Computer graphics for the blind

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Abstract

This paper presents a tactile hard-copy system which help an "active tactile graphics" for the blind. Here the word "active" means that the blind can make graphics programs and deal with computer graphics by his own efforts. It translates the color graphics on the screen into an embossed dots image on paper. To get a precise embossed dots hard-copy close to the real graphics screen, we adopted a Braille printer plotter. The program stays resident in computer's memory, and a push of COPY key at any time starts to make an embossed hard-copy of the current graphic screen. By this system and computer language like C, the blind can try to make graphics programs and examine the colors and the graphic figures constructing the screen graphics. The system can extract several combinations of colors from the whole graphics selectively and make the hard-copys. This color selective hard-copys help the blind understand the whole graphics as a result, because each hard-copy reduces the complexity of the graphics and tends to be easier to examine by touch.

1 Introduction

We have developed a TSR(Terminate and Stay Resident) hard-copy system that translates color pixels on the screen into embossed dots on paper by Braille printer plotter. Recently color graphics capacity in Personal Computer(PC) and programming language like C is more and more powerful. Even under the DOS environment, many programs handle not only characters but also color graphics or images. The blind people can recognize almost all the character information on the screen through on-line screen reader using voice synthesizer and Braille display. (Braille display is an on-line translator from character to Braille.) On the other hand there are not good methods to recognize graphics or images on the screen. Especially real time methods are not put in practical use. We know several methods to present graphics for the blind, such as the screen search by OPTACON[4] or relief picture on micro capsule paper. We have already referred to the problems they have, and presented the system(tenzu,brlview) which give the sighted persons an easy way to make tactile graphics on paper for the blind[1][2]. We call this "passive tactile graphics" because the blind cannot make graphics by himself. And now, instead of the passive tactile graphics, we are going to attack "active tactile graphics". It means that the blind can recognize the graphics on the screen by himself and they can make color graphics program by himself.

2 Purpose

Our purpose is to make a system that support active tactile graphics. From this point of view we have made a graphics screen hard-copy system onto a Braille printer plotter. We call this system BHCOPY hereafter. BHCOPY makes the following matters possible through the embossed dots hard-copy.
(1)The blind can feel graphics and colors on the PC's screen
(2)The blind can make color graphics program on the PC's screen by himself

Picture 1. ESA721 Braille printer plotter

3 System Configuration

(1)PC(NEC PC9801FA) OS:MS-DOS Ver.3.3C,CPU:Intel80486SX,CLOCK:16MHz
(2)Braille printer plotter(NEW ESA721)[3]. Picture 1 shows the external appearance.The Braille printer plotter has 3 sizes of dot(Small/Medium/Large). The resolution is referred in section 5.

4 Method

Hard-copy originally means to copy all characters and graphics on screen onto paper as they are in the same resolution. Our personal computer(NEC PC9801series) has two types of memories as display memory, one is graphic VRAM(GVRAM) and the other is text VRAM(TVRAM). TVRAM reserves character codes to display characters on the screen. Some screen readers peek this TVRAM to read the screen and speak. Our hard-copy system BHCOPY peeks GVRAM. GVRAM reserves graphics pixel information on the screen. It has three color planes corresponding to three primary colors(Red,Green,Blue). So the number of colors is 8. The resolution of the PC's screen is 640*400 pixels. On the other hand, Braille printer plotter's resolution is 792*599(step size:0.34mm) but the effective resolution is far lower than that of the screen by the reason mentioned in the following section 5.
To compensate for the lack of resolution, the next operations are effective in the hard-copy process.
(1)hard-copy of the discriminated colors on the screen
(2)hard-copy of the separated colors on the screen
(3)hard-copy by superposition of the selected colors on the screen
(4)selection and control of dot-size and dot-interval on the Braille printer plotter

5 Resolution

The difference of effective resolutions between graphic screen and Braille printer plotter is very large as shown below.

(1)The resolution of graphics screen

Horizontal:<640

Vertical :<400

(2)The resolution of the Braille printer plotter

Plotter step size is about 0.34mm, so the resolution is as follows.

