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Pattern Recognition in High-Throughput Zebrafish Imaging

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Bibliography

- [1] T. Bäck, *Evolutionary Algorithms in Theory and Practice: Evolution Strategies, Evolutionary Programming, Genetic Algorithms*, Oxford Univ. press, 1996.
- [2] B. A. Barut, L. I. Zon, Realizing the Potential of Zebrafish as a Model for Human Disease, *Physiological Genomics* 2 (2000) 49–51.
- [3] J. S. Blackburn, S. Liu, A. R. Raimondi, M. S. Ignatius, C. D. Salthouse, D. M. Langenau, High-throughput imaging of adult fluorescent zebrafish with an LED fluorescence macroscope, *Nature Protocols* 6 (2011) 229–241.
- [4] E. Borestein, E. Sharon, S. Ullman, Combining Top-down and Bottom-up Segmentation, *Presceedings of IEEE Conference on Computer Vision and Pattern Recognition Workshop on Perceptual Organization in Computer Vision* (2004) 46.
- [5] G. Borgefors, Distance Transformations in Digital Images, *Computer Vision, Graphics, and Image Processing* 34/3 (1986) 344–371.
- [6] G. Borgefors, R. Strand, An Approximation of the Maximal Inscribed Convex Set of a Digital Image, *ICAIIP* (2005) 438–445.
- [7] P. J. H. Bronkorsta, M. J. T. Reinders, E. A. Hendriks, J. Grimbergen, R. M. Heethaar, G. J. Brakenhoff, On-line Detection of Red Blood Cell Shape using Deformable Templates, *Brakenhoff Pattern Recognition Letters* 21(5) (2000) 413–424.
- [8] R. Carvalho, J. de Sonnevile, O. W. Stockhammer, N. D. L. Savage, W. J. Veneman, T. H. M. Ottenhoff, R. P. Dirks, A. H. Meijer, H. P. Spaink, A High-Throughput Screen for Tuberculosis Progression, *PLoS One* 6(2).
- [9] T. F. Cootes, C. J. Taylor, D. H. Cooper, J. Graham, Active Shape Models - Their Training and Application, *Comput. Vision and Image Understanding* 61/1 (1995) 38–59.
- [10] T. F. Cootes, C. J. Taylor, A. Lanitis, Active Shape Models: Evaluation of a Multi-Resolution Method for improving Image Search, *Proceedings of the British Machine Vision Conference* 1 (1994) 327–336.
- [11] C. L. Cosma, K. Klein, R. Kim, D. Beery, L. Ramakrishnan, Mycobacterium Marium Erp is a Virulence Determinant required for Cell Wall Integrity and Intracellular Survival, *Infection and immunity* 74(6) (2006) 3125–3133.

