グラフィクスとCAD 20－7
（1986. 2. 14）

浮世絵合成システムPICS

小沢 一雅
（大阪電気通信大学工学部）

Title: An Ukiyoe Picture Synthesizing System PICS

Author: Kazumasa Ozawa,
Information Science Center,
Osaka Electro-Communication University, Neyagawa-shi, Osaka 572, Japan.

Keywords: Picture, Synthesis, Knowledge-base, Database, Art, Ukiyoe, Computer graphics.

Abstract

This paper presents a picture synthesizing system PICS, aiming to create the "Ukiyoe" colour pictures of desired compositions by computer. PICS consists of the main controller, database and knowledge-base. A number of the semantic picture elements (SPEs) extracted from Ukiyoe landscapes have been stored in the database. The rules in the knowledge-base act to detect semantic contradictions between SPEs contained in a given composition. Description of an Ukiyoe picture and its composition has been discussed in terms of binary relations on a set of SPEs. Two works experimentally created by PICS have also been presented.

1. Introduction

In recent years, computer graphics has now been accepted as a powerful tool not only for industrial or scientific development but also for creation of artistic articles. Artistic applications done so far include TV graphic design [1], commercial picture design [2], utilization as a medium for artistic painting [3], computer animation [4] and others [5-9]. As far as these existing applications are concerned, it appears that all of the pieces or materials to compose a final picture should be given on each occasion by means of a graphic scanner or by hand. As a matter of course, this is a reasonable idea when we aim such a new medium as that for completely free drawing [3]. On the other hand, when we could limit the style of pictures to handle, another approach would be applicable to implementation of a computer graphic system useful for a specialized artistic task. Appropriate limitation on the set of pictures to be created provides the advantages to introduce the database of picture primitives or pieces, which will play a key role in improvement of productivity of pictures.

This paper presents a picture synthesizing system PICS which can create a set of pictures in the special style, known as Ukiyoe, by assembling and editing pieces stored in its database. Ukiyoe, a world of colour wood prints, was originated from the artistic movement started in the 17th century and is characterized by the precise colour wood prints depicting landscapes or contemporary life and pleasures. The common structure of the colour wood prints is basically simple compared with the other styles of paintings; comparably small number of colours, even or flat painting and sharp edging. As another specialty of Ukiyoe, it should be noted that the drawing is not completely perspective in contrast to photography. But, it seems a positive reason why Ukiyoe have been maintaining its special artistic worth that no other painting can take the place.

In spite of the relative uniformity of the pictures, Ukiyoe forms a world of more than thousands of the pictures each of which has a marked individuality. One Ukiyoe landscape,

for example, is composed of about a hundred pieces, on an average, including houses, travelers, trees, mountains and so on. At our final goal, we aim to decompose a large number of Ukiyoe pictures into such pieces and, also, to keep them systematically in the large-scaled database. On the first phase, we have built a small-sized database of the pieces extracted from the famous Ukiyoe landscapes for our fundamental research.

Briefly, PICS creates Ukiyoe-like pictures by assembling pieces in its database. One of our problems is to find how to synthesize "natural" Ukiyoe pictures. Ruleless assembling of the pieces will create the pictures much removed from natural ones. We suppose that a collection of the between-piece rules effectively acts for creation of the natural pictures. Each of the rules should be acquired logically, heuristically or statistically. In PICS, a small number of the between-piece rules in the knowledge-base have been employed for detection of unnatural configuration of the pieces.

2. Picture Description

Not only Ukiyoe's but any picture can conceptually be decomposed into a number of the pieces each of which represents a close semantic existence such as a house, a bridge or a traveler. Call these pieces the semantic picture elements (SPEs). Actually, it would not necessarily be feasible to separate, physically, SPEs contained in a given picture. It seems to be one of the reasons that boundaries between SPEs are, in most cases, not sharply depicted in terms of fine lines. As mentioned, Ukiyoe pictures can be characterized by the sharp edging due to the precise wood printing. This special quality is very helpful for clipping-like separation of SPEs.