793*600 for 10*11 inch Braille paper

726*480 for 8*10 inch Braille paper

The resolution seems enough to plot embossed dot graphics. But the dots have to be embossed suitably isolated each other not to break paper. It means we have to put intervals of 3 or 5 steps between the dots. So the effective resolution which do not break paper is regarded as the value shown in the following clause (3).

(3)The effective resolution of Braille image for 8*10 inch Braille paper

Horizontal:145-242

vertical :96-160

6 Functions and how to use

We have two types of mode to make a screen hard-copy. One is a TSR(Terminate and Stay Resident) executable program, and the other is a subroutine callable objective program.

(1)TSR program mode(named BHCOPY)

To load and stay resident BHCOPY program, bhcopy command needs to be executed. Once the program is resident, a push of the COPY key at any time starts to make an embossed dots hard-copy of the graphics screen. BHCOPY has several options to change the hard-copy mode. The important options are color selection, dot-s size selection, and dot-interval selection. To change those parameter options, once you haft release the residence and execute the command with new parameters again. The command format is as follows.

(a)Command format

bhcopy [-r] [-?] [-d{0|1|2}] [-i{3|5|7|9}] [-c{a|r|g|b|y|c|m|w|f}]

Default parameters of bhcopy are regarded as "bhcopy -d0 -i5 -ca".

Meaning of the option parameters is as follows.

r-remove the resident program

?-show how to use

d-select dot size(0:Small,1:Medium,2:Large)

i-select dot interval(1unit(step)=0.34mm)

c-select color to make hard-copy

'a':All color,'r':Red,'g':Green,'b':Blue,

'y':Yellow,'c':Cyan,'m':Magenta,'w':White,

'f':read color-dot one-to-one correspondence table from file(col2dot.tab)

(b)Command sample

A>bhcopy -d0 -i3 -cy<return>

Only yellow pixels are extracted and hard-copied using small size dot with interval 3.

A>bhcopy -r<return>

BHCOPY program is removed from memory.

(2)Subroutine callable mode(named GHCOPY)

In this mode users can link the GHCOPY object module and call the function in their program. The calling format is as follows. The meaning of parameters is same as the TSR program mode.

(a)Calling format in C language

void ghcopy(int dotsize,int interval,char color)

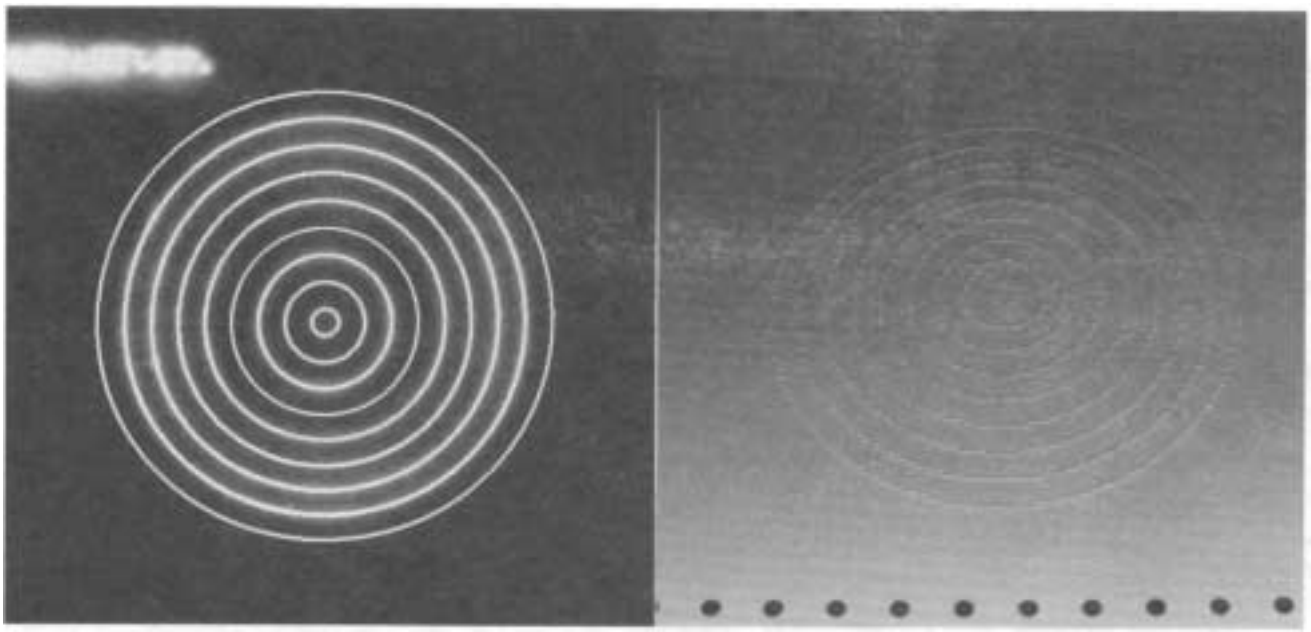
(b)Sample Program

```
void main(void) {ghcopy(0,5,'w');ghcopy(1,7,'g');}
```

