

# Two-stage high-precision visual inspection of surface mount devices

Hong Kyu Chung

Rae-Hong Park

Sogang University

Department of Electronic Engineering

C.P.O. Box 1142

Seoul 100-611, Korea

E-mail: rhpark@ccs.sogang.ac.kr

---

**Abstract.** A two-stage high-precision algorithm for detecting the orientation and position of the surface mount device (SMD) is described. In the preprocessing step, a coarse orientation of the SMD is obtained by line fitting. A high-precision fuzzy Hough transform (FHT) is applied to the corner points to estimate precisely the orientation of the device, with its position determined by using four detected corner points. The FHT employed has a real-valued accumulator over the limited range of angles that is determined in the preprocessing step. Computer simulation with a number of test images shows that the parameters obtained by the presented algorithm are more accurate than those by conventional methods such as the moment method, projection method, and Hough transform methods. It can be applied to fast and accurate automatic inspection and placement systems. © 1997 SPIE and IS&T. [S1017-9909(97)00904-5]

---

## 1 Introduction

With the development of industrial electronic technology, various surface mount devices (SMDs) used in many electronic goods have been highly functional and integrated, and they have become smaller and lighter. Recently by using robots, productivity has been dramatically increased and computers can easily control a robot for mounting SMDs on a printed circuit board (PCB) automatically, precisely, and flexibly. It is reported that the pitch between SMD leads is getting smaller, for example, less than 0.5 mm,<sup>1</sup> the number of leads are getting larger, and the size of the devices is becoming smaller. So one of the most important things for a mounting system is to employ fast and high-precision vision algorithms for detecting the orientation and position of SMDs. If position or orientation error occurs, it is necessary to pass the detected parameters over to a robot control system to compensate for misalignment. Examples of vision based industrial applications<sup>2</sup> are found in several areas such as a die bonding system,<sup>3</sup> VLSI mask inspection,<sup>4</sup> PCB inspection,<sup>5</sup> and SMD inspection and position alignment system under special illumination.<sup>6,7</sup> This paper presents a fuzzy Hough transform (FHT) based algo-

gorithm for precisely detecting the orientation and position of the SMD. This algorithm can be applied to a fast and high-precision visual inspection system.

Conventional algorithms for detecting the orientation and position of the SMD are briefly reviewed. A moment method<sup>8</sup> which finds the line passing through the principal axis of an object can be used to detect the orientation and position of the device by calculating the first and second moments. Horn obtained the information of orientation and position from data projected along horizontal, vertical, and diagonal directions.<sup>8</sup> This projection method is faster than the moment method, however, for multiple objects overlapped in the projection space, it cannot detect each object correctly. In the conventional Hough transform (HT) method, each edge point was transformed by a given parametric equation, and the cell having the maximum value in the parameter space was detected to determine the final orientation. This HT based method is robust to noise, but it requires complex computations. To reduce the computation time required for the HT, only corner points were used which were detected by a contour following and corner finding algorithm.<sup>9</sup> Also the algorithm with subpixel accuracy using morphology<sup>10</sup> was presented for accurate inspection.

The HT technique is effective in finding several pieces of lines in an image with low sensitivity to noise, but it requires high computational complexity when parameters in a Hough domain require high precision. Compared to conventional methods, the proposed two-stage algorithm requires much less computation, and detects the orientation and position more precisely. In the preprocessing step, corner points are detected based on the chain codes of edge contours of SMD leads. Then the extracted corner points are separated into two groups with each group existing in opposite sides to the principal axis of the SMD. Then the coarse angle of the principal axis is obtained by averaging two angles detected by a moment line fitting algorithm with two groups of corner points.

The FHT is applied to the detected corner points of SMD leads over the limited angle range that is determined in the preprocessing step. The FHT used is different from the conventional HT techniques in accumulating the vote.

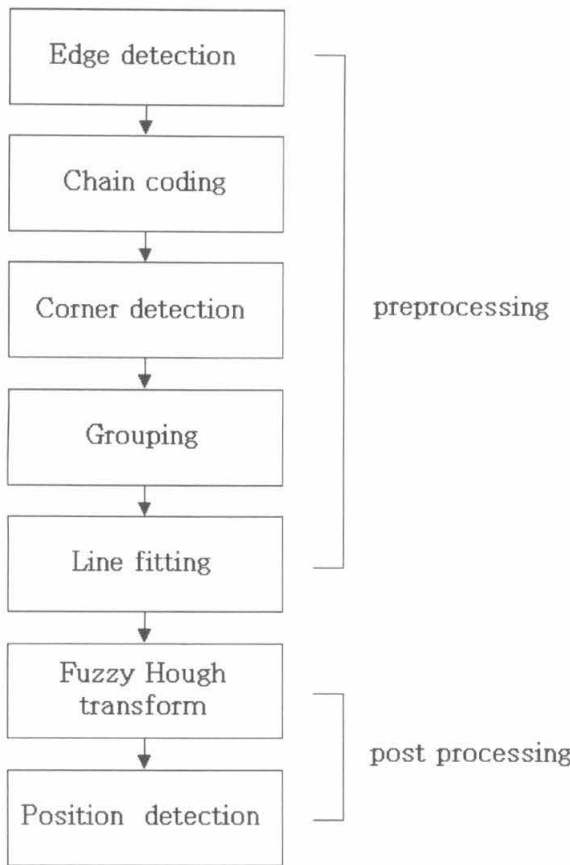


Fig. 1 Flowchart of the proposed detection algorithm of orientation and position of the SMDs.

The FHT uses a real-valued accumulator to employ a real membership function that is centered at a parameter value computed. The results of the FHT are better than those of the conventional HT. The limited angle range in the HT is determined by the coarse angle obtained in the previous step. Thus the orientation of the SMD can be detected more precisely with much finer resolution of the Hough array. The SMD position may also be determined by using the detected orientation and its four corner points.

## 2 Detection of the Orientation and Position of the SMD

A two-stage algorithm that detects the orientation and position of the SMD based on the FHT is proposed in this paper. A preliminary version of this paper was presented in Ref. 11. It consists of preprocessing and post processing steps, as shown in Fig. 1. Each unit is briefly described in the following.

### 2.1 Preprocessing Step

The detection algorithm analyzes a gray level image of the SMD. In a preprocessing step, its boundary points as well as corner points are detected. Based on coordinate values of extracted corner points, two groups are formed with each group existing in the opposite side with respect to the prin-

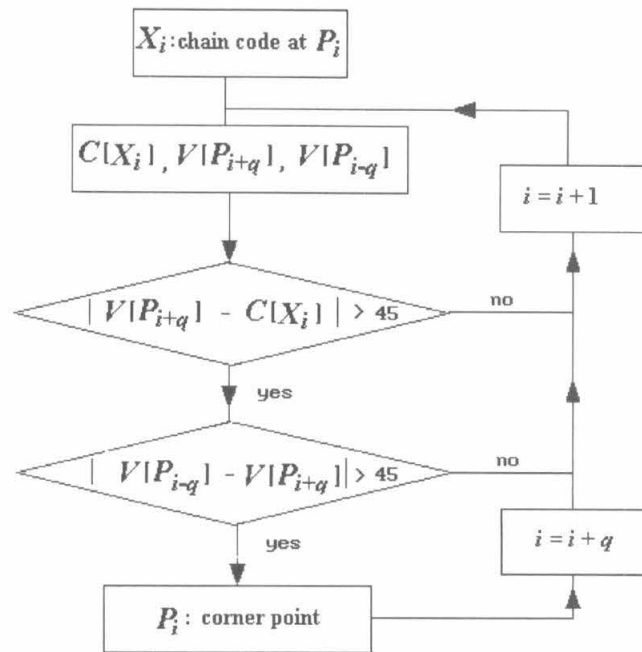


Fig. 2 Flowchart of the corner detection algorithm.

cipal axis of the SMD. Then the coarse orientation of the principal axis is obtained by averaging two angles detected by a moment line fitting algorithm.

First, the gray level image is smoothed for noise reduction and the smoothed image is converted to a binary image by thresholding. Then boundary points are detected and represented by chain codes,<sup>12</sup> in which an initial point and a set of successive 8-directional vectors are specified. Corner points of the SMD are feature points describing its boundaries. There are several methods<sup>13</sup> to detect them from the given chain codes. In this research, we extract them by tracing directional vectors which are represented by the difference chain codes.

The flowchart of the corner extraction algorithm is shown in Fig. 2. Let  $X_i$  represent the chain code at point  $P_i$ , and  $C[X_i]$  denote the chain code value at point  $P_i$  represented as an integer multiple of 45 (degrees). For example,  $C[X_i]$  is equal to 90 (degrees) if the chain code  $X_i$  is equal to 2.

If two conditions  $|V[P_{i+q}] - C[X_i]| > 45$  (degrees) and  $|V[P_{i-q}] - V[P_{i+q}]| > 45$  (degrees) are satisfied, the point  $P_i$  is determined as an edge point, where  $V[P_{i-q}]$  represents the angle in degree between the horizontal line and a line connecting two points  $P_{i-q}$  and  $P_i$ . The angle  $V[P_{i+q}]$  is similarly defined. We select  $q$  experimentally, ranging 4 to 12, depending on the noise level of an input image and the type of the SMD.

Next, detected corner points are separated into two groups that are located in the opposite sides with respect to the principal axis of the SMD. Then each group is fitted to a line and the fitted line is used to detect the coarse orientation. Let  $c_i$  denote the detected corner point,  $1 \leq i \leq I$ , where  $I$  signifies the number of corner points, and  $V(c_{i+1})$  represent the angle in degree between the horizontal line and a line connecting current corner point  $c_i$  and the next

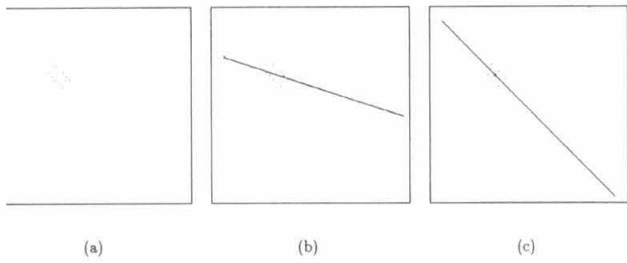


Fig. 3 Extracted corner points and the detected principal axis. (a) Extracted corner points. (b) Line fitting by the least-squares method. (c) Line fitting by the moment method.

one  $c_{i+1}$ , then a grouping algorithm is described as follows:

1. Initialize  $i$ .
2. Calculate  $V(c_{i+1})$ .
3. If  $V(c_{i+1})$  is different from the angle of grouping vectors previously detected and stored in memory,  $c_{i+1}$  is determined as a new starting corner point and it forms a new group.

