ZEBRA | COMPUTING MOIRE ANIMATIONS

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This paper documents the development and application of a set of computational tools under the name ZEBRA to support and facilitate the design, simulation and realization of two and three-dimensional moiré animation installation. Additionally to traditional two-dimensional moiré animations, the authors implemented the above tools to examine a novel approach which combines the depth of field and motion of the spectator to achieve a large-scale, analogue animation effect in three dimensions. The tools were established to aid the design of an interactive sculptural installation for a memorial in Cyprus which was completed in March 2017. ZEBRA is currently in beta testing and will be launched as a plugin for Grasshopper 3D in the near future.

Keywords: *Moire, Animation, Raytracing*

INTRODUCTION

This paper documents the development and application of a set of computational tools under the name ZEBRA to support and facilitate the design, simulation and realization of two and three-dimensional moiré animation installation (Figure 1). The tools aim at automating the processes and verifying the legibly of the results of analog animation produced by the interaction of two superimposed layers; a grating (a transparent screen with evenly spaced strips) and a composite image formed by parts of the frames in the animation. The technique is based on masking all, but one, frames of the animation at a time, using the grating layer. The 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 (Sperling, 1966). The method is encountered in literature as Moire Animation, Barrier Grid Animation, Picket-fence Animation, Kinegram, Magic Moving Images, or Scanimation.

Since the above technique is proposed to be utilized in a built environment context, the 2d Moiré Animation method is therefore modified to meet new constraints and parameters imposed by the suggested 3d Moiré Animation technique. The computational tools presented in this paper were developed as part of the design workflow to address the difficulties of assessing the legibility of the animation effect implemented in the case study project. Since the technique is based on the utilization of a limited amount of low resolution frames (usually 4-6), a frequent visual evaluation of a large number of iterations was necessary to ensure the legibility and flow of the animation. The actual slicing and recomposing of frames presents a laborious and time consuming process that would otherwise hinder the exploration of a large number of design options or the optimization of the selected designs. Furthermore, variations of the width of the grating slit can affect the animation results in terms of speed and legibility. The investigation becomes even more complex when 3D

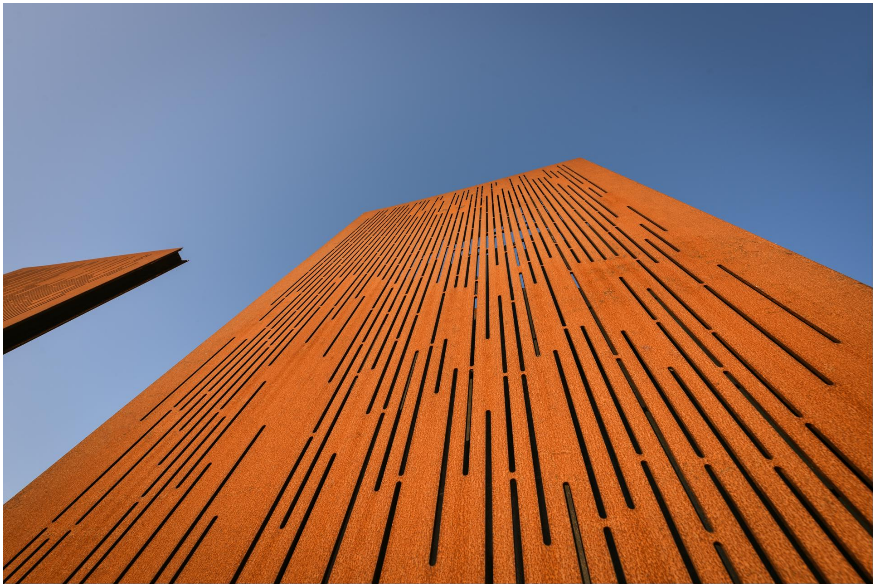


Figure 1
Memorial Stele Grating Close Up View (Photographer, C. Solomou)

moire animation parameters are added as the material thickness and spacing of the two layers can both affect the outcome. As a result, the research team opted for developing a set of tools to facilitate the design process and asses the design results.

