

REFERENCES

- [1] Rafael. C. Gonzalez. and Richard. E. Wood. Digital Image Processing. 2nd Ed. *Prentice Hall*,(2002): 42-57.
- [2] Pentland. A.P. 1987. Depth of Scene from Depth of Field. *IEEE Internaional Journal Transactions on Pattern Analysis and Machine Intelligence* 9(4): 523-531.
- [3] Wong. K.T. and Ernst. F. 2004. Master thesis Single Image Depth-from-Defocus. *Delft university of Technology and Philips Natlab Research, Eindhoven, The Netherlands*.
- [4] Nayar. S.K. and Nakagawa. Y. 1994. Shape from Focus. *IEEE Internaional Journal Transactions on Pattern Analysis and Machine Intelligence* 16(8): 824-831.
- [5] Elder. J.H. and Zucker. S.W. 1998. Local Scale Control for Edge Detection and Blur Estimation. *IEEE International Journal Transactions on Pattern Analysis and Machine Vison* 20(7).
- [6] Gabor.D. 1946. Theory of Communication. *Journal of Instrument and Electricl Engineering London* 93(3):429-457
- [7] Simon. H., Neural Networks. 2nd Ed. New Jersey: Prentice Hall,(1999):10-175.
- [8] Torralba. A. and Oliva. A. 2002. Depth Estimation from Image Structure. *IEEE International Journal Transactions on Pattern Analysis and Machine Intelligence* 24(9): 1226-1238.
- [9] Saxena. A., Chung. S.H. and Ng. A. Y. 2005. Learning Depth from Single Monocular Images. *Proceedings of the 19th Annual Conference on Neural Information Processing Systems*.
- [10] George. B. Rafael.C. and Vilota. R., Fast wavelet transforms and numerical algorithms I. *Communications on Pure and Applied Mathematics* 44(2): 141-183.
- [11] Goh. L. 1996. A New Method for Texture Classification Based on Wavelet Transform. *Proceeding of International Symposium on Time-Frequency and Time-Scale Analysis* 3: 29-32.
- [12] Yutthana. L., Chidchanok. L., Rajalida. L., and Shin'i'chi. S. 2008. 3D Shape Recovery from Single Image by using Texture Information. *Proceedings of International Conference on Control, Automation and System*, Seoul, Korea, October 14-17.

APPENDICES

Appendix I

Table of Region Image Depth Ordering Results

This Appendix I describes the Table of region depth ordering classification results from cross validation process. Table A.1 to A.5 shows the percentage error of classification in each regions. Table A.6 to A.10 shows the percentage error and its average of the cross validation results in false-positive of foreground(pF), false-negative of foreground(nF), false-positive of middleground(pM), false-negative of middleground(nM), false-positive of background(pB), and false-negative of background(nB) in all five groups of cross validation image.

% Error	Foreground	Middleground	Background
Test image 1	0.75	8.00	9.75
Test image 2	0.75	4.25	3.00
Test image 3	1.50	3.50	3.00
Test image 4	7.25	16.00	10.50
Test image 5	14.00	19.75	12.75
Test image 6	3.75	18.00	11.75
Test image 7	2.25	3.50	12.75
Test image 8	12.25	49.50	37.75
Test image 9	17.50	37.25	9.75
Test image 10	35.00	75.00	29.00
Test image 11	0.25	13.50	12.50
Test image 12	0.50	9.00	7.50
Test image 13	2.25	4.75	3.75
Test image 14	4.25	14.00	4.00
Test image 15	0.50	1.50	0.50
Test image 16	54.50	11.75	62.25
Test image 17	15.25	13.00	16.00
Test image 18	26.00	19.25	7.00
Test image 19	38.50	7.50	36.25
Test image 20	2.25	15.50	10.25
Test image 21	1.25	15.75	17.25
Test image 22	1.25	18.50	11.25
Test image 23	0.50	40.25	26.00
Test image 24	15.25	39.75	20.75
Test image 25	19.25	18.25	19.50
Average Error	11.07	19.08	15.79

A.1 The error and its average of depth's ordering regions in foreground, middleground and background in group 1.

% Error	Foreground	Middleground	Background
Test image 1	25.00	52.75	16.00
Test image 2	7.00	11.50	42.75
Test image 3	5.50	11.25	5.25
Test image 4	12.25	42.75	8.00
Test image 5	2.25	33.75	31.25
Test image 6	17.25	42.00	28.00
Test image 7	7.25	16.75	37.00
Test image 8	0.75	13.75	18.00
Test image 9	2.75	31.25	2.50
Test image 10	23.25	30.25	8.00
Test image 11	12.75	20.75	11.00
Test image 12	1.50	18.75	4.50
Test image 13	4.50	14.75	11.00
Test image 14	7.25	7.75	19.50
Test image 15	17.75	19.00	9.75
Test image 16	9.25	7.75	9.50
Test image 17	16.00	8.25	15.25
Test image 18	14.50	32.75	17.00
Test image 19	3.50	8.00	18.00
Test image 20	5.00	15.00	2.25
Test image 21	4.50	14.50	9.25
Test image 22	14.25	33.25	9.50
Test image 23	0.50	0.50	14.50
Test image 24	2.25	6.75	4.50
Test image 25	0.75	10.25	1.50
Average Error	8.7	20.16	5.75

A.2 The error and its average of depth's ordering regions in foreground, middleground and background in group 2.

% Error	Foreground	Middleground	Background
Test image 1	14.00	17.50	16.00
Test image 2	20.75	24.25	7.25
Test image 3	11.00	29.75	11.25
Test image 4	4.00	31.00	24.00
Test image 5	6.75	19.50	19.75
Test image 6	10.00	14.75	9.25
Test image 7	4.75	28.25	13.25
Test image 8	2.50	7.00	2.00
Test image 9	34.25	38.50	14.00
Test image 10	3.50	4.25	6.25
Test image 11	3.50	7.00	4.50
Test image 12	11.75	18.75	5.25
Test image 13	2.00	7.25	10.25
Test image 14	9.25	16.25	8.50
Test image 15	18.75	19.25	2.00
Test image 16	11.00	15.75	19.00
Test image 17	8.75	14.50	6.50
Test image 18	6.50	7.25	2.75
Test image 19	0.75	0.50	0.50
Test image 20	14.50	14.50	21.00
Test image 21	2.25	23.00	15.50
Test image 22	5.75	11.75	8.75
Test image 23	2.75	11.00	8.75
Test image 24	4.50	39.00	41.50
Test image 25	8.25	8.50	4.50
Average Error	8.87	17.16	11.2

A.3 The error and its average of depth's ordering regions in foreground, middleground and background in group 3.

% Error	Foreground	Middleground	Background
Test image 1	6.50	17.00	13.00
Test image 2	12.50	33.25	15.50
Test image 3	11.50	22.25	9.25
Test image 4	9.50	12.50	6.25
Test image 5	27.75	42.00	7.25
Test image 6	7.25	12.75	13.75
Test image 7	0.50	35.25	30.00
Test image 8	11.25	13.75	13.00
Test image 9	25.00	31.00	2.00
Test image 10	20.00	5.00	29.25
Test image 11	8.50	4.75	4.50
Test image 12	8.50	14.75	11.00
Test image 13	9.50	16.75	24.50
Test image 14	0.25	16.75	6.25
Test image 15	8.50	17.75	7.25
Test image 16	2.50	7.00	5.25
Test image 17	1.75	14.00	18.75
Test image 18	8.00	13.50	4.25
Test image 19	3.50	11.00	16.00
Test image 20	4.50	14.25	14.25
Test image 21	1.75	12.75	12.00
Test image 22	14.50	31.50	16.50
Test image 23	2.50	33.50	32.50
Test image 24	1.25	19.00	8.75
Test image 25	14.50	19.75	12.50
Average Error	8.87	18.87	5.75

A.4 The error and its average of depth's ordering regions in foreground, middleground and background in group 4.

