presented, one after the other [1].

This paper documents a novel adaptation of the technique for large scale applications within the built environment. The traditional 2d Moiré Animation method [2], is

G. Di Marco et al. (Eds.): xArch 2023, LNCE 343, pp. 25–33, 2024.
https://doi.org/10.1007/978-981-97-0621-1_4

therefore modified to meet new parameters and constraints imposed by the suggested 3d Moiré Animation technique [3]. It is to be noted that Moiré abstract patterns and effects, produced by superimposing two “gratings”, are considered by the authors a separate study set and a different category from Moiré Animations, which produce legible movement of specific images. A flock of flying birds and a performer’s walking figure are examined for the purpose of this study.

Since 2D Moiré Animation is based on a limited amount of frames (usually 4–6), improved technical design, careful selection and preparation of suitable subjects are required to ensure legibility and flow of the animation [4]. Such process requires constant revisiting and visual evaluation of the outcome involving laborious and time consuming workflow through which the designer needs to slice and recompose each frame of the animation. Additionally, variations of the width of the grid can affect parameters like speed and legibility of the animation [5].

3D Moiré Animations on the other hand, are guided by the properties of perspective projection [6] since it is the spectator who moves rather than the two surfaces. The setup becomes even more complex as new parameters affecting the results are added, such as:

- The grating material thickness (e.g. a 10 mm thickness offers a different reading than 3 mm)
- The spacing of the two layers (e.g. 50 mm offers a different reading than 40 mm)
- The spectators speed and
- The spectators viewpoint

To address the aforementioned space parameter, the design team opted for developing a set of computational tools to assist the design workflow. The tools under the name ZEBRA enabled the exploration of a large number of design options and the visual optimization of the selected results through numerous legibility assessment iterations. The above tools were directly associated with digital fabrication techniques which became an integral part of the workflow. Within the above framework, the research expands upon the findings of two realized case studies and the computational tools developed as part of their design workflow. The juxtaposition of the two case studies presents an evolution in animation complexity and verifies the validity of the tools in facilitating design, simulation and construction of large scale prototypes. The research and projects presented depart from existing work in the field [2, 4, 7] as they present applications of the technique in fundamentally different context and viewing conditions than any of their predecessors. It is further proposed that 3D Moiré Animation could potentially have applications in other fields, such as architecture [6], depending on what the commissioning authority intends to achieve.

Drawing from examples like the “Inogon Naval Lights” [8], it is suggested that the outcomes may exhibit applied uses such as signage for wayfinding, traffic calming methods or even destination art in public spaces. The technique could therefore be useful in applications requiring low maintenance or affordable and sustainable alternatives enabling large scale animation effects.

2 Methodology and ZEBRA Computational Toolset

This paper expands upon the definition of 3D Moiré Animation as analogue and low maintenance large-scale legible animations on physical structures which are composed by spacing the grating and the composite image on a static apparatus [3]. The effect is therefore generated by the movement of the spectator, while the structure remains static as opposed to 2D Moiré where all the layers are required to move in different directions. ZEBRA was developed to assist the above workflow by automating the steps associated with the procedure. The following chapter presents the stages of the process along with the computational tools developed during each phase.

2.1 2D Moiré Animation

The Moiré effect is a well-known phenomenon which occurs when repetitive structures (such as screens, grids or gratings) are superposed or viewed against each other. It consists of a new pattern of alternating dark and bright areas which is clearly observed at the superposition although it does not appear in any of the original structures [9].

In the case of 2D Moiré Animation, the goal is to produce movement/animation for specific images when a layer of specific grid lines or gratings interacts with a previously sliced image, joining those patterns into legible movement. The width of those lines depends on the desired resolution of the animation, the number of frames and even the viewing speed which is generated by the user. (see Fig. 1).

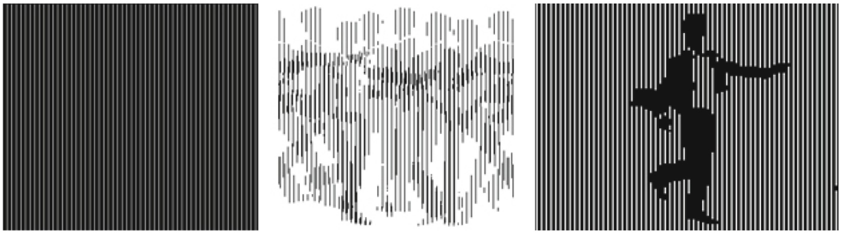

Fig. 1. 2D Moiré Animation by Rufus Batler Seder.