- [12] J. Cousty, G. Bertrand, L. Najman, M. Couprie, Watershed Cuts: Minimum Spanning Forests and the Drop of Water Principle, *Transactions on Pattern Analysis and Machine Intelligence*. 31 (2009) 1362–1374.
- [13] O. Cuisenaire, B. Macq, Fast and Exact Signed Euclidean Distance Transformation with Linear Complexity, *IEEE International Conference on Acoustics, Speech and Signal Processing* 6 (1999) 3293–3296.
- [14] P. Danielsson, Euclidean distance mapping, *Comput. Graph. Image Process.* 14 (1980) 227–248.
- [15] R. Fabbri, L. D. F. Costa, J. C. Torelli, O. M. Bruno, 2D Euclidean Distance Transform Algorithms: A Comparative Survey, *ACM Computing Surveys* 40 (2008) 1–44.
- [16] P. F. Felzenszwalb, Representation and Detection of Shapes in Images, Ph.D. thesis, MIT, 2003.
- [17] N. Funobiki, M. Isogai, An Eye-Contour Extraction Algorithm from Face Image using Deformable Template Matching, *Mem. of the Fac. of Eng.* 40 (2006) 78–87.
- [18] A. Garrido, N. P. de la Blanca, Applying Deformable Templates for Cell Image Segmentation., *Pattern Recognition* 33/5 (2000) 821–832.
- [19] S. George, T. Xia, R. Rallo, Y. Zhao, Z. Ji, S. Lin, X. Wang, H. Zhang, B. France, D. Schoenfeld, R. Damoiseaux, R. Liu, S. Lin, K. A. Bradley, Y. Cohen, A. E. Nel, Use of a High-Throughput Screening Approach Coupled with In Vivo Zebrafish Embryo Screening To Develop Hazard Ranking for Engineered Nanomaterials, *ACS Nano* 5/3 (2011) 1805–1817.
- [20] R. Gerlai, High-Throughput Behavioral Screens: the First Step towards Finding Genes involved in Vertebrate Brain Function using Zebrafish, *Molecules* 15.4 (2010) 2609–2622.
- [21] R. Gonzales, R. Woods, *Digital Image Processing*, Addison-Wesley, London, 2nd edn., 2001.
- [22] X. He, R. S. Zemel, D. Ray, Learning and Incorporating Top-Down Cues in Image Segmentation, *Lecture Notes in Computer Science* 3951 (2006) 338–351.
- [23] A. K. Jain, Y. Zhong, M. P. Dubuisson-Jolly, Deformable Template Models: A Review, *Signal Processing* 71/2 (1998) 109–129.
- [24] A. K. Jain, Y. Zhong, S. Lakshmanan, Object Matching Using Deformable Templates, *IEEE Transactions on Pattern Analysis and Machine Intelligence* 18/3 (1996) 267–278.

- [25] C. A. Karlovich, R. M. John, L. Ramirez, D. Y. Stainier, R. M. Myers, Characterization of the Huntington's Disease (HD) Gene Homologue in the Zebrafish *Danio rerio*, *Gene* 217(1-2) (1998) 117–25.
- [26] M. Kass, A. Witkin, D. Terzopoulos, Snakes: Active Contour Models, *International Journal of Computer Vision* 1/4 (1987) 321–331.
- [27] C. Kervrann, F. Heitz, A Hierarchical Static Framework for the Segmentation of Deformable Objects in Image Sequences, *IEEE Computer Vision Pattern Recognition* (1994) 724–728.
- [28] H. Y. Kim, S. A. de Araujo, Grayscale Template-Matching Invariant to Rotation, Scale, Translation, Brightness and Contrast, *IEEE Pacific-Rim Symposium on Image and Video Technology, Lecture Notes in Computer Science* 4872 (2007) 100–113.
- [29] F. Krolupper, J. Flusser, Polygonal Shape Detection for Recognition of Partially Occluded Objects, *Pattern Recognition Letters* 28 (2007) 1002–1011.
- [30] B. Leroy, I. Herlin, L. Cohen, Multi-resolution Algorithms for Active Contour Models, *ICAOS* (1996) 58–65.
- [31] A. Levin, Y. Weiss, Learning to Combine Bottom-Up and Top-Down Segmentation, *Lecture Notes in Computer Science* 3954 (2006) 581–594.
- [32] J. P. Lewis, Fast Template Matching, *Vision Interface* 95 (1995) 120–123.
- [33] L. Liu, S. Sclaroff, Region Segmentation via Deformable Model-Guided Split and Merge, *Boston University Computer Science Technical Report* 241 (2000) 98–104.
- [34] R. Liu, S. Lin, R. Rallo, Y. Zhao, R. Damoiseaux, T. Xia, S. Lin, A. Nel, Y. Cohen, Automated Phenotype Recognition for Zebrafish Embryo Based In Vivo High Throughput Toxicity Screening of Engineered Nano-Materials, *PLoS ONE* 7(4) (2012) 1.
- [35] M. R. Loken, *Immunofluorescence Techniques in Flow Cytometry and Sorting*, Wiley, 1990.
- [36] D. R. Love, F. B. Pichler, A. Dodd, B. R. Copp, D. R. Greenwood, Technology for High-throughput Screens: the Present and Future using Zebrafish, *Current opinion in biotechnology* 15/6 (2004) 564–571.
- [37] D. G. Lowe, Distinctive Image Features from Scale-invariant Keypoints, *International Journal of Computer Vision* 60(2) (2004) 91–110.
- [38] L. Lucchesse, S. K. Mitra, Color Image Segmentation: A State-of-the-Art Survey, *Proceedings of the Indian National Science Academy* 67(2) (2001) 207–221.
- [39] B. L. Miller, D. E. Goldberg, Genetic Algorithms, Tournament Selection, and the Effects of Noise, *Complex Systems* 9 (1995) 193–212.

