Robotype: Studies of Kinetic Typography by Robot Display for Expressing Letters, Time and Movement

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ABSTRACT

Humans use letters, which are two-dimensional static symbols, for communication. Writing these letters requires body movement as well as spending a certain amount of time; therefore, it can be demonstrated that a letter is a trajectory of movement and time. Based on this notion, the author conducted studies regarding multidimensional kinetic typography, primarily using robots to display a letter and visualize its time and movement simultaneously. This paper describes the project background and design of the three types of robotic displays that were developed and discusses possible expressions using robotic displays.

Humans invented words to communicate with each other and letters to record these words. Owing to letters, humans have been able to communicate beyond the present into the future. The durability of paper is substantially longer than a human life span, and thus letters written on paper can be retained almost indefinitely. Although the written letters themselves do not move, humans require moving their body and spending time to create them.

The movement and time spent by the writer are usually apparent in the brush or pen stroke of the letter. The shading, blurring and density of ink demonstrate the behavior and movement of the writer over time; one can deduce the writer's emotion or thought. Thus, our letters are not only two-dimensional symbols that convey messages, but also involve the time and movements that humans devote toward communication.

The time and movement observed in handwriting have not been regarded as important for letterpress printing and computer monitors that have appeared more recently. However, could it be possible to obtain a display technology for letters that coexists with time and movement beyond the two-dimensional plane? With the development of such a technology, we could determine implications beyond those of the words themselves. Based on this notion, we explored a new form of typography. We began by developing a multi-dimensional display for kinetic typography, primarily using robot technology and the illusion of depth. We named the project and the devices Robotype.

We have developed three types of Robotype thus far: Sujigen for displaying Arabic numerals, Mojigen [1] for the Roman alphabet, and 7×7 [2] primarily for double-byte characters such as Japanese. Each display is designed with conventional computer displays as a motif. In this paper, we describe the design of Robotype, its kinetic typography and the possibility of its expression.

Background

Multi-Dimensional Display

A common method to display a computer-generated multidimensional image in the real world is to place actual pixels in the space. In the example of using light as a pixel, a three-dimensional shape can be represented by arranging pixels sterically using an LED matrix cube [3] and plasma [4] or by using the afterimage of a rotating light source such as an LED strip [5]. Although the viewpoint is limited, a three-dimensional depth can be represented by superimposing transmissive planar displays [6,7]. Displays that use physical objects as a voxel, which is a pixel with volume, also exist. *Kinetic Rain* by Art + Com [8] is an exceptional work that displays three-dimensional patterns using an array of hanging weights controlled

  Leonardo, Vol. 51, No. 4, pp. 386–393, 2018 doi: 10.1162/LEON_a_01648

via motors. In addition, inFORM [9] can be mentioned as a tabletop display that expresses three-dimensional shapes using a grid of linear actuators.

In recent years, Fuwa-Vision [10] and f VisiOn [11] have been established as technologies that realize holography, similar to Princess Leia projected by R2-D2 in the movie *Star Wars*.

Kinetic Typography Using Computer

Letters traditionally have been shaped using media and tools such as stones and chisels or paper and brushes. Moreover, kinetic typography was developed via the invention of film. Computer technology is also guiding new expressions of typography in the same context.

One of the advantages of computational typography is letter generation and movement through human–computer interaction or coding itself. Forerunners generated the shape of letters and the kinetic movement of typography by algorithm, as observed in 1990s' works by John Maeda [12] and typography using modern creative coding platforms [13]. This advantage is also utilized in *Text Rain* by Camille Utterback [14], which enabled interaction between poetry and the user's entire body. Another advantage is enabling physical materials to become computational displays via DA converters and actuators. Although these are nearly two-dimensional displays, related works exist where letters and numbers are displayed by mechatronics [15,16]. Further, several planar displays exist where letters and numbers are displayed by controlling natural substances such as water [17], bubbles [18], moss [19] and fur [20].