The ZEBRA tool is developed as a user cluster in Grasshopper 3D and consists of a number of components that automatically produce the two constituent parts of a 2D Moiré Animation (a grating and an interlaced image). Additional utilities enable the visualization of the animation. ZEBRA operates by reducing each frame of an original animation into vertical strips, and later combining them into one composite image. The grating is then produced based on the number of animation frames and the user desired resolution/speed. The toolset accepts Closed Curves as input and any number of frames is permitted [3].

In contrast to the traditional black-on-white-background layout (see Fig. 1.) of the technique, ZEBRA also offers the option of inverting the composition colours. The operation improves legibility at large distances especially when the background is artificially lit. (see Fig. 2).

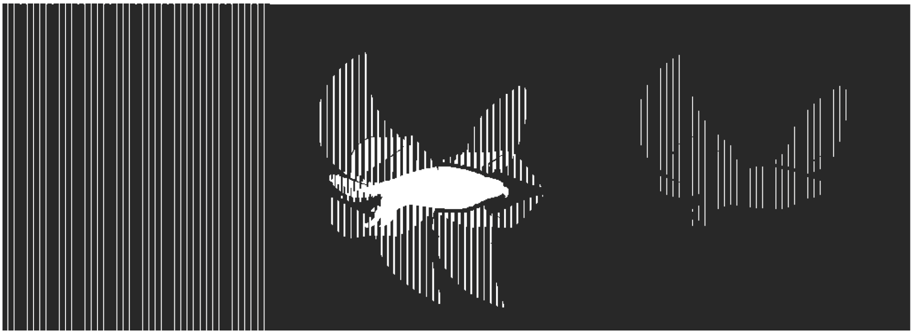

Fig. 2. Inverted Transparent Mask layer (Grating), Composite image and Result

Finally the user is able to visually examine the legibility and flow of the animation using the 2D Animator component which translates the grating horizontally over the interlaced image, revealing one frame at a time, and therefore enabling the animation effect.

2.2 3D Moiré Animation

3D Moiré capabilities were incorporated into ZEBRA by the formation of a set of components which synthesize the grating and the interlaced image into a 3D Apparatus based on two parameters defined by the user; material thickness and layers' spacing (see Fig. 3). Visually examining the results of the animation at this stage pre-supposes additional user input to define the spectator's path (distance to apparatus) and speed.

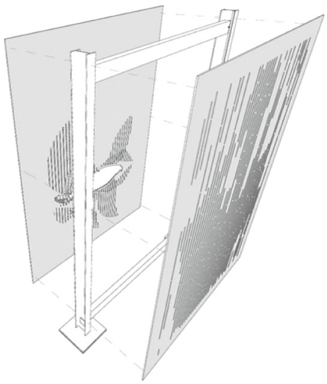

Fig. 3. Exploded view of a 3DMoiré Apparatus

To assess legibility of 3D Moiré Animations, the impact of the combination of all 2D and 3D Moiré parameters had to be investigated. The difficulties of assessing all possible iterations with realistic visual outputs lead to establishing a parametric raytracing framework able to produce analytic results. The framework was formulated using Grasshopper 3D plugin in Rhino 3D with iterative loops using the Anemone plugin and Microsoft Excel integration using GHowl plugin. Custom coded C# components were also used in conjunction to the above.

Data recording and graph plotting would yield useful findings on the connection between frame visibility and frame transition overlap. Comparing graphs and metrics enabled the research team to assign a legibility rating to each design option, assuming constant viewer speed and distance from the grating layer (see Fig. 4). Despite the fact that the raytracing analysis was conducted for the purposes of the case studies, such functionality is not yet part of ZEBRA toolset. Future work aims at incorporating a legibility rating component.