- [40] M. Monici, Cell and Tissue Autofluorescence Research and Diagnostic Applications, *Biotechnol Annu.* 11 (2005) 227–56.
- [41] A. E. Nezhinsky, I. Martorelli, F. J. Verbeek., Detection of Developmental Stage in Zebrafish Embryos in a high throughput processing environment, *Proceedings 20th Annual Belgian-Dutch Conference on Machine Learning* (2011) 97/98.
- [42] A. E. Nezhinsky, E. J. M. Stoop, A. A. Vasylevska, A. van der Sar, F. J. Verbeek, Spatial Analysis of Bacterial Infection Patterns in Zebrafish, *Benelearn* 21.
- [43] A. E. Nezhinsky, F. J. Verbeek, Efficient and Robust Shape Retrieval from Deformable Templates, Leveraging Applications of Formal Methods, Verification and Validation. Applications and Case Studies, *Lecture Notes in Computer Science* 7610 (2012) 42–55.
- [44] H. P. Ng, S. H. Ong, P. S. Goh, K. W. C. Foong, W. L. Nowinski., Template-based Automatic Segmentation of Masseter Using Prior Knowledge, *IEEE Southwest Symposium on Image Analysis and Interpretation 2006* (2006) 208–212.
- [45] R. Nohre, Deformed Template Matching by the Viterbi Algorithm, *Pattern Recognition Letters* 17/14 (1996) 1423–1428.
- [46] N. Otsu, A Threshold Selection Method from Gray Level Histogram, *IEEE Transactions on Systems Man Cybernet* 9 (1975) 62–66.
- [47] H. Peng, F. Long, X. Liu, S. K. Kim, E. W. Myers, Straightening *Caenorhabditis elegans* Images, *Bioinformatics* 24/2 (2008) 234–242.
- [48] A. Ramirez, Circle Detection on Images using Genetic Algorithms, *Pattern Recognition Letters* 27/6 (2006) 652–657.
- [49] C. B. Rohde, M. F. Yanik, Subcellular In vivo Time-lapse Imaging and Optical Manipulation of *Caenorhabditis elegans* in Standard Multiwell Plates, *Nature Communications* 2 (2011) 271.
- [50] H. Samet, M. Tamminen, Efficient Component Labeling of Images of Arbitrary Dimension Represented by Linear Bintrees, *IEEE Transactions on Pattern Analysis and Machine Intelligence* 10/4 (1988) 579–586.
- [51] J. Sethian, *Level Set Methods: Evolving Interfaces in Geometry, Fluid Mechanics Computer Vision and Material Sciences.*, Cambridge University Press, 1999.
- [52] L. Shapiro, G. Stockman, *Computer Vision*, Prentice Hall, 2002.
- [53] G. E. Sotak, K. L. Boyer, The Laplacian-of-Gaussian Kernel: a Formal Analysis and Design Procedure for Fast, Accurate Convolution and Full-frame Output, *Computer Vision, Graphics, and Image Processing* 48/2 (1989) 147–189.