Assume a set of SPEs clipped from Ukiyoe pictures be given. Let S be the set. Here, we consider the picture synthesizing problem on S. In theory, when given a subset of S, infinite pictures can be created by changing configuration and sizes of the SPEs. In other words, the same subset provides different pictures according to different compositions. It is, however, a delicate problem to state clearly what the composition is. We consider that a collection of relations on S plays an important role in determination of the composition.

To discuss the composition fundamentally, we introduce the following binary relations on S.

$$\left.\begin{array}{l}\text{"is-on" / "is-over"}\\ \text{"is-behind"}\\ \text{"is-left-of"}\end{array}\right\} \qquad (1)$$

Consider Figure 1, for example. The picture consists of six SPEs; SKY, MOON, MOUNTAIN, CEDAR, SAMURAI and GROUND. The picture can be described in terms of the relations given by (1), which are written as directed graphs shown in Figure 2.

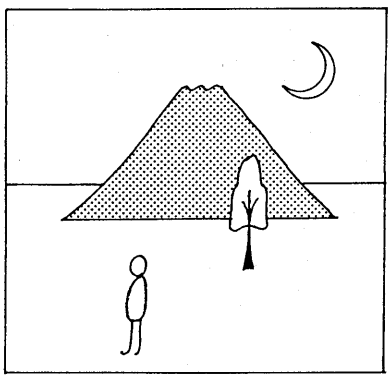


Figure 1. An example picture.

In order to give a more detailed description, we will need, as a matter of course, to introduce much more relations such as "is-surrounded-by", "is-far-from", "is-near", "touches" and so on. In this paper, for simplicity, we shall discuss our problem

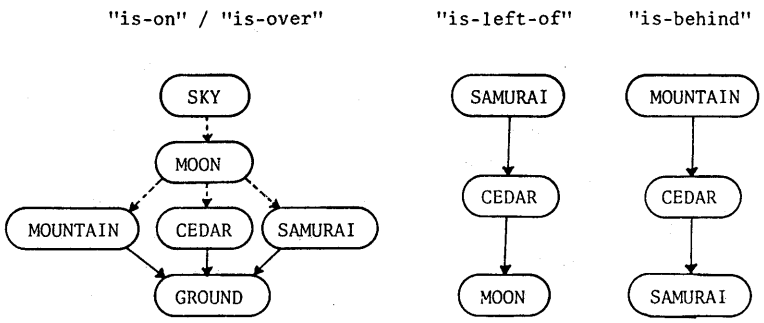


Figure 2. Relations.

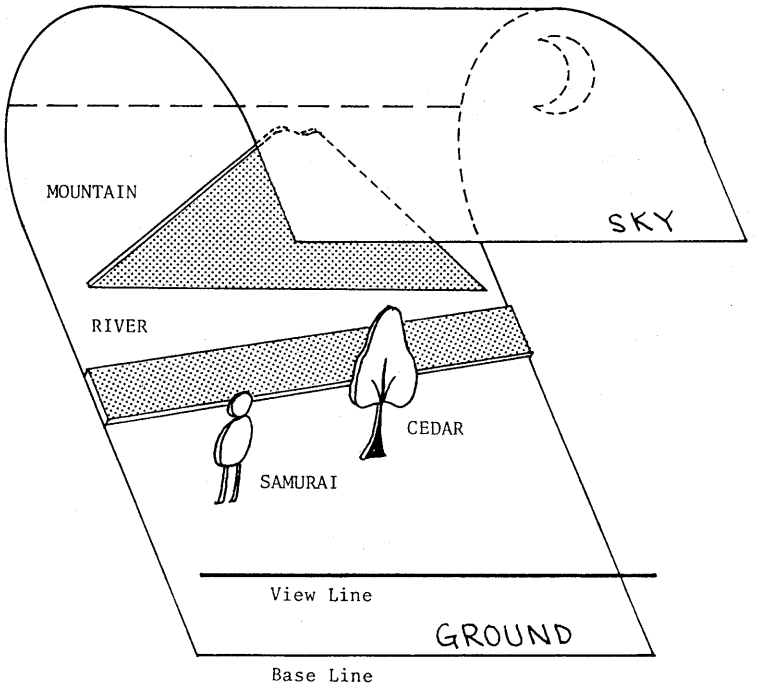


Figure 3. 3D-Model for an Ukiyoe picture.

within the range of the relations defined by (1).