Principal Concept of the Robotype Display

Exploring through the history of multidimensional displays, it appears that most prior arts aim to realize volumes to computed three-dimensional images. Moreover, there is a possibility to explore the design of multidimensional kinetic typography via computing. Our objective is to design a display for letters that is also able to express letters' time and movement; we were inspired by the seismograph because of this realization.

Figure 1 illustrates our principal concept regarding the Robotype display. A string is deformed by actuators, and the string is observed as the letter (A) from the front view. Simultaneously, the trajectory of time and movement can be observed from other points of view. This expression using an optical illusion of depth is also observed in the works of advanced graphic designers and sculptors [21–23]. If this string is deformed using robot arms, it is possible not only to express the dynamic strokes as a live animation but also to express the trajectory of the strokes. The trajectory appears as a brush stroke or a spill of ink on paper in handwritten letters.

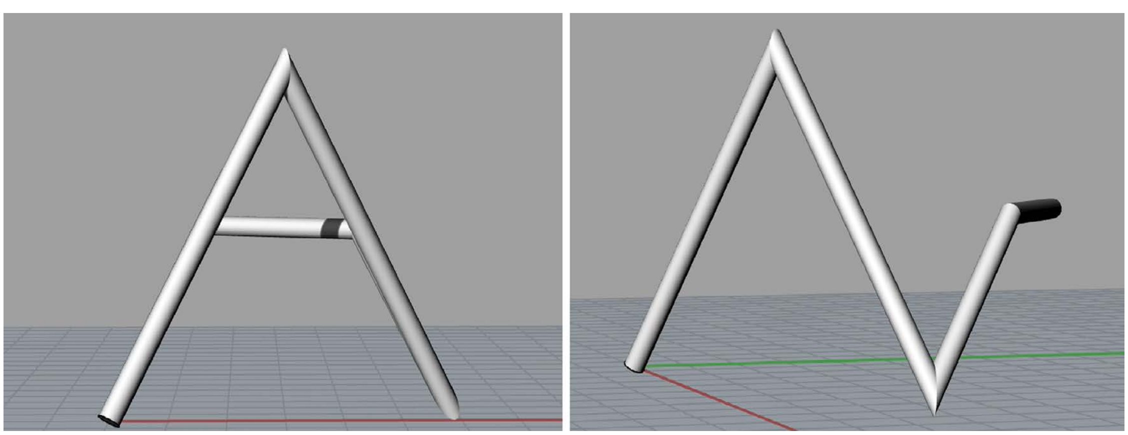

Fig. 1. Robotype concept (left: front view; right: side view). (© Yuichiro Katsumoto)

Thus, we decided to pursue this concept and developed Robotype for numbers, alphabets and double byte characters, primarily Japanese. As described in the following subsection, each Robotype was designed with respect to the motif of a seven-segment display, vector scan display and bitmap display.

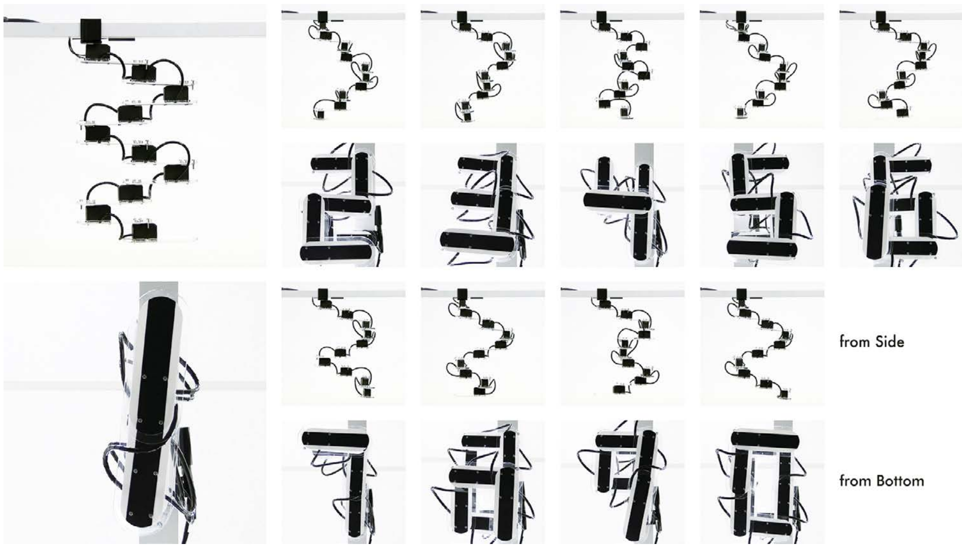

Fig. 2. Sujigen and its display numbers. (© Yuichiro Katsumoto)

