

Development of Motion Image Printer

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Abstract

We developed a new motion image printer, which can print 6 images directly on the back of lenticular lens sheet using a thermal head. Motion picture can be seen as viewer's head movement. The printer system consists of a video camera, a personal computer, and the developed printer. We also developed a software which selects 6 images automatically from image sequences shot by users.

Introduction

We developed a new motion image printer of heat sublimate recording system which can print six images on the back of a lenticular lens sheet, allowing the individual images to be seen separately depending on the viewing angle. From a moving picture taken by a video camera, six images can be selected and printed on the lenticular sheet, so that a moving picture can be enjoyed spuriously by varying the sheet angle. The basic principle is same as in printing of solid image on a lenticular sheet. In the solid image, images for the right eye and left eye corresponding to the both eyes are printed in stripes in the vertical direction. By contrast, in the developed motion image printer, a same image is seen by the both eyes, and images are printed in stripe in the lateral direction so that different images may be seen depending on the viewing angle. This paper first reports the recording mechanism and head driving system of the motion image printer for realizing a high picture quality with less crosstalk between images. It is followed by the description of the system configuration for taking and printing a moving image by using the developed motion image printer. Finally, effective images for this motion image printer are demonstrated.

Recording Principle

Recording Mechanism

According to the new motion image printer, six images are divided into strips, recombined, and are directly recorded on the back of a lenticular lens, so that a spurious moving picture can be observed from the front side of the lens.

The recording mechanism of the developed motion image printer is shown in Figure 1. A flat platen is used to realize high precision of position in recording. The lenticular lens is arranged so that the lens longitudinal direction may be orthogonal to the thermal head, and the lens pitch of the lenticular sheet corresponds to the heating element pitch of the thermal head. In this state, by pressing the positioning side of the lenticular sheet to a defining plate by a pressing plate, the lens longitudinal direction of the lenticular sheet can be held parallel to the feed direction of platen.

Such mechanism has realized high position precision recording on the lenticular sheet. However, due to manufacturing error of lenticular sheet or thermal expansion or contraction of the lenticular sheet by temperature changes during recording, when the lens pitch is deviated from the setting, the recording position may be deviated. Accordingly, this printer is provided with a mechanism for heating and keeping the lenticular sheet at a desired temperature. It intentionally induces thermal expansion on the lenticular sheet, and deviation of the lens pitch from the set point is corrected.

The outline of specification of the developed printer is as follows.

Thermal head: 300 DPI end face type
Lenticular sheet: Vinyl chloride
Lens pitch: 100 DPI
Lenticular sheet thickness: 1.1 mm
Ink sheet: Y, M, C, Y, M, C, white layer

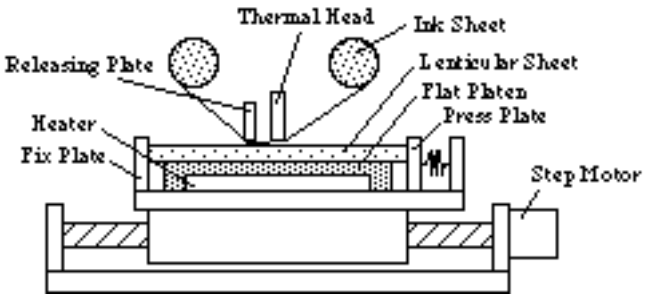

Figure 1. A schematic drawing of Motion Image Printer

High Resolution Recording Method

In this printer, using the 300 DPI end face type thermal head, six images are recorded on the lenticular sheet (lens pitch 100 DPI). Accordingly, by double scanning (writing twice), high resolution recording of 600 DPI is realized. Steps of high resolution recording are shown below.

[Step 1]
Of a spurious moving picture composed of six images, the first, third and fifth images are printed.

[Step 2]
The lenticular sheet is moved relatively by 1/2 of the heating element pitch with respect to the thermal head.

[Step 3]
Finally, the second, fourth and sixth images are printed.

Driving Method of Thermal Head

In recording of spurious moving picture of high quality, different images are recorded by the adjacent heating elements of the thermal head, and hence reduction of crosstalk between images is important. Accordingly, as the driving method of thermal head, the zigzag lattice layout for driving the adjacent heating elements alternately has been studied.

By one scanning, recording 300 DPI in square lattice layout and zigzag lattice layout, recorded pixels were observed and compared by microphotograph. As a result, in the zigzag lattice layout, pixels were more separate than in the square lattice layout, and it was found effective for reducing the crosstalk. Moreover, in zigzag lattice layout, since relatively uniform gaps can be formed among pixels, and 600 DPI recording by double scanning is possible.

Motion Image Printer System

System Configuration

A system configuration is shown in Figure 2. After obtaining a motion image consisting of M frames in the image input unit (A), six images to be printed by the motion image printer are selected out of M frames in the image selecting unit (B). In the result display unit (C), six images are displayed sequentially, and the motion of selected images is confirmed. The six confirmed images are combined into one image in the image combining unit (D) to be printed by the motion image printer, and it is transferred to the motion image printer, and the combined image is printed on the lenticular sheet.

