Machine Vision and Applications (2013) 24:1327–1329
DOI 10.1007/s00138-013-0543-8

EDITORIAL

Machine learning in medical imaging

Pingkun Yan · Kenji Suzuki · Fei Wang · Dinggang Shen

Published online: 31 August 2013

There is no doubt that medical imaging has become indispensable in disease diagnosis and therapy. With advances in medical imaging, new imaging modalities and methodologies such as cone-beam/multi-slice CT, 3D ultrasound imaging, tomosynthesis, diffusion-weighted magnetic resonance imaging (MRI), positron-emission tomography (PET)/CT, electrical impedance tomography, and diffuse optical tomography, the imaging information available for clinical decision making has been erupting. To take full advantage of medical imaging, new algorithms and methods are demanded in the medical imaging field to better process the overwhelming volume of data. However, due to the large variations and complexity in the medical imaging data, it is generally hard to derive analytic solutions or simple equations to represent objects such as lesions and anatomies in medical imaging data. Therefore, tasks in medical imaging require "learning from examples" for accurate representation of data and prior knowledge, which is exactly the focus of machine learning. Thus, machine learning in medical imaging has become one of the most promising growing fields. Machine learning is currently playing an essential role in the medical imaging field, including computer-aided diagnosis, image segmentation, image registration, image fusion, image-guided therapy, image annotation, and image database retrieval.

P. Yan (✉)
Philips Research North America, Briarcliff Manor, NY 10510, USA
e-mail: pingkun@ieee.org

K. Suzuki
Department of Radiology, University of Chicago, Chicago, IL 60637, USA

F. Wang
IBM Almaden Research Center, San Jose, CA, USA

D. Shen
Department of Radiology and BRIC, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

The main aim of this special issue is to help advance the scientific research within the broad field of machine learning in medical imaging. The special issue was planned in conjunction with the International Workshop on Machine Learning in Medical Imaging 2011 [1]. Being the first workshop on this topic, it has been successfully held together with the International Conference on Medical Image Computing and Computer-Assisted Intervention (MICCAI) for four consecutive years since 2010. This special issue is one in a series of special issues of journals on this topic [2]. The focus of the special issue is on major trends and challenges in this area. It presents work aimed at identifying new cutting-edge techniques and their use in medical imaging.

The majority of the papers included in this special issue were presented in a preliminary form at the International Workshop on Machine Learning in Medical Imaging, held in Toronto, Canada on September 18th, 2011. Together with some other new submissions, the submitted papers underwent two rounds of rigorous peer review. At the end, a small set of papers in total of 11 was selected to be included in this special issue to ensure a high quality outcome. There were quite several other good papers, which however, were not able to be included into the special issue due to the limited space. Those papers were later recommended for publication as regular papers of the journal, *Machine Vision and Applications*.

The special issue covers a wide spectrum of machine learning methods with their applications in different medical imaging modalities and targeted organs. The biomedical imaging modalities included in this special issue include CT [3,5,10], PET [4], MRI [6,11–13], histology images [7,9], and echocardiograms [8]. The targeted organs or structures include vertebrae [3,10], thoracic structures [5], breast

tissue [6,9], lung [7], heart [8], knees [11,13], brain [12], as well as a phantom [4]. The fusion of machine learning methods and medical imaging applications further demonstrates the versatility and productivity of this multidisciplinary research after years of development. In this special issue, a dictionary-based classification method using a cascade of simultaneous orthogonal matching pursuit classifiers [3] was applied to image-guided spine surgery. The statistical lesion activity computation (SLAC) [4], topological characterization of lesion enhancement patterns [6], a morphological tissue pattern-based classification [7], and the random subspace classifier ensembles [9] were used for cancer detection and classification. An online boosting algorithm [5] was designed for automatically detecting anatomic structures. As for the classical task of medical image segmentation, new attempts including using AdaBoost for defining local and global priors [8], sample-driven active shape models [10], unified extreme learning machines and discriminative random fields [13] were investigated. A partial least square-based method was developed for diagnosing knee osteoarthritis [11]. A cortical thickness network was established using the kernel-based method for predicting Alzheimer's disease [12].

