

DigitalPinDirector: a digital pinscreen editor for images and realtime animation in low cost personal computers

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Abstract: *This paper presents the main characteristics of the traditional Pinscreen, the way it works, its problems and results achieved. The first Digital Pinscreen system is presented, along with its main characteristics and limitations. The rest of the paper describes and presents the DigitalPinDirector: a system that enables a full and true creative access to the unique visual and animation characteristics of the Pinscreen.*

Palabras clave: Pinscreen; Digital Pinscreen; Computer Animation; NPR; Chiaroscuro

Introduction

The traditional Pinscreen is an image creation and animation technique created and patented in 1932 by Alexander Alexeieff and Claire Parker (Alexeieff, 1932) whose visual results are similar to “animated engravings”: images and films with appealing poetic visuals, with non-sharp outlines, reproducing the Mezzo-Tinta, *chiaroscuro* visual effect of engravings in motion. Although results have appealed to directors and artists, the complexity of the construction of the Pinscreen and its difficult manipulation and time consuming use, with low levels of productivity, makes it a rare technique despite the interest manifested by the artistic community (McLaren, 1972).

Between 1989 and 1995, a computer simulation model for a Digital Pinscreen (Lopes, 1992, 31–42) was created, enabling results impossible to achieve with the traditional Pinscreen, followed by the creation of the digital Pin Editor (Lopes, 1995), targeting artistic use and solving the productivity problem. Cost limitations of the development environment, Silicon Graphics workstations based, prevented the spread of the Digital Pinscreen.

Advances in technology, particularly in low cost personal computers (PC), made it possible to simulate the traditional Pinscreen on a PC, without the need for high-end hardware. The DigitalPinDirector is a complete system for producing and directing Digital Pinscreen images and animations in the Microsoft Windows environment, expanding the interaction methods, creating new interactive mechanisms for animations, and integrating the production and directing tasks of a project in a single environment.

The Traditional Pinscreen

The Pinscreen device is composed by a white surface evenly perforated by thousands of small holes occupied by metal black headless pins, 0.5 mm in diameter, whose level of salience from the surface can be adjusted. Existing Pinscreens, depending on the size, are composed from 80,000 to one million pins. The one used by Jacques Drouin at the National Film Board of Canada (NFBC), is composed by 240 thousand pins (Drouin, 1976).

The device is lit by an oblique light source that creates the shadows of the pins on the white surface. When the

pins are not protruding (their heights are zero), they will cast no shadow, so the result is a white image. When the pins are fully protruding (at maximum heights) the pins' shadows overlap covering the entire surface, thus producing a black tonality. Gradually decreasing the heights of the pins will allow some light to pass between the pins and reach the white surface, this results in a shade of grey. Adjusting the height of groups of pins it is possible to control the amount of light that reaches the surface, creating different shades of grey.

Creating images is achieved by manipulating the heights of groups/regions of pins with several objects (bulbs, spoons, forks) or specifically developed manipulators (McLaren, 1972) (Lopes, 1999).

Usually, when working on a Pinscreen, the starting point is a black image, all pins protruding: pushing the pins from the front creates lighter shades of grey; pushing the pins from the back creates darker greys. The animation is done by incremental changes on a complete image, photographing the image, then creating a new image from the previous one, photographing the new image again until the sequence is completed and captured in sequence in film, frame by frame. In this process, an error made in one frame may implicate redoing the complete sequence. On the 240 thousand pins Pinscreen the animator is able to work in the front and easily reach the back for corrections. This is the way Jacques Drouin works. With the big Pinscreens this is not possible and either it is mounted on a vertical axis to enable rotation, or there is a second person in the back helping manipulating the pins. The first film created with the Pinscreen, "*Une Nuit sur le Mont Chauve*" (Alexeieff, 1933) has an image and animation poetic quality not matched by any other animation technique and it was very well received by critics and the artistic community. It is 8 minute long and took 3 years to complete, due to the complex process of the Pinscreen. Mainly due to the severe productivity constraints, the Pinscreen did not become an everyday used animation technique. Fig. 1. shows Alexander Alexeieff and Claire Parker working on the 240 thousand Pinscreen at the NFBC.

