Research on the Production Method of Three-Dimensional Image Scanimation

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Abstract The quantity of image frames, the widths of transparent slits, and the black bars on the scanline are the three basic elements of scanimation. Besides, the size of scanimation, the color and contrast of scanimation, and the brightness of scanline, etc, can also influence the optical illusion of scanimation. Based on the recent principle of production of 2D scanimation, and through asking questions, and making corresponding experiment, this research finally gets to the conclusion. Based on the principle of production of 3D scanimation, and through various basic testing, this paper aims to verify how to bring out the best visual effects (optical illusion) of animated illusion scanimation in publications by using the 3D animation in the publications. And the future goal is to study and flexibly use Z-axis space in the scanimation.

Key Words : Scanimation, Three-dimensional animation, Optical illusion, Quantity of image frames, Scanline

Received 17 October 2016, Revised 25 November 2016 Accepted 20 December 2016, Published 28 December 2016
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ISSN: 1738-1916

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1. Introduction

1.1 Objectives and Background of the Research

With the continuous development and progress of science and technology, art and design also show a rapid development. From the human’s expressing their ideas through original simple graphics to the recent various computer graphics (CG) works, the content design is now used almost everywhere, in such fields as graphs, two-dimensional designs, animation, three-dimensional movie, virtual reality (VR), and so on. Art design shows itself in more and more different forms[1].

In the late 1650s, Dutch mathematician Christiaan Huygens, invented ‘The Magic Lantern’, and opened the door to animation[2]. ‘The Magic Lantern’ was the first equipment of animation, uses visual illusion and optical illusion to achieve the animation of images. Over time, thaumatrope, phenakistoscope, zoetrope, praxinoscope, stroboscope and scanimation were invented. All of them are forms of visual illusion animation. Among them, as an easily-made art form, scanimation can show a variety of visual effects by simple stripe displacement. This kind of animation technique is hundreds of years old and known under several names: picket fence animation, barrier grid animation, Moiré animation, kinegrams, to name a few. Recently, it found some attention through books such as “Magic Moving Images: Animated optical illusions” by Colin Ord or the”Gallop!: A Scanimation Picture Book”, “Swing!: A Scanimation Picture Book”, “Waddle!: A Scanimation Picture Book” series by Rufus Butler Seder[3]. Based on the principle of production of scanimation, and through various basic testing, this paper aims to verify how to bring out the best visual effects of animated illusion scanimation in publications by using the three-dimensional animation in the published content since it could make the delicate yet boring books come alive and display interesting visual effects by using simple visual illusion[1].

1.2 Range of the Research

The research methods of this paper are as follows: First, replace the original 2D plane animation with a 3D one, analyzing and classifying the basic elements which might have an influence on the final visual effect of scanimation according to the principles of plane scanimation[1]. Then test and compare the visual effect of the final rendering by changing the elements one by one. Finally sum up the results and analyze the influence of the change of each element, bringing out the best visual effect of 3D illusion animation scanimation.

Although the entire test involved in this thesis are supposed to be shown in a dynamic way, the author could only show it with static pictures due to the limitation of the thesis form. All the dynamic graphics animation involved in this paper are contained in the corresponding QR code attached below for your reference.

2. Theoretical Background

2.1 The Concept of Scanimate

The term scanimation is derived from ‘scanimate’, an analog computer animation (video synthesizer) system developed from the late 1960s to the early 1980s[4]. This kind of animation technique is known under several names: picket fence animation, barrier grid animation, Moiré animation, kinegrams, to name a few. Scanimation is a combination of ‘scan’ and ‘animation’. It is an animation technique where one can create the illusion of motion on plain paper[5].

2.2 The Characteristics of Scanimation

Scanimation is a kind of analog computer animation,
which is a kind of linear motion using the principle of stripe’s “persistence of vision”. The characteristic of scanimation is that it consists of two static pictures. They overlap and generate dynamic visual effect[6,7]. It is a plane animation of fixed movement cycle.

2.3 The Principles of Scanimation

Three-dimensional (3D) scanimation involves two layers, a background 3D image, usually a simple animation silhouette; and a scanline, which is a transparent sheet with evenly spaced black bars on it. To make the background 3D image, it is necessary to dissect the original animation into simple animation’s image frames, process them and superimpose them into a synthesized image.

On a scanline, the transparent portions are the transparent slits, and the black portions are the black bars. In one scanline, all transparent slits have the same width, and the width of every black bar is equal.

The synthesized image appears blurry or jagged, but when the transparent sheet is placed on top of the image and the sheet is moved horizontally across the 3D background image, the 3D image begins to animate. This animation uses visual illusion.

3D Scanimation’s basic formula is[4]:
The width of the transparent slit (1-unit amount) + The width of the black bar = Image frame quantity

2.3.1 The Components of Scanimation

According to the scanimation’s basic formula, it can be drawn that the basic components of scanimation are the width of the transparent slit, the width of the black bar and animation’s image frame quantity.