Sujigen

Initially, we designed Robotype for Arabic numerals, called Sujigen (Fig. 2). A seven-segment display is the most common computing display for numbers; with its minimal function and beauty, this design is still used in calculators with a bitmap screen. Using this display as a motif, we developed one long robot arm with 10 segments and designed it as a mobile that hangs from the ceiling. In addition, we choreographed this Robotype with circular motion by referring to a dial face and clocks.

This robot arm consists of 10 segments. Each segment consists of two layers of acrylic board (transparent and white) shaped as a running track (length: 140 mm; width: 55 mm). A black tissue tape is sealed under the acrylic layers for drawing an actual line segment. A servomotor is installed at one end of each acrylic frame and this servomotor, Herkulex DRS-0201 [24], can rotate through 320°. Numbers in a seven-segment display are composed of straight lines and right angles; therefore, the servo is set to rotate to four types of angles: 0°, 90°, 180° and 270°.

Each segment is linked together so that the position of the servomotor is staggered, and the segments rotate horizontally. The total height of Sujigen mobile is 400 mm, and its weight is approximately 1,200 g. At one end of the mobile, an ABS adapter is located for connecting the device to the ceiling or beams.

Sujigen displays numbers by rotating each segment simultaneously. Therefore, numbers will appear from a spiral as if they were written in a single stroke (Fig. 3). This number can be observed by looking up from below. Simultaneously, the trajectory of the transition between the numbers can be visualized from the side as shown in Fig. 2. The rotation angle of each servomotor is preset for each displayed number, and the transition time is set to 2 sec. This transition time was determined to drive Sujigen elegantly and as fast as possible.

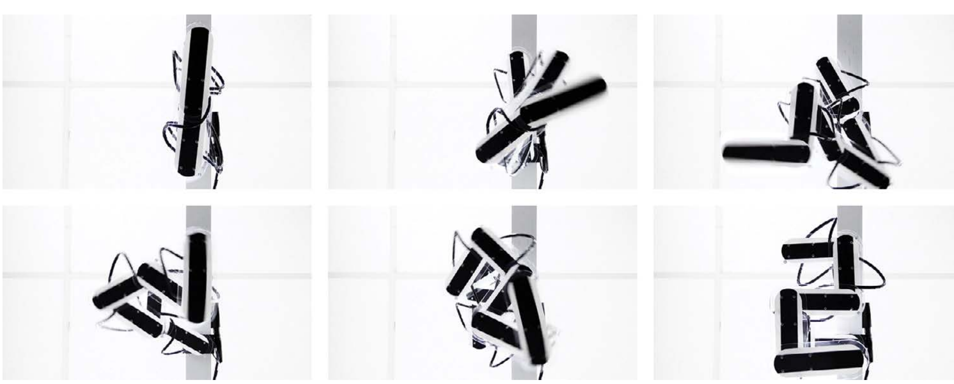

Fig. 3. Kinetic typography of Sujigen (from 1 to 2). (© Yuichiro Katsumoto)

Theoretically, it is possible to display numbers with eight segments and motors using this design; however, to avoid unattractiveness caused by parallax of its depth, and to maintain the weight balance of the kinetic mobile, we decided to add two more segments for Sujigen.

Mojigen

The second Robotype was designed for the Roman alphabet and named Mojigen (Fig. 4). A display called the vector scan can show figures on a screen using the trajectory of a rapidly moving beam. This display does not rasterize images, and therefore it beautifully expresses a line as a pure line. Similar to the vector scan display, we aimed to display letters via beautiful lines with certain anchor points. As a result, this display distinctly reflects the concept of Robotype.