% Error	Foreground	Middleground	Background
Test image 1	2.50	11.25	9.00
Test image 2	4.00	15.00	22.25
Test image 3	2.25	28.25	24.25
Test image 4	6.50	4.75	11.25
Test image 5	8.25	18.00	12.50
Test image 6	10.25	23.50	21.50
Test image 7	0.50	3.75	1.50
Test image 8	0.75	7.75	5.00
Test image 9	3.25	3.00	9.75
Test image 10	8.75	21.50	9.50
Test image 11	2.50	8.75	5.50
Test image 12	2.25	14.00	10.50
Test image 13	3.25	8.75	7.75
Test image 14	1.00	18.00	9.00
Test image 15	1.00	10.25	6.00
Test image 16	0.50	8.25	6.50
Test image 17	4.25	7.00	4.50
Test image 18	1.50	3.50	3.25
Test image 19	0.50	23.75	6.00
Test image 20	4.50	10.75	12.00
Test image 21	62.25	10.25	3.75
Test image 22	74.00	15.75	10.75
Test image 23	60.50	4.25	15.25
Test image 24	61.25	18.50	17.75
Test image 25	79.50	9.75	6.50
Average Error	16.23	12.33	5.75

A.5 The error and its average of depth's ordering regions in foreground, middleground and background in group 5.

% Error	pF	nF	pM	nM	pB	nB
Test image 1	0.75	1.00	6.75	2.25	1.00	9.75
Test image 2	1.50	0.25	1.25	4.00	2.50	1.50
Test image 3	0.50	2.00	3.00	1.50	0.25	3.75
Test image 4	3.75	4.50	11.00	6.00	0.50	11.00
Test image 5	4.25	10.75	14.75	6.00	4.75	9.00
Test image 6	1.25	3.50	16.75	2.25	0.25	12.50
Test image 7	2.75	0.50	4.00	0.50	0.25	13.50
Test image 8	12.25	1.00	37.50	13.00	0.25	38.50
Test image 9	5.00	13.50	20.75	17.50	4.25	6.50
Test image 10	1.25	34.75	33.50	42.50	28.50	1.50
Test image 11	0.50	0.75	1.00	13.50	11.50	2.00
Test image 12	0.25	1.25	1.00	9.00	7.50	1.00
Test image 13	1.00	2.25	0.50	5.25	3.50	1.25
Test image 14	4.25	1.00	3.25	11.75	2.50	2.50
Test image 15	0.25	0.25	0.25	2.25	0.25	0.25
Test image 16	55.25	0.25	7.00	5.75	0.50	62.75
Test image 17	11.00	5.25	13.75	0.25	0.25	16.75
Test image 18	26.75	0.25	0.25	20.00	0.25	7.75
Test image 19	0.50	39.00	2.25	6.25	33.25	4.00
Test image 20	0.25	3.00	4.00	12.50	8.75	2.50
Test image 21	2.00	0.25	0.50	16.25	11.75	6.50
Test image 22	2.00	0.25	3.50	16.00	9.25	3.00
Test image 23	1.00	0.50	7.50	33.75	22.75	4.25
Test image 24	0.25	16.00	18.25	22.50	21.50	0.25
Test image 25	0.25	20.00	18.75	0.50	20.25	0.25
Average False	5.55	6.48	9.24	10.84	7.85	8.9

A.6 The error and its average of the cross validation results in false-positive of foreground(pF), false-negative of foreground(nF), false-positive of middleground(pM), false-negative of middleground(nM), false-positive of background(pB), and false-negative of background(nB) in cross validation image groups 1.

% Error	pF	nF	pM	nM	pB	nB
Test image 1	6.25	19.75	6.00	47.75	37.00	6.75
Test image 2	3.25	4.75	4.50	8.00	0.75	5.50
Test image 3	2.25	4.25	7.25	5.00	0.25	8.75
Test image 4	6.50	6.75	37.75	6.00	0.25	32.00
Test image 5	2.25	1.00	13.00	21.75	20.75	8.25
Test image 6	18.00	0.25	26.75	16.25	0.25	37.75
Test image 7	8.00	0.25	10.50	7.25	0.75	18.25
Test image 8	0.75	1.00	1.00	13.75	1.25	2.25
Test image 9	3.00	0.75	10.00	22.25	2.25	6.75
Test image 10	12.75	11.50	18.50	12.75	0.25	11.75
Test image 11	1.00	12.75	14.50	7.25	3.50	2.00
Test image 12	0.75	1.75	0.75	19.00	11.00	1.00
Test image 13	0.25	5.25	15.50	0.25	0.25	20.25
Test image 14	1.00	7.25	5.75	3.00	1.25	9.50
Test image 15	0.25	18.50	19.75	0.25	0.25	10.25
Test image 16	7.50	2.75	2.25	6.50	4.50	11.75
Test image 17	0.25	16.75	9.00	0.25	14.50	3.50
Test image 18	0.25	15.25	32.50	1.25	0.25	18.75
Test image 19	3.25	1.25	6.25	2.75	0.50	2.75
Test image 20	0.25	5.75	13.50	2.50	0.50	9.75
Test image 21	0.25	5.25	5.25	10.25	10.25	0.25
Test image 22	0.25	15.00	15.25	19.00	15.25	0.25
Test image 23	0.25	0.25	0.25	0.25	5.25	0.25
Test image 24	1.25	2.00	4.50	3.25	0.75	1.75
Test image 25	1.50	0.25	2.25	9.00	6.25	0.50
Average False	3.25	6.41	11.3	9.82	5.52	9.22

A.7 The error and its average of the cross validation results in false-positive of foreground(pF), false-negative of foreground(nF), false-positive of middleground(pM), false-negative of middleground(nM), false-positive of background(pB), and false-negative of background(nB) in cross validation image groups 2.

% Error	pF	nF	pM	nM	pB	nB
Test image 1	0.75	14.25	8.75	9.75	1.50	15.50
Test image 2	0.25	21.50	22.75	2.50	2.50	5.75
Test image 3	6.25	5.75	3.25	27.50	10.25	2.00
Test image 4	1.75	3.25	9.75	22.25	18.50	6.50
Test image 5	2.75	5.00	5.00	15.50	18.75	2.00
Test image 6	0.25	10.75	7.00	8.75	7.25	3.00
Test image 7	5.50	0.25	18.50	10.75	0.50	13.75
Test image 8	2.50	1.00	1.25	6.75	1.75	1.25
Test image 9	2.25	33.00	36.75	2.75	5.50	9.50
Test image 10	2.00	2.50	1.75	3.50	1.50	5.75
Test image 11	3.00	1.50	2.00	6.00	0.25	5.25
Test image 12	0.25	12.50	19.50	0.25	0.25	6.00
Test image 13	1.00	2.00	4.00	4.25	0.25	11.00
Test image 14	0.25	10.00	14.75	2.50	0.25	9.25
Test image 15	0.25	19.50	20.00	0.25	0.75	2.25
Test image 16	11.75	0.25	15.75	1.00	0.50	19.50
Test image 17	0.75	9.00	13.75	1.75	0.50	7.00
Test image 18	1.25	6.25	6.50	1.75	1.00	2.75
Test image 19	0.25	1.50	1.00	0.50	0.25	1.25
Test image 20	0.25	15.25	14.00	1.50	0.25	21.75
Test image 21	1.75	1.50	1.50	22.50	15.00	1.50
Test image 22	6.25	0.50	2.75	10.00	5.75	4.00
Test image 23	2.25	1.50	2.25	9.75	9.25	0.50
Test image 24	5.25	0.25	39.25	0.75	0.25	42.25
Test image 25	9.00	0.25	0.25	9.25	0.25	5.25
Average False	2.71	7.16	10.88	7.28	4.11	8.18

A.8 The error and its average of the cross validation results in false-positive of foreground(pF), false-negative of foreground(nF), false-positive of middleground(pM), false-negative of middleground(nM), false-positive of background(pB), and false-negative of background(nB) in cross validation image groups 3.

