Abstract

In this study, an attempt was made to create a multicolor print based on a digital portrait photo. Inspired by the trend of taking a self-portrait (selfie) or using a purikura (print club) machine, and the “Cool Japan” movement, it is thought that it might be an entertaining experience to have one’s “ukiyo-e”-nized portrait. The idea is extended further to have a woodcut print because it would be more entertaining and educational to experience the printing process by oneself. Image processing techniques were employed for modifying a photo so that it had a flat-colored ukiyo-e-like expression. These pictures were further converted to produce the three-dimensional (3D) geometric data for printing the woodblocks by a 3D printer. One can print a multicolor woodcut print on paper using ink and these woodblocks by following the same production process as that for a real multicolored woodblock print. The feasibility of the idea was demonstrated by producing the woodblocks and using them to print a real multicolor print work.

Keywords: 3D Printer/Digital fabrication/Image Processing/Multi-color Woodcut Print

1. Introduction

In recent years, many camera applications and purikura (print club) machines equipped with fascinating image processing filters have been developed to beautify or to add various entertaining effects to portrait pictures. Simultaneously, Japanese culture is gathering a broad attention. These trends have inspired the author’s interest in having one’s own portrait picture converted into a “ukiyo-e”-nized expression. It would be more entertaining to print it on paper as a real multicolor woodcut print by following the same production process as ukiyo-e.

Ukiyo-e is well-known as a genre of traditional Japanese pictorial art form representing contemporary life and cultures, mainly of the Edo era of Japan. Especially, the works produced by woodcut printing called “nishiki-e” are widely recognized among different ukiyo-e forms, and their artistry has been highly appreciated worldwide. Nishiki-e realizes multicolored representation by using multiple woodblocks, each of which corresponds to a different color. Its production process is complicated and should be performed by a team of artisans with different kinds of expertise. The production of woodblocks and the printing of multicolor prints could provide an interesting and educational experience to anyone who is not familiar with the creation process of the art. However, it would be difficult to implement the exact process of the printing. Especially, great expertise is needed to carve the woodblocks by using chisels. It takes a long time to prepare all the woodblocks for the necessary colors even if one could manage it.

The use of digital fabrication technologies could help to follow the production process more casually without losing the core idea of the process. Digital fabrication is widely recognized as a valuable tool for transforming digital data into real objects. It would be possible to pro-
duce the woodblocks if one could prepare their 3D geometric data and realize them by using a 3D printer. This was achieved by applying image processing techniques for converting an original portrait to a flat-colored picture and then extracting the regions for each of the different-colored parts. One can obtain the 3D model of the woodblocks by means of the decomposed color regions.

The present work also includes an educational aspect by attempting to let people experience the process of production of a multicolored woodcut print. Digital fabrication and 3D printers are used not only for the production of manufacturing parts, but also for creating artistic works. There have also been attempts to use a 3D printer for reproducing lost ancient artifacts. Among these works are the restoration of ancient Japanese mirrors and Greek vases. The present attempt does not aim to reproduce an artwork completely but is similar to these works in that it uses new digital fabrication tools for an ancient art form.

3. Ukiyo-e Production Process

The production process of ukiyo-e woodcut prints (nishiki-e) is described in this section for clarifying the task. There are several steps involved in producing a printed work, each of which is performed by an artisan of specific expertise. Therefore, the entire production is accomplished by a group of such artisans.

The entire production process is roughly divided into the following steps.

1. Drawing a sketch (Figure 1, top)
2. Engraving contour lines
3. Coloring
4. Engraving a woodblock for each color (Figure 1, middle)
5. Printing (Figure 1, bottom)

First, the painter draws an original drawing to be a base motif for the prints. Subsequently, a woodblock of outlines of the original paint is engraved by the engraver. The painter fills the colors on the paper printed by that woodblock. Based on this colored painting, the engraver engraves multiple woodblocks, each of which is intended for printing a single color. Finally, the printer prints the work by spreading ink on the woodblocks and copying it by placing a paper on the block and rubbing it with a barren. The printing is repeated as many times as the number of colors used in the work. Therefore, special care is required while placing paper on each block such that the accumulated colors are aligned properly in composing
The original drawing.

