Shape analysis for phenotype characterisation from high-throughput imaging

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Title: Shape analysis for phenotype characterisation from high-throughput imaging
Date: 2017-10-17

References

[1] Thain, M., Hickman, M.: Penguin dictionary of biology. Penguin books (2004)

[2] Nezhinsky, A.: Pattern recognition in high-throughput zebrafish imaging. PhD thesis, Leiden University (2013)

[3] Cao, L.: Biological model representation and analysis. PhD thesis, Leiden University (2014)

[4] Tleis, M.: Image analysis for gene expression based phenotype characterization in yeast cells. PhD thesis, Leiden University (2016)

[5] Thompson, D.: On growth and form. On growth and form. (1942)

[6] Koch, B., Stougaard, J., Spaink, H.: Keeping track of the growing number of biological functions of chitin and its interaction partners in biomedical research. Glycobiology **25** (2015) 469–482

[7] Veneman, W., Marín-Juez, R., de Sonneville, J., Ordas, A., Jong-Raadsen, S., Meijer, A., Spaink, H.: Establishment and optimization of a high throughput setup to study staphylococcus epidermidis and mycobacterium marinum infection as a model for drug discovery. Journal of Visualized Experiments (2014)

[8] Sang, J.: Drosophila melanogaster: the fruit fly. Encyclopedia of Genetics (2001) 157–162

[9] White, J., Southgate, E., Thomson, J., Brenner, S.: The structure of the nervous system of the nematode Caenorhabditis elegans. Philos Trans R Soc Lond B Biol Sci **314** (1986) 1–340

[10] Rosenthal, N., Brown, S.: The mouse ascending: perspectives for human-disease models. Nature Cell Biology **9** (2007) 993–999

[11] Rennekamp, A., Peterson, R.: 15 years of zebrafish chemical screening. Current Opinion in Chemical Biology **24** (2015) 58–70

[12] Howe, K., et al.: The zebrafish reference genome sequence and its relationship to the human genome. Nature **496** (2013) 498–503

[13] Kimmel, C., Ballard, W., Kimmel, S., Ullmann, B., Schilling, T.: Stages of embryonic development of the zebrafish. Developmental Dynamics **203** (1995) 253–310

[14] Ali, S., Champagne, D., Spaink, H., Richardson, M.: Zebrafish embryos and larvae: A new generation of disease models and drug screens. Birth Defect Research (Part C) **93** (2011) 115–133

[15] Deo, R., MacRae, C.: The zebrafish: scalable in vivo modeling for systems biology. Wiley Interdiscip Rev. Syst. Biol. Med. **3** (2011) 335–346

[16] Moro, E., et al.: Generation and application of signaling pathway reporter lines in zebrafish. Mol. Genet. Genomics **288** (2013) 231–242

[17] He, S., Lamers, G., Beenakker, J.M., Cui, C., Ghotra, V., Danen, E., Meijer, A.H., Spaink, H.P., Snaar-Jagalska, B.: Neutrophil-mediated experimental metastasis is enhanced by VEGFR inhibition in a zebrafish xenograft model. Journal of Pathology **227** (2012) 431–445

[18] Sacco, A., Roccaro, A., Ma, D., Shi, J., Mishima, Y., Moschetta, M., Chiarini, M., Munshi, N., Handin, R., Ghobrial, I.: Cancer cell dissemination and homing to the bone marrow in a zebrafish model. Cancer Research **76** (2016) 463–471

[19] Verbeek, F., Boon, P.: High-resolution 3d reconstruction from serial sections: microscope instrumentation, software design, and its implementations. In: International Symposium on Biomedical Optics, International Society for Optics and Photonics (2002) 65–76

[20] Welten, M.: Spatio-temporal gene expression analysis from 3D in situ hybridization images. PhD thesis, Leiden University (2007)

[21] Pardo-Martin, C., Allalou, A., Medina, J., Eimon, P., Wählby, C., Yanik, M.: High-throughput hyperdimensional vertebrate phenotyping. Nature Communications **4** (2013) 1467

[22] Tang, X., van't Hoff, M., Hoogenboom, J., Guo, Y., Cai, F., Lamers, G., Verbeek, F.: Fluorescence and bright-field 3D image fusion based on sinogram unification for optical projection tomography. In: IEEE Conference on Bioinformatics and Biomedicine, IEEE (2016) 403–410