Alexeieff-Parker Pinscreen Vs. Ward Fleming Pinscreen
The Ward Fleming Pinscreen (WFP) was created in 1976 (Fleming, 2011) and has great similarities with the original Alexeieff-Parker Pinscreen (APP), but the results achieved are very different. In the APP, the images are formed by the shadows casted on the visible white surface while in the WFP the images are formed by the

density of the adjacent shiny chromed nails with no surface visible between them. On the APP the density of the pins is very high, resulting in engraving like images, while on the WFP the density of the pins is low, producing coarse images. The pins in the APP present friction in order to enable fine height control and grey generation, while the WFP pins move freely. The APP pins are made very thin (0.5 mm diameter), black and pointy on both ends in order to be almost invisible in the frame, only the casted shadows create the images, in the WFP they are very visible and there are no casted shadows.



Fig. 1. Working on the 240 thousand pins Pinscreen (1972).

The Digital Pinscreen

The Digital Pinscreen was developed between 1989 and 1995 by Pedro Faria Lopes (Lopes, 1995) and allowed to simulate the traditional Pinscreen with gains both in ease of use and productivity. Although it is possible to simulate the Pinscreen using computer graphics 3D primitives, this approach is not suitable for realtime manipulation of the pins. On a Pinscreen, it is the shadows of the pins that create the image and not the pins themselves. This means that there is no need to visually represent the pins, but only the shadows they cast. Furthermore, the shadow can be simplified as a rectangle with a length proportional to the height of the pin and rotated in conformity with the light source. This means that the shadow of a pin has two properties: length and orientation (Lopes 1995).

As for the light source, assuming the light is very far from the surface (parallel rays), moving it around in a tridimensional space only has repercussions in a two-dimensional plane: it only changes the length and/or orientation of the shadows of the pins, making it easier

to change directly the shadows instead of the light source. By defining a maximum shadow vector (MSV) as the length and orientation of the shadow, a pin would cast it if its height was maximum; other pin heights would have the same orientation of the MSV and its length would be proportional to the length of the MVS. Representing the shadows as rectangles and controlling the MSV, allow a fundamental shift in the way the Pinscreen image synthesis can be accomplished: visually, it is possible to work only in 2D instead of 3D, which will result in very high gains in terms of visualization, interaction and ultimately, in efficiency that will allow processing of hundreds of thousands of pins in realtime.

In animation, in the digital Pinscreen it is possible to go back to a previous image and change it, which is impossible in the traditional Pinscreen.

The computer simulation also allows automation: given any two images (keyframes), it is possible to automatically generate the intermediary images (inbetweens, virtual frames) by interpolation of the pin's heights, creating an animation.

DigitalPinDirector

The DigitalPinDirector was developed for Windows operating systems using the C programming language and OpenGL. The system requirements are easily met by most of today's computers: Windows XP, Vista or 7 as operating system, at least 1GB of RAM and at least a 2 GHz processor.

The software is composed by four modules: image production and edition, animation, import/export and GUI (Graphical User Interface). All these modules are built over a data structure that consists of a base entity, called *screen*, that stores the heights of the pins (height matrix), the MSV and the duration of the interpolation that connects this *screen* to the next (if any). Another entity called *animation* encapsulates several *screens* and the properties shared by all *screens* as pin resolution, space between pins and pin width.

Image production and edition

The image production and edition module applies the image synthesis algorithms in order to translate the pins' heights into accurate visual information. The module must draw, when necessary, the shadows on the screen, whether it's a keyframe or a virtual frame and, in case there's input from the user, mirror it on the height matrix or MSV.

The image synthesis algorithm doesn't take into account the particularities of a digital environment: the representation of a continuous space (the surface of a Pinscreen) in a discrete space (the screen of a computer). In order to minimize this transition into a discrete space, antialiasing techniques present in the OpenGL library were used.