% Error	pF	nF	pM	nM	pB	nB
Test image 1	7.25	0.25	0.75	17.25	11.50	2.50
Test image 2	0.50	13.00	29.00	5.25	5.25	11.25
Test image 3	0.25	12.25	20.75	2.50	6.00	4.25
Test image 4	8.25	2.25	8.00	5.50	3.50	3.75
Test image 5	1.00	27.75	42.75	0.25	0.75	7.50
Test image 6	5.75	2.50	6.00	7.75	0.25	14.50
Test image 7	0.25	1.25	36.00	0.25	0.25	30.75
Test image 8	0.25	12.00	6.50	8.25	12.50	1.50
Test image 9	0.25	25.75	31.50	0.50	0.50	2.50
Test image 10	0.25	20.75	1.25	4.75	23.50	6.75
Test image 11	1.75	7.75	3.00	2.75	5.25	0.25
Test image 12	0.25	9.25	15.50	0.25	0.25	11.75
Test image 13	0.25	10.25	16.50	1.25	2.25	23.25
Test image 14	1.00	0.25	10.75	7.00	0.50	6.75
Test image 15	0.25	9.25	18.25	0.50	0.25	8.00
Test image 16	2.25	1.25	4.25	3.75	0.50	5.75
Test image 17	0.25	2.50	14.75	0.25	0.25	19.50
Test image 18	6.50	2.50	3.00	11.50	0.25	5.00
Test image 19	4.25	0.25	5.50	6.50	0.25	16.75
Test image 20	5.25	0.25	8.25	7.00	0.50	14.75
Test image 21	2.50	0.25	13.00	0.75	0.25	12.75
Test image 22	7.75	7.75	8.25	24.25	17.25	0.25
Test image 23	3.25	0.25	33.75	0.75	0.25	33.25
Test image 24	2.00	0.25	4.25	15.75	4.50	5.25
Test image 25	4.25	11.25	11.00	9.75	8.25	5.25
Average False	2.63	7.24	14.12	5.77	4.19	10.15

A.9 The error and its average of the cross validation results in false-positive of foreground(pF), false-negative of foreground(nF), false-positive of middleground(pM), false-negative of middleground(nM), false-positive of background(pB), and false-negative of background(nB) in cross validation image groups 4.

% Error	pF	nF	pM	nM	pB	nB
Test image 1	2.25	1.25	7.00	5.25	3.00	7.00
Test image 2	4.25	0.75	13.50	2.50	3.50	19.75
Test image 3	2.25	1.00	27.75	1.50	0.25	25.00
Test image 4	6.50	1.00	5.00	0.75	0.75	11.50
Test image 5	5.75	3.50	13.75	5.25	0.50	13.00
Test image 6	11.00	0.25	17.25	7.25	0.25	22.25
Test image 7	0.25	0.25	2.00	2.75	1.00	1.50
Test image 8	0.50	1.25	8.25	0.50	1.25	4.75
Test image 9	3.50	0.75	0.25	3.75	2.25	8.50
Test image 10	0.75	9.00	21.00	1.50	1.75	8.75
Test image 11	2.75	0.75	5.75	4.00	1.00	5.50
Test image 12	1.00	2.25	11.25	3.75	2.25	9.25
Test image 13	0.25	4.00	9.50	0.25	0.25	8.50
Test image 14	1.75	0.25	11.25	7.75	3.75	6.25
Test image 15	0.50	1.50	6.75	4.50	1.00	6.00
Test image 16	0.25	1.25	9.00	0.25	0.25	7.25
Test image 17	0.25	5.00	7.75	0.25	0.25	5.25
Test image 18	2.00	0.50	3.50	1.00	0.75	3.50
Test image 19	0.25	0.25	17.25	7.50	0.50	6.50
Test image 20	0.25	5.25	11.50	0.25	0.50	12.50
Test image 21	42.75	20.50	5.25	6.00	0.75	4.00
Test image 22	51.25	23.75	13.00	3.75	0.25	11.50
Test image 23	21.50	40.00	3.75	1.50	3.75	12.50
Test image 24	37.00	25.25	19.25	0.25	0.25	18.50
Test image 25	53.75	26.75	5.50	5.25	1.25	6.25
Average False	10.1	7.05	10.24	3.09	1.25	9.81

A.10 The error and its average of the cross validation results in false-positive of foreground(pF), false-negative of foreground(nF), false-positive of middleground(pM), false-negative of middleground(nM), false-positive of background(pB), and false-negative of background(nB) in cross validation image groups 5.

Appendix II

The Validation Images

Appendix II shows five validating images groups that contain 125 images categorized into 5 groups. They are shown in Fig. B.1 to B.5.

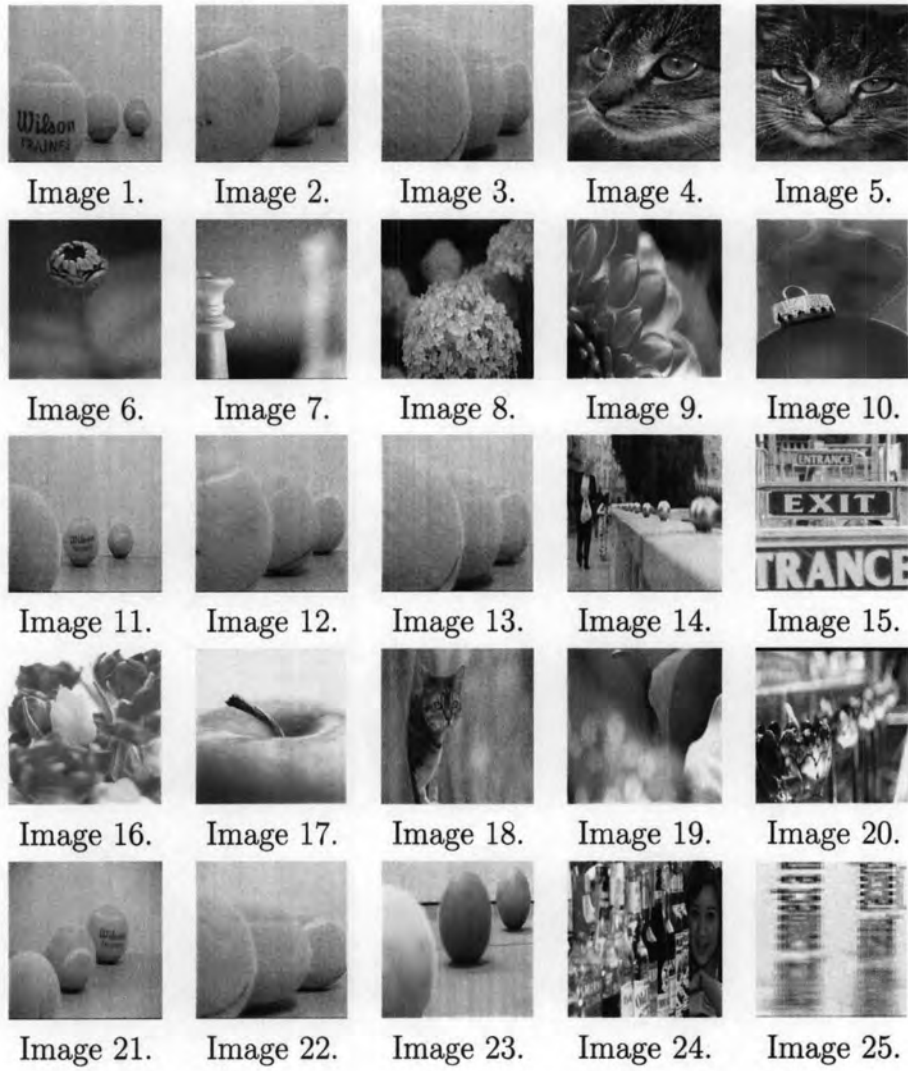


Figure B.1 Validating images group 1.