[23] McGrath, P., Li, C.: Zebrafish: a predictive model for assessing drug-induced toxicity. Drug Discovery Today **13** (2008) 394–401

[24] Dalal, N., Triggs, B.: Histograms of oriented gradients for human detection. In: IEEE Conference on Computer Vision and Pattern Recognition. Volume 1., IEEE (2005) 886–893

[25] Krizhevsky, A., Sutskever, I., Hinton, G.: Imagenet classification with deep convolutional neural networks. In: Advances in Neural Information Processing Systems. (2012) 1097–1105

[26] Pardo-Martin, C., Chang, T., Koo, B., Gilleland, C., Wasserman, S., Yanik, M.: High-throughput in vivo vertebrate screening. Nature Methods **7** (2010) 634–636

[27] Szeliski, R.: Computer vision: algorithms and applications. Springer Science & Business Media (2010)

[28] Caselles, V., Kimmel, R., Sapiro, G.: Geodesic active contours. International Journal of Computer Vision **22** (1997) 61–79

[29] Comaniciu, D., Meer, P.: Mean shift: A robust approach toward feature space analysis. IEEE Transactions on Pattern Analysis and Machine Intelligence **24** (2002) 603–619

[30] Hartley, R., Zisserman, A.: Multiple view geometry in computer vision. Cambridge University Press (2003)

[31] Fitzgibbon, A., Cross, G., Zisserman, A.: Automatic 3D model construction for turn-table sequences. In: European Workshop on 3D Structure from Multiple Images of Large-Scale Environments, Springer (1998) 155–170

[32] Friedman, J., Hastie, T., Tibshirani, R.: The elements of statistical learning. Volume 1. Springer Series in Statistics Springer, Berlin (2001)

[33] Bishop, C.: Pattern recognition. Machine Learning **128** (2006) 1–58

[34] Van Wijk, R., et al.: The zebrafish as model for translational systems pharmacology: expanding the allometric scale in vertebrates with five orders of magnitude, (ISSN 1871-6032)

[35] Van Wijk, R., et al.: A parent-metabolite pharmacokinetic model of paracetamol in zebrafish, (ISSN 1871-6032)

[36] Pham, L., Kanther, M., Semova, I., Rawls, J.: Methods for generating and colonizing gnotobiotic zebrafish. Nature Protocols **3** (2008) 1862–1875

[37] Ordas, A., et al.: Testing tuberculosis drug efficacy in a zebrafish high-throughput translational medicine screen. Antimicrobial Agents and Chemotherapy **59** (2015) 753–762

[38] Nezhinsky, A., Verbeek, F.: Pattern recognition for high throughput zebrafish imaging using genetic algorithm optimization. In: IEEE Conference on Pattern Recognition in BioInformatics. Springer (2010) 301–312

[39] Kantae, V., Krekels, E., et al.: Pharmacokinetic modeling of paracetamol uptake and clearance in zebrafish larvae: Expanding the allometric scale in vertebrates with five orders of magnitude. Zebrafish **13** (2016) 504–510

[40] Guo, Y., Veneman, W., Spaink, H., Verbeek, F.: Silhouette-based 3D model for zebrafish high-throughput imaging. In: IEEE Conference on Image Processing Theory, Tools and Applications, IEEE (2015) 403–408

[41] Chan, T., Vese, L.: Active contours without edges. IEEE Transactions on Image Processing **10** (2001) 266–277

[42] Li, C., Huang, R., Ding, Z., Gatenby, J., Metaxas, D., Gore, J.: A level set method for image segmentation in the presence of intensity inhomogeneities with application to MRI. IEEE Transactions on Image Processing **20** (2011) 2007–2016

[43] Zhang, Y., Matuszewski, B., Shark, L., Moore, C.: Medical image segmentation using new hybrid level-set method. In: Conference on BioMedical Visualization, IEEE (2008) 71–76

[44] Bai, P., Liu, Q., Li, L., Teng, S., Li, J., Cao, M.: A novel region-based level set method initialized with mean shift clustering for automated medical

image segmentation. Computers in Biology and Medicine **43** (2013) 1827–1832

[45] Kass, M., Witkin, A., Terzopoulos, D.: Snakes: Active contour models. International Journal of Computer Vision **1** (1988) 321–331