The composition to fix a picture involves more pictorial information than that of relations on S: Even if given a collection of relations such as Figure 2, it is impossible to fix uniquely one picture. To do this, the extra specifications should be required, which include those of sizes of all the SPEs, their precise positioning and colour coordination. On the same collection of relations, different physical specifications also offer different pictures. Then it can be regarded that the composition is determined by the between-SPE relations and the physical specifications.

In addition, note that the composition of an Ukiyoe picture, though physically two-dimensional itself, can be well-handled in the context of a sort of three-dimensional world. Figure 3 presents the 3D-Model that illustrates a three-dimensional understanding of the composition of an Ukiyoe picture. Most

SPEs are presented as standing thin plates parallel to the base line. Another type of SPEs, including RIVER, SEA and MOON, are thin plates closely put on the GROUND surface or on the SKY surface. Note that the view line, above and parallel to the base line, is assumed in contrast to the view point in the perspective drawing. The picture is approximately given as a vertically perspective but horizontally orthogonal projection of the SPEs into a plane parallel to the view line. In this projection, sizes of SPEs are reduced non-linearly according to their distances to the base line.

Finally, consider the creation of natural Ukiyoe pictures. As mentioned, we introduce the rules employed for detection of unnatural parts in a given composition. The rules are defined on a set S* extended from S. First, we introduce the attribute that represents a common property over a number of SPEs. For example, for two SPEs, SEA and RIVER in S, we can define an attribute WATER as their common property. Symbolically, we write

$$\text{WATER} = (\text{SEA}, \text{RIVER}). \qquad (2)$$

Another example can be written by

$$\text{TREE} = (\text{PINE1}, \text{PINE2}, \text{WILLOW}, \text{CEDAR}).$$

Where, in this case, PINE1 and PINE2 assign differently depicted pine shapes.

By merging a properly defined collection of attributes into S, we have the extended set S*. Symbolically, we have

$$S^* = S \cup \{\text{attributes}\} \quad . \qquad (3)$$

Corresponding to (1), Our rules are written in terms of such relations on S* as follows.

$$\left.\begin{array}{l}\text{"must-be-on" / "must-be-over"}\\ \text{"must-be-behind"}\\ \text{"must-be-left-of"}\end{array}\right\} \quad (4)$$

In principle, it should be required that the rules reflect a variety of underlying regulations in compositions or drawing of Ukiyoe pictures. Such regulations appear to be closely related to creation of natural pictures. It follows that much more relations should be introduced other than (1) to obtain the effective rules. Practically, acquisition of the rules might be carried out heuristically, or sometimes, logically or statistically.

To illustrate what the rules are, the following examples are presented:

Rules

PERSON* must-be-on BBG*
TREE* must-be-on GROUND
BOATMAN must-be-on BOAT
MOUNTAIN must-be-behind ANY*

Attributes (indicated by *)

PERSON* = (SAMURAI, GIRL)
BBG* = (BOAT, BRIDGE, GROUND)
TREE* = (PINE1, PINE2, WILLOW, CEDAR)
ANY* = (all SPEs in S)

Each of the relations belonging to a given composition is compared with the rules. Through such a comparing process, contradictions, if there are, can be detected.

3. System

A view of PICS

PICS has experimentally been implemented as the first step towards the final goal that will make it possible to create "new" but "natural" Ukiyoe pictures. The underlying ideas of PICS will be, however, still effective in its future versions. Figure 4 illustrates the global structure of PICS.

As previously discussed, a picture can not be fixed until its composition is definitely presented. Another problem is to find how to instruct the system in the composition. The very relations such as Figure 2, for example,

are not suitable for the instructions. Instead, a PICS user can enter his composition in the form of the specially designed entry plan, as shown in Figure 5, which we can easily draw on the graphic display using the cursor. Note that the entry plan is very corresponding to the ground plan of the 3D-Model shown in Figure 3.