Each group of corner points extracted in the previous step forms two parallel lines. Figure 3(a) shows an example of detected corner points. Detection of the coarse orientation may be performed by the line fitting method. However, note that we may obtain the incorrect orientation with the least-squares line fitting method, as illustrated in Fig. 3(b). The line fitting method is somewhat sensitive to noise, thus the final detection of orientation is achieved by the high-precision HT that is robust to noise.

To obtain the exact orientation, we use the moments of inertia<sup>14</sup> of edge points forming two parallel lines. Let  $M_{ij}$  denote the  $(i+j)$ 'th moment as given by

$$M_{ij} = \sum_x \sum_y (x-x_0)^i (y-y_0)^j f(x,y), \quad (1)$$

where  $f(x,y)$  represents the gray level at  $(x,y)$ , and  $(x_0,y_0)$  denotes its centroid as defined by

$$x_0 = \frac{\sum_x \sum_y x f(x,y)}{\sum_x \sum_y f(x,y)}, \quad (2)$$

$$y_0 = \frac{\sum_x \sum_y y f(x,y)}{\sum_x \sum_y f(x,y)}. \quad (3)$$

We determine the orientation  $\alpha$  of the SMD by minimizing the cost function  $E$  defined by

$$E = \sum_x \sum_y d^2(x,y) f(x,y), \quad (4)$$

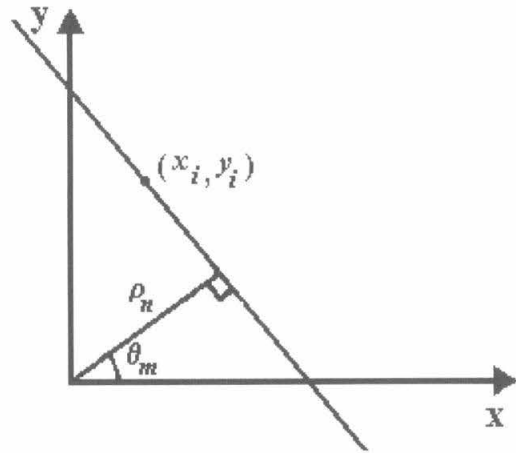


Fig. 4 Hough transformation to the  $\rho$ - $\theta$  parameter space.

where  $d(x,y)$  denotes the distance to the fitted line from a point  $(x,y)$ .<sup>8</sup> The orientation  $\alpha$  is calculated by

$$\alpha = \frac{1}{2} \tan^{-1} \frac{2M_{11}}{M_{20} - M_{02}}, \quad (5)$$

where  $\alpha$  represents the angle between the fitted line and the  $x$  axis. As shown in Fig. 3(c), the moment line fitting gives better results than the least-squares line fitting method.

### 2.2 Post Processing Step

In the post processing step, the final orientation of the SMD is determined. In this paper, an FHT is applied to the detected corner points over the limited angle range centered at the coarse orientation value computed in the preprocessing step. Also its position is detected by using the four corner points.

The HT<sup>15</sup> is a well-known method for extracting line segments in an image. Dominant line segments are detected by finding the peak parameter values in the HT domain. The line equation passing through a point  $(x_i, y_i)$  can be expressed as

$$\rho_n = x_i \cos \theta_m + y_i \sin \theta_m, \quad (6)$$

where  $\rho_n$  denotes the distance to the line from the origin and  $\theta_m$  signifies the angle between the  $x$  axis and the line perpendicular to the detected line. Figure 4 shows a line and its Hough transformation to the  $\rho$ - $\theta$  parameter space. The coordinate value  $(x_i, y_i)$  in a  $D_x \times D_y$  image plane is transformed into the parameter space  $(\rho, \theta)$ . Then the parameter indices  $n$  and  $m$  satisfy the inequalities as given by

$$-\frac{\sqrt{D_x^2 + D_y^2}}{\rho_q} \leq n \leq \frac{\sqrt{D_x^2 + D_y^2}}{\rho_q}, \quad 0 \leq m \leq \frac{180}{\theta_q}, \quad (7)$$

where  $\rho_q$  and  $\theta_q$  denote the quantization step sizes of  $\rho$  and  $\theta$ , respectively. The angle is assumed to be in the range of 0 and 180 degrees.

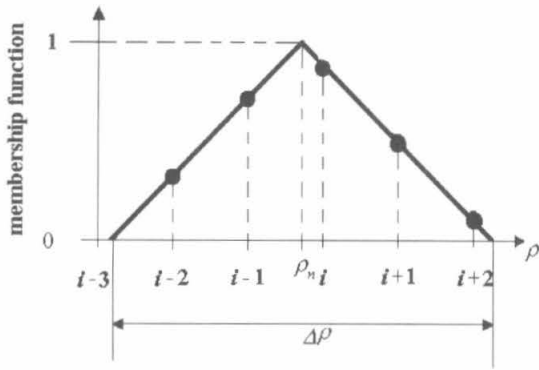


Fig. 5 FHT accumulator.

In the conventional HT, though  $\rho$  is real, the parameter space  $(\rho, \theta)$  is incremented by one. But in the FHT employed, the parameter space  $(\rho, \theta)$  accumulates the real value. Figure 5 shows an example of the real-valued accumulation process of the FHT using a triangular membership function, where  $\rho_n$  is located between the  $(i-1)$ 'st and  $i$ 'th cells. The point  $\rho_n$  calculated by Eq. (6) has a weight factor of one, and adjacent integer points have real weight values specified by a membership function centered at  $\rho_n$ . In the case of noisy images, the FHT gives better results than the conventional HT. The membership functions considered in our experiments are shown in Fig. 6. Two-dimensional exponential, circular, and triangular membership functions

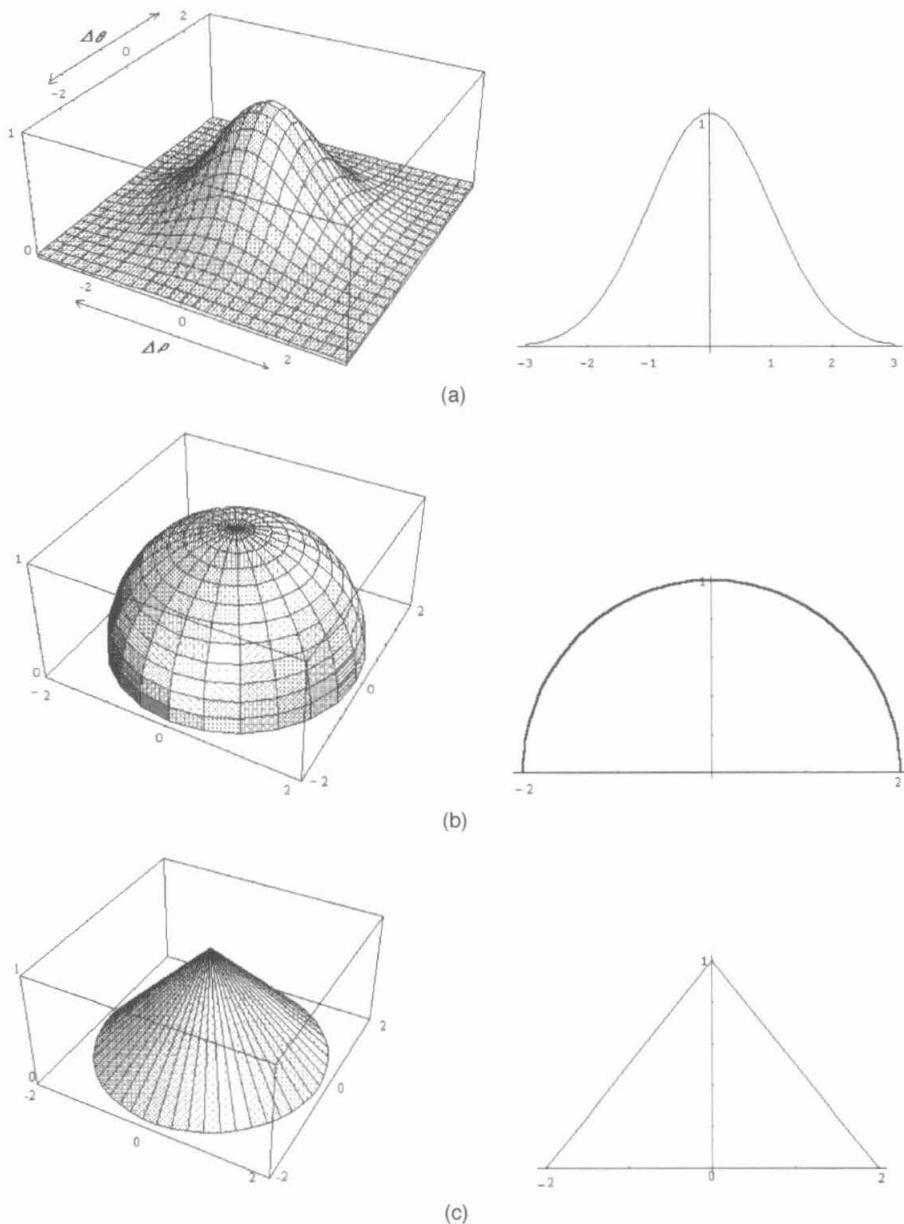


Fig. 6 Membership functions employed in FHT. (a) Exponential membership function. (b) Circular membership function. (c) Triangular membership function.

along with their 1-D profiles are shown in Figs. 6(a), 6(b), and 6(c), respectively. The proposed algorithm was simulated with several fuzzy membership functions: 2-D membership functions applied to the  $\rho$  and  $\theta$  axes, and 1-D membership functions applied only to the  $\rho$  axis. In our experiments, both the width  $\Delta\rho$  and  $\Delta\theta$  are selected experimentally and set to 5.

After transformation, the cell having the highest vote is selected. The accuracy of orientation detection depends on the quantization step size of an angle. In the post processing step, detection of orientation is performed over the limited range centered at the angle detected roughly in the preprocessing step. Note that we use only corner points of SMD leads and detect precisely its orientation using by the high-precision FHT.