[46] Osher, S., Sethian, J.: Fronts propagating with curvature-dependent speed: algorithms based on Hamilton-Jacobi formulations. Journal of Computational Physics **79** (1988) 12–49

[47] Goldenberg, R., Kimmel, R., Rivlin, E., Rudzsky, M.: Fast geodesic active contours. IEEE Transactions on Image Processing **10** (2001) 1467–1475

[48] Chen, Y., Tagare, H., Thiruvenkadam, S., Huang, F., Wilson, D., Gopinath, K., Briggs, R., Geiser, E.: Using prior shapes in geometric active contours in a variational framework. International Journal of Computer Vision **50** (2002) 315–328

[49] Chan, T., Zhu, W.: Level set based shape prior segmentation. In: IEEE Conference on Computer Vision and Pattern Recognition. Volume 2., IEEE (2005) 1164–1170

[50] Cremers, D., Rousson, M., Deriche, R.: A review of statistical approaches to level set segmentation: integrating color, texture, motion and shape. International Journal of Computer Vision **72** (2007) 195–215

[51] Schoenemann, T., Cremers, D.: Introducing curvature into globally optimal image segmentation: Minimum ratio cycles on product graphs. In: IEEE Conference on Computer Vision, IEEE (2007) 1–6

[52] Schoenemann, T., Kahl, F., Masnou, S., Cremers, D.: A linear framework for region-based image segmentation and inpainting involving curvature penalization. International Journal of Computer Vision **99** (2012) 53–68

[53] Cohen, L., Kimmel, R.: Global minimum for active contour models: A minimal path approach. International Journal of Computer Vision **24** (1997) 57–78

[54] Chen, D., Mirebeau, J., Cohen, L.: Global minimum for a Finsler elastica minimal path approach. International Journal of Computer Vision (2016) 1–26

[55] Ray, S., Turi, R.: Determination of number of clusters in k-means clustering and application in colour image segmentation. In: Conference on Advances in Pattern Recognition and Digital Techniques, Calcutta, India (1999) 137–143

[56] Chuang, K., Tzeng, H., Chen, S., Wu, J., Chen, T.: Fuzzy c-means clustering with spatial information for image segmentation. Computerized Medical Imaging and Graphics **30** (2006) 9–15

[57] Ren, X., Malik, J.: Learning a classification model for segmentation. In: IEEE Conference on Computer Vision, IEEE (2003) 10–17

[58] Ning, J., Zhang, L., Zhang, D.and Wu, C.: Interactive image segmentation by maximal similarity based region merging. Pattern Recognition **43** (2010) 445–456

[59] Cheng, Y.: Mean shift, mode seeking, and clustering. IEEE Transactions on Pattern Analysis and Machine Intelligence **17** (1995) 790–799

[60] Cootes, T., Taylor, C.J., Cooper, D., Graham, J.: Active shape models-their training and application. Computer Vision and Image Understanding **61** (1995) 38–59

[61] Lafferty, J., McCallum, A., Pereira, F.: Conditional random fields: Probabilistic models for segmenting and labeling sequence data. **1** (2001) 282–289

[62] Zhang, Y., Brady, M., Smith, S.: Segmentation of brain MR images through a hidden Markov random field model and the expectation-maximization algorithm. IEEE Transactions on Medical Imaging **20** (2001) 45–57

[63] Girshick, R., Donahue, J., Darrell, T., Malik, J.: Rich feature hierarchies for accurate object detection and semantic segmentation. In: IEEE Conference on Computer Vision and Pattern Recognition. (2014) 580–587

[64] Long, J., Shelhamer, E., Darrell, T.: Fully convolutional networks for semantic segmentation. In: IEEE Conference on Computer Vision and Pattern Recognition. (2015) 3431–3440

[65] Zheng, S., Jayasumana, S., Romera-Paredes, B., Vineet, V., Su, Z., Du, D., Huang, C., Torr, P.: Conditional random fields as recurrent neural networks. In: IEEE Conference on Computer Vision. (2015) 1529–1537

[66] Weickert, J., Romeny, B., Viergever, M.: Efficient and reliable schemes for nonlinear diffusion filtering. IEEE Transactions on Image Processing **7** (1998) 398–410

[67] Xu, G., Zhang, Z.: Epipolar geometry in stereo, motion and object recognition: a unified approach. Volume 6. Springer Science & Business Media (2013)

