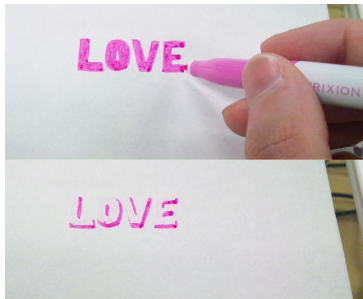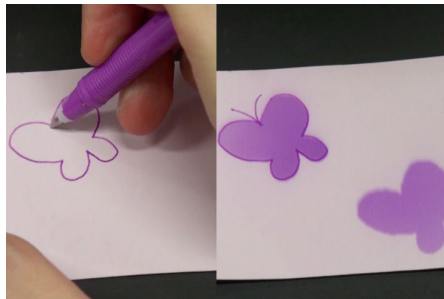# Hand-rewriting: Automatic Rewriting like Natural Handwriting

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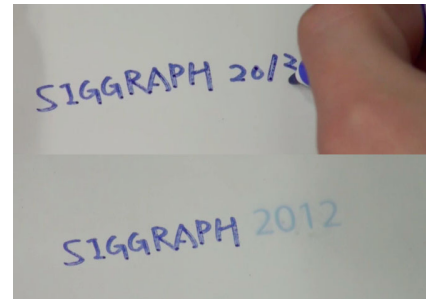Takeshi Naemura
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Fig.1: Decorating characters by erasing effect

Fig.2:Automatic painting by color-forming effect

Fig.3:Automatic correction by combination of both effect

1. Introduction

Approaches for combining handwriting acts and control by computer are gaining force. As two types of general classifications of these approaches, the "pen tablet" and the "digital pen" are often cited. As for the former approach, in addition to being able to display handwritten information, it can display drawing effects and additional information related to that information. Data output by this approach, however, can only be handled by digital-type displays. As for the latter approach, although written information acquired as paper input can be digitized, it is not possible to express additional information as output on paper (i.e., a paper display). In contrast to those two approaches, the system proposed by the authors—called "Hand-rewriting"—automatically performs "rewrite" processing on paper in correspondence with handwriting using pen and paper. More specifically, with the proposed system, when the user writes on a piece of paper with a pen, for example, the information written on the paper is automatically erased as required, and additional information is displayed on the paper in natural print-like colors.

2. Hand-rewriting

The "Hand-rewriting" system combines two technical innovations. The first one is a function that automatically erases specific areas of the paper, without the need to use an eraser, when the user writes letters or draws pictures on the paper. Local erasure on the paper in this manner can express letters and pictures written in thermochromic ink by means of thermal conversion by laser heating. As a thermochromic ink pen, a commercial pen ("FRIXION," Pilot Pen Co., Ltd.) with 24 colors (including black, blue, purple, and pink) is used. This pen can erase the color of written letters (i.e., make them colorless and transparent) by means of frictional heat generated by rubbing with a special rubber. In detail, local colors are erased by irradiating a black film coated on the underside of the paper with laser light from a galvanometer scanner controlled by a captured image. When it hits the film, the light is converted to heat, and when the temperature reaches about$140°$ F, colors of local areas are erased. The galvanometer scanner can control a laser beam to a distance of 0.068 mm (in the case of letter-size paper).

The second innovation is a function that can repeatedly display additional related information on the paper in color when the user writes letters or sketches pictures on the paper. The local colors on the paper are created by projecting an ultraviolet (UV) pattern from a UV projector onto paper coated with photochromic material (PM). As the PM, "spiropyran" (which produces color under UV light and returns gradually to colorless and transparent when the UV light is blocked) is used. In detail, four types of PM were used: blue, purple, pink, and yellow purchased from KIROKUSOZAI Co., Ltd. Each PM requires a different time for producing and loosing its respective color. For the projecting the UV pattern, a UV projector fitted with a "digital micromirror" (which can illuminate in units of pixels) and an invisible (i.e., 365-nm wavelength) light source is used [Hashida et al., 2011].

Applying the above-described control technologies, three types of interactive applications of the Hand-rewriting system have been developed. The first application is focused on controlling erasure of colors. For example, as shown in Fig. 1, when the user writes something by hand in the Roman alphabet, this application automatically erases parts of the characters, and the effect is to transform the letters into ornamental writing. The second application is controlling generation of colors. As shown in Figure 2, when the user sketches something by hand, this application automatically colors the interior of the outline sketch, and the effect is to replicate the sketch itself in the manner of a stamp. The third application utilizes controlling generation and erasure of colors at the same time. When the user makes a mistake while writing something, this application automatically erases the incorrect part and displays a guide giving the correct entry in color. Using these applications, the user could enjoy performing various creative activities on the paper by freely using both kinds of control (i.e., generation and erasure of colors).

3.Concluding remarks

A system by which a computer performs "automatic rewrite processing" on paper—by means of temperature control and ultraviolet-light control—in correspondence with handwriting using a pen and paper was developed. From now onwards, it is planned to experimentally investigate the possibility of linking this system with other electronic pen devices.

References

HASHIDA, T., KAKEHI, Y., AND NAEMURA, T. 2011. Photochromic Sculpture: Volumetric Color-forming Pixels, *In Proceedings of SIGGRAPH2011 Emerging Technologies*