Overview of the 2015 Workshop on Medical Computer Vision — Algorithms for Big Data (MCV 2015)

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Abstract. The 2015 workshop on medical computer vision (MCV): algorithms for big data took place in Munich, Germany, in connection with MICCAI (Medical Image Computing for Computer Assisted Intervention). It is the fifth MICCAI MCV workshop after those held in 2010, 2012, 2013 and 2014 with another edition held at CVPR 2012 previously. This workshop aims at exploring the use of modern computer vision technology in tasks such as automatic segmentation and registration, localisation of anatomical features and extraction of meaningful visual features. It emphasises questions of harvesting, organising and learning from large–scale medical imaging data sets and general–purpose automatic understanding of medical images. The workshop is especially interested in modern, scalable and efficient algorithms that generalise well to previously unseen images. The strong participation in the workshop of over 80 persons shows the importance of and interest in Medical Computer Vision. This overview article describes the papers presented at the workshop as either oral presentations or posters. It also describes the three invited talks that received much attention and a very positive feedback and the general discussions that took place during workshop.

Keywords: medical image analysis, medical computer vision, segmentation, detection

1 Introduction

The Medical Computer Vision workshop (MCV) took place in conjunction with MICCAI (Medical Image Computing for Computer–Assisted Interventions) on Ocotber 9, 2015 in Munich, Germany. This fifth workshop on medical computer vision was organised in connection with MICCAI after the workshops in 2010 [12], 2012 [10], 2013 [11] and 2014 [14] and an additional workshop at CVPR in 2012. The workshop received 22 submissions and ten papers were accepted as oral presentations and another 5 papers were accepted as posters. In addition to these scientific papers three invited speakers presented, linked to the main topics of the workshop, so big data and clinical data intelligence, multi–scale modelling and machine learning approaches for medical imaging with a comparison of decision forests with deep learning. All these approaches were also strongly represented at the main MICCAI conference. This article summaries the presentations and posters of the workshop and also the main discussions that took place during the sessions and the breaks. All papers are presented in the post workshop proceedings that allowed authors to include the comments that were received during the workshop into the final versions of their texts.

2 Papers Presented at the Workshop

The oral presentations were separated into four topic areas: papers on predicting disease, atlas exploitation and avoidance, machine learning–based analysis and the last session on advanced methods for image analysis.

2.1 Predicting Disease

Daianu et al. [2] identify latent factors that explain how sets of biomarkers cluster together and how the clusters significantly predict cognitive decline in Alzheimer's disease (AD). Meanwhile, to diagnose Alzheimer's with higher accuracy, Liu et al. [8] employ a multi–atlas strategy which models the relationships among the atlases and among the subjects and an ensemble AD/MCI (Mild Cognitive Impairement) classification approach.

2.2 Atlas Exploitation and Avoidance

Zografos et al. [19] present a novel atlas–free approach for simultaneous organ segmentation using a set of discriminative classifiers trained to learn the multi–scale appearance of the organs of interest. Karasawa et al. [6] in contrast present a method to segment the pancreas in contrasted abdominal CT in which only training examples with similar vascular systems to the target subject are used to build a structure–specific atlas.

2.3 Machine Learning–Based Analysis

Dvorak et al. [3] propose a convolutional neural network to form a local structure prediction approach for 3D segmentation tasks and apply it for brain tumor segmentation in MRI. Using a different machine learning strategy Wang et al. [16] develop a sequential random forest guided by voting based probability maps and apply it for the automated segmentation of cone–beam computed tomography in cases of facial deformity. Meng et al. [9] use a different random forest approach based on regression forests with added capabilities to ensure spatial smoothness and apply it to impute missing cortical thickness maps in longitudinal studies of developing infant brains.

2.4 Advanced Methods for Image Analysis

Yu et al. [17] develop an efficient image reconstruction algorithm for parallel dynamic MRI, which does not require coil sensitivity profiles and models the correlated pixel intensities across time and across coils using a joint temporal sparsity.

Krenn et al. [7] use research algorithms that were submitted in the VISCERAL benchmark to run them on non–annotated data sets. Label fusion of the results of challenge participants then allows to create a so–called silver corpus that has shown to be better than the best system in the competition and can be useful to train new algorithms. The approach uses relatively simle label fusion.