The position of the SMD may also be determined using a grouping algorithm in the preprocessing step. After extracting four corner points, its position is determined as an intersecting point determined by two diagonal lines.

The presented algorithm requires a high-quality image for good performance, in which binarization is employed. The threshold value for binarization is a critical value for good performance of the algorithm. So a perfect back-lighted image without impulse noise is required. If the detected edge is blurred or not reliable, the algorithm might yield the angle or position different from the accurate one.

### 3 Experimental Results and Discussions

Computer simulation is performed on a MIPS workstation using C language. Each input image is  $512 \times 512$  and it is uniformly quantized to eight bits. Figure 7 shows eight test images which are used in experiments. The whole test images were captured by a camera with backlighting. Test images in Figs. 7(a), 7(b), 7(c), and 7(d) are rectangular-type SMDs with 14 pins. Their orientations are 0, 5,  $-6$ , and 7 degrees with their positions being (226, 253), (238, 241), (202, 274), and (249, 268), respectively. Note that the position is defined by the center coordinate of the device, with (0,0) representing the top left point of an image. The orientation is represented by an angle between the principal axis of the SMD and the horizontal  $x$  axis. The test images in Figs. 7(e), 7(f), 7(g), and 7(h) are the square quad flat package (QFP) type SMDs with 80 pins. Their orientations are 3,  $-1$ , 1, and  $-4$  degrees with their positions being (274, 281), (272, 240), (251, 281), and (266, 283), respectively.

Figure 8 illustrates extracted corner points of test images shown in Fig. 7, where the symbol  $\times$  shows grouping points. Blunt leads of the SMD cause slight positional error in detecting orientation. Table 1 lists the preprocessing results, where the detected angle is obtained by averaging two angles computed from two lead groups. Table 1 shows that the preprocessing step gives coarse orientations of the devices and a small amount of error exists due to noise.

A performance comparison of various orientation detection methods is listed in Table 2. Also Fig. 7 shows the final results with detected center position represented by a white dot and orientation by a line. Orientation detection by the HT is equivalent to selecting a peak in the Hough array cell. If the maximum value occurs at multiple cells which

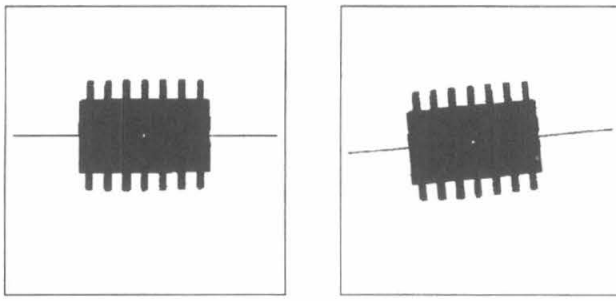
are adjacent, the final orientation is determined by averaging their orientation angles. The original HT method using all the edge points detected requires high computational complexity. In computer simulations, the  $\theta$ -resolution of the proposed technique in the HT is set to 0.01, 0.02, and 0.05 degree, and the search angle range is set to  $\pm 2$  degrees from the coarse orientation detected in the preprocessing step.<sup>11</sup> In the proposed two-stage algorithm, high precision in orientation and position is accomplished by small parameter resolution whereas reduction in computation time is achieved by small search angle range, which is possible by coarse detection of orientation in the preprocessing step. Note that moment and projection methods cannot be applied to QFP types, because the moment of inertia is diagonal for perfectly symmetric QFP types. For example, for test images in Figs. 7(e) through 7(h), the moment and projection methods detect the orientation incorrectly while the proposed algorithm can detect it correctly (see Table 2). The presented algorithm employs a 2-D exponential fuzzy membership function that produces better results than any other membership functions shown in Fig. 6. Note that the polarity of the SMD is not considered; in other words, the orientation of a rectangular SMD has a periodicity of 180 degrees and that of a QFP type SMD has a periodicity of 90 degrees. Thus the orientation of a rectangular SMD ranges from  $-90$  to 90 degrees and that of a QFP type SMD ranges from 0 to 90 degrees.

A performance comparison of various position detection methods is listed in Table 3. In terms of the accuracy of position detection, the performance of the presented algorithm is better than that of the conventional algorithms. Note that the accuracy of the detected position by the presented algorithm is higher than that of the conventional algorithms.

A comparison of the computation time is illustrated in Table 4. As observed in Table 4, the computational complexity of the presented algorithm is greatly reduced by the preprocessing step, compared with that of the conventional HT method. The search angle range is set to  $\pm 2$  degrees from the coarse orientation. If the search angle range is further decreased, it can further reduce the computation time.

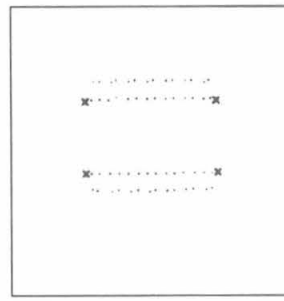
### 4 Conclusions

This paper presents a two-stage high-precision algorithm using the FHT for detecting the orientation and position of the SMD. The presented algorithm consists of two steps: a preprocessing step and post processing step, in which corner points of the SMD are detected and the FHT is applied to only corner points over the limited range of angles determined by the preprocessing step. Note that high precision in orientation and position detection, and reduction in computation time are achieved by the coarse detection of orientation in the preprocessing step. Computer simulation shows that the presented algorithm gives better performance than other conventional algorithms with lower computational complexity and higher precision in orientation. Further research will focus on the development of the faster and more precise visual inspection algorithm, and on investigation of its hardware implementation.



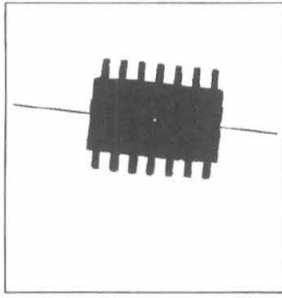
(a)

(b)



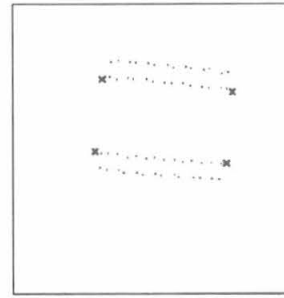
(a)

(b)



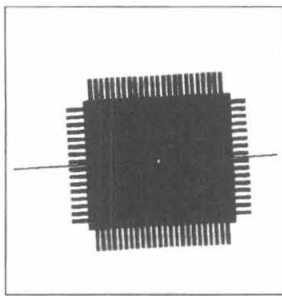
(c)

(d)



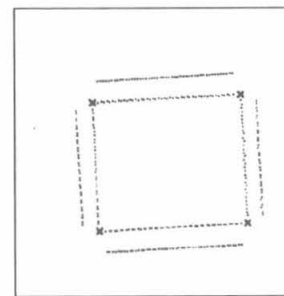
(c)

(d)



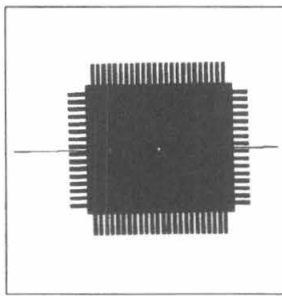
(e)

(f)



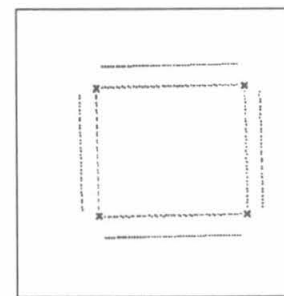
(e)

(f)



(g)

(h)



(g)

(h)

Fig. 7 Test images.

Fig. 8 Extracted corner points of Fig. 7.

**Table 1** Line fitting results in the preprocessing step (unit: degree).

test images	orientation	
	detected	correct
Fig. 7(a)	0.682	0
Fig. 7(b)	5.349	5
Fig. 7(c)	-5.349	-6
Fig. 7(d)	7.519	7
Fig. 7(e)	3.023	3
Fig. 7(f)	-0.912	-1
Fig. 7(g)	0.806	1
Fig. 7(h)	0.445	-4

**Table 2** Results of orientation detection (unit: degree).

methods	test images											
	Fig. 7(a)	Fig. 7(b)	Fig. 7(c)	Fig. 7(d)	Fig. 7(e)	Fig. 7(f)	Fig. 7(g)	Fig. 7(h)				
moment <sup>B</sup>	0.738	5.702	-5.264	7.696	2.912	-5.273	-0.779	-3.772				
projection <sup>B</sup>	0.098	5.094	-6.056	7.119	-0.953	-5.279	-3.146	-7.528				
Hough { Proposed	edge	1	1.000	5.750	-5.250	8.000	3.500	-1.250	1.250	-4.125		
	corner	1	1.000	6.000	-6.500	7.725	3.500	-1.250	-1.500	-4.000		
	non fuzzy		0.01	0.190	5.040	-5.780	7.340	3.030	-1.175	1.010	-4.030	
			0.02	0.124	5.040	-5.770	7.340	3.040	-1.180	1.020	-4.030	
			0.05	0.125	5.250	-5.750	7.200	3.100	-1.175	1.050	-4.025	
		2-D Exponential Fuzzy		0.01	0.005	5.000	-5.991	7.005	3.000	-1.010	1.000	-4.000
				0.02	0.030	5.032	-5.974	7.014	3.010	-1.030	1.000	-4.000
		0.05	0.085	5.070	-5.985	7.075	3.040	-1.050	0.995	-4.010		
	correct orientation	0.0	5.0	-6.0	7.0	3.0	-1.0	1.0	-4.0			

**Table 3** Results of position detection.

test images	methods			
	moment <sup>B</sup>	projection <sup>B</sup>	proposed method (fuzzy)	correct position
Fig. 7(a)	(225, 252)	(225, 253)	(226.88, 253.14)	(226, 253)
Fig. 7(b)	(239, 241)	(239, 241)	(238.10, 241.02)	(238, 241)
Fig. 7(c)	(201, 274)	(201, 274)	(202.01, 274.00)	(202, 274)
Fig. 7(d)	(249, 268)	(249, 268)	(249.01, 268.05)	(249, 268)
Fig. 7(e)	(120, 136)	(120, 136)	(120.20, 136.00)	(120, 136)
Fig. 7(f)	(272, 241)	(272, 241)	(272.02, 240.01)	(272, 240)
Fig. 7(g)	(251, 281)	(251, 281)	(251.00, 281.03)	(251, 281)
Fig. 7(h)	(265, 283)	(266, 283)	(266.01, 283.03)	(266, 283)

**Table 4** Comparison of the computation time.

methods	moment <sup>B</sup>	projection <sup>B</sup>	Hough	Hough	proposed methods	
			transform (edge points)	transform <sup>9</sup> (corner points)	non fuzzy	fuzzy
time (sec)	0.32	0.29	8.02	2.10	0.17	0.42

## Acknowledgment

This work was supported in part by the Engineering Research Center for Advanced Control and Instrumentation (Korea Science and Engineering Foundation).