LITERATURE REVIEW - EXISTING WORK AND HISTORICAL BACKGROUND

In this part the framework within which the study is carried out is presented. The collection of precedents discussed is limited only to those exhibiting animation characteristics. Projects involving the utilization of Moiré Patterns and Effects are deemed relevant, but are purposely excluded as they are considered by the authors as a separate study set.

Variations and adaptations of the Moiré Animation technique can be traced throughout history as early as the end of the 18th century when the 'artificial fireworks' devices presented the illusion of movement by employing a dynamic patterning produced by moving a lined screen in juxtaposition to a perforated picture. Moiré Animation is also present in the 1898 Motograph Moving Picture Book which featured engravings of objects brought to life when an acetate transparency with a fine line pattern was moved slowly over the pictures (Herbert, n.d.). The technique is also evident in a series of postcards marketed under Alexander S. Spiegel's patent as Magic moving pictures by G. Felsenthal & Co and as Magic moving picture card by the Franklin Postcard Company. Similar cards have been published in Japan around 1920 as Cinematograph by SK and in France around 1940 as Mon cinema chez moi (Barrier grid animation and stereography, 2017). The Ombro Cinema toys, popular in 1920s France, also present a very relevant example. Operated by an analogue clockwork mechanism, the interlaced image (a paper roll) is moved behind a grating to produce an animation. According to Rufus Butler Seder after the 1920s it appears, that the progress of Moiré Animation technology comes to a recession, supplanted by the advent of conventional motion pictures, lenticular plastic imaging, holography and video (Herbert, n.d.).

Moiré Animation attracts new attention, over

Figure 2
Memorial Steles View during Night (Photographer . C. Solomou)

the last decade through a series of children books mainly by Colin Ord and Rufus Butler Seder (Shan and Chung, 2016) which according to Christine Chiou offer predominantly visual stimulation for aesthetic purposes, showing animations of running animals or rotating gears (Chiou, 2016). In addition, the quite recent example of The "Magic Carp-pet", designed by Johnii (John Leung) for ClarkeHopkinsClarke Architects in 2010, presents a unique 3D Moiré Animation instance which shares common characteristics with the project under study (Leung, 2010).

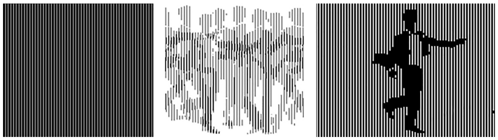


Figure 3
Dancing man scanimation illustrations by Rufus Batler Seder. (Heeza L'Univers du Cartoon, 2017)

The above examples can be categorized in three groups based on the apparatus-viewer interaction. The first and most populated category is the translation of the grating to produce the animation. Artificial Fireworks, Motograph, Magic Moving Pictures and recent Scanimation books, toys and gifts belong to this category. In the second group, the grating is kept static and the motion is transferred to the interlaced image. The most notable example of this category is the Ombro Cinema Toy. The third category involves no movement in any of the two layers but relies on the spectator to produce the animation. Such an apparatus requires the two layers to be spaced apart to enable interaction with the viewer. The "Magic Carp-pet", as well as the memorial presented in this paper belong to this category which is defined in this paper as 3D Moiré Animation. This last category seems to be facilitating scaling-up of the Moiré Animation due to the absence of moving parts on the apparatus. The notion is also supported by a few existing examples that utilize this third type of interaction with Moire Patterns in architecture (Brzezicki, 2011). In addition and based on the findings of this paper, 3D Moiré Animation operates on additional and more complex parameters than 2D Moiré Animation. The above, could partly explain why just a single example ("Magic Carp-pet") escaped the 2D

Animation technique and the scale of handheld objects.

As such the project presented, differentiates from previous examples as it attempts to apply the technique at a much larger scale and in a fundamentally different context and viewing conditions than any of its predecessors.