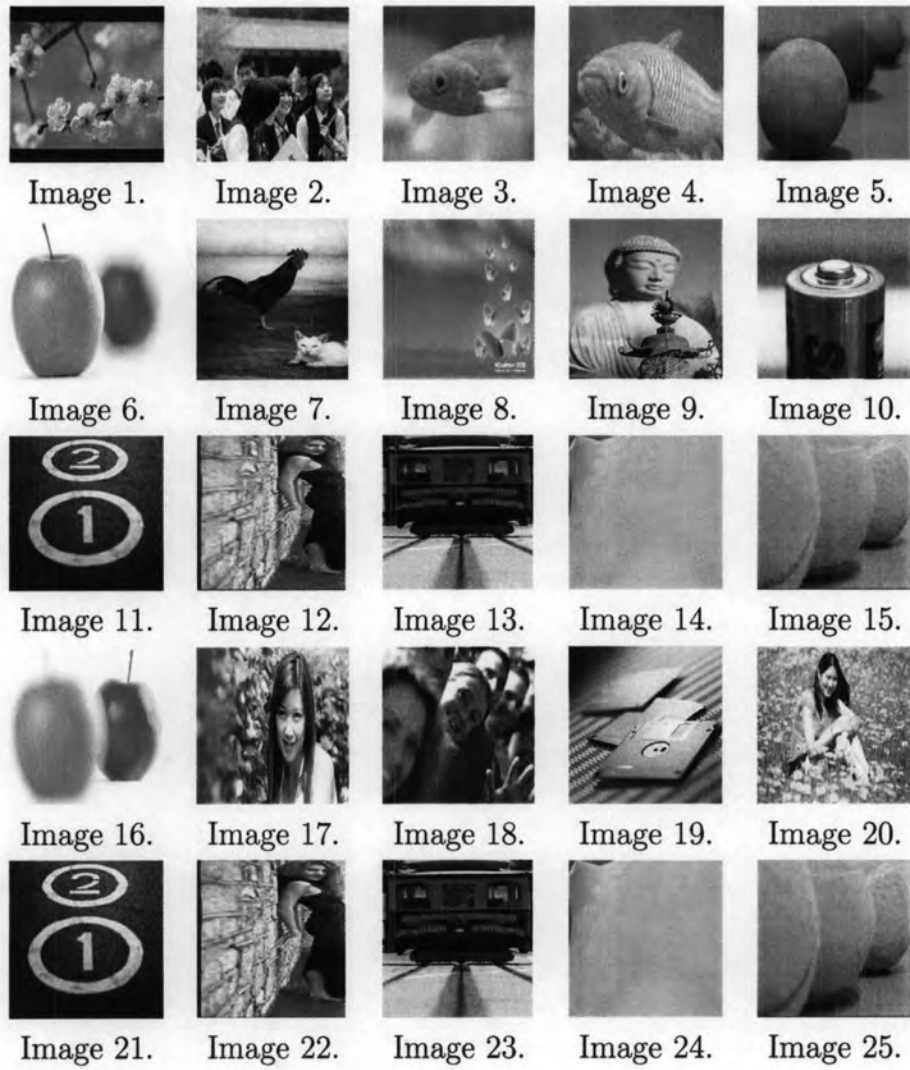


Figure B.2 Validating images group 2.



Figure B.3 Validating images group 3.



Figure B.4 Validating images group 4.



Figure B.5 Validating images group 5.

Appendix III Region Depth Ordering Images

Appendix III shows five region depth ordering images groups that contain 125 images categorized into 5 groups. They are shown in Fig. C.1 to C.5.

Note: The association of the color in each region,

- the white color associates with foreground,
- the gray color associates with middleground, and
- the black color associates with background.

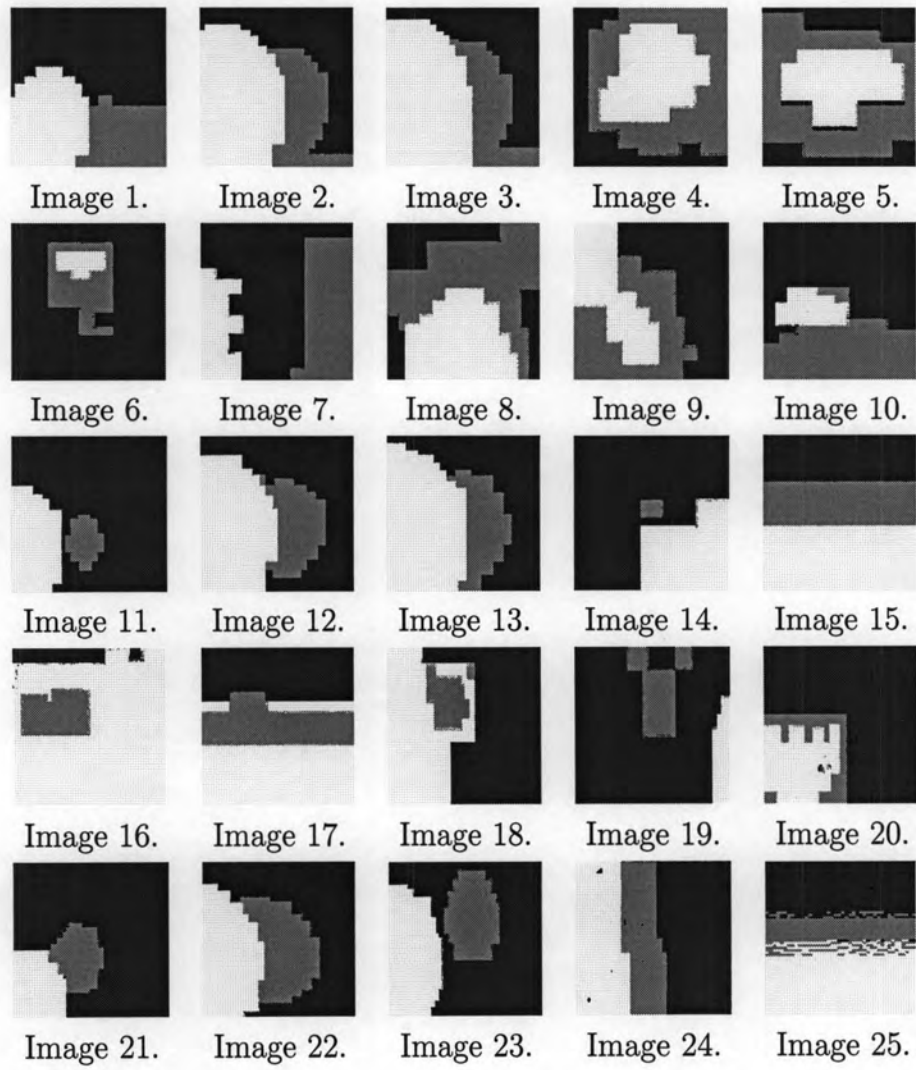


Figure C.1 Regions depth ordering groundtruth from the validation image group 1.