- [54] E. J. M. Stoop, T. Schipper, S. K. R. Huber, A. E. Nezhinsky, F. J. Verbeek, S. S. Gurcha, G. S. Besra, C. M. J. E. Vandenbroucke-Grauls, W. Bitter, A. M. van der Sar, Zebrafish Embryo Screen for Mycobacterial Genes Involved in Granuloma Formation reveals a Novel ESX-1 Component, *Disease Model Mechanisms* 4 (2011) 526–536.
- [55] E. J. M. Stoop, Bacterial Factors involved in Tuberculosis Infection, Ph.D. thesis, VU, 2013.
- [56] J. E. Sulston, E. Schierenberg, J. G. White, J. N. Thomson, The Embryonic Cell Lineage of the Nematode *Caenorhabditis Elegans*, *Developmental Biology* 100 (1983) 64–119.
- [57] S. Svensson, G. Borgefors, I. Nystrom, On Reversible Skeletonization Using Anchor-Points from Distance Transform, *Journal of Visual Communication and Image Representation* 10 (1999) 379–397.
- [58] H. D. Tagare, C. C. Jaffe, J. Duncan, Medical Image Databases a Content-based Retrieval Approach, *Journal of the American Medical Informatics Association* 4/3 (1997) 184–198.
- [59] W. Tao, H. Jin, Y. Zhang, Color Image Segmentation based on Mean Shift and normalized Cuts, *IEEE Transactions on Systems, Man, and Cybernetics* 37/5 (2007) 1382–1389.
- [60] E. Valveny, E. Marti, Deformable Template Matching within a Bayesian Framework for Handwritten Graphic Symbols Recognition, 3rd IAPR International Workshop on Graphics Recognition 1 (1999) 243–250.
- [61] F. J. Verbeek, P. J. Boon, High-resolution 3D Reconstruction from Serial Sections: Microscope Instrumentation, Software Design, and its Implementations, *International Symposium on Biomedical Optics. International Society for Optics and Photonics* 4621 (2002) 65–76.
- [62] A. Vogt, A. Cholewinski, X. Shen, S. G. Nelson, J. S. Lazo, M. Tsang, N. A. Hukriede, Automated Image-based Phenotypic Analysis in Zebrafish Embryos., *Developmental dynamics* 238/3 (2009) 656–663.
- [63] H. E. Voikman, H. Clay, D. Beery, J. C. Chang, D. R. Sherman, L. Ramakrishnan, Tuberculous Granuloma Formation is enhanced by a Mycobacterium Virulence Determinant, *PLoS biology* 2/11 (2004) 1946.
- [64] S. L. Walker, J. Ariga, J. R. Mathias, V. Coothankandaswamy, X. Xie, M. Distel, R. W. Koster, M. J. Parsons, K. N. Bhalla, M. T. Saxena, J. S. Mumm, Automated Reporter Quantification In Vivo: High-Throughput Screening Method for Reporter-Based Assays in Zebrafish, *PLoS ONE* 7(1) (2012) 1.

- [65] Y. N. Wu, Z. Si, C. Fleming, S. C. Zhu, Deformable Template as Active Basis, International Conference on Computer Vision 11 (2007) 1–8.
- [66] J. Yao, N. Khanna, P. Grogono, Fast Robust GA-Based Ellipse Detection, ICPR 2 (2004) 859–862.
- [67] J. You, E. Pissaloux, W. P. Shu, H. A. Cohen, Efficient Image Matching: A Hierarchical Chamfer Matching Scheme via Distributed Systems, Real Time Imaging 1 (1995) 245–259.
- [68] S. U. Yu, J. Shi, Object-Specific Figure-Ground Segregation, Computer Vision and Pattern Recognition (2003) 39–45.
- [69] H. Zhao, J. Zhou, A. Robles-Kelly, J. Lu, J. Yang, Automatic Detection of Defective Zebrafish Embryos via Shape Analysis, Digital Image Computing: Techniques and Applications (2009) 431–438.
- [70] Y. Zhong, A. K. Jain, Object Localization using Color, Texture and Shape, Pattern Recognition 33 (2000) 671–684.