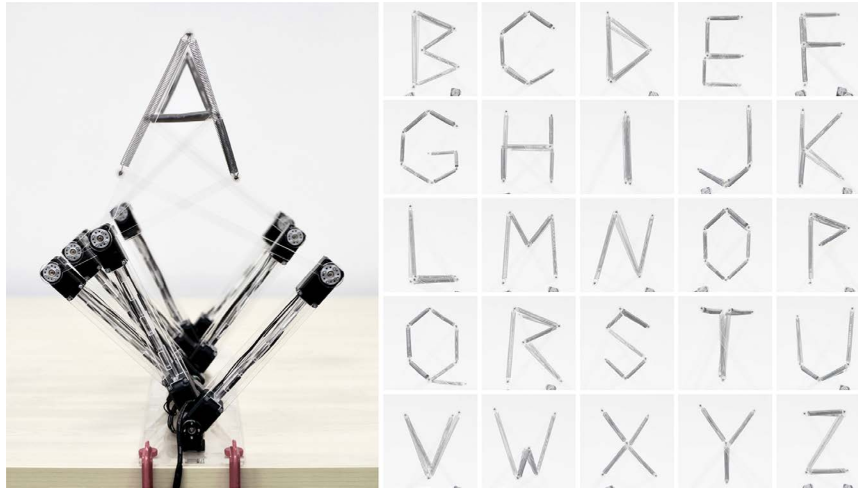

Fig. 4. Mojigen and its display alphabet. (© Yuichiro Katsumoto)

Mojigen consists of robot arms constructed by assembling transparent acrylic boards (5 mm thickness) and coil springs. Each robot arm consists of two joints equipped with the same motor as Sujigen. The design of each robot arm is shown in the left side of Fig. 5. The total length of the robot arm is 440 mm and it can move the tip arbitrarily within a range of 160 × 160 mm in air (blue and purple grid in the left of Fig. 5). This range of motion was determined by the torque of the motors and the tension force of the coil springs. The length of the arms and the motion range can be adjusted according to the motor specification.

For Mojigen, eight robotic arms are placed 60 mm apart on a long rectangular acrylic board (Fig. 5, right). This interval was set based on the thickness of the servomotor. The narrower the interval, the better the readability of the letters, as parallax is reduced.

A swivel, designed for fishing, is installed at the tip of the robotic arm; this is used to prevent twisting of the coil spring. A total of seven handicraft coil springs are installed, connecting each joint of the robotic arms. Initially, we planned to use rubber string instead of the coil springs; however, the elongation was not sufficient compared to the springs, and the rate of deterioration was severe.

Mojigen displays the alphabet in the air by moving each robotic arm to a preset position and extending the springs (Fig. 6). Similar to Sujigen, the letters are displayed to the front, with the trajectory of the movement and the elapsed time observed from other directions as shown in the right side of Fig. 5.

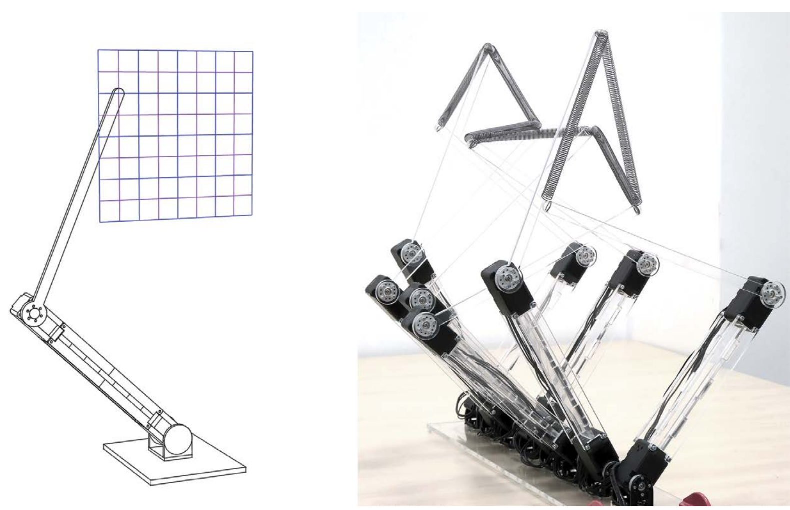

Fig. 5. Design of robot arm (left) and an actual working Mojigen (right). (© Yuichiro Katsumoto)