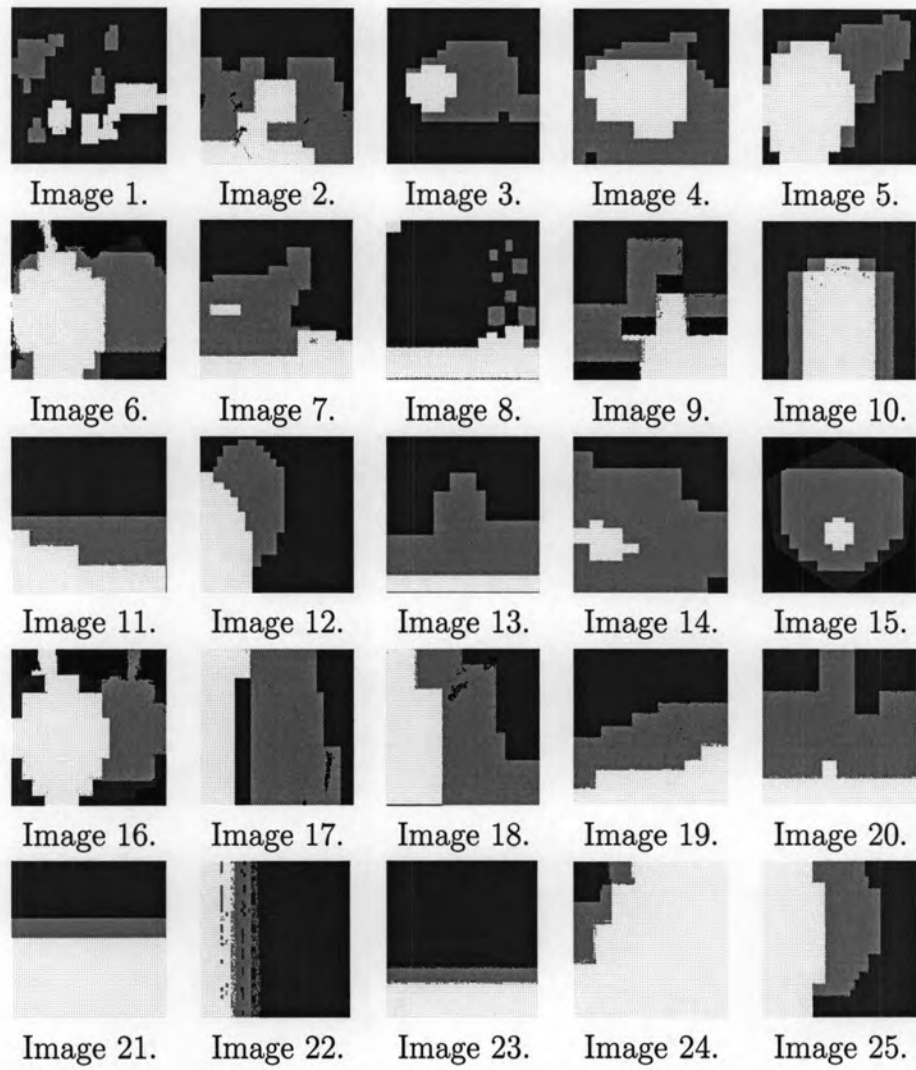


Figure C.2 Regions depth ordering groundtruth from the validation image group 2.

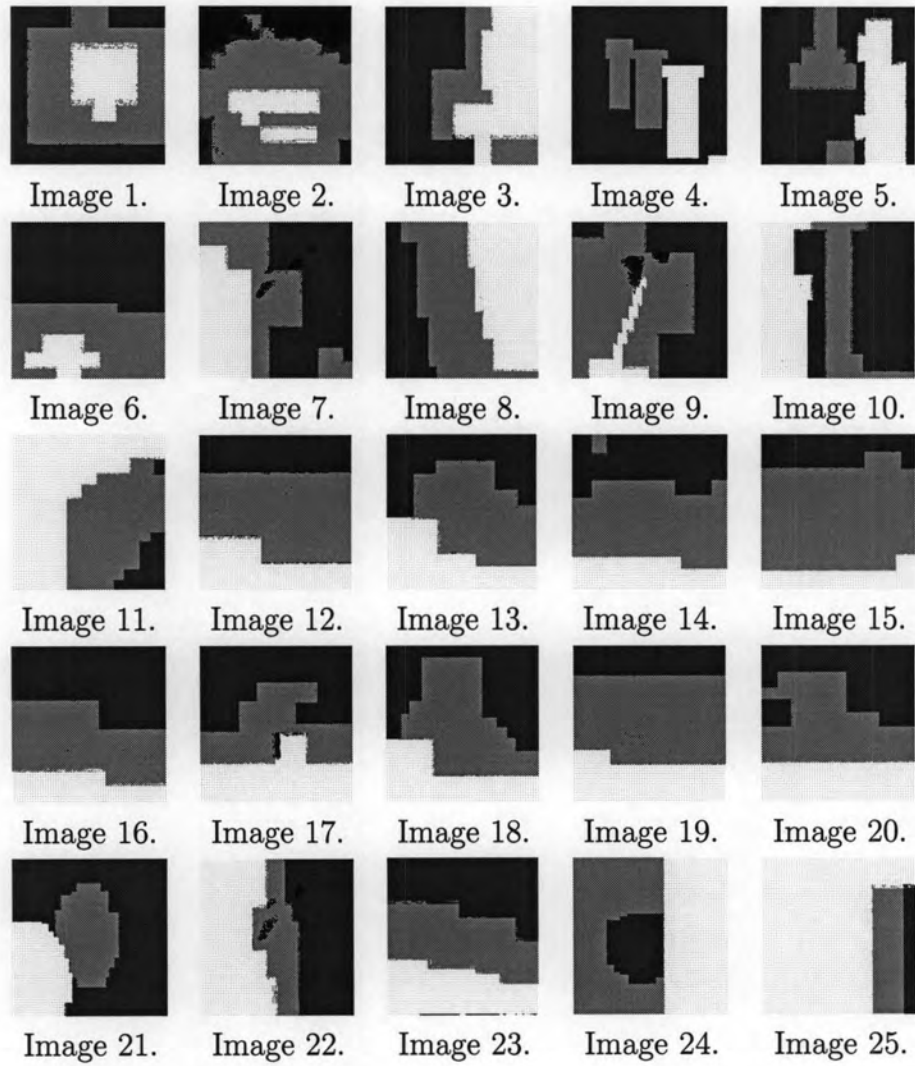


Figure C.3 Regions depth ordering groundtruth from the validation image group 3.