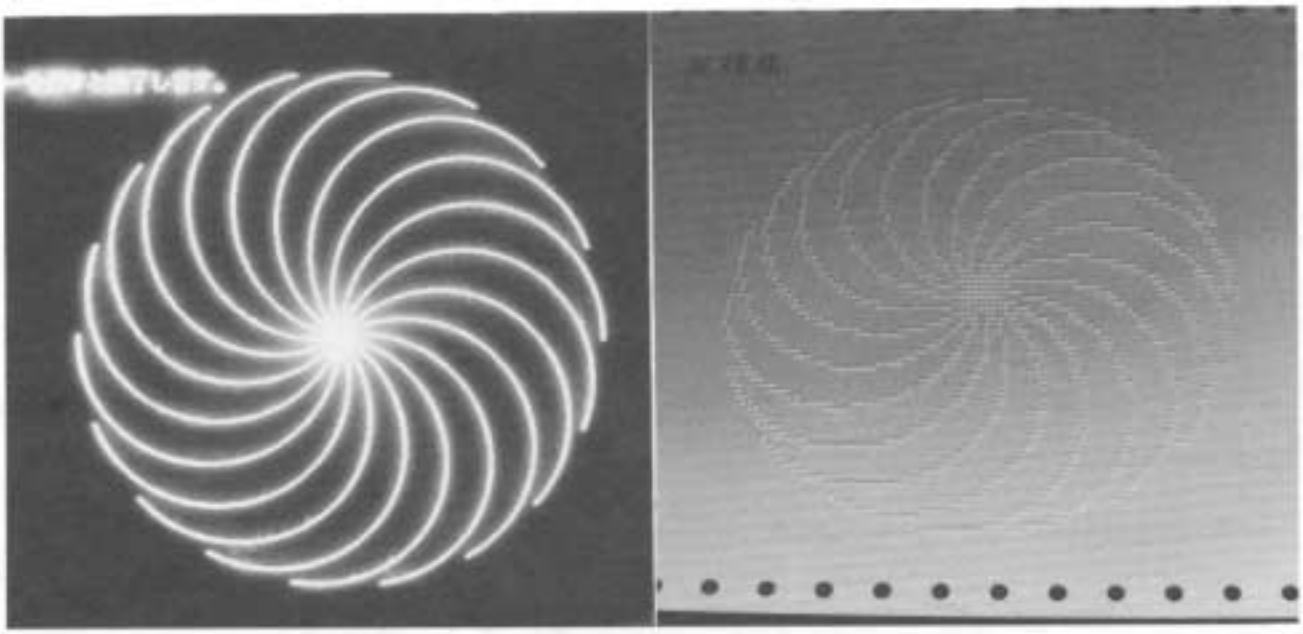
This code makes embossed graphics hard-copy by converting white pixels into small-size embossed dots, and green pixels into medium-size embossed dots.