[68] Zhang, Z., Deriche, R., Faugeras, O., Luong, Q.: A robust technique for matching two uncalibrated images through the recovery of the unknown epipolar geometry. Artificial Intelligence **78** (1995) 87–119

[69] Martin, W., Aggarwal, J.: Volumetric descriptions of objects from multiple views. IEEE Transactions on Pattern Analysis and Machine Intelligence (1983) 150–158

[70] Szeliski, R.: Rapid octree construction from image sequences. CVGIP: Image Understanding **58** (1993) 23–32

[71] Laurentini, A.: The visual hull concept for silhouette-based image understanding. IEEE Transactions on Pattern Analysis and Machine Intelligence **16** (1994) 150–162

[72] Matusik, W., Buehler, C., Raskar, R., Gortler, S., McMillan, L.: Image-based visual hulls. In: Annual Conference on Computer graphics and Interactive Techniques, ACM (2000) 369–374

[73] Franco, J., Boyer, E.: Exact polyhedral visual hulls. In: British Machine Vision Conference. (Volume 1.) 329–338

[74] Lazebnik, S., Furukawa, Y., Ponce, J.: Projective visual hulls. International Journal of Computer Vision **74** (2007) 137–165

[75] Furukawa, Y., Ponce, J.: Carved visual hulls for image-based modeling. In: European Conference on Computer Vision, Springer (2006) 564–577

[76] Kutulakos, K., Seitz, S.: A theory of shape by space carving. In: IEEE Conference on Computer Vision. Volume 1. (1999) 307–314

[77] Vogiatzis, G., Hernandez, C., Cipolla, R.: Reconstruction in the round using photometric normals and silhouettes. In: IEEE Conference on Computer Vision and Pattern Recognition. Volume 2. (2006) 1847–1854

[78] Kolev, K., Brox, T., Cremers, D.: Robust variational segmentation of 3D objects from multiple views. In: Joint Pattern Recognition Symposium, Springer (2006) 688–697

[79] Kolev, K., Klodt, M., Brox, T., Cremers, D.: Continuous global optimization in multiview 3D reconstruction. International Journal of Computer Vision **84** (2009) 80–96

[80] Cremers, D., Kolev, K.: Multiview stereo and silhouette consistency via convex functionals over convex domains. IEEE Transactions on Pattern Analysis and Machine Intelligence **33** (2011) 1161–1174

[81] Kolev, K., Brox, T., Cremers, D.: Fast joint estimation of silhouettes and dense 3D geometry from multiple images. IEEE Transactions on Pattern Analysis and Machine Intelligence **34** (2012) 493–505

[82] Galliani, S., Lasinger, K., Schindler, K.: Massively parallel multiview stereopsis by surface normal diffusion. In: IEEE Conference on Computer Vision. (2015) 873–881

[83] Savinov, N., Ladicky, L., Hane, C., Pollefeys, M.: Discrete optimization of ray potentials for semantic 3D reconstruction. In: IEEE Conference on Computer Vision and Pattern Recognition. (2015) 5511–5518

[84] Lensch, H., Heidrich, W., Seidel, H.P.: A silhouette-based algorithm for texture registration and stitching. Graphical Models **63** (2001) 245–262

[85] Hernández, C., Schmitt, F., Cipolla, R.: Silhouette coherence for camera calibration under circular motion. IEEE Transactions on Pattern Analysis and Machine Intelligence **29** (2007) 343–349

[86] Cao, L., Verbeek, F.J.: Analytical evaluation of algorithms for point cloud surface reconstruction using shape features. Journal of Electronic Imaging **22** (2013) 043008–043008

[87] Zhang, Y., Matuszewski, B., Shark, L., Moore, C.: Medical image segmentation using new hybrid level-set method. (In: IEEE Conference on BioMedical Visualization) 71–76

[88] Zhang, Z.: A flexible new technique for camera calibration. IEEE Transactions on Pattern Analysis and Machine Intelligence **22** (2000) 1330–1334

[89] Brown, M., Lowe, D.G.: Automatic panoramic image stitching using invariant features. International Journal of Computer Vision **74** (2007) 59–73

[90] Lagarias, J., Reeds, J., Wright, M., Wright, P.: Convergence properties of the Nelder–Mead simplex method in low dimensions. SIAM Journal on Optimization **9** (1998) 112–147