We would like to thank all the authors for their excellent contributions to this special issue and to all the reviewers for their high quality reviews and constructive suggestions. We hope that this special issue will inspire further ideas for creative research, advance the field of machine learning in medical imaging, and facilitate the translation of the research from bench to bedside.

References

1. Suzuki, K., Wang, F., Shen, D., Yan, P.: Machine Learning in Medical Imaging. Lecture Notes in Computer Science, vol. 7009. Springer, Berlin (2011)
2. Suzuki, K., Yan, P., Wang, F., Shen, D.: Special issue on machine learning in medical imaging. Int. J. Biomed. Imaging **2012**, 123727 (2012)
3. Wu, T., Jian, B., Zhou, X.S.: Automated identification of thoracolumbar vertebrae using orthogonal matching pursuit. Mach. Vis. Appl. (2012). doi:10.1007/s00138-012-0453-1
4. George, J., Vunckx, K., Van de Casteele, E., Tejpar, S., Deroose, C.M., Nuyts, J., Loeckx, D., Suetens, P.: SLAC: Statistical total lesion metabolic activity computation by fuzzy unsupervised learning of PET images. Mach. Vis. Appl. (2012). doi:10.1007/s00138-012-0454-0
5. Tajbakhsh, N., Wu, H., Xue, W., Gotway, M.B., Liang, J.: A novel online boosting algorithm for automatic anatomy detection. Mach. Vis. Appl. (2012). doi:10.1007/s00138-012-0455-z
6. Nagarajan, M.B., Huber, M.B., Schlossbauer, T., Leinsinger, G., Krol, A., Wismüller, A.: Classification of small lesions in dynamic breast MRI: eliminating the need for precise lesion segmentation through spatio-temporal analysis of contrast enhancement. Mach. Vis. Appl. (2012). doi:10.1007/s00138-012-0456-y
7. Wang, C.-W., Yu, C.-P.: Automated morphological classification of lung cancer subtypes using H&E tissue images. Mach. Vis. Appl. (2012). doi:10.1007/s00138-012-0457-x
8. Oktay, A.B., Akgul, Y.S.: Extraction of left ventricle borders with local and global priors from echocardiograms. Mach. Vis. Appl. (2012). doi:10.1007/s00138-012-0458-9
9. Zhang, Y., Zhang, B., Coenen, F., Lu, W.: Breast cancer diagnosis from biopsy images with highly reliable random subspace classifier ensembles. Mach. Vis. Appl. (2012). doi:10.1007/s00138-012-0459-8
10. Mysling, P., Petersen, K., Nielsen, M., Lillholm, M.: A unifying framework for automatic and semi-automatic segmentation of vertebrae from radiographs using sample-driven active shape models. Mach. Vis. Appl. (2012). doi:10.1007/s00138-012-0460-2
11. Marques, J., Igel, C., Lillholm, M., Dam, E.B.: Linear feature selection in texture analysis—a PLS based method. Mach. Vis. Appl. (2012). doi:10.1007/s00138-012-0461-1
12. Dai, D., He, H., Vogelstein, J.T., Hou, Z.: Accurate prediction of AD patients using cortical thickness networks. Mach. Vis. Appl. (2012). doi:10.1007/s00138-012-0462-0
13. Zhang, K., Lu, W., Marziliano, P.: The unified extreme learning machines and discriminative random fields for automatic knee cartilage and meniscus segmentation from multi-contrast MR images. Mach. Vis. Appl. (2012). doi:10.1007/s00138-012-0466-9