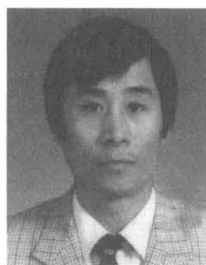
## References

1. Y. Todo, "Mounting technology heads for finer pitches and CFC-free cleaning," *Nikkei Electronics Asia* **1**, 18–26 (1992).
2. R. T. Chin, "Survey automated visual inspection: 1981 to 1987," *Computer Vision, Graphics, Image Process.* **41**, 346–381 (1988).
3. B. J. You, Y. S. Oh, and Z. N. Bien, "A vision system for an automatic assembly machine of electronic components," *IEEE Trans. Industrial Electronics* **IE-37**, 349–357 (1990).
4. D. B. Shu, C. C. Li, J. F. Mancuso, and Y. N. Sun, "A line extraction method for automated SEM inspection of VLSI resist," *IEEE Trans. Pattern Anal. Machine Intell.* **PAMI-10**, 117–125 (1988).
5. Y. Hara, H. Doi, K. Karasaki, and T. Iida, "A system for PCB automated inspection using fluorescent light," *IEEE Trans. Pattern Anal. Machine Intell.* **PAMI-10**, 69–77 (1988).
6. R. M. Haralick and L. G. Shapiro, *Computer and Robot Vision*, Vol. I, pp. 157–255, Addison-Wesley, Reading, MA (1992).
7. D. W. Capson and R. M. C. Tsang, "Automatic visual measurement of surface-mounting device placement," *IEEE Trans. Robotics and Automation* **RA-6**, 44–52 (1990).
8. B. K. P. Horn, *Robot Vision*, pp. 46–61, MIT Press, Cambridge, MA (1988).
9. G. C. Cha, I. S. Park, and J. S. Choi, "A study on the real-time processing of the position matching and inspection algorithm in SMT," *J. Korean Institute Telematics Electronics* **29-B**, 76–84 (1992).
10. H. K. Chung and R. H. Park, "High-precision inspection and alignment of surface mounting devices," *Optical Engineering* **35**, 1820–1827 (1996).
11. H. K. Chung and R. H. Park, "Orientation and position detection of surface mounted devices and printed circuit boards using the high-resolution FHT," *Optical Engineering* **33**, 2079–2082 (1994).
12. R. C. Gonzalez and P. Wintz, *Digital Image Processing*, pp. 392–394, Addison-Wesley, Reading, MA (1977).
13. H. C. Liu and M. D. Srinath, "Corner detection from chain-code," *Pattern Recognition* **23**, 51–68 (1990).

14. Z. Hussain, *Digital Image Processing*, pp. 165–166, Ellis Horwood, London (1991).
15. R. O. Duda and P. E. Hart, "Use of the Hough transformation to detect lines and curves in pictures," *Communs. ACM* **15**, 11–15 (1975).



**Hong Kyu Chung** received the BS and MS degrees in electronic engineering from Sogang University, Seoul, Korea, in 1992 and 1994, respectively. He was a HDTV design engineer at Samsung Electronics from February 1994 to January 1997. He is currently with LSI Logic Corporation. His research interests include ASIC design, CoreWare, computer vision, and image processing.



**Rae-Hong Park** received the BS and MS degrees in electronics engineering from Seoul National University, Seoul, Korea, in 1976 and 1979, respectively. He received the MS and PhD degrees in electrical engineering from Stanford University, Stanford, California, in 1981 and 1984, respectively. He joined the faculty of the Department of Electronic Engineering at Sogang University, Seoul, Korea, in 1984, where he is currently a professor. In 1990,

he spent his sabbatical year at the Computer Vision Laboratory of the Center for Automation Research, University of Maryland, College Park, Maryland, as a visiting associate professor. His current research interests are computer vision, pattern recognition, and video communication. He is a member of the KITE, KICS, KISS, KIEE, SPIE, and IEEE.



---

## BOOK REVIEWS

---

### Computer Visualization

Richard S. Gallagher, Ed. 352 pages. ISBN 0-8493-9050-8. CRC Press, Boca Raton, Florida (1994) \$79.95.

*Reviewed by* Lawrence A. Ray, Eastman Kodak Company, Transaction Imaging, Rochester, New York 14650-0312.

Anyone who has ever used a graph as a means of understanding data and mathematical concepts has already stepped into the realm of scientific visualization. However, this step is but the first of a longer journey into the potential of viewing data, and the insights that can be achieved when the power of computer graphics is applied. While it seems quite natural to view data in terms of graphs and charts, the use of computer visualization via computer graphics is a relatively recent phenomenon. The purpose of this book is to expose the scientific community to the techniques and methods of computer visualization.

This book is an edited collection of chapters, and as many such books, suffers from an irregular presentation and depth of content. On the whole it is a fair treatment of the subject and is a reasonable introduction to the topic. A natural use of scientific visualization is for computer-aided engineering, as the depiction of data sets on some engineering part. The use of false color-coded data across the surface representing some quantity, such as heat or stress, is obvious. What is not so obvious are the methods of conveying dynamic motions, flows, and time-dependent phenomena in an easy to understand manner. Finding the right paradigm to display data which simplifies the viewers' insight into a phenomenon is an art. One good aspect of this book is that it presents many instances where this occurs.

Richard S. Gallagher, the editor, is the head of computer graphics at Swanson Analysis Systems, a producer of CAD software. This is perhaps one reason the book seems largely written from the perspective of engineering. My objection to this is that the book advertises itself to be scientific visualization, not strictly engi-

neering visualization. The methods and approaches to other areas of visualization, such as molecular modeling, turbulence, and mathematics, are not presented as well as one would hope.

The book is segmented into three sections, with a total of ten chapters. The sections are introductory material, techniques, and application issues. The first chapter is the required introduction to the material, which is heavily weighted in terms of engineering applications, followed by a chapter that contains a brief description of computer graphics. Since a single chapter can hardly begin to encompass the field of computer graphics, the chapter is a high level overview of some of the most basic concepts. If one is already familiar with computer graphics, then the chapter can be omitted.

The most substantive material is in the section on techniques. Among the chapters of this section, the best chapters describe a unified framework for flow visualization and continuum volume displays. Both of these chapters break away from strict engineering methods and look at more general methods. In particular the use of flow fields, vector traces, and icons to represent data in a coherent manner are explored. Visual exploration of volumetric data brings a host of new problems. Being able to query the interior of volumetric data and methods of how to extract data in an efficient manner are described. The "Marching Cubes" algorithm is also touched on. Extracting isosurfaces within a volume is not a simple operation and one that if not done properly results in an unsatisfying visual result.

The chapter on producing animations is rather shallow. It is, at best, hints for the novice. Most of the information will become immediately apparent to anyone attempting to produce an animation and then have it recorded into a video format. Since it is unlikely that someone will purchase the equipment to perform this task without first gaining some experience by working with a knowledgeable person, the value of the chapter is limited.

Despite some of its shortcomings, this book is still worthwhile to one interested

in computer visualization. A potential reader should be aware of its bias toward mechanical engineering. While it is not a definitive treatment of the subject, it provides a valuable appreciation of what can be gained and what is required.

*Lawrence A. Ray is a research associate at Eastman Kodak Company. He received his PhD in mathematics from the University of Rochester and a BS from Union College. Dr. Ray is a frequent book reviewer for this journal.*

## 1 9 9 7 A U T H O R I N D E X

Each principal author's entry includes coauthors, title of paper, and location of the paper in Volume 6. A "See" reference means the person is a coauthor of the referenced paper.

### Aizenberg, Igor N.

: Processing of noisy and small-detailed gray-scale images using cellular neural networks, 06(03)272–285(Jul1997)

### Amin, Adnan

: **Iyer, Sankaran; Wilson, William H.:** Recognition of hand-printed latin characters based on a structural approach with a neural network classifier, 06(03)303–310(Jul1997).

### Astola, Jaakko T.

: See Jarske, Tiina: 06(03)357–367(Oct1997)

: See Melnik, Vladimir P.: 06(04)439–452(Oct1997)

### Bakshi, Manish

: **Fuhrmann, Daniel R.:** Improving the visual quality of JPEG-encoded images via companding, 06(02)189–197(Apr1997)

### Barrera, Junior

: **Dougherty, Edward R.; Tomita, Nina S.:** Automatic programming of binary morphological machines by design of statistically optimal operators in the context of computational learning theory, 06(01)54–67(Jan1997)

### Berns, Roy S.

: See Tanaka, Toru: 06(02)154–165(Apr1997)

### Bertrand, Gilles

: **Everat, Jean-Christophe; Couprie, Michel:** Image segmentation through operators based on topology, 06(04)395–405(Oct1997)

### Blue, James L.

: See Garris, Michael D.: 06(02)231–243(Apr1997)

: See Wilson, Charles L.: 06(03)379–385(Jul1997)

### Blume, Holger

: New algorithm for nonlinear vector-based upconversion with center weighted medians, 06(03)368–378(Jul1997)

### Boninsegna, Massimo

: **Coianiz, Tarcisio; Trentin, Edmondo:** Estimating the crowding level with a neuro-fuzzy classifier, 06(03)319–328(Jul1997)

### Bouvier, Eric

: **Cohen, Eyal; Najman, Laurent:** From crowd simulation to airbag deployment: particle systems, a new paradigm of simulation 06(01)94–107(Jan1997)

### Candela, Gerald T.

: See Garris, Michael D.: 06(02)231–243(Apr1997)

### Casazza, Peter G.

: **Christensen, Ole:** Approximation of the frame coefficients using finite dimensional methods, 06(04)479–483(Oct1997)

### Chen, Chang W.

: See Chen, Lulin: 06(04)467–478(Oct1997)

### Chen, Lulin

: **Chen, Chang W.; Parker, Kevin J.:** Adaptive feature enhancement for mammographic images with wavelet multiresolution analysis, 06(04)467–478(Oct1997)

### Christensen, Ole

: See Casazza, Peter G.: 06(04)479–483(Oct1997)