[91] Hansen, N., Ostermeier, A.: Completely derandomized self-adaptation in evolution strategies. Evolutionary Computation **9** (2001) 159–195

[92] Cao, L., Verbeek, F.: Evaluation of algorithms for point cloud surface reconstruction through the analysis of shape parameters. In: IS&T/SPIE Electronic Imaging, International Society for Optics and Photonics (2012) 82900G–82900G

[93] Desbrun, M., Meyer, M., Schröder, P., Barr, A.: Implicit fairing of irregular meshes using diffusion and curvature flow. In: Conference on Computer Graphics and Interactive Techniques, ACM Press/Addison-Wesley Publishing Co. (1999) 317–324

[94] Xiong, Z., Verbeek, F.: Segmentation of zebrafish larva inhomogeneous 3D images using the level-set method. Electronic Imaging **2016** (2016) 1–9

[95] Arridge, S.: Optical tomography in medical imaging. Inverse Problems **15** (1999) R41

[96] Levoy, M., Ng, R., Adams, A., Footer, M., Horowitz, M.: Light field microscopy. ACM Transactions on Graphics **25** (2006) 924–934

[97] Broxton, M., Grosenick, L., Yang, S., Cohen, N., Andalman, A., Deisseroth, K., Levoy, M.: Wave optics theory and 3D deconvolution for the light field microscope. Optics Express **21** (2013) 25418–25439

[98] Guo, Y., Veneman, W., Spaink, H., Verbeek, F.: Three-dimensional reconstruction and measurements of zebrafish larvae from high-throughput axial-view in vivo imaging. Biomedical Optics Express **8** (2017) 2611–2634

[99] Zhang, Z., Deriche, R., Faugeras, O., Luong, Q.: A robust technique for matching two uncalibrated images through the recovery of the unknown epipolar geometry. Artificial Intelligence **78** (1995) 87–119

[100] Seitz, S., Curless, B., Diebel, J., Scharstein, D., Szeliski, R.: A comparison and evaluation of multi-view stereo reconstruction algorithms. In: IEEE

Conference on Computer Vision and Pattern Recognition. Volume 1., IEEE (2006) 519–528

[101] Wei, J., Resch, B., Lensch, H.: Multi-view depth map estimation with cross-view consistency. In: British Machine Vision Conference. (2014)

[102] Yoon, K., Kweon, I.: Adaptive support-weight approach for correspondence search. IEEE Transactions on Pattern Analysis and Machine Intelligence (2006) 650–656

[103] Rhemann, C., Hosni, A., Bleyer, M., Rother, C., Gelautz, M.: Fast cost-volume filtering for visual correspondence and beyond. In: IEEE Conference on Computer Vision and Pattern Recognition, IEEE (2011) 3017–3024

[104] Liu, Y., Cao, X., Dai, Q., Xu, W.: Continuous depth estimation for multi-view stereo. In: IEEE Conference on Computer Vision and Pattern Recognition, IEEE (2009) 2121–2128

[105] Bleyer, M., Rhemann, C., Rother, C.: Patchmatch stereo-stereo matching with slanted support windows. In: British Machine Vision Conference. Volume 11. (2011) 1–11

[106] Galliani, S., Lasinger, K., Schindler, K.: Massively parallel multiview stereopsis by surface normal diffusion. In: IEEE Conference on Computer Vision. (2015) 873–881

[107] Furukawa, Y., Ponce, J.: Accurate, dense, and robust multiview stereopsis. IEEE Transactions on Pattern Analysis and Machine Intelligence **32** (2010) 1362–1376

[108] Huang, C., Cagniart, C., Boyer, E., Ilic, S.: A Bayesian approach to multi-view 4D modeling. International Journal of Computer Vision **116** (2016) 115–135

[109] Lowe, D.: Distinctive image features from scale-invariant keypoints. International Journal of Computer Vision **60** (2004) 91–110

[110] Rublee, E., Rabaud, V., Konolige, K., Bradski, G.: ORB: an efficient alternative to SIFT or SURF. In: IEEE Conference on Computer Vision, IEEE (2011) 2564–2571

[111] Wu, C., Agarwal, S., Curless, B., Seitz, S.: Multicore bundle adjustment. In: IEEE Conference on Computer Vision and Pattern Recognition, IEEE (2011) 3057–3064