Author Biographies

Pingkun Yan is a senior member research staff of Philips Research North America. Dr. Yan received his B.Eng. degree in Electronics Engineering and Information Science from the University of Science and Technology of China, and his Ph.D. degree in Electrical and Computer Engineering from the National University of Singapore. His research mainly focuses on computer vision, pattern recognition, machine learning and their applications in medical imaging. He has published more than 90 papers in top international journals and conferences including Medical Image Analysis, IEEE T-BME, IEEE T-CSVT, IEEE T-ITB, MICCAI, ICCV, CVPR, etc. He received the prestigious MICCAI NDI Award in 2005. He is also a recipient of Innovation in Industry Award Finalist in 2008 selected by New York Academy of Sciences. He is an associate editor of multiple international journals, including Machine Vision and Applications, Neurocomputing, and Neural Processing Letters. Dr. Yan is a Senior Member of the IEEE and Member of MICCAI.

Kenji Suzuki received his Ph.D. degree in Information Engineering from Nagoya University in 2001. From 1993 to 2001, he worked at Hitachi Medical Corporation, and then at Aichi Prefectural University as faculty. In 2001, he joined Department of Radiology at University of Chicago. Since 2006, he has been Assistant Professor of Radiology, Medical Physics, and Cancer Research Center there. Dr. Suzuki' research interests include computer-aided diagnosis and machine learning. He has published 230 papers (including 95 peer-reviewed journal papers). He has been serving as the Editor-in-Chief and an Associate Editor of 27 leading international journals including Medical Physics, International Journal of Biomedical Imaging, and Academic Radiology. He has received the Paul Hodges Award, three RSNA Certificate of Merit Awards and Research Trainee Prize, Cancer Research Foundation Young Investigator Award, SPIE Honorable Mention Poster Award, IEEE Outstanding Member Award, and Kurt Rossmann Excellence in Teaching Award. He has been a Senior Member of IEEE since 2004.

Dr. Fei Wang is a research staff member with the User Systems and Experience Research (USER) group at IBM Almaden Research Center. Before that, he conducted research on multi-modal mining for healthcare for over 5 years. His research interests include Social Computing, Pattern Recognition, Machine Learning, Intelligent Human-Computer

Interaction, Computer Vision, Biomedical Image Analysis, Statistical Data Mining and their applications to social media analysis and various healthcare applications. He has published over 50 peer-reviewed articles on various top journals and conferences, and filed over twenty patents (granted and pending applications) in above areas. Fei is an IEEE senior member and is active in several research communities, where he has co-organized/co-chaired conferences and workshops, and often serves on the technical program committees for key conferences in these areas. He is currently an associate editor of International Journal of Image and Graphics (IJIG), Journal of Radiology and Diagnostic Imaging (JRDI), and International Journal of Advances in Optical Communication and Networks (IJAOCN). He received his B.Sc. in Electrical Engineering from the University of Science and Technology of China in 2001, and his M.Sc. (2003) and Ph.D. (2006) in Computer Science from the University of Florida. He is a major contributor for several prestigious awards inside and outside of IBM, including Best Poster Award at Computers in Cardiology 2008, IBM Technical Achievement Award in 2009, and IBM Invention Plateau Award in 2010 and 2013.

Dinggang Shen is a Professor of Radiology, Biomedical Research Imaging Center (BRIC), Computer Science, and Biomedical Engineering in the University of North Carolina at Chapel Hill (UNC-CH). He is currently directing the Center for Image Informatics, the Image Display, Enhancement, and Analysis (IDEA) Lab in the Department of Radiology, and also the medical image analysis core in the BRIC. He was a tenure-track assistant professor in the University of Pennsylvanian (UPenn), and a faculty member in the Johns Hopkins University. Dr. Shen's research interests include medical image analysis, computer vision, and pattern recognition, has published more than 450 papers in the international journals and conference proceedings. He serves as an editorial board member for four international journals. He also serves in the Board of Directors, The Medical Image Computing and Computer Assisted Intervention (MICCAI) Society.