### Chung, Hong Kyu

: **Park, Rae-Hong:** Two-stage high-precision visual inspection of surface mount devices, 06(04)517–524(Oct1997)

### Cohen, Eyal

: See Bouvier, Eric: 06(01)94–107(Jan1997)

### Coianiz, Tarcisio

: See Boninsegna, Massimo: 06(03)319–328(Jul1997)

### Couprie, Michel

: See Bertrand, Gilles: 06(04)395–405(Oct1997) letter

### Decker, Luc

: **Jeulin, Dominique:** Random texture simulation by multi-species lattice-gas models, 06(01)78–93(Jan1997)

### Desnougues, Pascal

: See Zuyev, Sergei: 06(01)68–77(Jan1997)

### Dimmick, Darrin L.

: See Garris, Michael D.: 06(02)231–243(Apr1997)

### Dougherty, Edward R.

: Editorial: 06(01)4(Jan1997)

: Editorial: 06(2)152(Apr1997)

: Editorial: 06(03)268(Jul1997)

: See Barrera, Junior: 06(01)54–67(Jan1997)

### Drew, Mark S.

: See Finlayson, Graham D.: 06(04)484–493(Oct1997)

### Eckstein, Wolfgang

: **Steger, Carsten T.:** Architecture for computer vision application development within the HORUS system, 06(02)244–261(Apr1997)

### Eschbach, Reiner

: Error diffusion algorithm with homogenous response in highlight and shadow areas, 06(03)348–356(Jul1997)

### Everat, Jean-Christophe

: See Bertrand, Gilles: 06(04)395–405(Oct1997)

### Fagan, Anthony D.

: See McDonnell, J. D.: 06(01)114–124(Jan1997)

### Fairchild, Mark D.

: See Tanaka, Toru: 06(02)154–165(Apr1997)

### Finlayson, Graham D.

: **Drew, Mark S.:** Constrained least-squares regression in color spaces, 06(04)484–493(Oct1997)

### Fuhrmann, Daniel R.

: See Bakshi, Manish: 06(02)189–197(Apr1997)

### Garris, Michael D.

: **Blue, James L.; Candela, Gerald T.; Dimmick Darrin L.; Geist, Jon C.; Grother, Patrick J.; Janet, Stanley A.; Omidvar, Omid M.; Wilson, Charles L.:** Design of a handprint recognition system, 06(02)231–243(Apr1997)

### Geist, Jon C.

: See Garris, Michael D.: 06(02)231–243(Apr1997)

### Geng, Zheng J.

: **Shen, Weicheng:** Fingerprinting classification using fuzzy cerebellar model arithmetic computer neural networks, 06(03)311–318(Jul1997)

### Goutsias, John I.

: See Sivakumar, Krishnamoorthy: 06(01)31–53(Jan1997)

### Grother, Patrick J.

: See Garris, Michael D.: 06(02)231–243(Apr1997)

### Guillemaud, Regis

: See Payot, Etienne P.: 06(04)426–438(Oct1997)

### Gupta, Madan M.

: See Yan, Hong: 06(03)270–271(Jul1997)

- Salari, Ezzatollah**  
; See Lin, Sheng: 06(01)125–132(Jan1997)
- Schildkraut, Jay S.**  
; See Spaulding, Kevin E.: 06(02)208–230(Apr1997)
- Seo, Yang-Seock**  
; See Kim, Chang-Yeong: 06(02)166–180(Apr1997)
- Serra, Jean C.**  
; Equicontinuous random functions 06(01)7–15(Jan1997)
- Shen, Liang**  
; **Rangayyan, Rangaraj M.:** Lossless compression of continuous-tone images by combined inter-bit-plane decorrelation and JBIG coding, 06(02)198–207(Apr1997)
- Shen, Weicheng**  
; See Geng, Zheng J.: 06(03)311–318(Jul1997)
- Shi, Hongchi**  
; See Ritter, Gerhard X.: 06(04)393–394(Oct1997)
- Shorten, R. N.**  
; See McDonnell, J. D.: 06(01)114–124(Jan1997)
- Sivakumar, Krishnamoorthy**  
; **Goutsias, John I.:** Discrete morphological size distributions and densities: estimation techniques and applications, 06(01)31–53(Jan1997)
- Smith, Clifton**  
; See Vuori, Timo A.: 06(01)140–144(Jan1997)
- Spaulding, Kevin E.**  
; **Miller, Rodney L.;** **Schildkraut, Jay S.:** Methods for generating blue-noise dither matrices for digital halftoning, 06(02)208–230(Apr1997)
- Steger, Carsten T.**  
; See Eckstein, Wolfgang: 06(02)244–261(Apr1997)
- Tam, Peter K.**  
; See Li, Chun Hung: 06(03)286–293(Jul1997)
- Tanaka, Toru**  
; **Berns, Roy S.;** **Fairchild, Mark D.:** Predicting the image quality of color overhead transparencies using a color-appearance model, 06(02)154–165(Apr1997)
- Tomita, Nina S.**  
; See Barrera, Junior: 06(01)54–67(Jan1997)
- Trentin, Edmondo**  
; See Boninsegna, Massimo: 06(03)319–328(Jul1997)
- Trousset, Yves**  
; See Payot, Etienne P.: 06(04)426–438(Oct1997)
- Veelaert, Peter**  
; Selecting appropriate difference operators for digital images by local feature detection, 06(04)415–425(Oct1997)
- Voicu, Liviu**  
; **Myler, Harley R.;** **Weeks, Arthur R.:** Practical considerations on color image enhancement using homomorphic filtering, 06(01)108–113(Jan1997)
- Vuori, Timo A.**  
; **Smith, Clifton:** Three-dimensional imaging system with structured lighting and practical constraints, 06(01)140–144(Jan1997)
- Wang, Jian**  
; **Naghdy, Golshah A.;** **Ogunbona, Philip O.:** Wavelet-based feature adaptive resonance theory neural network for texture identification, 06(03)329–336(Jul1997)
- Weeks, Arthur R.**  
; See Voicu, Liviu: 06(01)108–113(Jan1997)
- Wilson, Charles L.**  
; **Blue, James L.;** **Omidvar, Omid M.:** Neurodynamics of learning and network performance, 06(03)379–385(Jul1997)  
; See Garris, Michael D.: 06(02)231–243(Apr1997)
- Wilson, William H.**  
; See Amin, Adnan: 06(03)303–310(Jul1997)
- Yaacoub, J.**  
; See Reveilles, Jean-Pierre: 06(04)406–414(Oct1997)
- Yan, Hong**  
; **Gupta, Madan M.:** Guest Editorial: Special Section on Neural Networks and Fuzzy Logic for Imaging Applications, 06(03)270–271(Jul1997)  
; See Mirhosseini, Ali R.: 06(03)294–302(Jul1997)
- Yu, Tian-Hu**  
; **Mitra, Sanjit K.:** Novel nonlinear predictive image coding algorithm. 06(02)181–188(Apr1997)
- Zelensky, Alexander A.**  
; See Melnik, Vladimir P.: 06(04)439–452(Oct1997)
- Zuyev, Sergei**  
; **Desnogues, Pascal;** **Rakotoarisoa, Hery:** Simulations of large telecommunication networks based on probabilistic modeling, 06(01)68–77(Jan1997)

# 1997 SUBJECT INDEX

Paper titles are indexed under appropriate subject terms, which are printed in boldface type. Each entry gives the paper title, the author(s), and location of the paper in Volume 6.

- Book reviews**  
JPEG video compression standard. By Joan L. Mitchell et al. (Langdon, Glen G.) 06(02)262–263(Apr1997)  
Multimedia tools and applications. By Borko Furht (Mehrotra, Rajiv) 06(03)386–387(Jul1997)  
Theory of three-dimensional computer graphics. By L. Szirmay-Kalos (Ray, Lawrence A.) 06(01)145–146(Jan1997)
- Cameras**  
Estimating the crowding level with a neuro-fuzzy classifier (Boninsegna, Massimo; Coianiz, Tarcisio; Trentin, Edmondo) 06(03)319–328(Jul1997)
- Character recognition**  
Recognition of hand-printed latin characters based on a structural approach with a neural network classifier (Amin, Adnan; Iyer, Sankaran; Wilson, William H.) 06(03)303–310(Jul1997)
- Coding**  
Improving the visual quality of JPEG-encoded images via companding (Bakshi, Manish; Fuhrmann, Daniel R.) 06(02)189–197(Apr1997)  
Lossless compression of continuous-tone images by combined inter-bit-plane decorrelation and JBIG coding (Shen, Liang; Rangayyan, Rangaraj M.) 06(02)198–207(Apr1997)  
Novel nonlinear predictive image coding algorithm (Yu, Tian-Hu; Mitra, Sanjit K.) 06(02)181–188(Apr1997)  
Postprocessing of transform coded images via histogram-based edge classification (McDonnell, J. D.; Shorten, R. N.; Fagan, Anthony D.) 06(01)114–124(Jan1997)  
Pyramidal piecewise uniform lattice quantization in the wavelet transform domain for image coding (Lin, Sheng; Salari, Ezzatollah) 06(01)125–132(Jan1997)  
Transform coding of signals using approximate trigonometric expansions (Memon, Qurban; Kasparis, Takis) 06(04)494–503(Oct1997)
- Color**  
Color and printer models for color halftoning (Kim, Chang-Yeong; Kweon, In S.; Seo, Yang-Seock) 06(02)166–180(Apr1997)  
Constrained least-squares regression in color spaces (Finlayson, Graham D.; Drew, Mark S.) 06(04)484–493(Oct1997)  
Methods for generating blue-noise dither matrices for digital halftoning (Spaulding, Kevin E.; Miller, Rodney L.; Schildkraut, Jay S.) 06(02)208–230(Apr1997)  
Practical considerations on color image enhancement using homomorphic filtering (Voicu, Liviu; Myler, Harley R.; Weeks, Arthur R.) 06(01)108–113(Jan1997)  
Predicting the image quality of color overhead transparencies using a color appearance model (Tanaka, Toru; Berns, Roy S.; Fairchild, Mark D.) 06(02)154–165(Apr1997)
- Computer graphics**  
Book Review: Theory of three-dimensional computer graphics. By L. Szirmay-Kalos (Ray, Lawrence A.) 06(01)145–146(Jan1997)
- Computer vision**  
Architecture for computer vision application development within the HORUS system (Eckstein, Wolfgang; Steger, Carsten T.) 06(02)244–261(Apr1997)
- Computers**  
Architecture for computer vision application development within the HORUS system (Eckstein, Wolfgang; Steger, Carsten T.) 06(02)244–261(Apr1997)  
Book Review: Computer visualization. By Gallagher (Ray, Lawrence A.) 06(04)525(Oct1997)  
Fingerprinting classification using fuzzy cerebellar model arithmetic computer neural networks (Geng, Zheng J.; Shen, Weicheng) 06(03)311–318(Jul1997)  
Two-stage high-precision visual inspection of surface mount devices (Chung, Hong Kyu; Park, Rae-Hong) 06(04)517–524(Oct1997)
- Contours**  
Error diffusion without contouring effect (Han, Wei-Yu; Lin, Ja-Chen) 06(01)133–139(Jan1997)
- Data compression**  
Lossless compression of continuous-tone images by combined inter-bit-plane decorrelation and JBIG coding (Shen, Liang; Rangayyan, Rangaraj M.) 06(02)198–207(Apr1997)
- Detection**  
Selecting appropriate difference operators for digital images by local feature detection (Veelaert, Peter) 06(04)415–425(Oct1997)
- Diffusion**  
Error diffusion algorithm with homogenous response in highlight and shadow areas (Eschbach, Reiner) 06(03)348–356(Jul1997)  
Error diffusion without contouring effect (Han, Wei-Yu; Lin, Ja-Chen) 06(01)133–139(Jan1997)  
Nonlinear operators for error diffusion (Jarske, Tiina; Astola, Jaakko T.) 06(03)357–367(Jul1997)
- Digital imaging**  
Maximum area triangle operator for edge detection (Reveilles, Jean-Pierre; Yaacoub, J.) 06(04)406–414(Oct1997)  
Selecting appropriate difference operators for digital images by local feature detection (Veelaert, Peter) 06(04)415–425(Oct1997)
- Document imaging**  
Error diffusion algorithm with homogenous response in highlight and shadow areas (Eschbach, Reiner) 06(03)348–356(Jul1997)  
Error diffusion without contouring effect (Han, Wei-Yu; Lin, Ja-Chen) 06(01)133–139(Jan1997)  
Methods for generating blue-noise dither matrices for digital halftoning (Spaulding, Kevin E.; Miller, Rodney L.; Schildkraut, Jay S.) 06(02)208–230(Apr1997)  
Nonlinear operators for error diffusion (Jarske, Tiina; Astola, Jaakko T.) 06(03)357–367(Jul1997)
- Edges**  
Maximum area triangle operator for edge detection (Reveilles, Jean-Pierre; Yaacoub, J.) 06(04)406–414(Oct1997)  
Postprocessing of transform coded images via histogram-based edge classification (McDonnell, J. D.; Shorten, R. N.; Fagan, Anthony D.) 06(01)114–124(Jan1997)