2.3.2 The Production Principle of Background Image Unit

Taking the dynamic graphs of English letter “Welcome” as an example, we extract the four phases of the letters change animation design and get four image frames as below [Fig. 1]. Firstly, we lay these 4 image frames in an overlap way, dividing them into many parts with equidistant line and marking them with red, yellow, green shades respectively, as the following [Fig. 2](left) shows.

![Fig. 1] 4 image frames of animation

![Fig. 2] The makes of same color and the makes of red

![Fig. 3] Remove other colors and parts background image

Let us take the dynamic graphical design of the first phase as example. If we superimpose this picture on the image with the equidistant lines, we can get [Fig. 2](right). When we remove the yellow, blue and green parts, we get [Fig. 3](left). In a similar way, we gain the images of the other three phases. At last, we put these four synthetic images in an overlapping pattern and now we have [Fig. 2](right), which is the background image.
2.3.3 The Production Principle of Scanline

Appeared in the previous section a picture of equidistance line, as shown in [Fig. 2](left). We randomly choose one of the colorful parts and make it transparent and cover the other three parts with black shade. For example, we turn the red part into transparent state and cover the other three parts with black shade and get [Fig. 4](left), the final scanline. In the scanline, the black part is stripe, and the transparent part is crack. At the same time, complying with the basic principle formula mentioned above, the sum of the stripe width (3) and the crack width (1) is equal to the number of animation frames (4), when the gap width default is classified as one unit.

![Fig. 4](https://example.com/fig4.png) The scanline of scanimation and the QR code

Put the scanline image on the background image, and move scanline image horizontally from left to right, then the static background image will change and move, which is called scanimation. (Scanning the QR code in [Fig. 4] for more information.)

3. Methods

Based on the recent principle of production of scanimation, and through asking questions, and making corresponding experiment, this research finally gets to the conclusion.

3.1 Problems of the Research

1) What influence the final visual effect in scanimation?
2) What effect will these factors have on scanimation?
3) Generally, the more image frames one animation have, the more continuous it will be. Is it the same when it comes to background image frames and scanimation?
4) What range of the background image frame quantity can lead to the best visual effect?
5) How to make the scanimation present the best effect?

3.2 Selection of the Variables and Invariants

There are four key elements in scanimation, the image frame quantity, background image size, the width of the transparent slit, and scanline size, we change one of them while remaining the other unchanged as we test the specific effect of a certain element during the whole experiment.

4. Results and Discussion

4.1 Image Frame Quantity Test

In general, the more animated image frames the animation has, the more smooth and natural looking it has. For example, to animate the transition from a circle to a square, if an animation uses only a picture of the circle and a picture of the square, it can only show the two transition states. If the animation also uses pictures showing the transition states of the two shapes, it will show how a circle gradually becomes a square in a continuous fashion. Whether it is a common animation such as walking, jumping, flying, or the transformations of different image, increasing the image frame quantity will improve the quality of animation.

The quantity of image frames is also one of the important factors affecting the quality of scanimation. If it is similar to the general animation, the more image frame numbers, the better effects will scanimation show? In the existing papers, it shows that if the image...
frame numbers in scanimation becomes 6, it will show the best effect. So, do all the image frame numbers in scanimation need to become 6? The purpose of our experiment is to find out whether or not image frame quantity affects scanimation the same way as simple animation. To prove the above idea, the following two tests are made.

We used the same set of 3D animation images in our experiment. We varied the number of image frames while keeping the animation image size constant (the animation image size is 436 * 330 pixels and resolution is 96 pixels/inch; the original animation used the character from others and the number of image frame is 8). We extracted 1 /2 /4 /6 /8 frames from this animation to form the ‘new’ animation, as shown in <Table 1>. Image frame quantity Test uses the same set of images to create scanimation, by varying the number of image frames.

| Quantity | Image Frame |
|----------|-------------|
| 1        | ![Image Frame 1] |
| 2        | ![Image Frame 2] |
| 4        | ![Image Frame 4] |
| 6        | ![Image Frame 6] |
| 8        | ![Image Frame 8] |

4.1.1 The Same Clearance Area Test

When the width of transparent slit on the scanline becomes 1 pixel in scanline image, according to 3D scanimation's basic formula, more image frame quantity can lead to wider black bar on the scanline, as shown in <Table 2>. And scanning the QR code in <Table 2>, we can get the corresponding scanimation image when image frame quantities are 1 frame /2 frame /4 frame /6 frame /8 frame, respectively.

| Image Frame | 1 | 2 | 4 | 6 | 8 |
|-------------|---|---|---|---|---|
| Scanimation image | ![Scanimation image] |
| Background image (5*magnification) | ![Background image 5] |
| Scanimation image (5*magnification) | ![Scanimation image 5] |
| QR code | ![QR code] |

4.1.2 The Same Line Set Test

When the total width of the transparent slit and the black bar in the scanline image is maintained constant (the sum is 6 pixels), by changing the image frame quantity, the corresponding change can be shown on the final scanline both the transparent slit and the black bar width. By scanning the QR code in <Table 3>, we can see the final effect of the corresponding scanimation image when image frame quantities are 2 frame /4 frame /6 frame, respectively.