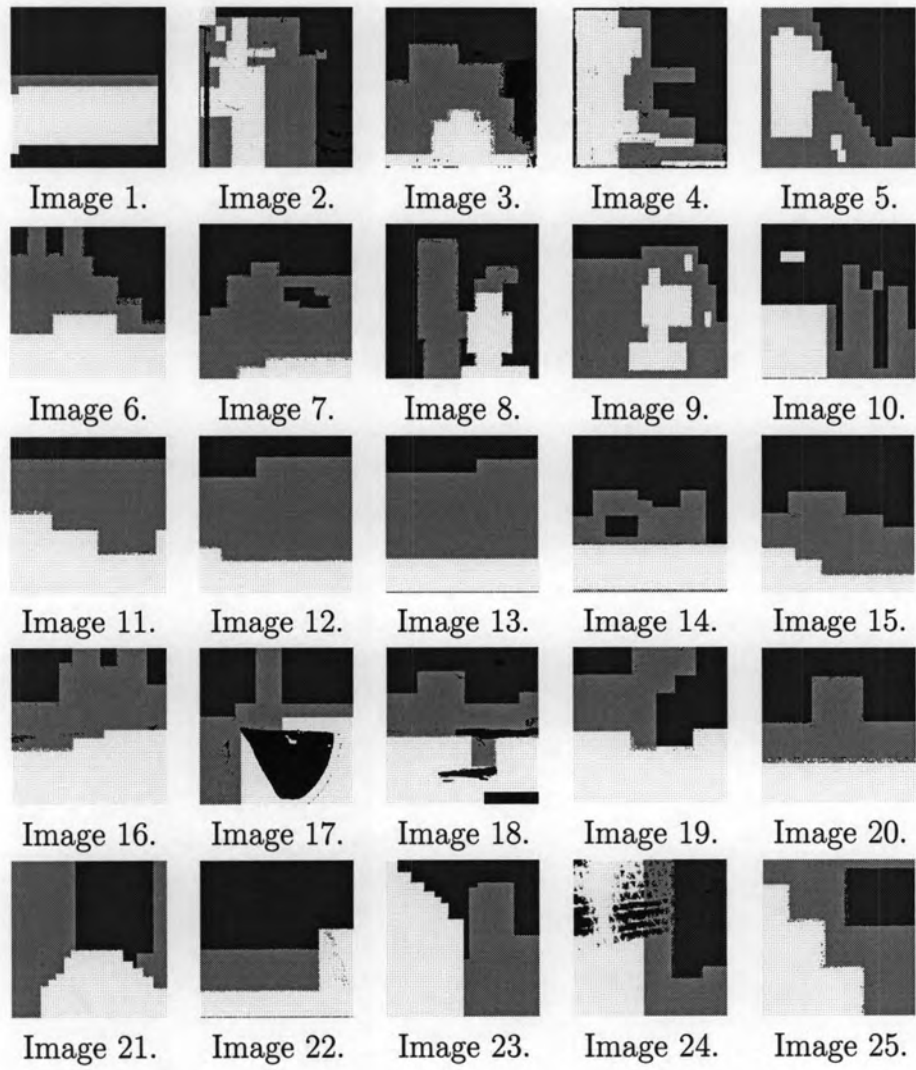


Figure C.4 Regions depth ordering groundtruth from the validation image group 4.

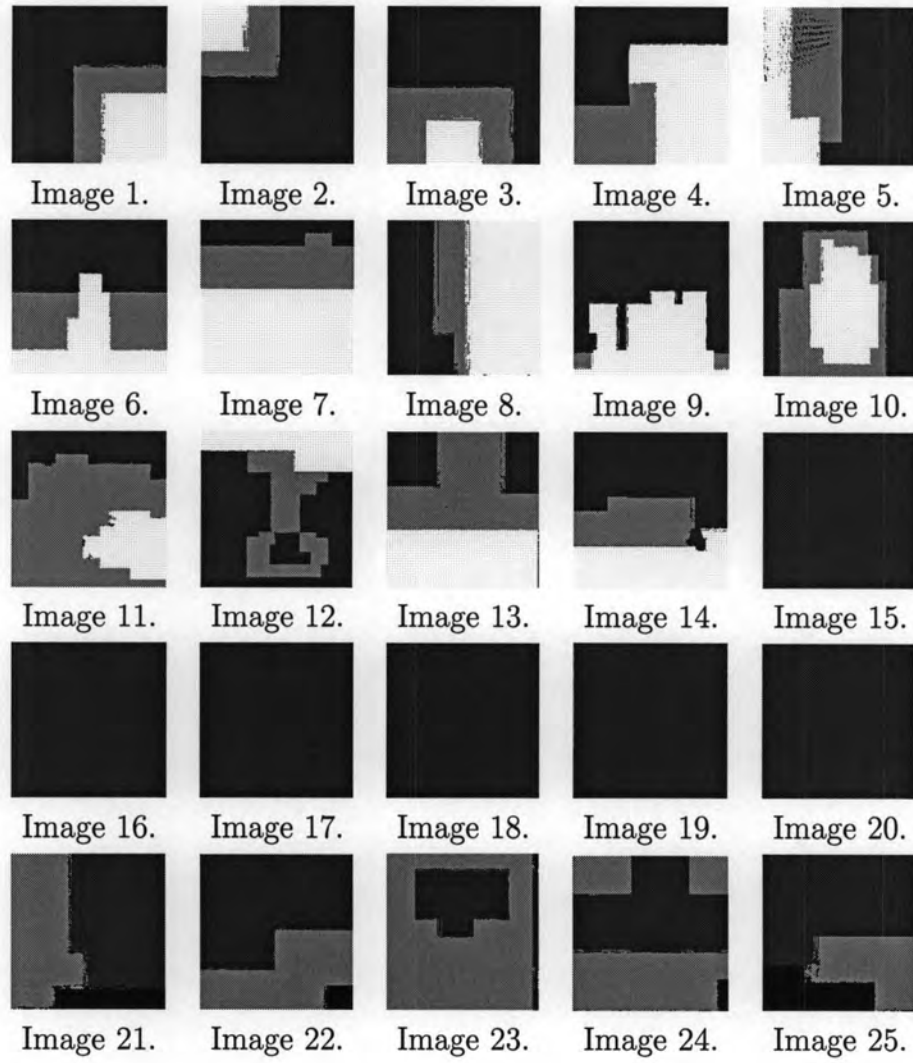


Figure C.5 Regions depth ordering groundtruth from the validation image group 5.

Appendix IV

Groundtruth of Region Images

Appendix IV shows five groundtruth of region images groups that contain 125 images categorized into 5 groups. They are shown in Fig. D.1 to D.5.

Note: The association of the color in each region,

- the white color associates with foreground,
- the gray color associates with middleground, and
- the black color associates with background.

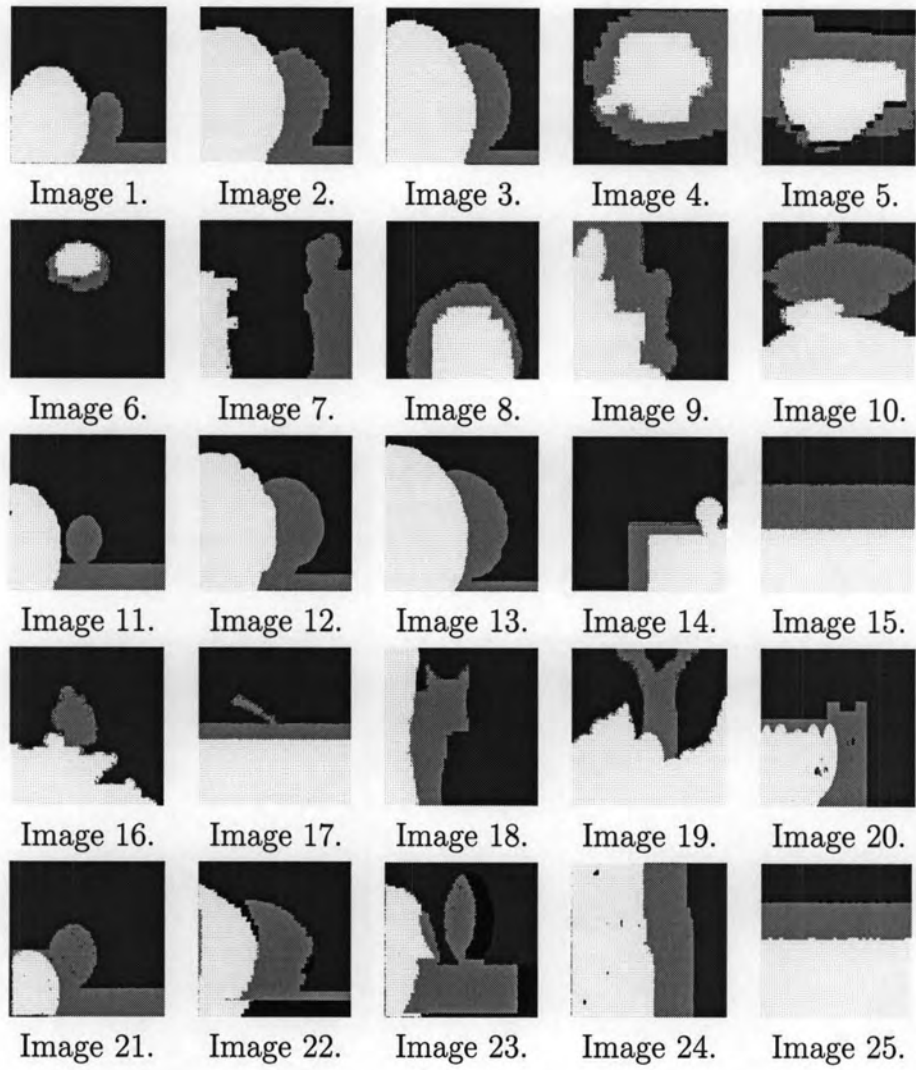


Figure D.1 Regions depth ordering results from the validation image group 1.