- Han, Wei-Yu**  
; **Lin, Ja-Chen**: Error diffusion without contouring effect, 06(01)133–139(Jan1997)
- Harvey, Neal R.**  
; See Kraft, Peter: 06(04)504–516(Oct1997)
- He, Wenjie**  
; **Lai, Mingjun**: Digital filters associated with bivariate box spline wavelets, 06(04)453–466(Oct1997)
- Huttunen, Heikki**  
; See Melnik, Vladimir P.: 06(04)439–452(Oct1997)
- Israel, Steven A.**  
; **Kasabov, Nikola K.**: Statistical, connectionist, and fuzzy inference techniques for image classification, 06(03)337–347(Jul1997)
- Iyer, Sankaran**  
; See Amin, Adnan: 06(03)303–310(Jul1997)
- Janet, Stanley A.**  
; See Garris, Michael D.: 06(02)231–243(Apr1997)
- Jarske, Tiina**  
; **Astola, Jaakko T.**: Nonlinear operators for error diffusion, 06(03)357–367(Jul1997)
- Jeulin, Dominique**  
; Guest Editorial: Special Section on Random Models in Imaging 06(01)6(Jan1997)  
; **Laurence, Pascal**: Simulation of rough surfaces by morphological random functions, 06(01)16–30(Jan1997)  
; See Decker, Luc: 06(01)78–93(Jan1997)
- Kasabov, Nikola K.**  
; See Israel, Steven A.: 06(03)337–347(Jul1997)
- Kasparis, Takis**  
; See Memon, Qurban: 06(04)494–503(Oct1997)
- Kim, Chang-Yeong**  
; **Kweon, In S.**; **Seo, Yang-Seock**: Color and printer models for color halftoning, 06(02)166–180(Apr1997)
- Kraft, Peter**  
; **Harvey, Neal R.**; **Marshall, Stephen**: Parallel genetic algorithms in the optimization of morphological filters: a general design tool, 06(04)504–516(Oct1997)
- Kweon, In S.**  
; See Kim, Chang-Yeong: 06(02)166–180(Apr1997)
- Lai, Mingjun**  
; See He, Wenjie: 06(04)453–466(Oct1997)
- Langdon, Glen G.**  
; Book Rvw: MPEG video compression standard. By Joan L. Mitchell et al., 06(02)262–263(Apr1997)
- Laurence, Pascal**  
; See Jeulin, Dominique: 06(01)16–30(Jan1997)
- Li, Chun Hung**  
; **Tam, Peter K.**: Modular expert network approach to histogram thresholding, 06(03)286–293(Jul1997)
- Lin, Ja-Chen**  
; See Han, Wei-Yu: 06(01)133–139(Jan1997)
- Lin, Sheng**  
; **Salari, Ezzatollah**: Pyramidal piecewise uniform lattice quantization in the wavelet transform domain for image coding, 06(01)125–132(Jan1997)
- Lukin, Vladimir V.**  
; See Melnik, Vladimir P.: 06(04)439–452(Oct1997)
- Marshall, Stephen**  
; See Kraft, Peter: 06(04)504–516(Oct1997)
- McDonnell, J. D.**  
; **Shorten, R. N.**; **Fagan, Anthony D.**: Postprocessing of transform coded images via histogram-based edge classification, 06(01)114–124(Jan1997)
- Mehrotra, Rajiv**  
; Book Rvw: Multimedia tools and applications. By Borko Furht, 06(03)386–387(Jul1997)
- Melnik, Vladimir P.**  
; **Lukin, Vladimir V.**; **Zelensky, Alexander A.**; **Huttunen, Heikki**; **Astola, Jaakko T.**: Nonlinear locally adaptive and iterative algorithms of image restoration, 06(04)439–452(Oct1997)
- Memon, Qurban**  
; **Kasparis, Takis**: Transform coding of signals using approximate trigonometric expansions, 06(04)494–503(Oct1997)
- Miller, Rodney L.**  
; See Spaulding, Kevin E.: 06(02)208–230(Apr1997)
- Mirhosseini, Ali R.**  
; **Yan, Hong**: Learning object models from graph templates, 06(03)294–302(Jul1997)
- Mitra, Sanjit K.**  
; See Yu, Tian-Hu: 06(02)181–188(Apr1997)
- Myler, Harley R**  
; See Voicu, Liviu: 06(01)108–113(Jan1997)
- Naghdy, Golshah A.**  
; See Wang, Jian: 06(03)329–336(Jul1997)
- Najman, Laurent**  
; See Bouvier, Eric: 06(01)94–107(Jan1997)
- Ogunbona, Philip O.**  
; See Wang, Jian: 06(03)329–336(Jul1997)
- Omidvar, Omid M.**  
; See Garris, Michael D.: 06(02)231–243(Apr1997)  
; See Wilson, Charles L.: 06(03)379–385(Jul1997)
- Park, Rae-Hong**  
; See Chung, Hong Kyu: 06(04)517–524(Oct1997)
- Parker, Kevin J.**  
; See Chen, Lulin: 06(04)467–478(Oct1997)
- Payot, Etienne P.**  
; **Preteux, Françoise**; **Trousset, Yves**; **Guillemaud, Regis**: Generalized support constraint for three-dimensional reconstruction from incomplete Fourier spectra, 06(04)426–438(Oct1997)
- Preteux, Françoise**  
; See Payot, Etienne P.: 06(04)426–438(Oct1997)
- Rakotoarisoa, Hery**  
; See Zuyev, Sergei: 06(01)68–77(Jan1997)
- Rangayyan, Rangaraj M.**  
; See Shen, Liang: 06(02)198–207(Apr1997)
- Ray, Lawrence A.**  
; Book Rvw: Theory of three-dimensional computer graphics. By L. Szirmay-Kalos, 06(01)145–146(Jan1997)  
; Book Rvw: Computer visualization. By Gallagher, 06(04)525(Oct1997)
- Revelles, Jean-Pierre**  
; **Yaacoub, J.**: Maximum area triangle operator for edge detection, 06(04)406–414(Oct1997)
- Ritter, Gerhard X.**  
; **Shi, Hongchi**: Guest Editorial: Special Section on Advances in Mathematical Imaging 06(04)393–394(Oct1997)