Inoue et al. [5] use higher order graph cuts to segment the posts major muscle, a difficult structure in terms of structure contrast. The approach uses prior knowledge to estimate shapes.

2.5 Poster Session

The poster session took place during the lunch break and allowed all authors to also present their results in a poster, which is often the most adapted form to foster discussions among persons working on closely related topics.

In [1], Adeli–M. et al. present an approach for the classification of Parkinson's disease patients using MRI data. A joint feature–sample section process is used to select the most robust subset of features leading to promising results on synthetic and real databases.

Zhang et al. [18] present an approach to multi–atlas segmentation. To solve the problem of potentially large anatomical differences between pair–wise registrations, coarse registrations are first obtained in a tree like structure to reduce the potential misalignment and improve segmentation results.

Shay et al. [15] present a new approach for the segmentation of the hippocampus in MRI infant brains . A boundary regression method is used to deal with the strong differences that infant brains have compared to adult brains.

A survey of mathematical structures for extending neurogeometry from 2D to 3D is presented in [13]. Low dose CT images are used with perfusion deconvolution.

In [4], Fang et al. present and approach to 4D hemodynamic data analysis by fusing the local anatomical structure correlation and temporal blood flow continuation. The approach limits local artefacts and leads to better results than previous approaches.

3 Invited Speakers

3.1 Volker Tresp

Volker Tresp from Siemens and LMU (Ludwig Maximilians University) Munich, Germany gave a talk about structured relational learning and the role of knowledge graphs in the capturing and representation of clinical data for large-scale learning problems. He discussed the role of tensor factorizations in the learning with graph structured data, and the possible impact on understanding, predicting, and modelling clinical events, and the large amount of linked clinical data available. The talk highlighted several aspect of big data in clinical environements and thus the topic of the workshop.

3.2 Pascal Fua

Pascal Fua of the EPFL (Ecole Polytechnique Federal de Lausanne), Switzerland presented impressive results on the use of machine learning techniques in the delineation of curvilinear structures, and reconstruction of networks such as neurons in microscopy data. Specifically he discussed approaches that overcome discontinuities and occlusions, to reconstruct a network despite imperfect data. A multi scale analysis was used.

3.3 Antonio Criminisi

The talk of Antonio Criminisi titled "Efficient Machine Learning for Medical Image Analysis" was visited by a large number of persons, as machine learning and choice of the right methods has really become a corner stone in medical imaging. Antonio is with Microsoft research in Cambridge, United Kingdom and he mentioned at the beginning of the talk that he as an expert on decision forests has taken some time to really ready into the literature on deep learning, one of the most discussed techniques in general at MICCAI 2015. He thus compared approaches of deep learning and the quite impressive performance he obtained with them but also a detailed comparison with random forests to select what technique might be best in which scenario. Random forests can in his view be reformulated as a neural network. Stability of results and also the amount of available training data were mentioned as examples to look into when choosing a technique. All applications of these techniques were on medical image analysis.

4 Discussions at the Workshop

One of the dominating topics at the conference and also at the workshop were the applied machine learning techniques and particularly the use of convolutional neural networks in various tasks of imaging such as segmentation, detection and classification. Choosing the right techniques and tools and then optimizing them is seen as a key to success.

Many people mentioned large data sets to be analysed as important for getting good results but also the challenges in getting large data sets. Multi-Centre studies and partly incomplete data sets were another topic discussed and where solutions would strongly help many of the existing techniques. Using data from severla centers can create larger cohorts but standardization of imaging and meta data are challenges.

Where many data sets are now available get much annotated data with segmentations or regions of interest remains a challenge. Annotations are expensive to obtaine and the tasks are often containing some subjectivity. In this context scientific challenges were highlighted as important to share data and also tools around a common objective.

5 Conclusions

Much positive feedback was given at the end of the workshop on the invited talks and the scientific presentations. The use of larger data sets and also longitudinal data were seen as important next steps. Quality ground truth and region annotations were other aspects mentioned to be important and the integration of image data with other clinical data sources to get more complete clinical analysis. Much work in medical computer vision is still required for the current challenges of quantitative medical image analysis and to bring at least a few of the tools into clinical practice in the foreseeable future.

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