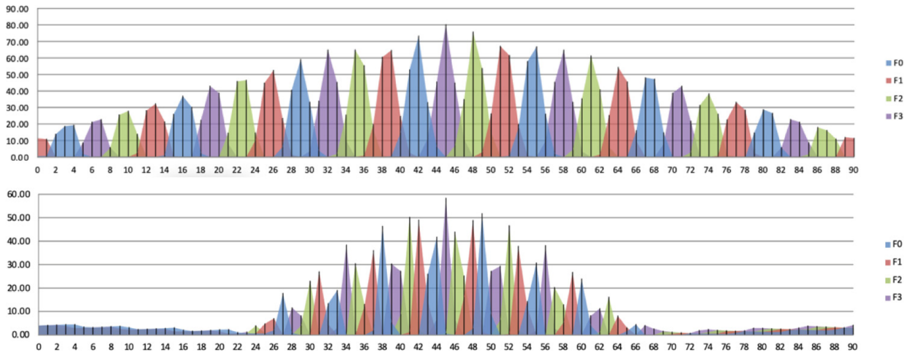

Fig. 4. Comparison of raytracing data graph to determine the best version in terms of animation legibility. Graph Above: 35 m distance/10 mm slits. Graph Bottom: 10m distance/10 mm slits

2.3 Digital Fabrication

Mainstream Digital Fabrication techniques (Laser-Cutting) were used in both projects to fabricate the grating and the composite image. Especially the complexity of the latter would render it extremely difficult to be realized using other means or methods. Due to the slenderness and height of the slits, the grating layer had to be structurally enhanced with horizontal connections to avoid weakening and swaying of the surface and therefore distortion of the animated image. A random horizontal connection pattern which would not interfere with the animation was computationally calculated and produced. Furthermore, the same algorithm enabled random reduction of slits to save on fabrication time while producing visually interesting and non-repetitive grating panels. This functionality is not yet included in ZEBRA toolset. Future work aims at incorporating a fabrication utility component.

3 Prototypes

This chapter expands on two realized case studies the juxtaposition of which illustrates an evolution in animation complexity and verifies the validity of the tools in facilitating design, simulation and construction of large scale prototypes.

3.1 Mari Memorial

The memorial is a private commission by the community of Mari in Larnaca, Cyprus to commemorate the 13 people fallen in a military accident, an explosion which left a large crater on the ground at the nearby Naval Base on 11th July 2011. Construction work was completed in 2017. The project is defined by two interrelated elements with symbolic references; a path/wall and a cavity/crater.

The path is framing the cavity forming the base of a weathered steel wall. The wall runs along the exterior edge of the pathway. This vertical steel element comprises 13 incrementing distinct steles (see Fig. 5). The steles act as individual 3D Moiré Animation apparatuses which are then perceived as an ever flying flock of birds. The effect is designed to be visible from the road while driving a vehicle.

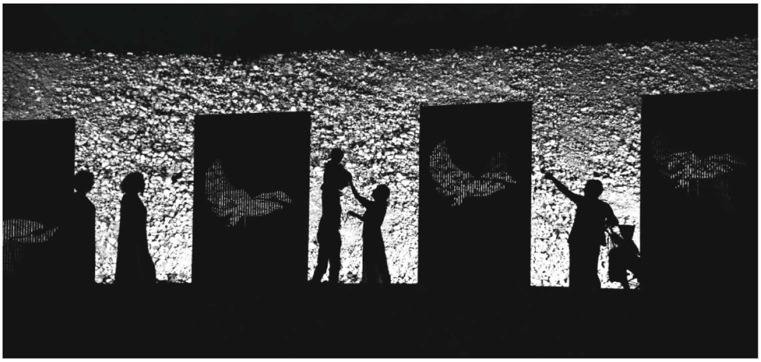

Fig. 5. Mari Memorial Steles (Photographer: C. Solomou)

3.2 Ripples

"Ripples", was a temporary installation commissioned by the 15th Nea Kinisi Dance Festival, organized by the Cyprus New Movement Dance Groups, Dancers and Choreographers. The interactive installation was designed with the purpose of attracting and engaging passers-by through animating a dancing figure. It comprises 12 individual panels forming a seamless horizontal surface, supported on a metal structure, which hosts the 3D Moiré Animation effect (see Fig. 6). The animation is visible from close proximity and was designed to engage pedestrians, skaters, cyclists etc. The project was on public display for two weeks during the Limassol Dance and Documentary Festivals in July 2018.