All of these works are difficult in each way and require expertise. It is desirable to substitute the drawing and engraving processes by digital means. The rest of the procedures should be done manually because these are the very part that enables a person to appreciate what the multicolor printing task is like.

4. Production Process

There are three major steps in producing a multicolor print from an original digital photo, and they are represented by the processes illustrated by different colors in Figure 2. These steps largely follow the processes performed for printing a nishiki-e described in the previous section.

Here, instead of drawing a sketch, the starting point is a digital photo. An image processing scheme is applied to flatten the colors of the photo and make it a picture to be printed. To produce a set of woodblocks, another image processing technique is used to decompose the picture into separated images, each of which corresponds to a region of different color. The decomposed images are converted to 3D geometry data by adding a height attribute to the extracted region. The woodblocks are produced from these geometry data by using a 3D printer.

The procedure for printing on paper is the same as the actual process, i.e., placing each color ink on the corresponding woodblock alternatively, and printing it on the same paper. The detailed procedures are described in the following sections.

4.1 Transformation of Portrait Picture

Instead of drawing a picture, a digital photo is used as an original source for creating woodblocks. Photos are taken in front of a monocolor screen for making the application of an image processing technique easier. It was decided to flatten the colors of a photo and add distinct outlines, because these modifications were expected to give the photo an ukiyo-e-like appearance. It is expected that such a conversion can be realized by applying certain image processing functions: one for flattening the colors and the other for extracting the contour lines. It is expected that deforming a person’s proportion can also contribute to adding a ukiyo-e look to a photo. The resulting pictures applying different deformation ratios are shown in Figure 3. The face size was magnified manually by a different magnitude in each picture. A deformation of a small ratio gave a good accent to the drawing, but the appearance became unappealing if the ratio became too large. This was not employed enough in this attempt, however. This effect should be pursued in future...
work.

The k-means smoothing method was used for reducing the colors. Reducing the colors results in eliminating the color gradation and realizes a flattened-color image. The parameters were set so that one could obtain a picture with four or five colors. Because it was necessary to prepare as many woodblocks as the used colors, the number had to be small for easing the preparation task. An attempt was also made to replace the colors of the original photo with those often used in real ukiyo-e works. This may also contribute to adding a ukiyo-e touch to a print. The colors for substitution were obtained by performing a histogram analysis on these works, and the colors were selected in the order of the area size for which these colors are used (Figure 4).

A color pallet was created for substituting the colors of the converted portrait picture. Thus, the converted picture was obtained after applying several image processing techniques. Figure 5 is an overview of the conversion process of a photo.

As for the final touch, a sign stamp was put onto the converted picture for mimicking nishiki-e works. An imitation sign was prepared, and it was placed at an arbitrary position (Figure 6).

4.2 Production of Woodblocks

To produce a woodblock using a 3D printer, the 3D geometric data for the blocks are needed. Furthermore, for realizing a multicolored woodcut print, there should be multiple woodblocks, because a different woodblock is needed for printing a different-colored region. It is easy to decompose a picture by colors because the picture is already converted so that it is composed only by a few flat colors (Figure 7).

Each of the decomposed monocolor pictures was converted to a black-and-white bicolor image, and an identical height to the black region was set to produce 3D geo-

Figure 4: Extract colors from nishiki-e prints

Figure 5: Portrait to ukiyo-e-like presentation

Figure 6: Pictures with stamps

Figure 7: Decomposing a picture into different color regions

Figure 8: Monochrome images and 3D geometry data
metric data (Figure 8). Woodblocks were obtained by printing these data using a 3D printer.

4.3 Printing on Paper

Once the woodblocks were produced, they were used alternatively with different-colored ink on the same paper to obtain a multicolor print. After ink of a certain color was spread over a corresponding woodblock, a paper was placed on it, and a baren, which is a disk-shaped pad, was used to transfer the color to the paper (Figure 9).