Unlike Sujigen, Mojigen drives each of the robotic arms from the front in turn. This is because the mechanism of Mojigen allows emphasis on the writing of the letters; those who observe this movement often comment that it is similar to synchronized swimming. The current Mojigen is designed to display capital letters. To achieve this, we decided that at least six robotic arms and five springs were required, but to display more natural and readable letters, we added two anchor points and lines.

Fig. 6. Kinetic typography of Mojigen (from A to B). (© Yuichiro Katsumoto)

In the current motor setting for gallery exhibition, the work requires approximately 3 sec to display one letter. Although it is technically possible to make it faster, overheating will occur owing to the current motor limitation.

7×7

A pangram called Iroha exists in Japan. A pangram is a type of word play that uses all the letters of one language. Iroha not only uses all Japanese Hiragana characters but also expresses traditional Japanese aesthetics (impermanence/ever-changing). From this aesthetics point of view, words are like bubbles on water, and so, they are not eternal or immovable. Based on this interpretation, we decided to develop a device named 7×7 (Fig. 7) to visualize Iroha as if Iroha already is passing in a space instead of representing characters by moving them.

Current computers are able to display Japanese characters, owing to a bitmap display. Therefore, we decided to construct 7×7 based on the concept of bitmap. As a result, various characters other than Japanese can be displayed using 7×7. Further, 7×7 is able to display a split letter like “i,” or a complicated curved letter like “ ξ .” The 7×7 consists of 49 voxels, an acrylic frame and a moving base (Fig. 8, left). This number of voxels was selected because 7×7 displays 49 characters (48 characters of Japanese Hiragana and one blank). For displaying Japanese characters, we referred to Misaki Gothic [25], which is a license-free computer font used primarily for dot matrix display. It is possible to display characters in a relatively smooth and fine manner by increasing the number of voxels and reducing the voxels’ size.

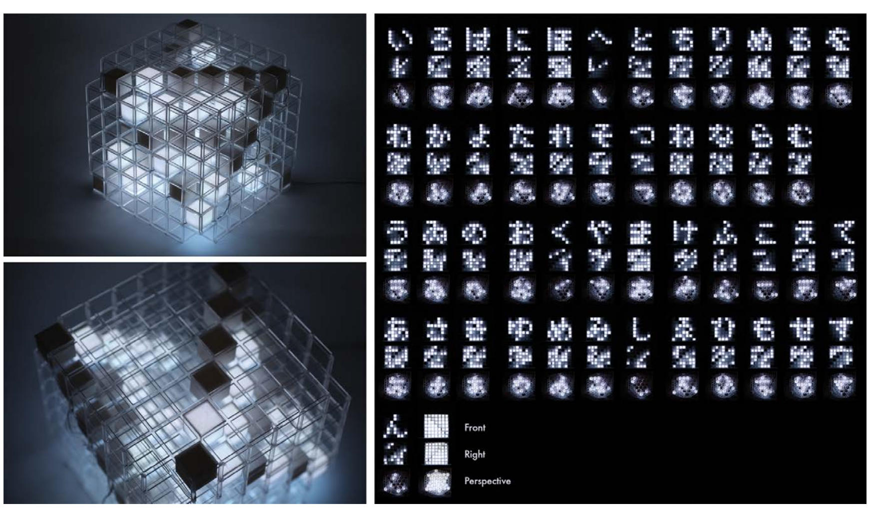

Fig. 7. 7×7 and its display Iroha. (© Yuichiro Katsumoto)

Each voxel is composed of white ABS cubes containing full color LEDs and wired to a microcontroller in the base. These voxels are arranged in a cubic structure constructed with transparent acrylic. Pixels in a conventional LCD are arranged in a plane matrix. However, in 7×7, they are arranged so that no voxel overlaps in any direction. This arrangement is realized by sequentially shifting the normal pixel arrangement in the depth direction and further reshifting a group of pixels forward