3.3 Comparison of Case Studies

The goal when designing Ripples was to achieve a continuous animation as opposed to individual animations on each panel of the Mari Memorial. Departing from distinct animations which is the predominant paradigm of traditional 2D Moiré animations became

Fig. 6. Ripples Installation (Photographer: P.Vrionides)

a challenge for the design team. The task was directly related to the arrangement and number of frames involved. Mari Memorial was composed using only 4 overlaid frames which created the movement of each individual bird in a repetitive loop. Ripples on the other hand, used 6 frames per loop organized in 11 groups resulting in a composition of 66 distinct frames forming a procession (see Fig. 7). In contrast to Mari Memorial, each animated loop was not constrained to a single panel, but certain frames would be shared between adjacent panels. While in Mari Memorial each frame was designed, in the case of Ripples the requirement was to produce the 12m animation by recording the actual movement of a real life performer. The recording process defined the scale of the installation. As a result, two sessions of sequential photos of the performer were taken from the same spot resulting in a long animation strip. At the end of the first half of the distance the performer "jumped" out of the frame and "landed" in the next section to conceal discontinuities in the animation and to avoid distortion of the images. The photo stills were taken with the use of a green screen and stripped from their background to produce the figures of the animation frames. It was decided to select 66 key frames to achieve a smooth animation flow.

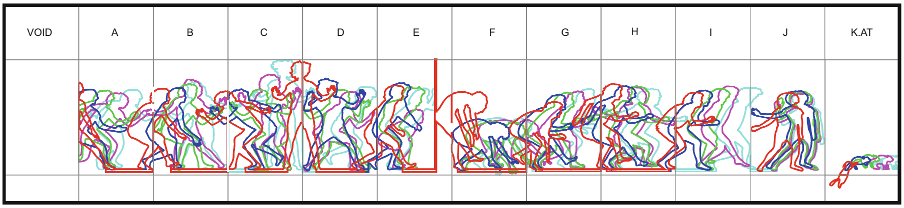

Fig. 7. Ripples Installation, key frames

Regarding the spectator, Ripples was designed to engage people with arbitrary paths rather than moving motor vehicles with predictable route and speed. Adaptation to the viewer path resulted in different layouts for the two projects. Mari Memorial is arranged along a curved path parallel to the road, whereas for Ripples the choice was a linear arrangement of panels parallel to the boundaries of the location and based on observations and assumptions for pedestrian movement across the site.

Legibility of the animation effect relied, among other factors, on a high contrast between the grating and the recomposed image. In Mari Memorial this was achieved using a uniform natural light-coloured background (white gravel), as opposed to the darker tone of the steles, which is artificially lit during the night to achieve the requested contrast. In the case of the Ripples installation and due to the absence of background uniformity, a semi-transparent layer (white polyester sheet) was stretched at the back of the installation surface and artificially lit during the night to enable the effect. The transparency of the background allowed visibility of the animation during daytime.

4 Conclusion

This paper expands upon the definition of 3D Moiré Animations [3] and illustrates through two realised case-studies that the process enables built-environment applications offering low maintenance and affordable alternatives to current technologies enabling large-scale animation effects. Furthermore, the juxtaposition of the two consecutive case studies illustrates an evolution in animation complexity and verifies the validity of the tools in assessing legibility of the animation effect while facilitating design, simulation and construction of large-scale prototypes.

In parallel, ZEBRA computational toolset is described. The plugin aims to facilitate the design, simulation and evaluation of 2D and 3D Moiré Animations for the built environment. The framework is assembled in Grasshopper 3d with the use of custom scripts written in C# programming language and most of its clusters are currently available as parts of ZEBRA. The plugin was set-up to interactively generate the constituent parts of 2D and 3D Moiré Animations while enabling the visualisation of the animation results. Future work aims at incorporating the 3D Moiré Animation legibility rating component and digital fabrication utility components in ZEBRA toolset.

Acknowledgement. Mari Memorial was funded by the Community Council of Mari, Larnaca, Cyprus and supported by the Committee of the Relatives of the victims of the Mari explosion. We thank Theresa Kwok, Stavros Voskaris, Christos Xenofondos and Maria Ioannou for their assistance during the design and construction phases of the project.

Ripples was funded by the 15th Nea Kinisi Dance Festival, and supported by SEAMLEXITY, the Multimedia and Graphic Arts Department of the Cyprus University of Technology and the Architecture Department of the University of Nicosia. We thank the performer Eleana Alexandrou and the volunteers Christina Christoforou, Natalie Moiseenkova, Rasha Zeneddin, Panagiotis Hadjioannou, Valentinos Charalambides, Stephani Milikouri, Costantina Yiannapi, Periklis Georgiou, Emilio Moraris and Maria Efthimiou for their assistance during the design and construction phases of the project.

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