According to the above two test, we can see that, as the number of images increases, the quality of general animation improves. In this test, the number of animation image frames is 8, and the animation visual effect is natural and smooth. In scanimation, when the width of the transparent slits is constant, the width of the black bars increases linearly with the number of image frames. As the width of the black bars on the scanline increases, a larger portion of the original background image will be blocked, and eventually the original animation cannot be seen clearly. In our experiment, when the number of images is 8, too much
of the background image is blocked by the black bars for the animation to be seen clearly; when the number of images is 4, the animation appears to be unnatural due to the small number of image frames in the background image. To ensure the continuity of the original animation, when the animation image frames quantity is 6, the scanimation visual effect is most ideal[1,8].

4.2 Size Test

In the above Chapters, a great number of tests are used to prove the influence on scanimation when we take the animation image frame quantity as a variable. Then, when the image frame quantity is taken as a constant value, what other factors will influence the visual effect of scanimation?

4.2.1 The Different Transparent Slit Size Test

Keeping the image frame quantity and the background images size same (the 3D animation image size is 1000 * 750 pixels and resolution is 96 pixels/inch; the original animation is the rotation upper case letter “T” and the animation image frame quantities are 6), when the width of scanline image is different, the final effect of scanimation will be different, as shown in <Table 4>. By scanning the QR code in <Table 4>, the effect images in the condition that the width of transparent slit in scanline image is 1 pixel / 2 pixels / 3 pixels / 4 pixels / 5 pixels/ 6 pixels, respectively will be shown.

4.2.2 The Different Background Images Size Test

By combining the above article content, we can see when taking an appropriate number of transparent slits of the scanline image, more image frame quantity will lead to wider corresponding scanline stripes. That is to say, the more we cover the background image, the less information we can obtain from it. Especially when the background image is in the form of graph too much covered parts will lead to deformation of the image. Then, if we keep the other variable unchanged and expand the background image, will the problem be solved?

According to the test, it is found that, in the condition of keeping an appropriate transparent slit size, when the image frame quantity is larger, unlimited expansion of background image size can make obscured parts become narrow and dense correspondingly, and we also can see a clear scanimation. But, when the scanimation is applied in the books (normally less than
A4 size), oversized background image size will not be able to be printed.

5. Conclusion

Our experiment studied the production method of three-dimensional image scanimation. The results of the experiments conducted in this study will assist further research on the illusion of motion in the three-dimensional image scanimation. The future goal is to study and flexibly use X-axis space in the scanimation.

REFERENCES

[1] Xinyi Shan, “The Impact of Image Frame Quantity on the Quality of Three-Dimensional Scanimation”, The International Association of Culture Contents, pp.58–59, 2016.

[2] http://www.luikerwaal.com/newframe_uk.htm?huygens_uk.htm

[3] http://animbar.mnim.org/

[4] B. S. Shim, “Effect of Scanimation, Based on Line Interference”, Korean Society of Basic Design & Art, Vol.15 No.1, pp.267–277, 2014.

[5] H. Cho, Y. Cho, B. S. Choi, S. J. Jeon, “A Study of the Motion Direction Preference of Using the Principles of Scanimation”, Korean Society of Basic Design & Art, Vol.16 No.1, pp.617–627, 2015.

[6] http://scanimationbooks.com/about-scanimation/

[7] Liu Jichang, Yang Fang, “The Moving Book”, The North Literature and Art Publishing House, 2012.

[8] http://thinkzone.wlonk.com/Kinegram/Kinegram.htm

[9] Mi Ra Heo, Sook Young Jeong, “A Study of Nail Art Applying Optical Illusion Effect”, Korean Beauty Society, Vol.16 No.1, pp.8–16, 2013.

[10] DongHyuk Yang, SooKyun Kim, “The Design of 2D Side-Scrolling Casual Games in a Multi-platform Environment”, Korea Convergence Society, Vol.6 No.4, pp.147–152, 2015.

[11] SeongHoon Lee, DongWoo Lee, “On Issue and Outlook of Wearable Computer Based on Technology in Convergence”, Korea Convergence Society, Vol.6 No.3, pp.73–78, 2015.

[12] SungDong Kim, JongKun Lee, “Efficient Customer Reception Policy with QR Code”, Convergence Society for SMB, Vol.2 No.1, pp.1–9, 2012.

[13] Kok Choong Lai, M.L.Dennis Wong, Syed Zahidul Islam, “HW/SW Co-design of a Visual Driver Drowsiness Detection System”, Convergence Society for SMB, Vol.3 No.1, pp.31–41, 2013.

[14] Moon Young Lee, Jean Hun Chung, “A Study on the Technique of Producing Stereoscopic Image for 3D Animation”, The Treatise on the Plastic Media, Vol.11 No.4, pp.85–92, 2008.

[15] Seder, Rufus Butler, Schulz, Charles M, “Peanuts: a Scanimation Book”, New York: Workman, 2014.