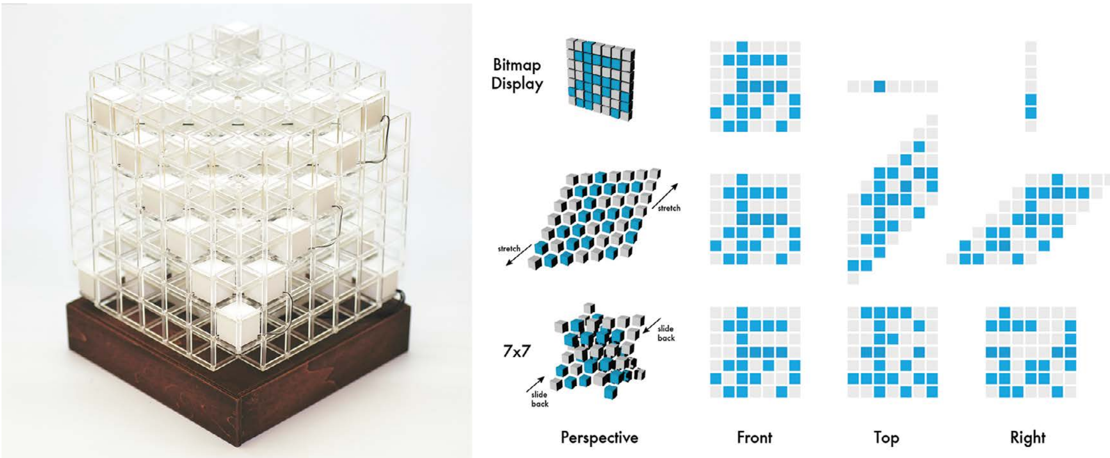

Fig. 8. 7×7 with moving base (left) and voxel shifting of 7×7 (right). (© Yuichiro Katsumoto)

(Fig. 8, right). The total size of the acrylic structure is 200 × 200 × 200 mm. Further, this structure is mounted on a moving base to rotate the structure in an arbitrary direction.

To express the impermanence of Iroha, we choreographed kinetic typography to display Iroha as being transient. The 7×7 displays Japanese characters by illuminating LEDs when Iroha is imagined as moving in space and passing through the structure of 7×7 (Fig. 9).

Thus, the LEDs gradually light from the back toward the front, and then gradually turn off in the same manner (Fig. 10). Owing to the fact that the voxels do not overlap each other, the character is displayed to the front and the fragmentation of movement and time are observed from other directions (Fig. 7, right).

The lighting point of voxels and the rotation angle of the motor are preprogrammed. Even if the cubic structure is turned via the mounting base or by a human, the characters are always displayed to the front. Therefore, to indicate that the characters are flowing in space, 7×7 rotates the structure. The moving base changes the front face of the cubic structure after every paragraph displayed in the previous exhibition [26].

Discussion

Robotype is a computer display that allows letters to coexist with time and movement in physical space. Any of the Robotypes could be used like an automaton clock. Furthermore, we believe that poetry and haiku are suitable for Robotype because they are in-between spoken and written language. We were convinced of this by displaying a meaningful pangram using 7×7.

The current Robotype follows a minimal path based on mechanical efficiency. However, choreographing its movement and timeline using a computer, Robotype can display words with the associated emotion intact. For example, the speed of movement makes it