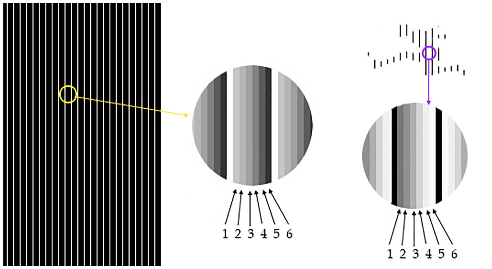


Figure 4 Relationship between frame vertical slits and transparent mask, Illustrations by David Phillips, Barrier-Grid (Or Picket-Fence) Animation, 2012

Further to that, it is suggested that 3D Moiré Animations could potentially have additional applications. Animated Signage for wayfinding or commercial purposes for example could be a domain where the method and proposed tools could be applied offering low maintenance and affordable alternatives to current technologies enabling large scale animation effects.


Figure 5 Moire Animation Frames

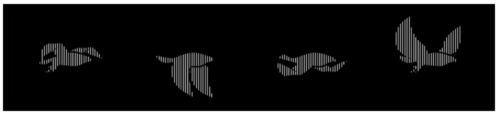


Figure 6 Moire Animation sequence

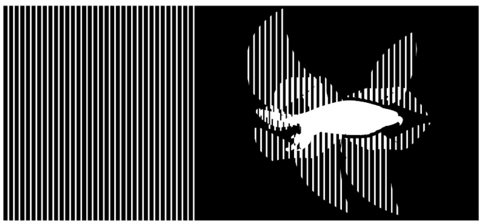


Figure 7 Composite image with Transparent Mask layer (Grating)

METHODOLOGY AND COMPUTATIONAL TOOLS DEVELOPMENT

This paper defines and investigates 3D Moiré Animation as the generation of a legible, large scale analogue animation on physical structures, having the grating and the composite image spaced apart and static (Figure 2). The animation effect is consequently generated by the motion of the spectator. As already mentioned, the technique, encompasses the parameters used in classic 2D Moiré Animations but also proposes a series of new ones that outline the perception of the animation. ZEBRA has been developed to assist the above workflow by automating the majority of the operations involved in the process. The design team was therefore able to examine a large number of alternatives and verify their performance/legibility before moving to construction. This chapter presents the stages of the process along with the ZEBRA tools developed along each phase.

2D MOIRE ANIMATION PARAMETERS

According to Shan and Chung (2016) there are four key parameters affecting legibility in 2D Moire Animation (Scanimation), the number of frames used, the image physical dimensions, width of the transparent slit and the width of the grating strips. The animation is achieved by reducing each frame of the original compilation into vertical strips (slits), later combined together into a composite scattered looking image. The dimensions of the slits depend on the desired resolution of the animation and number of frames. A striped mask layer is then imposed on top of the scattered composition which reveals a frame at a time, and thus when translated horizontally enables the animation effect.

The composition of the vertical strips containing the frames needs to occur sequentially, in order for the animation to be legible. As shown in figure 4 below, an animation consisting of n frames, would have distance between the slits comprising the same frame. The masking layer, would also have the same gap for the animation to work. Each frame is shifted by a horizontal unit in order not have an overlay.