[112] Djelouah, A., Franco, J., Boyer, E., Le Clerc, F., Pérez, P.: N-tuple color segmentation for multi-view silhouette extraction. In: European Conference on Computer Vision, Springer (2012) 818–831

[113] Esteban, C., Schmitt, F.: Silhouette and stereo fusion for 3D object modeling. Computer Vision and Image Understanding **96** (2004) 367–392

[114] Ihrke, I., Kutulakos, K., Lensch, H., Magnor, M., Heidrich, W.: Transparent and specular object reconstruction. In: Computer Graphics Forum. Volume 29., Wiley Online Library (2010) 2400–2426

[115] Ye, J., Ji, Y., Li, F., Yu, J.: Angular domain reconstruction of dynamic 3D fluid surfaces. In: IEEE Conference on Computer Vision and Pattern Recognition, IEEE (2012) 310–317

[116] Liu, D., Chen, X., Yang, Y.: Frequency-based 3D reconstruction of transparent and specular objects. In: IEEE Conference on Computer Vision and Pattern Recognition. (2014) 660–667

[117] Qian, Y., Gong, M., Yang, Y.: 3D reconstruction of transparent objects with position-normal consistency. In: IEEE Conference on Computer Vision and Pattern Recognition. (2016) 4369–4377

[118] Savinov, N., Häne, C., Ladicky, L., Pollefeys, M.: Semantic 3D Reconstruction with Continuous Regularization and Ray Potentials Using a Visibility Consistency Constraint, IEEE (2016)

[119] Han, X., Leung, T., Jia, Y., Sukthankar, R., Berg, A.: MatchNet: unifying feature and metric learning for patch-based matching. In: IEEE Conference on Computer Vision and Pattern Recognition. (2015) 3279–3286

[120] Zbontar, J., LeCun, Y.: Stereo matching by training a convolutional neural network to compare image patches. Journal of Machine Learning Research **17** (2016) 1–32

[121] Lorensen, W., Cline, H.: Marching cubes: A high resolution 3D surface construction algorithm. In: ACM Siggraph Computer Graphics. Volume 21., ACM (1987) 163–169

[122] Rother, C., Kolmogorov, V., Blake, A.: Grabcut: Interactive foreground extraction using iterated graph cuts. In: ACM Transactions on Graphics. Volume 23., ACM (2004) 309–314

[123] van Wijk, R., Krekels, E., Hankemeier, T., Spaink, H., van der Graaf, P.: Systems pharmacology of hepatic metabolism in zebrafish larvae. submitted (2017)

[124] Brown, M., Lowe, D.: Automatic panoramic image stitching using invariant features. International Journal of Computer Vision **74** (2007) 59–73

[125] Laurentini, A.: The visual hull concept for silhouette-based image understanding. IEEE Transactions on Pattern Analysis and Machine Intelligence **16** (1994) 150–162

[126] Furukawa, Y., Ponce, J.: Carved visual hulls for image-based modeling. International Journal of Computer Vision **81** (2009) 53–67

[127] Field, H., Ober, E., Roeser, T., Stainier, D.: Formation of the digestive system in zebrafish. i. liver morphogenesis. Developmental Biology **253** (2003) 279–290

[128] Maloney, L., Dal Martello, M.: Kin recognition and the perceived facial similarity of children. Journal of Vision **6** (2006)

[129] Fang, R., Tang, K., Snavely, N., Chen, T.: Towards computational models of kinship verification. In: IEEE Conference on Image Processing. (2010) 1577–1580

[130] Dal Martello, M., Maloney, L.: Where are kin recognition signals in the human face? Journal of Vision **6** (2006)

[131] Xia, S., Shao, M., Fu, Y.: Kinship verification through transfer learning. In: International Joint Conference on Artificial Intelligence. Volume 3. (2011) 2539–2544

[132] Lu, J., Zhou, X., Tan, Y., Shang, Y., Zhou, J.: Neighborhood repulsed metric learning for kinship verification. IEEE Transactions on Pattern Analysis and Machine Intelligence **36** (2014) 331–345

[133] Dibeklioğlu, H., Salah, A., Gevers, T.: Like father, like son: Facial expression dynamics for kinship verification. In: IEEE Conference on Computer Vision. (2013) 1497–1504

[134] Felzenszwalb, P., Huttenlocher, D.: Pictorial structures for object recognition. International Journal of Computer Vision **61** (2005) 55–79