Input can occur in two ways: directly, when the user uses the mouse cursor to change the heights of the pins, and indirectly, when the user uses a command such as setting all heights to zero. There are four tools available to interact directly with the Pinscreen: brush, eraser, clone and height picker. The brush allows decreasing the distance between the heights of a set of pins and a preset value. This means that the height of the pin will increase or decrease according to whether it is greater or smaller than the preset value.

The eraser increases or decreases the heights of a set of pins (pushes or pulls the pins) as the user clicks with the right or left mouse button.

The clone tool allows copying an area of the screen to another area. After selecting the clone tool, the user clicks on the starting point of the area to be cloned, then clicks and drags the mouse where he wants the area to be copied.

The height picker tool can be used to retrieve the height of a pin on the screen or to manually input a value. This value can then be used as the preset value of the brush tool.

It is important to mention that in the traditional Pinscreen one cannot drag a tool along the screen, the gesture of drawing, or else the metal pins would bend or break. "Drawing" on the traditional Pinscreen is done by pressing against a set of pins, then adjusting the position of the tool and pressing again, and so on. The DigitalPinDirector allows dragging the tool on the screen so the drawing process is natural. It is also possible to create new shapes for the brush and eraser, and save them on an external file that can be loaded into the editor. Fig. 2 shows a sample of an image created in the DigitalPinDirector.

Animation with the DigitalPinDirector

There are two ways to create animations with the DigitalPinDirector: frame by frame and interpolation. Both types can be used in the same animation.

Frame by frame animation is done by creating an image and, then, by creating a series of images obtained by incrementally changing the previous image. This is how animations are done in the traditional Pinscreen. On the DigitalPinDirector, this is done easily by duplicating the

current image and placing it right after the original image on the timeline to be edited. The process can then be repeated until the animation is done. It is also possible to go back to any frame and change it, delete it or duplicate it. Besides frame by frame animation, it is also possible to create an interpolation of heights of the pins and/or MSV. To do this, the user must create two frames: a start image and an end image. Then he chooses how many frames the interpolation should have. These new frames are called virtual frames and no information is stored about them: the necessary information is calculated in realtime by reading the values of the start and end images when the virtual frame needs to be drawn. This implies that, first, the virtual frames cannot be edited and, second, changes to either the start or end image are reflected in realtime on the virtual frames, the animation. It is also possible to convert a virtual frame into a keyframe. The practical effect is creating a keyframe between the start and end frames and creating two interpolations: one from the start frame to the new frame and another from the new frame to the end frame.

The DigitalPinDirector also allows previewing the animation, which is impossible to do in the traditional pinscreen. At any time, the user can chose to play back the animation from the start or from the current frame at 25 fps. By previewing the animation, the user can go back and correct it in an easy, fast and direct way.



Fig. 2. Image created with the DigitalPinDirector.

Import/Export and GUI

The import/export module allows converting an image in digital format to a keyframe by converting each pixel of the image into the height of a pin. The resulting ke-

yframe is editable and can also be used as start or end image of an interpolation.

It is possible to export one frame or the entire animation as MS Bitmap file sequence, enabling postprocessing with any video editing software.

It is also possible to import a conventional video and render it as Pinscreen, or use it to create animation.

The GUI Module is divided into four areas: Menu, Screen, Info and Tools. The Screen area shows the visual representation of the pinscreen, the Info shows some information about the current session, the Tools area gives access to the most commonly used features during a session and shows the timeline, where the user can see the distribution of the keyframes (and virtual frames, if any) in the animation, and the Menu area contains all the features used more sporadically.

Conclusion

The DigitalPinDirector addresses the main problems in the traditional Pinscreen – the complexity of the creative process and the limited access – by offering a fully integrated environment for creating Digital Pinscreen images and animations, and creating new innovative forms of interaction and results, with a simple workflow, while the results maintain the poetic visual appeal of the traditional Pinscreen, this time in realtime.

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