For a given entry plan, PICS begins with the grammatical analysis on the composition to

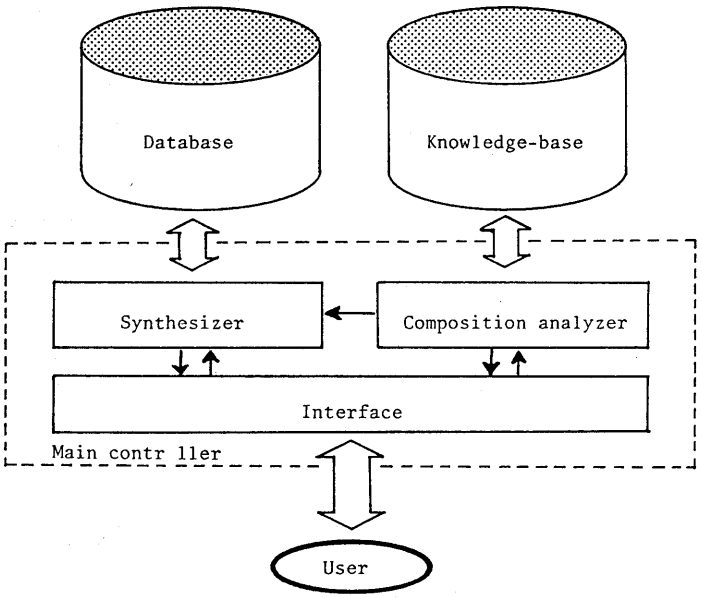


Figure 4. Global structure of PICS.

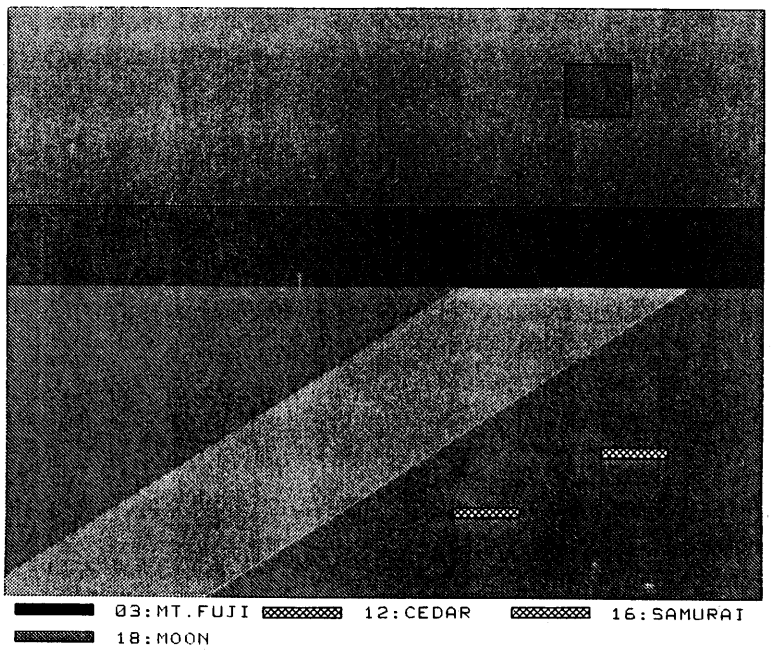


Figure 5. Entry plan.

find semantic contradictions between SPEs. In this process, rules in the knowledge-base are frequently consulted as their occasions call. If contradictions found, PICS cancels the causal SPEs in the entry plan. If not found, or after the above cancellation, the system moves to the next stage, demanding a couple of specifications on the meteorological conditions such as weathers and seasons. Given these specifications, PICS creates the final picture on the graphic display. Reduction of sizes and positionings of all the SPEs are automatically carried out by a heuristically defined non-linear transformation based on their orthogonal distances from the bottom line in the entry plan. Figure 6 shows a flow diagram to illustrate the picture synthesizing processes of PICS.

PICS has been implemented on the FACOM M360AP computer system with 6.54 MIPS dual processors, 12MB CPU memory and 446MB x 12 disk memory devices. The GR2414 colour graphic display unit employed offers 1280 x 1024 pixels resolution and freely optional 256 colours per each pixel. PICS has originally been written in FORTRAN 77 and the GCSP-II graphic subroutines.