7 Examples

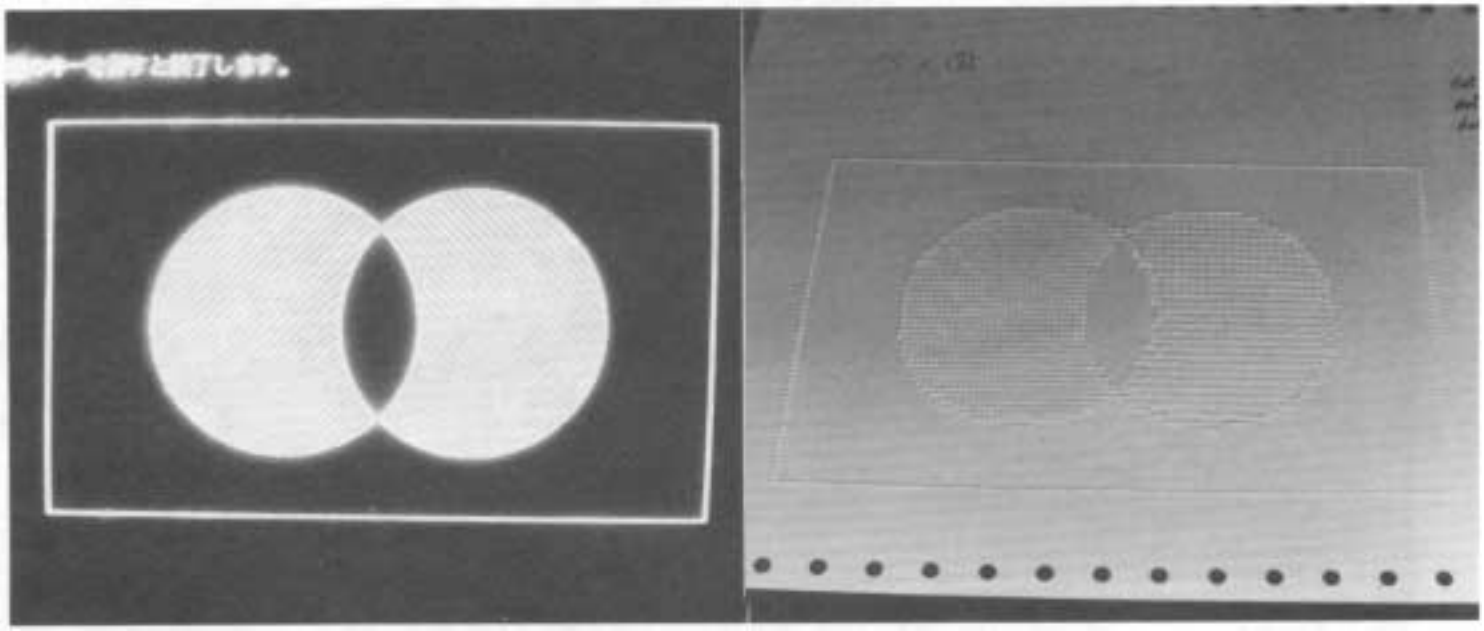
Some examples(named Flower,Concentric circles,Triangular and Quadratic wave,Venn diagram,sin/cos wave) are shown in Picture 2 to 6. They are shown as the pair of an original graphics on the screen and an embossed dots hard-copy. Only hard-copy outputs of a pie chart and a bar chart are shown in Picture 7,8. The original graphics are color and sampled and translated into an embossed dots pattern including one or three types of dot size by selection of option parameter.



