Neuro MRI Symposium ll: Basics of Advanced Neuroradiology Research for Beginners

SY07-1

Neuro MRI Symposium 2: Basics of Advanced Neuroradiology Research for Beginners

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Recent papers from neuroradiology have shown trend toward more quantitative and high-dimensional imaging parameters such as radiomics or histogram analysis, from previous qualitative imaging parameters such as visual assessment of radiological findings. In case of a study with quantitative imaging parameters, the research work may be more about number than images and more labor-intensive. In this talk, several open-source interfaces for image processing and analysis, and tips for such labor-intensive work of quantitative research will be introduced.

Keywords : Neuroradiology

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Basics of Deep Learning for Radiologists

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1. Brief overview of machine learning

Machine learning can be defined as the systematic study of algorithms and systems that improve their knowledge or performance with experience. It represents a set of methods and techniques developed recently in various fields such as computational statistics, pattern recognition, and artificial neural network, etc.

Three main components of machine learning are tasks, models, and features. A task refers to the problem we want to solve. A task could be roughly classified as supervised learning and unsupervised learning. We solve the problems with models generated by learning algorithms. A feature can be defined as an individual measurable property of a phenomenon being observed.

Recently, deep learning gained tremendous interest due to the progress it has showed in various fields including visual recognition and natural language processing. Deep learning uses a cascade of multiple layers of nonlinear processing units for feature extraction and transformation. The most commonly used algorithm in deep learning for handling medical images is convolutional neural network (CNN). Therefore, it is important for radiologists to understand the basic principle of CNN.

2. The architecture of convolutional neural network

1) Convolutional layer

A convolutional layer have neurons arranged in 3 dimensions: width, height, depth. This volume is processed by a number of filters, which represent the weights and connections in the convolution network. The neurons in a layer will only be connected to a small region of the layer before it, instead of all of the neurons in a fully-connected manner (e.g. AlexNet).

2) Max pooling

To aggressively reduce dimensionality of feature maps and sharpen the located features, a max pooling is often inserted after a convolutional layer. The essential idea behind max pooling is to break up each feature map into equally sized tiles.

3) Fully-connected layer

A fully connected layer will compute the class scores, resulting in volume of number of classes, where each value corresponds to a class score. As its name implies, each neuron in this layer will be connected to all the numbers in the previous volume.

3. Application of deep learning in radiology

In this lecture, several applications of deep learning algorithms in radiology, mainly focusing on neuroimaging studies, will be presented.

1) Classification

Classification refers to predicting a category to which the data belong. Recently, a study of automatic detection of critical finding on brain CT using deep learning has been demonstrated.

2) Segmentation

Segmentation is another promising task that machine learning can do. Currently, there are several challenges (or competitions) for the segmentation of lesions such as brain tumor, white matter hyperintensity, or ischemic stroke. This can potentially reduce the interobserver variability and help the application of radiomics-based study far more efficiently. Deep learning algorithms have shown excellent results in these tasks.

3) Regression

Regression in machine learning refers to predicting a real value rather than a class based on the data. Regression can be applied to estimating prognosis of various diseases. An example would be predicting overall survival in patients with glioblastoma.