[135] Xia, S., Shao, M., Luo, J., Fu, Y.: Understanding kin relationships in a photo. IEEE Transactions on Multimedia **14** (2012) 1046–1056

[136] Chen, Y., Hsu, W., Liao, H.: Discovering informative social subgraphs and predicting pairwise relationships from group photos. In: ACM Conference on Multimedia. (2012) 669–678

[137] Xiong, X., De la Torre, F.: Supervised descent method and its applications to face alignment. In: IEEE Conference on Computer Vision and Pattern Recognition. (2013) 532–539

[138] Ojala, T., Pietikainen, M., Maenpaa, T.: Multiresolution gray-scale and rotation invariant texture classification with local binary patterns. IEEE Transactions on Pattern Analysis and Machine Intelligence **24** (2002) 971–987

[139] Guo, G., Mu, G., Fu, Y., Huang, T.: Human age estimation using bio-inspired features. In: IEEE Conference on Computer Vision and Pattern Recognition. (2009) 112–119

[140] Dibeklioğlu, H., Salah, A., Gevers, T.: Are you really smiling at me? Spontaneous versus posed enjoyment smiles. In: European Conference on Computer Vision. (2012) 525–538

[141] Guo, G., Dyer, C., Fu, Y., Huang, T.: Is gender recognition affected by age? In: IEEE Conference on Computer Vision Workshops. (2009) 2032–2039

[142] Guo, G., Wang, X.: A study on human age estimation under facial expression changes. In: IEEE Conference on Computer Vision and Pattern Recognition. (2012) 2547–2553

[143] Wheeler, Q., Raven, P., Wilson, E.: Taxonomy: impediment or expedient? Science **303** (2004) 285–285

[144] Lammers, Y., Peelen, T., Vos, R.A., Gravendeel, B.: The HTS barcode checker pipeline, a tool for automated detection of illegally traded species from high-throughput sequencing data. BMC bioinformatics **15** (2014) 44

[145] Francoy, T., Wittmann, D., Drauschke, M., Müller, S., Steinhage, V., Bezerra-Laure, M., De Jong, D., Gonçalves, L.: Identification of Africanized

honey bees through wing morphometrics: two fast and efficient procedures. Apidologie **39** (2008) 488–494

[146] Silla Jr, C., Freitas, A.: A survey of hierarchical classification across different application domains. Data Mining and Knowledge Discovery **22** (2011) 31–72

[147] Wheeler, E., Baas, P., Gasson, P.: IAWA list of microscopic features for hardwood identification. (1989)

[148] Belongie, S., Malik, J., Puzicha, J.: Shape context: A new descriptor for shape matching and object recognition. In: NIPS. Volume 2. (2000)

[149] Ricard, J., Coeurjolly, D., Baskurt, A.: Generalizations of angular radial transform for 2D and 3D shape retrieval. Pattern Recognition Letters **26** (2005) 2174–2186

[150] Jia, Q., Fan, X., Liu, Y., Li, H., Luo, Z., Guo, H.: Hierarchical projective invariant contexts for shape recognition. Pattern Recognition **52** (2016) 358–374

[151] Simonyan, K., Zisserman, A.: Very deep convolutional networks for large-scale image recognition. arXiv preprint arXiv:1409.1556 (2014)

[152] Szegedy, C., Liu, W., Jia, Y., Sermanet, P., Reed, S., Anguelov, D., Erhan, D., Vanhoucke, V., Rabinovich, A.: Going deeper with convolutions. In: IEEE Conference on Computer Vision and Pattern Recognition. (2015) 1–9

[153] He, K., Zhang, X., Ren, S., Sun, J.: Deep residual learning for image recognition. In: IEEE Conference on Computer Vision and Pattern Recognition. (2016) 770–778

[154] Xu, K., Ba, J., Kiros, R., Cho, K., Courville, A., Salakhudinov, R., Zemel, R., Bengio, Y.: Show, attend and tell: Neural image caption generation with visual attention. In: International Conference on Machine Learning. (2015) 2048–2057

[155] Ren, S., He, K., Girshick, R., Sun, J.: Faster R-CNN: Towards real-time object detection with region proposal networks. In: Advances in Neural Information Processing Systems. (2015) 91–99