- Processing of noisy and small-detailed gray-scale images using cellular neural networks (Aizenberg, Igor N.) 06(03)272–285(Jul1997)
- Two-stage high-precision visual inspection of surface mount devices (Chung, Hong Kyu; Park, Rae-Hong) 06(04)517–524(Oct1997)
- Filtering**
- Practical considerations on color image enhancement using homomorphic filtering (Voicu, Liviu; Myler, Harley R.; Weeks, Arthur R.) 06(01)108–113(Jan1997)
- Processing of noisy and small-detailed gray-scale images using cellular neural networks (Aizenberg, Igor N.) 06(03)272–285(Jul1997)
- Filters**
- Digital filters associated with bivariate box spline wavelets (He, Wenjie; Lai, Mingjun) 06(04)453–466(Oct1997)
- Nonlinear locally adaptive and iterative algorithms of image restoration (Melnik, Vladimir P.; Lukin, Vladimir V.; Zelensky, Alexander A.; Huttunen, Heikki; Astola, Jaakko T.) 06(04)439–452(Oct1997)
- Nonlinear operators for error diffusion (Jarske, Tiina; Astola, Jaakko T.) 06(03)357–367(Jul1997)
- Parallel genetic algorithms in the optimization of morphological filters: a general design tool (Kraft, Peter; Harvey, Neal R.; Marshall, Stephen) 06(04)504–516(Oct1997)
- Fourier transforms**
- Generalized support constraint for three-dimensional reconstruction from incomplete Fourier spectra (Payot, Etienne P.; Preteux, Françoise; Troussat, Yves; Guillemaud, Regis) 06(04)426–438(Oct1997)
- Fuzzy logic**
- Estimating the crowding level with a neuro-fuzzy classifier (Boninsegna, Massimo; Coianiz, Tarcisio; Trentin, Edmondo) 06(03)319–328(Jul1997)
- Fingerprinting classification using fuzzy cerebellar model arithmetic computer neural networks (Geng, Zheng J.; Shen, Weicheng) 06(03)311–318(Jul1997)
- Guest Editorial: Special Section on Neural Networks and Fuzzy Logic for Imaging Applications (Yan, Hong; Gupta, Madan M.) 06(03)270–271(Jul1997)
- Statistical, connectionist, and fuzzy inference techniques for image classification (Israel, Steven A.; Kasabov, Nikola K.) 06(03)337–347(Jul1997)
- Wavelet-based feature-adaptive resonance theory neural network for texture identification (Wang, Jian; Naghdy, Golshah A.; Ogunbona, Philip O.) 06(03)329–336(Jul1997)
- Gases**
- Random texture simulation by multi-species lattice-gas models (Decker, Luc; Jeulin, Dominique) 06(01)78–93(Jan1997)
- Halftones**
- Color and printer models for color halftoning (Kim, Chang-Yeong; Kweon, In S.; Seo, Yang-Seock) 06(02)166–180(Apr1997)
- Hough transforms**
- Two-stage high-precision visual inspection of surface mount devices (Chung, Hong Kyu; Park, Rae-Hong) 06(04)517–524(Oct1997)
- Image analysis**
- Automatic programming of binary morphological machines by design of statistically optimal operators in the context of computational learning theory (Barrera, Junior; Dougherty, Edward R.; Tomita, Nina S.) 06(01)54–67(Jan1997)
- Statistical, connectionist, and fuzzy inference techniques for image classification (Israel, Steven A.; Kasabov, Nikola K.) 06(03)337–347(Jul1997)
- Image compression**
- Improving the visual quality of JPEG-encoded images via companding (Bakshi, Manish; Fuhrmann, Daniel R.) 06(02)189–197(Apr1997)
- Lossless compression of continuous-tone images by combined inter-bi plane decorrelation and JBIG coding (Shen, Liang; Rangayyan, Rangaraj M.) 06(02)198–207(Apr1997)
- Novel nonlinear predictive image coding algorithm (Yu, Tian-Hu; Mit Sanjit K.) 06(02)181–188(Apr1997)
- Pyramidal piecewise uniform lattice quantization in the wavelet transform domain for image coding (Lin, Sheng; Salari, Ezzatollah) 06(01)125–132(Jan1997)
- Image enhancement**
- Practical considerations on color image enhancement using homomorphic filtering (Voicu, Liviu; Myler, Harley R.; Weeks, Arthur R.) 06(01)108–113(Jan1997)
- Image processing**
- Approximation of the frame coefficients using finite dimensional method (Casazza, Peter G.; Christensen, Ole) 06(04)479–483(Oct1997)
- Architecture for computer vision application development within the HORUS system (Eckstein, Wolfgang; Steger, Carsten T.) 06(02)244–261(Apr1997)
- Discrete morphological size distributions and densities: estimation techniques and applications (Sivakumar, Krishnamoorthy; Gout John I.) 06(01)31–53(Jan1997)
- Estimating the crowding level with a neuro-fuzzy classifier (Boninsegna, Massimo; Coianiz, Tarcisio; Trentin, Edmondo) 06(03)319–328(Jul1997)
- Learning object models from graph templates (Mirhosseini, Ali R.; Ya Hong) 06(03)294–302(Jul1997)
- Maximum area triangle operator for edge detection (Reveilles, Jean-Pi Yaacoub, J.) 06(04)406–414(Oct1997)
- Methods for generating blue-noise dither matrices for digital halftoning (Spaulding, Kevin E.; Miller, Rodney L.; Schildkraut, Jay S.) 06(02)208–230(Apr1997)
- Modular expert network approach to histogram thresholding (Li, Chun Hung; Tam, Peter K.) 06(03)286–293(Jul1997)
- New algorithm for nonlinear vector-based upconversion with center weighted medians (Blume, Holger) 06(03)368–378(Jul1997)
- Parallel genetic algorithms in the optimization of morphological filters general design tool (Kraft, Peter; Harvey, Neal R.; Marshall, Stephen) 06(04)504–516(Oct1997)
- Selecting appropriate difference operators for digital images by local feature detection (Veelaert, Peter) 06(04)415–425(Oct1997)
- Three-dimensional imaging system with structured lighting and practical constraints (Vuori, Timo A.; Smith, Clifton) 06(01)140–144(Jan1997)
- Image processing, nonlinear**
- Novel nonlinear predictive image coding algorithm (Yu, Tian-Hu; Mit Sanjit K.) 06(02)181–188(Apr1997)
- Image quality**
- Predicting the image quality of color overhead transparencies using a color-appearance model (Tanaka, Toru; Berns, Roy S.; Fairchild, Mark D.) 06(02)154–165(Apr1997)
- Image restoration**
- Nonlinear locally adaptive and iterative algorithms of image restoration (Melnik, Vladimir P.; Lukin, Vladimir V.; Zelensky, Alexander A.; Huttunen, Heikki; Astola, Jaakko T.) 06(04)439–452(Oct1997)
- Image segmentation**
- Image segmentation through operators based on topology (Bertrand, Gilles; Everat, Jean-Christophe; Couprie, Michel) 06(04)395–405(Oct1997)
- Imaging**
- Adaptive feature enhancement for mammographic images with wavelet multiresolution analysis (Chen, Lulin; Chen, Chang W.; Parker, Kevin J.) 06(04)467–478(Oct1997)
- Approximation of the frame coefficients using finite dimensional method (Casazza, Peter G.; Christensen, Ole) 06(04)479–483(Oct1997)

- Automatic programming of binary morphological machines by design of statistically optimal operators in the context of computational learning theory (Barrera, Junior; Dougherty, Edward R.; Tomita, Nina S.) 06(01)54-67(Jan1997)
- Digital filters associated with bivariate box spline wavelets (He, Wenjie; Lai, Mingjun) 06(04)453-466(Oct1997)
- Discrete morphological size distributions and densities: estimation techniques and applications (Sivakumar, Krishnamoorthy; Goutsias, John I.) 06(01)31-53(Jan1997)
- Equicontinuous random functions (Serra, Jean C.) 06(01)7-15(Jan1997)
- Error diffusion algorithm with homogenous response in highlight and shadow areas (Eschbach, Reiner) 06(03)348-356(Jul1997)
- Generalized support constraint for three-dimensional reconstruction from incomplete Fourier spectra (Payot, Etienne P.; Preteux, Françoise; Troussset, Yves; Guillemaud, Regis) 06(04)426-438(Oct1997)
- Guest Editorial: Special Section on Advances in Mathematical Imaging (Ritter, Gerhard X.; Shi, Hongchi) 06(04)393-394(Oct1997)
- Guest Editorial: Special Section on Random Models in Imaging (Jeulin, Dominique) 06(01)6(Jan1997)
- Image segmentation through operators based on topology (Bertrand, Gilles; Everat, Jean-Christophe; Couprie, Michel) 06(04)395-405(Oct1997)
- Improving the visual quality of JPEG-encoded images via companding (Bakshi, Manish; Fuhrmann, Daniel R.) 06(02)189-197(Apr1997)
- Simulations of large telecommunication networks based on probabilistic modeling (Zuyev, Sergei; Desnougues, Pascal; Rakotoarisoa, Hery) 06(01)68-77(Jan1997)
- Transform coding of signals using approximate trigonometric expansions (Memon, Qurban; Kasparis, Takis) 06(04)494-503(Oct1997)
- Imaging systems**
- Generalized support constraint for three-dimensional reconstruction from incomplete Fourier spectra (Payot, Etienne P.; Preteux, Françoise; Troussset, Yves; Guillemaud, Regis) 06(04)426-438(Oct1997)
- Predicting the image quality of color overhead transparencies using a color-appearance model (Tanaka, Toru; Berns, Roy S.; Fairchild, Mark D.) 06(02)154-165(Apr1997)
- Three-dimensional imaging system with structured lighting and practical constraints (Vuori, Timo A.; Smith, Clifton) 06(01)140-144(Jan1997)
- Journal of Electronic Imaging**
- Editorial (Dougherty, Edward R.) 06(01)4(Jan1997)
- Editorial (Dougherty, Edward R.) 06(02)152(Apr1997)
- Editorial (Dougherty, Edward R.) 06(03)268(Jul1997)
- Machine vision**
- Three-dimensional imaging system with structured lighting and practical constraints (Vuori, Timo A.; Smith, Clifton) 06(01)140-144(Jan1997)
- Two-stage high-precision visual inspection of surface mount devices (Chung, Hong Kyu; Park, Rae-Hong) 06(04)517-524(Oct1997)
- Mammography**
- Adaptive feature enhancement for mammographic images with wavelet multiresolution analysis (Chen, Lulin; Chen, Chang W.; Parker, Kevin J.) 06(04)467-478(Oct1997)
- Mapping**
- Constrained least-squares regression in color spaces (Finlayson, Graham D.; Drew, Mark S.) 06(04)484-493(Oct1997)
- Modular expert network approach to histogram thresholding (Li, Chun Hung; Tam, Peter K.) 06(03)286-293(Jul1997)
- Mathematical imaging**
- Adaptive feature enhancement for mammographic images with wavelet multiresolution analysis (Chen, Lulin; Chen, Chang W.; Parker, Kevin J.) 06(04)467-478(Oct1997)
- Approximation of the frame coefficients using finite dimensional methods (Casazza, Peter G.; Christensen, Ole) 06(04)479-483(Oct1997)
- Digital filters associated with bivariate box spline wavelets (He, Wenjie; Lai, Mingjun) 06(04)453-466(Oct1997)
- Generalized support constraint for three-dimensional reconstruction from incomplete Fourier spectra (Payot, Etienne P.; Preteux, Françoise; Troussset, Yves; Guillemaud, Regis) 06(04)426-438(Oct1997)
- Guest Editorial: Special Section on Advances in Mathematical Imaging (Ritter, Gerhard X.; Shi, Hongchi) 06(04)393-394(Oct1997)
- Image segmentation through operators based on topology (Bertrand, Gilles; Everat, Jean-Christophe; Couprie, Michel) 06(04)395-405(Oct1997)
- Maximum area triangle operator for edge detection (Reveilles, Jean-Pierre; Yaacoub, J.) 06(04)406-414(Oct1997)
- Nonlinear locally adaptive and iterative algorithms of image restoration (Melnik, Vladimir P.; Lukin, Vladimir V.; Zelensky, Alexander A.; Huttunen, Heikki; Astola, Jaakko T.) 06(04)439-452(Oct1997)
- Selecting appropriate difference operators for digital images by local feature detection (Veelaert, Peter) 06(04)415-425(Oct1997)
- Mathematical morphology**
- Equicontinuous random functions (Serra, Jean C.) 06(01)7-15(Jan1997)
- Parallel genetic algorithms in the optimization of morphological filters: a general design tool (Kraft, Peter; Harvey, Neal R.; Marshall, Stephen) 06(04)504-516(Oct1997)
- Matrices**
- Methods for generating blue-noise dither matrices for digital halftoning (Spaulding, Kevin E.; Miller, Rodney L.; Schildkraut, Jay S.) 06(02)208-230(Apr1997)
- Morphology**
- Automatic programming of binary morphological machines by design of statistically optimal operators in the context of computational learning theory (Barrera, Junior; Dougherty, Edward R.; Tomita, Nina S.) 06(01)54-67(Jan1997)
- Discrete morphological size distributions and densities: estimation techniques and applications (Sivakumar, Krishnamoorthy; Goutsias, John I.) 06(01)31-53(Jan1997)
- Multimedia**
- Book Rvw: Multimedia tools and applications. By Borko Furht (Mehrotra, Rajiv) 06(03)386-387(Jul1997)
- New algorithm for nonlinear vector-based upconversion with center weighted medians (Blume, Holger) 06(03)368-378(Jul1997)
- Networks**
- Neurodynamics of learning and network performance (Wilson, Charles L.; Blue, James L.; Omidvar, Omid M.) 06(03)379-385(Jul1997)
- Simulations of large telecommunication networks based on probabilistic modeling (Zuyev, Sergei; Desnougues, Pascal; Rakotoarisoa, Hery) 06(01)68-77(Jan1997)
- Neural networks**
- Design of a handprint recognition system (Garris, Michael D.; Blue, James L.; Candela, Gerald T.; Dimmick, Darrin L.; Geist, Jon C.; Grother, Patrick J.; Janet, Stanley A.; Omidvar, Omid M.; Wilson, Charles L.) 06(02)231-243(Apr1997)
- Estimating the crowding level with a neuro-fuzzy classifier (Boninsegna, Massimo; Coianiz, Tarcisio; Trentin, Edmondo) 06(03)319-328(Jul1997)
- Fingerprinting classification using fuzzy cerebellar model arithmetic computer neural networks (Geng, Zheng J.; Shen, Weicheng) 06(03)311-318(Jul1997)
- Guest Editorial: Special Section on Neural Networks and Fuzzy Logic for Imaging Applications (Yan, Hong; Gupta, Madan M.) 06(03)270-271(Jul1997)
- Learning object models from graph templates (Mirhosseini, Ali R.; Yan, Hong) 06(03)294-302(Jul1997)
- Modular expert network approach to histogram thresholding (Li, Chun Hung; Tam, Peter K.) 06(03)286-293(Jul1997)
- Neurodynamics of learning and network performance (Wilson, Charles L.; Blue, James L.; Omidvar, Omid M.) 06(03)379-385(Jul1997)