Image Selecting Method

As the image to be printed by the motion image printer, as described in the next section relating to the image studies, images containing periodic action are effective. Hence, a method for automatically selecting images for one period out of motion images containing periodic action was studied. In this case, however, the motion images should satisfy the following conditions.

The background image is still.

The object is a single piece, making reciprocal motions.

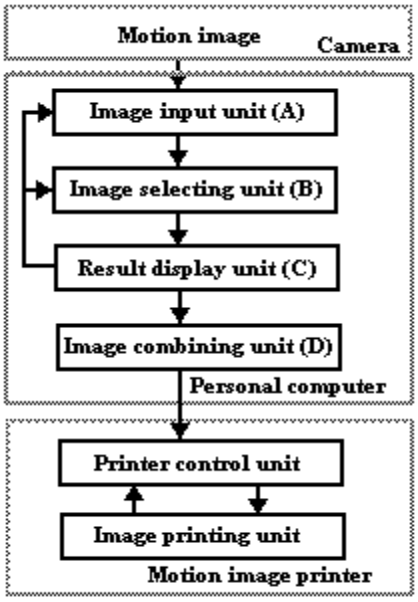

Figure 2. Construction of motion image printer system

As a simple method, a method of sampling the time at equal intervals may be considered, but it is impossible to detect if changing from forward direction to reverse direction while the object is making reciprocal motions, and the sampling intervals are fixed if the moving speed of the object varies, and the motion of the selected image is unnatural. In this system, therefore, a technique of detecting the moving area of image and selecting images in one period adaptively on the basis of the moving area has been developed.

Steps of the developed image selecting method are given below.

[Step 1]
An image I(f) (f: frame number) of M frames is processed by LPF, and a down-sampled image S(f) is prepared.

[Step 2]
A differential value between frames of image S(f) is calculated, and the region of which differential value is over the threshold value This is detected as moving area. The rate of the moving area of the entire image is defined as R(f) [%]. The rate R(f) of frame number f is shown in Figure 3.

[Step 3]
The minimum value of R(f) is calculated.

[Step 4]
The longest section between minimum values is detected, and the integral value Z(fe) of the moving areas at the start point fs and end point fe of the section is calculated.

[Step 5]
From the integral value Z(fe) up to the end point, nZ(fe)/5 (n = 0 to 5) is calculated, and the integral value Z(f) up to frame f having the closest value to the calculated value is determined, and I(f) at this time is the selected image.

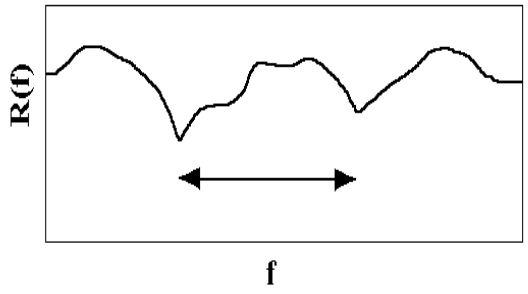

Figure 3. Detected moving area

Study on Image

Only six images can be recorded on the lenticular sheet, and the shooting technique and image making rule different from the video image consisting of 30 frames per second are needed. Accordingly, an effective image suited to motion image printer was analyzed from three aspects, that is, combination of changing attributes of individual elements for composing the image (formal aspect), meaning of the entire image or individual constituent elements for the user (context aspect), and characteristic of reproducing medium as card (medium characteristic aspect).

Analysis from Formal Aspect

When an image is decomposed into individual constituent elements, we have the background (B), main object (O), sub-object (S), and viewpoint (V). Possible attribute changes of elements B, O, S, and V are shown in Figure 4. As for S, same attribute change as in O is present, but since the role is to render and decorate the motion of O, there is no smaller classification. Actually, there are various images by combining them, and such combination seems to produce the synergistic effect of canceling effect as the image effect. Hence, images were created by combining attribute changes of B, O, S, and V shown in Figure 4, and the image effects were evaluated.