[156] Silver, D., Huang, A., Maddison, C., Guez, A., Sifre, L., Van Den Driessche, G., Schrittwieser, J., Antonoglou, I., Panneershelvam, V., Lanctot, M.,

et al.: Mastering the game of go with deep neural networks and tree search. Nature **529** (2016) 484

[157] Russakovsky, O., Deng, J., Su, H., Krause, J., Satheesh, S., Ma, S., Huang, Z., Karpathy, A., Khosla, A., Bernstein, M., Berg, A., Li, F.: Imagenet large scale visual recognition challenge. International Journal of Computer Vision **115** (2015) 211–252

[158] Martins, J., Oliveira, L., Nisgoski, S., Sabourin, R.: A database for automatic classification of forest species. Machine Vision and Applications **24** (2013) 567–578

[159] Costa, E., Lorena, A., Carvalho, A., Freitas, A., Holden, N.: Comparing several approaches for hierarchical classification of proteins with decision trees. In: Brazilian Symposium on Bioinformatics, Springer (2007) 126–137

[160] Barbedo, J., Lopes, A.: Automatic genre classification of musical signals. EURASIP Journal on Applied Signal Processing **2007** (2007) 157–157

[161] Dekel, O., Keshet, J., Singer, Y.: Large margin hierarchical classification. In: International Conference on Machine Learning, ACM (2004) 27

[162] Cesa-Bianchi, N., Gentile, C., Zaniboni, L.: Hierarchical classification: combining Bayes with SVM. In: International Conference on Machine Learning, ACM (2006) 177–184

[163] Cesa-Bianchi, N., Gentile, C., Zaniboni, L.: Incremental algorithms for hierarchical classification. Journal of Machine Learning Research **7** (2006) 31–54

[164] Wang, H., Shen, X., Pan, W.: Large margin hierarchical classification with mutually exclusive class membership. Journal of Machine Learning Research **12** (2011) 2721–2748

[165] Tsoumakas, G., Katakis, I.: Multi-label classification: An overview. International Journal of Data Warehousing and Mining **3** (2006)

[166] Wei, Y., Xia, W., Huang, J., Ni, B., Dong, J., Zhao, Y., Yan, S.: CNN: Single-label to multi-label. arXiv preprint arXiv:1406.5726 (2014)

[167] Zhao, F., Huang, Y., Wang, L., Tan, T.: Deep semantic ranking based hashing for multi-label image retrieval. In: IEEE Conference on Computer Vision and Pattern Recognition. (2015) 1556–1564

[168] Wang, J., Yang, Y., Mao, J., Huang, Z., Huang, C., Xu, W.: CNN-RNN: A unified framework for multi-label image classification. In: IEEE Conference on Computer Vision and Pattern Recognition. (2016) 2285–2294

[169] Yan, Z., Zhang, H., Piramuthu, R., Jagadeesh, V., DeCoste, D., Di, W., Yu, Y.: HD-CNN: hierarchical deep convolutional neural networks for large scale visual recognition. In: IEEE Conference on Computer Vision. (2015) 2740–2748

[170] Pereira, S., Gravendeel, B., Wijntjes, P., Vos, R.: OrchID: a generalized framework for taxonomic classification of images using evolved artificial neural networks. bioRxiv (2016)

[171] Ruck, D., Rogers, S., Kabrisky, M., Oxley, M., Suter, B.: The multilayer perceptron as an approximation to a bayes optimal discriminant function. IEEE Transactions on Neural Networks **1** (1990) 296–298

[172] Jia, Y., Shelhamer, E., Donahue, J., Karayev, S., Long, J., Girshick, R., Guadarrama, S., Darrell, T.: Caffe: Convolutional architecture for fast feature embedding. arXiv preprint arXiv:1408.5093 (2014)

[173] van der Maaten, L., Hinton, G.: Visualizing data using t-SNE. Journal of Machine Learning Research **9** (2008) 2579–2605

[174] Guo, Y., Liu, Y., Bakker, E., Guo, Y., Michael, L.: CNN-RNN: A large-scale hierarchical image classification framework. Multimedia Tools and Applications (2017)

[175] Verbeek, F., et al.: Visualization of complex data sets over Internet: 2D and 3D visualization of the 3D digital atlas of zebrafish development. In: Electronic Imaging, International Society for Optics and Photonics (2001) 20–29

[176] Verbeek, F.: Lecture notes of Image Analysis in Microscopy. Leiden University (2017)