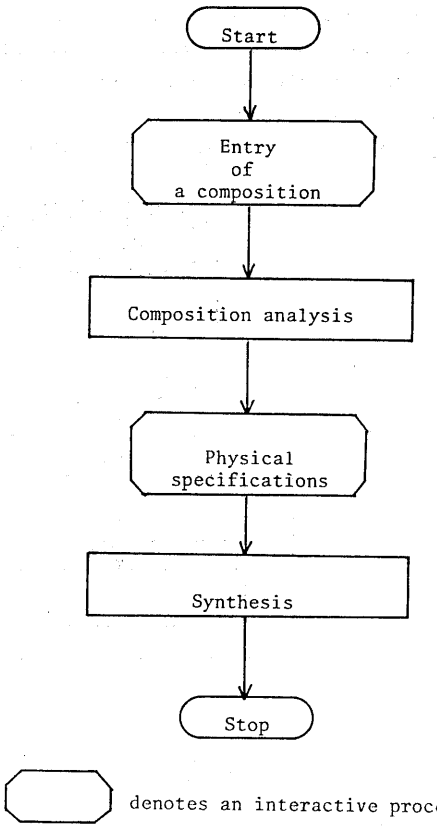


Figure 6. Flow diagram of the picture synthesizing processes.

Database

The SPEs clipped from a number of Ukiyoe landscapes have systematically been stored in the database of PICS. In our case, a SPE is described as a tuple of evenly coloured zones and lines (See Figure 7). Since actual Ukiyoe landscapes have different colour tones according to weathers, seasons and hours, it is required to design our database so that we can smoothly select the optimal colour palette. Besides, the database structure partially depends on the characteristic of the graphic display unit employed.

The logical structure of the PICS database is illustrated in Figure 8. Table is the look-up table playing a key role in retrieval, of which attributes include FILE-NAME and

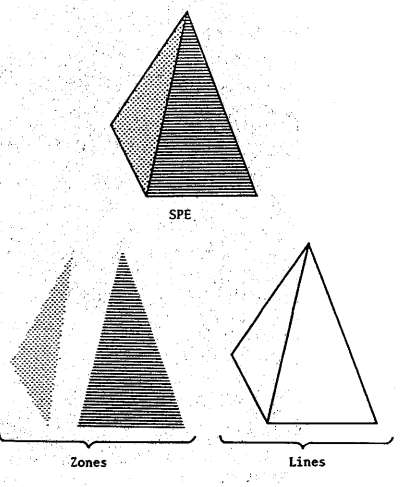


Figure 7. Zones and lines decomposed from a SPE.

COLOUR-NUM. A value of FILE-NAME specifies a data file concerning the shapes of zones and lines for drawing a SPE. COLOUR-NUM assigns the colour numbers each of which corresponds to a tuple of RGB brightnesses defined in Palette.

PICS' works

The two PICS' works are shown in Figure 9. Since the database for our experiment is very small-sized, it is obviously impossible to create a variety of artistically fascinating Ukiyoe works by the present PICS. The SPEs employed for Work 1 include SKY, CLOUD1, FUJI1, GROUND, SEA and BIGWAVE. For Work 2, we employ MOUNTAINS, SKY, RIVER, CEDAR x 2, PINE1, SAMURAI, GROUND and GROUND1. The time needed for drawing has been about 130 seconds per picture. As seen in Figure 9, the compositions of Work 1 and Work 2 are fairly trite. Nevertheless, readers will find it interest to compose fascinating Ukiyoe-like pictures by computer.