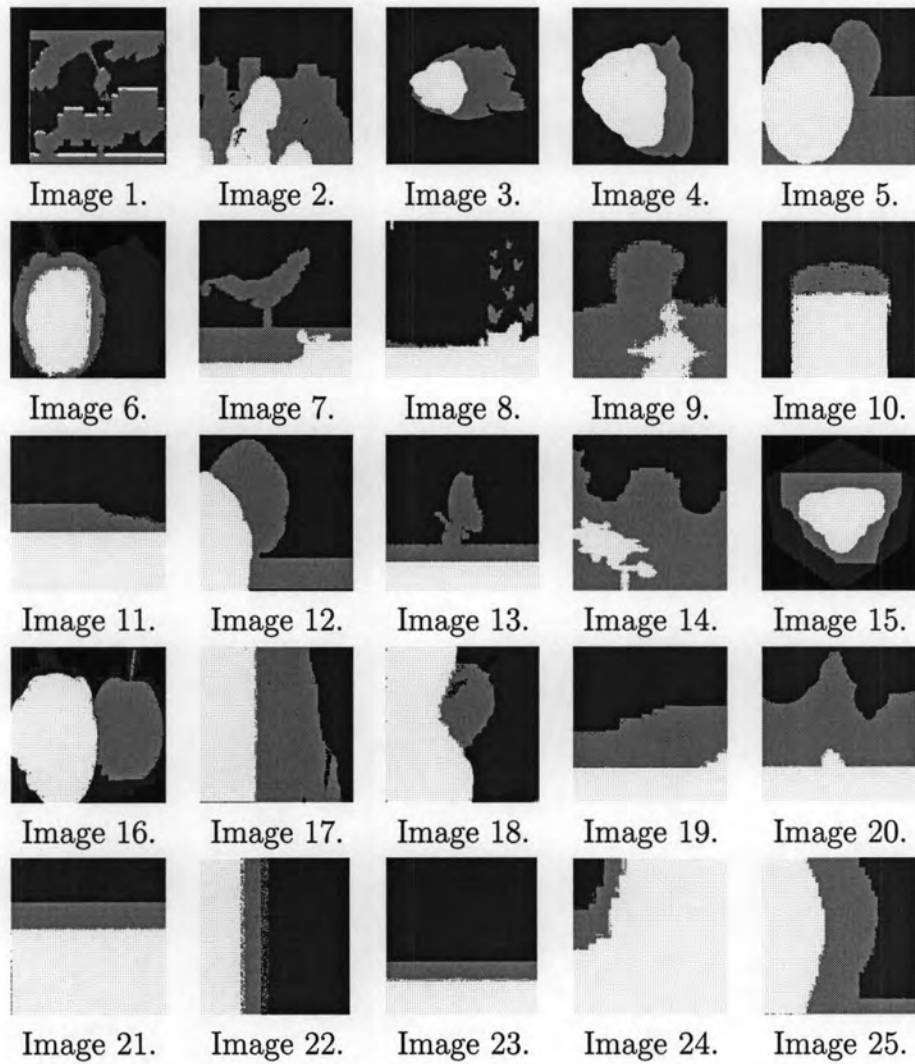


Figure D.2 Regions depth ordering results from the validation image group 2.

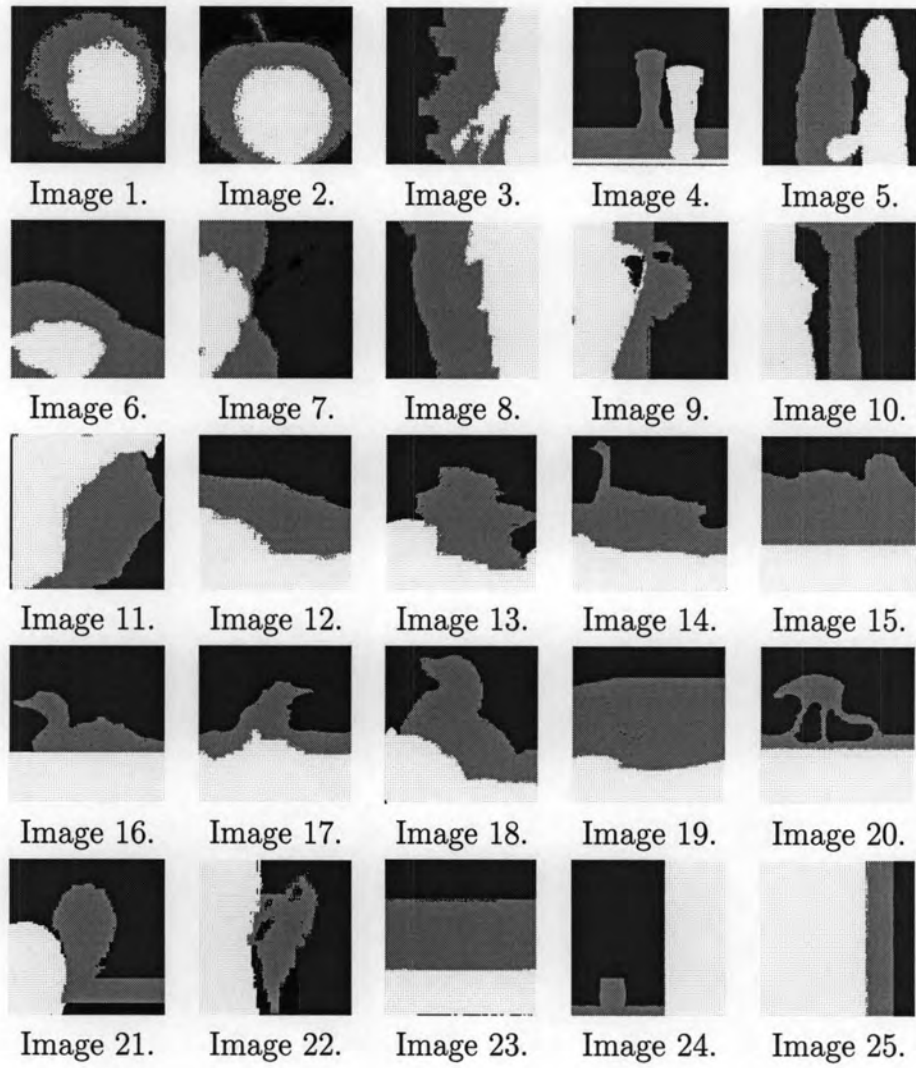


Figure D.3 Regions depth ordering results from the validation image group 3.