![Figure 9: Printing process on paper](image)

In using the woodblocks produced by the 3D printer, it was observed that smoothing the surface of the block with fine sandpaper is required. Otherwise, ugly irregularity was observed in the printing. Figure 10 shows the difference between nonsmoothed and smoothed woodblock surfaces. The irregularity of spreading ink is observed in the nonsmoothed block (left image of Figure 10).

![Figure 10: Difference between the surface conditions](image)

To avoid the irregularity, one should also use an appropriate ink. Because the woodblocks produced by the 3D printer were made of plastic, and because plastic repulses water, it was slightly difficult to spread low-viscous ink on the surface uniformly. An attempt was made to use an oil ink for printing a woodcut print.

5. Discussion

In this work, an attempt was made to convert a portrait photo to a ukiyo-e-nized picture and make it a real multicolor woodblock print. It is the author’s belief that the attempt was successful in demonstrating this is possible. A set of woodblocks and purikura like stickers were produced from a self-portrait photo (Figure 11). It was also possible to produce a multicolor print on paper in the same way as by ukiyo-e production (Figure 12).

![Figure 11: Woodblock and purikura stickers](image)

![Figure 12: Variation of printed works](image)

Although there was some success in producing woodblock prints, it was observed that there are other issues that should be pursued further for realizing the quality originally anticipated. First, because of the early stage in attempting this approach, only a simple image processing of smoothing colors was employed for converting an original photo to obtain an expression that has a ukiyo-e look. Only a simple assumption was made in defining the
features of ukiyo-e representation. We mainly considered a feature arising from woodcut prints i.e., the painted colors should be flattened. Other factors, such as deforming the representation, should be considered for making a portrait have the features of famous ukiyo-e works. We consider devising a more suitable image processing method that includes such a deformed representation.

The colors of the converted picture were replaced by those extracted from existing ukiyo-e works. Substitution of colors can be arbitrary, and a different selection of colors can produce variation in the output representations (Figure 13). It is also possible to use the combination of colors used for manga or animation characters. This would result in an interesting representation wherein the applied picture is reminiscent of the original work.

Because there were difficulties in printing on paper with ink, we feel a need to examine the suitability of materials in printing the woodblocks. Wooden material can be used with a 3D printer. We anticipate that the use of wood material would facilitate spreading ink uniformly over the woodblock’s surface. The means of producing woodblocks should also be considered. A 3D printer was used for this purpose in this attempt. However, because the desired process is an engraving of wood, a computer numerical control router can imitate the original process more precisely and would be more suitable for this purpose. We employed a 3D printer this time because it is the most convenient device for producing a real object from digital data, especially in terms of availability and usability. In terms of the quality of printing, the variations in printing ink and paper may also influence the results. Such aspects should also be examined in future study.

When considering the user experience in converting a picture from an original portrait, it is preferable not to require many configurations on the parameters on the conversion. However, certain users would like to choose the colors and other options by themselves. It is necessary to examine the amount of controllability when systemizing this process.

6. Conclusion

Rendering one’s photo a ukiyo-e manner and producing a woodblock print of that picture were considered. One of the goals of this work was to examine whether creating a multicolor woodcut print from a digital photo is feasible, and a woodcut print was successfully created by producing the woodblocks using image processing techniques and a 3D printer. We consider that we were able to demonstrate an example of the use of digital fabrication for an application other than practical fabrication.

Because the study was in the early stage of this attempt, the focus was on the successful completion of the entire process, and we have not been able to pursue a good quality of the output. It was observed that there are issues for improving the quality, such as devising an image processing method for mimicking the style of ukiyo-e representation better.

The ukiyo-e look was sought as the motif in this work by considering that the experience of printing by following the traditional practice would be an educational and entertaining experience. However, because the whole process can be applied to pictures of any other design if they are flat-colored, it would be possible to produce printed works of a unique expression by employing a different image processing effect. We would like to pursue a broader range of applications of the same approach in future.

Figure 13: Variation of color combinations
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