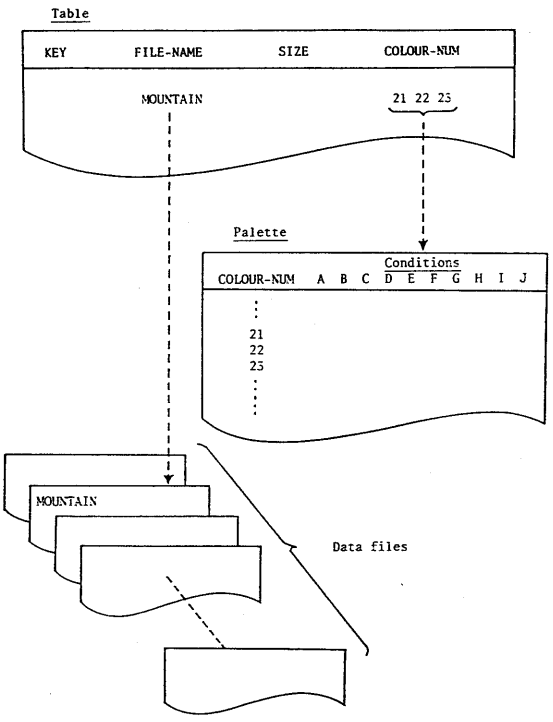
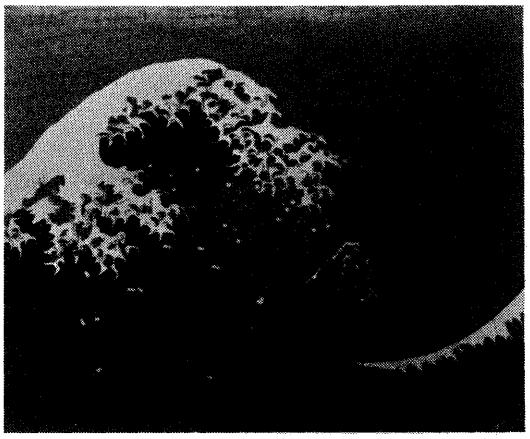


Figure 8. Logical structure of the database.

4. Conclusion

Good compositions offer good pictures. Who creates the composition is not any computer, but a human being. In principle, no computer



Work 1

Work 2

Figure 9. PICS' works.

can play any extraordinarily important role in artistic tasks. However, inspecting precisely an artistic task such as painting, there seems to be much more room for introduction of computers.

The experimental system PICS suggests that a computer will act well within the limits, provided its role is definitely assigned. As already mentioned, PICS has been implemented as on the first phase towards our final goal. Especially, our present collection of the rules is so small-sized that we have not been able to show their effectiveness practically but theoretically.

One of our future problems is, basically, acquisition of a large number of SPEs and rules. In order to extend the range of the rules, much more relations on SPEs should be introduced so that a variety of regulations implicitly involved in Ukiyoe pictures could be written in terms of rules. Then, according to given compositions, very natural Ukiyoe pictures would be synthesized by PICS.

Acknowledgement

The author thanks Mr. K. Seko for his helpful cooperation.

References

[1] N.Tanton: 'FLAIR' - A micro-processor-based tool for graphic design, Int. Broadcast Eng., 12, 178, pp12-13, July 1981.

[2] J.B.Hanson & P.J.Willis: A graphic arts display system, Proc. of Electronic Displays '82 and Information Display Systems, 3, p9, Oct. 1982.

[3] F.Herbert: The art of computer graphic - computer graphics in art, Comput. and Graphics, 7, 3-4, pp381-3, 1983.

[4] S.Hayward: Computers for animation, Butterworth, 1984.

[5] T.Agui et al: A painting algorithm of monochromic images using color sequences, Trans. IECE (Japan), J67D, 3, pp321-6, March 1984.

[6] R.Weinberg: Parallel processing image synthesis and anti-aliasing, Comput. Graphics, 15, 3, pp55-62, Aug. 1981.

[7] R.Kicklighter: A high-quality color image simulator, Digest of 1977 SID Int. Symposium, pp128-9, April 1977.

[8] R.J.Kalush,Jr. & A.G.Kalush: Drawing pictures using printer plotting, Creative Comput., 7, 1, pp136-140, Jan. 1981.

[9] H.W.Franke: Computer art from DIBIAS, Page, No.48, pp5-10, 1981.

[10] K.Ozawa: A picture synthesizing system with a database of semantic picture elements of "Ukiyoe" colour wood-printed pictures, BPRA 3rd Int. Conference, St.Andrews, Sept. 1985.