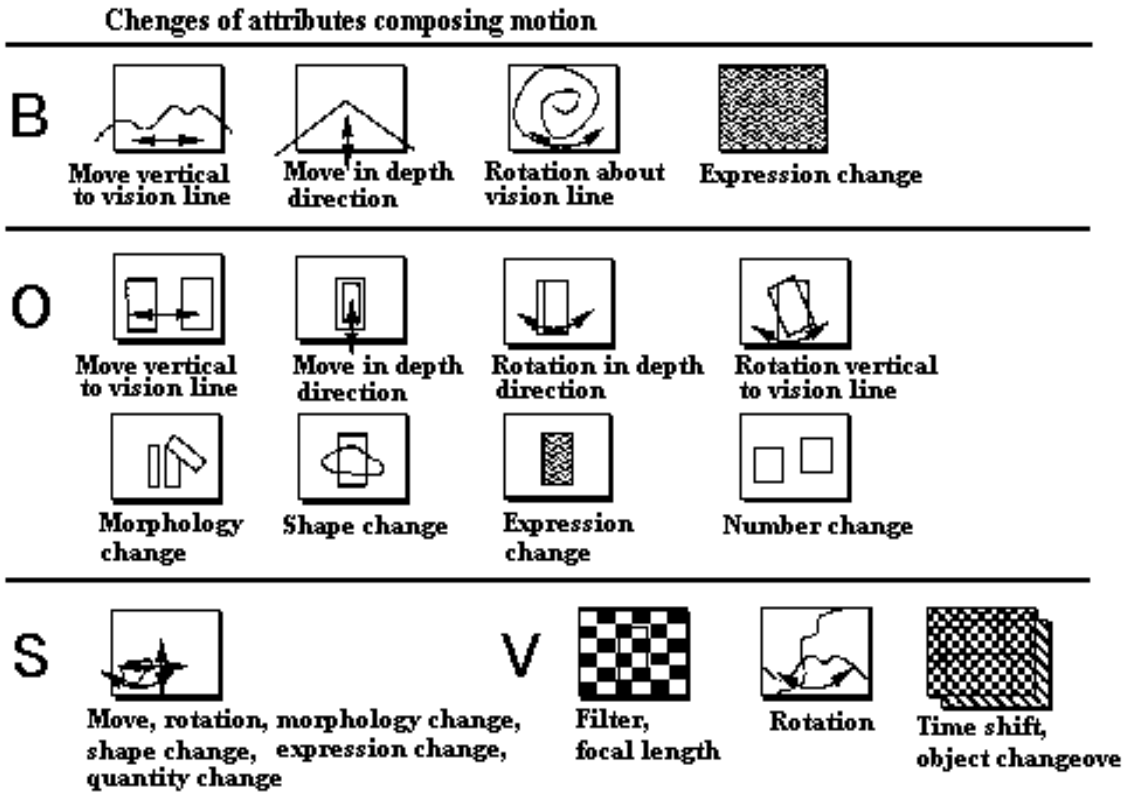

Figure 4. Changing of attribute

As a result of evaluation, it was found effective to use the change of a certain constituent member as a motif, and combine changes of others in order to emphasize this motif, rather than moving all of B, O, S and V. By combination, it was found that (1) the effect of emphasizing the lapse of time, (2) the effect of emphasizing the motion, and (3) the effect of emphasizing the configuration were obtained.

Analysis from Context Aspect

As a major factor for determining the effect of the meaning of the image, we must consider the sentiment of the viewer about the image. However, the sentiment mainly depends on the personality of the viewer, and it is hard to evaluate. On the other hand, to emphasize the meaning of the image, it seems effective to combine the natural image with the CG image. Hence, by combining the natural image and CG image, the effect of the CG image on the meaning of the natural image was evaluated.

As a result of evaluation, by expressing the surprise or fun explicitly by the CG image, the CG image was effective for amplifying the sentiment on the natural image, non-realistic world or changes can be expressed by combining the CG image and natural image, and the effect of giving the sentiment of surprise or funniness was brought about.

Analysis from Medium Characteristic Aspect

The reproducing medium printed on a card shaped lenticular sheet is to held by the observer by hand and rotated to enjoy the moving image spuriously, and the card itself does not have the time axis for reproducing the moving picture. Accordingly, the observer can create the time axis at will, and hence the reproduction by the card has a different effect from the actual time change of the image (Figure 5). In four playback patterns in Figure 5, the image motions and changes were combined, and the image effect was evaluated.

As a result of evaluation, playback patterns P1 and P4 were not related with the image motion or change, playback pattern P2 was effective in the reversible image motion, not becoming non-routine motion, if played in the reverse direction, and playback pattern P3 was effective in the image having periodic motion and change.

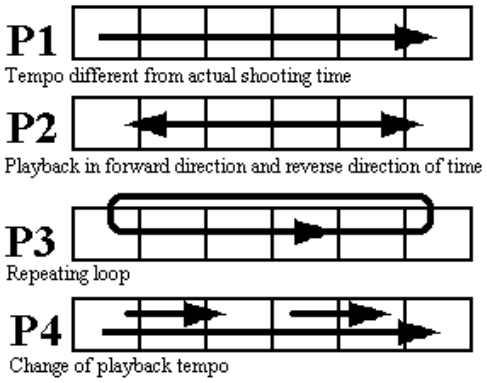

Figure 5. Playback pattern

Conclusions

This report relates to the motion image printer capable of observing spurious motion image by directly printing six images on the lenticular sheet, specifically describing the recording mechanism for realizing high picture quality, head driving method, image selecting method for realizing automation of shooting, and the image suited to motion image printer.

The developed motion image printer is excellent in promptness in printing and processability of image, and wide applications are expected. Henceforth, by increasing the number of images that can be printed, we are endeavoring to realize a print card capable of observing more smooth moving pictures, and shorten the printing time.