KHBM-KSMRM Joint Symposium

SY20-1

Introduction to deep learning

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Deep learning is a branch of machine learning technology based on multiple processing layers to learn representation of data. This area is very rapidly developing and growing in various fields and is getting a lot of social attention in the last few years. In particular, image understanding with deep learning have shown a great success in applications including the detection, segmentation, and recognition of objects. These achievements are beginning to be used in real life beyond the research stage. In recent years, such successful technologies have been transferred to the field of medical imaging and notable results are emerging in several areas. In the field of MR research, early deep learning studies focusing on various topics (reconstruction, denoising, segmentation, detection, classification, etc.) are being introduced and it is hoped that deep learning will open up a new field of MR research. In this talk, the key concepts of deep learning and its potential applications will be introduced from the perspective of MR scientists.

Keywords : Deep learning, Machine learning, AI, CNN

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SY20-2

Deep learning approach for compressed sensing MRI

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Purpose: Compressed sensing MRI (CS-MRI) from single and parallel coils is one of the powerful ways to reduce the scan time of MR imaging with performance guarantee. However, the computational costs are usually expensive. This paper aims to propose a computationally fast and accurate deep learning algorithm for the reconstruction of MR images from highly down-sampled k-space data.

Theory: Based on the topological analysis, we show that the data manifold of the aliasing artifact is easier to learn from a uniform subsampling pattern with additional low-frequency k-space data. Thus, we develop deep aliasing artifact learning networks for the magnitude and phase images to estimate and remove the aliasing artifacts from highly accelerated MR acquisition.

Methods: The aliasing artifacts are directly estimated from the distorted magnitude and phase images reconstructed from subsampled k-space data so that we can get an aliasing-free images by subtracting the estimated aliasing artifact from corrupted inputs. Moreover, to deal with the globally distributed aliasing artifact, we develop a multi-scale deep neural network with a large receptive field.

Results: The experimental results conrm that the proposed deep artifact learning network effectively estimates and removes the aliasing artifacts. Compared to existing CS methods from single and multi-coli data, the proposed network shows minimal errors by removing the coherent aliasing artifacts. Further-more, the computational time is by order of magnitude faster.

Conclusion: As the proposed deep artifact learning network immediately generates accurate reconstruction, it has great potential for clinical applications.

Keywords : Deep learning, Artifact learning, Convolutional neural network, Compressed sensing, Parallel imaging

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SY20-3

Deep learning approaches to functional MRI data analysis

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From the technical breakthrough in about a decade ago, the deep learning approaches based on the deep neural networks (DNNs) have been dominating various machine learning applications such as the computer vision, speech recognition, and natural language processing. In more recent years, the deep learning approaches have been shown the efficacy in the neuroimaging data analysis. In this talk, I would like to introduce the completed and on-going studies using the DNN models in our lab.

In our DNN models for the neuroimaging data, the sparsity of the weight parameters is systematically controlled to circumvent the curse-of-dimensionality issue. Our DNN models with this weight sparsity control scheme have been applied to the classification of the schizophrenic patients from the healthy controls using the whole brain functional connectivity patterns and to the classification of the sensory motor tasks using the whole brain neuronal activation patterns. In our on-going studies, the DNN models are applied to predict the emotional responses of the human and to predict the temporal dynamics of fMRI data in a time-delayed auto-encoder framework.

Our proposed DNN models have shown the superior classification performance than the currently popular support vector machine classifier. Also, the DNN models extracted the hierarchical feature representations from the fMRI data. The prediction performance of the fMRI data using our proposed DNN models are also promising and the interpretation of the results are reasonable.

These studies have successfully shown the capacity of our DNN models with the weight sparsity control scheme to the fMRI data analysis and the potential to the neuroimaging data analysis in general.

Keywords : Deep Neural Network, Functional Magnetic Resonance Imaging, Neuroimaging

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SY20-4

Neuroimaging to machine learning and reverse

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Neuroimaging has played a great role in understanding human intelligence, which has served conceptual bases for the development of artificial intelligence, a recent term for an old name "machine learning". Among different fields of machine learning, deep learning has proven its success in various application areas. Several combinatory studies of neuroimaging and deep learning have shown similarity between how human brain and deep learning work. This is because machine learning is established on the neurobiological architecture of the brain. The more we learn about the brain using neuroimaging, the more we may generate a biologically plausible architecture for the artificial intelligence. Not only machine learns the brain for evolving its architecture. Brain science using neuroimaging takes advantage of the deep learning in analyzing neuroimaging data for various diagnostic applications. Conversely, machine learns the hidden brain architecture utilizing big neuroimaging data. The successful classification and prediction of brain disease using neuroimaging may reveal the representation of hidden features for brain disease. It may provide biomarkers of the brain and thus enhances our understanding of the brain disease. In the current talk, combinatory examples of the machine learning in the neuroimaging and vice versa will be presented.

Keywords : Neuroimaging, Machine learning, Deep learning, Brain science