- Processing of noisy and small-detailed gray-scale images using cellular neural networks (Aizenberg, Igor N.) 06(03)272–285(Jul1997)
- Recognition of hand-printed latin characters based on a structural approach with a neural network classifier (Amin, Adnan; Iyer, Sankaran; Wilson, William H.) 06(03)303–310(Jul1997)
- Statistical, connectionist, and fuzzy inference techniques for image classification (Israel, Steven A.; Kasabov, Nikola K.) 06(03)337–347(Jul1997)
- Wavelet-based feature-adaptive adaptive resonance theory neural network for texture identification (Wang, Jian; Naghdy, Golshah A.; Ogunbona, Philip O.) 06(03)329–336(Jul1997)
- Noise**
- Nonlinear locally adaptive and iterative algorithms of image restoration (Melnik, Vladimir P.; Lukin, Vladimir V.; Zelensky, Alexander A.; Huttunen, Heikki; Astola, Jaakko T.) 06(04)439–452(Oct1997)
- Postprocessing of transform coded images via histogram-based edge classification (McDonnell, J. D.; Shorten, R. N.; Fagan, Anthony D.) 06(01)114–124(Jan1997)
- Optical character recognition**
- Design of a handprint recognition system (Garris, Michael D.; Blue, James L.; Candela, Gerald T.; Dimmick, Darrin L.; Geist, Jon C.; Grother, Patrick J.; Janet, Stanley A.; Omidvar, Omid M.; Wilson, Charles L.) 06(02)231–243(Apr1997)
- Particles**
- From crowd simulation to airbag deployment: particle systems, a new paradigm of simulation (Bouvier, Eric; Cohen, Eyal; Najman, Laurent) 06(01)94–107(Jan1997)
- Pattern recognition**
- Design of a handprint recognition system (Garris, Michael D.; Blue, James L.; Candela, Gerald T.; Dimmick, Darrin L.; Geist, Jon C.; Grother, Patrick J.; Janet, Stanley A.; Omidvar, Omid M.; Wilson, Charles L.) 06(02)231–243(Apr1997)
- Neurodynamics of learning and network performance (Wilson, Charles L.; Blue, James L.; Omidvar, Omid M.) 06(03)379–385(Jul1997)
- Recognition of hand-printed latin characters based on a structural approach with a neural network classifier (Amin, Adnan; Iyer, Sankaran; Wilson, William H.) 06(03)303–310(Jul1997)
- Printing**
- Color and printer models for color halftoning (Kim, Chang-Yeong; Kweon, In S.; Seo, Yang-Seock) 06(02)166–180(Apr1997)
- Quantization**
- Pyramidal piecewise uniform lattice quantization in the wavelet transform domain for image coding (Lin, Sheng; Salari, Ezzatollah) 06(01)125–132(Jan1997)
- Random models**
- Automatic programming of binary morphological machines by design of statistically optimal operators in the context of computational learning theory (Barrera, Junior; Dougherty, Edward R.; Tomita, Nina S.) 06(01)54–67(Jan1997)
- Discrete morphological size distributions and densities: estimation techniques and applications (Sivakumar, Krishnamoorthy; Goutsias, John I.) 06(01)31–53(Jan1997)
- Equicontinuous random functions (Serra, Jean C.) 06(01)7–15(Jan1997)
- From crowd simulation to airbag deployment: particle systems, a new paradigm of simulation (Bouvier, Eric; Cohen, Eyal; Najman, Laurent) 06(01)94–107(Jan1997)
- Guest Editorial: Special Section on Random Models in Imaging (Jeulin, Dominique) 06(01)6(Jan1997)
- Random texture simulation by multi-species lattice-gas models (Decker, Luc; Jeulin, Dominique) 06(01)78–93(Jan1997)
- Simulation of rough surfaces by morphological random functions (Jeulin, Dominique; Laurence, Pascal) 06(01)16–30(Jan1997)
- Simulations of large telecommunication networks based on probabilistic modeling (Zuyev, Sergei; Desnougues, Pascal; Rakotoarisoa, Hery) 06(01)68–77(Jan1997)
- Remote sensing**
- Statistical, connectionist, and fuzzy inference techniques for image classification (Israel, Steven A.; Kasabov, Nikola K.) 06(03)337–347(Jul1997)
- Roughness**
- Simulation of rough surfaces by morphological random functions (Jeulin, Dominique; Laurence, Pascal) 06(01)16–30(Jan1997)
- Segmentation**
- Image segmentation through operators based on topology (Bertrand, Gilles; Everat, Jean-Christophe; Couprie, Michel) 06(04)395–405(Oct1997)
- Signal processing**
- New algorithm for nonlinear vector-based upconversion with center weighted medians (Blume, Holger) 06(03)368–378(Jul1997)
- Simulations**
- From crowd simulation to airbag deployment: particle systems, a new paradigm of simulation (Bouvier, Eric; Cohen, Eyal; Najman, Laurent) 06(01)94–107(Jan1997)
- Textures**
- Random texture simulation by multi-species lattice-gas models (Decker, Luc; Jeulin, Dominique) 06(01)78–93(Jan1997)
- Transforms**
- Constrained least-squares regression in color spaces (Finlayson, Graham D.; Drew, Mark S.) 06(04)484–493(Oct1997)
- Transform coding of signals using approximate trigonometric expansions (Memon, Qurban; Kasparis, Takis) 06(04)494–503(Oct1997)
- Video**
- Book Rvw: MPEG video compression standard. By Joan L. Mitchell et al (Langdon, Glen G.) 06(02)262–263(Apr1997)
- Vision**
- Architecture for computer vision application development within the HORUS system (Eckstein, Wolfgang; Steger, Carsten T.) 06(02)244–261(Apr1997)
- Visualization**
- Book Rvw: Computer visualization. By Gallagher (Ray, Lawrence A.) 06(04)525–0(Oct1997)
- Wavelet transforms**
- Pyramidal piecewise uniform lattice quantization in the wavelet transform domain for image coding (Lin, Sheng; Salari, Ezzatollah) 06(01)125–132(Jan1997)
- Wavelets**
- Adaptive feature enhancement for mammographic images with wavelet multiresolution analysis (Chen, Lulin; Chen, Chang W.; Parker, Kevin J.) 06(04)467–478(Oct1997)
- Approximation of the frame coefficients using finite dimensional methods (Casazza, Peter G.; Christensen, Ole) 06(04)479–483(Oct1997)
- Digital filters associated with bivariate box spline wavelets (He, Wenjie; Lai, Mingjun) 06(04)453–466(Oct1997)
- Learning object models from graph templates (Mirhosseini, Ali R.; Yan, Hong) 06(03)294–302(Jul1997)
- Wavelet-based feature-adaptive adaptive resonance theory neural network for texture identification (Wang, Jian; Naghdy, Golshah A.; Ogunbona, Philip O.) 06(03)329–336(Jul1997)