Figure 8
The 3DMoire parameter space

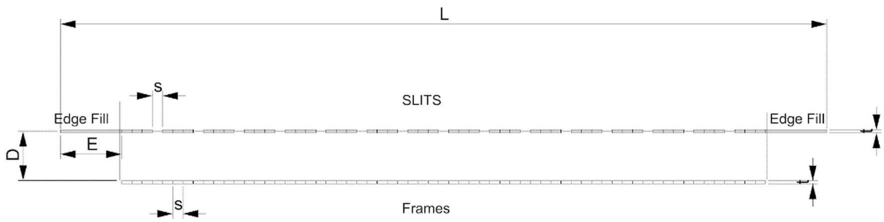
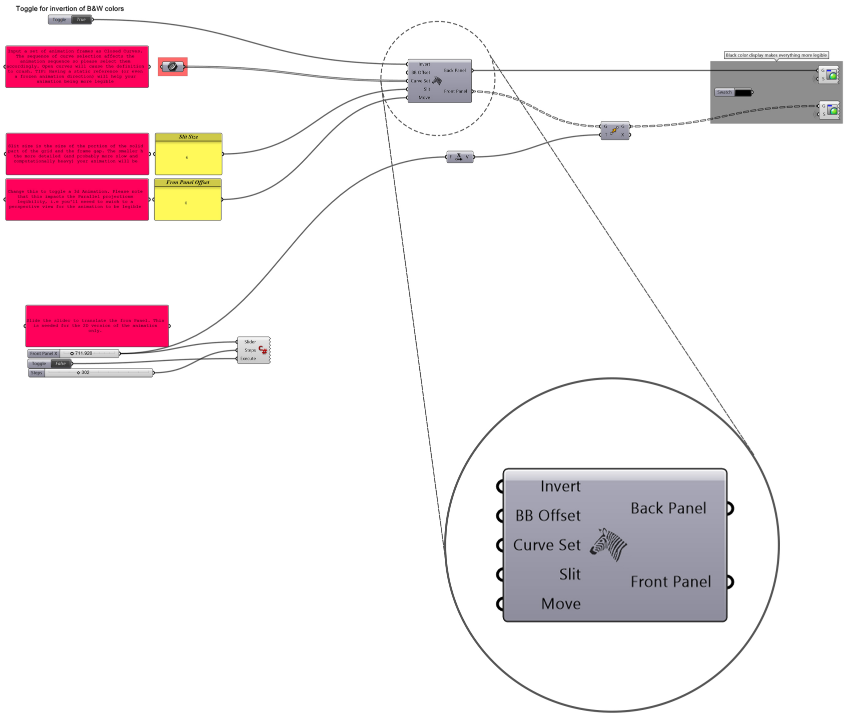


Figure 9
The frameworks grasshopper Definition



As illustrated in figure 5 below, the frames need to be abstracted to a solid silhouette, reinforcing Rufus notion that legibility of the animation depends on the meaning and technical interpretation of the images utilised. In addition, keeping parts of the frames intact, allows for improved perception of the illusion (Phillips, 2012).

X = (N-1)SLITWIDTH (1)

ZEBRA 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 moire animation (the grating and the interlaced image), by importing a set of predefined frames. Additional utilities enable the visualization of the animation. The plugin operates by reducing each imported frame of the original animation into vertical strips (slits), and later combines them together into a composite scattered looking image. The grating, a striped mask layer is then produced based on the number of imported animation frames and the user desired resolution/speed. Finally the user is able to visually examine the results of the animation using the 2D Animator component which translates the grating horizontally over the interlaced image, revealing a frame at a time, and therefore enabling the animation effect.

The tools are set to accept Closed Curves as input, following the animation frames' sequence. Any number of frames is accepted and their bounding boxes are automatically divided into slits based on the desirable resolution set by the user.

Differentiating from the typical black-on-white-background layout of the technique, ZEBRA has the option to invert the Black & White colours, which work in a contrasting manner in relation to the transparent grid. The contrast between the two would improve legibility at large distances. When figure 3 is compared with figures 6 and 7, it is evident that the solid illustration revealed on the first image is substituted with a stripped one on the latter case. The stripped result is clearly generated by the inversion of the frame colours.

The 2D animation slider component was assembled using an addon compiled by David Rutten which allows for a controlled viewing motion at desired speeds.

3D MOIRE ANIMATION PARAMETERS

A three-dimensional perception of the problem would mainly depend on the perspective view through the grating onto the frames layer. The animation setup becomes more complex at this stage, and involves examining the influence of the distance between the two layers, the thickness of the layers, the path (distance) and moving speed of the spectator (Figure 8).