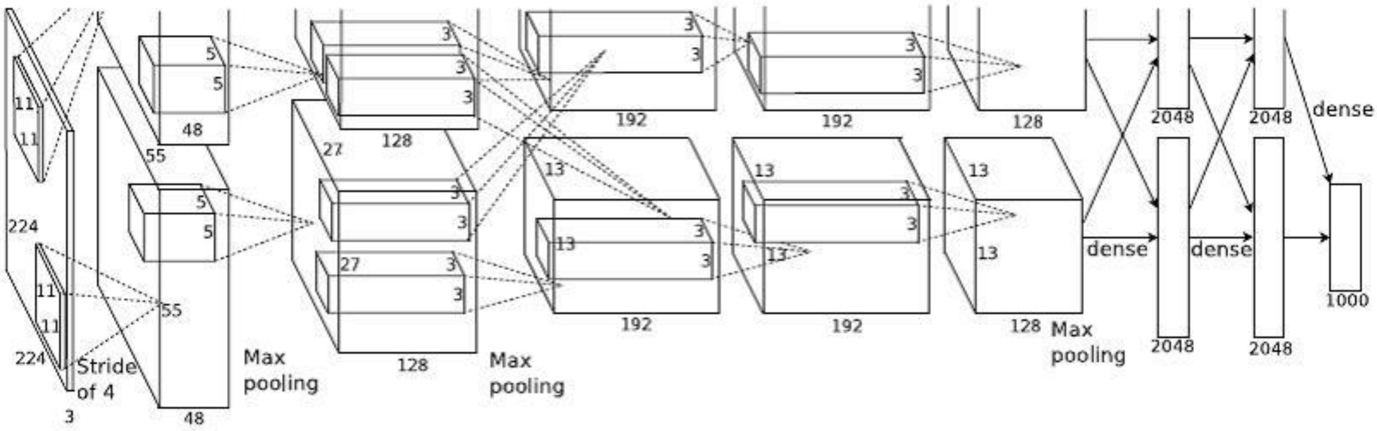

Fig.1. Architecture of convolutional neural network. Krizhevsky A, Sutskever I, Hinton GE. ImageNet classification with deep convolutional neural networks. Advances in neural information processing systems (2012).

Keywords : Deep learning, Machine learning, Convolutional neural network (CNN), Neuroradiology

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Basics of Radiomics in Neuroradiologic Research

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1. Radiomics Pipeline
1-1. Imaging acquisition and preprocessing
1-2. Defining the region of interest
1-3. Radiomic feature extraction
1-4. Feature selection and classifier modeling strategies according to outcomes

2. Practical Considerations
2-1. Statistical modeling
2-2. Generalizability issue

Radiomics utilizes high-dimensional imaging data to discover the association with diagnostic, prognostic, predictive endpoint or radio-genomics. It is an emerging field of study that potentially depicts the intra-tumoral heterogeneity from quantitative and classified high-throughput data. The radiomics approach has an analytic pipeline where the imaging features are extracted, processed, and analyzed. In this talk, I will describe the potential role of radiomics in oncologic studies, the basic analytic pipeline, and special data handling with high-dimensional data, to facilitate the radiomics approach as a tool for personalized medicine in oncology. I will give some illustrating examples of the promise in neuro-oncology research in diagnostic and prognostic studies. Finally, I will give future consideration for radiomics as a new imaging biomarker in oncology in conjunction with the imaging biomarker roadmap for cancer studies.

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Keywords : Radiomics, Neuro-Oncology, Imaging biomarker

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Basics of SWI and QSM for neuroradiology research

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While MRI is based on complex signal, majority of clinical application of MRI utilize magnitude of the signal. Recently, interest to phase of the signal has been increased. Many studies explore the processing methods for phase contrast of MR images and their clinical applications. One of the successful applications is susceptibility-weighted images (SWI), which utilized both phase and magnitude information. Because SWI has excellent contrast to hemorrhages and other iron-rich tissues, SWI almost replaced the conventional T2*-weighted gradient echo image. In addition, for tailored phase contrast, variations of processing and applying phase image filters was also introduced. Moreover, filtered phase images, which is a byproduct of SWI processing can be used for susceptibility (semi-)quantification. Quantitative susceptibility mapping (QSM) gives more accurate measure of susceptibility of each voxel. Compared to raw/filtered phase images or susceptibility mapping, QSM gives quantitative, and comparable values of local susceptibility of each voxel. However, compared to SWI, practical applications of QSM are still under study. This talk will cover basic principles of SWI and QSM for medical doctors, and introduce their current and potential applications for neuroimaging researches.

Keywords : Susceptibility-weighted images, Quantitative susceptibility mapping, Clinical application