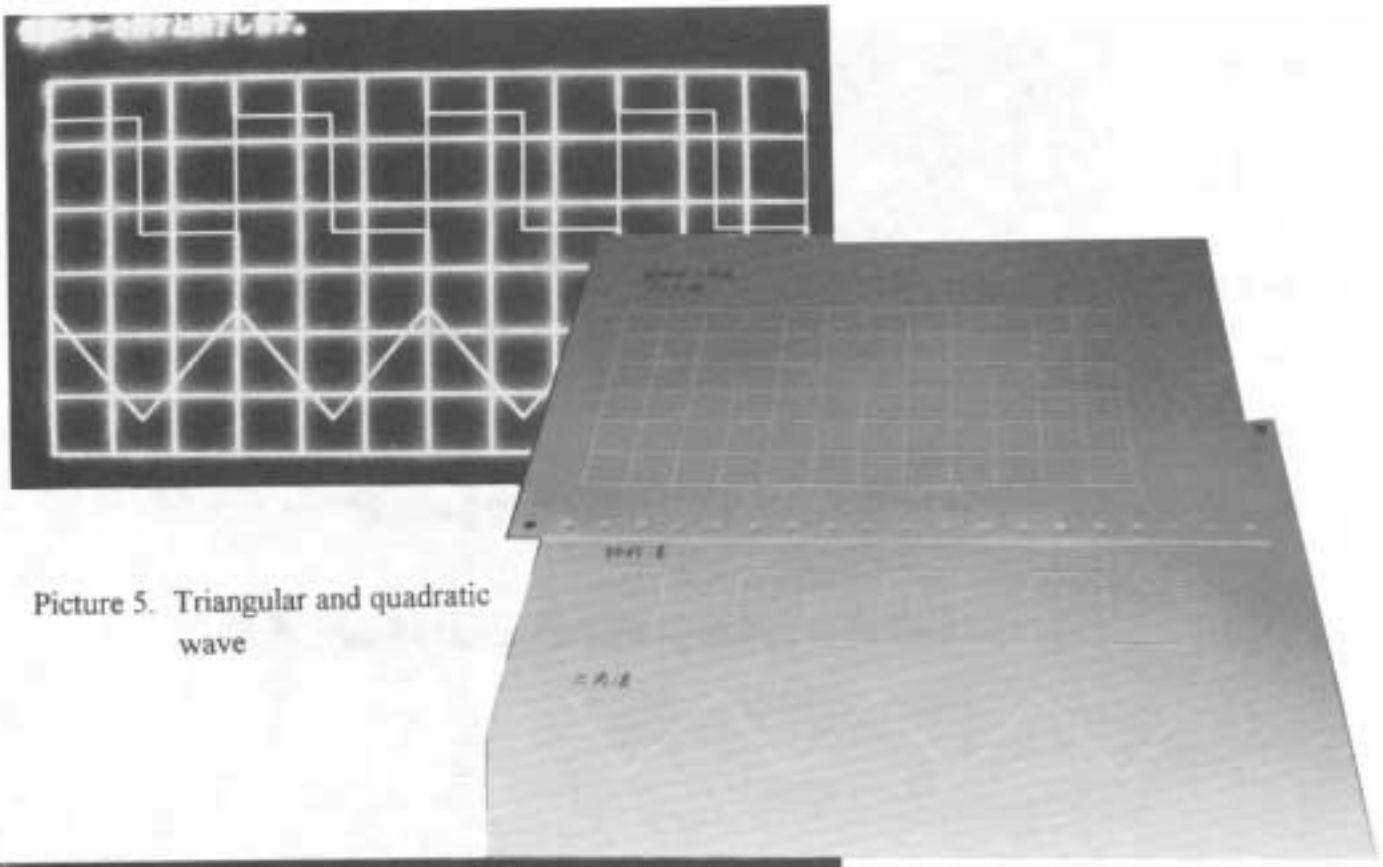
Picture 2. Concentric circles



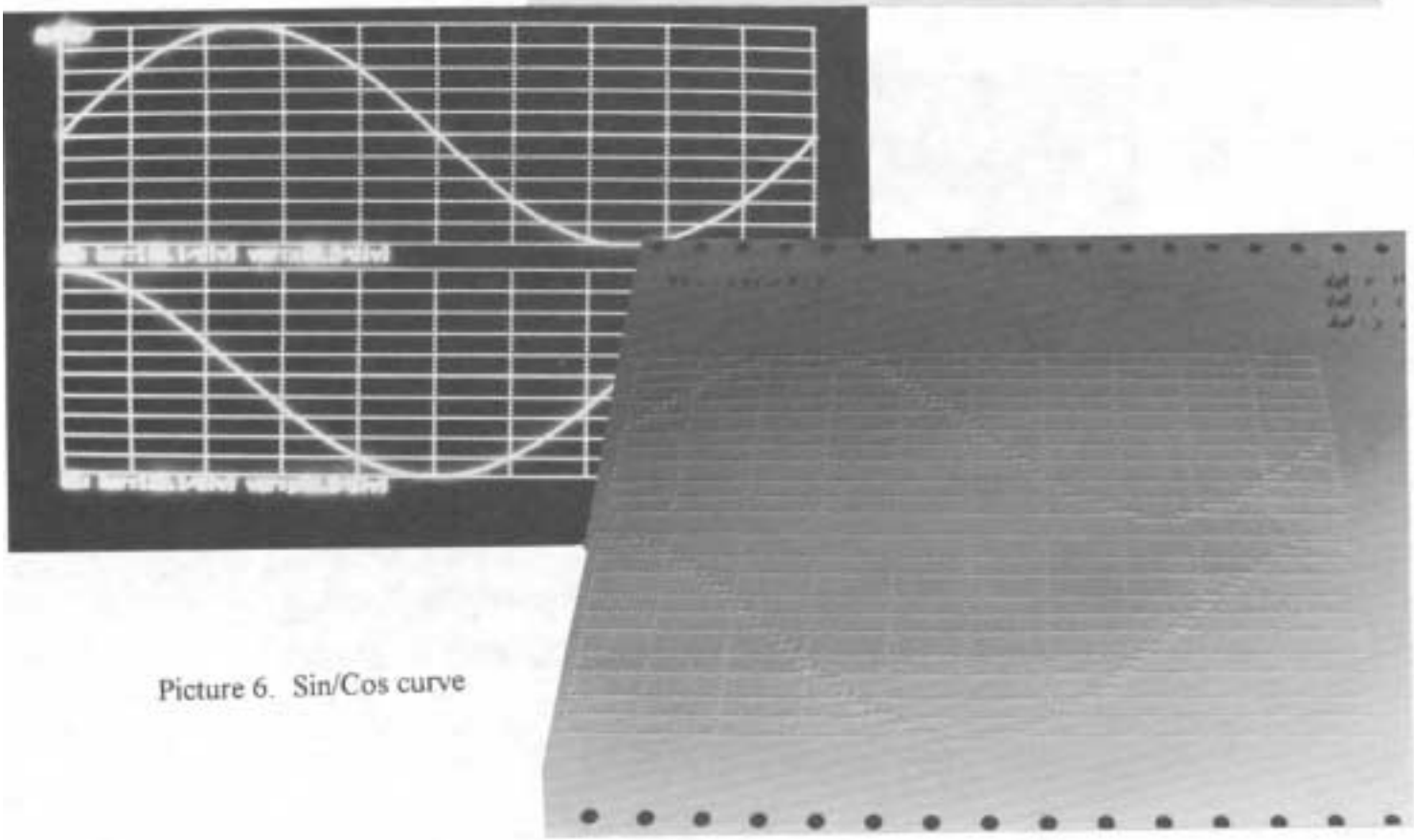
Picture 3. Flower



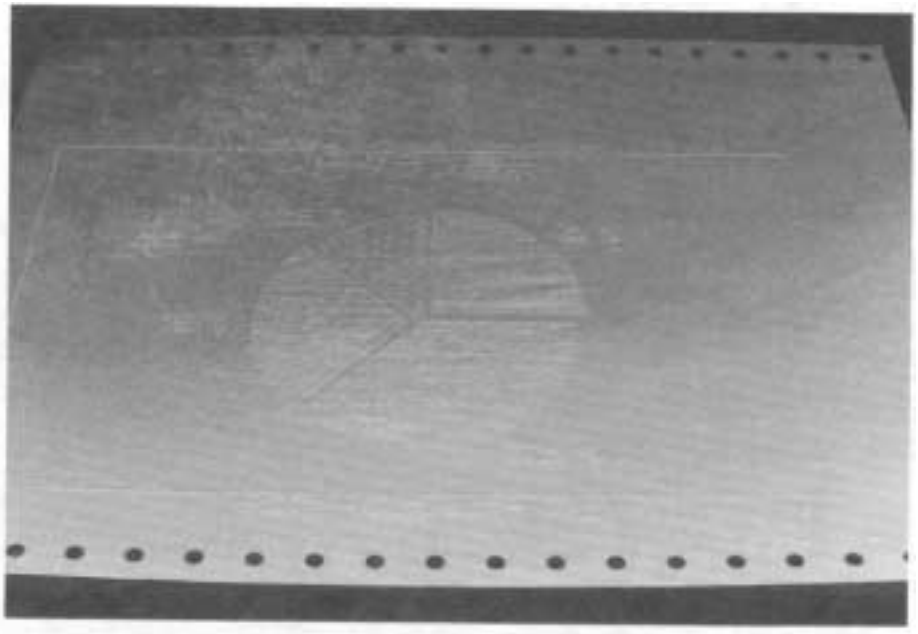
Picture 4. Venn diagram



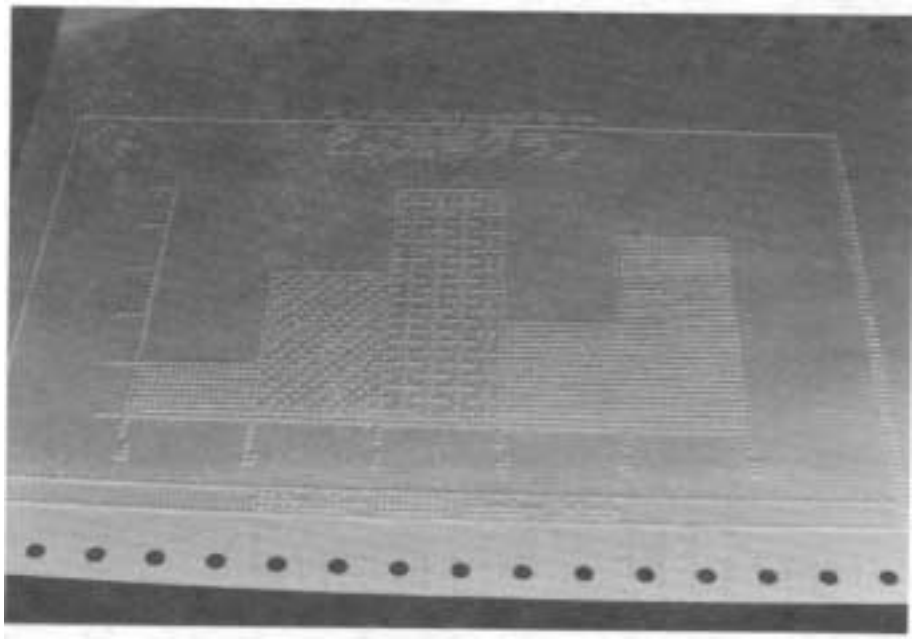
Picture 5. Triangular and quadratic wave



Picture 6. Sin/Cos curve



Picture 7. A hard-copy of pie chart



Picture 8. A hard-copy of bar chart

8 Result and discussion

We have proposed a prototype system for the "active tactile graphics for the blind" as an embossed dots hard-copy system on PC. And we find out the following facts and make them possible in our system.

Color graphics on the screen tend to be colorful and complex for the blind to recognize at once by tactile sensation. So that the blind can recognize these complex graphics by tactile sensation, simplification process of the picture elements is essential. From this point of view we propose to decompose the graphics on the screen into several elements according to colors and produce each color pattern as a hard-copy. This process not only simplifies the color graphics but also help the blind find out the color organization of the graphics. After that decomposition and recognition process, the superposed hard-copy of all color elements can also be understood as a whole graphics.

We are often asked by blind persons to translate graphics characters into Braille characters in a hard-copy process. But I have to say it's too hard. The reason is as follows. On the GVRAM, there are no character and geometric information left such as character codes, dot, line, rectangle, circle and so on other than pixels. To make this possible, maybe a kind of high performance pattern recognition method has to be put in.

References

[1]Satoshi INA:Development of 2D Tactile Graphics Editor and Printing System for Document with Braille and Graphics.,IEICE EIC,Vol.J77-D-II,No.10,pp1973-1983,1994.(in Japanese)

[2]Satoshi INA:Personal computer aided tactile graphics system.,International Conference on higher education for students with disabilities,ABSTRACTS pp.C-II-c,1993.

[3]JTR Inc.:NEW ESA721braille printer user's manual,1990

[4]Telesensory Systems Inc.,OPTACON user's manual