3D Moiré capabilities are incorporated into ZEBRA by the creation of a set of components which combined the grating and the interlaced image into a 3D Apparatus based on two parameters defined by the user; material thickness and layers spacing (Figure 9). Visually examining the results of the animation at this stage pre-supposes additional user input to define the spectator's path (distance) and moving speed. These parts are analysed and explained in the raytracing investigation presented in Figure 10.

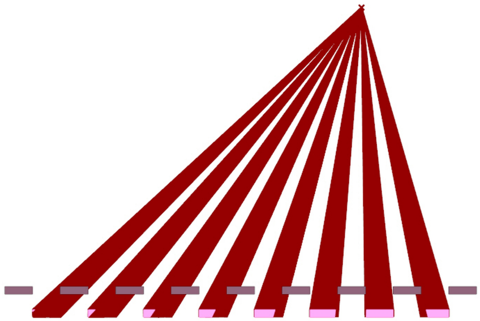


Figure 10
Raytracing visualisation (Grasshopper 3D)

Raytracing Investigation and Legibility Rating

Since the legibility of the 3D animation depended on perspective aspects rather than pure translation between the two layers, the impact of the combination of all 2D and 3D Moire 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 Sharp components were also used in conjunction to the above.

The frames of the animation were illustrated with distinctive colours repeated with the desired pattern. A ray producing source would be placed along the spectator path, casting rays towards the grating, having a layer structure shown above. At each given step increment along the path the algorithm traced the rays which passed through the grating and were projected onto the frames (Figure 8 & 10). Those rays would signify the visible portions of each frame at any given instance on the path.

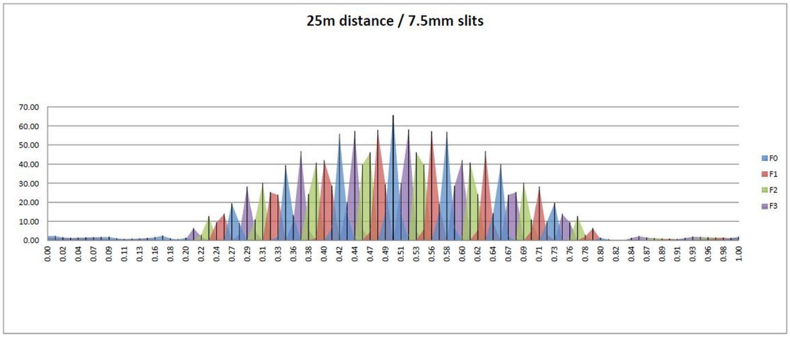


Figure 11
Raytracing visualisation with a 4 frame animation

Figure 12
Overall Memorial View (Photographer, C.Solomou)

Recording and plotting the generated data in graphs (Figure 11) would yield important findings on the relation on the frame visibility and frame transition overlap of the animation. Comparing Graphs and their characteristics enabled the designing team to rate the animation legibility for each design option assuming a constant spectator speed and distance from each grating.

Even though the raytracing investigation was carried out for the purposes of the case study, such functionality is not currently included in the ZEBRA tool set. Future work aims at incorporating a legibility rating component for different 3D Moire apparatus setups.

CONCLUSION

The paper proposes a sub-categorisation of Moire Animations into 2D Moire Animations and 3D Moire Animations. It is suggested that the latter facilitates scaling-up and thus enabling built-environment applications offering low maintenance and affordable alternatives to current technologies enabling large-scale animation effects. (Figures 12)

In parallel, ZEBRA computational toolset is introduced. 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 Sharp 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 Moire Animations while enabling the visualisation of the animation results.

Work currently under development involves the compilation of the raytracing components into modules and their incorporation into ZEBRA. This will enable a legibility rating for 3D Moire Animation Setups generated through an analytical process.

ACKNOWLEDGEMENT

The project was supported by the Community Council of Mari, Larnaca, Cyprus and 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.

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