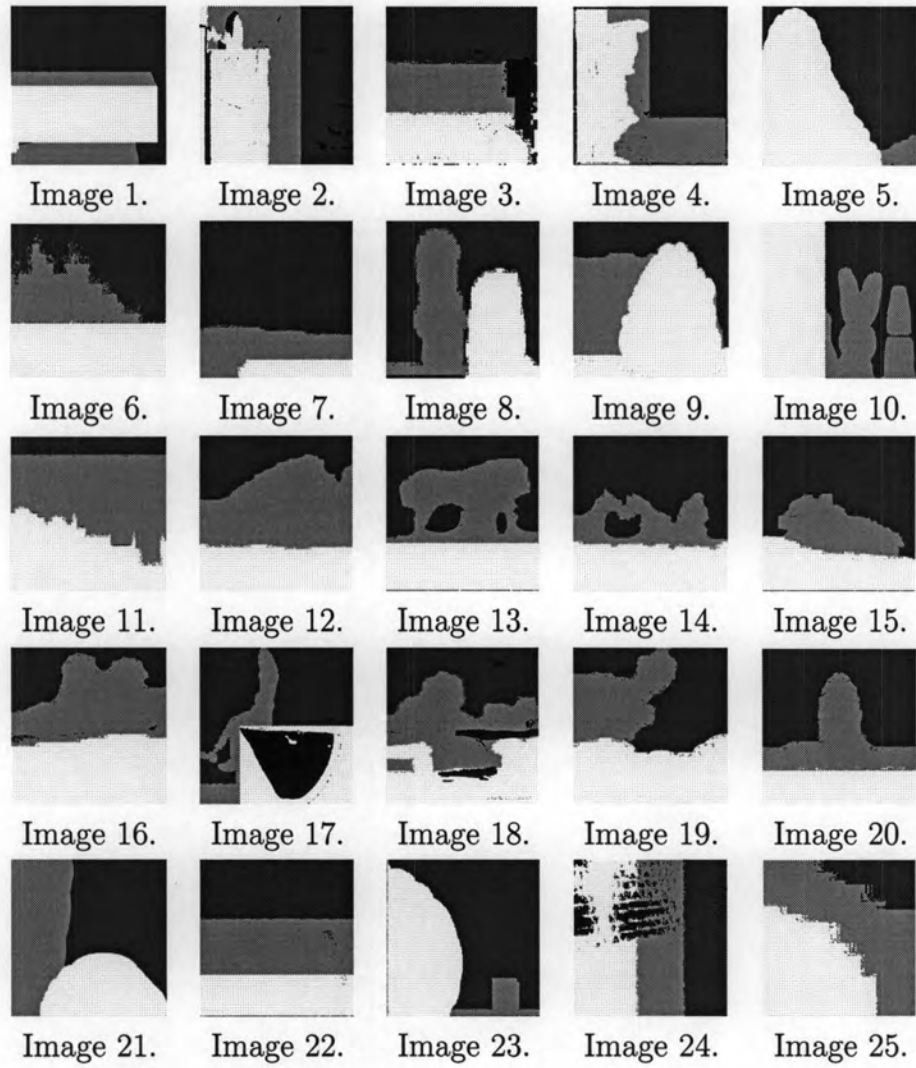


Figure D.4 Regions depth ordering results from the validation image group 4.

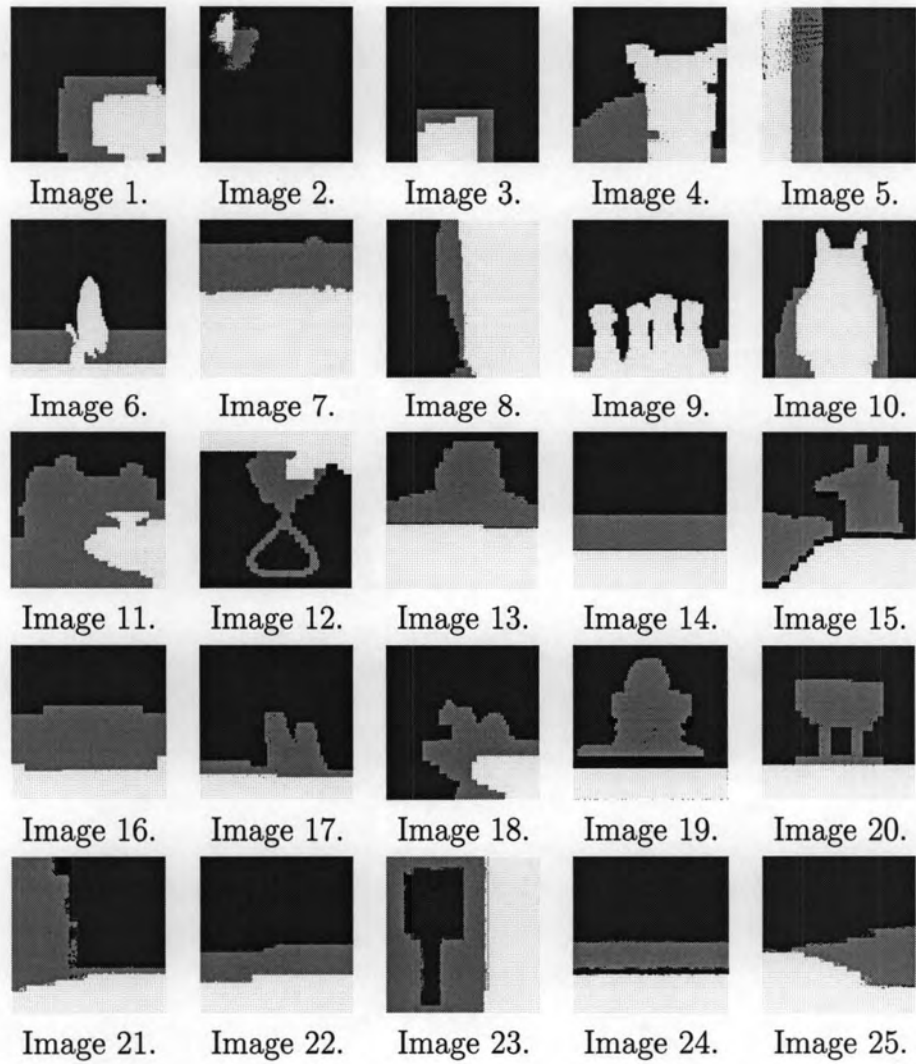


Figure D.5 Regions depth ordering results from the validation image group 5.

VITAE

Name: Mr Yutthana Lila.

Date of Birth: 23th May, 1973.

Place of Birth: Nakhonsawan, Thailand.

Educations:

- Ph.D., Program in Computer Science, Department of Mathematics, Chulalongkorn University, Thailand. (May 2003 - Present)
- Ph.D., Visiting researcher, National Institute of Information Computer Vision Laboratory, Tokyo, JAPAN (March - August 2007)
- M.Sc., Program in Imaging Technology, Department of Photographic and Printing Technology, Faculty of Science, Chulalongkorn University, Thailand. (June 1999 - May 2003)
- B.Sc., Program in Medical Instrumentation, Department of Industrial Physic and Medical Instrumentation, Faculty of Applied Science, King Mongkut's Institute of Technology North Bangkok, Thailand. (June 1994 - April 1998)

Publications, National and International Conferences:

- L. Yutthana, L. Chidchanok and L. Rajalida, "Sharpness Classification of Gray-Scaled Image Based on Variance Intensity and Neural Network", *The 1st Mathematics and Physical Science Graduate Congress*, Bangkok, Thailand, Decembe, 2005.
- L. Yutthana, L. Chidchanok and L. Rajalida, "Fourier Based Image Sharpness Measure Technique by using Neural Network", *The 3th joint Conference on Computer Science and Software Engineer (JCSSE)2006*, Bangkok, Thailand, July, 2006.
- L. Yutthana, L. Chidchanok, and L. Rajalida, "Object's Depth Ordering in Monocular Image by Using Multi Neural Network Classification", *Proceedings of International Conference on Control, Automation and System*, Busan, Korea, October 18-21, 2006.
- L. Yutthana., L. Chidchanok, L. Rajalida, and S. Satoh. "3D Shape Recovery from Single Image by using Texture Information", *Proceedings of International Conference on Control, Automation and System*, Seoul, Korea, October 14-17, 2008.