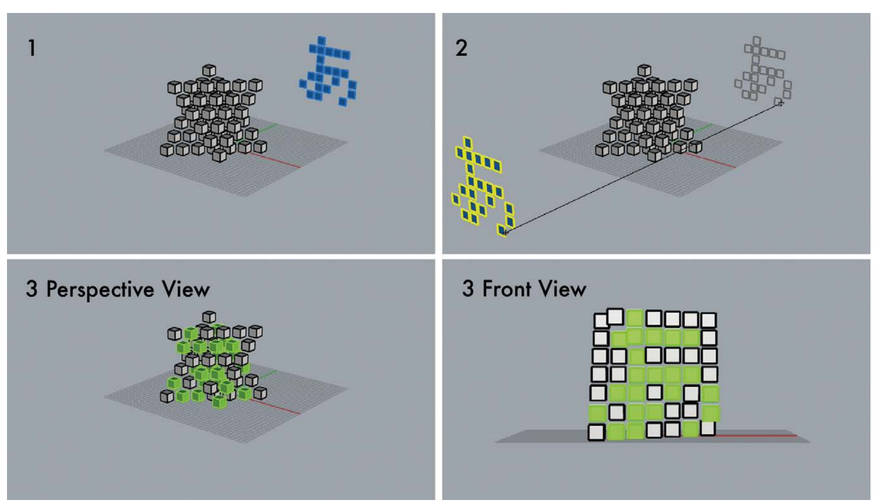

Fig. 9. Concept of kinetic typography of 7×7. (© Yuichiro Katsumoto)

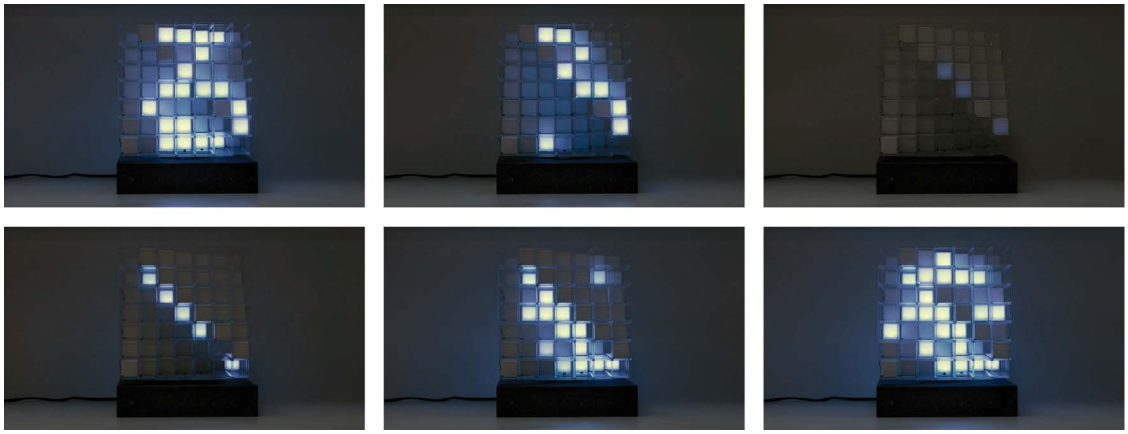

Fig. 10. Kinetic typography of 7×7 (from る to を). (© Yuichiro Katsumoto)

possible to express the gentleness or roughness of words, and the font size can express volume. To display words and lines, multiple Robotypes will stand in a line. Thus, words can be displayed similar to a group of dancers choreographed to articulate a ballet performance. This would exude presence beyond the kinetic typography in the two-dimensional monitor if it is realized. It would be interesting for poets and novelists to be able to interactively manipulate Robotype since it can materialize the artist's emotions in real time. As letters and languages inspire poets, there might be poetry inspired by Robotype too. For this purpose, we intend to develop software to animate Robotype.

Robotype is controlled using multiple actuators so that it cannot stop completely. When it seems to be stopped, it vibrates finely. It is a type of error that is caused by the twist of springs, acrylic distortion and heat accumulated in the motor, but the error provides daily changes to Robotype behavior. Several audiences commented that they perceived beauty in this uncertainty and we therefore regard this in the same manner as ink bleeding; it is a particular nuance of the Robotype.

Conclusion

This paper describes the research on Robotype, which involves a series of kinetic typography using robotics. Robotype is also a device that is able to display letters considering their time and movement. We have created three types of Robotype: for Arabic numerals, the Roman alphabet and Japanese characters. In the future, we plan to increase the number of displays and to explore how to express poetry and haiku while considering time and movement.

Acknowledgment

This research is supported by the National Research Foundation of the government of Singapore under a funding initiative from the Interactive Digital Media Programme Office.

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